Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

Multiple framework contract for the procurement of studies and other supporting services on impact assessments and evaluations (ENTR/172/PP/2012/FC)

Final Report

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EXECUTIVE SUMMARY

This report presents the results of the project “Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation”. A consortium consisting of Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIIP) / TNO has carried out this project for the Directorate-General Climate Action of the European Commission.

Objective and scope

The objective of this study is to assess possible impacts of post-2020 EU CO₂ legislation for light-duty vehicles (LDVs = passenger cars and light-commercial vehicles (LCVs or vans)) on the competitiveness of affected sectors in Europe. In line with the guidelines laid out in the Commission’s "Competitiveness Proofing“ Toolkit (SEC(2012) 91) the study assesses three elements of competitiveness:

- **Cost competitiveness**: impacts from a micro-economic perspective based on costs of compliance;
- **Innovation competitiveness**: impacts from the perspective of a company’s or sector’s capacity to innovate resulting from the need to introduce innovations to comply with regulatory requirements;
- **International competitiveness**: impacts from a macro-economic perspective, looking e.g. at resulting impacts on trade flows and cross-border investments.

In 2014 the European Commission has started the process of preparing a proposal for the post-2020 EU CO₂ legislation for LDVs by initiating a series of supporting studies. In the absence of a concrete proposal the focus of this study is on identifying possible competitiveness impact pathways and analysing their dependence on choices with respect to target and modalities. Elements of the legislation that are relevant for assessing competitiveness impacts include:

- **Metric**: The current legislation is based on tailpipe, or tank-to-wheel (TTW), CO₂ emissions as measured on the type approval test. For post-2020 legislation also other options are considered including well-to-wheel (WTW) CO₂ emissions or a move towards energy consumption from a tank-to-wheel or well-to-wheel perspective.
- **Target level**: This determines the relative stringency of the EU legislation compared to legislation in other regions.
- **Target function**: The target function determines how the required reduction efforts are distributed over the different regulated entities. For the post-2020 legislation both mass and footprint are considered as possible utility parameters for differentiating the target. Also the shape and slope of the target function are to be defined.
- **Modalities**: A number of other design options, which are still to be defined, may affect impacts of the legislation on competitiveness. These include e.g. a phase-in, pooling of targets, super-credits for vehicles meeting specific criteria, eco-innovations or other ways of rewarding off-cycle emission reductions, trading of emission credits, banking and borrowing, combining passenger cars and (part of the) LCVs under a single target, including mileage weighting and/or embedded emissions (vehicle life cycle), and excess emission premiums.
Focus
The assessment covers four selected main affected sectors:
- automotive manufacturers
- automotive suppliers
- energy industry
- (professional) end users

In assessing competitiveness impacts the focus has been on comparing impacts on affected sectors in the EU vs. those in other regions. This means that possible impacts on competition between manufacturers from different EU member states have not been assessed. Furthermore the analysis has focussed on the Δ, i.e. possible changes in competitiveness resulting from the legislation. Current market shares are results of the existing competitiveness situation, based on costs and attractiveness of existing products and services. The analysis has focussed on the question of how these market shares could be affected as a result of post-2020 EU LDV CO₂ legislation, defined by changes in the relative costs and attractiveness of the products of different companies (e.g. manufacturers / manufacturer groups) that could be induced by the legislation.

Approach
Possible impacts on cost competitiveness, innovation competitiveness and international competitiveness have been assessed in separate work packages. These assessments have been supported by the collection of sectorial information from literature and relevant databases as well as by interaction with various stakeholders. The latter has been organised by sending detailed questionnaires to a wide range of stakeholders from different affected sectors as well as a stakeholder consultation workshop with selected representatives from the automotive manufacturing and components supply industry.

Conceptual model
Figure 1 illustrates the main conceptual model that has been used to identify possible competitiveness impact pathways of post-2020 EU LDV CO₂ legislation. In general the competitiveness of companies is determined by the price and value of their products or services relative to the price and value of products or services of competing companies (selling similar products or services or alternatives that can serve as a substitute). Changes in the price and value of a company’s product or service will change the relative attractiveness of the product or service which will lead to changes in market shares. The price and value of a company’s products or services are determined by the company’s capabilities to produce and sell attractive products or services, which in turn are determined by a range of resources. Changes in market shares and profits resulting from changes in the competitiveness of a company’s products are likely to affect the company’s financial and other resources, causing a feedback loop. This model has been used to analyse on the one hand how the legislation might affect the resources and capabilities of (companies in) affected sectors in different regions and on the other hand how regional differences in the resources and capabilities of (companies in) affected sectors might affect their ability to deal with the consequences of the legislation.
Perspective

As mentioned above the focus of the analysis is on impacts of EU CO\textsubscript{2} legislation on the competitiveness of European sectors versus those in other regions. Specifically for automotive manufacturers and suppliers this assessment has been approached from a company perspective as well as a more overall sectorial perspective, leading to two different cases:

- EU manufacturers vs. competing manufacturers from other regions;
- EU manufacturing vs. manufacturing in other regions.

In “EU manufacturing” it is clear that EU means production locations for vehicles, components and materials in the EU. How to define what are EU manufacturers is a more difficult question. This study has identified four options:

- Current main association membership for the EU market;
- Original association membership;
- Location of headquarters / owner;
- Share of the vehicles sold in the EU that are manufactured in the EU.

In the end no single definition was used. Instead an attempt has been made to draw conclusions that are robust under different definitions.

The connection between the two perspectives for analysing competitiveness impacts resulting from CO\textsubscript{2} legislation is illustrated in the Figure 2 for the case of car and component manufacturers. Competitiveness impacts from a manufacturer perspective are first of all determined by the compliance mechanisms chosen...
by EU and non-EU car manufacturing companies. These include changes to the overall vehicle design (including e.g. improved aerodynamics or the use of light-weight materials), improving the efficiency of conventional engines and powertrains or applying alternative powertrains. The average impacts of those choices on the price and value / quality of the vehicles from manufacturers from different regions determine possible changes in competitiveness between EU and non-EU companies. The impact of compliance strategies on the price of vehicles from manufacturers from different regions is strongly affected by the regions in which these manufacturers produce their vehicles and the regions from which they source their components and materials. The average costs of manufacturing vehicles and components in the EU and other regions are what makes up the competitiveness of these regions from a manufacturing perspective. In this way the competitiveness of EU and non-EU manufacturing affects the competitiveness of EU and non-EU manufacturers. The other way around, choices of car manufacturers (also called original equipment manufacturers or OEMs) to manufacture cars in a certain region or source components from a certain region determine production volumes and thus economies-of-scale in that region, which affect the competitiveness of that region relative to other regions from a manufacturing perspective.

**Figure 2 – Relation between assessing cost competitiveness impacts from the perspective of car manufacturers or car manufacturing**

**Cost competitiveness**

**Compliance mechanisms**

The cost impacts of post-2020 EU CO₂ legislation on individual manufacturers are determined on the one hand by the stringency of the target (determined by the overall target level and the distribution of required reduction efforts over different manufacturers) and by the costs of various measures that need to be applied to meet the target.

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Manufacturer specific targets and the resulting required reduction efforts are effectively defined by:

- the target function;
- the sales portfolio / average utility value of the OEM;
- additional modalities, such as pooling, banking & borrowing, eco-innovations, and super-credits.

The main compliance mechanisms available to OEMs for meeting their specific targets are:

- technical options:
  - improving efficiency of internal combustion engine vehicles (ICEVs);
  - increase share of alternatively fuelled vehicles (AFVs)
    - including e.g. natural gas vehicles (NGVs), battery-electric vehicles (BEVs), plug-in hybrids (PHEVs) and fuel cell vehicles (FCEVs)
  - apply eco-innovations
- non-technical options, e.g.:
  - changing vehicle design (affecting utility) or portfolio (affecting average utility);
  - utilisation of test flexibilities or paying excess premiums

The net costs of meeting the target are determined by the way in which manufacturers apply and combine the various technical and non-technical options and the way these are distributed over the (various segments in the) product portfolio.

An overview of the main direct pathways for competitiveness impacts on EU vs. non-EU manufacturers is presented in Figure 3. No competitiveness impacts are to be expected if the following two conditions are simultaneously met:

- the regulation results in targets of similar stringency for EU and non-EU OEMs, and
- the costs of similar compliance mechanisms are the same for EU and non-EU OEMs.

Competitiveness impacts are definitely expected if the legislation on average results in the same level of stringency of targets for EU and non-EU OEMs, but the costs of compliance for the same product (portfolio) are different for manufacturers from different regions. The same holds if costs of the same compliance mechanisms are similar for manufacturers from different regions but targets are different on average. When
both targets and costs are different, it depends on the way in which these are different, whether the regulation may be expected to lead to net impacts on the competitiveness of EU and non-EU OEMs. Competitiveness impacts may also occur if manufacturers from different regions choose different compliance mechanisms with different costs to meet targets of similar stringency. However, if such choices are not forced by the legislation, the resulting competitiveness impacts are not to be attributed to the legislation.

**Important factors affecting cost competitiveness**

In the assessment of possible pathways, through which the competitiveness of automotive manufacturers and suppliers can be affected, a number of important factors have been identified.

**Target level / CO₂ legislation in other regions**

Economies of scale are likely to play a significant role in the cost of compliance. These are affected by the size of the sales of different OEMs in the EU market and in other markets with similar or different CO₂ legislation. An advantage may be expected for OEMs with higher sales on the EU market, if EU legislation is more stringent than in other regions. The impact on competition in other markets depends on extent to which OEMs differentiate their products for different markets.

An important question is how to determine the relative stringency of CO₂ legislation in different countries or regions. Such a comparison depends not only on the target level as such but also on definitions of the targets in different regions (including the test procedure on which it is based) and possible differences in regional fleet composition (where the stringency of a higher target for a fleet of on average larger cars may be equivalent to that of a lower target for a fleet of on average smaller cars). For the period beyond 2020 such a comparison is furthermore difficult to make as the targets in the EU and several other regions are not yet known for 2025 and 2030. Based on existing targets for 2020, however, regional differences in the stringency of targets for passenger cars appear less prominent that what is suggested by the target level alone. For LCVs fleet averages required in the EU are quite similar to those in Japan, but lower than those required in the US and China. Especially for the US, however, it should be taken into account that the vehicles sold there are generally different from those sold in the EU.

**Slope of target function in relation to average utility value**

The shape and slope of the target function for post-2020 legislation affect the competition between individual OEMs depending on their sales distributions. A net effect on competition between EU and non-EU OEMs is only expected if average sales distributions are markedly different. Ways in which the slope of the limit function may affect competitiveness between OEMs are indicated in Figure 4.

Due to the dominance of EU manufacturers on the EU market, the average utility (mass or footprint) of cars sold by EU manufacturers on the EU market is insensitive to the definition of what is an EU manufacturer. The average utility of OEMs from other regions, however, is not only different from the average for EU OEMs, but also strongly dependent of whether the definition e.g. labels Toyota and Hyundai as European OEMs (based on their membership of ACEA or large production facilities in the EU) or as Japanese and Korean OEMs, based on original association membership or location of headquarters. The choice of target function is therefore expected to have an impact on the average relative stringency of the regulation for EU vs. non-EU OEMs. In this respect it should, however, be noted that the slope of the 2020 target function for
cars is already quite flat. For post-2020 legislation the slope is likely to become flatter so that variations in average targets for manufacturer from different regions as function of their average utility are likely to be quite small.

**Figure 4 – Ways in which the slope of the target function may affect competitiveness between OEMs**

**Technology costs**
Competitiveness impacts are likely to occur if the costs of efficiency improvement in ICEVs and the costs of manufacturing AFVs are different for EU and non-EU manufacturers. Such differences may result from:
- Differences in labour costs and productivity in different regions;
- Differences in capital costs and cost of capital in different regions;
- Economies of scale, determined by existing production volumes and by the effects of EU CO\textsubscript{2} legislation on these volumes determined by choices made by OEMs in response to the legislation regarding the regions where they manufacture their vehicles or source components from.

The cost of components from regional suppliers will be different for the same reasons as the cost of manufacturing vehicles in different regions may be different (e.g. wages, taxes, etc.).

A significant net impact of regional differences in costs factors for production (labour, capital, etc.) on the relative price of products is only to be expected if the ratio of these cost factors for additional or new technologies applied to the vehicles are different than for the baseline vehicles.

**Influence of market presence and the economic crisis**
Differences in the presence of different OEMs in different markets are mentioned as a driver for competitiveness impacts in combination with effects of the economic crisis. EU OEMs have a stronger focus on the EU market, and over the past 6 years have made losses there which some could not recover by profits in in other markets, unlike their non-EU competitors. This influences their (financial) capability to
comply with post-2020 targets. The question, of course, is whether that is a structural issue or specifically related to the current situation and the strong and lasting response of EU market to the crisis.

**Premium vs. volume manufacturers**

Whether an OEM is a premium or volume manufacturer may be a stronger determinant for its ability to deal with impacts of CO₂ legislation than whether it is European or not. EU premium OEMs are said to be in a better position than EU volume OEMs to deal with post-2020 legislation, as EU premium manufacturers:

- are less affected by the economic crisis;
- can recover losses in the EU market through profits in other markets;
- face limited competition on the EU market from non-EU OEMs;
- have a client-base with high willingness to pay for innovative technologies.

Overall possible competitive advantages are identified for premium OEMs despite the fact that they are faced with higher costs due to more stringent targets (resulting from the choice of a relatively flat slope of the target function for 2015) and other factors leading to higher additional costs per vehicle. EU volume OEMs may be more likely to lose market share to non-EU volume OEMs and EU premium OEMs. The high share of EU companies in premium markets would mean that on average EU OEMs could have a competitive advantage over non-EU OEMs.

**Cost competitiveness: conclusions from a car manufacturer perspective**

Many possible impact pathways have been identified that might have negative as well as positive impacts on the competitiveness of EU OEMs. This is due to the large number of compliance mechanisms and the large number of resources and capabilities that may be different for different OEMs. Overall this makes it appear less likely that the regulation as a whole would lead to large net impacts on competitiveness of EU OEMs. Nevertheless choices with respect to specific elements of the legislation could enhance the possibility of specific competitiveness impacts to occur.

There are strong indications that the capability of EU OEMs to develop advanced ICEVs and AFVs may be less than that of non-EU OEMs, especially if for meeting post-2020 targets powertrain electrification becomes an important compliance mechanism. This lower capability is caused by different factors including the worse financial position of EU OEMs, the technological focus of EU OEMs (and their suppliers) on diesel technology rather than hybrid/electric propulsion, and a possible future shortage of skilled R&D personnel in the EU.

There are various impact pathways related to the ability to manufacture vehicles with CO₂-reducing technologies at competitive cost, but for most of these pathways the likeliness, sign and size of impacts are difficult to judge. Japanese OEMs appear to be in a better position to scale up production of electric and hybrid vehicles, while EU OEMs may have a possible advantage to achieve cost reductions for integration of different powertrains due their advanced platform approach.

The ability to sell at competitive prices is not only determined by additional costs of manufacturing vehicles with CO₂-reducing technologies, but also by e.g. the amount of R&D costs to be earned back per vehicle, the ability to cross-subsidize within the product portfolio, and the ability to absorb losses. On all of these aspects there are differences between EU and non-EU OEMs.
Timing of the legislation, specifically the lead time between announcement of the target and the actual target year, is expected to affect the above impacts. A short lead time leads to higher costs for developing and marketing new technologies, which are more difficult to bear for OEMs with a less strong financial position.

**Cost competitiveness: conclusions from a car manufacturing perspective**

It is concluded that post 2020 EU LDV CO₂ legislation has **no direct impacts** on the cost competitiveness of EU car manufacturing as the legislation is targeted at the CO₂ performance of vehicles and not at factors that determine the costs of producing cars or their components. A limited number of possible indirect impacts, however, has been identified. Impact pathways seem to be quite generic and the same for the car and van regulation. Actual impacts will depend on the specific design of both regulations beyond 2020.

Possible pathways for **indirect impacts** include:

- **Access to materials and costs of materials**, which could be different for EU and non-EU OEMs. This is especially likely for e.g. electric powertrains and vehicle light-weighting;
- **Possible positive or negative impacts** in relation to regional differences in the cost of components for advanced ICEVs and AFVs, depending e.g. on the relative stringency of EU legislation compared to that in other regions (affecting economies of scale) or whether components are required for which suppliers are mainly located outside Europe;
- **Regional differences in labour costs**, which may have impacts of unknown sign depending on the design of the legislation. This includes possible effects of a (temporary) shortage of qualified personnel for the development as well as manufacturing of vehicles with advanced technologies.

Furthermore some potential pathways have been found relating to differences in costs of capital goods, transport costs and tariffs, and sales volumes over which R&D costs can be divided. The size and sign of these impacts depend mainly on the relative stringency of EU legislation.

**Cost competitiveness: conclusions from a component manufacturer perspective**

The ability of EU suppliers to develop and manufacture components for CO₂ reduction in passenger cars and vans appears likely to be less than that of non-EU competitors. This is specifically the case if regulation increases the demand for vehicles with electric powertrains, due to the technology position and financial position of EU suppliers and expected shortages in skilled R&D personnel. The ability of EU suppliers to sell at competitive prices may be affected by their limited ability to absorb (temporary) losses.

Other possible pathways, that have been identified, relate to manufacturing costs depending on costs of labour and equipment as well as economies of scale in the EU and other regions, to the costs of materials and R&D costs per unit of product and to the ability to cross-subsidize over the product portfolio. The sign and size of these impacts is difficult to estimate. Overall, however, the likeliness of negative competitiveness impacts to occur for EU suppliers seems somewhat higher than for EU vehicle manufacturers.
Cost competitiveness: conclusions from a component manufacturing perspective

Also here it is concluded that post 2020 EU LDV CO₂ legislation has no direct impacts on the cost competitiveness of EU component manufacturing as the legislation is targeted at the CO₂ performance of vehicles and not at factors that determine the costs of producing cars or their components.

A limited number of possible indirect impacts have been identified:

- Impacts relating to the access to and costs of materials, which could be different for EU and non-EU suppliers, e.g. regarding materials for electric powertrains and vehicle light-weighting. The sign and size of effects cannot be determined at this stage, but effects likely to be more pronounced for component manufacturing than for car manufacturing;

- With respect to the costs of purchased components small positive impacts could occur as a result of economies of scale if the EU has more stringent regulation than other regions or if a large share of new (sub)components for advanced ICEVs and AFVs would be produced in the EU. Small negative impacts may occur if (sub)components for advanced ICEVs and AFVs are mainly produced outside the EU.

Regional differences in labour costs may have an impact of unknown sign and size on the competiveness of EU suppliers as new technologies may require more/less labour or have a higher/lower share of (manual) labour in assembly/production. In addition some possible indirect impact pathways have been identified which relate to differences in the costs of capital goods and the volume of sales over which R&D costs can be divided. The size and sign of these impacts depend on the relative stringency of EU legislation.

Also from the supply industry perspective impact pathways seem to be quite generic and the same for the car and van regulation. Actual impacts will depend on the specific design of both regulations beyond 2020.

Cost competitiveness: conclusions for the fuel supply sector

The energy supply sector can be divided into:

- producers of fuels and other energy carriers, including the oil refining industry for petroleum based fuels and companies involved in electricity generation or the production of other alternative (bio)fuels and energy carriers (e.g. hydrogen);

- distributors of fuels and other energy carriers, including fuel distributors and operators of filling stations and operators of electricity distribution networks and operators of charging stations.

Both sub-sectors contain large, medium-size and small companies. The analysis of possible competitiveness impacts has been done separately for the two sub-sectors.

Fuel producers

An effective CO₂ regulation for cars and vans in the EU is likely to lead to reduced profitability of EU refineries, if capacity is not adjusted. This is due to declining demand for petroleum fuels putting pressure on the prices of fuels and to reduced refinery utilisation rates, leading to an increase in cost per unit production. This will have a negative effect on the ability of EU refineries to compete on the EU market with imports from Russia or new state-of-the art refineries being opened in India and the Middle-East.

The ability of EU companies in the fuel production sector to deal with changes in the EU market depends on various factors such as:
• the size of their European activities and the share of these in their global activities;
• the extent to which they produce in the EU for the EU market or also import and export to and from the EU.

The net effects are difficult to predict with available information.

In decisions of fuel producing companies on (dis)investments in refining capacity, also the status of facilities may play a role. Decommissioning refinery capacity is more costly for newer than for older facilities. In this respect there are likely differences between different refineries in Europe, but these have not been assessed. The closing of refineries in the EU will lead to a loss of jobs and of value added within the EU. This is not a competitiveness impact, but rather an economic impact that is likely to happen if EU LDV CO2 legislation is effective. The effect, however, could be amplified by fact that EU fuel producers are affected more severely by CO2 legislation than competing producers outside the EU. The latter is due to the fact that these non-EU fuel producers operate new facilities and have a large share of their sales in growing markets.

**Fuel distribution**

Fuel distribution companies, i.e. companies operating distribution infrastructure and filling stations, in the EU operate locally or regionally. They are not directly competing with companies in other regions. From an EU vs. non-EU perspective therefore no competitiveness impacts are to be expected. The reduced demand for petroleum-based fuels could lead to negative economic impacts on this sub-sector of the fuel supply sector, including a significant loss of jobs and value added, but also in this case these are not to be classified as competitiveness impacts.

**Cost competitiveness: conclusions for professional end users of LDVs**

Post-2020 EU LDV CO2 legislation is likely to lead to higher purchase costs for vehicles and lower operating costs due to lower energy costs. The net effect on total cost of ownership (TCO) depends on a range of factors including the target levels, compliance strategies chosen by OEMs, procurement decisions by the end-users and developments in the costs of technologies and various energy carriers.

For professional end users the TCO for using vehicles is an element in their cost of doing business. If post-2020 EU LDV CO2 legislation affects the TCO of vehicles, it directly affects the costs of doing business for all companies that use LDVs (professional end-users). Changes in the cost of doing business for a company affect the price of products and/or services. This may affect competition in the market leading to a change in market shares. Net competitiveness impacts, however, are only to be expected if the ΔTCO resulting from the post-2020 legislation works out differently for different companies in same market.

Given that the focus is on EU vs. non-EU companies, competitiveness impacts are only expected for EU companies that provide products / services that are competing on the EU market or other markets with products / services from non-EU companies. This would appear to be the case only for a limited share of professional end-users of LDVs. For manufacturers of goods that compete on international markets the majority of transport costs will be related to transport over larger distances by truck, rail, ship or air. Positive impacts are to be expected if the legislation leads to net a reduction of end-user costs for EU-based companies, as is the case for the current legislation up to 2020. If different regions have LDV CO2 regulations with similar stringency, EU companies will benefit more as fuel prices are higher in Europe. The
size of the impact, however, is expected to be small as the costs of operating LDVs are generally only a small fraction of the cost of doing business (in contrast to the costs of operating HDVs).

No competitiveness impacts are expected for EU-based SMEs, which in their operations make extensive use of LDVs. EU SMEs are generally not competing with non-EU companies, regardless of whether or not these LDVs are directly used for providing transport services. For those EU SMEs that are competing with non-EU companies on the EU or foreign markets, the costs associated with the use of LDVs will generally be a small share of the total transport costs. EU companies that are competing on the EU market will all be similarly affected by cost impacts resulting from EU LDV CO₂ legislation.

**Innovation competitiveness**

*Car manufacturers and suppliers*

The regulation is expected to have impacts on RDI investment choices regarding product innovation and the prioritisation of R&D expenditures. Due to limited resources, innovation in CO₂ reduction technologies will go at the expense of other innovations.

The regulation is expected to enhance the trend of externalisation of OEM RDI activities to Tier 1 suppliers as well as through joint R&D with other OEMs.

Post 2020 legislation is likely to increase the demand for AFVs, particularly for powertrain electrification, and will consequently pose innovation requirements in this area. This creates demand for R&D personnel with specific technological knowledge/skills. This personnel may have to be recruited internationally, given expected shortages in the EU. In this respect, the legislation imposes less need for adjustment to ‘first movers’, particularly non-EU OEMs and suppliers (Japan) with a stronger technology / patent position in electric propulsion.

*Energy suppliers*

The regulation does not create innovation requirements for conventional fuel suppliers. Increasing shares of AFVs may require innovation by suppliers of alternative fuels (e.g. electricity and hydrogen), but as most of these companies are only competing on the EU market this is not expected to affect innovation competitiveness of this sector.

*Professional end users*

The main impact of the legislation on professional end users is through the resulting change in total cost of ownership (ΔTCO). This does not lead to innovation requirements for this sector. Moreover, given the small share of LDV operating costs in the total costs of doing business, it is also not expected to affect the capacity of these companies to innovate their products and services.

An increased share of AFVs, however, may require some innovation in fleet operation, but as most EU end-users of LDVs are not in competition with companies from outside the EU this is not expected to affect innovation competitiveness.
International competitiveness

Car manufacturers and suppliers

International competitiveness impacts depend partly on the net cost competitiveness impacts at the EU level. However, as the size and sign of these impacts depend on details of legislation which are still to be defined, international competitiveness impacts are difficult to assess at this stage. International competitiveness impacts are furthermore dependent on the impacts on innovation competitiveness.

Overall it is concluded that EU-based manufactures hold strong international competitive positions in passenger cars and components but not in LCVs. As a result of CO$_2$ emission legislation, trade competitiveness of the EU manufacturers of vehicles and automotive components is not expected to change to a great extent. Overall the regulation is likely to be trade-neutral, with the view that the stringency of CO$_2$ legislation will be broadly similar in the EU and in main competing regions.

Many second-order effects are possible, however, and these may have a positive or negative sign depending on the relative stringency of EU targets post-2020 and details of the legislation. Competitiveness impacts are possible in narrower defined markets. EU OEMs might to some extent lose in competitiveness in gasoline vehicles while gain in competitiveness in diesel vehicles. Asian component manufacturers may achieve competitive advantages in electric car components while EU manufacturers may win market shares in diesel engine components. Some extra inward Foreign Direct Investment (FDI) flows may result, due to required investments in EU production plants of non-EU OEMs, but their magnitude is unclear.

General conclusions

For many identified possible impact pathways no conclusions can be drawn on the sign and size of the net impacts as these depend on the target level(s) and details of the post-2020 LDV CO$_2$ legislation in the EU and other regions, which at the moment are not known. Nevertheless the following high-level conclusions can be drawn:

- Post-2020 EU LDV CO$_2$ legislation will not directly affect competitiveness of EU car manufacturing, component manufacturing and fuel or energy supply industry, with direct meaning: through direct impact on the cost factors of production.
- For professional end-users some direct competitiveness impacts possible. The legislation affects the costs of operating passenger cars and vans, which are part of their cost of doing business. However, for the type of EU companies that are in competition with companies from other regions the share of costs related to using cars and vans in their total cost of doing business will generally be small, so that this impact is probably not significant.

There are a large number of indirect pathways that could result in competitiveness impacts for OEMs and component suppliers. The likelihood and size of these indirect impacts depend on:

- the way in which the legislation is designed, especially the stringency of target and the shape and slope of the target function;
• ways in which resources and capabilities of EU companies and sectors may be different from those of non-EU competitors, as these determine the ability of companies and sectors to deal with consequences of the EU legislation.

The detailed decomposition of possible pathways in the report provides a consistent assessment framework that will help to identify concrete impacts of specific proposals for post 2020 legislation to be developed in the course of 2015.

Various possible cost competitiveness impacts on the EU automotive manufacturing and component supply industry, both from a company (manufacturers) and a sectorial (manufacturing) perspective, were found to relate to:

The economic / financial situation of European OEMs, with the EU automotive sector appearing to be more strongly affected by the economic crisis than the industry in other regions. It is a question, however, whether that remains the case up to 2030.

The market position of EU car manufacturers, with EU OEMs having a larger share in premium markets.

Technology positions, with non-EU OEMs and suppliers having a stronger position in electric powertrains. European targets that require, or provide a strong incentive for, implementing AFVs could provide competitiveness benefits for non-EU manufacturers.

Economies of scale, with likely positive impacts for the EU automotive sectors if EU legislation is more stringent than legislation in other regions.

Based on an overview of various impact pathways, the likeliness of negative competitiveness impacts for EU suppliers seems somewhat higher than for LDV manufacturers.

Innovation competitiveness impacts on EU OEMs and component suppliers may relate to:

• R&D on efficient ICEVs and AFVs going at the expense of other innovations.
• Innovation readiness, with non-EU OEMs and suppliers benefiting from a “first mover” advantage in electric powertrains.
• Shortage of R&D personnel with skills for new technologies in the EU leading to global recruitment

Competitiveness impacts on the EU fuel supply industry:

• EU legislation may exacerbate already increasing competition between EU refineries and new refineries in other regions;
• No competitiveness impacts expected on the fuel / energy distribution sector.

Competitiveness impacts on professional end users:

• No significant competitiveness impacts expected.
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GLOSSARY

ACEA  European Automobile Manufacturers' Association
AFV   Alternative Fuel Vehicle
BEV   Battery Electric Vehicle
EU    European Union
FCEV  Fuel Cell Electric Vehicle
GHG   Greenhouse Gas
ICEV  Internal Combustion Engine Vehicle
JAMA  Japan Automobile Manufacturers' Association
KAMA  Korea Automobile Manufacturers' Association
LCV   Light Commercial Vehicle
LDV   Light Duty Vehicle
NEDC  New European Driving Cycle
OEM   Original Equipment Manufacturer
PHEV  Plug-in Hybrid Electric Vehicle
RDI   Research and Development and Innovation
TCO   Total Cost of Ownership
TTW   Tank-to-Wheels
WLTP  Worldwide harmonized Light vehicles Test Procedures
WTW   Well-to-Wheels
1. Introduction
This report presents the results of the project “Assessment of competitiveness impacts of post-2020 LDV CO$_2$ regulation”. A consortium consisting of Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIIP) / TNO has carried out this project for the Directorate-General Climate Action of the European Commission.

The objective of this study is to deliver an empirical evaluation of the possible competitiveness impacts of future regulatory CO$_2$ targets for cars and light commercial vehicles (LCVs). This will cover the main elements included in the current Regulations or considered for beyond-2020 scenarios. The results of the study are to provide a qualitative sectorial analysis and as well as a quantification of identified impacts when feasible.

The main question to be answered is what effects the legislation could have on cost and innovation competitiveness of individual companies and, in turn, on international competitiveness of the European automotive industry and other affected sectors. The sectors considered in the study include automotive manufacturers (OEMs), automotive component suppliers, energy supply companies and professional end users.

1.1 Policy context of this study
The European Commission is currently starting up preparatory work for the development of proposals for regulation of the CO$_2$ emissions of light duty vehicles (LDV’s) beyond 2020. New legislative proposals are expected to be made by the Commission in 2015. In the context of the decision process on the 2020 legislation in Council and Parliament, the co-legislators made a number of requests and in particular the European Parliament proposed an indicative target range of 68-78 g/km for the passenger car legislation for 2025.

During 2012 and 2013 two studies were carried out to increase the insight in various issues related to post-2020 LDV CO$_2$ regulation and to evaluate a number of possible modalities. Service requests #4 and #8, under Framework Contract No ENV.C.3./FRA/2009/0043, paid specific attention to the choice of regulatory metric, various pros and cons of the different options and their expected impact on manufacturer choices and the cost-effectiveness of the regulation for reducing CO$_2$ emissions.

In 2014 further analysis has started to provide inputs for the preparation of a proposal for post-2020 regulation. These include an ex-post evaluation of the current legislation, assessments of costs and potentials of various technologies in the 2020-30 timeframe and a more comprehensive assessment of the modalities for LDV CO$_2$ regulations beyond 2020. The latter project will make use of the results of this project with respect to competitiveness impacts.

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1 Annex 1 contains a description of the current CO$_2$ legislation.
2 Consideration of alternative approaches to regulating CO$_2$ emissions from light duty road vehicles for the period after 2020, [TNO2013a].
3 Analysis of the influence of metrics for future CO$_2$ legislation for Light Duty Vehicles on deployment of technologies and GHG abatement costs, [TNO2013b].
With respect to future CO₂ legislation two notions are important. First, that there are an increasing number of compliance mechanisms that manufacturers apply. Second, that attention to possible competitiveness impacts is becoming more and more relevant.

**An increasing number of compliance mechanisms**

For the targets up to 2020 the most important compliance mechanism for manufacturers is to apply efficiency-improving technologies to the conventional vehicles (ICEVs) that they produce. These include among other things more efficient engines and transmissions, start-stop systems and various levels of powertrain hybridisation, efficient auxiliaries, low rolling resistance tyres, improved aerodynamics, and weight reduction measures. As a result of the additional technology light-duty ICEVs become more expensive to buy, while at the same time cheaper to operate, due to the lower fuel consumption. The net economic effect depends on a range of factors including the target set in the legislation, the direct cost of compliance, the price of fuels and various indirect economic impacts.

In the future, replacing a share of the conventional vehicle sales by vehicles with alternative powertrains, including e.g. plug-in hybrids (PHEVs), battery-electric vehicles (BEVs) and fuel cell vehicles (FCEVs) will become an increasingly important compliance mechanism. For targets below around 70 g/km it will even be necessary for meeting the target to sell a finite share of such alternatives as the CO₂-emissions of ICEVs are unlikely to be reduced beyond that point with the technologies currently in view. The cost structure of these vehicles is different from that of ICEVs, and their introduction may affect the structure of the automotive sector.

**Increased attention for possible competitiveness impacts**

The CO₂ legislation affects the costs and cost structure of manufacturing, owning and operating light duty vehicles. As a result the legislation has economic impacts, and may directly or indirectly affect the competitiveness of companies in various economic sectors.

European Commission legislative proposals are accompanied by an Impact Assessment, an element of which deals with the legislation’s impact on competitiveness of affected sectors. Recently the Commission has been putting more emphasis on the analysis of the impacts of new policy proposals on enterprise competitiveness within the Commission's integrated impact assessment approach. Specific operational guidance for assessing impacts on sectorial competitiveness within the Commission Impact Assessment System are laid down in SEC(2012) 91. The reason for this is that the Commission wishes to respond to the need for better-targeted tools to boost productivity and growth in times of the economic slowdown. The economic crisis has had, and is still having, strong impacts on the sales of new vehicles in Europe. Industrial stakeholders and some Member States with large automotive industries are therefore stressing that economic and competitiveness impacts are fully accounted for in the development of proposals for further tightening of European CO₂ regulation for LCVs. The topic of competitiveness in relation to the economic crisis and EU policy was also addressed in the CARS21 initiative.

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1.2 Project objectives and results

The objective of this study is to deliver an empirical ex-ante evaluation of the impacts on competitiveness of possible regulatory CO₂ targets for cars and light commercial vehicles for the period beyond 2020. The study is ex-ante because, at the moment, there is no proposal for this legislation.

This report contains the results of the study, consisting of a qualitative sectorial analysis as well as a quantification of identified impacts when feasible. This result will enable the European Commission to include insights on competitiveness impacts in the process of developing proposals for post-2020 regulation rather than just performing a “check” on the impacts after finalising the proposal.

1.3 Project scope

The project team has developed and employed a methodological framework for the ex-ante assessment of competitiveness impacts of post-2020 CO₂ legislation for LDVs. The study has focussed on possible impacts of this legislation on competitiveness of Europe compared to the rest of the world, and assessed impacts with respect to:

- cost competitiveness;
- innovation competitiveness;
- international competitiveness.

Legislation affects competition if it has different (economic) impacts for similar affected entities. For the analysis the following sectors were considered:

- automotive manufacturers;
- automotive component suppliers;
- energy supply industry;
- professional end-users.

The main elements of the current legislation are considered in the analysis, complemented with additional elements considered for post-2020 legislation. The main elements of the current legislation are:

- target for average emissions;
- mass as utility parameter;
- a linear mass-based target line with defined slope;
- derogations;
- super-credits;
- eco-innovations;
- phase-in.

In addition, the following elements for post-2020 legislation have been considered:

- alternative utility parameter, e.g. footprint;
- alternative metric, e.g. Well-to-Wheels Greenhouse Gas (WTW GHG) emissions or WTW or TTW (Tank-to-Wheels) energy consumption.
The project was explicitly about the possible effects on the competitiveness of Europe versus the rest of the world, looking at the region as a whole, including companies operating in Europe in the affected sectors compared to companies operating in other countries. The project therefore didn’t look at differential issues between member states or between separate manufacturers. In the assessment no explicit subdivision was made in different categories of OEMs or suppliers (for example based on the car segment they focus on or the type of parts they are specialising in). Possible impacts of whether OEMs are volume or premium manufacturers, however, are acknowledged and analysed in the report. With respect to affected sectors the study did not consider impacts in vehicle retailing, insurance or repair. Companies in these sectors are predominantly EU companies competing with other EU companies in the EU market. For that reason no competitiveness impacts are to be expected from the perspective of EU vs. other regions.

1.4 Reading guide
The methodological approach used in the project is described in chapter 2. Chapter 3 presents a market and sectorial overview (with additional information in Annex 2). Next, policy options and possible compliance mechanisms are explored in chapter 4. The results of this exploration, together with the market and sectorial overview, serve as a starting point for the analysis of possible impacts. The identified possible impacts on cost competitiveness of different affected sectors are presented in chapters 5 to 10. After that, chapter 11 analyses innovation competitiveness impacts while chapter 12 deals with the impacts on international competitiveness. A summary of the various impacts, conclusions and recommendations can be found in chapter 13. More detailed results and background data are provided in the annexes.
2. Methodological assessment framework

2.1 The structure of the project

The way in which different activities in the project interacted to achieve the overall results is pictured in Figure 5. The columns represent the various activities that were carried out, of which the collection of sectorial information and the stakeholder interviews are general activities that support the three specific assessments of different competitiveness impacts. Information was collected via desk research and by means of a number of interviews with representatives of OEMs, component suppliers and fuel suppliers, and the relevant associations for these sectors (a list of interviewees is contained in Annex 3). Also, an intermediate stakeholder meeting involving these parties was organised in Brussels. At that meeting the preliminary results of the study were discussed and elaborated.

The project has been split in two phases. In the first phase (upper half in Figure 5) the focus has been on a general exploration of possible pathways through which the post-2020 CO₂ legislation might impact competitiveness of affected sectors. In the second phase (lower half in the figure), results from the collection of sectorial information and stakeholder interviews are used to assess in a qualitative and as far as possible quantitative manner to which extent identified pathways are likely to lead to significant impacts.

Following the approach outlined in the Commission’s Competitiveness Proofing Toolkit the investigation of competitiveness impacts has been structured along three key dimensions, namely:

- **Cost competitiveness**, the cost of doing business, which includes cost of intermediate inputs (incl. energy) and of factors of production (labour and capital);
- **Innovation competitiveness** (defined as capacity to innovate), e.g. the capacity of the business to produce more and/or higher quality products and services that meet better customers’ preferences;
• **International competitiveness**, e.g. the differential impact of the two dimensions above on the European industries’ market shares and revealed comparative advantages vis-à-vis international competitors.

These dimensions were investigated for each category of stakeholder considered. Below a short explanation is provided of each of the criteria.

*Cost competitiveness*

Cost competitiveness relates to the (direct or indirect) impact of the legislation on the costs sustained by a company in particular, or by the industry it belongs to in general, and to the impact of possible differences in these cost impacts on the competition between companies or sectors. With respect to the role of CO\textsubscript{2} legislation, the impacts relate to the compliance costs sustained by Original Equipment Manufacturers (OEMs) in order to achieve the targets (or to manage the inability to meet these targets). The impact on different OEMs and segments is explored in detail in the studies underlying the legislative proposals.

Based on the compliance actions put in place by OEMs, the investigation of cost competitiveness impacts is also extended to other categories of stakeholders. Examples of topics being investigated under the cost competitiveness criteria include:

- **OEMs**: the costs to meet the target, as well as the difference in costs for different categories of OEMs, the cost of required technical innovations and the increased cost of components purchased from suppliers;
- **Component suppliers**: the costs caused by satisfying new requirements from OEMs through the development of innovative components and the effect on margins;
- **Fuel suppliers**: the impact of the legislation on overall fuel demand, fuel prices and consequently revenues and margins by industry players;
- **End users**: possible changes both in terms of vehicles’ price and total cost of ownership (TCO).

*Innovation competitiveness*

The impacts on innovation competitiveness relate to the effects of the policy on a company’s innovation capacity, which may then impact on its competitiveness (measured either by market shares, or leadership in a specific market segment etc.).\textsuperscript{5} Impacts are generated if the legislation influences the capacity to innovate of industry players, notably by altering their innovation choices. The need to innovate to comply with regulatory requirements may change the relative positioning of industry players.

The assessment of relevant impacts in this study requires the consideration of the following three aspects:

1) The effect of the policy may have both a positive and a negative influence on innovation competitiveness depending on the innovation capabilities of OEMs and first tier suppliers, in particular EU vs. non-EU OEMs and first tier suppliers;

2) The nature of impacts may differ depending on the innovation capabilities and compliance strategies chosen by the different OEMs and suppliers, and

3) The nature and timing of impacts may differ depending on how advanced OEMs and suppliers are in the innovation processes needed to comply with the regulation.

**International competitiveness**

International competitiveness impacts arise if EU firms and industries are impacted differently than non-EU ones in any of the areas outlined above, leading to higher or lower competitiveness of the EU vis-à-vis international competitors. A selection of the aspects investigated under the international competitiveness dimension includes:

- The “relative” levels of stringency of the targets imposed on EU and non-EU OEMs;
- The international distribution of capabilities in the innovation areas relevant to CO₂ legislation (e.g. diesel engines, electrification, batteries);
- The distribution of the required skills (e.g. electric and system engineering) globally, as well as differences in cost of labour between different regions/nations;
- Availability of investment capital in different countries.

To explore, investigate and assess the current status of international competitiveness, as well as the impacts of post-2020 CO₂ legislation, the following indicators suggested in Step 12 of the Competitiveness Proofing Toolkit have been used:

- **Export market shares**, showing how much of the total ‘world’ exports of cars, LCVs and components are covered by the export of a particular country or region;
- **Revealed Comparative Advantage**, comparing the share of automotive and component sector exports in the EU’s total manufacturing exports with the share of exports of a group of reference countries for the same sectors (i.e. calculation of the Balassa Index);
- **Trade Balances**, comparing passenger car, LCV and component trade balances to a) the total volume of trade, exports plus imports (relative trade balances) and to b) the figures of reference countries;
- **Unit Labour Costs**, comparing the automotive industry cost of labour to the corresponding index in reference countries.

These dimensions are investigated and assessed in Chapter 12 of the report.

**2.2 A general model of competitiveness**

In general the competitiveness of companies is determined by the price and value of their products or services relative to the price and value of products or services of competing companies (selling similar products or services or alternatives that can serve as a substitute). Changes in the price and value of a company’s product or service will change the relative attractiveness of the product or service which will lead to changes in market shares. The price and value of a company’s products or services are determined by the company’s capabilities to produce and sell attractive products or services, which in turn are determined by a range of resources, as illustrated in Figure 6. Changes in market shares and profits resulting from changes in the competitiveness of a company’s products are likely to affect the company’s financial and other resources, causing a feedback loop.
In assessing the competitiveness impacts of a piece of legislation the focus is on the change caused (delta or Δ), both in terms of differences between similar affected entities and in terms of the changes in market positions of these entities compared to the reference situation. A delta in the resources of a company relative to those of its competitors leads to a delta in the capabilities of these companies to respond to the (consequences of the) legislation, which in turn may translate into a delta in costs and price of the products of the competing entities which influences the equilibrium in the market leading to changes in market shares.

From a cost competitiveness point of view legislation thus affects competition if it has different (economic) impacts for similar affected entities. In the case of post-2020 CO₂ legislation for cars and vans such entities can e.g. be individual car manufacturers competing on the European market. For meeting the targets set in the LDV CO₂ legislation automotive manufacturers can choose from a range of compliance mechanisms. The impact of these compliance mechanisms on the costs and value of their products may affect their competitiveness if these impacts are significantly different from those incurred by their competitors. But also the European automotive industry as a whole can be seen as an affected entity as it can be considered to compete on a global market not only for customers but e.g. also for investors.

Impacts on innovation competitiveness can be assessed within the same framework related to resources and capabilities, as it concerns the impact of available R&D resources on the ability to meet targets as well as the impact of legislation on R&D resources.
International competitiveness, assessed from a macro-economic perspective, can be considered as the overall resulting impacts of changes in cost competitiveness and innovation competitiveness on e.g. trade flows and cross-border investments.

In other words, the model depicted in Figure 6 can be applied not only to competition between companies but also – like in this study – to competition between industries or industry sectors from different regions (in this case industry in the EU versus industry in other regions) operating on the same market.

### 2.3 Identifying pathways for competitiveness impacts by means of mindmaps

For the different affected sectors as considered in this study, mindmaps have been drawn up to assess the pathways through which elements of the EU LDV CO\(_2\) legislation might lead to competitiveness impacts. For cost competitiveness these mindmaps connect:
- elements of the legislation to different compliance strategies;
- (effects of) different compliance strategies to possible differences in resources and capabilities of companies;
- resulting differences in the cost and purchase price of vehicles as well as their operating costs to impacts on competitiveness.

The mindmaps are mainly used in chapters 5 to 10, where they are employed to assess the effect and significance of various possible pathways for cost competitiveness impacts. Based on the insights from these mindmaps, in chapter 11 and 12 innovation and international competitiveness are assessed.

To draw conclusions on the competitiveness impact of the EU LDV CO\(_2\) regulations the following two issues need to be taken into consideration:
- **Counteracting competitiveness impacts**: For a given company or region, different pathways may at the same time lead to competitiveness impacts, which have different signs (positive or negative). The net effect of these different pathways is not necessarily significant. The more pathways with differing signs exist, the more likely it is that the net effect will be zero.
- **Options for mitigating competitiveness impacts**: The analysis of pathways assumes that no measures are taken by affected entities to mitigate impacts on competitiveness. However, in general there will be a range of options available to automotive manufacturers and companies in other affected sectors that may help to counteract any competitiveness impacts of the legislation. This reduces the likelihood of the legislation causing significant net competitiveness impacts. In chapter 5, therefore, possible mitigation measures are also discussed in the context of the assessment of different affected sectors.

### 2.4 Defining cases: focus on Europe versus the rest of the world

As the focus of the analysis is on the competitiveness of EU sectors versus those in other regions, the analysis aims at identifying whether and how the costs of complying with the EU LDV CO\(_2\) legislation could

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\(^6\) **NOTE:** To facilitate printing on A3 paper, the larger mindmaps presented in this report are also provided in a separate pdf-document.
be different for European companies versus companies from other regions and on how this effects innovation and international competitiveness. For the affected sectors the analysis is separated into two cases:

- European companies vs. competing companies from other regions;
- European manufacturing or production vs. manufacturing or production in other regions.

The first approach starts from the impacts of the regulation on the price and value of products of competing companies, while the second approach is based on identifying first and second order impacts on cost factors of production in different regions. A more detailed explanation, including the relation between the two approaches is provided in chapter 5.

Both analyses rely on identifying whether and how the EU legislation could lead to:

- different levels of stringency of the targets imposed on EU and non-EU OEMs;
- differences in the costs for EU and non-EU OEMs of complying with similar targets, which in turn may be the result of:
  - EU and non-EU OEMs choosing (or being forced to choose) different compliance mechanisms with different cost implications to meet similar targets;
  - costs of similar compliance mechanisms being different for EU vs. non-EU OEMs.

The latter two aspects strongly relate to the capabilities and resources of companies. One of the main goals of the analysis, therefore, is to identify whether regional differences exist in the capabilities and resources of companies and whether and how these could lead to different costs of compliance with the EU LDV CO₂ legislation.

For the end user sector the analysis focuses on identifying whether and how the legislation could lead to changes in the costs of operating LDVs and their share in the costs of doing business that are different for EU companies than for competing non-EU companies.

### 2.5 Definitions of EU vs. non-EU manufacturers

The distinction between EU manufacturers and manufacturers from outside the EU may be intuitively clear, but when a closer look is taken the distinction is less obvious. Many OEMs from Japan and Korea produce a significant share of their EU sales in large manufacturing plants in the EU. Consistent with that large European presence, Toyota and Hyundai have recently become members of ACEA. Ford was originally US-based, but started establishing European branches in 1925 and has been developing vehicles for the European market in Europe since the 1930’s. Opel is since 1929 part of US-based GM but started as a German company. More recently some originally European manufacturers have been taken over by companies from outside Europe, such as Jaguar-Landrover (owned by Tata, based in India) and Volvo (owned by Geely, based in China). The ownership issue is more diffuse in the strategic partnership between Renault and Nissan. This was not a merger or an acquisition, but instead the two companies are joined together through a cross-shareholding agreement (and also to a lesser extent with Daimler). The structure of buying each other’s shares was also used in a more recently announced cooperation between General Motors and PSA Peugeot Citroën for the joint development of a new vehicle platform.
In the light commercial vehicle market the ownership situation appears less complex (although there appears to be a larger proportion of brand engineering), but as many EU-based OEMs manufacture a large share of their vehicles outside the EU in Turkey, the identification of companies as being EU or not still depends on the definition that is used. In any case, from the perspective of the competitiveness of the EU automotive manufacturing sector, where jobs and cross border investments are important indicators, vehicles manufactured outside the EU should be considered to originate from non-EU automotive manufacturing sectors.

To assess possible differences between EU and non-EU manufacturers the following (non-exhaustive list of) different definitions could be used:

1. Current main association membership for the EU market:
   - Classification as EU vs. Japanese, Korean and other according to membership of associations ACEA, JAMA, KAMA, and other / unknown.
   - Toyota (incl. Lexus) and Hyundai are included as members of ACEA.
   - In this definition Ford and GM are EU manufacturers as they are members of ACEA.
   - “Other / unknown” contains e.g. manufacturers from the US, China, India, and Malaysia.

2. Original association membership:
   - Classification as EU, Japanese, Korean and other according to original membership of associations ACEA, JAMA, KAMA, and other / unknown.
   - Toyota (incl. Lexus) is included as a member of JAMA and Hyundai as a member of KAMA.
   - In this definition Ford and GM are EU manufacturers as they are original members of ACEA.
   - “Other / unknown” contains e.g. manufacturers from the US, China, India, and Malaysia.

3. Location of headquarters / owner
   - Classification as EU, Japanese, Korean and other according to location of the owner or headquarter by region: EU, Japan, Korea and other (including US).
   - Chrysler counts as EU as it is owned by Fiat.
   - “Other” includes Ford and GM having US-based ownership and Volvo and Jaguar-Landrover being owned respectively by companies from China and India.

4. Share of vehicles sold in the EU that are manufactured in the EU
   - A possible definition could be to define an EU manufacturer as having a minimum of e.g. 50% of its EU sales manufactured in the EU.
   - For example, 67% of the cars sold by Toyota in the EU are produced in the EU. At a stakeholder meeting Toyota indicated that it aims to increase this to 75% in the future.

If what is an EU manufacturer is defined on the basis of option 4, then the distinction between the perspectives of EU vs. non-EU manufacturers and EU vs. non-EU manufacturing becomes less clear, as the motivation for manufacturers to locate a large share of their production in the EU depends to a large extent on the competitiveness of European manufacturing compared to manufacturing in other regions. Other reasons for manufacturing in the EU include the possible benefits of having design and production located closer to the customer in order to market cars that appeal to EU customers.
In Annex 5 an analysis is provided of sales distributions of EU vs. non EU manufacturers based on the first three of the above definitions. Table 58 and Table 59 in that annex contain an overview of how brands / manufacturers in the 2013 EEA monitoring database are divided over the different categories in the first three definitions given above.

In the end no single definition was used in the assessment of potential competitiveness impact pathways. Given that most conclusions needed to remain qualitative in view of their dependence on details of the legislation that are still to be determined, an attempt has been made to draw conclusions that are robust under different definitions.
3. Market and sectorial overview

3.1 Automotive manufacturers

In the automotive market, vehicle sales in the more mature markets have mostly plateaued, with sales in the EU dropping significantly due to the crisis of the last years (-4.44% on an annual basis between 2007 and 2013 for passenger cars and -7.05% for LCVs). Vice versa, the emerging markets act as a catalyst for growth especially due to their rapidly growing economies and large and young populations. Other than the effect on distribution of sales worldwide, the economic context, combined with the legislative framework, is having an impact on the profitability of the automotive business, with several groups (EU and non-EU headquartered) recording losses in the EU markets and cross-subsidizing the EU business through the profits in other regions.

In Europe, the issue of profitability has progressively led OEMs to react through mitigation strategies which include:

- Pursuit of the co-operation model through alliances and partnerships with other OEMs to achieve cost savings;
- Increasing geographical presence on the most profitable markets worldwide;
- Delocalisation of production facilities from Western to Eastern Europe and Turkey. Nonetheless, due to the benefits of just-in-time production, proximity to customers, as well as the issues of trade tariffs and logistics costs, production is likely to stay relatively close to sales;
- Change in the make-vs-buy choice and increasing reliance on component suppliers.

### Table 1 - Share of European sales of major automotive groups

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>HQ Country</th>
<th>% of sales in Europe</th>
<th>Total sales 2013 worldwide (x1000)</th>
<th>Manufacturer</th>
<th>HQ Country</th>
<th>% of sales in Europe</th>
<th>Total sales 2013 worldwide (x1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renault</td>
<td>France</td>
<td>59%</td>
<td>2,125</td>
<td>Nissan</td>
<td>Japan</td>
<td>14%</td>
<td>4,825</td>
</tr>
<tr>
<td>PSA</td>
<td>France</td>
<td>58%</td>
<td>2,189</td>
<td>Tata</td>
<td>India</td>
<td>11%</td>
<td>1,192</td>
</tr>
<tr>
<td>BMW</td>
<td>Germany</td>
<td>44%</td>
<td>1,964</td>
<td>Suzuki</td>
<td>Japan</td>
<td>13%</td>
<td>2,857</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>Germany</td>
<td>43%</td>
<td>9,729</td>
<td>Toyota</td>
<td>Japan</td>
<td>9%</td>
<td>8,871</td>
</tr>
<tr>
<td>Daimler (Mercedes-Benz)</td>
<td>Germany</td>
<td>41%</td>
<td>1,565</td>
<td>Hyundai</td>
<td>Korea</td>
<td>9%</td>
<td>4,622</td>
</tr>
<tr>
<td>Fiat</td>
<td>Italy</td>
<td>23%</td>
<td>4,330</td>
<td>Fuji</td>
<td>Japan</td>
<td>6%</td>
<td>724</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Japan</td>
<td>23%</td>
<td>1,257</td>
<td>Honda</td>
<td>Japan</td>
<td>4%</td>
<td>4,323</td>
</tr>
<tr>
<td>Geely (incl. Volvo cars)</td>
<td>China</td>
<td>23%</td>
<td>977</td>
<td>Isuzu</td>
<td>Japan</td>
<td>4%</td>
<td>639</td>
</tr>
<tr>
<td>Ford</td>
<td>US</td>
<td>21%</td>
<td>6,330</td>
<td>Dongfeng</td>
<td>China</td>
<td>0%</td>
<td>2,567</td>
</tr>
<tr>
<td>General motors</td>
<td>US</td>
<td>16%</td>
<td>9,715</td>
<td>Changan</td>
<td>China</td>
<td>0%</td>
<td>2,120</td>
</tr>
<tr>
<td>Mazda</td>
<td>Japan</td>
<td>16%</td>
<td>1,331</td>
<td>Brilliance</td>
<td>China</td>
<td>0%</td>
<td>207</td>
</tr>
</tbody>
</table>

OEMs are global companies with distributed regional production facilities, sales and distribution channels and local marketing strategies, therefore the economic downturn in Europe affects not only EU-headquartered companies, but all companies active in the EU. The extent to which a specific OEM has been

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7 Source: VVA analysis based on financial statements for the year 2013
impacted is influenced by the share of its sales in Europe. French companies are the most exposed with 60% of their sales being in the EU, German ones follow with sales between 40 and 45%, whereas Fiat and US companies have sales ranging between 16 and 23% (Table 1).

OEMs consider CO₂ legislation to hamper profitability by imposing compliance costs. This may be more relevant for “volume” manufacturers, whose customers tend to have a low acceptance of environmental technologies, resulting in a challenge for OEMs to transfer the cost of innovation to end users. In contrast, “premium” manufacturers have significantly less difficulty in finding user acceptance (and thus adding a price premium), as innovation is a key part of the selling proposition of their vehicles. A clustering based on the average price and weight of the vehicles sold in the EU leads to a clear segmentation:

- Fiat, Ford, General Motors, Hyundai, Nissan, PSA, Renault and Toyota can be considered as “volume” manufacturers;
- BMW, Daimler and Geely (Volvo) can be considered as “premium” manufacturers;
- Volkswagen (group) is a specific case, as within the group Audi is a premium manufacturer, Skoda and Seat are volume manufacturers and Volkswagen is on the highest end of the same cluster.

Vehicle manufacturers can also be categorised based on the type of engine of the vehicles sold in the EU. Groups with a stronger European presence and a focus on premium vehicles exhibit a higher share of diesel engine sales. Vice versa, brands of non-EU groups focusing on volumes tend to exhibit higher shares of petrol engine sales.

According to some of the interviewed stakeholders, competences in diesel engines are currently a source of competitive advantage in complying with the requirements of CO₂ legislation. Stakeholders noted, in this sense, that the Euro 6-2 legislation will reduce this advantage – the same effect is foreseen for ambitious CO₂ targets, as it is expected that they could not be fulfilled through diesel.

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8 Source: VVA elaboration based on ICCT data, year 2012
3.2 Component suppliers

The vehicle components sector is highly fragmented. In recent years, however, consolidation has started to take place also among suppliers which is leading to the creation of mega-suppliers leaving less space for small and regional suppliers. Mega-suppliers are able to provide local support by building factories close to OEMs but they also have an international presence, which gives them the possibility to better mitigate regional recessions.

Automotive suppliers represent a significant source of innovation in the automotive industry. Tier-one suppliers, in particular, are playing an increasingly prominent role in innovation and technological development. Moreover, the ongoing suppliers consolidation will give rise to stronger OEM-supplier relationships as the former are becoming more dependent on their suppliers.

In 2015, about 70% of R&D value creation will be generated by suppliers and engineering service providers. The importance of tier-one suppliers in innovation and product development will escalate. Mega-suppliers are already playing a bigger role in innovation in the areas of power train, interior design, and chassis components - historically the R&D domains of carmakers.

3.3 Employment and labour productivity in the automotive industry

According to data from OICA, more than 8 million people worldwide were directly employed in 2005 in the manufacturing of vehicles and their components, representing more than 5% of the world’s total manufacturing employment. In the EU, according to Eurostat (data on NACE code 29) more than 2 million people are directly employed in the automotive industry, almost half of them in the manufacture of parts and accessories. Key categories of employees according to skill include mechanics, electricians, engineers, IT expert, together with sales and marketing specialists and product managers, accountants, business and financial specialists. In terms of geographical spread Germany alone accounts for 36% of the total direct employment. Other large EU large Member States each account for 6% to 10%.

Before the crisis, there had been a trend of increasing employment especially in new Member States. The decline in demand and production since mid-2008 and the resulting restructuring of the industry have brought a significant number of job cuts, hitting, among others, the United Kingdom (-42% in 2011 compared to 2007), France and Spain (-20% and -19%), Hungary (-13%) and Italy (-7%). In the same period, some Central and Eastern European countries experienced steady growth, including Bulgaria (+54%), Slovakia (+20%) and Romania (+18%). In 2012, figures improved slightly with Central and Eastern European countries continuing their growth, Germany growing quite significantly (+4%) and Member States hit the most by the crisis remaining at 2011 levels.

Labour costs and labour productivity represent an important aspect of an industry’s ability to remain effective. Since competition is particularly intense for small-sized cars, producers of lower segment cars have moved, or are moving, a great part of their production to countries with lower production costs. On the contrary, premium segment cars are still largely assembled on traditional sites. The new facilities for volume segment cars have been built with the latest technology, making these sites attractive for both lower labour costs and productivity reasons.
The fact that costs are influenced by a series of specific factors (degree of automation of plants, efficiency and production competences of the manufacturer, type of vehicle produced, labour productivity based on skills, etc.) makes it extremely difficult to compare the different impacts of labour costs on vehicles. However, important differences exist between countries within the same region for all the major markets. In the EU, countries such as Poland, Slovakia and Hungary offer personnel costs a factor of 5 times lower than European countries such as Germany, France and Italy. Moreover, Turkey is extremely competitive in terms of labour costs – this is one of the reasons leading many OEMs (Ford, Toyota, Fiat, Hyundai among others) to invest in production facilities in Turkey. Similar trends can be observed both in Central and North America and Asia.

Labour costs are only a partial indicator of a country’s attractiveness. The most relevant indicator behind the choice of an OEM on a manufacturing location is labour productivity. EU labour productivity figures suggest that the distances between EU 15 and EU 13 are smaller than what emerges solely from a comparison of personnel costs.

3.4 Trade performance and comparative advantages

The analysis shows that the automotive market is mainly a regional one, with vehicles typically produced in the region where they are sold. Of all the cars sold in Europe, 86% are manufactured in Europe. The key reasons for this include:

- Trade barriers;
- Benefits of geographical presence and just-in-time production;
- Transportation and logistics costs.

Trade within the same region is a common practice, when enabled by favourable combinations of geographical proximity, offset in labour costs and absence of trade barriers. This is the case for Turkey and Mexico.

In spite of the barriers to trade caused by logistics costs and import tariffs, the EU automotive industry is a global player delivering its products worldwide. The automotive sector contributes positively to the EU trade balance with trade surplus around USD 100 billion when considering vehicle manufacturing (trade surplus in 2012 was USD 81 billion) and vehicle components (trade surplus summed up to USD 21 billion).

The EU has a revealed comparative advantage (RCA) in the car manufacturing market, a comparative disadvantage in the LCV manufacturing market (due to the relevant trade flows from Turkey) and a comparative advantage in CO₂ related component manufacturing.

3.5 Cost of capital and financial indicators

The implementation of the legislation does not directly affect the financial sector, however indirect impacts could take place if significant investments are needed by OEMs, their suppliers and other affected sectors. In this framework, competitiveness impacts (related to the cost dimension) depend on different levels of the cost of capital for companies.
At the beginning of 2014 the cost of capital for EU OEMs was reported to be on average slightly lower than the one for non-European competitors. Regarding the automotive supplier sector, EU companies face higher costs of capital than non-EU competitors.

Another relevant factor affecting the financial situation of companies is the availability of investment capital for companies. Interviewees claim that OEMs facing major investments in the EU might have a disadvantage in accessing capital compared to international competitors facing similar investments in countries such as the United States.

### 3.6 R&D and innovation

Focusing on the R&D investment in new technologies, the automotive sector is the largest investor in R&D in the EU with over 32 billion euros of expenditure and accounting for 25% of total R&D spending. In Germany the sector accounts for more than 30% of all R&D spending. In the Czech Republic, Sweden, France and Japan it exceeds 15%. The key areas for R&D investment by vehicle manufacturers are safety, connectivity and fuel efficiency and eco innovation.

The ratio between R&D and total staff for different OEMs (and brands) ranges between 1:5 and 1:25, as shown in the figure below.

<table>
<thead>
<tr>
<th>Automaker</th>
<th>R&amp;D staff</th>
<th>R&amp;D staff Total staff ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW Group</td>
<td>11,359</td>
<td>1:10</td>
</tr>
<tr>
<td>Daimler</td>
<td>14,700</td>
<td>1:19</td>
</tr>
<tr>
<td>FIAT Group</td>
<td>18,700</td>
<td>1:12</td>
</tr>
<tr>
<td>General Motors 10</td>
<td>17,000</td>
<td>1:10</td>
</tr>
<tr>
<td>Nissan</td>
<td>16,120</td>
<td>1:10</td>
</tr>
<tr>
<td>Opel</td>
<td>6,800</td>
<td>1:5</td>
</tr>
<tr>
<td>PSA</td>
<td>14,500</td>
<td>1:13</td>
</tr>
<tr>
<td>Renault</td>
<td>16,426</td>
<td>1:7</td>
</tr>
<tr>
<td>Toyota</td>
<td>14,000</td>
<td>1:24</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>23,000</td>
<td>1:25</td>
</tr>
</tbody>
</table>

Focusing on **patenting**, from the early 2000s the “non-environmental” patenting rate dramatically declined while the “environmental” patenting continued peaking. The leaders in alternative power patents during the 2006-2011 period included Toyota, Honda, Denso, General Motors and Panasonic. At country level, Japan accounts for 35.2% of alternative power innovation, followed by China (28.4%), USA (10.3%) and South Korea 9%. Germany ranks in the top five (being 5th with 7.8%) and is the first EU country, followed by France (1.7%) and the UK (0.6%). The leading position of Japanese companies in alternative power patents may be explained by their early and strong positioning in the electric vehicle global market.

The innovation process in the automotive sector has shifted towards **more integrated partnerships** with systems and component suppliers. Around 24% of automotive firms cooperate with suppliers, 19% with...
customers, 13% with universities and 8% with research institutions. First tier component suppliers and global mega suppliers increasingly coordinate the supplier and innovation networks which entail the coordination of a network of other first tier suppliers and tier 'n' suppliers. OEMs on their end select first tier suppliers and try to retain influence in terms of project-organisation and development-expertise.

In Europe the most active country in Joint Ventures and Strategic Alliances (JVAs) is Germany. In the period 1994-2014, Germany launched more than 260 JVAs, almost twice the amount launched by the second European country (France, followed by Italy and the United Kingdom). The most common countries with which these JVAs took place include China, the US, Japan, India and Russia.

3.7 Fuel demand

In the past, final energy demand in the transport sector had grown in line with transport activity; however, fuel efficiency improvements led by environmental legislation already in place are foreseen to stabilise demand by 2050, despite the projected upward trends in freight and passenger transport activities.

As an effect of current measures, the structure of passenger cars fleet in terms of engine and the trends in energy consumption are foreseen to experience:

- In the short-medium term a progressive reduction of the share of gasoline, continuing the trend of recent years;
- In the longer term, the progressive erosion of the diesel engine share in favour of hybrid, plug-in electric and BEVs.

Upcoming EU policy measures, which will represent the actions implementing the Roadmap for moving to a competitive low carbon economy in 2050, will further impact fuel demand. By aiming to deliver greenhouse gas reductions in line with the 80 to 95%, they could reduce total primary energy consumption by about 30% compared with 2005 levels, implying a decline of imports of oil and gas by 50% by 2050 compared to 201111.

Focusing on the transport sector, the Communication highlights that in 2005 greenhouse gas emissions increased by 30% in 2005 vis-à-vis 1990 levels (with transport being the only sectors among those considered showing an increase). Upcoming measures are foreseen to bring emissions back to 1990 levels by 2030 (emissions change will range from +20% to -9% against 1990 levels) and to bring marked reductions by 2050 (-54% to -67%).

3.8 Fuel prices

Comparing retail fuel prices for EU customers with those in other countries (assuming that existing differences will remain similar over time) reveals that the price to end users is higher, so that improvements in the fuel efficiency of vehicles will have a stronger impact on TCO for EU end-users than for users of similar cars in other regions. Future savings are likely to be further amplified in case post-2020 CO₂ targets for the EU are more ambitious than those adopted in non-EU countries.

11 As an effect of the action suggested in the Communication ‘A Roadmap for moving to a competitive low carbon economy in 2050, Brussels, 25.5.2011 COM(2011) 112 final/2
3.9 Professional end users
There are many different categories of professional end users of vehicles, which could potentially be indirectly impacted by CO\textsubscript{2} legislation. They can be categorised in two groups: professional car end users and professional users of LCVs. Most of the categories of end users compete locally using the same type of vehicles, even if they are global companies. The latter regards postal and courier delivery services and multinational companies using LCVs for goods distribution to retail stores.

3.10 Automotive industry: market projections to 2020 and beyond
In 2020 global light vehicle sales are foreseen to reach approximately 117 million units per year, against sales of around 70 million today. Most of the growth will stem from emerging markets, above all from Asia-Pacific followed by Eastern Europe and Latin America. At that moment, Asia-Pacific will likely account for almost half of global light-vehicle sales. Considering emerging markets, Chinese and Indian OEMs are in a favoured position compared to OEMs from other establishing countries.

Regional vehicle segments are also expected to change. China will benefit considerably from the premium segment’s growth until 2025, while Europe will maintain its supremacy in the same segment. India will significantly increase its share in the small vehicle segment, which will represent a major opportunity. It already accounts for 30% of global sales and could reach 30 million units in 2020. More than 60% of this market is located in emerging economies, where sales are expected to grow by an annual 5-6% rate until 2020. Success in this key segment requires a low-cost business model characterised by a limited number of body types based on a single platform and a limited offer range. Modularity will thus become an even more fundamental success driver.

In terms of production, although the triad (United States, Europe, and Japan) will no longer represent the centre of growth, three out of four vehicles sold globally in 2020 will be still made by established OEMs from those regions. As OEMs are switching progressively to a local-for-local production model, it is expected that suppliers will also follow. In regions such as Asia, production volumes are expected to rise up to 70%, with positive impacts on the growth of the local supplier base.

Focusing on the progress against CO\textsubscript{2} emission targets, in Europe the 2020 target is expected to be largely achieved through advancements of technologies to conventional (ICE) vehicles. For some OEMs it will be necessary or beneficial to achieve part of the reduction through increased electrification.

Considering R&D, alternative power will see continuous innovation, even beyond 2020. This will influence also the split of value creation among vehicle modules. Electric drives will be the strongest growth sector in production increasing by 20% on an annual basis in terms of value creation.
4. Policy options and compliance mechanisms

4.1 Introduction
As the details of a proposal for post-2020 LDV CO₂ legislation are still to be determined, it is not possible to assess specific competitiveness impacts of a specific piece of legislation. In view of the large amount of options available for different elements of the legislation and the even larger number of possible ways in which these can be combined, it is considered premature at this stage to focus the assessment on a limited number of scenarios that could be considered as likely.

Instead a more generic approach is used to assess possible competitiveness impacts of post-2020 LDV CO₂ regulation, the results of which will also facilitate designing the legislation in such a way that these impacts are minimised. To that end the analysis focuses on creating an understanding of how choices made with respect to individual elements of the regulations (target level and modalities) may affect competitiveness. In doing so, it is necessary to understand the compliance mechanisms available to manufacturers. Choices with respect to individual elements of the regulations will determine the need to implement less or more advanced compliance strategies. The different modalities and options as well as the compliance mechanisms foreseen for meeting post-2020 targets are described in this chapter.

4.2 Policy options for post-2020 regulation
The policy instrument for which competitiveness impacts are assessed in this report is the European LDV CO₂ legislation for the period beyond 2020. For this legislation the European Commission has not yet defined a proposal. Compared to the existing pieces of legislation for 2015/17 and the agreed amendments for the 2020 targets, many of the modalities are still open. This concerns:

- the target year(s);
- the target level(s);
- the metric for which this target is to be defined, e.g. tank-to-wheel or well-to-wheel CO₂ emission;
- the utility parameter (e.g. mass or footprint) used to differentiate the overall target into manufacturer-specific targets and the shape / slope of the target function;
- possibilities for a joint legislative target for passenger cars and (one or more categories of) LCVs;
- possibilities for including mileage weighting;
- possibilities for including embedded emissions;
- a set of more detailed modalities including e.g. a phase-in period, derogations, super credits, eco-innovations, penalties and possibilities for pooling, banking and/or trading.

The target year(s)
Given that currently targets are set for 2015/17 and for 2020 a likely next target year would be 2025. Currently the European Commission is starting up the process of preparing a proposal for post-2020 LDV CO₂ legislation.
The target level(s)

The Commission has not yet started the preparation of proposals for post 2020 regulation of CO\(_2\) emissions from light duty vehicles, but different target levels have been proposed by various stakeholders and are informally being discussed. In the context of the decision process on the 2020 legislation in Council and Parliament, the European Parliament has proposed an indicative target range of 68 - 78 g/km for the passenger car legislation for 2025. For the post 2020 passenger car and LCV targets no figures have been formally proposed yet.

Target levels are defined on the basis of a type approval test procedure. The current targets are based on the NEDC test cycle and further test procedures defined in UNECE R83 and R 101. In the coming years the current test procedure will be replaced by the Worldwide Harmonized Light Vehicles Test Procedure (WLTP). This procedure includes a new test cycle, the WLTC, and modified specifications of test conditions and procedures. It is the Commission’s intention to implement the WLTP by 2017.

Adoption of the WLTP in the CO\(_2\) legislation will require translation of the existing NEDC-based targets to equivalent targets based on the new WLTC cycle and the associated test procedures. Preparatory work for that is on-going, through a close cooperation between DG CLIMA and DG Enterprise, supported by the JRC, and carried out in close consultation with automotive manufacturer associations and Member States.

Comparison with passenger car CO\(_2\) regulation in other countries

Competitiveness impacts of European LDV CO\(_2\) legislation will depend on the extent to which other regions develop and implement LDV CO\(_2\) legislation of similar or different stringency. An overview of currently existing or planned legislation for passenger cars, including targets translated to NEDC-equivalent values (based on simulation of different vehicle configurations over the different test cycles\(^{12}\)), is shown in Figure 8, taken from [ICCT 2014a]. It shows that in all of the larger passenger car markets CO\(_2\) legislation is in place or planned. For the European and Asian markets targets are only defined up to 2020. The graph also shows that the targets in Europe and Japan are lower than those in other regions, which all appear of more or less similar. The 68 - 78 g/km bandwidth informally mentioned for the 2025 EU passenger car target is significantly below the 2025 targets set in the US and Canada. The relative stringency of the legislation in Europe and elsewhere not only depends on the target level but also on the characteristics of the fleets (average mass, size, power, etc.) to which they are applied. Taking into account that cars in the US and Canada are on average larger and more powerful than those in Europe, while the markets in both Europe and Japan are characterized by a large share of small to medium-size vehicles, the stringency of passenger car CO\(_2\) legislation in those four regions is probably less different than suggested by the difference in target levels as shown in Figure 8.

Table 3 provides an overview of the attributes of passenger car CO\(_2\) legislation in different countries / regions (taken from [ICCT 2014a]). It show that in terms of regulated metric and utility parameter the structure of the legislation in Asian countries is fairly similar to that in the EU. For markets in Northern America a footprint-based legislation applies.

\(^{12}\) See: http://www.theicct.org/test-cycle-conversion-factors-methodology-paper
**Figure 8** - Comparison of CO₂ regulations for passenger cars in different regions in gCO₂/km, normalized to the NEDC\(^{13}\)

**Table 3** – Overview of attributes of passenger car CO₂ legislation in different countries / regions (taken from [ICCT 2013b])

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Regulated metric</th>
<th>Attribute</th>
<th>Form</th>
<th>Categories, classes, other provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fuel Economy</td>
<td>Fuel Consumption</td>
<td>CO₂/GHG</td>
<td>Weight</td>
</tr>
<tr>
<td>European Union⁵</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>United States</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Japan</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>China</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Canada</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>South Korea⁶</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mexico</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>India</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison with CO₂ regulation for LCVs in other countries

An overview of currently existing CO₂ standards for light commercial vehicles is shown in Figure 9 (see also [ICCT 2013a and 2014a]. It shows that the fleet averages required in the EU are quite similar to those in Japan, albeit with different target years, but lower than those required in the US and China. Especially for the US, however, it should be taken into account that the vehicles sold there as light trucks are generally different from the LCVs sold in the EU.

Figure 9 - Comparison of CO₂ regulations for Light Commercial Vehicles / Light Trucks in different regions in gCO₂/km, normalized to the NEDC

The metric

Target levels depend on the parameter for which the regulation sets a target (metric). The existing legislation applies to the so-called Tank-to-Wheel (TTW) CO₂-emissions of vehicles as measured on the type approval (TA) test.

The metric applied to the regulation for reducing CO₂ emissions from light duty vehicles may promote certain drivetrain technologies and discourage others. Besides improving the energy consumption of conventional vehicles (ICEVs), alternative powertrains using alternative energy carriers will be needed to meet medium to long term targets. These alternatives include battery-electric vehicles (BEVs or EVs), plug-in hybrid vehicles (PHEVs) and fuel cell electric vehicles (FCEVs), which under a TTW CO₂ based metric are considered low to

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zero emission vehicles (LEVs). However, depending on the WTT emissions associated with the production of energy carriers for these LEVs, different technology mixes, chosen to meet the target, have different impacts on the average WTW emissions of new vehicles as well as on the average costs for meeting the target.

As a result, the drivetrain technologies that are promoted by a given metric when viewed from a manufacturer’s perspective may not be the most cost effective way to reduce transport WTW CO₂ emissions from a societal perspective. In order to ensure cost-effectiveness from a policy perspective, insights into the relationship between possible regulatory metrics, manufacturer responses in terms of applying different technologies, and the societal cost-effectiveness of WTW CO₂ emission reduction are crucial. Manufacturers will choose technologies for meeting a target on the basis of additional manufacturer costs on the one hand (which affect the sales prices of vehicles or the profitability of the manufacturer) and impacts on total cost of ownership for the end-user on the other hand (end-users may be willing to purchase a car that is more expensive to buy but cheaper to drive due to lower energy costs).

Ideally the metric and target stimulate manufacturers to choose technologies that reduce CO₂ emissions most cost-effectively from a societal point of view. This is the case when the optimal share of LEVs from a manufacturer’s point of view, based lowest additional manufacturer costs or the manufacturer’s weighing of impacts on manufacturer costs and end-user costs, aligns with the share that leads to the lowest costs from a societal point of view.

The main options for the metric for regulating CO₂ emissions from light duty vehicles beyond 2020, as identified by the Commission and analysed in [TNO 2013a and 2013b], are:

a. regulating vehicle CO₂ emissions
   - tailpipe CO₂ emissions as in existing Regulation (= TTW CO₂ emissions)
   - tailpipe CO₂ emissions for ICEs with exclusion of Zero Emission Vehicles
   - tailpipe CO₂ emissions with notional GHG intensity for Zero Emission Vehicles
   - tailpipe CO₂ emissions adjusted to take account of WTW emissions (= WTW GHG emissions)

b. regulating vehicle energy use
   - energy used in the vehicle per vehicle-km (= TTW energy consumption)
   - energy use per vehicle-km adjusted for WTW consumption (= WTW energy consumption)

c. The above approaches can be combined with size-dependent (lifetime) mileage weighting. Also inclusion of embedded emissions in the WTW approaches listed above is considered.

In addition [TNO 2013a] has reviewed some regulatory options such as inclusion of road fuel use in the EU ETS, a vehicle manufacturer based trading scheme based on lifetime vehicle GHG emissions, a cap and trade system for vehicle manufacturers, of total CO₂ emissions of vehicles sold (expressed in g/km). These options, however, are not considered in the context of this study.

As several of these modalities significantly affect the competitiveness impacts, assumptions need to be made on specific options for these modalities to allow a qualitative or quantitative assessment. The study will try to draw conclusions with respect to possible competitiveness impacts which are independent of detailed
decisions on the modalities for future legislation, or will indicate how the choice of modalities could affect impacts on competitiveness.

**The utility parameter**

The utility parameter is a vehicle characteristic that can be used to differentiate the overall target into manufacturer-specific targets. This is done by defining a utility based target function, which for every vehicles describes a target as function of the vehicle’s value for the utility parameter. Per vehicle these targets are non-binding, but binding manufacturer targets are defined by sales-averaged weighting of the targets for all vehicles sold by the manufacturer in the target year.

The current Regulations are based upon mass as the utility parameter. [TNO 2011] and [TNO 2012a] have fairly conclusively shown that the only useful options for the utility parameter are mass or footprint for cars. For LCVs, it is unclear whether footprint would be desirable. The poor correlation between CO₂ and footprint for this vehicle category, however, is an artefact of the NEDC’s artificial cut-off in test mass. For vans, therefore, the issue of the utility parameter would require further assessment also in view of the consequences of moving from the NEDC to the WLTP.

**The shape / slope of the target function**

The current regulations for cars and vans define manufacturer-specific targets using a linear target function expressed as $T = T_{avg} + a \cdot (m - m_0)$, with $T$ the specific target, $T_{avg}$ the overall fleet average target (e.g. 130 g/km for passenger cars in 2015), and $m_0$ the (assumed) average mass of vehicles sold in Europe in the target year. The European Commission can adjust $m_0$ to counteract e.g. impacts of so-called autonomous mass increase (vehicle models getting heavier over time) on the overall achieved fleet average.

![Figure 10 – Mass-based target functions in the current regulations for passenger cars and vans](image)

Differentiation of the targets for different manufacturers using a utility-based target function means that the impacts of the legislation on manufacturers of on average smaller / lighter or larger / heavier depend on the shape and slope of this target function. The definition of the target function leads to differences in the distances to target for different manufacturers and thus to differences in the costs of technologies that need to be applied for reaching the target. This combined with the different fuel cost savings associated with the
required reductions determines the net impact on the end user costs (ΔTCO) of the vehicles produced by each manufacturer. The change in purchase price and the ΔTCO affect the attractiveness of cars to end users, so that differences in Δprice and ΔTCO between manufacturers, as a result of the modalities of the legislation might affect their relative competitiveness. This is e.g. illustrated in Figure 12 to 15 of section 7.9 of the Commission’s Impact Assessment for the amendments to Regulation (EC) No 443/2009 and Regulation (EU) No 510/2011 (see: SWD(2012) 213).

The target functions used in the current CO₂ legislation for LDVs are presented in Figure 10. For the passenger car regulation in 2020 it can be seen that the slope is already becoming very flat. The question arises whether a differentiation of the target based on vehicle mass or size continues to be meaningful in the long term. Figure 11 shows the footprint-based target functions as used in the 2017 and 2025 US Cars and Light-Truck Standards. Using a floor (for small cars) and a ceiling (for large cars) in the limit function has also been considered for the EU legislation (see [TNO 2011]. An assessment on the basis of the EU sales database, however, indicated that in the European situation such a modality would offer negligible benefits in terms of the costs for meeting the target or the avoidance of undesired distributional impacts among manufacturers.

**Figure 11 - Footprint-based target functions for the 2017 and 2025 US Cars and Light-Truck Standards (taken from [ICCT 2013a])**

![Footprint-based target functions for the 2017 and 2025 US Cars and Light-Truck Standards](image)

Possibilities for a joint legislative target for passenger cars and (one or more categories of) LCVs

One option that is seriously considered by the European Commission is to include the smallest LCVs, Class I N1 vehicles, in the CO₂ legislation for passenger cars. Other options for combining the passenger car and LCV legislation include:

- The targets and associated modalities for cars and vans could still be designed separately but merged into one text (i.e. in the same Regulation). This is a formal way of bringing the two vehicle categories under the same legislation;
- Bringing part of the LCV market together with passenger cars under a single target. The categories of LCVs to be joined with passenger cars may be based on the current class I, II and III definitions for N1 vehicles, may include N2 vehicles or may be based on definitions still to be devised.
- The two vehicle categories could be combined under a single target. Some of these options have been assessed in previous studies (e.g. [TNO 2012]).

The question of merging the passenger cars and vans regulation or not is actually not really a modality, but rather a matter of the scope of the legislation. But it does interact with other modalities, such as the utility parameter for example. Also the test procedure for vans (esp. with respect to the WLTP) is an issue that can have implications for merging the two regulations.

**Possibilities for including mileage weighting**

In general different vehicle segments (e.g. size classes) have different average annual mileages and different average lifetimes. Including mileage weighting in the CO\(_2\) regulation has the potential to increase the cost effectiveness and/or efficiency of the regulation as manufacturers would be stimulated to account of lifetime mileage in the distribution of reduction efforts over different vehicle models / segments. However, this measure requires reliable data on average life time mileage of different car segments, which are currently not available on EU-scale.

**Inclusion of embedded emissions**

Embedded emissions are emissions occurring in the production and/or decommissioning phase of products. So far CO\(_2\) regulation only targets emission in the use phase of vehicles. Indirect, so-called rebound effects may occur if the legislation promotes vehicles with low or zero CO\(_2\) emission technologies for which the embedded emissions are significantly larger than those of ICEVs. There is evidence for EVs and PHEVs that this is the case.

This option would promote OEMs to take responsibility for environmental impacts occurring in the production of materials, components and vehicles as well as in the decommissioning phase. Such chain management is becoming more and more common as a way for companies to control their ecological footprint and other direct and indirect societal impacts.

**Eco-innovations and other ways of giving credit to technologies that reduce real-driving emissions**

The European Commission is considering the option of expansion of the CO\(_2\) legislation to include CO\(_2\) reductions that can be achieved outside the standard test procedure. A substantial proportion of vehicle energy use and CO\(_2\) emissions are accounted for by energy using devices that are not activated during the normal test procedure. This is not expected to change substantially with the introduction of the WLTP. In recognition of this the current regulations are complimented by specific measures addressing mobile air conditioning systems and the eco-innovation scheme. In the US already a system of off-cycle credits has been introduced. In considering options for continuing or expanding the eco-innovation scheme the Commission is also paying attention to the likelihood that the scheme will lead to technologies that improve the competitiveness of EU manufacturing. Giving credit to the CO\(_2\)-reduction potential of new technologies that specifically reduce emission in real-world driving further increases the number of compliance mechanisms that manufacturers have available for meeting the target.
Super credits
The EU LDV CO\textsubscript{2} regulation gives manufacturers additional incentives to produce vehicles with extremely low emissions (below 50g/km). For the passenger car target in 2015 each low-emitting car will be counted as 3.5 vehicles in 2012 and 2013, 2.5 in 2014, 1.5 vehicles in 2015 and then 1 vehicle from 2016 to 2019. Super-credits will also apply in the second stage of emission reductions, from 2020 to 2023. Each low-emitting car will be counted as 2 vehicles in 2020, 1.67 in 2021, 1.33 in 2022 and 1 from 2023. For this second step there will be a cap on the scheme’s contribution to the target of 7.5 g/km per manufacturer over the three years. Under the LCV regulation each low-emitting van will be counted as 3.5 vehicles in 2014 and 2015, 2.5 in 2016, 1.5 vehicles in 2017 and then 1 vehicle from 2018 onwards. Manufacturers are able to claim this ‘super credit’ for a maximum of 25,000 vans over the 2014-17 period. Similar provisions could be part of the post-2020 legislation with possible modification of the emission threshold, the super credit factors and the timing.

A phase-in period
A target for a given target year may be accompanied by a phase-in period in which a year-by-year increasing share of each manufacturer’s sales is required to meet the specific target.

Derogations
The current legislation contains derogations for so-called small volume and niche manufacturers. Independent manufacturers of passenger cars which sell between 1000 and 10,000 vehicles per year and which cannot or do not wish to join a pool can propose their own emissions reduction target, which is subject to approval by the Commission. The Commission decides on the acceptance of such a proposed specific target on the basis of a set of agreed criteria which include the manufacturer’s emissions reduction potential. Manufacturers selling between 10,000 and 300,000 cars per year can apply for a fixed target of a 25% reduction from their 2007 average emissions for the period 2012 to 2019, and a 45% reduction from the 2007 level as of 2020. The extent to which such a target is more lenient than the target set by the mass-based target function depends on the average mass.

LCV manufacturers which are responsible for fewer than 1000 new van registrations per year in the EU are exempted from having a specific emissions target. Independent manufacturers which are responsible for fewer than 22,000 van registrations per year can propose their own emissions reduction target for approval by the Commission.

Penalties
If the average CO\textsubscript{2} emissions of a manufacturer’s fleet exceed its limit value in any year from 2012 onwards, the manufacturer has to pay an excess emissions premium for each car registered. This premium amounts to €5 for the first g/km of exceedance, €15 for the second g/km, €25 for the third g/km, and €95 for each subsequent g/km. From 2019, the cost will be €95 from the first gram of exceedance onwards.

The value of the penalty in € per g/km is tuned to the marginal costs for meeting the target. For post-2020 targets the penalty value may thus change depending on the target level chosen and cost curves estimated for meeting the target.
Possibilities for pooling, banking and borrowing and/or trading

Manufacturers can group together to form a pool which can act jointly in meeting the emissions target. The regulation states that in forming a pool, manufacturers must respect the rules of competition law and the information that they exchange should be limited to average specific emissions of CO₂, their specific emissions targets, and their total number of vehicles registered. Obviously, for pooling to be beneficial for all parties involved an OEM that has difficulty in meeting its own specific target will need to offer certain financial or other advantages to the other OEMs in the pool.

The current regulation does not provide the possibility for banking and borrowing, but this option is part of a long list of options being assessed in preparation of a proposal for the post-2020 legislation. Banking and/or borrowing is a scheme that allows manufacturers to have more flexibility in the compliance with a specific emission target for a specific year. When the average CO₂ emission of the new vehicle sales is below the specific emission target for that year, the manufacturer or group of manufacturers can bank the difference as emission allowances. When the average CO₂ emission value exceeds the specific emissions target in another year, the manufacturer can offset these excess emissions with ‘banked’ emission allowances from preceding year(s) or ‘borrow’ emission allowances, which have to be ‘paid back’ in subsequent years. This mechanism allows manufacturers to flexibly deal with the introduction of new technologies, decreasing the risk of paying excess emissions premiums, while maintaining the overall reduction trajectory. For banking and borrowing to make sense it should be combined with a trajectory of declining annual target values.

4.3 Possible compliance strategies of OEMs

Possible competitiveness impacts of the LDV CO₂ legislation on OEMs, as well as on the other affected sectors studied in this report, depend on the compliance mechanisms chosen by manufacturers for meeting the targets set by the legislation and the impact that these compliance mechanisms have on the costs of manufacturing, buying and operating vehicles. A graphical overview of compliance mechanisms available to vehicle manufacturers is presented in Figure 12. The main compliance mechanisms are:

- Technical options
  - applying additional CO₂ reducing technologies to ICEVs
  - applying eco-innovations or other technologies that deliver CO₂ savings outside the normal test procedure
  - increasing shares of alternatively fuelled vehicles (AFVs)

- Non-technical options
  - utilising test flexibilities
  - increase the average utility parameter value (without affecting CO₂)
  - selling smaller or less performant cars
  - change sales (eligibility for derogation)
  - pool with other OEM group
  - pay excess premiums for non-compliance

For assessing the 2015-2020 legislation the main compliance mechanism considered was application of efficiency improving technologies to ICEVs. The option of selling alternatively fuelled vehicles (such as
BEVs, PHEVs and FCEVs) could be ignored for assessing the targets (see [TNO 2011] and [TNO 2012]) as these technologies were not needed and were still relatively expensive.

An overview of the most important technical options for meeting post-2020 targets is provided in Table 4. The table includes a column with options that yield reductions outside the test cycle, which could become relevant either through an eco-innovations scheme or by including other provisions that reward the application of such technologies in the post-2020 legislation. Most of the options listed in the table are already applied in vehicles on the market, but further innovation may be required to improve the performance of these technologies or to reduce costs.

Depending on their level and definition, post-2020 targets may require alternative low-CO₂ or zero-CO₂ emission technologies to be marketed. Beyond 2020 the costs of these technologies are expected to become more competitive. As the marginal costs for further improvement of the fuel efficiency of ICEVs increase non-linearly, marketing AFVs will become an increasingly important compliance mechanism for meeting post-2020 targets (see e.g. [TNO 2013b]). The costs for achieving CO₂ reductions through efficiency improvement in ICEVs and the marketing of AFVs not only depend on the costs of the individual technologies, but also on the way in which their application is divided over vehicle models in different size segments. In general it may be expected that OEMs will strive for a distribution of reduction efforts over models and segments that leads to the lowest compliance costs.

### Table 4 - Important technical compliance options for the 2020-2030 timeframe

<table>
<thead>
<tr>
<th>Options for ICEVs and HEVs that yield reductions on the test cycle</th>
<th>Technologies reducing vehicle resistance and auxiliary energy consumption</th>
<th>Options that yield reductions outside the test cycle</th>
<th>Alternative energy carriers and propulsion systems (AFVs*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technologies improving powertrain efficiency</td>
<td>Technologies reducing vehicle resistance and auxiliary energy consumption</td>
<td>Options that yield reductions outside the test cycle</td>
<td>Alternative energy carriers and propulsion systems (AFVs*)</td>
</tr>
<tr>
<td>low friction design and materials</td>
<td>body-in-white weight reduction (advanced steel, aluminium, fibre reinforced plastics, etc.)</td>
<td>efficient lighting</td>
<td>natural gas vehicles (NGVs)</td>
</tr>
<tr>
<td>direct injection petrol engines</td>
<td>light-weight components other than BIW</td>
<td>waste heat recovery</td>
<td>(dedicated) biofuel vehicles</td>
</tr>
<tr>
<td>variable valve timing and actuation</td>
<td>improved aerodynamics</td>
<td>efficient air conditioning / vehicle thermal management</td>
<td>battery-electric propulsion (BEV)</td>
</tr>
<tr>
<td>advanced combustion concepts</td>
<td>low rolling resistance tyres</td>
<td>solar roof</td>
<td>plug-in hybrids (PHEVs) and extended-range electric vehicles (EREVs)</td>
</tr>
<tr>
<td>various degrees of engine downsizing</td>
<td>electric auxiliaries, e.g. electric power steering, oil and water pumps. etc.</td>
<td>efficient auxiliaries</td>
<td>fuel cell electric propulsion on hydrogen (FCEV)</td>
</tr>
<tr>
<td>advanced transmissions</td>
<td>efficient auxiliaries</td>
<td>tyre pressure monitoring</td>
<td></td>
</tr>
<tr>
<td>electrification:</td>
<td>start-stop system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mild / medium / full hybridisation</td>
<td>mild / medium / full hybridisation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) Alternatively Fuelled Vehicles or AFVs
Figure 12 – Overview of compliance strategies available to OEMs for meeting targets defined by post-2020 LDV CO₂ legislation

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For PHEVs net effect of super-credits is also dependent on net TA CO₂ emission of PHEVs.

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If applied technologies affect (average) utility value of vehicles in years when super-credits are applicable.

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Excess emissions premiums for non-compliance remaining share of ICEVs contribution of eco-innovations towards meeting OEM-specific target net contribution of AFVs towards meeting OEM-specific target.
In relation to these technical compliance mechanisms it must be noted that the extent to which they contribute to meeting the target also depends on the response of consumer and end-users to OEMs offering new technologies. If the consumer acceptance of e.g. battery-electric vehicles is lower than an OEM expects, higher reductions will have to be achieved by making ICEVs more efficient or by selling other types of AFVs.

Besides technical options to reduce the CO₂ emissions of new vehicles on the type approval test also a number of other technical and non-technical compliance mechanisms may contribute to meeting the target. In general an OEM will apply more than one option to meet the target.

### 4.4 Description and prioritisation of OEM compliance mechanisms

The compliance strategies to meet post 2020 CO₂ target, as indicated in Figure 12, are described below. An evaluation is made of their relevance for meeting future targets, resulting in a prioritisation of the mechanisms to be assessed in detail.

**Technical options**

**Applying additional CO₂ reducing technologies to ICEVs**

The main compliance mechanism for post 2020 legislation will be the application of technologies to ICEVs that reduce the vehicles’ energy consumption and CO₂ emissions. These measures include engine improvements, various levels of engine down-sizing, exhaust heat recovery, advanced transmissions, start-stop systems and various levels of powertrain hybridisation, lightweight construction and materials, improved aerodynamics, low rolling resistance tyres, and efficient auxiliaries (e.g. pumps, power steering, air conditioning). Increasing levels of CO₂-emission reduction in ICEVs can be achieved by combining different technologies. The most cost effective packages per level of reduction constitute a non-linear cost curve of which examples from [TNO 2011], developed for the 2020 time horizon, are shown in Figure 13.

![Figure 13 - Examples of cost curves for CO₂ reduction in passenger cars](image)

*On the left specific cost curves for medium-sized passenger cars on petrol in 2020 as developed in [TNO 2011]. On the right average additional costs of new passenger cars as function of the achieved average CO₂ emissions in the 2020-2030 timeframe, developed for the modelling carried out in [TNO 2013b] on the basis of the scenario a) cost curves from [TNO 2011]*
Cost curves for the 2025-30 period are being developed in an on-going project commissioned by DG CLIMA. It is expected that these will show larger reduction potentials at lower additional manufacturer costs, due to new technologies becoming available and improved performance and reduced costs of existing technologies.

**Relevance: Important**

This compliance mechanism is considered very important as ICEVs will remain a large share in the post-2020 new vehicle fleet and this mechanism offers a large and largely cost-effective reduction potential. This strategy results in CO₂ reduction both in the test procedure and in the ‘real world’, although the level of reduction may be different on the test from the real-world due to the limited representativeness for real-world driving of the test cycle and test condition.

**Applying eco-innovations or other technologies that deliver CO₂ savings outside the normal test procedure**

The current legislation states that manufacturers may receive emission credits contributing to the achievement of their specific CO₂ target for the application of so-called eco-innovations. These are innovative technical measures applied to vehicles which reduce the energy consumption and CO₂ emissions under real-world driving conditions but that do not (or not significantly) affect the CO₂ emissions as measured on the type approval test. Examples are waste heat recovery, solar roofs and LED lighting. For cars and LCVs the total contribution of those technologies to reducing the specific emissions target of a manufacturer is limited to 7 gCO₂/km under the current regulation.

A supplier or a manufacturer which applies for a measure to be approved under the current legislation as an "eco-innovation" must submit a report, including a verification report undertaken by an independent and certified body, to the Commission. An important issue with eco-innovations is the assessment of their impact on real-world CO₂ emissions. These depend on the characteristics of the technology, the level of uptake in the market, the use of the technology by vehicle drivers and on regional conditions. The latter may be driving patterns (e.g. relevant for the impact of waste-heat recovery), regional solar irradiation patterns (relevant for solar roofs and efficient air conditioners) and day length and weather conditions (relevant for e.g. LED lights). For other eco-innovations other conditions may have to be taken into account.

The take up of eco-innovations has demonstrated that there are substantial alternative cost effective routes to reducing real-world LDV CO₂ emissions. The Commission therefore considers it appropriate that such options also be considered for inclusion as part of the post 2020 regime. The way in which incentives for applying technologies that reduce “off-cycle” CO₂ emissions rather than only type approval emission, are to be included in post-2020 LDV CO₂ legislation may differ from the current approach, which, as mentioned above, gives credits to technologies that are approved by the European Commission as eco-innovations under very specific conditions.
Relevance: Important
Given the increasing marginal costs of technologies for further reduction of CO₂ emissions of ICEVs, it is to be expected that in post-2020 legislation more attention will be paid to technologies that reduce real world CO₂ emissions even if these are not counted within the test procedure.

The essence of this compliance strategy is to add new technologies or components to vehicles or to improve the efficiency of existing technologies or components. For assessing competitiveness impacts this strategy can thus be dealt with in the same way as the option of applying additional technologies to ICEVs that reduce CO₂ emissions on the type approval test, provided that the provisions that specify what is an eco-innovation work out similarly for EU and non-EU manufacturers.

Increasing shares of AFVs
The extent to which AFVs contribute to meeting post-2020 targets depends on the metric chosen. Under a TTW CO₂-based metric BEVs and FCEVs count as zero-emission, while PHEVs have very low emissions, often below 50 g/km. Under other metrics their “scores” are less different from those of ICEVs. Nevertheless, in most cases marketing a finite share of AFVs will bring OEMs closer to their target.

Relevance: Important
Beyond 2020, and depending on the metric and target level, this is expected to become an increasingly important compliance mechanism. Introducing AFVs may be cost effective from an OEM perspective as it helps to avoid having to apply CO₂ reduction measures to ICEVs with high marginal costs. In view of meeting long term targets (60% reduction of transport GHG emissions by 2050 relative to 1990) introducing AFVs can even be considered a necessary transition pathway.

Non-technical options
Utilising test flexibilities
Over the last decade OEMs have learned to exploit flexibilities in the test procedures to achieve lower type approval test results that do not represent actual CO₂ emission reductions while driving. These flexibilities relate to unclear definitions or bandwidths in the specifications of test conditions for the coast-down test and the chassis dynamometer test as well as for their execution and in the specifications for the condition of the test vehicle. For cars [TNO 2012b] estimates that some 16 g/km of the reduction achieved between 2002 and 2012 may be attributable to this mechanism, while additional potential is still available. Replacing the NEDC-based test procedure by the new WLTP will reduce the room for exploiting flexibilities, but is not expected to solve this problem entirely.

Relevance: Less important
Optimising test conditions for vehicles has been going on for several years already. We assume that all manufacturers will have the same knowledge and ability to apply flexibilities in the period post-2020. The introduction of the new test procedure in 2017 will enhance this level playing field. Moreover, the utilization of flexibilities can be ‘developed’ at relatively low cost and may be expected to be fully exploited by 2020.
Increase average utility parameter value (without affecting CO₂)

Increasing the average utility parameter value increases an OEM’s specific target. The extent to which this strategy effectively reduces the distance to target, however, depends on the slope of the utility-based target function and the way in which increasing the utility parameter value affects CO₂ emissions. Increasing mass increases CO₂ emissions, but the slope of the current mass-based target function is lower than the slope of the relation between mass and CO₂ making this unattractive. Increasing footprint is likely to have lower impacts on CO₂, but is more difficult to realise without changing the design of vehicles.

Relevance: Unimportant

The slope of the utility function, which determines the CO₂ targets of manufacturer groups, is already rather flat and could become even flatter in post-2020 legislation. Increasing the average utility value would then result in a higher CO₂ target. Since there is a trade-off between changing the utility parameter of a vehicle and its CO₂ emissions, this mechanism could increase the distance to target.

Selling smaller or less performant cars

Assessments of the costs for meeting targets for the 2015-2020 period (see [TNO 2006], [CE 2009], [TNO 2011] and [TNO 2012]) have always assumed that the characteristics of the new vehicle fleet in terms of vehicle segment distributions and typical vehicle performance would not change between the reference year and the target year. One reason for using this assumption has been that selling smaller cars as a compliance mechanism involves negative direct costs (smaller cars are cheaper), but would also involve finite positive welfare costs which are difficult to account for in the type of cost assessment made for the CO₂ legislation. Also, at least up to 2020, the technological changes needed to achieve the CO₂ reduction without affecting vehicle size or performance were found to be cost-effective from an end-user point of view, so that it was considered unlikely that vehicle down-sizing or down-rating would be needed as a compliance mechanism. Finally the effectiveness of selling smaller cars is limited under a target function with a finite slope. Together with the fact that margins on small cars are generally very small, this makes it unlikely that OEMs would purposely choose vehicle down-sizing as a compliance mechanism in the short to medium term.

However, selling smaller or less performant cars can in principle be a means to reduce the average CO₂ emissions of the new vehicles sales. With more stringent longer term targets, and possibly an even flatter slope of the target function, this option may become more relevant. The impact of vehicle down-sizing or down-rating on the distance to target depends on the utility parameter and the slope of the target function, as well as the adjustment of the target function to correct for the impact of the changing average utility value.

Selling on average smaller vehicles may not just be a matter of sales shifting to smaller segments. The VW XL1 is an interesting example of an innovative vehicle model in which reduced size is combined with advanced technology to achieve a vehicle with extremely low CO₂ emissions ¹⁵.

A shift in sales towards smaller or less performant vehicles may not be a strategy for OEMs, but may also be a knock-on consequence if there were an increase in the price of new cars as a result of technologies applied to meet future CO₂ standards.

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¹⁵ See e.g. http://en.wikipedia.org/wiki/Volkswagen_1-litre_car
Relevance: Medium importance
Although it may be considered unlikely that EU CO\textsubscript{2} standards for beyond 2020 will be set at levels that will require OEMs to sell on average smaller or less performant cars, an assessment of competitiveness impacts of the post-2020 legislation should at least pay attention to the possible consequences of a shift in sales towards smaller or less performant vehicles occurring as a knock-on consequence of the vehicle price increase that results from applying new CO\textsubscript{2} reducing technologies. Different companies may be more or less able to cater for such a shift in consumer preferences.

Change sales (eligibility for derogation)
Manufacturers whose sales are close to one of the thresholds between large volume manufacturers, niche manufacturers and small volume manufacturers may choose to manage their sales in such a way that they fall into or remain in a category with a less stringent target.

Relevance: Unimportant
Under the current regulation for some of the OEMs able to benefit from a niche derogation, there is actually no benefit to receiving one. It is not likely that manufacturers will lower their sales under a derogation threshold to ease their CO\textsubscript{2} target. And if they are able to do this, they may generally not be considered serious competitors for large volume manufacturers. The only exception to that could be in small manufacturers of sports and other high-end vehicles that compete against such vehicles sold by OEMs with a wider product portfolio. These, however, have more room for internal averaging of the costs of compliance as well as for achieving economies of scale for applied technologies, so that the derogation provision can actually be considered a means to avoid a competitiveness disadvantage for smaller volume manufacturers.

Pool with other OEM group
Pooling with a manufacturer with lower average CO\textsubscript{2} emissions is a possible strategy to meet the target as a manufacturer group. It is especially attractive for manufacturers with smaller sales volumes and high average CO\textsubscript{2} emissions as a result of selling vehicles with above-average performance or other characteristics.

Relevance: Less important
Under the current regulation a total of 12 pooling agreements have been established for passenger cars and 2 for vans\textsuperscript{16}. These, however, all only contain cooperation between companies that in the design of the regulations were already considered to be part of the same manufacturer group. So, although it appears that significant use of made of this provision, it does not lead to impacts that deviate from those assessed in the design of the legislation.

Pay excess premiums for non-compliance
If a manufacturer is not able to meet its specific target, or only at marginal costs that exceed the penalty, it can choose to pay excess emissions premiums for non-compliance. The fact that excess emissions premiums are the same for all manufacturers caps the marginal cost for meeting the target for all

\textsuperscript{16} See: https://circabc.europa.eu/w/browse/3c090b5c-c2c5-4a7f-a04f-16e665532ecd, and https://circabc.europa.eu/w/browse/afed517d-5f6b-4fdc-ad44-7c5e4947b9a4
manufacturers, thus effectively reducing possible competitiveness impacts that may arise from the fact that cost curves (and other factors) may not be the same for all manufacturers from all regions.

Relevance: Less important
For this study we assume that manufacturers will meet their targets. It is in the end the level of excess premium that to a large extent influences manufacturers’ choices to meet the target or pay the fine for not meeting it. It is assumed that the level of excess premiums for the post-2020 legislation will be tuned to the estimated marginal costs for meeting the target(s) set by this legislation.

4.5 Key conclusions
- Targets for LDV CO\textsubscript{2} legislation beyond 2020 and the modalities of achieving them have not yet been determined. The European Commission is considering a wide range of options, including the modalities already used in the existing legislation as well as a range of new modalities. Important issues will be the choice of metric (e.g. TTW or WTW CO\textsubscript{2} emissions or energy consumption), the possible inclusion of embedded emissions and the utility parameter.
- In all of the larger passenger car markets CO\textsubscript{2} legislation is in place or planned, at least up to 2020. The targets in Europe and Japan are lower (in gCO\textsubscript{2}/km) than those in other regions, which all appear of more or less similar stringency. The 68 - 78 g/km bandwidth proposed by the European Parliament for the 2025 EU passenger car target is significantly below the 2025 targets set in the US and Canada. The relative stringency of the legislation in Europe and elsewhere not only depends on the target level but also on the characteristics of the fleets (average mass, size, power, etc.) to which they are applied. Taking into account that cars in the US and Canada are on average larger and more powerful than those in Europe, while the markets in both Europe and Japan are characterized by a large share of small to medium-size vehicles, the stringency of passenger car CO\textsubscript{2} legislation in those four regions is probably less different than suggested by the difference in target levels.
- In terms of regulated metric and utility parameter the structure of the passenger car CO\textsubscript{2} legislation in Asian countries is fairly similar to that in the EU. For markets in Northern America a footprint-based legislation applies.
- For vans the fleet averages required in the European CO\textsubscript{2} regulation are quite similar to those in Japan, but lower than those required in the US and China. Especially for the US, however, it should be taken into account that the vehicles sold there as light commercial vehicles are generally different from those sold in the EU.
- OEMs have a wide range of technical and non-technical options at their disposal for complying with post-2020 LDV CO\textsubscript{2} legislation. Technical options are considered the most important compliance mechanism, and will thus receive priority in the assessment of possible competitiveness impacts.
- Compared to the 2015-2020 period the number of technical options that will be applied by OEMs to comply with the post-2020 legislation is expected to increase significantly. Besides improved or new technologies for efficiency improvement in ICEVs it is expected that OEMs will market a range of alternatively fuelled vehicles. Depending on how they are rewarded in the legislation, the application of technologies that reduce off-cycle CO\textsubscript{2} emissions may also increase.
5. Impacts on cost competitiveness: the automotive manufacturer perspective

5.1 Introduction

As mentioned in section 2.4, to assess cost competitiveness impacts on the affected sectors (automotive manufacturing industry, automotive supply industry, energy supply industry and end-users) it is useful to separate the analysis into two cases:

- EU companies vs. competing companies from other regions;
- EU manufacturing / production vs. manufacturing / production in other regions.

In this chapter separate assessments are presented for the cases of automotive manufacturers and automotive manufacturing. In chapter 7 similar analyses are undertaken for the cost competitiveness impacts on automotive suppliers and on the automotive components manufacturing industry.

The two perspectives are complementary, as illustrated in Figure 14. Cost competitiveness impacts from a manufacturer perspective are first of all determined by the compliance mechanisms chosen by EU and non-EU car manufacturing companies. These include changes to the overall vehicle design (including e.g. improved aerodynamic of the use of light-weight materials), improving the efficiency of conventional engines and powertrains or applying alternative powertrains. The average impacts of those choices on the price and value / quality of the vehicles from manufacturers from different regions determine possible changes in cost competitiveness between EU and non-EU companies. The impact of compliance strategies on the price of vehicles from manufacturers from different regions is strongly affected by the regions in which these manufacturers produce their vehicles and the regions from which they source their components and materials. The average costs of manufacturing vehicles and components in the EU and other regions are what makes up the cost competitiveness of these regions from a manufacturing perspective. In this way the cost competitiveness of EU and non-EU manufacturing (of cars as well as of components and materials) affects the cost competitiveness of EU and non-EU manufacturers. The other way around, choices of OEMs to manufacture cars in a certain region or source components from a certain region determine production volumes and thus economies-of-scale in that region, which affect the cost competitiveness of that region relative to other regions from a car and component manufacturing perspective.

For the other two affected sectors (i.e. the fuel supply sector and professional end users) the two perspectives are less distinct. Within the energy sector (chapter 9) oil companies are in global competition, but fuel supplied to the EU market is largely produced in the EU, and other affected energy suppliers are largely not competing with companies from other regions. Especially for end-users (chapter 10) many of the possibly affected EU companies are not competing with non-EU companies, and if they are the impact of a change in costs of operating passenger cars and vans is likely to be a very small part of their cost of operations.

For the first case (EU vs. non-EU companies) the focus is on identifying possible reasons for the impacts of the LDV CO₂ legislation on the cost and value of products being different for EU companies than for
competing companies from other regions. This starts with identifying how the products / services change as a result of the compliance mechanisms chosen by OEMs to meet their specific targets under the legislation.

For the second case (EU vs. non-EU manufacturing) the focus is on identifying possible impacts of the LDV CO₂ legislation on the cost of manufacturing or production or the cost of doing business. This analysis should start with an assessment of possible impacts of the legislation on the various cost components that determine the cost of doing business, such as the cost of labour, labour skills and labour productivity, and the cost of capital. Identified possible impacts on cost competitiveness of EU manufacturing are relevant because as a second order effect such impacts may encourage or discourage both EU and non-EU manufacturers to move production facilities from other regions to the EU or from the EU to other regions, with a positive or negative impact on employment in the EU.

If European manufacturers are defined as having a minimum of xx% of their EU sales manufactured in the EU (definition 4 in section 2.5), then the distinction between the two perspectives becomes less clear, as the motivation for manufacturers to locate a large share of their production in the EU depends on the cost competitiveness of European manufacturing compared to manufacturing in other regions.

### 5.2 Overall methodology

In this chapter “mindmaps” are used in two different ways for analysing the extent to which post-2020 LDV CO₂ legislation in Europe might lead to impacts on cost competitiveness:

- **Overall mapping of impact pathways:** Mindmaps have been developed that illustrate how different aspects of the legislation may lead to different compliance strategies of OEMs (or response strategies of companies in other affected sectors), and how these in turn affect cost competitiveness as a result of differences in impacts on the cost and value of products or services which depend on the differences in resources and capabilities of different companies;

- **Detailed analysis of determinants of possible cost competitiveness impacts:** Mindmaps have also been used to decompose complex if-then-else reasonings that determine under which conditions (ways in which certain determinants may have different values for different competing companies or regions) various aspects of the legislation may or may not lead to positive or negative impacts on cost competitiveness.

These mindmaps should be read from left to right. Links between elements indicate that an element affects other elements. Feedback loops, where outcomes of a reasoning affect (on the right hand side) affect starting points (on the left hand side) are indicated by arrow-shaped connectors.

The largely qualitative reasoning in the second type of mindmaps often lead to identification of questions for further quantitative data analysis which may be used to determine whether or not certain identified conditions for cost competitiveness impacts are met. Data questions generally relate to identifying possible differences in the characteristics of EU and non-EU companies or sectors. Whenever such data were or could be made

17 NOTE: To facilitate printing on A3 paper, the mindmaps presented in this report are also provided in a separate pdf-document.
available to the consortium, such questions are answered in this chapter. When that is not the case the questions are listed as recommendations for further work.

**Figure 14 – Relation between assessing cost competitiveness impacts from the perspective of car manufacturers or car manufacturing**
5.3 Pathways for impacts on the cost competitiveness of automotive OEMs

An overview of the main direct pathways for cost competitiveness impacts on EU vs. non-EU manufacturers is presented in Figure 15. No cost competitiveness impacts are to be expected if the following two conditions are simultaneously met:

- the regulation results in targets of similar stringency for EU and non-EU OEMs, and
- the costs of similar compliance mechanisms are the same for EU and non-EU OEMs.

Cost competitiveness impacts are definitely expected if the legislation on average results in the same level of stringency of targets for EU and non-EU OEMs, but the costs of compliance for the same product (portfolio) are different for manufacturers from different regions. The same holds if costs of the same compliance mechanisms are similar for manufacturers from different regions but targets are different on average. When both targets and costs are different, it depends on the way in which these are different, whether the regulation may be expected to lead to net impacts on the cost competitiveness of EU and non-EU OEMs. Cost competitiveness impacts may also occur if manufacturers from different regions choose different compliance mechanisms with different costs to meet targets of similar stringency. However, if such choices are not forced by the legislation, the resulting cost competitiveness impacts are not to be attributed to the legislation.

As can be concluded from Figure 15, assessing cost competitiveness impacts on OEMs requires identifying whether and how EU legislation could lead to:

- different levels of stringency of the targets imposed on EU and non-EU OEMs;
- differences in the costs for EU and non-EU OEMs of complying with similar targets, which in turn may be the result of:
  o EU and non-EU OEMs choosing different compliance mechanisms with different cost implications to meet similar targets;
  o costs of similar compliance mechanisms being different for EU vs. non-EU OEMs.

The latter two are strongly related to the capabilities and resources of different companies. Analysing whether and how differences in capabilities and resources can be attributed to companies or manufacturing activities being European or non-European, and determining whether such differences lead to differences in the cost of compliance is the main challenge of this chapter.

But even if targets and compliance costs are on average similar for affected OEMs from different regions, and direct cost competitiveness impacts are therefore unlikely, there may still be non-negligible second order impacts. If the increased costs of manufacturing vehicles for the EU market would lead to lower margins and thus reduced profits for sales on the EU market, EU manufacturers may still have different abilities than non-EU manufacturers to deal with such impacts, e.g. as they may be less well placed to recover reduced profits on the EU market by profits in other markets in the same way as non-EU manufacturers can.
Besides differences in resources and capabilities to manufacture and market vehicles with CO₂-reducing technologies, a possible determinant for cost competitiveness impacts could be the ability of OEMs to recover reduced profits on the EU market through profits in other markets. This may not so much relate to OEMs being European or not but maybe more to OEMs being premium manufacturers or not. OEMs selling premium models in the EU market first of all have higher profit margins in that market and customers with a higher willingness-to-pay (lower price-elasticity). But it is also the EU manufacturers of premium brands that are selling a lot of cars in foreign markets.

A general analysis and detailed break-down of pathways along which the LDV CO₂ legislation and the capabilities and resources of OEMs can lead to cost competitiveness impacts of the legislation is graphically presented in the mindmap of Figure 16.

The following things are clear from Figure 16:
- Specific targets for manufacturers are affected by various aspects of the regulation;
- For meeting a given target a large number of compliance mechanisms are available;
- The costs for implementing these compliance mechanisms are determined by a large number of factors.

As a result of this there are a myriad of possible impact pathways that might have negative as well as positive impacts on the cost competitiveness of EU manufacturers. Although this might make it appear less likely that the post 2020 EU LDV CO₂ regulation as a whole would lead to net impacts on cost competitiveness of EU manufacturers, this cannot be concluded at this stage. Choices with respect to specific elements of the legislation could enhance the possibility of specific cost competitiveness impacts to occur. For that reason, before going into an analysis along the lines sketched above, first some considerations are worked out regarding the general consequences of different aspects of the legislation for OEMs.
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

Figure 16 – Overview of pathways along which the LDV CO₂ legislation and the capabilities and resources of companies can lead to cost competitiveness impacts on automotive manufacturers

Automotive manufacturers (OEMs)

Resources & capabilities

Legislation & compliance strategies
In case of non-average target, is determined by super-utility based on emissions-related premiums and innovations. Excess applied technologies credits may be affected by a linear target function related to the distribution of utility portfolio in the target year.

Compliance strategy depends on net TA CO2 emissions. For PHEVs, the net effect of emission of PHEVs technologies affects the value of vehicles other than BEVs.

Automotive manufacturers change sales weighted average of targets to increase average utility. Without affecting CO2 shares of AFVs in segment Y, they absorb losses by changes in market share because of loyal capabilities. Financially, OEMs can absorb losses by changes in market share because the customer base for segment Z is already applied to ICEVs and FCEVs.

The impacts on various resources and capabilities are determined through factor price competitiveness of company, sales volumes affecting a price and Δ price competitiveness within segment Z for OEM compared to other OEMs, sales volumes affecting a price and Δ price competitiveness within segment Y for other OEMs, and sales volumes affecting a price and Δ price competitiveness within segment X for other OEMs.

Comparative analysis shows that the cost of controlling the activity of the company, sales volume in segment Z, and sales volume in segment X have a significant impact on the company's competitiveness. The results of the analysis show that the marginal cost of additional technologies is higher, and cannot be added anymore. The cost pass-through factor reduces the cost competitiveness of ICEVs in segment Z.

The long-term cost competitiveness of ICEVs in segment X is affected by changes in sales volume in segment X. Total EU sales may change due to changes in market share and sales price and value of vehicles, which affect other resources and capabilities.

Long-term competitiveness of OEMs is affected by changes in sales volume in segment X, sales volume in segment Y, and sales volume in segment Z. The impact of non-average target is determined by super-utility based on emissions-related premiums and innovations.
5.4 General consequences of different aspects of the legislation

Target level and metric
Target levels for 2025 and 2030 have not yet been proposed by the European Commission. The European Parliament has proposed a bandwidth of 68-78 g/km for the 2025 target for passenger cars. Based on the cost curves for 2020, developed in [TNO 2011], the lowest average that can be achieved with applying CO\(_2\)-reducing technologies to ICEVs is around 70 g/km. From analyses in [TNO 2013b], however, it has become clear that already for targets above 75 g/km it becomes beneficial, both from a manufacturer perspective (striving for lowest average additional vehicle manufacturing costs) and from a user perspective (striving for lowest total cost of ownership), to meet the target with a mix of efficient ICEVs and alternatively fuelled vehicles (AFVs) such as BEVs, PHEVs and FCEVs. In the study, for a TTW CO\(_2\) target of 75 g/km the optimal shares of AFVs are found to be around 20-30\% (see Figure 17), increasing to around 40\% for a target of 65 g/km\(^{18}\). The reason for that is that the cost curves for efficiency improvement in ICEVs are strongly non-linear. Provided that the costs of AFVs go down as expected, at some point the marginal costs of further CO\(_2\) reduction in ICEVs become higher than the marginal costs of replacing ICEVs by AFVs.

The leverage between CO\(_2\)-reduction in ICEVs and introducing AFVs on the costs for meeting the target depend on the metric that is chosen for the legislation. Under a TTW CO\(_2\)-based target AFVs driving on electricity or hydrogen count as zero-emission, creating a strong leverage. Under WTW CO\(_2\)-based targets or TTW or WTW energy based targets the leverage is less pronounced, as AFVs do not count as zero under those metrics.

Figure 17 – Impact on costs from a manufacturer, end-user and societal perspective of introducing increasing shares of AFVs to meet a TTW CO\(_2\) target of 75 g/km in 2030 [TNO 2013b]. Additional costs are relative to reaching 130 g/km in 2015.

\(^{18}\) This result obviously depends on the cost curves for CO\(_2\) reduction in ICEVs and the costs for AFVs in 2025-2030 as assumed in the study. However, these are being updated in a new study for the European Commission.
Cost competitiveness impacts could result from differences in the abilities of different OEMs to market AFVs at competitive costs. In view of the focus on EU vs. rest of the world, this is a question of whether EU OEMs would by 2025-2030 be in a better or worse position to manufacture and sell AFVs that are affordable and attractive to their customers.

Overall an essential question is whether cost curves for efficiency improvement in ICEVs and costs of manufacturing AFVs are different for EU and non-EU manufacturers. This question is difficult to answer quantitatively, but in chapters 5 and 6 possible origins for cost differences will be explored with the help of qualitative and quantitative sectorial information (as summarized in chapter 3 and Annex 2).

The way in which the target level affects individual OEMs not only depends on the level and the metric but also on the shape and slope of the target function. Therefore no general conclusions can be drawn on this. The target level as such could influence competitiveness of EU manufacturers vs. non-EU OEMs if:
- the average costs for further CO$_2$ reduction in ICEVs are different from those of their competitors, or
- the average costs for manufacturing AFVs are different from those of their competitors.

Possible origins for regional differences in the costs of compliance mechanisms are explored in section 5.5.

The target level could also affect cost competitiveness between EU and non-EU manufacturers if OEMs are obliged to sell types of powertrains or other CO$_2$ reducing technologies in the EU which they cannot or need not sell in other regions. The latter case depends on the level of the CO$_2$ target or other obligations in the EU compared to targets in other regions. With respect to the overall target level the following reasoning applies:

- If the target in the EU is significantly more stringent than in other regions, EU manufacturers could benefit from that. The share of EU sales in their total sales is higher than for non-European OEMs as is their absolute sales in the EU. This means that EU manufacturers would have to apply certain CO$_2$ reducing measures to a larger volume of cars than non-EU manufacturers leading to economies of scale that their non-EU competitors cannot achieve. This would improve the cost competitiveness of EU manufacturers on the European market. Whether the cost competitiveness of European manufacturers on foreign markets is negatively affected in this case, depends on the extent to which they can differentiate their products for the EU and non-EU markets.
- If the EU target is significantly less stringent than in other large markets, the cost competitiveness of EU manufacturers on those markets would be negatively affected as they have a relatively low market share on foreign markets and would not be able to achieve the same economies of scale as the dominant non-EU OEMs that are active on those markets.

Figure 8 indicates that there are differences between the passenger car targets in different regions. Roughly speaking one could conclude that up to 2020 targets in the EU and Japan appear to be quite similar while targets in e.g. the US, Canada, Korea, China, India and Latin-American countries appear to be in the same bandwidth at a level some 20 g/km above the targets in the EU and Japan. In comparing targets, however, differences in fleets should be taken into account as already indicated in section 4.2.

Although it is not possible to predict how targets develop beyond 2020 in all these regions, it appears that cost competitiveness of EU versus Japanese manufacturers on the EU and Japanese market would be less...
affected by post 2020 target setting than cost competitiveness of EU OEMs versus those in the other aforementioned regions. If targets in those regions remain higher than in the EU one may expect EU manufacturers to benefit from that on the EU market in terms of lower compliance costs per vehicle sold. Whether their cost competitiveness on those other markets would be negatively affected probably also depends on whether EU OEMs sell “average” vehicles (“volume” models) on those markets or rather “high end” vehicles (“premium” models) (see also section 5.6).

The above reasoning can be considered to apply if OEMs from different regions are faced with on average similar targets on the same market. Whether that is the case, depends on how these targets are defined. If in a region the target is somehow differentiated as a function of a utility parameter, the effective stringency of the legislation in that region for different OEMs is determined by their sales distribution. If groups of OEMs from different regions have different sales distributions, their average targets will be different and cost competitiveness impacts could occur even if the targets in the home markets of the different regional OEM groups are similar. If the target is not differentiated or if groups of OEMs from different regions have similar sales distributions, the targets for those groups would be similar. In that case the cost competitiveness impact of different regulations in different regions is mainly determined by the differences in target levels.

Utility parameter and shape / slope of the target function

Possible cost competitiveness impacts resulting from different levels of stringency of the targets imposed on EU and non-EU OEMs or EU vs. non-EU manufacturing are determined by the shape and slope of the utility-based target function which is used to establish specific targets for individual OEMs and by the utility parameter used as a basis for differentiating the targets.

As competition takes place in the market, OEMs can be considered to compete within specific market segments, with the products offered in those segments, rather than at company level with their complete sales. This means that target functions that do not set targets of similar stringency for smaller and larger cars can affect competition in specific segments in the ways as indicated in Figure 18. The graph leads to the following general conclusions:

- If two OEMs are competing in the same market segment, but one has a narrower model portfolio than the other, then both a "flat" and a "steep" slope (compared to a neutral slope e.g. requiring similar reductions across the whole spectrum of utility values) is likely to affect the mutual cost competitiveness of both companies;
- Which of the OEM benefits in that case from the choice of the slope of the utility based limit function depends on whether the slope is “steep” or “flat” (with a “neutral" slope requiring similar relative reductions for smaller and larger cars);
- If two manufacturers are competing in the same market segment, and have similar model portfolios, then no impacts on cost competitiveness are to be expected from the slope of the target function.

There is no exact way to determine whether the stringency of the legislation is similar or different for two OEMs (or groups of related undertakings). In previous assessments two approaches have been used. In one approach targets are considered of similar stringency if they require the same relative reduction for both groups compared to the reference situation. If mass remains the utility parameter, this could be considered
generally the case if the post 2020 target line is such that the required relative reduction compared to the 2020 target is the same for all mass values (100% slope in the terminology of [TNO 2011]). In a second approach, which was an important tool in determining the burden sharing for the 2020 target, targets are considered of similar stringency if they lead to the same relative price increase (assuming the same costs curves for all OEMs). Given the non-linear nature of the cost curves that does not give the same result as an approach based on percentage level of reduction. Targets are fundamentally of the same stringency if the sales of two OEM groups are more or less equally distributed over the range of CO2 values. Post 2020 LDV CO2 legislation may thus lead to different effective targets, and thus to cost competitiveness impacts, if the sales of EU OEMs and those of non-EU OEMs are not equally distributed over the range of CO2 values.

The above reasoning, however, may be too simplistic. In the initial passenger car legislation for 2015 the slope was chosen flatter than the one based on same relative reduction over the entire CO2 range relative to the sales-weighted fit to the CO2 vs. mass data for the reference year19. As a consequence OEMs selling vehicles with an average mass above the overall EU sales average will have had to apply higher relative reductions to meet the 2015 and 2020 targets (have “climbed higher on the cost curve”) leading to higher marginal costs for further emission reductions. Alternatively equivalence of targets could thus be related to the effort to be made for meeting the target (e.g. expressed as relative price increase based on additional manufacturer costs times a mark-up factor divided by the average sales price, as was used for assessing distributional impacts in several previous studies). For vans the issue described here is not relevant as the target lines for the 2017 and 2020 targets were defined in such a way that compared to the reference situation similar reduction percentages are required for all mass values.

The impact of the shape and slope of the target function may be affected by the change in test procedure from NEDC to WLTP. Various technologies have different CO2-reduction potentials on the two test procedures, partly depending on the vehicle configuration, leading to cost curves being different for reductions on the two test procedures. The slope of a target function leading to equal relative price increases for different OEMs for a target based on the NEDC may thus be different from that for a target based on the WLTP. How this will work out, cannot be determined at this stage, as the process of developing a correlation function for CO2 emissions on the two tests and translation of targets is still on-going.

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19 This was done for two reasons: A flatter slope than the so-called 100% slope was needed to avoid opportunities for gaming with mass (bringing a vehicle closer to the target line by making it heavier) (see [IEEP 2007] and [AEA 2008]). Also it was considered that smaller vehicles already contribute towards the overall EU objective to reduce CO2 emissions of the European vehicle fleet, and that there might be some additional reduction potential in larger vehicles as these on average tend to have a higher power-to-mass ratio than smaller vehicles.
Figure 18 – Ways in which the slope of the target function may affect cost competitiveness between OEMs

- **Slope of linear utility-based target line**
  - **Steep slope**
  - **Flat slope**

**Sales distribution**

**OEM A**
- Mainly large vehicles
- Broad spectrum

**OEM B**
- Mainly small vehicles
- Broad spectrum

**NO, no impact on competitiveness of OEM A relative to OEM B**

**YES, beneficial for OEM A**

**OEM A** has a tight target for its large vehicles and may therefore need to reduce more in small cars or cross subsidize costs, and therefore has no room for internal optimisation, but due to lenient target also does not need that.

**OEM B** has a tight target for smaller vehicles and may therefore need to reduce more in large cars or cross subsidize costs. Targets for OEM A and B are similar and insensitive to slope of target function.

**Favourable for OEM A**

**Favourable for OEM B**

*Note: The diagram illustrates various scenarios for the slope of the target function and their implications on cost competitiveness between OEM A and OEM B.*
**Choice of utility parameter**

If the utility parameter is changed to footprint the situation is more complicated. Average mass and footprint values of OEMs are not totally correlated, so that the required reduction per OEM not only depends on its average footprint and the slope of the footprint based utility function but also on how his position relative to the average is different for footprint compared to mass.

Annex 5 contains graphs with sales distributions in which sales in the EU are grouped for manufacturers from Europe, Japan, Korea and other regions (using different definitions of what are European and non-European manufacturers). One can see that sales distributions based on mass and footprint are different. For mass the differences in average utility between EU and non-EU OEMs are larger than for footprint. Furthermore for footprint sales distributions of EU and non-EU OEMs are more symmetric. From this it can be concluded that for footprint as utility parameter the choices with respect to the shape and slope of the target function are less likely to lead to impacts on cost competitiveness of EU vs. non-EU manufacturers than for mass.

**Other modalities**

**Possibilities for a joint legislative target for passenger cars and (one or more categories of) LCVs**

Overall the stringency of the current LCV legislation is significantly less than for cars. This means that especially in the category of smaller vans, which are either car-derived or share a large number of their components with car models, the potential for CO\(_2\)-reduction is larger than what is used to meet the LCV target. A joint regulation for cars and small vans is likely to effectively lower the target for small vans, while it allows the target function for larger vans to be defined in a way that is more suitable for that category of vehicles (see example in Figure 19).

Possible ways in which this may lead to cost competitiveness impacts:

- If sales shares N1/M1 are different for EU OEMs and non-EU OEMs, overall or in the LCV categories that are joint with the passenger car legislation, the targets for EU and non-EU OEMs may be affected differently.
- Increasing the scope of the passenger car legislation to also include small vans increases the room for internal averaging and optimisation of reduction potentials and costs for OEMs selling both passenger cars and vans. OEMs that do not sell (significant quantities of) vans on the EU market would not benefit from this. Given that van sales are typically 10% of passenger car sales the size of this effect is expected to be small.

Possible impacts will depend on details of how the targets are joined. Different options lead to different changes in the stringency of the legislation for small / car derived vans and larger vans. OEMs are affected differently depending on their sales in different categories. Other options for joining the passenger cars and vans legislation, as already discussed in section 4.2, include:

- The targets and associated modalities for cars and vans could still be designed separately but merged into one text (i.e. in the same Regulation);
- Bringing part of the LCV market together with passenger cars under a single target. The categories of LCVs to be joined with passenger cars may be based on the current class I, II and III definitions for N1 vehicles, may include N2 vehicles and may be based on definitions still to be devised.
- The two vehicle categories could be combined under a single target. The first option has no cost competitiveness impacts as it is only a formal way of joining two pieces of legislation into a single regulation. The other two options could have impacts on cost competitiveness depending on the exact definition of the combined legislation as well as on the different positioning of EU and non-EU manufacturers in the cars and vans markets.

**Possibilities for including mileage weighting**

Including lifetime mileage weighting in the target setting is first of all a means to increase the cost effectiveness of the regulation as it promotes OEMs to apply more CO$_2$-reduction technologies in vehicles with higher absolute lifetime savings as a consequence of their larger lifetime mileage. [Ricardo-AEA 2014] estimates that mileage weighting reduces the costs for compliance by around 1.5% for vehicle manufacturers (analysed using both mass and footprint as utility parameter)).

In comparing a sales weighted target (as used in the current legislation) with a sales and lifetime mileage weighted target requires definition of equivalent targets. The approach used in [Ricardo-AEA 2014] is the following:

Given a target function $T(U)$, with $U$ the utility parameter, for the sales weighted target and an assumed division of the market into $m$ segments (for simplicity sake), a sales-weighted manufacturer specific target $T_{OEM}$ is defined as:
In this equation \( n_i \) is the sales of the OEM in segment \( i \), \( U_i \) the average utility of vehicles in segment \( i \). The manufacturer has the freedom to optimise the applied levels of \( \text{CO}_2 \) reduction over the various segments leading to realised \( \text{CO}_2 \) emissions \( e_i \) per segment for which the sales average meets the target:

\[
T_{OEM} = \frac{\sum_{i=1}^{m} n_i \cdot T(U_i)}{\sum_{i=1}^{m} n_i}
\]

For translating this to an equivalent mileage-weighted target the overall lifetime emissions \( E_{OEM} \) are calculated which are realised with the sales that are optimised under the sales-weighted target. It is then demanded that the OEM realises the same absolute emission level but with the freedom to divide the reduction efforts over the different segment in a way that is optimised with respect to the lifetime mileage of the vehicles. This leads to alternative \( \text{CO}_2 \) emission levels \( e'_i \) per segment.

\[
E_{OEM} = \frac{\sum_{i=1}^{m} n_i \cdot e_i \cdot d_i(U_i)}{\sum_{i=1}^{m} n_i} = \sum_{i=1}^{m} n_i \cdot e'_i \cdot d_i(U_i)
\]

In the above equation \( d_i(U_i) \) is the average lifetime mileage of vehicles in segment \( i \) (which will in any case be a function of \( U_i \), but may also depend on the type of fuel (e.g. petrol vs. diesel) or powertrain used (e.g. ICEV vs BEV)). If mileage weighting is to be introduced it will most likely be based on uniform default mileage values (as function of the value of the utility parameter and possible other vehicle attributes) which are by definition the same for all manufacturers.

It is clear from the above that in the extreme case of an OEM that only sells vehicles in a single segment, this OEM would not have room to optimise under a mileage-weighted target and would apply the same reductions in both cases. OEMs with a wide product portfolio would thus benefit the most from the cost reductions associated with mileage weighting. This could affect competition between OEMs with different sales portfolios. Whether it affects cost-competitiveness from an EU vs. non-EU perspective depends on the extent to which EU and non-EU manufacturers have markedly different sales portfolios in the EU market:

- Based on analyses in sections 3.1 and 5.6 and the information in Annex 5 it appears that sales distributions of EU and non-EU volume manufacturers as function of mass or footprint are quite similar.
- EU OEMs, however, tend to have a higher share of diesels in their portfolio which, according to [Ricardo-AEA 2014] on average have a higher lifetime mileage. This would mean that EU OEMs would benefit more from a mileage-weighted target than non-EU OEMs.
- A further distinction between EU and non-EU OEMs is the stronger presence of EU-OEMs in the premium market, with some OEMs strongly focussing on that market. For premium OEMs with a relatively narrow sales portfolio, mileage weighting could lead to moderate negative impacts on cost competitiveness relative to EU and non-EU OEMs with a wider portfolio. This could reduce the possible positive cost competitiveness impacts identified for premium manufacturers in section 5.6.
A detailed assessment of possible impacts of a sales- and mileage-weighted target would depend on the details of its implementation. Also in a mileage-weighted target a target function would need to be defined. Its slope would be different from that of a sales-weighted target if in defining the slope account is taken of the differences in lifetime mileage between vehicles with different utility. As larger vehicles tend to have higher lifetime mileages, this could lead to a flatter slope which would affect competition between OEMs with different average utilities.

**Possibilities for including embedded emissions**

If embedded emissions are to be introduced it will in first instance most likely be based on uniform default embedded emission values for different technologies, possibly as function of the value of the utility parameter [TNO2013a]. This will affect the extent to which different technologies contribute to meeting a manufacturer-specific target and thus their cost-effectiveness from a manufacturer point of view. In fact, as the embedded emissions of AFVs are generally higher than of ICEVs, this modality tends to level the effectiveness of different technologies, similar to the effect of changing the metric from TTW CO$_2$ to WTW CO$_2$. In the terminology of [TNO 2013a] it reduces the leverage between introducing a finite share of AFVs and the remaining reductions required in ICEVs for meeting the target. Compared to the current TTW CO$_2$ metric, therefore, including embedded emissions will reduce the strong incentive that low targets provide for marketing AFVs with zero or very-low TTW CO$_2$ emissions. This means that potential cost competitiveness related to possibly different capabilities of EU and non-EU manufacturers for manufacturing and marketing AFVs will be greatly reduced. Given that non-EU OEMs have a stronger position in vehicles with electric powertrains, it can be concluded that including embedded emissions is likely to reduce possible negative cost competitiveness impacts compared to a TTW CO$_2$-based legislation that does not include embedded emissions. Overall, however, this modality is not expected to lead to significant direct impacts on cost competitiveness.

**Phase-in period**

In a phase-in period manufacturers are required to meet the target with a share of their sales that increases over time as the target year approaches. This to some extent reduces the flexibility that manufacturers have with respect to timing of the introduction of new technologies. As introducing advanced technologies is often aligned with model updates or new model introductions, a phase-in may increase the pressure for OEMs of which the timing of model cycles is less compatible with the timing of the legislation. However, there are no reasons to assume a difference in this compatibility for EU and non-EU OEMs. Furthermore a phase-in period works out the same for all OEMs as it does not affect manufacturer specific reduction efforts. Overall it is therefore concluded that this modality does not cause cost competitiveness impacts.

**Derogations for small volume and niche manufacturers**

OEMs selling small numbers of vehicles in the EU are not necessarily small volume manufacturers worldwide. This case is more likely to apply to non-EU manufacturers, and as a result these on average could be likely to benefit more from this modality than EU manufacturers. The extent to which this is the case obviously also depends on the way in which the targets for small volume and niche manufacturers are defined. Regulation (EC) No 443/2009 contains a derogation for manufacturers which sell between 10,000 and 300,000 new passenger cars per year in the EU, allowing them to use a target which is a 25 % reduction
on their average specific emissions of CO₂ in 2007. Depending on the 2007 average, however, this target is not necessarily higher than the one set by the target function that applies to large volume manufacturers.

Furthermore the following two considerations lead to concluding that possible cost competitiveness impacts from derogations will not be significant:

- The volumes sold by manufacturers that would be eligible for derogation are too small to have a significant effect on the cost competitiveness of the EU car industry as a whole;
- Secondly, it is clear that as soon as competitive advantages for manufacturers that are eligible for derogation would translate into significantly increased market shares, these manufacturers would no longer be eligible for derogation.

**Super credits**

Companies with a stronger than average technology and market position in AFVs are more likely to benefit from super credits. If the technology and market position in AFVs of EU manufacturers is on average different from that of non-EU manufacturers, this modality could affect cost competitiveness.

**Eco-innovations**

Eco-innovations reward the application of technologies that reduce CO₂ emissions on the road but not (significantly) on the type approval test. The rewards depend on the benefits of these technologies under European driving conditions and are thus the same for all OEMs regardless of their region of origin or location of manufacturing. Cost competitiveness impacts could only arise from differences in costs for applying technologies that qualify as eco-innovations. Reasons for why these costs could be different for EU and non-EU manufacturers are the same as for technologies that can be implemented to reduce CO₂ emissions on the type approval test. From that perspective the mechanisms through which including eco-innovations (or similar provisions for promoting the application of technologies that reduce off-cycle CO₂ emissions) could lead to cost competitiveness impacts are expected to be the same as for a legislation which only targets CO₂ emission reductions on the type approval test. In practice specific cost competitiveness impacts may arise if the relative capabilities for marketing off-cycle CO₂-reducing technologies of EU OEMs compared to non-EU OEMs would be different from the relative capabilities for marketing on-cycle CO₂-reducing technologies.

On the other hand, however, including eco-innovation increases the amount of compliance mechanisms available to OEMs. This could provide an opportunity for some OEMs to reduce possible negative cost competitiveness impacts resulting from having weaker capabilities than their competitors in manufacturing CO₂-reducing technologies that are rewarded by the type-approval test procedure.

For eco-innovations that are developed by component suppliers it can be stated that they are in principle available to all OEMs. As a result the likelihood of differences in OEMs’ abilities to manufacture and sell vehicles with such eco-innovations is small.
Penalties (excess emissions premiums)

Penalties are the same for all manufacturers. But the attractiveness of using penalties as a “safety valve” for avoiding high compliance costs, or likelihood that penalties will be used in this way, depends on the marginal costs for meeting the target. These marginal costs are different for different manufacturers. In that sense penalties can be considered to reduce cost competitiveness impacts of the legislation as they set an upper limit to the marginal costs of compliance that is equal for all manufacturers. It is acknowledged, however, that there may be image-costs associated with following a strategy aimed at paying the penalty rather than meeting the target. These may be different for different OEMs, depending on their target customers.

Possibilities for pooling, banking and/or trading

Pooling

Allowing manufacturers to pool their targets provides an opportunity for OEMs that have difficulties in meeting their specific target at acceptable marginal costs to use part of the “emission allowance” of another OEM that is able to achieve larger reductions than required by its specific target at lower marginal costs. A pooling provision does not specify how the OEM that directly benefits from pooling should compensate the costs involved for the other OEM which has to apply additional reduction efforts.

It is reasonable to assume that an OEM that is able to achieve larger reductions than required by its specific target will only be willing to pool targets with another OEM if that leads to net benefits for the profitability of the company in the short or long term. While pooling thus reduces negative cost competitiveness impacts for OEMs that have difficulties in complying with CO₂ legislation, it may be expected to generate positive cost competitiveness impacts for OEMs that are able to comply more easily than their competitors. For both partners in a pool the pooling thus has positive impacts, so their relative cost competitiveness can be considered largely unaffected. Their joint cost competitiveness, however, may improve relative to OEMs that do not engage in pooling. The extent to which this leads to net positive or negative cost competitiveness impacts for EU OEMs vs. non-EU OEMs depends on the distribution per region of OEMs for which the target is less or more challenging, on the extent to which these OEMs choose to make use of the possibility of pooling, as well as the extent to which pools are formed between OEMs from the same region. If OEMs from one region pool while OEMs from another do not the relative cost competitiveness of the industry in the two regions is affected.

Manufacturers can pool their target with other manufacturers from the same region or from a different region. Existing close collaborations between OEMs from the different regions (e.g. Renault and Nissan on conventional and electric vehicles and collaboration between BMW and Toyota on diesel engines, the joint development of a fuel cell system, joint development of architecture and components for a sports vehicle, and joint research and development of lightweight technologies) show that there are no barriers that would inhibit OEMs from different regions to work together. This is expected to apply also to pooling of targets, so that manufacturers from different regions can be considered to benefit equally from this modality.
Trading

Allowing manufacturers to trade emission credits serves a similar purpose as pooling, with the main differences being that the compensation for using another OEM’s “emission allowance” has to be financial and is organised in a dedicated “market-place”. Also credits can be bought from / sold to more than one OEM, and the system could be anonymous. The effects are expected to be largely similar.

A difference with pooling, depending on how the trading scheme is operated, is that an OEM that sells credit may have no control over who buys the credits. OEMs may thus unwantedly “help” their competitors. A phenomenon that is more likely to occur under a trading scheme than under pooling is that new entrants that specialize in AFVs, and which thus have average CO₂ emissions well below their targets, can obtain additional revenue from selling credits. The current situation in Europe is that such new entrants are more likely to come from outside the EU than from inside (e.g. electric vehicle manufacturer Tesla and BYD, which in China also sells ICEVs but currently only sells battery-electric vehicles in the EU). As a consequence the modality of trading may positively affect the cost competitiveness of new market entrants from outside the EU.

Based on the above, it is concluded that trading schemes may have similar cost competitiveness impacts as pooling, in the sense that they may alleviate some competitiveness impacts and increase other compared to regulatory schemes without trading. Especially in the competition between vested OEMs on the EU market and specialised new entrants trading may have negative cost competitiveness impacts for EU manufacturers.

Banking & borrowing

Banking and borrowing is a modality that can be used to improve flexibility of a CO₂ legislation based on a fixed target year, without sacrificing the overall reductions that are to be achieved. OEMs are allowed to compensate possible overshoots in some years (average above target) by undershoots in CO₂ emissions in other years. This may help to reduce the costs for meeting the target for OEMs that have model cycles that are incompatible with the target year or strongly varying sales volumes. It does not have consequences for OEMs for which the target is less challenging. As such it is concluded that banking and borrowing is not expected to have negative cost competitiveness impacts as such, but that it may alleviate possible cost competitiveness impacts compared to legislative schemes without this provision.

Summary of possible impacts associated with different modalities

Overall conclusions with respect to possible cost competitiveness impacts associated with different modalities discussed above based on the mindmap are summarized in Table 5. From the overview it is clear that the modalities themselves do not directly lead to cost competitiveness impacts. However, for various modalities it is possible that they may lead to, or at least contribute to cost competitiveness impacts depending how they are implemented in combination with specifics of the market (e.g. positions of EU and non-EU OEMs in terms of sales distribution). Note that "Maybe" could result in either positive or negative cost competitiveness changes.
### Table 5 - Summary of possible OEM cost competitiveness impacts associated with different modalities

<table>
<thead>
<tr>
<th>Modality</th>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target level</td>
<td>Maybe</td>
<td>• Cost competitiveness impacts may occur if cost curves for efficiency improvement in ICEVs and costs of manufacturing AFVs are different for EU and non-EU manufacturers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o The size of these impacts would then be affected by the target level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Differences between EU and non-EU OEMs in costs of technologies are likely as EU OEMs have a focus on efficient diesel technology while non-EU OEMs (currently) have more experience in electric propulsion technologies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Differences in cost curves may result from:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o regional differences in resources and capabilities of OEMs;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Possible origins for regional differences in the costs of compliance mechanisms are explored in section 5.5.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o differences in economies of scale.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Differences in economies of scale for EU and non-EU OEMs may result from:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o differences in sales volumes of advanced technologies in the EU and in other regions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o differences in the stringency of CO₂ legislation in the EU and in other regions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If EU legislation is more stringent than in other regions this would improve the cost competitiveness of EU manufacturers on the European market.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Whether the cost competitiveness of European manufacturers on foreign markets is negatively affected in this case, depends on the extent to which they can differentiate their products for the EU and non-EU markets.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If the EU target is significantly less stringent than in other large markets, the cost competitiveness of EU manufacturers on those markets would be negatively affected as they have a relatively low market share on foreign markets and would not be able to achieve the same economies of scale for advanced ICEVs and AFVs as the dominant non-EU OEMs that are active on those markets.</td>
</tr>
<tr>
<td>Change of metric from TTW CO₂</td>
<td>No</td>
<td>• Other metrics than TTW CO₂ have a lower leverage between CO₂-reduction in ICEVs and the share of AFVs. This would reduce possible cost competitiveness impacts associated with regional differences in the abilities of OEMs to market AFVs at competitive prices.</td>
</tr>
</tbody>
</table>
### Modality: Utility parameter and shape / slope of the target function

<table>
<thead>
<tr>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>• Target function defines effective stringency of target per manufacturer. Possible cost competitiveness impacts depend on the:</td>
</tr>
<tr>
<td></td>
<td>o shape and slope of the target function</td>
</tr>
<tr>
<td></td>
<td>o sales distributions of EU vs. non-EU manufacturers, specifically their average utility compared to the overall EU average</td>
</tr>
<tr>
<td></td>
<td>• A “neutral” slope (requiring e.g. similar % retail price increase for all values of the utility parameter) will not lead to cost competitiveness impacts.</td>
</tr>
<tr>
<td></td>
<td>• A “steep” or “flat” slope may lead to cost competitiveness impacts.</td>
</tr>
<tr>
<td></td>
<td>o As EU OEMs have a larger share in premium segments (larger and heavier cars), a flat slope is likely to cause negative cost competitiveness impacts for the EU car industry.</td>
</tr>
<tr>
<td></td>
<td>o However, as buyers of premium cars have a higher willingness-to-pay for new technologies a steep slope may be more harmful for volume OEMs than a flat slope is for premium OEMs.</td>
</tr>
<tr>
<td></td>
<td>• Sales distributions based on mass and footprint are different:</td>
</tr>
<tr>
<td></td>
<td>o For mass the differences in average utility between EU and non-EU OEMs are larger than for footprint.</td>
</tr>
<tr>
<td></td>
<td>o For footprint sales distributions of EU and non-EU OEMs are more symmetric.</td>
</tr>
<tr>
<td></td>
<td>• So for footprint as utility parameter choices with respect to the shape and slope of the target function are less likely to lead to impacts on cost competitiveness of EU vs. non-EU manufacturers.</td>
</tr>
<tr>
<td></td>
<td>• The change from NEDC to WLTP is likely to affect the stringency of targets for different OEMs, but impacts can at this stage not be assessed.</td>
</tr>
</tbody>
</table>

### Modality: Joint legislative target for passenger cars and (one or more categories of) LCVs

<table>
<thead>
<tr>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>• Cost competitiveness impacts depend on the exact definition of the combined legislation as well as on the different positioning of EU and non-EU manufacturers in the cars and vans markets.</td>
</tr>
<tr>
<td></td>
<td>o The share of EU OEMs of the EU LCV market is on average higher than for non-EU OEMs, so EU OEMs would be more affected by this modality.</td>
</tr>
</tbody>
</table>

### Modality: Including mileage weighting

<table>
<thead>
<tr>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>• Mileage weighting improves cost effectiveness of the regulation. The extent to which EU and non-EU OEMs benefit differently from that depends on differences in their sales portfolios:</td>
</tr>
<tr>
<td></td>
<td>o Based on sales divisions over mass or footprint no significant cost competitiveness impacts are expected for volume manufacturers;</td>
</tr>
<tr>
<td></td>
<td>o EU OEMs could benefit more due to their higher diesel share. Diesels tend to have higher lifetime mileages;</td>
</tr>
<tr>
<td></td>
<td>o EU premium manufacturers could be negatively affected if their sales portfolio is narrower than that of their non-EU competitors. This would counteract possible positive cost-competitiveness impacts identified for EU premium manufacturers related to other impact pathways.</td>
</tr>
</tbody>
</table>
## Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation

<table>
<thead>
<tr>
<th>Modality</th>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Including embedded emissions</td>
<td>Unlikely</td>
<td>• May reduce possible negative cost competitiveness impacts compared to legislation that does not include embedded emissions</td>
</tr>
<tr>
<td>Phase-in period</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Derogations for small volume and niche manufacturers</td>
<td>No</td>
<td>• OEMs that sell small numbers of vehicles in the EU but are large volume manufacturers worldwide could in principle benefit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• But volumes sold by manufacturers that would be eligible for derogation are too small to have a significant effect on the cost competitiveness of the EU car industry as a whole.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• And as soon as competitive advantages for specific manufacturers would translate into significantly increased market shares, these manufacturers would no longer be eligible for derogation.</td>
</tr>
<tr>
<td>Super-credits</td>
<td>Maybe</td>
<td>• If the technology and market position in AFVs of EU manufacturers is on average different from that of non-EU manufacturers, this modality could affect cost competitiveness.</td>
</tr>
<tr>
<td>Eco-innovations</td>
<td>Unlikely</td>
<td>• Cost competitiveness impacts may arise if the relative capabilities for marketing off-cycle CO\textsubscript{2}-reducing technologies of EU OEMs compared to non-EU OEMs would be different from the relative capabilities for marketing on-cycle CO\textsubscript{2}-reducing technologies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o But eco-innovations developed by suppliers are available to all OEMs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Including eco-innovation increases the amount of compliance mechanisms available to OEMs. This could provide an opportunity for some OEMs to reduce possible negative cost competitiveness impacts.</td>
</tr>
<tr>
<td>Penalties (excess emissions premiums)</td>
<td>No</td>
<td>• Penalties can be considered to limit any cost competitiveness impacts of the legislation as they set an upper limit to the marginal costs of compliance that is equal for all manufacturers.</td>
</tr>
<tr>
<td>Pooling</td>
<td>Maybe</td>
<td>• Reduces cost so lowers any cost competitiveness impacts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Could only lead to a net impact if OEMs from one region form pools while OEMs from another don’t.</td>
</tr>
<tr>
<td>Trading</td>
<td>Maybe</td>
<td>• Likelihood of cost competitiveness impacts higher than for pooling.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• OEMs buying credits may “help” their competitors. However, they will only buy if it also “helps” them.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New entrants specializing in low emission vehicles may benefit.</td>
</tr>
<tr>
<td>Banking &amp; borrowing</td>
<td>No</td>
<td>• Reduces cost so only outcome is to reduce any possible competitiveness impacts.</td>
</tr>
</tbody>
</table>
5.5 Possible regional origins for differences in costs of compliance mechanism

If manufacturers from the EU and other regions have to meet targets of similar stringency (or achieve similarly challenging CO₂ emission reductions), their ability to comply with the post-2020 LDV CO₂ regulation, and the resulting costs of compliance, might be different due to reasons that have to do with them being European or non-European. Concerning the latter, differences may result from two different perspectives:

- regional differences in the conditions for doing business, e.g. different costs, regulations or availability of suppliers for various technologies, under the assumption that the cost of doing business for EU manufacturers are more strongly determined by the situation in the EU than that of non-EU manufacturers (e.g. because a larger share of their manufacturing is located outside the EU);
- differences in the characteristics of EU and non-EU manufacturers that simply “happen to be the case” for other reasons than regional differences in the conditions for doing business. E.g. the financial position, patent and knowledge position or customer loyalty may on average be different for EU and non-EU manufacturers.

Such elements may lead to differences in the abilities of OEMs to develop the improved ICEVs and AFVs needed to meet their specific targets, to manufacture them at a competitive cost level and to sell them to customers in Europe.

Using the model explained in Figure 6 in section 2.2, identifying possible regional origins for differences in costs of compliance mechanism for EU and non-EU manufacturers, can be done by analysing resources and capabilities that play a role in a manufacturer’s ability to comply with targets set by the CO₂ regulations and to see whether there are regional differences in these resources and capabilities. An attempt to identify such relevant resources and capabilities is made in Figure 20.

In the main capabilities, which are influenced by a range of underlying capabilities and resources, a distinction is made in:

- the ability to manufacture at lower marginal costs within a segment compared to other competitor(s), and
- the ability to manufacture at lower average marginal costs compared to competitor(s).

This distinction is relevant as competition in the marketplace is firstly within segments. Overall market shares and profits, reflecting cost competitiveness at company level, are the summed result of competition in various segments. As indicated in Figure 16, the impact of CO₂ legislation on a company’s cost competitiveness in a segment may be affected by the extent to which a company is able to strategically divide CO₂ reduction efforts over different segments or to cross-subsidize between segments.

Resources for which regional differences may influence capabilities of EU and non-EU manufacturers to comply with post-2020 CO₂ regulation in a cost-competitive manner include:

- the financial position of companies, which influences their ability to develop more efficient ICEVs and AFVs as well as their ability to temporarily absorb losses if competition does not allow full pass-through of the costs of compliance;
In return the financial position is affected by the profitability of a company’s operations, which may be affected by the CO₂ legislation

- **the knowledge position of companies**, which influences their ability to develop more efficient ICEVs and AFVs vehicles;
  - The **patent position** is part of the knowledge position and not only influences the ability to develop advanced ICEVs and AFVs but also to generate revenues by selling patents or licenses;

- **the facilities of companies**, more specifically;
  - their efficiency of production;
  - their geographical location, which influences cost of labour and possible other cost factors of production, and also determines transport costs;

- access to suppliers able to deliver components for the technologies more efficient ICEVs and AFVs, and the cost at which these suppliers are able to sell the required components;

- **the portfolio** of companies, which may determine:
  - why the same CO₂ reduction in vehicles with similar utility value may be more expensive for one or the other OEM;
  - the extent to which OEMs can optimize the application of CO₂ reducing technologies over the entire sales portfolio and as well as to differentiate cost pass-through factors per segments (effectively allowing cross-subsidizing between segments).

- **the customer base**, which is characterised by aspects such as;
  - the brand loyalty of customers, also associated with the brand image;
  - willingness to pay, or price elasticity;
  - the division of sales over Europe and markets outside the EU.

Below the influence of these resources, and of possible regional differences therein, on relevant capabilities of companies are discussed in more detail.

### Ability to develop improved ICEVs and AFVs

An OEMs ability to develop more efficient ICEVs and AFVs is influenced by a range of factors:

- knowledge and technology position of the OEM and its suppliers and the resulting efforts required to improve the knowledge and technology position:
  - technologies already developed or even marketed;
  - available patents

- R&D capacity
  - capability for and costs of carrying out the required R&D
  - capability for and costs of acquiring licences

- financial position, which determines the ability to invest in the required R&D and product development.

- supplier base, which determines an OEM’s access to advanced components

Below for each of these factors an assessment is made of the extent to which regional differences can give rise to differences in the compliance costs for EU and non-EU manufacturers to an extent that the relative price ratio of their products is affected. For all aspects it should be noted that any conclusions based on the
current situation of the sector may not necessarily remain valid in the 2020-2030 timeframe as a result of unpredictable changes in e.g. the economy or manufacturer strategies.

Knowledge / technology position of the OEM and its suppliers and the resulting efforts required to improve knowledge / technology position

An OEM's R&D and other efforts for meeting LDV CO\textsubscript{2} targets can be divided in general R&D to develop the technologies required for meeting the targets as well as the general skills for manufacturing and or applying these technologies to the OEM's products and specific R&D efforts for applying technologies to specific car models.

If the required reductions for meeting LDV CO\textsubscript{2} targets are more or less the same for competing OEMs, differences in required R&D efforts between EU and non-EU manufacturers could in principle result from:
- differences in the technologies required to meet the target resulting from differences in technologies already used to meet earlier legislative targets;
- differences in the current technology position of OEMs (technologies already developed, patents);
- differences in the access to suppliers that can deliver the required technologies;
  - see under “supplier base”

In Annex 2 (section A2.5) evidence is provided that Japanese OEMs and suppliers have a stronger patent position and specialization than European OEMs in the field of technologies related to alternative propulsion such as electric and hybrid vehicles. From a technology position perspective therefore European targets that require or provide a strong incentive for implementing AFVs could provide cost competitiveness benefits for non-EU manufacturers.

R&D capacity

An OEM's capacity to carry out R&D and to innovate is e.g. influenced by regional factors such as:
- the ability to invest in R&D (see next subsection)
- available R&D facilities
- availability, focus and quality of the regional knowledge infrastructure (universities, R&D companies);
- availability of trained personnel with the required knowledge and skills.

In all major automotive manufacturing countries in the EU there appears to be a strong knowledge infrastructure. As indicated in Annex 2 European OEMs on average have a higher R&D intensity than OEMs from other regions. It is difficult to say whether that means that they have a good starting point for doing additional R&D to meet LDV CO\textsubscript{2} targets or that R&D budgets are already stretched. In any case it means that they can more easily shift R&D efforts without affecting the overall cost structure of the company.

Stakeholders have indicated, however, that the availability of trained R&D staff with the required knowledge and skills may become a limiting factor, as certain trends initiated or amplified by the CO\textsubscript{2} legislation lead to a shift in the required types of personnel, specifically a shift from mechanical engineers to electrical engineers and IT specialists.
**Financial position, determining the ability to invest in the required R&D and product development**

A company’s financial position influences its ability to invest in R&D and product development. From this perspective the EU LDV CO\textsubscript{2} legislation could be considered to have an impact on the cost competitiveness of European OEMs if:

1. the legislation would affect the profitability of EU OEMs more than non-EU OEMs, or
2. the financial position of EU OEMs is different from that of non-EU OEMs to begin with.

1) This could occur if the legislation leads to a significant change in the costs of buying or owning a vehicle, which would influence overall sales in the EU. For EU manufacturers, sales on the EU market generally are a higher share of their global sales, so that changes in the volume of the EU market will more strongly affect their profitability than that of non-EU manufacturers. This is illustrated in the right-hand side of the mindmap displayed in Figure 16. Whether the post-2020 LDV CO\textsubscript{2} legislation will have a negative or positive effect on EU car sales depends on the target level and on the marginal costs for achieving that target. The development of fuel prices also plays a role. As a target has not been proposed yet and the costs of technologies post-2020 is still being assessed, at this point in time no conclusions can be drawn on the likeliness or magnitude of the impact on sales volumes.

2) This could be the case if EU manufacturers have been more severely affected by the economic crisis than their non-EU competitors. Interviewed stakeholders claim that this is the case, due to the fact that the EU economy, and as a consequence the car market in the EU, have stagnated more strongly than in other regions. This is confirmed by the sectorial information presented in section A2.1.3. Where other regions have seen growing sales again since mid-2009, this is not the case for Europe. LDV sales in EU have decreased by around 25% between 2007 and 2013. Production capacity has not been adjusted by the same amount leading to overcapacity and reduced profitability. This has affected EU OEMs more than non-EU OEMs as EU OEMs sell a larger share of their production in EU (see Table 28 in section A2.1.4 of Annex 2).

For the financial capabilities of companies to invest in R&D also the cost of acquiring capital are relevant. In section A2.4 of Annex 2 it is stated that in the beginning of 2014 the cost of capital for European car manufacturing companies was reported to be on average slightly lower than for non-European competitors. The question is whether such a difference would still exist in the 2020-2025 timeframe.

**Supplier base**

If the required reductions for meeting LDV CO\textsubscript{2} targets would be more or less the same for competing OEMs, differences in required RD&D efforts between EU and non-EU manufacturers could in principle result from differences in the access to suppliers that can deliver the required technologies.

Although there are strong regional relationships between OEMs and suppliers, industry stakeholders have indicated that the automotive supply market is a global market, so that in principle all OEMs have equal access to components that are developed and manufactured by automotive suppliers in different regions.
**Ability to manufacture at competitive costs within a given segment**

An OEM’s ability to manufacture more efficient ICEVs and AFVs in a cost-competitive manner is influenced by a range of factors:

- aspects of the knowledge / technology position of the OEM and its suppliers
  - technologies already developed or even marketed (providing experience and economies of scale)
  - costs of (acquiring) licences
- manufacturing costs for CO₂ reducing technologies for ICEVs and AFVs
  - costs of materials
  - costs for purchasing (sub)components
  - cost efficiency of production facilities determined by e.g.:
    - direct overhead and labour costs
    - equipment and tooling costs
    - other costs such as operation and maintenance of buildings
  - impact of economies of scale

Below for each of these factors an assessment is made of the extent to which regional differences can give rise to differences in the compliance costs for EU and non-EU manufacturers to an extent that the relative price ratio of their products is affected.

**Technologies already developed or even marketed**

In this context the question is whether EU and non-EU manufacturers have a different position in the marketing of technologies that are relevant for meeting longer term legislative targets. Overall EU manufacturers have a stronger position in diesel technology. On technologies such as engine down-sizing, direct injection petrol engines, aerodynamics or lightweight materials differences are less apparent or EU manufacturers may even be in a stronger position. For a long time Japanese manufacturers were dominant in the supply of hybrid-electric vehicles, but more recently that appears to be changing with more and more European manufacturers marketing (plug-in) hybrid variants of their models. Regarding full electric vehicles non-European manufacturers currently have larger production volumes, but also here several EU OEMs appear to be catching up quickly, so that in the context of post-2020 targets differences may be expected to be smaller than today.

**Costs of (acquiring) licences**

If OEMs wish to apply technologies for CO₂ reduction which are patented by other companies, there may be costs involved for acquiring the licence to produce these technologies or for buying the patents. The other way around, OEMs that own patents for technologies that other companies wish to apply may generate revenue from licencing or from selling these patents. Therefore, if future CO₂ legislation would require the widespread application of technologies for which OEMs from Europe have more / less patents than non-EU OEMs, this would have positive / negative impacts on the cost competitiveness of EU manufacturers. This pathway strengthens the impacts of differences in technology positions.
There is evidence that the cost of patenting is significantly higher in Europe than in other regions\textsuperscript{20}, due to the need to have patents translated and validated by a large number of national patent offices. This could hamper EU companies in generating revenues from licensing.

**Manufacturing costs for CO\textsubscript{2} reducing technologies for ICEVs and AFVs**

For components for CO\textsubscript{2} reduction in ICEVs and for AFVs that are manufactured by OEMs themselves, differences in the manufacturing costs for EU and non-EU OEMs depend on the efficiency of their production facilities and on a range of factors that relate to the geographic location of their facilities. The latter include regional differences in e.g. production labour costs and taxes as well as transport costs for bringing vehicles produced outside the EU to European countries. Labour productivity (linked to the level of automation) and economies of scale also come into play, as these influence the cost efficiency of production facilities. All these factors are further explored in the paragraphs below.

The extent to which regional differences in cost factors for production can affect the overall costs of manufacturing vehicles depends on the share of own (component) manufacturing (as opposed to assembling purchased components), the share of vehicles manufactured outside the EU in the EU sales, and the share of regionally different costs in the total costs of manufacturing. Concerning the make-or-buy issue with respect to components it should be noted that currently many suppliers have production facilities close to the car manufacturing plants to which they supply the components. For a large share of purchased components labour cost levels will thus be similar to those in the manufacturing of the cars in which they are applied.

**Geographical distribution of facilities: Impact of regional differences in cost of labour and other cost factors**

Differences between OEMs or regions with respect to labour costs or to other cost components of car manufacturing may lead to a difference in the absolute cost of compliance for competing companies. However, if the price increase for one manufacturer is higher than that of his competitor by the same factor as the ratio of the prices of the two companies’ baseline products, the ratio of the prices of the two products stays the same and cost competitiveness may be considered not significantly affected. The fact that labour costs and other costs factors differ between regions therefore does not automatically lead to significant cost competitiveness impacts of the EU CO\textsubscript{2} legislation. The price ratio of competing products, however, can be significantly affected if the ratio of the different cost components for the additional technology, added to meet the CO\textsubscript{2} targets, differs from that in the base product.

So if manufacturing of the technologies, required to meet EU targets, would require a higher share of labour costs or of any other cost component than the manufacturing of the baseline vehicle, regional differences in labour and other manufacturing cost factors could lead to cost competitiveness impacts. For many of the technologies needed to make ICEVs more efficient this is not expected as they concern improvements of existing components / technologies. More advanced technologies, such as electric, hybrid or fuel cell propulsion systems or application of advanced lightweight materials, however, may require relatively more

labour in the manufacturing or disproportionately higher or lower tooling costs, and may thus alter the ratio of various cost components of manufacturing.

In addition to the above regional differences in labour costs could be caused by regional differences in the availability of labourers with specific skills required for developing and manufacturing advanced ICEVs and AFVs or their components. This is specifically the case if there is scarcity of such skilled labourers. In general this can be considered a temporary effect, but it could affect costs over timescales that are relevant to the CO$_2$ regulation.

**Equipment and tooling costs and other costs such as operation and maintenance of buildings**

Geographical differences in labour costs indirectly also work out on the equipment and tooling costs and other costs such as operation and maintenance of buildings. Furthermore equipment and tooling costs are affected by the cost of capital.

**Economies of scale**

The impact of economies of scale on the costs of manufacturing vehicles with CO$_2$ reducing technologies or AFVs depends on the total number of vehicles to which these technologies are applied. These in turn depend on:

- sales volumes in the EU market;
- sales volumes of vehicles with the same technologies in markets in other regions.

For different OEMs sales volumes of specific CO$_2$-reducing technologies on the EU market depend on:

- the manufacturer specific target, which determines the need to apply various advanced technologies;
- the compliance strategies of the OEMs, i.e. the choice of applied technologies and other compliance mechanisms chosen by OEMs to meet their specific targets.

This latter aspect is a matter of choice for OEMs and can thus be considered not to lead to cost competitiveness impacts. The first aspect relates to possible cost competitiveness aspects associated with the shape and slope of the target function, and has been explored in detail in section 5.4.

Sales volumes of advanced technologies in other regions depend on:

- sales volumes of OEMs in other regions;
- whether markets in these regions are subject to CO$_2$ regulations of similar or different stringency as the EU LDV CO$_2$ legislation. An overview of passenger car regulations in different regions is provided in Figure 8 in section 4.2.

In relation to the issue of the EU having similar or different CO$_2$ legislation compared to other regions, attention should be paid to the question of whether and to what extent EU manufacturers will differentiate their products for the EU market and other markets. If they do, vehicles for other markets do not require additional technology and therefore will not be directly affected in their costs. Reduced economies of scale due to this product differentiation, however, might have a second order impact on costs of these vehicles. Specifically CO$_2$ reduction measures related to weight and aerodynamics require redesign of vehicles and production processes. This issue has not been further analysed, but monitoring the amount of product
differentiation in different markets in the coming years could be an effective instrument to assess the relative stringency of regulatory and other demands on fuel consumption in different markets.

In as far as costs of CO\(_2\) reducing technologies and AFVs depend on the costs of components purchased from suppliers (see paragraph below), these costs depend on economies of scales applying to these suppliers. These not only depend on sales volumes of the OEM under consideration but also of sales volumes of other OEMs to which the supplier supplies the components for fuel efficient ICEVs and AFVs.

**Costs of materials / costs for purchasing (sub)components**

Post-2020 CO\(_2\) legislation is likely to affect the demand by OEMs and suppliers for certain materials and (sub)components. Differences in compliance costs for EU and non-EU OEMs could result from regional differences in the costs of materials and (sub)components. Such regional differences do exist as the cost factors affecting the costs of (producing) materials or (sub)components (e.g. the cost of energy and the cost of labour) are different in different regions.

The market for materials and components, however, can be considered a global market, meaning that all OEMs in principle have access to products of most or all suppliers worldwide. If that is the case only different costs associated with transporting materials or components from the supplier to manufacturers in different regions would effectively lead to regionally different costs for materials or components.

If CO\(_2\) legislation leads to a change in the demand for materials and (sub)components, OEMs may be expected to adapt their supplier base in order to be able to purchase these materials and (sub)components at competitive costs.

**Width of product portfolio in the EU market – possibilities for internal averaging**

As the targets set by the EU LDV CO\(_2\) legislation do not apply to individual vehicle models, but to the sales-weighted average at the level of a manufacturer group, OEMs have a certain degree of freedom to divide reduction efforts (i.e. the amount of CO\(_2\)-reducing technologies applied to vehicles) over their models or segments. As a result they can e.g. choose to apply less CO\(_2\) reducing technologies in market segments with stronger price competition and more in segments where the costs of these technologies can more easily be absorbed. OEMs with a wider product portfolio in the EU market (i.e. wider distribution of sales over different size or market segments) have more room for that than OEMs that only sell a limited number of models in one or a few segments of the EU market.

The comparison of sales distributions based on different definitions of what are European and non-European manufacturers, as presented in Annex 5, suggests that overall manufacturers from different region have similarly wide portfolios, but that EU manufacturers have a higher share of their sales in the segments of larger (and most likely premium) car models. Combined with the fact that advanced technologies may be easier to sell in those segments, the larger portfolio width of EU manufacturers may be considered to lead to a positive cost competitiveness impact as it allows EU manufacturers to limit the cost increase of vehicles in the small and medium size segments. It should be acknowledged, however, that in these segments OEMs are competing to some degree on g/km (e.g. through CO\(_2\)-differentiated taxes) and fuel economy, so that
there is limit to the extent to which they can avoid application of CO$_2$-reducing measures in small and medium size segments.

**Ability to manufacture at competitive average costs**
The overall ability of a manufacturer to manufacture vehicles meeting the CO$_2$ target set by the European legislation is determined by factors such as:

- the ability to apply the same technologies in a large number of models in the product portfolio;
- the ability to scale up production of low CO$_2$ ICEVs and AFVs already in the product portfolio;
- the width of the product portfolio in the EU market offering possibilities for cost optimisation through division of reduction efforts over different segments;
- the ability to manufacture at competitive costs in the different segments included in the product portfolio.

**Ability to apply the same technologies in a large number of models in the product portfolio**

OEMs that have small sales volumes in a large number of segments may be expected to have higher average compliance costs (and higher average production costs to begin with) than OEMs that have high sales in a small number of segments, due to the fact that the latter achieve economies of scale by the fact that the same technologies can be applied in a large number of models in the product portfolio.

In this respect the increasing “platform” approach can be seen as a trend that enhances the ability to apply similar technologies in a large number of models. EU OEMs appear to be somewhat more advanced in this. Another strategy, specifically applied in LCVs but also to some degree in cars, is “brand engineering”, where different OEMs cooperate in developing a vehicle model. Such a model is then sold under different brand names with sometimes minor differences in technology and small cosmetic differences to make them fit the design language of the different brands.

**Ability to scale up production of low CO$_2$ ICEVs and AFVs already in the product portfolio**

This ability relates to differences in compliance strategies between OEMs in view of the existing as well as future legislation. Some OEMs focus on applying modest CO$_2$ reductions to a large number of their sales (e.g. engine down-sizing), while other OEMs market a limited amount of very low CO$_2$-emitting vehicles (e.g. the hybrids that have been in the portfolio of Toyota for more than 15 years now). While the latter strategy may in the short term be expected to lead to higher average additional costs per vehicle, it does allow OEMs to gradually achieve economies of scale and increase their production capability. This not only leads to lower costs for technologies needed to meet longer term targets, but may also allow them to increase volumes of these technologies more rapidly than their competitors.

It is expected that powertrain electrification, more specifically increasing levels of hybridisation, will become more important for meeting post-2020 CO$_2$ targets. As such Japanese OEMs may be considered to have a competitive advantage, although, as said before, EU OEMs appear to be catching up lately specifically with plug-in hybrid variants of their models.
**Width of product portfolio in the EU market – possibilities for cost optimisation**

The width of the product portfolio not only allows OEMs to adjust the amount of CO\textsubscript{2} reducing technologies in the various models in different segments to the ability of these segment to absorb the associated additional manufacturing costs. As the cost curves for CO\textsubscript{2} reduction in different segments are different, a wide product portfolio also allows OEMs to divide CO\textsubscript{2} reduction efforts over models / segments in such a way that average additional manufacturer costs over the whole portfolio are minimized (see e.g. [IEEP 2007]).

Differences in the width of the product portfolio of EU and non-EU OEMs could therefore affect average compliance costs and thus lead to cost competitiveness impacts. The comparison of sales distributions based on different definitions of what are EU and non-EU manufacturers, as presented in Annex 5, suggests that overall the sales distributions of manufacturers from different regions have similar width. Nevertheless there may be subgroups of manufacturers with narrower product portfolios. From that perspective, in Europe there appears to be a stronger division between manufacturers of mainstream, small and medium size vehicles (e.g. Fiat, PSA, Renault and to a lesser extent GM and Ford) and manufacturers with a higher share of larger and premium models (e.g. BMW and Mercedes), while large Asian manufacturers (Toyota, Hyundai) appear to have more overlapping portfolios. In that sense it could be the case that many EU OEMs have less room for cost optimal distribution of reduction efforts than the major non-EU OEMs. But this is only likely to be a significant problem for them if they are selling at the smaller end of the market. For those OEMs selling only at the upper end there is less of a problem to pass on costs.

EU manufacturers have a higher share of their sales in the segments of larger (and most likely premium) car models. This should be considered as allowing them to distribute reduction efforts in a way that may not be optimal from an average additional manufacturing cost perspective but that is optimal from a sales and profitability perspective.

**Ability to manufacture at competitive costs in the different segments included in the product portfolio**

Besides the overall mechanisms described above, the average compliance cost over the whole product portfolio is affected by compliance costs in the different market segments.

**Ability to sell at competitive prices**

The ability to sell efficient ICEVs or AFVs at a competitive price in the EU market depends on a range of factors that may differentially impact on EU and non-EU OEMs including:

- the additional manufacturing costs in different segments or models;
- the impact of R&D costs on vehicle costs or price;
- the costs of bringing products to the market including transport costs, tariffs, distribution costs and dealer margins;
- the ability to cross-subsidize within the product portfolio;
- the ability to absorb losses.
The additional manufacturing costs in different segments or models
Possible causes of regional differences in the costs of manufacturing low-CO₂ ICEVs and AFVs have been discussed above.

Impact of R&D costs on vehicle costs or price
The magnitude of the required R&D costs associated with developing products that meet the requirements of post-2020 EU LDV CO₂ legislation may be different for different OEMs. The regional aspects that may lead to regional differences in R&D costs are the same as those discussed in relation to the impact of R&D capacity on the ability to develop improved ICEVs and AFVs (see previous subsection).

The ways in which R&D costs can be passed through and their impact on vehicle prices may depend on (the stringency of) CO₂ legislation in other regions and the size of the sales of competing companies worldwide and in different regions.

- If European legislation is much tighter than that in other regions, OEMs need to make specific R&D efforts for the cars they sell in Europe. The R&D costs for meeting EU LDV CO₂ standards can be considered relatively independent of the amount of cars sold in Europe. OEMs can choose to pass on those costs to cars sold in Europe only or distribute them over their worldwide sales. In both cases differences in sales volumes in Europe or in other regions affect the way in which additional R&D costs may affect the prices of products of competing companies on the EU market.

- If other regions have legislation of similar stringency as the EU, and if OEMs decide to pass through R&D costs for meeting those standards only to the vehicles sold in markets where the standards apply, the R&D costs can be divided over a larger amount of vehicles. OEMs selling cars mainly in Europe may have a disadvantage over OEMs that also sell cars in other regions with similar legislation.

The costs of bringing products to the market including international transport costs, tariffs, local distribution costs and dealer margins
Transport costs and tariffs depend on the location of production. For vehicles manufactured within the EU transport costs for bringing them to the EU market are relatively low and tariffs do not apply. For non-EU manufacturers transport costs and costs associated with tariffs will generally be higher. Information on import tariffs for cars, vans and components in the EU and other regions are presented in Table 57 in Annex 4. Tariffs on car and van imports to the EU are 9.7% resp. 12.3%. With 3.8% the tariff on components is much lower, allowing EU OEMs to import components and providing an incentive for non-EU OEMs to locate manufacturing plants in the EU. The commercial cost to transport a car from Asia to Europe is highly dependent on many factors (such as volume, number of ports, size of cars, etc.) but a ball park figure for larger shipments\(^{21}\) on existing routes would be around US$ 900. Transport costs from Europe to Asia are about US$ 100 lower, i.e. around US$ 800. Overall the costs of bringing a car manufactured in Asia to the EU market is 1500 Euro or higher for small to medium size cars and significantly higher for premium models.

However, transport costs are not expected to be significantly influenced by the type of technologies applied to vehicles. Insurance costs may be somewhat higher if vehicles become more expensive due to the

\(^{21}\) Information obtained from industry contacts.
application of CO₂ reducing measures. In terms of the effect on the price ratio of cars manufactured inside and outside of the EU transport costs could be considered to have a small benefit in favour of cars manufactured outside the EU, as higher fixed cost mark-ups on top of the manufacturing costs dampen the relative impact of an absolute increase in manufacturing costs on the vehicle price. But given that transport costs are expected to increase somewhat with the value of the car, this effect is expected to be small.

Tariffs scale with the value of the imported products, so if cars become more expensive as a result of the EU LDV CO₂ legislation, the absolute amount of tariffs paid on imported cars will increase. Overall the effect of transport costs and tariffs is at most directly proportional to the increase in price, and therefore does not affect the price ratio of cars manufactured inside and outside of the EU if the technology costs are the same in both regions.

It can thus be concluded that international transport costs and tariffs do not constitute a pathway through which European CO₂ legislation can be expected to have a significant impact on cost competitiveness.

Distribution costs within EU countries and dealer margins for cars sold in Europe are determined by conditions of the EU car market and the EU economy in general. These can therefore be considered the same for EU and non-EU manufacturers and thus do not constitute a pathway through which European CO₂ legislation can be expected to have a significant impact on cost competitiveness.

**The ability to cross-subsidize within the product portfolio**
The additional costs of CO₂-reducing measures applied to ICEVs or of alternative propulsion technologies do not necessarily need to be passed on one-on-one to the price of vehicles on which these technologies are applied. OEMs can choose to divide compliance costs over their product portfolio in a way that suits the ability of different market segments to absorb these costs. The width of an OEM’s product portfolio determines the ability of an OEM to apply cross-subsidisation.

**The ability to absorb losses**
Finally OEMs can decide not to pass through all compliance costs to their customers. In that case these costs reduce the profitability of the company. The ability of companies to (temporarily) absorb losses depends on their financial position. This aspect is further discussed below.

**Ability to sell new products to customers / maintain customer base and to pass through costs of compliance**
Differences in the consumer base of companies may mean that some OEMs can more easily sell fuel efficient ICEVs or AFVs with alternative powertrains to their customers. Customer loyalty, perceived value of new technologies, cost awareness and spending power of the customer base are factors that affect the extent to which compliance costs can be passed on to consumers through increasing vehicle prices. Theoretically, therefore, differences in customer base between EU and non-EU manufacturers might lead to differences in their ability to pass on compliance costs to their customers. Inability to pass through costs has a negative impact on the profitability of a company and direct and indirect impacts on its cost competitiveness.
In as far as regional differences in the ability of OEMs to sell new products and pass through costs are associated with them being premium or mainstream manufacturers, such differences are analysed in section 5.6. The conclusion is that premium OEMs can more easily sell new technologies to their customers. As EU manufacturers are more strongly represented in the premium segment this would constitute a competitive advantage for the EU industry as a whole.

**Ability to invest or to absorb (temporary) losses**  
If an OEM complying with EU CO\(_2\) regulations requires significant investments in R&D, product development and production facilities, these upfront costs need to be absorbed by that OEM or the technology needs to be purchased from a supplier. The company’s financial reserves and borrowing capacity determine its ability to make the necessary investments.

If an OEM chooses to not pass on compliance costs to customers through price increases, these costs have to be absorbed by the OEM at the expense of profit. Absorbing losses may be necessary for a short period of time (e.g. until sufficient cost reductions have been achieved to make the compliance costs competitive) or during a longer period of time or because these factors contribute to brand value. Reduced profits affect a company’s financial health and therefore have a long term effect on cost competitiveness, e.g. through a reduced ability to invest in R&D and product development.

In stakeholder consultations it was indicated by various OEMs that the financial position of some EU OEMs may be temporarily worse than that of non-EU OEMs for a number of reasons. The European car market was more heavily affected by the economic crisis. EU OEMs sell a larger share of their vehicles on the EU market and are therefore less able to compensate losses on the EU market by profits in other markets.

**Ability to exploit test flexibilities**  
In Figure 20 the ability to exploit flexibilities in test procedures is indicated as a possible origin of cost competitiveness impacts. Exploiting flexibilities allows OEMs to sell vehicles with lower price than competing models from other OEMs. On paper these vehicles have low fuel consumption but their real-world fuel consumption is higher than that of competing models from other OEMs.

The availability of test flexibilities is obviously the same for EU and non-EU OEMs as both certify their vehicles for the EU market against the same test procedure. It is also unlikely that their abilities to exploit test flexibilities, which would e.g. relate to knowledge of these flexibilities and the capabilities of test facilities, would be markedly different. The willingness to exploit flexibilities, however, could be different. From stakeholder information it is understood that some Asian manufacturers initially had reservations about exploiting test flexibilities as the culture of their region requires them to act according to the “spirit of the law” rather than only according to the “letter of the law”. In the context of the existing CO\(_2\) legislation and national fiscal promotion schemes for low-CO\(_2\) vehicles this was said to create unfair competition between Asian and European manufacturers. However, in the context of post-2020 CO\(_2\) legislation such cultural differences are not expected to play a significant role anymore for various reasons:

- First of all the WLTP will eliminate some and reduce other flexibilities that exist in the NEDC;
• Secondly, more recently various investigations into the increasing difference between real-world and type approval CO\(_2\) emissions (as e.g. summarized in [ICCT 2014]) indicate that utilisation of test flexibilities is no longer mainly seen in the eco-models of companies but across the complete model portfolio of manufacturers and that it is also applied by OEMs from different regions.

Overall therefore test flexibilities are not considered to create a pathway for cost competitiveness impacts.

**Summary of possible cost competitiveness impacts associated with regional differences in resources and resulting capabilities**

Table 6 provides a summary of possible cost competitiveness impacts on automotive manufacturers associated with regional differences in resources and resulting capabilities as analysed above. From the overview it is clear that for many capabilities and resources regional differences are expected to lead to likely or possible impacts on the cost competitiveness of EU vs. non-EU car manufacturers. The size and sign of the expected effects are different for different capabilities and resources, meaning that is not possible to draw a conclusion on the overall net effect.

**Table 6 - Summary of possible cost competitiveness impacts on EU automotive manufacturers associated with regional differences in resources and resulting capabilities**

<table>
<thead>
<tr>
<th>Capability</th>
<th>Resource</th>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to develop improved ICEVs and AFVs</td>
<td>R&amp;D capacity</td>
<td>Yes</td>
<td>Stakeholders foresee a shortage in the EU of R&amp;D personnel with the skills needed for technologies that are necessary to meet post-2020 CO(_2) targets, specifically those related to electric powertrains.</td>
</tr>
<tr>
<td>Patent position</td>
<td>Yes</td>
<td>-</td>
<td>Non-EU OEMs have a stronger patent position in technologies for electric and hybrid vehicles.</td>
</tr>
<tr>
<td>Financial position</td>
<td>Yes</td>
<td>-</td>
<td>Profitability and financial position of some EU OEMs was more strongly affected by economic crisis than of non-EU OEMs</td>
</tr>
<tr>
<td>Supplier base</td>
<td>Maybe</td>
<td>?</td>
<td>EU suppliers have stronger focus on diesel technology. But OEMs can source components globally.</td>
</tr>
<tr>
<td>Ability to manufacture at competitive costs within segment</td>
<td>Technologies already developed</td>
<td>Yes</td>
<td>Japanese OEMs already have a higher share of AFV technologies. But EU OEMs are catching up.</td>
</tr>
<tr>
<td>Cost of licences</td>
<td>Yes</td>
<td>+/-</td>
<td>If future CO(_2) legislation would require the widespread application of technologies for which OEMs from Europe have more / less patents than non-EU OEMs, this would have positive / negative impacts on the cost competitiveness of EU manufacturers. This pathway strengthens the impacts of differences in technology positions.</td>
</tr>
<tr>
<td>Labour costs</td>
<td>Maybe</td>
<td>?</td>
<td>There are large regional differences in labour costs. But these only impact cost competitiveness if the share of labour costs in car manufacturing changes as a result of compliance strategies for meeting CO(_2) targets.</td>
</tr>
<tr>
<td>Capability</td>
<td>Resource</td>
<td>Impact</td>
<td>Comments / questions</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>--------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Equipment and tooling costs</td>
<td>Maybe?</td>
<td>• Possible impacts partly related to economies of scale (see below)</td>
</tr>
<tr>
<td></td>
<td>Economies of scale</td>
<td>Maybe?</td>
<td>• Depending on sales volumes on EU and non-EU markets, slope of the target function in EU legislation, and on stringency of CO₂ legislation in EU and other regions.</td>
</tr>
</tbody>
</table>
|                                                | Cost of materials and (sub)components         | Maybe (small) | • Regional differences in costs of materials that need to be sourced regionally.  
• Different transport costs for materials that can be sourced globally. |
|                                                | Ability to optimize division of reduction efforts over product portfolio | Yes (small) | • Some EU manufacturers may be able to keep additional costs for small vehicles lower through lower CO₂ reductions as these can be compensated in larger and premium models. |
| Ability to manufacture at competitive average costs | Ability to supply same technology in large number of models | Yes    | • Possible advantage for EU OEMs due to advanced platform approach                                                                                     |
| Ability to scale up production of existing advanced ICEVs and AFVs | Yes                                           | -      | • Japanese OEMs already have a higher share of hybrid technologies. But EU OEMs are catching up.                                                        |
| Ability to optimize division of reduction efforts over product portfolio | Maybe                                        | ?      | • Overall portfolio width is similar for OEMs for different regions.  
• But some EU OEMs have focus on either cheap volume models or premium models, with the latter posing less of a problem than the first. |
| Ability to sell at competitive prices          | Additional manufacturing costs               | Maybe? | • see above                                                                                                                                              |
| Impact of R&D costs on price                   | Maybe?                                       | ?      | • Depending on whether EU target is more stringent or not the impact on the cost competitiveness of EU OEMs may be positive or negative.       
• Relates to the amount of vehicles over which R&D costs associated with CO₂ legislation can be divided.  
• Positive impact expected if EU legislation is more stringent. |
| Costs of bringing products to the market       | No                                           |        | • Small effects possible, but net effect considered not significant.                                                                                   |
5.6 Impacts on premium vs. volume manufacturers

As indicated in the previous section certain abilities of a manufacturer, e.g. the ability to market CO₂-reducing technologies or the ability to absorb (temporary) losses could be correlated to whether or not a significant share of the manufacturer group’s or OEM’s sales consists of premium brands or premium models. This aspect was also an important input from interactions with stakeholders.

Competitiveness impacts on the EU car industry associated with the issue of premium vs. volume manufacturers may occur if EU and non-EU manufacturers have significantly different market shares in volume and premium segments. Data on this are provided in section 3.1 Conclusions that can be drawn from that information are that:

- all premium OEMs on the EU market are EU manufacturers (BMW + Daimler + Volvo +Jaguar Land Rover), based on their ACEA membership and location of production in the EU (Jaguar Land Rover and Volvo are owned by non-EU companies but vehicles are mainly manufactured in EU);
- 7 manufacturer groups (Ford, General Motors, Hyundai, Nissan, PSA, Renault and Toyota) out of the 12 considered have a very similar positioning with respect to price and weight and can be considered volume manufacturers;
- Volkswagen combines premium and volume brands.

From the above it is clear that European car manufacturers have a higher share in the sales of vehicles in premium segments on the EU market.

Figure 21 and Figure 22 explore possible mechanisms through which the post-2020 EU LDV CO₂ regulation may have different impacts on premium manufacturers and volume / mainstream manufacturers (i.e. OEMs without a significant share of) premium models in their sales portfolio and focussing on affordable vehicles.
produced in large volumes). It is clear from these graphs that besides characteristics of the different types of OEMs with respect to portfolio, customer base and financial capabilities also the target setting, both target level (relative to that in other regions) and the slope of a utility-based target function, plays a role in the way in which the legislation might lead to different cost competitiveness impacts for premium and volume manufacturers:

- A relatively stringent EU target, compared to other regions, is likely to create some competitive advantage for EU OEMs due to their higher market share in the EU and the resulting stronger economies of scale for the applied CO₂-reducing technologies. Premium brands may be better placed to deal with a stringent target. Premium brands tend to be more profitable and have a more loyal customer base with a high willingness to pay for advanced technologies. European premium brands are also quite successful and thus profitable in foreign markets.

- A flatter slope requires a relatively larger reduction effort for premium manufacturers as premium cars are on generally larger, more performant and more luxuriously equipped than volume and mainstream models. This larger reduction effort, and the resulting higher compliance costs may to some extent counteract the advantages that premium brands may have with respect to their ability to sell vehicles with advanced and more costly CO₂-reducing technologies.

Figure 21 shows that the cost competitiveness of EU premium brands relative to non-EU premium brands, EU volume brands as well as non-EU volume brands is determined by the net impact of several factors with opposite signs:

- In the case of competition with non-EU premium brands the EU premium brands have the advantage of stronger economies of scale for CO₂-reducing technologies due to their higher sales volumes on the EU market. This would be further amplified if the EU target is more stringent than targets in other regions. This effect, however, is counteracted by e.g. the generally higher labour costs in the EU compared to other regions. Overall the net effect may be positive, based on the observation that the higher labour costs are not hindering EU premium brands to be successful in the US and Asian markets;

- In the case of competition with EU volume manufacturers EU premium brands may be negatively affected by higher costs for CO₂-reducing technologies due to lower overall sales volumes. This, however, is counteracted by their stronger financial position and the ability to cross-subsidize the costs of CO₂ reduction in volume modules from the higher margins on premium models. Overall their appears to be a real possibility that EU premium manufacturers win market share from EU volume brands as a result of EU CO₂ legislation. This effect would be smaller if the slope of the target function is flat;

- A similar situation of counteracting effects applies to the competition between EU premium brands and non-EU volume brands. In that case, however, the higher labour costs for EU OEMs mean that if the net effect is positive or negative, it is correspondingly smaller or larger than for competition with EU volume manufacturers.
Assessment of competitiveness impacts of post-2020 LDV CO2 regulation

Figure 21 – Possible cost competitiveness impacts on premium manufacturers

EU premium manufacturers
higher average marginal costs than volume manufacturers

Customers Portfolio relatively stringent target compared to volume manufacturers average mass above EU average willingness to pay:
high acceptance of new technology:
high brand loyalty:
high ability to pass through costs to customers
ability to cross subsidize between premium and mainstream models high volume of premium models low volume of mainstream models higher power-to-weight ratio with non-EU premium manufacturers with EU volume manufacturers with non-EU volume manufacturers EU manufacturers have higher volumes on EU market EU manufacturers have more economy of scale for CO2-reducing measures EU manufacturers have higher labour costs premium manufacturers have lower volumes premium manufacturers have less economy of scale for CO2-reducing measures higher technology costs for CO2-reducing measures to mainstream vehicles compared to EU volume manufacturers what is net effect on competition with EU volume manufacturers? premium manufacturers have lower volumes EU manufacturers have higher labour costs premium manufacturers have less economy of scale for CO2-reducing measures what is net effect on competition with non-EU volume manufacturers? what is net effect on competition with non-EU premium manufacturers?

Possible positive effect on cost competitiveness of EU premium manufacturers compared to non-EU premium manufacturers

Possible positive effect: Premium manufacturers could win market share from volume manufacturers

Limit impact on profitability significant sales in other regions high profits in other regions Financial capabilities profitable on EU market despite economic crisis strong ability to absorb costs/losses

Judgement based on apparent success of EU premium manufacturers on foreign markets with lower labour costs what is net effect on competition with non-EU premium manufacturers? If net effect is positive/negative it is smaller/larger than for competition with EU volume manufacturers?

Competition Judgement based on stakeholder inputs. If current situation with relatively flat slope is continued Size of effect smaller/larger if slope of target function is flat/steep.
Figure 22 – Possible cost competitiveness impacts on European mainstream manufacturers

- Customers
  - Limited ability to absorb costs / losses
  - Low sales in other regions
  - Low profits in other regions

- Competition
  - EU volume manufacturers
  - Non-EU volume manufacturers
  - EU premium manufacturers
  - Non-EU premium manufacturers

- EU volume manufacturers
  - Lower average marginal costs than premium manufacturers
  - Higher economy of scale
  - Higher labour costs

- Non-EU volume manufacturers
  - Lower average marginal costs than EU manufacturers
  - Less economy of scale

- EU premium manufacturers
  - Higher marginal costs
  - Higher volumes in mainstream market
  - Limited ability to cross subsidize between premium and volume models

- Non-EU premium manufacturers
  - Lower volumes in mainstream market
  - Higher ability to cross subsidize premium and standard models

- Possible negative effect on EU mainstream manufacturers
  - Lower average marginal costs
  - Higher volumes on EU market
  - More economy of scale

- Possible negative effect on non-EU volume manufacturers
  - Lower average marginal costs
  - Higher volumes in non-EU market
  - Better position to absorb costs / losses

- Possible negative effect on premium manufacturers
  - Higher marginal costs
  - Higher volumes in premium market
  - Limited ability to cross subsidize premium and standard models

- Financial capabilities
  - Losses on EU market due to economic crisis
  - Limited ability to absorb costs / losses
  - Strong impact on profitability

- Customers
  - Low sales in other regions
  - Low profits in other regions
  - Limited ability to absorb costs / losses
  - Low ability to pass through costs to customers
  - Low willingness to pay for new technology
  - Low brand loyalty

- Portfolio
  - High volume of mainstream models
  - Lower power-to-weight ratio
  - With non-EU premium manufacturers
  - Higher volumes in non-EU market
  - More economy of scale
  - Lower average marginal costs
  - Higher average mass
  - Limited ability to cross subsidize premium and standard models
  - Lower sales in other regions
  - Low profits in other regions

- Effect may be positive / negative if EU target is more / less stringent than targets in other regions.
As indicated in Figure 22 such counteracting pathways also play a role in the competition between EU volume manufacturers and non-EU volume manufacturers and between EU and non-EU premium manufacturers:

- In the competition between EU and non-EU volume manufacturers the positive pathway related to stronger economies of scale for EU manufacturers in applying technologies to meet the EU target is counteracted by negative pathways associated with higher labour costs in the EU, the (current) worse financial state of various EU OEMs, and their limited ability to compensate losses on the EU market by profits in other markets. The size and sign of the net effect is probably strongly dependent on the relative stringency of the EU target compared to other regions.

- For the same reasons as explained above EU volume manufacturers could possibly lose market share to EU (and non-EU) premium brands as a result of EU CO2 legislation, with the sign of the effect depending on the slope of the target function.

Overall the analysis in Figure 21 indicates that EU premium manufacturers might benefit from post-2020 EU legislation, and could win market shares not only from competing non-EU premium manufacturers but also from competing premium models of mainstream manufacturers. The latter results from the fact that volume and mainstream manufacturers may not be able to reduce CO2 emissions in their premium models as easily as premium manufacturers may be able to.

What is also clear from this analysis is that the financial health of EU manufacturers plays a strong role in estimating the net cost competitiveness impact. From stakeholder inputs it appears that the financial position of some EU manufacturers, specifically those with volume brands, is currently more heavily affected than that of non-EU OEMs, due to the strong impacts of the economic crisis on the European car markets. The extent that this remains valid in the coming years is uncertain.

### 5.7 Impact of timing of the legislation on competitiveness

For an individual OEM the cost of compliance with future CO2 targets not only depends on average costs of technologies, but also on the speed with which the OEMs needs to develop and implement these new technologies. A short lead time between announcement of the legislation and the target year or incompatibility of the timing of the legislation (target year) with the model cycles of an OEM will lead to higher costs of compliance. The first aspect, however, is expected to work out the same for all OEMs and is not depending on whether they are EU or non-EU OEMs. The second aspect will be different for different OEMs, but as the timing of model cycles is different for different models and generally not aligned between manufacturers from the same region there is no reason to assume that there will be regional differences in the extent to which the timing of the legislation is compatible with model cycles.

Timing of the legislation may lead to cost competitiveness impacts in an indirect way. If a short lead time between announcement of the legislation and the target year leads to higher costs of compliance some OEMs may be better able to deal with these higher costs than others, depending on their financial position.
5.8 Options available to OEMs to counteract cost competitiveness impacts of EU LDV CO$_2$ regulation

It should be noted that identified possible pathways for cost competitiveness impacts do not necessarily need to lead to actual impacts as OEMs may have means to counteract these impacts.

If an OEM would be faced with disproportionately higher costs (compared to its competitors) for manufacturing vehicles that meet EU targets, the following options are available for reducing these costs:

- Improve the technology position by investing in specific R&D or acquiring patents;
- Engage in strategic alliances with other OEMs to cooperate on technical developments or on the development and manufacturing of new vehicle models;
- Reduce manufacturing costs by increasing efficiency of existing plants or by relocating manufacturing e.g. to regions with lower labour costs or from outside EU to inside EU to avoid transport costs and tariffs;
- Seek price reductions from suppliers or purchase components from suppliers with lower prices, e.g. as a result of manufacturing in lower wage countries inside or outside the EU;
- Make use of modalities that increase the flexibility of the legislation (e.g. pooling targets) to (temporarily) reduce the costs of compliance.

5.9 Conclusions on cost competitiveness impacts from the automotive manufacturer perspective

Assessing cost competitiveness impacts on OEMs requires identifying whether and how the European post-2020 LDV CO$_2$ legislation could lead to:

- different levels of stringency of the targets imposed on European and non-European OEMs;
- differences in the costs for European and non-European OEMs of complying with similar targets, which in turn may be the result of:
  - European and non-European OEMs choosing different compliance mechanisms with different cost implications to meet similar targets;
  - costs of similar compliance mechanisms being different for European vs. non-European OEMs.

In view of the second aspect the essential question is whether cost curves for efficiency improvement in ICEVs and costs of manufacturing AFVs are different for EU and non-EU manufacturers. This question is difficult to answer quantitatively, but in this chapter possible origins for cost differences have been explored with the help of qualitative and quantitative sectorial information.

From an analysis of ways in which the regulation may affect the price and quality of products the following things can be concluded:

- Specific targets for manufacturers are affected by various aspects of the regulation;
- For meeting a given target a large number of compliance mechanisms is available;
- The costs for implementing these compliance mechanisms are determined by a large number of factors.

As a result of this there are a myriad of possible impact pathways that might have negative as well as positive impacts on the cost competitiveness of EU manufacturers. This makes it appear less likely that the post 2020 EU LDV CO$_2$ regulation as a whole would lead to net impacts on cost competitiveness of EU
manufacturers. Nevertheless choices with respect to specific elements of the legislation could enhance the possibility of specific cost competitiveness impacts occurring. For that reason first an assessment was made of the general consequences of different aspects (modalities) of the legislation on the cost competitiveness of EU vs. non-EU OEMs.

The modalities as such do not directly lead to pronounced cost competitiveness impacts. However, for various modalities it is possible that they lead to, or at least contribute to small indirect cost competitiveness impacts depending how they are implemented in combination with specifics of the market (e.g. positions of EU and non-EU manufacturers in terms of sales distribution):

- The target level strongly determines the extent to which costs differences for similar technologies between EU and non-EU OEMs affect their cost competitiveness. Whether the EU target is more or less strict than that in other regions, together with the market shares of EU and non-EU OEMs on the EU and other markets, determines economies of scale for CO\textsubscript{2} reducing technologies (a more stringent target leads to a cost competitiveness improvement for EU OEMs);
- If sales distributions over different vehicle segments are different for EU and non-EU OEMs, the utility parameter and the shape and slope of the target function determine the relative (average) stringency of targets for these groups of OEMs. For footprint as utility parameter choices with respect to the shape and slope of the target function are less likely to lead to impacts on cost competitiveness. Overall, from an EU vs. non-EU perspective sales distributions and average utility values are not very different, so that impacts associated with a future sloped target function are expected to be relatively small;
- Other modalities, such as a joint legislative target for cars and vans, mileage weighting, super–credits, eco-innovations, pooling and trading may lead to different abilities for EU and non-EU OEMs to meet their targets and might thus affect cost competitiveness.

Resources of OEMs, defined by their financial position, knowledge position, facilities for R&D and manufacturing, supplier base and their product portfolio and customer base determine their capability to implement compliance mechanisms for meeting future CO\textsubscript{2} targets. An analysis of possible regional differences in these resources and capabilities, based on a qualitative analysis augmented with data collected in chapter 3, Annex 2 and input from stakeholder consultation, revealed the following possible impacts:

- The capability of European OEMs to develop advanced ICEVs and AFVs may at present be less than that of non-EU OEMs, especially if powertrain electrification becomes an important compliance mechanism. Origins for this are the fact that the financial position of EU OEMs has been more heavily affected by the economic crisis than that of non-EU OEMs, EU OEMs have focussed on diesel technology rather than hybrid or electric propulsion and a possible shortage of skilled R&D personnel;
- With respect to the ability to manufacture vehicles with CO\textsubscript{2}-reducing technologies at competitive costs, various cost factors might lead to cost competitiveness impacts but for most of them the likelihood, sign and size of these impacts are difficult to judge. Japanese OEMs appear in a better position to scale up production of electric and hybrid vehicles and to benefit from their lead in this technology, but EU OEMs are catching up fast. EU OEMs may have a possible advantage to achieve cost reductions for integration of different powertrains due their advanced platform approach;
The ability to sell at competitive prices is not only determined by the additional costs of manufacturing vehicles with CO$_2$-reducing technologies, but also by e.g. the amount of R&D costs to be earned back per vehicle, the ability to cross-subsidize within the product portfolio, and the ability to absorb losses. Concerning the latter the current financial position of EU OEMs, if continued over the next years, could cause negative cost competitiveness impacts;

The ability to sell vehicles with new technologies on the EU market seems better for (some) EU OEMs due to their stronger position in premium segments of the market. Concerning the latter, stakeholder inputs as well as a decomposition of pathways seems to suggest that whether an OEM is a premium or volume manufacturer may be a stronger determinant for its ability to deal with the impacts of CO$_2$ legislation than whether it is European or not.

Timing of the legislation, specifically the lead time between announcement of the target and the target year is expected to affect these impacts. A shorter lead time leads to higher costs for developing and marketing new technologies, which are more difficult to bear for OEMs with a less strong financial position.
6. Impacts on cost competitiveness: the automotive manufacturing perspective

6.1 Introduction
For the case of cost competitiveness impacts on EU car manufacturing the focus is on identifying possible impacts of the LDV CO₂ legislation on the cost of manufacturing or the cost of doing business. This analysis starts with an assessment of possible impacts of the legislation on the various cost components that determine the cost of doing business, such as the cost of labour and the cost of capital.

The main cost components that determine the costs of manufacturing cars are:
- material costs
- costs of purchased components
- labour costs
- capital costs (machines, tooling, etc.)
- costs of overheads:
  - management
  - marketing
  - logistics
  - R&D

The cost competitiveness of EU car manufacturing is determined by the total average costs of manufacturing per unit of production in the EU compared to those in other regions.

The total cost ratio between manufacturing in the EU and other regions may change as a result of the EU LDV CO₂ legislation:
- if one or more cost factors change as a result of the LDV CO₂ legislation and this change is different in the EU than in other regions;
- if application of new technologies or other activities needed to comply with LDV CO₂ legislation affect the shares of different cost factors in the total production costs, and if the ratio of these cost factors for EU vs. other regions are significantly different. This could e.g. be the case if new components require more labour and less mechanized production and labour costs in the EU differ strongly from those in other regions.

In determining impacts of the EU LDV CO₂ legislation on the various costs factors and subsequent cost competitiveness impact pathways a distinction can be made in different types of impacts on cost factors:
- Direct impacts:
  - Does the regulation directly affect a cost factor per unit used?
    - Examples of such direct impacts from other types of policy instruments are a change in cost of labour due to stricter labour conditions or higher taxes, or a change in price of steel due to higher production costs as a result of environmental regulation for industry or higher energy prices.
Assessment of competitiveness impacts of post-2020 LDV CO$_2$ regulation

- In general LDV CO$_2$ legislation is not expected to have such direct impacts as the legislation is targeted at the CO$_2$ performance of cars and not at factors that determine the costs of producing cars or their components.

- **Indirect impacts:**
  - 1$^{st}$ order:
    - Does the regulation affect the amount of units used? E.g. does it require more/less labour or steel to be used per car?
    - Does it require other types of a certain unit to be used leading to other costs? E.g. does it require electrical engineers instead of mechanical engineers or lightweight materials instead of steel? And are costs of these other types of units higher/lower?
    - In both of these cases the cost competitiveness of the EU automotive manufacturing industry may be affected if there is a strong difference between costs per unit for these production factors in Europe and in other regions.
  - 2$^{nd}$ order:
    - Does the regulation indirectly affect a cost factor per unit used? E.g. an increase in the price of certain types of labour, materials or components due to (temporary) scarcity as a result of supply not being able to meet the growing demand caused by new regulation.
    - In this case the cost competitiveness of the EU automotive manufacturing industry may be affected if such 2$^{nd}$ order effects occur to different extents in different regions.

6.2 Identification of possible pathways for cost competitiveness impacts on EU car manufacturing

A mindmap of impact pathways of post-2020 LDV CO$_2$ legislation on the cost competitiveness of EU car manufacturing is presented in Figure 23.

As can be seen from Figure 23 only a limited number of pathways seem to result in likely impacts on cost competitiveness of EU car manufacturing, and in those cases impacts generally seem positive, i.e. that the cost competitiveness of EU manufacturing might improve. Conclusions seem to be quite generic and the same for the car and van regulation. Also they do not seem to depend very much on the target level or the choice of modalities.

Below the different cost factors and associated possible pathways for cost competitiveness impacts are discussed using a list of questions. These refer to the pathways shown across the mind map from left to right and in order from top to bottom.

*Does post-2020 EU LDV CO$_2$ regulation lead to regionally different impacts related to the cost of materials?*

- Not directly. The regulation does not directly affect the cost of materials per unit of material as it applies to vehicles and not to factors that determine the costs of material production.
- Indirectly the costs of materials as a share in the total costs of manufacturing can be affected along two pathways:
• The legislation will change demand for existing materials. Also it may lead to demand for new materials (e.g. for electric propulsion components or light-weight bodies) which may be more expensive per vehicle than steel and other currently used materials.

• The impact depends on whether EU OEMs (need to) source these materials from within the EU or from a global market:
  o For materials that are sourced regionally there may be different costs in different regions due to differences in e.g. labour and energy costs for producing these materials or transport costs for raw materials. This may lead to a cost competitiveness impact for EU manufacturing but the sign and size of the effect cannot be determined at this stage as it requires detailed information on the exact materials that are affected, the costs of producing these materials in different regions and on whether or not EU manufacturers have the opportunity to select suppliers from outside the EU if production of these materials would be more expensive in the EU. Overall, however, the effect is expected to be small as for many materials there is a global market with a global price.
  o For materials that are sourced globally (i.e. for which there is a global market), OEMs have the freedom to purchase these materials from regions where costs are lowest. Also all OEMs in principle have equal access to the suppliers of these materials. As a result no cost difference is expected for car manufacturing in different regions except for possible differences in transport costs. This, however, is expected to be a small factor.

• Indirect effects may also come from price increases due to (temporary) scarcity of materials resulting from production capacity not being able to match the increased demand.
  o This impact pathway is considered to be unlikely as:
    • for many materials that are relevant to advanced ICEVs and AFVs the production is already being scaled up in the EU and other regions;
    • due to large number of compliance strategies dependence on limited number of materials is unlikely;
    • for now it foreseen that the date of announcement of the post-2020 legislation gives enough lead time to the target year.
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

Final Report
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Do different cost elements per unit production increase or decrease more in EU than in other regions to the extent that costs in EU and non-EU regions may lead to different cost factors for EU vs other regions? Does post-legislation differ? Cost and high-dependency on utility function moves to non-EU regions. If share of cost factors in new components manufactured in different regions... 

Δcosts through difference in economies of scale and learning effects in EU and other regions... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Could provide... 

Effects on... 

Would new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in... 

Do new technologies affect the share of cost factors in production that move from large-scale to small-scale between regions? 

Δcosts through difference in...
Does post-2020 EU LDV CO$_2$ regulation lead to regionally different impacts related to the cost of purchased components?

- Not directly. The regulation does not directly affect the cost of components as it applies to cars and not to factors that determine the costs of component manufacturing.
- Indirectly the costs of purchased components as a share in the total costs of manufacturing can be affected along two pathways:
  - The legislation will change demand for components as improved or new components will have to be applied to reduce vehicle CO$_2$ emissions. Differences in this change in costs for EU manufacturing compared to non-EU manufacturing may come from differences in economies of scale or dependence of components costs on location of production:
    - Differences in economies of scale
      - If the majority of components for vehicles manufactured in a region are also manufactured in that region, as is the case for a large share of automotive components, and if the EU has more stringent LDV CO$_2$ regulation than other regions, production volumes of improved / new components will be higher in the EU leading to lower costs as a result of economies of scale. This results in a possible (positive) impact.
      - If new components are less expensive in the EU than in other regions, this would also make it more likely that non-EU manufacturers would purchase components manufactured in the EU (for use in cars for the EU and other markets). This would improve the cost competitiveness of the EU supply industry.
    - If other regions have LDV CO$_2$ regulation of similar stringency, economies of scale for required components will be similar in different regions. In that case this pathway will not result in cost competitiveness impacts.
  - If the average utility value for the sales of European manufacturers on the EU market is different from that of non-EU manufacturers, the shape and slope of the utility-based target function (and possibly also other modalities) may lead to targets for EU manufacturers that on average are of different stringency than for non-EU manufacturers. If a larger share of cars sold by EU manufacturers in the EU are manufactured in the EU than is the case for cars sold in the EU by non-EU manufacturers, and if components for cars are mainly manufactured in the same region where the cars are manufactured, then the different required reduction efforts for EU and non-EU manufacturers may lead to differences in the demand for improved or new components that may lead to differences in economies of scale of similar components manufactured in EU and other regions. This may affect the cost competitiveness of EU car manufacturing, but sign and size of the impact cannot be determined in the absence of a proposed target function. The likeliness of this impact pathway is further determined by the stringency of LDV CO$_2$ regulation in different regions.
    - In Annex 5 it is shown that overall the sales distributions for cars manufactured by European, Japanese, Korean and other OEMs are
different in detail but do not show very large difference in the average mass and footprint. **The impact of the above-described pathway is therefore expected to be limited.** For passenger cars this is further influenced by the observed trend that the absolute slope of the target function decreases with a decreasing target level.

- **Dependence of component costs on location of production**
  - The location of production affects component costs e.g. through differences in the cost of labour in different regions. If the share of labour costs in the total cost of new components is different from the share of labour costs in the reference vehicle, differences in labour costs for manufacturing components may affect the cost ratio of vehicles manufactured in the EU and in other regions. Different combinations of conditions lead to different conclusions on the resulting cost competitiveness impacts as shown in the graph below.

**Figure 24 – Impact of the location of production on compliance costs**

- If new components for cars manufactured in the EU for EU market are produced in the EU, absolute manufacturing costs of new components are the same. However, transport costs are higher for EU car manufacturing. **YES**
- If new components for cars manufactured outside the EU are produced in the EU, absolute manufacturing costs of new components are the same. But transport costs are lower for EU car manufacturing. **YES / +**
- If new components for cars manufactured in the EU are produced in competing region outside EU, absolute manufacturing costs of new components are the same. But transport costs are higher for EU car manufacturing. **NO**
- If new components for cars manufactured in other region for EU market are produced in that region, absolute manufacturing costs of new components are the same. But transport costs are higher for EU car manufacturing. **MAYBE**
- If new components for cars manufactured in EU for EU market are produced in competing region outside EU, absolute manufacturing costs of new components are the same. But transport costs are lower for EU car manufacturing. **NO**
- If share of cost factors in new components is similar to that of baseline car, e.g. for electrical components, cost ratio for components will be similar as cost ratio of baseline product. **NO**
- If share of cost factors in new components is different to that of baseline car, e.g. for mechanical components, differences in labour costs and other cost factors between EU and other regions may lead to different cost ratio for these components. **MAYBE**

- If new components for cars sold in the EU are manufactured in the EU both for EU and non-EU car manufacturing, the component costs will be the same but due to higher transport costs for use of these components in non-EU car manufacturing there could be a **positive impact on the cost competitiveness** of EU manufacturing.

- **Possible negative cost competitiveness impacts** may arise if new components for cars sold in the EU are manufactured outside the EU both for EU and non-EU car manufacturing (but are more expensive for EU manufacturing due to higher transport costs), or if components are manufactured in the same region as the vehicles (and are cheaper in other regions due to lower labour costs or other cost factors).
  - Although a majority of automotive parts tend to be produced close to the production locations of OEMs, these OEMs would source them elsewhere if overall they were cheaper, if it concerns specialised components (e.g. for electric powertrains) produced by a limited number of suppliers, or e.g. if
production of these components is energy or labour intensive and therefore located in counties with cheap energy or labour.

- In order to be able to judge whether identified possible cost competitiveness impacts are likely or likely to be significant the following questions would need to be answered:
  - Are EU/non-EU ratios for various cost factors markedly different?
  - What is the size of transport costs from other regions to the EU and how does that compare to differences between manufacturing costs of components in the EU and outside the EU?
- Overall the expected net impact depends on which case is valid. In addition it should be noted that the situation is not static. EU OEMs that now source components regionally may choose to source components from suppliers in other regions if these have significantly lower costs. Suppliers from outside the EU may also choose to locate production facilities in EU.

- Indirect effects may also come from price increases due to (temporary) scarcity of components resulting from production capacity not being able to match the increased demand.
  - This impact pathway is considered to be unlikely as:
    - for many components that are relevant to advanced ICEVs and AFVs the production is already being scaled up in the EU and other regions;
    - due to the large number of compliance strategies dependence on a limited number of components is unlikely;
    - for now it is foreseen that the date of announcement of the post-2020 legislation gives enough lead time to the target year.

Does post-2020 EU LDV CO₂ regulation lead to regionally different impacts related to the cost of labour?

- Not directly. The legislation does not have a direct effect on labour conditions, wages, taxes or other factors that determine the costs per unit of labour.

- An indirect impact pathway could occur if the amount of labour needed to manufacture a car would change as a result of the legislation and if the costs of labour are different for different regions. In that case the share of labour costs as part of the total costs of car manufacturing would be affected differently in the EU than in other regions as would the ratio of total costs between EU and other regions.

  - The question is whether it is likely that the amount of labour required for manufacturing cars could change as a result of the legislation. Examples of possible origins for this are:
    - Assembly of electric powertrains is less labour intensive than of mechanical power trains (less components).
    - Construction of vehicle bodies from composites and other alternative materials may be more labour-intensive than construction of steel bodies.

  - Important questions for determining the size of possible cost competitiveness impacts are:
    - What are the differences in wages between regions?
    - What degree of automation and hours per vehicle produced?
o What's the share of labour costs in car manufacturing and is that different in different regions?

- Indirectly there could be an effect on labour costs per vehicle and as a share of the total costs of manufacturing vehicles if labourers with new skills are required and if these would not be sufficiently available. This is not considered to apply to the compliance route of making ICEVs more efficient, as that very much relies on incremental improvements of existing technologies. But it could result from the need to sell or increase the share of AFVs. These contain novel technologies with more emphasis on electrical and chemical engineering than on mechanical engineering.
  - If this applies to EU and non-EU manufacturing equally it does not affect cost competitiveness as the relative cost ratio between regions will remain the same.
  - This could happen if the availability of skilled labour for the new technologies is lower or higher in the EU than in other regions of the world and if recruiting from other regions is restricted.
  - It is likely to apply more to R&D and product development than to manufacturing, as manufacturing requires limited amounts of specialised labourers and production labourers can be trained to acquire new skills.
  - This is only a temporary effect, as it may be expected that skills of available labourers will be changed to meet the changing demands through training.
  - No new skills are needed for employees with jobs in management and overhead and limited additional personnel is required in those areas. The administrative requirements of post-2020 legislation are expected to be similar to those of the current legislation.

**Does post-2020 EU LDV CO₂ regulation lead to regionally different impacts related to the cost of capital goods?**

- There is no direct impact expected as the regulation does not affect the factors that determine the cost of capital goods per unit of production.
- Indirect effects on total costs of capital goods as part of the costs of manufacturing vehicles are expected as new technologies are likely to require new manufacturing equipment (e.g. autoclave for carbon fibre bodies).
  - Cost competitiveness impacts are expected only if the cost difference between new and existing capital goods is different from the overall average difference in costs of equipment in different regions. This seems fairly unlikely.
- In addition indirect effects are possible in relation to the efficiency of production for advanced ICEVs and AFVs.
  - If the EU has more stringent legislation than other regions the production volumes of advanced ICEVs and AFVs will be higher in the EU than in other regions, given that the majority of vehicles sold in the EU is manufactured in the EU. This leads to learning effects and more efficient use of capital goods, which may have a small positive impacts on the cost competitiveness of the EU car manufacturing industry.
- Scarcity of capital goods could occur if the demand for new equipment increases fast. This is not expected as most technologies for compliance with post-2020 LDV CO₂ legislation do not seem to require extremely specialised or complex production tools for car manufacturing (for component manufacturing this may be different) and OEMs have significant time to plan ahead.
If large investments would be needed to adapt production processes in a short period of time, and especially if these investments are associated with high risks, this could affect the cost of capital. This would only be the case with very rapid reduction trajectories. This would only seem to lead to cost competitiveness impacts if targets for EU OEMs are on average more stringent than for non-EU OEMs.

Does post-2020 EU LDV CO\textsubscript{2} regulation lead to regionally different impacts related to the overhead costs?

- No direct impacts on the costs per unit of overhead activity are expected, but the amount of overhead per unit product might change.
- Possible impacts can be assessed per type of overhead costs:
  - **Management**: Limited additional personnel are expected to be required. Administrative requirements of post-2020 legislation would be similar to those of current legislation, which are minimal. In a transition phase additional management efforts could be required to acquire new components or implement new production methods. This aspect does not generically affect cost competitiveness of production in EU.
  - **Marketing**: Additional marketing efforts may be necessary to inform clients about new technologies and to use these to enhance brand value. These costs need to be passed on to cars sold in the EU, but not to cars manufactured in the EU for markets outside the EU if these markets do not have similar legislation. Foreign OEMs have to make similar efforts for imports to the EU. The cost per car will depend on sales volumes in the EU. This aspect does not generically affect cost competitiveness of production in the EU.
  - **Logistics**: Shipping costs per unit of transport activity are not directly affected. Indirect impacts may result e.g. from increasing insurance costs for transport as a result of cars becoming more expensive. If the EU has more stringent legislation than other regions, imports to EU may be more severely affected than distribution of cars manufactured in EU for EU market due to the longer transport distances. This would be a small positive cost competitiveness impact for EU car manufacturing. If EU regulation is of similar stringency as in other regions, imports to EU and exports from EU are similarly affected and no cost competitiveness impact would be expected for this pathway.
  - **R&D costs**: Additional R&D will be necessary to develop (LDVs with) new technologies. These costs need to be passed on to LDVs sold in EU, but not to LDVs manufactured in the EU for markets outside the EU if these markets do not have similar legislation. Foreign OEMs have to make similar efforts for imports to the EU. Cost per LDV may depend on sales volumes in the EU. This aspect does not generically affect cost competitiveness of production in the EU. Also the relation between R&D costs and the overall costs of manufacturing LDVs in the EU or in other regions is weak. R&D is carried out at company level, and how R&D costs are passed through in the price of products is a strategic decision of companies. Nevertheless this aspect may be considered to cause impacts on overall cost competitiveness, which would appear to be positive if the EU has more stringent regulation than other regions and negative if the reverse is the case.
Cost competitiveness of performing R&D in the EU (company R&D or by R&D organisations) may be affected, e.g. if EU legislation promotes innovation more than legislation in other regions.

### 6.3 Conclusions regarding cost competitiveness impacts on EU vehicle manufacturing

Table 7 - Summary of possible cost competitiveness impacts on EU automotive manufacturing

<table>
<thead>
<tr>
<th>Cost factor</th>
<th>Impact</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material costs</td>
<td>Maybe</td>
<td>• Relates to possible regional difference in materials needed for advanced ICEVs and AFVs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sign and size of the effect cannot be determined at this stage, but significant impacts appear unlikely.</td>
</tr>
<tr>
<td>Costs of purchased</td>
<td>Maybe</td>
<td>• Small positive impacts could occur if the EU has more stringent regulation than other regions or if large share of new components for advanced ICEVs and AFVs are produced in the EU.</td>
</tr>
<tr>
<td>components</td>
<td>+</td>
<td>• Small negative impacts may occur if component for advanced ICEVs and AFVs are mainly produced outside the EU.</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+/-</td>
<td>• Finite impacts may occur if the effective stringency of the target is different for EU and non-EU OEMs:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Sign and size depend on target function which is not yet known.</td>
</tr>
<tr>
<td>Labour costs</td>
<td>Yes</td>
<td>• An impact of unknown sign and size is possible as new technologies may require more/less labour or have a higher/lower share of (manual) labour in assembly / production. This will only lead to a finite effect if labour costs are different in different regions.</td>
</tr>
<tr>
<td>Costs of capital goods</td>
<td>Maybe</td>
<td>• Depending on possible regional differences in the costs of production tools for advanced ICEVs and AFVs</td>
</tr>
<tr>
<td></td>
<td>+/-</td>
<td>• Positive / negative impacts associated with economies of scale and learning effects due to higher / lower volumes if EU has more / less stringent legislation than other regions</td>
</tr>
<tr>
<td>Overheads</td>
<td>Yes</td>
<td>• Vehicles get more expensive. For transport costs that increase with the value of the vehicle, the impact on vehicles imported from distant regions is relatively larger than for cars manufactured in the EU.</td>
</tr>
<tr>
<td></td>
<td>+/-</td>
<td>• The number of vehicle sales over which R&amp;D costs can be divided depends on the relative stringency of CO₂ regulation in the EU and other regions (positive impacts if EU regulation is more stringent).</td>
</tr>
</tbody>
</table>

The total cost ratio between EU manufacturing and other regions may change as a result of the EU LDV CO₂ legislation:

- if one or more cost factors change as a result of the LDV CO₂ legislation and this change is different in the EU than in other regions;
- if application of new technologies or other activities needed to comply with LDV CO₂ legislation affects the shares of different cost factors in the total production costs, and if ratios of these cost factors for EU vs. other regions are significantly different.
It is concluded that post 2020 EU LDV CO\(_2\) legislation has no direct impacts on the cost competitiveness of EU car manufacturing as the legislation is targeted at the CO\(_2\) performance of cars and not at factors that determine the costs of producing cars or their components. A limited number of possible indirect impacts, however, have been identified, of which the combined net impact may still be significant:

- The access to materials as well as the costs of these materials could be different for EU and non-EU OEMs. This especially relates to materials for electric powertrains and vehicle light-weighting;
- Possible positive or negative cost competitiveness impacts are identified in relation to regional differences in the cost of components for advanced ICEVs and AFVs, depending e.g. on the relative stringency of EU legislation compared to that in other regions or whether components are required for which suppliers are mainly located outside Europe;
- Regional differences in labour costs may have an impact of unknown sign and size as new technologies may require more/less labour or have a higher/lower share of (manual) labour in assembly / production. Given the wage levels in different EU Members States this may also exacerbate the current shift of production facilities within the EU to Central and Eastern Europe;
- Some impact pathways have been identified that relate to differences in the costs of capital goods, transport costs and tariffs, and the volume of sales over which R&D costs can be divided. The size and sign of these impacts depend on the relative stringency of EU legislation, with a positive impacts likely of the EU legislation is more stringent than that in other regions;

Conclusions seem to be quite generic and the same for the car and van regulation.
7. Impacts on cost competitiveness: the component manufacturer perspective

7.1 Introduction
Companies supplying components (including materials such as steel) to automotive manufacturers operate in a business-to-business market. Price and quality determine the attractiveness of their products, together with a range of other factors such as the ability to meet the OEMs supply chain requirements (e.g. just-in-time delivery). Assuming that the latter aspects are not affected by LDV CO$_2$ regulation, the focus for assessing cost competitiveness impacts on suppliers will be on analysing whether European suppliers would be in a better, equal or worse position than suppliers from other regions to meet the additional demand by OEMs for components for efficient ICEVs and AFVs in a cost-competitive way. This chapter focuses on assessing cost competitiveness impacts from the manufacturer (i.e. company) perspective. An analysis of cost competitiveness impacts on EU automotive component manufacturing (i.e. a sectorial perspective) is provided in chapter 8.

7.2 Identification of impact pathways
Pathways along which the LDV CO$_2$ legislation and the capabilities and resources of companies can lead to cost competitiveness impacts on automotive supplier companies are presented in Figure 25. A decomposition of relevant resources and capabilities of suppliers as a basis for determining regional differences that may lead to cost competitiveness impacts on suppliers is presented in Figure 26.

Figure 25 shows that the demand for new components and materials for advanced ICEVs and AFVs, resulting from the CO$_2$ legislation, is primarily determined by the compliance strategies chosen by OEMs. Over the last decades OEMs have come to rely more and more on R&D and new product development carried out by their Tier 1 suppliers, so that the ability of these suppliers to develop and manufacture advanced components is also a strong influencing factor in an OEM’s choices regarding the strategy for complying with the post-2020 LDV CO$_2$ regulation.

Differences in the abilities of suppliers to offer new components and materials for advanced ICEVs and AFVs to their clients at competitive prices determine the impacts of post-2020 LDV CO$_2$ regulation on the mutual cost competitiveness of suppliers. Possible regional differences in these abilities may lead to cost competitiveness impacts on European automotive suppliers or the EU automotive supply industry. What makes an automotive supplier European can again be defined in different ways, such as:

- membership of CLEPA, the European association of automotive suppliers;
- location of headquarters and/or major R&D centres in the EU;
- having production facilities in the EU.

For the analysis from a manufacturing perspective (see chapter 8) the latter definition is relevant. For the distinction between EU and non-EU in the analysis of regional differences between automotive component manufacturers the first two definitions are most relevant, but it is assumed that for suppliers with headquarters in the EU also the majority of their production is located in the EU. Given that suppliers often have factories close to those of their clients, and given that the majority of vehicles sold in the EU are
manufactured in the EU, it may be assumed that a large part of the components for vehicles affected by EU CO₂ legislation are manufactured in the EU. Reasons for why components are manufactured around assembly plants relate not only to costs but also to supply chain reliability, just-in-time delivery, reduction of inventories at the OEMs’ production plants, flexibility and responsiveness of supply, etc.. However, for more specialised components it is less likely that the suppliers’ production plants are located in the vicinity of the OEMs’ manufacturing locations.

An analysis of possible regional differences in the resources and capabilities of automotive suppliers can be based on the mindmap depicted in Figure 26. The structure of Figure 26 is very similar to that for the decomposition of relevant resources and capabilities of OEMs (Figure 20). Some noticeable differences are:

- the dependence of economies of scale on the share of EU and non-EU OEMs among the clients of a supplier and the sales of these clients in the EU and in other regions;
- a more limited impact of the existing product portfolio on capabilities, with focus on:
  - already having components for advanced ICEVs and AFVs in the portfolio may enable faster increase in the supply and sales share of such components;
  - that a wide power range of available ICEV and AFV powertrain components is necessary to grasp a significant proportion of the market;
  - that a wide product portfolio may enable some level of cross-subsidizing with other products to allow competitive pricing of the ICEV and AFV components supplied to OEMs for meeting targets of the LDV CO₂ legislation.

Possible regional differences are expected to affect cost competitiveness in similar ways as analysed for OEMs. These include regional differences in:

- knowledge positions and existing product portfolios for specific technologies;
- wages and other factors determining the cost of operations;
- access to materials and (sub)components.

An assessment of whether such differences exist and to what extent they influence cost competitiveness will have to answer similar questions for suppliers as have been listed in section 6 for automotive manufacturers.

Resources for which regional differences may influence capabilities of EU and non-EU automotive component and material suppliers to respond to changing needs of their customers resulting from the need to comply with post-2020 CO₂ regulation in a cost-competitive manner include:

- the **financial position** of companies, which influences their ability to develop materials and components for efficient ICEVs and AFVs as well as their ability to temporarily absorb losses if competition does not allow full pass-through of the costs;
  - In return the financial position is affected by the profitability of a company’s operations, which may be affected by the CO₂ legislation;
- the **knowledge position of companies**, which influences their ability to develop materials and components for more efficient ICEVs and AFVs vehicles;
  - The **patent position** is part of the knowledge position and not only influences the ability to develop advanced materials and components for ICEVs and AFVs but also to generate revenues by selling patents or licenses;
the facilities of companies, more specifically;
  o their efficiency of production;
  o their geographical location, which influences cost of labour and other cost factors of production, and also determines transport costs;
• access to suppliers able to deliver (sub-)components and materials for the manufacturing of components for more efficient ICEVs and AFVs, and the cost at which these suppliers are able to sell the required components and materials;
• the portfolio of companies, which may determine:
  o the speed with which suppliers can ramp up production of existing components and materials for efficient ICEVs and AFVs;
  o the extent to which suppliers can sell packages of components (systems);
  o the extent to which suppliers can cross-subsidise costs over different products in the portfolio;
• the customer base, which is characterised by aspects such as;
  o the loyalty of customers;
  o the share of EU and non-EU OEMs among the clients of a supplier and the sales of these clients in the EU and in other regions.

Below the influence of these resources, and of possible regional differences therein, on relevant capabilities of companies are discussed in more detail.

Ability to develop components for improved ICEVs and AFVs

A supplier’s ability to develop components and materials for more efficient ICEVs and AFVs is influenced by a range of factors:

• knowledge / technology position of the supplier and the resulting efforts required to improve the knowledge / technology position:
  o technologies already developed or even marketed;
  o available patents;
• R&D capacity:
  o capability for and costs of carrying out the required R&D;
  o capability for and costs of acquiring licences;
• financial position, which determines the ability to invest in the required R&D and product development;
• supplier base, which determines a supplier’s access to advanced (sub-)components and materials.

Below for each of these factors an assessment is made of the extent to which regional differences can give rise to differences in the compliance costs for EU and non-EU suppliers to an extent that the relative price ratio of their products is affected.
Figure 25 – Overview of pathways along which the LDV CO₂ legislation and the capabilities and resources of companies can lead to cost competitiveness impacts on automotive supply companies

**Automotive component & material suppliers**

**Resources & capabilities**

- Financial position can affect other resources “instantly”
- **Resources**
  - Finance
  - Customer base
  - Knowledge
  - Patents
  - Facilities
  - Supplier network
  - Product portfolio
- **Capabilities**
  - Ability to develop required components
  - Ability to produce at lower costs than competitor
  - Ability to sell at lower price than competitor
  - Ability to sell licenses

- **Other compliance strategies related to suppliers**
  - Applying eco-innovations
  - Applying additional CO₂ reducing technologies to ICEVs

- **Additional demand related components**
  - Additional demand for AFV components
  - Additional demand for CO₂ reducing technologies for ICEVs

**Legislation & OEM compliance strategies**

- **CO₂ legislation**
  - Target
  - Target for OEM
  - Increasing shares of AFVs
  - Applying additional CO₂ reducing technologies to ICEVs

- **Other compliance strategies**
  - Using flexibilities or applying for derogation
  - Do not affect suppliers

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**Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation**

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Assessment of competitiveness impacts of post-2020 LDV CO2 regulation

- Decomposition of relevant resources and capabilities of automotive supply companies as basis for determining regional differences that may lead to cost competitiveness impacts

**Automotive material and component suppliers**

- **Knowledge**
  - Knowledge of CO2 reduction technologies for ICEVs
  - Knowledge of AFV powertrain related components
  - Other knowledge
    - Patents in low CO2 emission technologies (ICEV or alternatives)
- **Regional knowledge infrastructure**
- **Pats**
- **Need to acquire licenses**
  - Costs of licenses
- **Facilities**
  - (Car manufacturers)
  - (Sales to EU OEMs)
  - (Sales to non-EU OEMs)
- **Geographical sales distribution**
  - Share of EU market in sales of customers
  - Share of non-EU markets in sales of customers
- **Ability to use equity to strengthen resources / capabilities**
  - Ability to bear losses resulting from not transferring costs to end users
- **Ability to cheaply transfer resources / capabilities**
  - Ability to sell improved / new components to current customers
  - Ability to cross subsidise products inter-regionally
- **Ability to maintain current customers even when sales price is higher**
  - Ability to achieve economies of scale of technologies needed to meet EU target
  - Ability to develop components for improved ICEVs and AFVs
- **Ability to cross subsidise products**
  - Ability to develop improved ICEVs and AFVs
  - Ability to cheaply transfer resources / capabilities

**Resources**

- **Access to required resources**
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**Externalities**

- Decomposition of relevant resources and capabilities of determining regional differences that may lead to cost competitiveness impacts
If price cross-elasticities or profit margins are different in different market segments, then cross-subsidising with components in segments with relatively high elasticity or profit margins is possible.
Knowledge / technology position of the supplier and the resulting efforts required to improve knowledge / technology position

The R&D and other efforts, carried out by suppliers to develop products for vehicles meeting LDV CO₂ targets, can be divided in general R&D to develop the required technologies required as well as the general skills for manufacturing these technologies.

If OEMs require similar products from different suppliers, then differences in required R&D efforts between EU and non-EU suppliers could in principle result from:

- differences in the current technology position of OEMs (technologies already developed, patents);
- differences in the access to suppliers that can deliver the required sub-technologies;
  - see under “supplier base”

In the stakeholder consultation European suppliers have indicated that Asian suppliers have better knowledge and skills in electrification and in particular batteries. As a result they may have a competitive advantage over European suppliers if EU LDV CO₂ regulation would lead to an increased electrification of powertrains.

R&D capacity

A supplier’s capacity to carry out R&D and to innovate is e.g. influenced by regional factors such as:

- the ability to invest in R&D (see next subsection)
- available R&D facilities
- availability, focus and quality of the regional knowledge infrastructure (universities, R&D companies);
- availability of trained personnel with the required knowledge and skills.

As was also concluded with respect to the R&D capacity of OEMs, the conditions for carrying out R&D are good in Europe and do not give rise to concerns over cost competitiveness impacts.

In the stakeholder consultation automotive suppliers have indicated that in the EU the availability of trained R&D staff with the required knowledge and skills may become a limiting factor.

Financial position, determining the ability to invest in the required R&D and product development

With respect to the “finance” resource the EU LDV CO₂ legislation could be considered to have an impact on the cost competitiveness of European suppliers if:

- the legislation would affect the profitability of EU suppliers more than of non-EU OEMs, or
- the financial position of EU suppliers is different from that of non-EU suppliers to begin with.

The first case could occur if post-2020 EU LDV CO₂ legislation would lead to a significant change in the overall sales in the EU. Reduced sales of cars lead to lower sales of components. As EU suppliers have a high share of EU OEMs as clients, which turn have a higher share of their sales in the EU than non-EU OEMs, EU suppliers would be more strongly impacted by a change in EU car sales. The extent to which this is likely to occur depends on the target level, the additional costs of technologies for advanced ICEVs and AFVs that are needed to meet the target, and the impact of those additional costs on car sales.
Counteracting this would be a greater dependence on suppliers for higher technology components and systems.

The second situation could be the case if EU suppliers are, similarly to EU manufacturers, more severely affected by the economic crisis than their non-EU competitors. Given that most of the main suppliers are global players, however, this situation is less likely than in the case of automotive manufacturers.

For the financial capabilities of companies to invest in R&D also the cost of acquiring capital are relevant. In section A2.4 it is stated that in the beginning of 2014 the cost of capital for European suppliers companies was reported to be on average slightly higher than for non-European competitors. The question is whether such differences are still likely to exist in the 2020-2025 timeframe.

**Supplier base**

Differences in the R&D effort required between EU and non-EU suppliers could in principle result from differences in the access to suppliers of sub-technologies that are needed for the development of components and materials for advanced ICEVs and AFVs. It appears that Tier 1 non-EU suppliers have a stronger position in technologies for electric powertrains while EU suppliers have a stronger position in diesel engine technology, it is likely that such differences also exist for their Tier 2 suppliers.

**Width of product portfolio**

A wide product portfolio, in terms of supplying components for a wide range of powertrain technologies, could require suppliers to innovate a large share of their components. This could hinder their ability to develop the required new components or increase the costs for development per unit manufactured. In relation to this suppliers have indicated in the stakeholder consultation that post-2020 EU LDV CO₂ legislation will lead to a strong diversification in powertrain technologies and configurations, which in turn demands increased diversification of components. The ability of the automotive supply industry to develop an increasing number of new products will be strongly determined by the rate of innovation that is required, which in turn is determined by the target levels of post-2020 CO₂ regulation. To what extent the ability to diversify is different for EU and non-EU suppliers is unclear. In second order this may relate to their financial positions, which may be different as EU OEMs and their suppliers have been more severely affected by the economic crisis than their non-EU competitors. To what extent this remains the case in the period up to the new post-2020 target years is a question.

**Ability to manufacture at competitive costs**

A supplier’s ability to manufacture more components and materials for efficient ICEVs and AFVs in a cost-competitive manner is influenced by a range of factors:

- aspects of the knowledge / technology position of the supplier
  - technologies already developed or even marketed (providing experience and economies of scale)
  - costs of (acquiring) licences
- manufacturing costs for CO₂ reducing technologies for ICEVs and AFVs
  - costs of materials
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

- costs for purchasing (sub)components
- cost efficiency of production facilities determined by e.g.:
  - direct overhead and labour costs
  - equipment and tooling costs
  - other costs such as operation and maintenance of buildings
- impact of economies of scale

Below for each of these factors an assessment is made of the extent to which regional differences can give rise to differences in the compliance costs for EU and non-EU suppliers to an extent that the relative price ratio of their products is affected.

**Portfolio - Technologies already developed or even marketed**

The question is whether EU and non-EU suppliers have a different position in the marketing of technologies that are relevant for meeting longer term legislative targets. Similar to EU OEMs, EU suppliers have a stronger position in diesel technology. On technologies such as engine down-sizing, direct injection petrol engines, aerodynamics or lightweight materials differences are less apparent or EU manufacturers may even be in a stronger position. It is claimed that Asian suppliers have a stronger position in components for electric powertrains.

**Costs of (acquiring) licences**

If component manufacturers wish to apply technologies for CO₂ reduction which are patented by other companies, there may be costs involved for acquiring the licence to produce these technologies or for buying the patents. The other way around, component manufacturers that own patents for technologies that other companies wish to apply may generate revenue from licencing or from selling these patents. Therefore, if future CO₂ legislation would require the widespread application of technologies for which suppliers from Europe have more / less patents than non-EU suppliers, this would have positive / negative impacts on the cost competitiveness of EU suppliers. This pathway strengthens the impacts of differences in technology positions.

There is evidence that the costs of patenting is significantly higher in Europe than in other regions, due to the need to have patents translated and validated by a large number of national patent offices. This could hamper EU companies in generating revenues from licensing.

**Manufacturing costs for CO₂ reducing technologies for ICEVs and AFVs**

Overall the possible factors that determine (regional differences in) component manufacturing costs are the same as for the manufacturing of vehicles by OEMs. For components for CO₂ reduction in ICEVs and for AFVs differences in the manufacturing costs for EU and non-EU suppliers depend on the efficiency of their production facilities and on a range of factors that relate to the geographic location of their facilities. The latter include regional differences in e.g. labour costs and taxes as well as transport costs for bringing components produced outside the EU to European countries. Economies of scale also come into play, as these influence the cost efficiency of production facilities. All these factors are further explored in the paragraphs below.
The extent to which regional differences in cost factors for production can affect cost competitiveness of suppliers depends on the share of regionally different costs in the total costs of manufacturing materials and components, and on whether these shares change as a result of the CO\textsubscript{2} legislation.

**Geographical distribution of facilities: Impact of regional differences in cost of labour and other cost factors**

As for OEMs, the fact that labour and other cost factors differ between regions does not automatically lead to cost competitiveness impacts of the EU CO\textsubscript{2} legislation on automotive suppliers. The price ratio of competing products, however, can be affected if the ratio of the different cost components for manufacturing the new technologies, demanded by OEMs for meeting post-2020 CO\textsubscript{2} targets, differs from that in the existing products. For many technologies needed to make ICEVs more efficient this is not expected as they concern improvements of existing components or technologies. More advanced technologies, such as components for electric, hybrid or fuel cell propulsion systems or application of advanced lightweight materials may require more or less labour in the manufacturing or disproportionately higher or lower tooling costs, and may thus alter the ratio of various cost components of manufacturing.

Regional differences in labour costs could be caused by regional differences in the availability of labour with specific skills required for developing and manufacturing components and materials for advanced ICEVs and AFVs or their components. This is specifically the case if there is scarcity of such skilled labourers and depends on the ability to recruit from elsewhere. In general this can be considered a temporary effect, but it could affect costs over timescales that are relevant to the CO\textsubscript{2} regulation.

**Equipment and tooling costs and other costs such as operation and maintenance of buildings**

Geographical differences in labour costs indirectly also affect equipment and tooling costs and other costs such as operation and maintenance of buildings. Equipment and tooling costs are also affected by the cost of capital.

**Economies of scale**

The impact of economies of scale on the costs of manufacturing components for advanced ICEVs or AFVs depends on the total number of vehicles to which these components are applied. That in turn depends on a supplier’s sales to EU and non-EU OEMs and their sales volumes of vehicles with these advanced technologies in the EU and other regions markets.

Sales volumes of vehicles with advanced CO\textsubscript{2}-reducing technologies in the EU market depend on the target set for the post-2020 legislation and the way in which various modalities (e.g. the metric) affect the compliance strategies chosen by OEMs.

Sales volumes of advanced technologies in other regions depend on:
- sales volumes of OEMs in other regions;
- whether markets in these regions are subject to CO\textsubscript{2} regulations of similar or different stringency to the EU LDV CO\textsubscript{2} legislation. An overview of passenger car regulations in different regions is provided in Figure 8 in section 4.2.
If the client base of European suppliers is dominated by European OEMs, then more stringent regulation in the EU compared to other regions may be expected to lead to higher economies of scale for EU suppliers than for non-EU suppliers manufacturing components for vehicles for the EU market from non-EU OEMs. This would thus constitute a positive cost competitiveness impact.

**Costs of materials / costs for purchasing (sub)components**

Post-2020 CO₂ legislation is likely to affect the demand by suppliers for certain materials and (sub)components. Differences in component costs for EU and non-EU suppliers could result from regional differences in the costs of materials and (sub)components. Such regional differences do exist as the cost factors affecting the costs of (producing) materials or (sub)components (e.g. the cost of energy and the cost of labour) are different in different regions.

The market for materials and components, however, can be considered a global market, meaning that all suppliers in principle have access to products of most or all material and sub-component (Tier 2) suppliers worldwide. If that is the case only different costs associated with transporting materials or components from the supplier to manufacturers in different regions would effectively lead to regionally different costs for materials or components.

If CO₂ legislation leads to a change in the demand for materials and (sub)components, Tier 1 suppliers may be expected to adapt their supplier base in order to be able to purchase these materials and (sub)components at competitive costs.

**Ability to sell at competitive prices**

The ability to sell components and materials for efficient ICEVs or AFVs at a competitive price depends on a range of factors including:

- the manufacturing costs of the components and materials;
- the impact of R&D costs on price of the components and materials;
- the ability to cross-subsidize within the product portfolio;
- the ability to absorb losses.

**The additional manufacturing costs in different segments or models**

Possible causes of regional differences in the costs of manufacturing components and materials for low-CO₂ ICEVs and AFVs have been discussed above.

**Impact of R&D costs on the price of components and materials**

The magnitude of the required R&D costs associated with developing products that meet the requirements of OEMs, associated with their need to meet post-2020 EU LDV CO₂ targets, may be different for different suppliers. The regional aspects that may lead to regional differences in R&D costs are the same as those discussed in relation to the impact of R&D capacity on the ability to develop components and materials for improved ICEVs and AFVs (see above).
The ways in which R&D costs can be passed through and their impact on component prices may depend on (the stringency of) CO\(_2\) legislation in other regions, the resulting size of the sales of components for advanced ICEVs and AFVs worldwide, and on the sales of other components by suppliers for the EU market and markets in other regions.

- If European legislation is much tighter than that in other regions, suppliers need to make specific R&D efforts for components to be applied to cars sold in Europe. The R&D costs resulting from EU LDV CO\(_2\) standards can be considered relatively independent of the amount of cars sold in Europe. Suppliers can choose to pass on those costs to the CO\(_2\)-reducing technologies for vehicles sold in Europe only or distribute them over their worldwide sales. In both cases differences in sales volumes for European vehicles or vehicles sold in other regions affect the way in which additional R&D costs may affect the prices of products of competing companies.

- If other regions have legislation of similar stringency to the EU, and if suppliers decide to pass through R&D costs for meeting those standards only to components for vehicles sold in markets where the standards apply, the R&D costs can be divided over a larger amount of components. Suppliers delivering components to OEMs that mainly sell cars in the EU may have a disadvantage over suppliers that also sell components for cars sold in other regions with similar legislation.

**The costs of bringing products to the market including international transport costs and tariffs**

Transport costs and tariffs depend on the location of production of the components and the locations of vehicle manufacturing plants of the OEMs to which these components are supplied. No impact on cost competitiveness is expected from this cost factor, as for components for advanced ICEVs and AFVs the ratio of transport costs for EU and non-EU suppliers is expected to be roughly the same as for components supplied for use in vehicles with today’s technology.

**Width of product portfolio**

A wide portfolio of components, in terms of supplying many different components for the same powertrain technologies, may enable suppliers to sell systems (packages of components) rather than single components. This not only means that benefits of system integration can achieved, but it also allows the supplier to grasp a larger share of the automotive value chain. There is no information available on which to judge whether the abilities of EU suppliers in this respect differ from those of non-EU suppliers. One could imagine, however, that close proximity of component or system manufacturing plants to vehicle manufacturing plants could be a benefit as it enables larger sub-systems to be supplied and improves reliability, responsiveness and reduces inventory. This could provide a competitive advantage for EU suppliers.

The additional costs of new components for advanced ICEVs and AFVs do not necessarily need to be passed on one-on-one to the prices of these components. Suppliers can choose to divide costs over their product portfolio in a way that suits the ability of different market segments to absorb these costs or over time. The width of a supplier’s product portfolio determines the ability of a supplier to apply cross-subsidisation. Costs can also be distributed over a longer time when EU stringency is in advance of non-EU legislation. Technology can be licenced to or produced in other regions later.
**The ability to absorb losses**

Finally suppliers can decide not to pass through all costs to their customers in which case this reduces the profitability of the company. The ability of companies to (temporarily) absorb losses depends on their financial position. This aspect is further discussed below.

**Ability to sell new products to customers / maintain customer base**

Customer loyalty in a business-to-business market is obviously a different issue than in the consumer market. The extent to which OEMs are willing to buy components for advanced ICEVs and AFVs from their existing suppliers, even if these might be more expensive than those offered by competing suppliers, depends on other factors than costs that determine the relationship between supplier and OEM. These factors may include quality of the products, supplier proximity to OEM production plants (especially for larger systems with higher transport costs), the flexibility of the supplier to respond to changing OEM needs, joint R&D programmes, ownership / shareholder relations, etc.. Cost competitiveness impacts could occur if EU OEMs would e.g. be more inclined than non-EU OEMs to switch to alternative suppliers if these can deliver components at lower costs. No information is available upon which one can judge whether there are regional differences in these relationships.

In this context it is also interesting to look at the extent that EU manufacturers will be able to market vehicles that are developed for meeting EU CO₂ standards in other regions. This not only depends on the CO₂ regulation in those countries, but also on fuel prices. As fuel prices are generally higher in the EU than in other regions levels (due to higher tax levels), improvements in the fuel efficiency of vehicles resulting from compliance to increasingly stringent targets will generate higher fuel cost savings for EU end-users than for users of similar LDVs in other regions (and thus shorter payback times). This means that LDVs developed to meet EU CO₂ standards are less attractive in other regions, especially if CO₂ legislation there is more lenient. Consequently EU manufacturers may need to differentiate their production in LDVs for the EU market (with CO₂ reducing technologies) and LDVs for other markets (with less added CO₂ reducing technologies). This, however, reduces economies of scale compared to a situation in which vehicles for both markets are the same. The net effect on costs of LDVs manufactured for other markets depends on a balance between lower costs for additional technologies and higher production costs due to lower economies of scale.

**Ability to invest or to absorb (temporary) losses**

If a given supplier meeting the changing demands of OEMs for complying with EU CO₂ regulations requires significant investments in R&D, product development and production facilities, these upfront costs need to be financed by the supplier. The company’s financial reserves and borrowing capacity determine its ability to make the necessary investments.

If these costs cannot subsequently be fully passed on to customers through the price of the products, these costs would have to be absorbed by the supplier reducing their profit. Absorbing losses may be necessary for a short period of time (e.g. until sufficient costs reductions have been achieved to make the component costs competitive) or during a longer period of time. Reduced profits affect a company's financial health and therefore have a long term effect on cost competitiveness, e.g. through a reduced ability to invest in R&D and product development.
The financial position of EU suppliers may be worse than that of non-EU suppliers for a number of reasons. This is a potential pathway for cost competitiveness impacts provided that this situation remains valid in the coming decade up to the target year for the post-2020 legislation.

7.3 Conclusions on cost competitiveness impacts from the perspective of component manufacturers

Conclusions on cost competitiveness impacts from the perspective of component manufacturers are summarized in Table 8.

Table 8 - Summary of possible cost competitiveness impacts for automotive suppliers associated with regional differences in resources and resulting capabilities

<table>
<thead>
<tr>
<th>Capability</th>
<th>Resource</th>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to develop components for improved ICEVs and AFVs</td>
<td>R&amp;D capacity</td>
<td>Yes</td>
<td>• Stakeholders foresee a shortage in the EU of R&amp;D personnel with the skills needed for technologies that are necessary to meet post-2020 CO₂ targets.</td>
</tr>
<tr>
<td></td>
<td>Patent position</td>
<td>Maybe</td>
<td>• Non-EU suppliers have a stronger patent position in technologies for electric and hybrid vehicles.</td>
</tr>
<tr>
<td></td>
<td>Financial position</td>
<td>Yes</td>
<td>• Profitability and financial position of EU suppliers is currently more strongly affected by economic crisis than of non-EU competitors</td>
</tr>
<tr>
<td></td>
<td>Portfolio width</td>
<td>Maybe</td>
<td>• Amount of required R&amp;D determined by amount of CO₂-related products in portfolio.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• CO₂ legislation likely to lead to powertrain diversification requiring product diversification from suppliers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>o To what extent that affects the ability to develop products and leads to cost competitiveness impacts depends on possible differences in the financial situation of EU and non-EU suppliers.</td>
</tr>
<tr>
<td></td>
<td>Supplier base</td>
<td>Maybe</td>
<td>• EU Tier 1 suppliers have stronger focus on diesel technology, while non-EU suppliers have a stronger position in electric powertrain components.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• This difference may apply also to their Tier 2 suppliers.</td>
</tr>
<tr>
<td>Ability to manufacture at competitive costs</td>
<td>Ability to scale up production of technologies already developed</td>
<td>Yes</td>
<td>• EU Tier 1 suppliers have stronger focus on diesel technology, while non-EU suppliers have a stronger position in electric powertrain components.</td>
</tr>
<tr>
<td></td>
<td>Cost of licences</td>
<td>Yes</td>
<td>• If future CO₂ legislation would require the widespread application of technologies for which OEMs from Europe have more / less patents than non-EU OEMs, this would have positive / negative impacts on the cost competitiveness of EU manufacturers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+/-</td>
<td>• This pathway strengthens the impacts of differences in technology positions.</td>
</tr>
<tr>
<td></td>
<td>Labour costs</td>
<td>Maybe</td>
<td>• There are large regional differences in labour costs. But</td>
</tr>
</tbody>
</table>

Final Report
Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIIP), TNO for DG CLIMA
### Assessment of competitiveness impacts of post-2020 LDV CO\(_2\) regulation

<table>
<thead>
<tr>
<th>Capability</th>
<th>Resource</th>
<th>Impact</th>
<th>Comments / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>these only impact cost competitiveness if the share of labour costs in component manufacturing changes as a result of compliance strategies for meeting CO(_2) targets.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>o This may be the case if the targets require significant shares of AFVs or e.g. application of light-weight composites.</td>
</tr>
<tr>
<td>Equipment and tooling costs</td>
<td>Maybe</td>
<td>?</td>
<td>• Possible impacts partly related to economies of scale (see below)</td>
</tr>
<tr>
<td>Economies of scale</td>
<td>Maybe</td>
<td>?</td>
<td>• Depending on sales volumes of components to EU and non-EU OEMs, which are determined by the customer base of EU and non-EU suppliers and by the stringency of CO(_2) legislation in EU and other regions.</td>
</tr>
<tr>
<td>Cost of materials and (sub)components</td>
<td>Maybe</td>
<td>(small)</td>
<td>• Regional differences in costs of materials that need to be sourced regionally.</td>
</tr>
<tr>
<td>Ability to sell at competitive prices</td>
<td>Manufacturing costs</td>
<td>Maybe</td>
<td>?</td>
</tr>
<tr>
<td>Impact of R&amp;D costs on price</td>
<td>Maybe</td>
<td>?</td>
<td>• Depending on whether EU target is more stringent or not the impact on the cost competitiveness of EU suppliers may be positive or negative.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>o Relates to the amount of components over which R&amp;D costs associated with CO(_2) legislation can be divided.</td>
</tr>
<tr>
<td>Costs of bringing products to the market</td>
<td>No</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Ability to cross-subsidize within portfolio</td>
<td>Maybe</td>
<td>?</td>
<td>• Overall portfolio width may be different for suppliers from different regions.</td>
</tr>
<tr>
<td>Ability to absorb losses</td>
<td>Yes</td>
<td>-</td>
<td>• Related to financial position of European suppliers; see below</td>
</tr>
<tr>
<td>Ability to sell new products / maintain customer base</td>
<td>Customer loyalty</td>
<td>Unknown</td>
<td>• No information is available upon which one can judge whether there are regional differences in OEM-supplier relationships.</td>
</tr>
<tr>
<td>Ability to absorb losses</td>
<td>Financial position</td>
<td>Yes</td>
<td>-</td>
</tr>
</tbody>
</table>
Concerning possible cost competitiveness impacts associated with regional differences in resources and resulting capabilities of component suppliers the following conclusions have been drawn:

- The ability of EU suppliers to develop components for CO₂ reduction in passenger cars and vans appears likely to be less than that of non-EU competitors, specifically if the post-2020 regulation would increase demand for vehicles with electric powertrains. This is related to their technology position, their financial position as well as to foreseen shortages in skilled R&D personnel;
- The EU suppliers’ weak position in electric powertrain technologies could hamper them in manufacturing at competitive cost. Factors such as the cost of labour, cost of equipment, economies of scale associated with the customer base and the stringency of the legislation and the cost of materials could lead to impacts on cost competitiveness, but the sign and size of these impacts is difficult to estimate;
- The ability of EU suppliers to sell at competitive prices may be affected by their limited ability to absorb (temporary) losses. Other factors such as manufacturing cost, R&D cost per unit of product and the ability to cross-subsidize over the product portfolio could lead to impacts on cost competitiveness, but the sign and size of these impacts is difficult to estimate;
- The limited ability to absorb losses appears to negatively affect EU supplier cost competitiveness.

Compared to LDV manufacturers the likeliness of negative cost competitiveness impacts for EU suppliers seems somewhat higher.
8. Impacts on cost competitiveness: the component manufacturing perspective

8.1 Possible cost competitiveness impact pathways for EU automotive component manufacturing

A mindmap of impact pathways of post-2020 LDV CO$_2$ legislation on the cost competitiveness of EU component manufacturing is presented in Figure 27. This mindmap follows the same structure as that explained in section 6 for assessing cost competitiveness impacts on EU vehicle manufacturing (Figure 23).

As can be seen from Figure 27 also for component manufacturing only a limited number of pathways seem likely to result in impacts on cost competitiveness of EU manufacturing. Where impacts are possible they may be positive or negative. Conclusions seem to be quite generic and the same for the car and van regulation.

*Does post-2020 EU LDV CO$_2$ regulation lead to regionally different impacts related to the cost of materials?*

- Not directly. The regulation does not directly affect material costs per unit of material as it applies to LDVs and not to factors that determine the costs of material production.
- Indirect pathways are very similar to those identified for LDV manufacturing (see section 6). The size and sign of possible impacts may, however, be different for component manufacturing as this requires different materials than LDV manufacturing. An example are materials used for electric powertrain components, such as lithium for batteries, copper for wiring and rare earth metals for magnets in electric motors. The access of EU suppliers to such materials may be different than suppliers in e.g. China. This also means that it may be more likely for component manufacturing than for LDV manufacturing that indirect effects result from price increases due to (temporary) scarcity of materials resulting from production capacity not being able to match the increased demand.
Do different cost elements per unit production increase or decrease more in EU than in other regions to the extent that they may lead to regionally different cost factors for EU vs other regions? If yes, is there a competitiveness impact for EU legislation affecting costs?

Legend: *YES*, *NO*, *MAYBE*.

- **YES**: If one or more cost factors for EU vs other regions may be affected, they will affect the shares of different activities needed to comply with legislation in EU. This will lead indirectly to different cost factors for EU vs other regions. These cost factors will affect the competitiveness impact for EU legislation affecting costs. Economies of scale and learning effects for non-EU production may require new technologies or other strategies dependence on limited marketing.

- **NO**: If new technologies or other strategies dependence on limited marketing is not considered, no competitiveness impact for EU legislation affecting costs will result. Legislation may affect the shares of different activities needed to comply with legislation in EU. This will lead indirectly to different cost factors for EU vs other regions. These cost factors will affect the competitiveness impact for EU legislation affecting costs. Economies of scale and learning effects for non-EU production may require new technologies or other strategies dependence on limited marketing.

- **MAYBE**: If new technologies or other strategies dependence on limited marketing is not considered, no competitiveness impact for EU legislation affecting costs will result. Legislation may affect the shares of different activities needed to comply with legislation in EU. This will lead indirectly to different cost factors for EU vs other regions. These cost factors will affect the competitiveness impact for EU legislation affecting costs. Economies of scale and learning effects for non-EU production may require new technologies or other strategies dependence on limited marketing.
Does post-2020 EU LDV CO₂ regulation lead to regionally different impacts related to the cost of purchased (sub)components?

- Not directly. The regulation does not directly affect the cost of components as it applies to LDVs and not to factors that determine the cost of component manufacturing.
- Indirectly the costs of purchased (sub)components as a share in the total costs of manufacturing components can be affected in the same way as was identified for the costs of purchased components for LDV manufacturing. This leads to similar cost-competitiveness impact pathways as identified for the case of LDV manufacturing (see section 6.2).
  - Positive cost competitiveness impacts for EU component manufacturing may arise due to economies of scale if the EU has more stringent LCV CO₂ regulation than other regions and if (sub)components for EU component manufacturing are also manufactured in Europe. Negative impacts may arise if the EU has less stringent legislation than other regions.
  - Positive cost competitiveness impacts for EU component manufacturing are to be expected as a result of differences in transport costs and tariffs if the EU (sub)component industry is able to deliver products to the EU as well as non-EU supply industry, and negative impacts if new (sub)component technologies are mainly manufactured in non-EU countries.
  - Overall the expected net impact depends on which cases are valid. In addition it should be noted that the situation is not static. EU suppliers that now source (sub)components regionally may choose to source (sub)components from Tier 2 suppliers in other regions if these have significantly lower costs. Tier 2 suppliers from outside the EU may also choose to locate production facilities in EU.
  - Indirect effects resulting from price increases due to (temporary) scarcity of production capacity for (sub)components is also here considered unlikely.

Does post-2020 EU LDV CO₂ regulation lead to regionally different impacts related to the cost of labour?

- Not directly. The legislation does not have a direct effect on labour conditions, wages, taxes or other factors that determine the costs per unit of labour.
- For the case of component manufacturing indirect pathways for cost competitiveness impacts related to labour costs are identical to those described for vehicle manufacturing.

Does post-2020 EU LDV CO₂ regulation lead to regionally different impacts related to the cost of capital goods?

- No direct impact is expected as the regulation does not affect the factors that determine the cost of capital goods per unit of production.
- Indirect effects on the costs of capital goods as part of the costs of manufacturing components mainly relate to possible differences in economies of scale and learning effects caused by differences in production volumes that relate to the level of stringency of legislation in the EU and other regions and the main production location for new components for advanced ICEVs and AFVs.
  - Positive cost competitiveness impacts may be expected if the EU has more stringent CO₂ legislation than other regions and if components for LDVs, sold in the EU, are mainly
manufactured in the EU. Other combinations of relative levels of stringency and production location could lead to negative or no cost competitiveness impacts.

- Cost competitiveness impacts are expected only if the cost difference between new and existing capital goods is different from the overall average difference in costs of equipment in different regions.
- Cost competitiveness impacts are in principle conceivable if there would be regional differences in the costs of tools and equipment for manufacturing new components to be applied in advanced ICEVs and AFVs. It is unclear whether this is to be expected but overall it appears quite unlikely.

- If large investments would be needed to adapt production processes in a short period of time, and especially if these investments are associated with high risks, this could affect the cost of capital. Differences in the profitability and financial position of EU and non-EU suppliers could then affect cost competitiveness.

**Does post-2020 EU LDV CO\textsubscript{2} regulation lead to regionally different impacts related to the overhead costs?**

- No direct impacts on the costs per unit of overhead activity are expected, but the amount of overhead per unit product might change.
- Possible cost competitiveness impact pathways are only identified in relation to the volume of products over which R&D costs can be divided. These depend on sales volumes which are determined by the stringency of CO\textsubscript{2} regulations in the EU and other regions and by the location of component manufacturing. There would be a positive impact if technologies developed and used in the EU market could subsequently be sold or licensed for use in non-EU markets.

### 8.2 Conclusions regarding cost competitiveness impacts on EU automotive component manufacturing

Table 9 summarizes the identified possible cost competitiveness impacts on automotive component manufacturing. Likely pathways for impacts are identified, but in the absence of a concrete proposal for the post-2020 targets and the modalities with which these are implemented it is at this stage not possible to predict the net sign and size of these impacts.

For component manufacturing only a limited number of pathways seem to result in likely impacts on EU manufacturing cost competitiveness. Where impacts are possible, they may be positive or negative. Conclusions seem to be quite generic and the same for the car and van regulation.

It is concluded that post 2020 EU LDV CO\textsubscript{2} legislation has no direct impact on the cost competitiveness of EU component manufacturing as the legislation is targeted at the CO\textsubscript{2} performance of LDVs and not at factors that determine the costs of producing them or their components.

A limited number of possible indirect impacts has been identified:

- The access to materials as well as the costs of these materials could be different for EU and non-EU suppliers. This especially relates to materials for electric powertrains and vehicle light-weighting.
and size of the effect cannot be determined at this stage, but effects are likely to be more pronounced for component manufacturing than for car manufacturing;

- With respect to the costs of purchased components small positive impacts could occur if the EU has more stringent regulation than other regions or if a large share of new (sub)components for advanced ICEVs and AFVs are produced in the EU. Small negative impacts may occur if (sub)components for advanced ICEVs and AFVs are mainly produced outside the EU;

- Regional differences in labour costs may have an impact of unknown sign and size as new technologies may require more or less labour or have a higher or lower share of (manual) labour in assembly or production;

- Some indirect impact pathways have been identified that relate to differences in the costs of capital goods and the volume of sales over which R&D costs can be divided. The size and sign of these impacts depend on the relative stringency of EU legislation.

Conclusions seem to be quite generic and the same for the car and van regulation.

Table 9 - Summary of possible cost competitiveness impacts on automotive component manufacturing

<table>
<thead>
<tr>
<th>Cost factor</th>
<th>Impact</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material costs</td>
<td>Maybe</td>
<td>• Relates to possible regional difference in materials needed for manufacturing components for advanced ICEVs and AFVs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sign and size of the effect cannot be determined at this stage, but effects are likely to be more pronounced for component manufacturing than for car manufacturing.</td>
</tr>
<tr>
<td>Costs of purchased (sub)components</td>
<td>Maybe +</td>
<td>• Small positive impacts could occur if the EU has more stringent regulation than other regions or if a large share of new (sub)components for advanced ICEVs and AFVs are produced in the EU.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Small negative impacts may occur if (sub)component for advanced ICEVs and AFVs are mainly produced outside the EU.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Finite impacts may occur if the effective stringency of the target is different for EU and non-EU OEMs:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Sign and size depend on target function which is not yet known.</td>
</tr>
<tr>
<td>Labour costs</td>
<td>Yes +/-</td>
<td>• An impact of unknown sign and size is possible as new technologies may require more or less labour or have a higher or lower share of (manual) labour in assembly or production. This will only lead to a finite effect if labour costs are different in different regions.</td>
</tr>
<tr>
<td>Costs of capital goods</td>
<td>Maybe</td>
<td>• Depending on possible regional differences in the costs of production tools for advanced ICEVs and AFVs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Significant impacts not considered likely.</td>
</tr>
<tr>
<td></td>
<td>+/-</td>
<td>• Positive / negative impacts on cost competitiveness associated with economies of scale and learning effects due to higher / lower volumes if EU has more / less stringent legislation than other regions</td>
</tr>
<tr>
<td>Overheads</td>
<td>Yes +/-</td>
<td>• The number of car sales over which R&amp;D costs can be divided depends on the relative stringency of CO2 regulation in the EU and other regions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Positive impacts expected if EU regulation is more stringent.</td>
</tr>
</tbody>
</table>
9. Effects of post 2020 regulation on cost competitiveness of the energy supply industry

9.1 Introduction

The post-2020 LDV CO\textsubscript{2} regulation does not directly affect the costs of producing petroleum-based transport fuels or alternative fuels or energy carriers for transport, as it does not target any of the factors that determine the costs of producing these energy carriers. Indirect impacts are very likely, though, as the legislation will affect the demand for different energy carriers and different companies may have different abilities to cope with this changing demand.

The energy supply sector can be divided into:
- producers of fuels and other energy carriers
  - the oil refining industry for petroleum based fuels
  - electricity generation
  - production of alternative (bio)fuels and energy carriers (e.g. hydrogen)
- distributors of fuels and other energy carriers
  - fuel distributors and operators of filling stations
  - operators of electricity distribution networks and operators of charging stations

Both sub-sectors contain large, medium-size and small companies. The analysis of possible cost competitiveness impacts will be done separately for the two sub-sectors.

The post-2020 EU LDV CO\textsubscript{2} legislation will lead to reduced demand for petrol and diesel. The extent to which it leads to increased use of alternative energy carriers, such as LPG, CNG / LNG, liquid biofuels, biogas, electricity or hydrogen, will depend on details of the regulation and how OEMs respond. Important modalities are the target level, the metric and specific provisions for alternative technologies such as super-credits. If the metric remains to be based on TTW CO\textsubscript{2} emissions as measured on the type approval test, low post-2020 targets are likely to promote the uptake of zero TTW emission energy carriers such as electricity and hydrogen, but also the demand for methane fuels may increase as this has lower CO\textsubscript{2} emissions per unit of energy. The demand for biofuels is not affected by a regulation based on TTW CO\textsubscript{2} emissions as measured on the type approval test, as the use of biofuels does not affect direct exhaust CO\textsubscript{2} emissions. This would be different if the regulation would give credits to vehicles running on biofuels\textsuperscript{22}. If WTW CO\textsubscript{2} emissions, or TTW or WTW energy consumption, is chosen as the metric, the leverage between conventional and alternative fuels would be greatly reduced (see [TNO 2013a]), and the increased demand for alternative energy carriers as a result of the legislation would be less pronounced.

\textsuperscript{22} As is currently the case in article 6 of Article 6 (Specific emissions target for alternative-fuel vehicles) of Regulation (EC) 443/2009, which specifies that credits are given to vehicles capable of running on E85 sold in countries where at least 30\% of the filling stations provide this type of alternative fuel complying with the sustainability criteria for biofuels set out in relevant Community legislation.
Effects of resources and legislation on cost competitiveness of companies in the energy supply sector

Figure 28 – Overview of pathways along which the LDV CO2 legislation and the capabilities and resources of companies can lead to cost competitiveness impacts on companies in the energy supply sector (focus on energy production sector)

Assessment of competitiveness impacts of post-2020 LDV CO2 regulation
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

Effects of resources/capabilities & legislation/OEM compliance strategies on competitiveness
9.2 Cost competitiveness impacts on producers of fuels and other energy carriers

Possible impact pathways of the legislation on producers of energy carriers for transport are sketched in Figure 28. Main impact pathways relate to the impact of changes in production volumes of different energy carriers on the production costs for these energy carriers, as well as on the extent to which additional costs can be passed on to the consumer.

Whether the identified impacts of the regulation on energy producers affect cost competitiveness, in the definition used in this report, depends on whether companies are effectively competing (in the EU or on other markets), on how the impacts affect costs for different competing companies or industries and if such differences are region-dependent. Changes in the cost of producing energy carriers only lead to cost competitiveness impacts if costs are different for different companies. Even if the impacts of the legislation, in terms of changes in demand and requirements to (dis)invest in production and distribution infrastructure and the resulting impact on costs, would be similar for different energy supply companies, their abilities to deal with these impacts may be different. This would also lead to possible impacts on cost competitiveness. A question therefore is whether there are regional differences in these abilities for the EU and non-EU fuel producing industry and whether this affects their competition on the EU market or globally.

Producers of petroleum-based fuels

For the EU petroleum industry a reduction in the use of petrol and diesel by LDVs in the EU, as a result of LDVs becoming more fuel efficient, could lead to a reduced utilisation of existing production facilities (refineries) and distribution infrastructure (pipelines, filling stations), leading to higher production costs per unit of product. This could exacerbate a currently on-going trend of increased under-utilisation of refining capacity in the EU that is illustrated in Figure 29. Very likely refineries and distribution facilities will need to be closed, which may represent destruction of capital if this is done before the end of their economic lifetime. The latter, however, is less likely as many of Europe’s refineries are already in use for several decades. If, on the other hand, the older and less efficient refineries are closed, this could actually lead to a reduction in average production costs.

While costs per unit output could increase, the declining market is likely to increase competition which puts pressure on prices. As indicated in section A2.6.2 such competition does not only exist between European refineries / fuel suppliers. Diesel from EU refineries is already supplemented with diesel imported from the US and FSU, the latter often still needing processing in the EU, while according to FuelsEurope23 in the coming years EU refineries are expected to encounter competitive pressure from newly opened refineries in India and the Middle-East, which have production capacities that for some amount of time will exceed local demand.

23 https://www.fuelseurope.eu/dataroom
Reduced LDV diesel consumption in the EU, resulting from post-2020 LDV CO$_2$ legislation, will decrease the need for diesel imports. But as LDV petrol demand will also decrease, and HDV diesel demand does not (or at least not at the same rate), the diesel to petrol ratio in the demand from the transport sector further increases. This will worsen the mismatch with the optimal refinery output mix and may therefore put more pressure on the profitability of EU refineries.

The EU is a net exporter of gasoline and EU refinery products compete on markets outside the EU. The US is an important market for EU petrol exports, but due to CO$_2$ regulations in place in the US and the mandating of ethanol blending, demand for gasoline from the US will decline. This will reduce opportunities for EU refineries to export surplus gasoline further reducing this option for EU refineries. However demand is growing elsewhere. The size of this effect will depend on the stringency of future legislation in the US and the rate at which demand grows in other markets.

The extent to which companies can absorb lower margins or even losses, depends on their financial position, the share of their EU sales in their sales world-wide, and developments in markets in other regions. The extent to which EU refineries are owned by global companies, and the extent to which these are able and willing to sustain low profits or losses on these refineries, are thus important factors. Information on these aspects, however, has not been collected so that no conclusions can be drawn on this. However, there is evidence major oil companies are seeking to divest from EU refining.

If the focus is on EU versus non-EU companies, the following conclusions can be drawn with respect to cost competitiveness impacts for producers of petroleum based fuels:

- A declining demand for petroleum fuels, resulting from post-2020 EU LDV CO$_2$ legislation, will put pressure on the price of fuels. At the same time refinery utilisation rates are expected to go down unless there are sufficient refinery closures, leading to an increase in costs per unit production. The combination
of the two will strongly reduce profitability of EU refineries. This means that it will become more difficult for the products of these refineries to compete on the EU markets with imports from Russia or new state-of-the-art refineries being opened in India and the Middle-East.

- Refineries are mostly owned by large, often global companies competing on various regional markets. The ability of companies to deal with changes in the EU market may depend on the size of their European activities and the share of these in their global activities. Impacts may also depend on the extent to which they produce in the EU for the EU market or also import and export to and from the EU. With the information available it is not possible to “predict” what the strategic decisions of such global companies will be in response to the effects of post-2020 EU LDV CO\textsubscript{2} legislation on the demand for fuels in Europe.

- In decisions on (dis)investments in refining capacity, also the status of facilities may play a role as decommissioning refinery capacity is more costly for newer than for older facilities. It is likely that there are differences in this respect between different refineries in Europe, but this has not been assessed. The need to close refineries in Europe may thus affect competition within the EU refining sector, but this is not to be considered a cost competitiveness impact for the EU refining sector as a whole.

- Closing of refineries in the EU will lead to a loss of jobs and of value added within the EU. This is an economic impact that is likely to happen if EU LDV CO\textsubscript{2} legislation is effective, but that could be amplified by the fact that European fuel producers are affected more severely by the legislation than producers outside the EU which operate new facilities and have a large share of their sales in markets that are still growing.

**Producers of alternative energy carriers**

If car manufacturers choose to meet the target with an increasing share of alternatively fuelled vehicles, this will lead to increased demand for e.g. natural gas, electricity, hydrogen and/or biofuels. Whether this may lead to cost competitiveness impacts for EU companies producing these energy carriers depends on the type of energy carrier:

- **Natural gas**: Production infrastructure for natural gas exists and will be able to provide the additional supply needed. Improved utilisation of existing infrastructure may offer potential cost reductions, but the net impact on costs depends strongly on the purchasing price of the additional natural gas. Additional demand for natural gas in Europe will be largely met by imports from Russia or other regions (by pipeline or in the form of LNG transported by ship), but within the EU will be mostly traded and transported by European (and often still national) companies. Also these can thus be considered not to compete with non-EU companies, so that no cost competitiveness impacts are to be expected for EU natural gas supply companies or the EU natural gas supply industry as a whole.

- **Electricity**: The existing production infrastructure for electricity will be able to provide the additional supply needed in the 2020-2030 timeframe. Also here improved utilisation of existing infrastructure may offer potential cost reductions, but the net impact on costs depends strongly on the price of the additional primary energy used for electricity production. Electricity is not traded between the EU and other regions at any significant scale. Electricity production and supply companies tend to have a regional focus, so that European electricity production and supply companies can be considered not to compete with companies in other regions. As a result LDV CO\textsubscript{2} legislation will not have cost competitiveness impacts
on the EU electricity generation industry. Mutual cost competitiveness of EU companies, may be affected though.

- **Hydrogen:** Existing hydrogen production infrastructure (e.g. at refineries) may be able to generate additional hydrogen to supply the first vehicles on the market. Already at fairly modest market penetration levels investments in hydrogen production infrastructure is likely to be necessary. Hydrogen can in theory be transported over longer distances allowing for trade between regions, but in the next decades it is not expected that this will happen, among other things because long distance transport of hydrogen is less practical due to its low density. Hydrogen production and distribution will be organised within the EU, so that also here companies can be considered not to compete with companies outside the EU. This means that also for the EU hydrogen production industry no cost competitiveness impacts are to be expected from post-2020 LDV CO\textsubscript{2} legislation.

- **Biofuels:** As indicated above, post-2020 EU LDV CO\textsubscript{2} legislation will only lead to increased demand for biofuels if a different metric is chosen than the current one or if specific provisions would be included that promote the marketing of vehicles running on biofuels. If demand for biofuels increases, this will improve the utilisation of existing production capacity, and will require investments in additional production infrastructure. Liquid biofuels can be easily transported over long distances, and their production occurs largely in global competition (albeit in a market that is heavily distorted based on subsidies). If EU CO\textsubscript{2} legislation for cars would lead to higher demand growth in Europe than in other markets, this could lead to higher investments, accelerated economies of scale and innovation in products and production systems in Europe. This may improve the cost competitiveness of European biofuels production, as it provides European companies a possible cost advantage for competition on the EU market as well as other markets. As biogas production, especially from waste streams, is more likely to happen within Europe for the European market, such competitive advantages would not occur for the biogas industry.

**Further considerations**

In the above it is assumed that different energy carriers are not supplied by the same company. Also it is assumed that companies producing one energy carrier are not in competition with companies that produce other energy carriers. These assumptions, however, may not be true or may not remain true. If oil companies decide to become energy suppliers to the transport sector rather than fuel suppliers, they could grasp part of the market for new energy carriers. Depending on their resources and capabilities some may be in a better position to pursue such a strategy than others. This would not only blur the distinction between the two energy producing sub-sectors but could also be seen as a strategy to cope with a reducing demand for petroleum fuels in Europe. Although such a transition is promoted by the Fuel Quality Directive, which contains elements aiming at decarbonisation of energy carriers for transport at company level, it is at this point unclear whether oil companies will adopt such a strategy.

A further interaction between the two subsectors is via the EU-ETS. All large energy producing plants are subject to this cap & trade system for CO\textsubscript{2}. If alternative energy carriers produced in the EU are not fully derived from renewable or other low-CO\textsubscript{2} primary energy sources, emission rights need to be bought for the additional production of alternative energy carriers. A shrinking petroleum industry could generate revenue from selling credits. CO\textsubscript{2} emissions per unit energy output are generally lower in the petroleum industry than in (partly fossil based) production of electricity and hydrogen. On the other hand final energy demand...
reduces when vehicle propulsion switches from petroleum fuels to electricity or hydrogen. It is therefore unclear whether the possible supply of credits from the petroleum industry is likely to be smaller or larger than the demand from a growing electricity and hydrogen generation industry.

Besides cost competitiveness impacts on companies of the changes in costs of energy production as a consequence of the LDV CO\textsubscript{2} regulation could also affect the mutual cost competitiveness of ICEVs and AFVs. This may in turn affect the choice of compliance mechanisms by OEMs, leading to a possible feedback loop to the consequences of the legislation that are the starting point for assessing cost competitiveness impacts on the energy supply industry.

9.3 Cost competitiveness impacts on distributors of fuels and other energy carriers

Distribution of conventional fuels
The structure of the European fuel distribution sector is very much different from that of the fuel production sector. As indicated in section A2.6.1, major oil companies (ExxonMobil, Shell, BP, Total and Chevron) now own just a third of Europe’s petrol filling stations and this share may even decline as the largest oil companies are now seen to place greater emphasis on upstream activities, namely exploration and production. Independent petrol retailers, most of which are SMEs, own 20% of all petrol filling stations across Europe. The rest of the market is served by larger, independent fuel distribution and retail companies.

Margins on the sales of fuel are generally low in Europe, so that filling stations have to earn an increasing share of their income through the shop-sales of other products. A decline in EU petrol and diesel sales as a result of the CO\textsubscript{2} legislation will lead to decreasing turnover for existing filling stations. With costs remaining the same, this will lead to even lower profit on the fuel sales. Very likely the number of filling stations will continue to reduce in the coming 10-15 years, or become more automated, leading to a loss of jobs in the sector. Stakeholders believe that SMEs are more likely to suffer from this than larger companies active in the sector.

If LDV manufacturers choose to meet the target with an increasing share of alternatively fuelled vehicles, this will lead to increased demand for e.g. natural gas, electricity, hydrogen and/or biofuels. The impact of a decreasing petrol and diesel sales on the EU fuel distribution sector can be reduced if these companies capture a significant part of the market for these new energy carriers. For biofuels this is likely to happen, but natural gas and hydrogen can in principle be integrated in existing filling stations. Even fast charging stations for electric vehicles could become part of “energy stations” serving a range of conventional and alternative energy carriers.

The above impacts, however, should be qualified as economic rather than cost competitiveness impacts from an EU versus non-EU point of view. Fuel supply companies operate locally or regionally, but do not directly compete with companies in other regions (apart from some cross-border competition between adjacent EU and non-EU countries). Even if companies from outside the EU take an increasing share in the EU fuel distribution and supply infrastructure (for example Lukoil and Q8), they would operate those facilities
in the EU. This would therefore not affect jobs, value added or investments in the EU in a significant way, compared to these facilities being owned by EU companies.

Distribution of alternative fuels
Increasing the supply of alternative energy carriers requires investments in the distribution and supply infrastructure for these energy carriers. This is especially the case for natural gas, electricity and hydrogen, less so for liquid biofuels. For biofuels blended in conventional petrol and diesel no additional distribution infrastructure is needed. Selling dedicated biofuel vehicles (e.g. E85 or B100) would require investment in distribution of these dedicated fuels, but costs would be more limited than for electricity and hydrogen as this infrastructure is incremental to the existing transport fuel distribution system.

In the period in which this infrastructure is expanded the market for companies that build such infrastructure or supply components for it will increase. This could lead to economies of scale and innovations in products and production processes, which will improve the cost competitiveness of such companies also on markets outside the EU.

9.4 Conclusions on cost competitiveness impacts on the fuel supply sector

- A declining demand for petroleum fuels, resulting from post-2020 EU LDV CO₂ legislation, will increase competition in fuel supply. For fuel producing companies lower volumes mean that refinery utilisation rates are expected to go down, leading to an increase in costs per unit production, unless sufficient refinery closures occur. The combination of the two will strongly reduce profitability of EU refineries. This means that it will become more difficult for the products of these refineries to compete on the EU market with imports from Russia or new state-of-the art refineries being opened in India and the Middle-East.
- Refineries are mostly owned by large, often global companies competing on various regional markets. The ability of companies to deal with changes in the EU market may depend on the size of their European activities and the share of these in their global activities. Impacts may also depend on the extent to which they produce in the EU for the EU market or also import and export to and from the EU. With the information available it is not possible to “predict” what the strategic decisions of such global companies will be in response to the effects of post-2020 EU LDV CO₂ legislation on the demand for fuels in Europe.
- Closing of refineries in the EU will lead to a loss of jobs and of value added within the EU. This is an economic impact that is likely to happen if EU LDV CO₂ legislation is effective, but that could be amplified by the fact that European fuel producers are affected more severely by the legislation than producers outside the EU which operate new facilities and have a large share of their sales in markets that are still growing.
- Companies that operate fuel distribution infrastructure and filling stations in the EU operate locally or regionally, and are not directly competing with companies in other regions (apart from some cross-border competition between adjacent EU and non-EU countries). Reduced demand for petroleum-based fuels could lead to negative economic impacts on this sub-sector of the fuel supply sector, including a significant loss of jobs and value added, but these are not to be classified as cost competitiveness impacts.
10. Effects of post 2020 regulation on cost competitiveness of (professional) end users

10.1 Introduction
For companies that use cars and vans, either to provide transport services to clients or as part of their own operations, the total cost of ownership (TCO) for using these vehicles is an element in their cost of doing business. If the post-2020 EU LDV CO\textsubscript{2} legislation affects the TCO of vehicles, it directly affects the costs of doing business for all companies that use LDVs (professional end-users).

10.2 Identification of possible impact pathways
Pathways along which post-2020 EU LDV CO\textsubscript{2} legislation may lead to cost competitiveness impacts on professional end-users are indicated in Figure 30. Changes in the cost of doing business for a company affect the price of its products and/or services, which may affect competition in the market and lead to a change in market shares. If prices change similarly for all competitors, an overall change in the volume of the market is likely to occur. This may lead to a change in the utilization of facilities of these companies and thus to a further change in the costs per unit product or service. If these effects work out differently for competing companies, e.g. as a consequences of differences in their resources and capabilities that are associated with the region in which they are based or operate, cost competitiveness may be affected.

Making ICEVs more energy-efficient generally leads to a higher vehicle price but lower fuel costs. The net effect on TCO depends on the amount of efficiency improvement, the related additional vehicle costs and the costs per unit of fuel. Figure 31 indicates that levels that may come into view for the 2020-2030 period can be achieved with net negative costs to the end user based on cost curves for 2020 emission reductions. It is expected that new cost curves for the 2020-30 period will suggest higher reductions to be possible at lower costs, further increasing the cost effective reduction potential for the-end user.

Alternative fuelled vehicles (AFVs) tend to be more expensive than ICEVs. The fuel costs per kilometre differ strongly for different energy carriers, partly because no or less tax is levied on them. Currently most AFVs (without tax incentives) have a TCO that is higher than that of ICEVs. In the 2020-30 timeframe the TCO of most AFVs is expected to approach that of ICEVs.

In addition to a change in TCO the technologies applied to ICEVs as well as AFVs may have an impact on the reliability and operability of vehicles, which may affect the value of the product or services supplied. Implementing BEVs with limited range may affect the way in which end-users use their vehicles and may even require changes in their operations or way of providing services. This may be seen as a reduction in the value added by operating such vehicles. On the other hand, the use of electric powertrains is expected to lead to lower maintenance costs, which may improve the TCO of BEVs.
Figure 30 – Overview of pathways along which the LDV CO₂ legislation and the capabilities and resources of companies can lead to cost competitiveness impacts on (professional) end-users
Factors affecting Δ price competitiveness of end user:
- Δ quality of provided service
- Δ costs of provided service
- Cost pass-through factor
- Δ price of provided services

Factors affecting Δ price competitiveness for other end user(s):
- Δ quality of provided service
- Δ price of provided service

Δ price competitiveness for end user
- Δ competitiveness
- Δ volume of products or services

Δ long term cost competitiveness of company

Δ short term cost competitiveness of company

In case better competitive position results in higher profits

Δ profitability

Sales volumes affect cost of production and profitability of production facilities

Impact of changes in short term competitiveness on long term competitiveness are determined through impacts on various resources and capabilities

Δ long term cost competitiveness of company

Δ short term competitiveness of company

abilities to provide service at lower costs compared to other (professional) end users

abilities to maintain current customers even though price of services is higher

In case better competitive position results in higher profits

Δ long term cost competitiveness of company

Δ short term competitiveness of company

Δ price competitiveness of end user

Δ volume of products or services
Calculations as presented in Figure 17 (see section 5.4) indicate that at least for BEVs and PHEVs compliance strategies consisting of a combination of improving ICEV efficiency and introducing a finite share of AFVs leads to a net reduction of cost from an end-user perspective. Provided that the target is not set extremely low, post-2020 CO$_2$ legislation may thus be expected to lead to an on average net reduction in the TCO of LDVs for end-users. This, however, remains to be confirmed by currently on-going studies with respect to costs and modalities of post 2020 LDV CO$_2$ regulations.

*Figure 31 – Indicative assessment of impacts on costs to end-users of CO$_2$ emission reduction in passenger cars and vans, based on 2020 cost curves derived in [TNO 2011] and [TNO 2012]*

Changes in the TCO of vehicles only lead to cost competitiveness impacts if the changes in costs are different for different, competing companies. In this respect it seems reasonable to assume that companies that compete on the same market in the EU with similar products or services will have similar LDV fleets. If these fleets are registered in the EU, also for non-EU companies, the TCO of these vehicles, and the cost of doing business for companies using them, will be affected similarly as a result of the LDV CO$_2$ legislation. From this perspective the legislation does not affect the competition between companies on the EU market.

The condition that LDV fleets are registered in the EU seems applicable to companies that use LDVs for transport services to clients, as LDVs are not used for long-distance interregional transportation of persons or goods. As a consequence companies that use LDVs for transport services to clients are most likely EU-based companies, which are not in competition with companies from other regions.

For EU companies that use LDVs as part of their operations for providing other products or services, which may be competing with products and services from non-EU companies on the EU market as well as on markets in other regions, the change in TCO of LDVs affects their cost of doing business and thus the cost of their products and services. Whether this affects their cost competitiveness relative to companies from other regions depends on whether other regions have LDV CO$_2$ legislation of similarly stringency as well as on the fuel prices in the EU and other regions. The fact that post-2020 EU CO$_2$ legislation is in principle expected to lead to net reduction of end-user costs, can be considered a positive cost competitiveness impact of the
legislation. If different regions have LDV CO₂ regulations with similar levels of stringency, EU companies are expected to benefit more as fuel prices are generally higher in Europe than in other regions. This means that the fuel cost savings per unit of CO₂ reduction are higher in Europe. However, the size of this impact is expected to be small. For companies that are not directly involved in the transport of people and goods, transport costs are usually only a small part of the total cost of operation, and the majority of transport costs will be related to goods transportation using HGVs (trucks) or other modes of transport. The costs of these are not affected by the LDV CO₂ legislation. This means that even if CO₂ legislation in other regions would lead to higher cost reductions for companies from those regions, the negative cost competitiveness impacts would be limited.

10.3 SMEs

The wide variety of end-users contains a large number of SMEs. EU-based SMEs making extensive use of LDVs in their operations will in general not be competing with non-EU companies, even if the LDVs are not directly used for providing transport services. Companies competing on the EU market will be similarly affected by post-2020 LDV CO₂ regulations. For end-user SMEs, therefore no impact on their cost competitiveness is expected.

10.4 Conclusions on cost competitiveness impacts on professional end-users

Cost competitiveness impacts for professional end-users of LDVs are only to be expected for EU companies that provide products or services that compete on the EU market or other markets against products and services from non-EU companies. Positive impacts are expected as the post-2020 EU CO₂ legislation is in principle expected to lead to net reduction of end-user costs. If different regions have LDV CO₂ regulations with similar levels of stringency, EU companies are expected to benefit more as fuel prices are generally higher in the EU. However, the size of this impact is expected to be small, as the costs of operating LDVs is generally only a small fraction of the cost of doing business. These slightly lower costs for companies operating in the EU will result in a net positive (albeit small) improvement in EU cost competitiveness overall.

EU-based SMEs, which in their operations make extensive use of LDVs, will in general not be competing with non-EU companies, regardless of whether or not these LDVs are directly used for providing transport services. Companies competing on the EU market will be similarly affected by post-2020 LDV CO₂ regulations. For end-user SMEs, therefore no impact on their competitiveness is expected.
11. Impacts on innovation competitiveness

11.1 Introduction

The key question regarding innovation impacts of the post-2020 LDV CO\textsubscript{2} legislation is whether and how the LDV CO\textsubscript{2} regulation can impact on innovation activities and innovation capabilities of the affected sectors (including OEMs, component manufacturers, energy supply companies and professional end users) and as a consequence influence their innovation competitiveness.

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**Innovation Definitions**

Key terms used throughout this section in the context of this study are understood as follows:

**Innovation activities** are any activities of a company or other organisation that aim at contributing to the implementation of new or improved products and processes. Activities may be innovative as such but not necessarily as non-novel activities are necessary for implementation.\textsuperscript{24}

**Innovation capability** is a set of attributes of a company or other organisation that enable them to effectively engage in innovation activities. These factors are grouped as follows in the context of this study: 1) Capacity for in-house R&D, 2) Capacity for in-house product and process innovation, supply of skills etc., 3) Capacity for R&D externalisation, 4) Capability to produce and acquire industrial patents and 5) Access to finance.

**Firm Competitiveness** is the ability to compete in markets for goods or services.\textsuperscript{25} Competitive Advantage gives a firm (an OEM or component manufacturer) an edge over its rivals.\textsuperscript{26}

**Impacts on innovation competitiveness** relate to effects of a policy on a company's innovation capability that impacts on their competitiveness (measured either by market share or leadership in a specific market segment).\textsuperscript{27} The need to introduce innovations to comply with regulatory requirements may change the relative positioning between industry players. Note that: 1) the effect of the policy may in fact have both a positive and a negative influence on innovation competitiveness depending on the innovation capabilities of OEMs and component manufacturers, in particular EU vs. non-EU OEMs and component manufacturers, 2) the nature of impacts may differ depending on both innovation capabilities and compliance strategies chosen by different OEMs and component manufacturers and 3) the nature and timing of impacts may differ depending on how advanced OEMs and component manufacturers are in the innovation process needed to comply with the regulation.

The LDV CO\textsubscript{2} legislation has been found to generally promote innovation in terms of development and deployment of advanced technologies for conventional and alternative vehicles according to the Commission’s Impact Assessment study (2013) regarding 2020 targets. This can be seen in increases in the rate of deployment of CO\textsubscript{2} reducing technologies in new LDVs. According to the public consultation held in 2011, “72% of stakeholders and 83% of individuals agreed or partly agreed that EU regulation of road vehicle emissions stimulates innovation in the automotive sector and helps keep Europe's automotive

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\textsuperscript{26} See the Economist’s Glossary available at: http://www.economist.com/economics-a-to-z/c#node-21529835

\textsuperscript{27} See Competitiveness Proofing Toolkit, available at: http://ec.europa.eu
Depending on the rate at which OEMs need to apply new technologies or other innovative solutions to comply with post-2020 LDV CO\textsubscript{2} legislation and on the economic conditions and financial capacity of the automotive industry, CO\textsubscript{2} reduction targets may pose challenges for research, development and innovation (RDI) both in terms of required knowledge, skills, budgets and timing of investment.

In terms of **Innovation Competitiveness** the 2013 impact assessment also concluded that there is no evidence suggesting that the implementation of 2020 targets would fundamentally alter the competitive position of EU OEMs. The conclusion was drawn due to the expectation that innovation capacity would increase as measured by data regarding R&D investments undertaken by OEM’s and component manufacturers (in terms of both investment size and type of investment). These investments, the authors observed, consolidated the leading position of EU OEMs in some of the transitional drive-train and fuel technologies (EC, 2013[a]). Similarly, no evidence on competitiveness impacts was found for skills i.e. R&D employment or IPR protection.

Analysing Innovation Competitiveness impacts of EU post-2020 LDV CO\textsubscript{2} legislation requires an understanding of the relative positioning of EU companies versus companies from other regions and the level and type of changes required to comply with the LDV CO\textsubscript{2} legislation. The reflection needs to include the following main elements:

- Other region’s current and expected stringency of LDV CO\textsubscript{2} legislation and current differences in the capabilities of EU companies versus companies from other regions. The innovation competitiveness landscape may change depending on the relative positioning of EU OEMs vs. OEMs from other regions with respect to innovative technologies required to comply with the post-2020 LDV CO\textsubscript{2} legislation.
- Demand for innovations driven by the LDV CO\textsubscript{2} regulation, in the EU and in other regions, which is critical for the competitiveness of EU OEMs depending on their current presence or aspiration to penetrate EU and foreign markets.
- Costs of carrying out the required RDI and costs of patenting and acquiring licences. Together with the general economic conditions, market trends and differences in labour and capital costs, decisions regarding relocation of R&D centres and/or development centres or externalising RDI activities may take place as a means to remain competitive in the market. While remaining competitive in a global market is of the essence for EU OEMs a significant part of the value creation may be lost.

In terms of the **temporal dimension of impacts**, it is important to consider whether and how the introduction of regulation influences time and timing of RDI activity needed to meet externally or internally imposed targets. More specifically, this relates to different needs of the innovation process in terms of capital investment, human resources and RDI infrastructures depending on the stage of the process. Different compliance strategies may impact the innovation process and also ultimately innovation competitiveness of an OEM or other related actors.

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In this context, innovation competitiveness impacts may be assessed not only in relation to the distance to the target (i.e. innovation gap) but also considering the past RDI activity and investments and overall innovation strategy of an actor in focus (e.g. have OEMs RDI strategies and investment been aligned with the direction of change imposed by the new regulatory pressure?). The latter relates to the dynamics of RDI developments, which may indicate whether new regulatory pressure requires short- or medium-term action. This dimension is relevant for analysing the relative positioning of EU OEMs compared to OEMs from other regions along the time pathway.

More specifically, by time-pathway dependent innovation competitiveness we refer to the differences in terms of resources, capabilities or market positioning from idea generation, through product design, R&D and testing to innovative ways to commercialise the product and/or service. Different compliance strategies aiming to reduce both the cost and the time of the entire process may impact RDI activity and investments and also ultimately innovation competitiveness of an OEM or other related actors.

11.2 Literature on innovation impacts of regulation
The literature dealing with the effect of regulation on innovative activities emphasises the need to take account of the systemic nature of innovation activities and the difficulties in attributing innovation effects to regulation. General findings from the literature review are presented below before looking at specific evidence on the automotive sector.

Relation between regulation and innovation: The introduction of the Porter hypothesis suggested that strict environmental regulations could induce efficiency and encourage innovations that help improve commercial competitiveness (Porter 1995). Empirical evidence compiled by the Community Innovation Survey - 2008 survey, that contains the environmental innovation module, showed that the regulatory factor plays an important role in introducing environmental innovations. The innovation literature nevertheless suggests that regulation is but one of the factors influencing innovation. Based on the innovation system approach innovation evolves within a system in which many interconnected factors play a role (e.g. framework conditions, technological capabilities, culture).

Type of regulation: Innovation effects have been found to be stronger when due to national rather than supra national regulation (i.e. involving more than one country) (Popp 2006). Also, the Community Innovation Survey - 2008 survey, showed that the importance of expected regulations is significant.

Sectorial divergence: Empirical evidence suggests that innovation effects of regulation vary by area (Frondel et al. 2007; Kammerer 2009). The Community Innovation Survey showed that transport was among the sectors introducing environmental innovation in response to regulation. Transport (29% of companies) is the fourth most highly influenced sector after water (47% of companies), energy generation (electricity, gas, steam and air conditioning supply; 40% of companies), mining (35% of companies) and construction (31% of companies). The influence from the prospect of future regulation was strikingly high for transportation (26% of companies) following three other sectors, in particular water (38% of companies), energy sector (37% of companies) and mining (27% of companies).
Type of Innovations induced by regulation: Evidence suggests that regulation plays an important role in fostering end-of-the-pipe technologies whereas other measures, such as environmental management schemes and energy and material cost saving measures, seem to be more important when it comes to the introduction of cleaner production technologies or resource efficiency measures (Frondel 2007, Fleiter 2013).

Attribution of impact to regulation: The attribution of innovation effects to a specific regulation is methodologically challenging as well as strongly context dependent. The academic work focussing on the interface of regulation and innovation is rather descriptive since the relation between regulation and innovation is complex, most often indirect and often evolving over long time periods and thus bearing effects with long time lags. A relevant distinction that is made is between intended and unintended and direct and indirect effects. This occurs since between the implementation and occurrences of a regulation’s effect, several other measures may be introduced which trigger changes and thus, other circumstances than the regulation itself may influence innovation.

In the automotive sector (and subsectors), the positive role that regulation and policies play in increasing environmental innovation is supported by the academic literature, notably with the use of patent data. De Vries and Medhi (2008) studied the role of environmental regulation in innovative activities in automotive emission control in the EU, the USA and Japan. The study was based on patenting data from 1975-2001. It brought evidence that increasingly integrated abatement strategies are due to policy “shocks” (regulation introduction). It also showed that a policy shock in other countries could spur innovation also in countries where such a shock is not occurring. However, the study was inconclusive on the impact of the stringency of regulation on innovation.

The study by Aghion et al. (2012) estimated the impact of a carbon tax proxied by data on tax-inclusive fuel prices on patenting activities in “clean” (e.g. electric and hybrid) and “dirty” (internal combustion engine) technologies in the automotive industry. The study used patenting data from 3,423 firms and individuals between 1965 and 2005 across 80 patent offices. Consistent with what theory predicts the study found that “clean” innovation is stimulated by increases in the tax-inclusive fuel prices (proxy for a carbon tax) whereas dirty innovation is depressed.

Volleberg (2010) also focused on the impacts of motor vehicle fuel taxes and mandatory fuel efficiency standards on relevant car-related innovation activity measured through patenting in selected car-producing countries. The study showed that important regulatory interventions by governments in Germany, Japan and the US have induced serious inventions in the car market. Regulatory pressure was considered much more important than autonomous and contemporaneous effects from changing net of tax fuel prices. Standards, in particular for CO₂ and to a lesser extent NOₓ emissions, strongly correlated with inventions in emission abatement (‘emission’), engine redesign (‘input’) and fuel efficiency (‘output’) technologies. Fuel taxes have an impact, in particular on the technologies that increase fuel efficiency. A limited effect is observed for fuel
efficiency standards, an expected outcome given that CAFE standards were only tightened in 2012 while Europe had no such standards prior to the current legislation which was agreed in 2009.

Patents are, however, but one output of innovation activity. An interesting complement to the latter findings is provided by the study conducted by the Sectoral Innovation Watch (SIW) based on survey data. The survey results indicated that the overall size and frequency of environmental regulations significantly associated with automotive innovations is relatively low compared to other sectors monitored in the SIW (Montalvo and Koop, 2011). The conclusion was based on the number of statistically significant correlations between specific types of innovation and regulations. The authors note that most of the regulatory attention focused on energy efficiency in final automotive goods while the rest of the provision system is not pressured directly by regulation to innovate but by specifications provided by OEMs. In other words, the pressure might be transmitted through the supply chain management dominated by main brand companies. Normally the dominating company indicates desired changes in intermediate goods to suppliers through new standards and design modifications.

11.3 Approach to assessing regulatory impacts on innovation competitiveness

The analysis considers whether regulatory impacts of different options and possible strategies may result in innovation in products and processes. Competitiveness impacts are subsequently assessed on the basis of the differences in RDI capacity and costs of RDI.

Innovation competitiveness focus

- The focus is on manufacturers and in particular the R&D and Innovation capacity of European companies and competing companies from other regions: To distinguish the European versus companies from other regions we refer to the analysis made in sub-chapter 2.5. The principal definition chosen is the location of headquarters / owner.
- The focus on European manufacturing versus manufacturing in other regions: the current concentrations of RDI activity and whether changes in the location of RDI activity to comply with the LDV CO₂ legislation would seem likely is addressed within the most relevant pillar, “Capacity for in-house R&D” and in particular “R&D investment in personnel (R&D centres)”.

To better understand the approach and structure of the chapter we summarise the steps undertaken in a flowchart (see figure 6.1) showing the four steps (top row from left to right) and a short description of key aspects (second row below each step).

In designing the approach considerations with respect to the timing of this assessment are made and in particular the main limiting factor the lack of a defined post-2020 LDV CO₂ legislation proposal. The way we deal with this is by grouping the regulation modalities in terms of their RDI intensity and focusing on main compliance strategies (step I). On the basis of the compliance strategies in the RDI context key questions are identified (step II) that help structure the collection of baseline data and form the basis of the interview questions to stakeholders (step III, see also Annex 3 on how the interviews were conducted). The assessment of impacts (step IV) is made based on the collected evidence and complemented by the insights provided in chapters five to ten.
**Modalities of the Regulation**

While the core focus is placed on compliance strategies as a result of a more stringent target, the impact of other modalities of the regulation on OEMs capacity to innovate and innovation competitiveness must also be assessed. Compliance strategies are expected to vary by legislative option. Given however the large variation of possible modalities, we emphasize compliance strategies irrespective of their link to the regulatory modality. The objective thus is to use our understanding of the modalities to identify the compliance strategies subsequently scrutinised in terms of their impact on capacity to innovate and competitiveness.

**Compliance strategies and corresponding RDI intensity**

Compliance strategies to the post-2020 LDV CO₂ legislation may vary in their degree of RDI intensity. This is showcased by reflecting on the identified options, distinguishing them in medium/high RDI intensive and low-RDI intensive options of compliance strategies. The degree of RDI intensity relates to technological innovation required by the legislation. Low RDI intensive compliance options may require more organisational or marketing rather than technological innovation from OEMs and are hence classified as low.

The potential OEM’s compliance strategies corresponding to the Medium to High RDI intensity in Table 10 where innovation is central include:

- Product and service innovation (in-house);
- Technological process innovation (in-house);
- Purchase of technology;
- Strategic partnering for R&D;
- Strategic partnering for product/service innovation;
- Organisational change (including vertical re-organisation of supply chain and/or geographical relocation).
Table 10 - RDI intensive compliance strategies options leading to a mix

<table>
<thead>
<tr>
<th>RDI technological intensity</th>
<th>Compliance Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium to High RDI intensity:</td>
<td>Applying additional CO$_2$ reducing technologies to ICEVs</td>
</tr>
<tr>
<td></td>
<td>Applying eco-innovations</td>
</tr>
<tr>
<td></td>
<td>Increasing shares of AFVs</td>
</tr>
<tr>
<td>Low RDI intensity:</td>
<td>Utilising test flexibilities</td>
</tr>
<tr>
<td></td>
<td>Increase average utility parameter value (without affecting CO$_2$)</td>
</tr>
<tr>
<td></td>
<td>Change sales (eligibility for derogation)</td>
</tr>
<tr>
<td></td>
<td>Pool with other OEM group</td>
</tr>
<tr>
<td></td>
<td>Pay excess premiums for non-compliance</td>
</tr>
</tbody>
</table>

Product and service innovation can result in new products and services introduced on the market by OEMs, including engine improvements, introduction of new materials (e.g. light-weight materials), new design etc. Low-carbon product or service innovation will also result in reduced CO$_2$ emissions in the use phase. Technological process innovation is innovation in production processes leading to labour and resource efficiency gains. Strategic partnerships for R&D and product/service innovation may be formed when the option of following the innovation cycle to develop the technologies in house is weighed against costs and time path considerations. Organisational change in the RDI context may be pursued to set up an appropriate organisational setting (e.g. sufficient supply of qualified labour, access to infrastructure) to develop the technologies required to meet the targets and/or cost of labour.

The translation of the compliance options of medium to high RDI intensity into “innovation language” represents the core of the subsequent analysis.

Key questions: Innovation Impact Matrix

To identify key questions (see Table 11) we start from the five dimensions as requested in the TOR (see column capacity to innovate pillars) and combine it with the EC’s Impact Assessment Competitiveness Proofing Toolkit. After having identified the questions we link each one of them to a set of indicators necessary for the baseline analysis (see columns proxies and source).

What Table 11 shows is that the literature review and quantitative indicators are used for the description of the baseline, while Stakeholders’ input primarily focuses on innovation impacts. The analysis is based on both qualitative and quantitative data. The former are sourced from the literature review (including both professional and academic literature) and interviews with selected stakeholders. The quantitative part includes the key RDI capacity indicators covering key innovation aspects requested by this study. While the analysis concentrates on EU vs. the rest of the world, we follow a bottom up approach and distinguish those two groups on the level of OEM/Component manufacturer.
**Table 11 - Innovation Impact Matrix**

<table>
<thead>
<tr>
<th>INNOVATION CAPACITY BASELINE</th>
<th>Questions assessing Innovation Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity to Innovate pillars</strong></td>
<td><strong>Proxies</strong></td>
</tr>
</tbody>
</table>
| (I) EC term: The potential impact on enterprises’ capacity to carry out R&D leading to innovation in its products, which can be further traced to the impact of the proposal on: supply of skills needed by the sector (Point 6.1.1)  
Our understanding: With respect to skills supply in the automotive sector we place ‘innovation impact’ within the context of capabilities of the sector to perform in house R&D enabled by both RDI personnel and RDI investment. This dimension extends to innovation impacts in terms of R&D personnel of OEMs.  
**Proposition 1:** The regulation impacts innovation strategy and RDI investment choices by influencing OEMs business strategy, notably related to product and service innovation.  
**Proposition 2:** By creating the need for specific R&D skills, the regulation influences the needs of RDI personnel of OEMs. |
| Capacity for in-house R&D | Total R&D personnel and researchers, in business enterprise sector (HC) | Eurostat CLEPA Labour Force Survey data  
Innovation Sectoral watch[31] | 1. Are the changes in OEMs’ strategy introduced as a direct response to the regulation likely to influence their current and future RDI strategy and investment?  
2. Are the changes in OEMs’ strategy introduced as a direct response to the regulation likely to influence the OEMs needs in terms of RDI personnel? |
| | Total R&D Investment | 2013 EU Industrial R&D Scoreboard |
| (II) EC term: The capacity to innovate in processes and product related services, including distribution, marketing and after-sales services (process innovation), which depends on the supply of management and organizational skills and talents (Point 6.3)  
Our understanding: With respect to process and product innovation in the automotive sector we place ‘innovation impact’ within the context the capacity to design and implement product and process innovation, including organisational and business model innovation.  
**Proposition 3:** The regulation impacts the design and implementation of innovative products.  
**Proposition 4:** The regulation impacts the design and implementation of innovative processes, including changes to business models of OEMs. |
| Capacity for in-house product and process innovation, supply of skills etc. | Share of Innovative enterprises | Community Innovation Survey (CIS) | 3. Does the regulation influence the process of design and implementation of innovative products? (ranging from the design of the entire car to changes in sub-components)  
4. Does the regulation influence the process of design and implementation of innovative services, including, including consideration for new product-service systems e.g. based on leasing and sharing)? |
| (III) EC definition: The sector’s capacity to bring to the market new products or improve the features of current ones (capacity for product innovation), which depends crucially on technical skills and application of new technologies (Point 6.2)  
Our understanding: With respect to innovation activities in the automotive sector we place ‘innovation impact’ within the context of RDI externalisation capacity (closely related to point 6.1.1) and the collaboration patterns of OEMs in the supply and value chain.  
**Proposition 5:** The regulation leads to externalisation of OEM’s RDI activities.  
**Proposition 6:** The regulation impacts RDI processes by creating the need for alternative forms of co-operation with external partners |

[31] Available at: http://ec.europa.eu/enterprise/policies/innovation/files/proinno/sector-report-automotive_en.pdf; A number of relevant sources and data are included in this publication.
### INNOVATION CAPACITY BASELINE

<table>
<thead>
<tr>
<th>Capacity to Innovate pillars</th>
<th>Proxies</th>
<th>Source</th>
<th>Questions assessing Innovation Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity for R&amp;D externalisation</td>
<td>Number of R&amp;D centres inside and outside Europe and interactions with production sites</td>
<td>Desk research</td>
<td>5. Does the regulation lead to externalising R&amp;D or changing the R&amp;D partners of OEMs? (e.g. purchasing existing technology, intensifying interactions with tier firms or production sites abroad or relocation of R&amp;D activity)</td>
</tr>
<tr>
<td></td>
<td>Cooperation</td>
<td>CIS &amp; desk research</td>
<td>6. Are the changes in RDI activities introduced as a direct response to the regulation likely to influence value chains the OEMs are part of?</td>
</tr>
</tbody>
</table>
|                              | Strategic alliances                                                     | desk research & SDC database on Joint Ventures/Alliances database | 6.1. Are OEMs likely to search for new RDI partners and engage in new strategic alliances?  
6.2. Are OEMs likely to search for new RDI component manufacturers?  
6.3. Are OEMs likely to engage in new strategic alliances? |
|                              | Automotive Clusters                                                    | Clusters observatory          | 6.4. Are OEMs likely to search for new RDI component manufacturers? |

(IV) **EC definition:** The potential impact on enterprises’ capacity to carry out R&D leading to innovation in its products, which can be further traced to the impact of the proposal on: the efficiency of protection of intellectual property rights (Point 6.1.2)

**Our understanding:** With respect to IPR in the automotive sector we place ‘innovation impact’ within the context of IPR strategies.

**Proposition 7:** The regulation impacts IPR strategies.

| Capacity to produce and acquire industrial patents | Counts of Patents registered | Innovation Sectoral watch & other | 7. Are the RDI changes introduced as a direct response to the regulation likely to influence OEMs IPR strategies?  
7.1. Does the regulation lead to changes in the approaches to protecting intellectual property (e.g. use of patents versus industrial secrets)?  
7.2. Does the regulation lead to changes in the approach to patenting and acquiring patents? |
|                                                      | Counts of CO2 reducing patents |                                |                                       |

(V) **EC definition:** Ability to access risk capital (Point 6.4)

**Our understanding:** With respect to access to risk capital in the automotive sector we place ‘innovation impact’ within the context of availability of venture capital

**Proposition 8:** The regulation leads to a need to attract risk capital.

| Access to finance | Venture Capital | ThomsonOne | 8. Are the R&D investments implied by conforming to the regulation likely to impact on OEM’s access to risk capital? |

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Assessment of competitiveness impacts of post-2020 LDV CO$_2$ regulation

**Innovation Impacts**

The assessment of innovation impacts of the LDV CO$_2$ legislation on innovation capacities of OEMs is followed by the assessment of the innovation competitiveness of EU manufacturers compared with manufacturers from other regions in terms of their differences ($\Delta s$) in ‘activities’, ‘outputs and results’ and ‘innovation strategies and strategic partnerships’. To facilitate the analysis a mapping exercise of key components is performed with the main purpose to: 1) identify the critical points to raise during interviews, 2) decompose the elements feeding into the impact analysis after the interviews took place and 3) re-assess the secondary data requirements to be collected before the interviews take place (see Figure 33).

The differences ($\Delta s$) are linked back to the innovation impact matrix and to their main components to be further analysed as shown in Table 12. Possible regulatory impacts on innovation activity are assessed based on a qualitative analysis backed when possible with quantitative data. Emphasis is placed on the following attributes:

- Directedness (direct and indirect effect);
- Likelihood (risk and uncertainty);
- Strength of impact (how strong is the probable direct impact on innovation activity);
- Strength of attribution (how strong is the attribution of innovation effect to the regulation);
- Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions);
- Timing of expected impacts (e.g. time lag between regulation and actual impact).

**Table 12 - Link between $\Delta s$ & innovation impact matrix**

<table>
<thead>
<tr>
<th>Differences ($\Delta s$)</th>
<th>Pathway components to be analysed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$ RDI activities</td>
<td>Capacity for in-house R&amp;D</td>
</tr>
<tr>
<td></td>
<td>Capacity for in-house product and process innovation</td>
</tr>
<tr>
<td></td>
<td>(In the context of: Availability of necessary skilled personnel and strategies for attracting talented professionals; Ability to constantly upgrade the R&amp;D infrastructure etc.)</td>
</tr>
<tr>
<td>$\Delta$ RDI outputs and results</td>
<td>Capacity to produce and acquire industrial patents</td>
</tr>
<tr>
<td></td>
<td>(In the context of: Application and capitalisation on patents; Introduction of new products or improved products (models) in the market; Development of new trademarks and design; Shifting to new business models, (e.g. from product to product-service systems), etc.)</td>
</tr>
<tr>
<td>$\Delta$ Innovation strategies and strategic partnerships</td>
<td>Capacity for R&amp;D externalisation</td>
</tr>
<tr>
<td></td>
<td>(In the context of: Capacity for building strategic alliances and legal partnerships with companies with complementary innovation capabilities for product development, commercialisation, diffusion; Capability to do forecast analysis and based on that develop long term innovation, R&amp;D strategies; Capability to analyse strength and weaknesses of the competitors and monitor their innovation development; Capability to find and enter new markets, adjust to needs of new markets (develop adjusted models for those) etc.)</td>
</tr>
<tr>
<td></td>
<td>Strategic cooperation</td>
</tr>
</tbody>
</table>
Figure 33 - Innovation Pathway Components

**Product Innovation**
- RD investment in personnel
- Compliance requires the development of new technologies which may require specific RD skills

**Process Innovation**
- Legislation leads to relocation of R&D
- Compliance influences the process of design and implementation of innovative services, including consideration for new product-service systems e.g. based on leasing and sharing

**Strategic Patents**
- R&D changes required as a direct response to the regulation likely influence OEMs IPR strategies
- Regulation leads to (+)    OEMs make use of sleeping patents
- Regulation leads to (-)    purchasing new technologies
- Regulation leads to (-)    changes in the approach to protecting intellectual property (e.g. use of patents versus industrial secrets)

**Strategic cooperation**
- R&D changes required as a direct response to the regulation lead to externalising R&D or changing the R&D partners of OEMs or influence value chains the OEMs are part of
- Regulation intensifies interactions with tier firm
- Regulation leads (+) to new strategic alliances
- Regulation leads to (+) new partners

**European Manufacturers vs. Manufacturers in other Regions**
- RD investment in new technologies
  - Compliance requires higher RD investments
  - RD prioritization takes place as a result of stringent regulation (toward more CO2 RDI)
  - Faster prototyping takes place

- Legislation leads to relocation of R&D
  - There is misalignment of CO2 regulation with other innovation aspects impacting the design of the car
  - Additional R&D inputs

- Strategic partnerships
  - Δ R&D outputs and results

**Does LDV CO2 legislation impact RDI activities?**
- The question is whether and how the changes introduced as a direct response to the regulation indirectly influence the overall capacity to innovate
11.4 Impacts on innovation competitiveness resulting from changes in regulatory framework and compliance strategies

Based on the indicators and the interview input from both EU and non-EU manufacturers we compare the baseline to the different compliance strategies thereby investigating the difference (Δ) in RDI activities, RDI outputs and results and Innovation strategies and strategic partnerships.

Baseline & stated impacts of CO₂ legislation

A summary of the Baseline’s key inputs coupled with the compliance impacts of the current legislation as discussed by OEMs are described in Table 13. While a distinction is made between EU OEMs and OEMs from other regions (distinguished according to the criterion of headquarters) similar points were raised by both. The collected inputs inform the subsequent chapter on assessment of the impact.

Automotive Manufacturers - Innovation capacity and innovation competitiveness impact

The impact assessment analysis combines the baseline information, interviews and insights from chapter 5. The objective is to describe pathways that lead to a positive, negative, neutral or inconclusive impact on the innovation capacity of OEMs and on the competitiveness impacts of EU OEMs compared with OEMs from other regions.

Table 13 - Baseline description & preliminary summary of OEM views

<table>
<thead>
<tr>
<th>EU OEMs VS OEMs from other regions</th>
<th>Current Legislation Compliance Impacts on R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDI activities</td>
<td>RDI activities</td>
</tr>
<tr>
<td>R&amp;D expenditure in Europe is 1.6 times higher than Asia (Japan and South Korea) and slightly lower (0.9) than the US (based on 2012 data). Trends show that the gap between Europe and Asia has been increasing and the gap between Europe and the US has been decreasing.</td>
<td>views of EU OEMs</td>
</tr>
<tr>
<td>R&amp;D intensity²³ in Europe is highest (ca. 4.6) compared to Asia and the US (with ca. 4.1 and 4.5 respectively)</td>
<td>Innovation strategies are only a part of all other strategies (product, service, marketing etc.). Cost optimization considerations do impact R&amp;D investments.</td>
</tr>
<tr>
<td>R&amp;D personnel in Europe indications on R&amp;D employment are limited. Anecdotal evidence of increasing R&amp;D employment is limited to premium OEMs.</td>
<td>R&amp;D activities are becoming more resource intensive because technology becomes obsolete more quickly (the case of cars and not so much vans).</td>
</tr>
<tr>
<td>Capacity for in-house R&amp;D</td>
<td>Innovation spending has increased and choices have to be made in terms of prioritising innovation efforts in different segments, which may lead to a competitive disadvantage in the longer term.</td>
</tr>
<tr>
<td></td>
<td>Mass market OEMs have not and will not most likely increase R&amp;D even further as they are already constrained and have had serious losses in last few years of economic crisis.</td>
</tr>
<tr>
<td></td>
<td>Finding people with the right set of skills in Europe is becoming increasingly difficult particularly in relation to EVs.</td>
</tr>
<tr>
<td></td>
<td>OEMs that are global are more profitable – because the EU market is less profitable than the foreign ones and can thus rely on external markets to finance innovation.</td>
</tr>
</tbody>
</table>

³³ R&D Intensity is calculated as the ratio between R&D investment and net sales
Assessment of competitiveness impacts of post-2020 LDV CO\(_2\) regulation

EU OEMs VS OEMs from other regions

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Current Legislation Compliance Impacts on R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views of EU OEMs</td>
<td></td>
</tr>
<tr>
<td><strong>Product Innovation</strong></td>
<td></td>
</tr>
<tr>
<td>● Regulation may impact the scope of innovation but not hugely the extent of the efforts; Regulatory pressure has led to incremental innovation.</td>
<td></td>
</tr>
<tr>
<td>● Market acceptance is the main driver particularly the case of mass production OEMs; Profitability is a pre-condition for ambitious innovation strategies.</td>
<td></td>
</tr>
<tr>
<td>● CO2 legislation was behind most of the efforts on ICEV.</td>
<td></td>
</tr>
<tr>
<td>● The more the target and the slope make targets stringent the bigger will be the push to AFVs and EVs.</td>
<td></td>
</tr>
<tr>
<td>● A significant share of OEMs R&amp;D expenses was already addressing CO2 reduction technologies. This is the case for both mass production and premium OEMs.</td>
<td></td>
</tr>
<tr>
<td>● Low hanging fruit related to ICEV innovation have been grabbed and the most resource intensive innovations are currently under development.</td>
<td></td>
</tr>
<tr>
<td>● Innovation is concentrated on powertrain-related innovation, engines, aerodynamics, affordable light-weight materials, catalytic converters</td>
<td></td>
</tr>
<tr>
<td>● Increasing efficiency of diesel engines is important for EU OEMs.</td>
<td></td>
</tr>
<tr>
<td>● Strategies on alternative fuel vehicles seem to vary across companies. Innovation in EVs and natural gas is in some cases no longer actively pursued nor is hybridisation.</td>
<td></td>
</tr>
<tr>
<td>Services Innovation:</td>
<td></td>
</tr>
<tr>
<td>● A number of OEMs got involved in car sharing initiatives. However the emergence of these business models/services was not driven by CO2 regulation, but rather it was a strategy to enter a new market and/or being prepared to potentially changing customer behaviours.</td>
<td></td>
</tr>
<tr>
<td>● Emerging trends like service innovation e.g. electricity contracts, applications locating charging stations, parking etc. is backing product innovation are occurring. Currently they are developed by premium OEMs and hence motivated by being on the cutting edge of innovation.</td>
<td></td>
</tr>
<tr>
<td>● Manufacturers that can differentiate their technology by product and market may have an advantage over premium manufacturers that apply technological innovations on all products.</td>
<td></td>
</tr>
</tbody>
</table>

Views of OEMs from other regions (or of EU OEMS regarding non EU OEMs)

<table>
<thead>
<tr>
<th>Product Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Regulation drives R&amp;D efforts.</td>
</tr>
<tr>
<td>● The focus of some OEMs has been on affordable low CO2 options to make fuel efficient vehicles available for everybody (better aerodynamics, light-weight materials that are still affordable) and bring the fleet average down (not just have some extreme show cases).</td>
</tr>
<tr>
<td>● No difference between EU and non-EU OEMs: Similar concerns regarding premium and mass production cars; Similar concerns on the impact because of regulation preventing focus in developing other technologies (e.g. autonomous driving) that can satisfy the demands’ needs, solving current challenges (e.g. “gridlock”) and therefore possibly generating revenues and margins.</td>
</tr>
<tr>
<td>● Differences between EU and non-EU OEMs in terms of accessibility and affordability of financial sources may exist if granted under more favourable conditions from third parties or governments (e.g. Chinese or US governments have substantially more favourable conditions for industry R&amp;D investments and in higher amounts available in comparison to the EU – for transport sector only around maximum 2bn will be granted from Horizon 2020).</td>
</tr>
<tr>
<td>● Differences between EU and non-EU OEMs in terms of direct or indirect support from the headquarters outside the EU that might give higher level of security and financial means for certain type of costs (like research, innovation etc.). It was however stressed that this works both ways as all ACEA members are global companies.</td>
</tr>
</tbody>
</table>
Assessment of competitiveness impacts of post-2020 LDV CO\(_2\) regulation

<table>
<thead>
<tr>
<th>EU OEMs VS OEMs from other regions</th>
<th>Baseline</th>
<th>Current Legislation Compliance Impacts on R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RDI outputs and results</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Capacity to produce and acquire industrial patents | • Patents on “alternative powered vehicles”: EU OEMs are significantly behind Asian OEMs and comparable to US OEMs | Views of EU OEMs  
  • IPR strategies are more relevant outside of Europe in particular China.  
  • No impact in the management of IPR and of patent portfolio strategies  
  • No shifts towards other form of protection of IP (e.g. industrial secrets) |
| Innovation strategies and strategic partnerships |          |                                               |
| Capacity for R&D externalisation | • R&D fundamental research centres of EU OEMs tend to be located in Europe. Non-EU OEMs have at least development centres in Europe.  
  • Collaboration/ Partnerships/ Clusters: OEMs (including both Motor vehicles and passenger car bodies & Motor vehicle parts and accessories) in the EU participate less than non EU OEMs in alliances (in ca. 40% of total Alliances between 2000-2014) | Views of EU OEMs  
  Partnerships  
  • Due to fierce competition R&D activities done internally at the moment may be reconsidered in the future.  
  • Partnerships with OEMs that own patents that are considered necessary or critical are considered.  
  • Partnerships, with other OEMs are less prominent in the case of premium OEMs for whom retaining a competitive advantage through technology leadership is critical.  
  • Alliances on technical matters are already happening in particular for German and Japanese OEMs (e.g. BMW and Mercedes announced very recently that they launch a new programme on HEV and PHEV components)  
  • Partnerships with other OEMs in non EU countries occur, because for example of obligations to launch joint ventures to produce in some countries (e.g. China)  
  Relocation  
  • Pressure on prices may lead to moving resource allocation for R&D to less expensive locations than Europe. |
| Views of OEMs from other regions (or of EU OEMS regarding non EU OEMs) | Partnership  
  • OEMs form partnerships and joint ventures to pool resources for R&D  
  Relocation  
  • Establishment of R&D centres active in CO\(_2\) emissions compliance in the EU of non EU OEMs are motivated by the different pace of legislation in Europe  
  Other  
  • Electrification will move a lot of value creation out of the industry and push towards players specialized in the production of electric motors and batteries.  
  • A big challenge are new players such as Tesla and possibly players that are currently in other businesses such as Google. This is due to the fact that the more stringent the legislation becomes, the more the sector needs restructuring and new competences. This creates opportunities for new players to enter the market – especially the ones with large resources – and this leads back to players such as Google.  
  • In case of radical changes incumbents will suffer from ‘legacy effects” such as out-of-date competences, employees’ skills, pension funds, etc. |
R&D investment in new technologies

According to interviews with OEMs, R&D budgets are set by OEMs as a % of turnover hence total innovation investment has not changed due to the existing regulations. As profitability has been decreasing R&D budgets have been under pressure. CO$_2$ related R&D has in fact consumed higher shares of RDI budgets as a consequence of CO$_2$ regulation but R&D investments in CO$_2$ reducing technologies to make engines more efficient, has occurred before the CO$_2$ regulation. The legislation has led to larger scale applications and possibly an acceleration of the innovation process particularly regarding innovations “in the pipeline”. That said regional priorities and other legislation restricts future substantial increases in CO$_2$ investments. On the other hand the increasing pressures on R&D dedicated resources, poses risks to R&D investments in other forward looking segments of the market like for example automated driving systems or infotainment.

From the baseline (see Annex 2) and interviews we infer that the regulation directly impacts R&D investments of OEMs. The likelihood is high particularly under the assumption that stringent targets will eventually push car manufacturers towards AFVs including those that have until now chosen a different compliance strategy like e.g. diesel. R&D investments are however not expected to increase in absolute value in the event of more stringent CO$_2$ regulation assuming profit margins remain low and price pressures continue. This appears to be the case irrespective of stringency or compliance strategy. The attribution of the absolute levels of R&D investment to the regulation appears low.

However, bearing in mind that: 1) R&D is viewed as a key driver for competitiveness irrespective of regulation, 2) CO$_2$ reducing technologies have been part of the R&D portfolio of companies, and 3) that in some cases CO$_2$ reducing technologies have already absorbed substantially more OEM funding due to the regulation, we can infer that R&D prioritisation may be further impacted depending on the stringency of the target, compliance strategy and related R&D effort (e.g. in house R&D or externalisation of R&D).

That said, cumulative innovation impacts may occur since OEMs opting to build core competences in CO$_2$ reducing technologies in house will need to use resources previously allocated to other R&D segments should profit margins remain low. In the case of low margins persisting in the short to longer term the availability of financing like through venture capital or the ability to cross subsidize losses in Europe by other markets overseas are determining factors.

As such the effect on innovation competitiveness of EU OEMs compared with OEMs from other regions is indirect since it is mainly driven by profitability and hence the positioning of OEMs in more or less profitable market segments across the globe. For example OEMs largely present in the EU markets and able to cross subsidize losses from markets outside of Europe could respond to stringent targets with increased R&D investments given higher total turnover. This has been observed in the case of premium manufactures. Mass producer manufacturers on the other hand are not in this position and are unlikely to increase R&D even further as they are already constrained and have had serious losses in the last few years of economic crisis. It hence appears difficult now and in coming years for these companies to increase R&D expenditure. Differences in the access to finance, for example the availability of venture capital, which tends to be higher in the US than Europe may also result in a competitive disadvantage to EU companies in the medium to longer term. Moreover, disadvantages may occur considering emerging competition from new players like...
Tesla or Google which possess the resources to finance technologies of the future and benefit from a ‘first mover’ advantage.

**Profit Margins**

Scotiabank (2013) reports\(^{34}\) that profitability for the five largest car manufacturers remains healthy, with gross margins at 10-year highs and net income consistently exceeding USD 50 billion per year since 2011. Profitability is highest in North America, but is improving in every region, including Western Europe, the only jurisdiction where the industry remains unprofitable. While car manufacturers have started to close plants in Western Europe, they continue to ramp up their capital expenditures in the rapidly-growing emerging markets of Asia and Latin America. Profit margins are higher on premium models whereas city or mini cars margins are thin. Many of the mini cars sell for less than EUR 10 000 (USD 13 860), barely more than the cost of making them. Experts suggest that the margins on city cars can only be 3% at best.\(^{35}\)

The EU new-car market has shrunk every year since peaking at 16 million units in 2007. New-car sales dipped 8% to 12 million in Europe in 2013. This negative trend is mainly attributed to the 2007-08 financial crisis that has led to a dramatic decline in consumption. On the other hand, the three premium German automakers have managed to avoid the EU sales declines due to the strong demand for their models in countries such as China and the United States.

Although highly conditional on a number of factors a brief overview of inferred impacts of post-2020 regulations on R&D and innovation investments is provided in Table 14.

**Table 14 – Summary: Post 2020 regulation impacts on R&D and innovation investments**

<table>
<thead>
<tr>
<th>Directedness (direct and indirect effect)</th>
<th>Likelihood (risk &amp; uncertainty)</th>
<th>Strength of impact (how strong is the probable direct impact on innovation activity)</th>
<th>Strength of attribution (how strong is the attribution of innovation effect to the regulation)</th>
<th>Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions)</th>
<th>Timing of expected impacts (e.g. time lag between regulation and actual impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct impact on OEMs R&amp;D investments implied by the regulation’s modalities: Regulation does not directly affect total R&amp;D spending but may influence allocation between different lines of R&amp;D expenditure</td>
<td>Low to Medium: Low with respect to absolute R&amp;D expenditures Medium in the case of R&amp;D prioritisation - highly dependent on target level and R&amp;D strategy</td>
<td>Low to Medium: Low with respect to absolute R&amp;D expenditures Medium in the case of R&amp;D prioritisation - highly dependent on target level and R&amp;D strategy</td>
<td>Low to Medium: Low with respect to absolute R&amp;D expenditures Medium in the case of R&amp;D prioritisation - highly dependent on target level and R&amp;D strategy</td>
<td>Yes: cumulative costs of regulation are possible; the regulation may run counter to other regulations e.g. safety, infotainment or fully automated vehicles that may become less prioritary - highly dependent on target level and R&amp;D strategy</td>
<td>No time lag: in anticipation of a stringent regulation options are investigated and actions undertaken</td>
</tr>
</tbody>
</table>

**R&D investment in personnel (R&D centres)**

According to interviews, OEMs and component manufacturers unanimously stress the increasing difficulty in finding people with the right set of skills in Europe. New skills both on new technologies and at system level - more complex profiles with a mix of knowledge from different domains, are scarce and student scholarships

\(^{34}\) Available at: [http://www.marketwired.com](http://www.marketwired.com)

\(^{35}\) Available at: [http://online.wsj.com/news](http://online.wsj.com/news)
Assessment of competitiveness impacts of post-2020 LDV CO\(_2\) regulation

no longer suffice. India, China, Pakistan are among the countries with highest engineering skills supplies and hence provide a current and increasingly important pool from which OEMs may source the necessary skills. Skills are therefore currently already sought outside Europe and made good use of in research centres (namely development centres but maybe also fundamental research centres) in those countries where the necessary skills are more easily available. Provided no constraints apply on global recruits the sector does not face particular skills shortage. Strategic R&D is however typically performed at headquarters.

According to the baseline (see Annex 2) and interviews we infer that the regulation directly impacts OEMs human capital requirements in R&D, should OEMs comply to stringent targets by in-house development (either in collaboration or using exclusively own resources). This may not necessarily translate into a growth of R&D personnel but a differentiation in the set of skills of people employed (considering that R&D budgets are tied to profit margins and hence differentiated for premium and mass manufacturers or more generally manufacturers compensating losses in Europe by sales overseas).

R&D skills may in fact be more actively sought outside Europe in the short term should OEMs respond to more stringent targets with an intensification of AFV and EV technologies. Shortage of skills in Europe altogether may however have the same effect irrespective of the stringency of the target. In fact R&D skills are already sought globally and are not limited to electrical engineering skills. Depending on the local conditions (namely the supply of the right set of skills) and R&D prioritisation, decisions to recruit globally at headquarters, increase capacity in some R&D centres at the expense of other R&D centres, or relocate R&D may be considered irrespective and in anticipation of the regulation with an eye to future global market trends.

The impact of the regulation is cumulative considering the R&D requirements and consequently skills implied by for example safety regulations and equally the requirements imposed by the market itself and the emerging competition.

Competitiveness impacts between EU OEMs and OEMs from other regions are not expected due to the nature of the industry, operating global production, supply and value chains and the relative ease of attracting talent from countries with lower income per capita. However, the loss of expertise within Europe further heightened in the sector by a possible increased tendency to relocate R&D centres and the impacts beyond the automotive sector is a competitiveness implication for Europe altogether. This aspect however falls beyond the scope of this study.

Although highly conditional on a number of factors a brief overview of possible impacts on R&D employment is provided in Table 15.

**Service innovation**

According to the interviews with OEMs, service innovation with respect to the aforementioned examples like car sharing and car leasing are motivated by the emerging new market opportunities that car manufacturers anticipate, as well as by consumer behaviour and not the CO\(_2\) legislation.
According to the baseline (see Annex 2) and interviews we can infer that there is no direct impact of the regulation on service innovation. The impact is rather induced in nature due to the fact that manufacturers complying to the regulation with for instance increased investments in AFVs and EVs may also couple their products with innovative services. Service innovation tends to be motivated by the intention of OEMs to interact directly with the end user and not from regulatory requirements. Consumer behaviour is nevertheless affected by regulation and hence does impact the type of service innovations which OEMs would seek to develop and make available to the consumer. In terms of innovation competitiveness there is insufficient information to assess the impacts in terms of EU OEMs vs. OEMs from other regions.

Although highly conditional on a number of factors a brief overview of possible impacts of post-2020 regulation on service innovation is provided in Table 16.

### Table 15 - Summary: Post 2020 regulation impact on R&D employment

<table>
<thead>
<tr>
<th>Directedness (direct and indirect effect)</th>
<th>Likelihood (risk &amp; uncertainty)</th>
<th>Strength of impact (how strong is the probable direct impact on innovation activity)</th>
<th>Strength of attribution (how strong is the attribution of innovation effect to the regulation)</th>
<th>Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions)</th>
<th>Timing of expected impacts (e.g. time lag between regulation and actual impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct impact on OEMs R&amp;D human capital requirements and R&amp;D recruitment.</td>
<td>Medium-High: due to current shortages of skills in Europe and pressures from regulation, market demand, competition.</td>
<td>Medium-High: due to current shortages of skills in Europe and pressures from regulation, market demand, competition.</td>
<td>Low-medium: regulation affects R&amp;D recruitment and decisions on R&amp;D relocation among other factors</td>
<td>Yes: the impact of regulation is cumulative given the increasing overall R&amp;D pressures for technological advances from other regulations, market demand and competition</td>
<td>No time lag: In anticipation of more stringent regulations R&amp;D staff is already employed from overseas and relocations of R&amp;D may already be happening/considered</td>
</tr>
</tbody>
</table>

### Table 16 - Summary: Post 2020 regulation impact on Service Innovation

<table>
<thead>
<tr>
<th>Directedness (direct and indirect effect)</th>
<th>Likelihood (risk &amp; uncertainty)</th>
<th>Strength of impact (how strong is the probable direct impact on innovation activity)</th>
<th>Strength of attribution (how strong is the attribution of innovation effect to the regulation)</th>
<th>Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions)</th>
<th>Timing of expected impacts (e.g. time lag between regulation and actual impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induced: no modality of the regulation is directly or indirectly linked to the provision of services</td>
<td>Low-medium: depending on the compliance strategy services may be more directly linked to specific products</td>
<td>Not applicable: no direct impact</td>
<td>Low due to the predominance of other demand related conditions</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>
Strategic patenting

Very limited information was provided during either the interviews or the workshop. Two main points were made: 1) Individual IPRs are not always desired or possible and hence IPRs may be shared by 2-3 OEMs and 2) IPR strategies are principally relevant outside of Europe and in particular China.

According to the baseline (see Annex 2) and interviews we can infer that the regulation may indirectly impact patenting activities by inducing OEMs to reconsider their patenting strategies. OEMs may be pushed towards more shared IPR should they decide to penetrate a market segment requiring technological capacities either currently under development or fully developed or both developed and commercialised by competitors. The availability of capital and ‘time to market’ are key considerations in such decision making process.

Shared IPR may hence take the form of collaboration - sharing development costs, or direct purchase of patent(s). Collaboration may occur for a single technology or a set of technologies and be temporary or be set up as a more long term collaboration like the case of Renault and Nissan that have announced their intention to deepen their integration by strengthening cooperation in R&D. In the case of OEMs using electrification as their compliance strategy, some form of shared IPR between EU and Japanese OEMs/ component manufacturers may become increasingly desirable should there be gains for all parties involved. There is however no available information on the current shared IPR strategies of those EU OEMs with formed relationships with Japanese OEMs.

Table 17 - Summary: Post 2020 regulation impact on IPR strategies

<table>
<thead>
<tr>
<th>Directedness (direct indirect induced effect)</th>
<th>Likelihood (risk &amp; uncertainty)</th>
<th>Strength of impact (how strong is the probable direct impact on innovation activity)</th>
<th>Strength of attribution (how strong is the attribution of innovation effect to the regulation)</th>
<th>Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions)</th>
<th>Timing of expected impacts (e.g. time lag between regulation and actual impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect impact on patenting strategies</td>
<td>Low-high: highly dependent on the current capabilities of OEMs as reflected in their patent portfolio and the compliance strategy</td>
<td>Low-high: highly dependent on the current capabilities of OEMs as reflected in their patent portfolio and the compliance strategy</td>
<td>Medium-high: depending on the compliance strategy and the current distance from the new targets patenting strategies will be strongly impacted</td>
<td>Yes: R&amp;D budgets need to cover a wide spectrum of innovations as a result of other regulations and market drivers and patenting is a costly endeavour</td>
<td>No time lag: Being a ‘first mover’, and achieving ‘speed to market’ impacts competitiveness. In anticipation of the regulation IPR strategies are re-considered hence no significant time lag is expected.</td>
</tr>
</tbody>
</table>

As in the case of R&D expenditure and R&D skills, patenting requirements are cumulative in nature given the requirements imposed by regulations, the market itself and the emerging competition. Patenting is resource intensive and time consuming leading to strategic choices and prioritisation being made for the medium to
longer term. Unexpected and/or significant changes in any of the influencing factors linked to the developed technologies can impact the return on investment with further consequences on market shares and survival.

That said a possible regulatory push towards electrification as the only means of compliance could lead to a competitive advantage for Japanese, but possibly also Chinese and Korean manufacturers/component manufacturers whose R&D and innovation investments are currently further ahead in the innovation cycle and hence benefit from a ‘first mover’ advantage. On the other hand some EU Manufacturers are catching up fast and given the breakthroughs accomplished already in the course of time, EU manufacturers may benefit from a higher ‘speed to market’.

Although highly conditional on a number of factors a brief overview of possible impacts of post-2020 regulation on IPR strategies is provided in Table 17.

Strategic collaboration
According to the interviews with OEMs strategic cooperation through partnerships with first tier producers or among OEMs have not been uncommon and are expected to become more relevant as stringent targets require technologies that may either not be readily available in-house (skills shortage altogether or early stage in the innovation cycle) or may not be cost-effective.

### The market for electric and hybrid vehicles

Today there are around 500,000 electric vehicles in the world (which is a small proportion of the approximately 1 billion road vehicle fleet). The amount has been growing, however earlier optimistic projections have been slightly tempered.

Core motivations behind the push for EVs include national and regional government regulations. Those reasons plus the underlying environmental and energy concerns that gave rise to mandates – and generally shared sentiment held by consumers – is continuing to spur demand.

Countries which showed the highest rate of growth from 2012 to 2013 were the Netherlands (338%), Norway (129%), Germany (105%) and the U.S. (81%). Those countries with the highest market share in 2013 were Norway (5.6%), the Netherlands (5.37%), France (0.65%), Sweden (0.57%) and the U.S. (0.62%).

The hybrid car market is increasing rapidly as more manufacturers introduce new and wider range of models into the market, giving consumers more options. The majority of the hybrid car market is American based and the second largest is Japan. Hybrids account for just over 1% of the global market, while Japan and the US together represent 84% of the global hybrid market.

Projections by Pike research show that the main increase in sales of hybrid-electric light-duty vehicle will take place in the Asia-Pacific and North America. The growth in the EU is expected to be rather insignificant.

According to the baseline (see Annex 2) and interviews we can infer that the regulation may indirectly impact collaboration strategies. Capabilities and risk sharing are among the reasons motivating such initiatives. Strategic collaborations are expected to become an important part of OEMs compliance strategies particularly in the event of a stringent target, a short time horizon for adjustment considering the length of the

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36 http://www.hybridcars.com/top-6-plug-in-car-adopting-countries/
37 http://mosaic.cnfolio.com/M528Coursework2007A204
innovation cycle and the different positioning of OEMs in technological capabilities. The regulation would therefore possibly heighten the urgency while the speed at which the market demands new technologies is expected to be slower particularly in the case of AFVs and EVs in Europe. In the case of other faster growing markets like Asia-Pacific and North America OEMs already present in those markets would benefit the most in the short term to medium term. As such among EU OEMs premium OEMs already present in those markets will suffer the least.

Although highly conditional on a number of factors a brief overview of inferences drawn with respect to R&D collaboration strategies is provided in Table 18.

**Table 18 - Summary: Post 2020 regulation impact on R&D Collaboration Strategies**

<table>
<thead>
<tr>
<th>Directedness (direct and indirect effect)</th>
<th>Likelihood (risk &amp; uncertainty)</th>
<th>Strength of impact (how strong is the probable direct impact on innovation activity)</th>
<th>Strength of attribution (how strong is the attribution of innovation effect to the regulation)</th>
<th>Cumulativeness (does the impact of regulation accumulate or run counter to other innovation drivers e.g. other policy measures or external market conditions)</th>
<th>Timing of expected impacts (e.g. time lag between regulation and actual impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect impact: no modality of the regulation is directly linked to R&amp;D collaboration strategies</td>
<td>Low-high: highly dependent on the current capabilities of OEMs as reflected in their R&amp;D &amp; patent portfolio and the compliance strategy</td>
<td>Low-high: highly dependent on the current capabilities of OEMs as reflected in their R&amp;D &amp; patent portfolio and the compliance strategy</td>
<td>Low-high: depending on the target level, compliance strategy, corresponding R&amp;D requirements and existing collaborations R&amp;D collaborations are expected to vary in urgency and form</td>
<td>Yes: R&amp;D budgets need to cover a wide spectrum of innovations as a result of other regulations and risks are high</td>
<td>No time lag: Collaborations are being considered in anticipation of the regulation</td>
</tr>
</tbody>
</table>

**LCVs - Innovation capacity and innovation competitiveness impact**

From a customers’ perspective, LCVs are mainly intended for businesses, including a lot of SMEs. Among key factors in the purchasing of an LCV has been fuel consumption and increasingly the rules on local delivery typically defined by municipalities or cities. A common practice has been for new LCVs to be re-sold after 2-3 years using the purchase price as a reference.

The market for LCVs is a factor of 10 smaller than the market for cars. Sales of LCVs are quite sensitive to economic fluctuations and have been particularly hit by the recent economic crisis. LCV customers have a low willingness to pay a premium for AFVs. In general, the market for premium LCVs is very small and hence margins are small.

From an innovative power perspective strong limitations apply due to the commercial use of those vehicles, namely the fact that the body of LCVs needs to carry the load and LCVs often have multiple uses. Making specific powertrains makes little commercial sense. Since technologies are transferable between the two types of vehicles, the innovation resources spent on LCVs are much smaller than for cars.
No evidence suggests that there would be any impact on innovation investment or the relocation of R&D centres, as technologies used in LCVs are typically a result of knowledge transferred from the technologies developed for cars. With respect to competitiveness between EU and non-EU OEMs should the regulation be coupled by other actions to stimulate the use of AFVs a negative impact for EU OEMs may occur as a result of the technological advantage of non-EU OEMs. This assumes non EU OEMs will more actively target the EU LCV market whereas they currently represent a minor share.

**LCV Sales**

EU sales of LCVs have dropped significantly over the last 5 years. New LCV sales are correlated with business investments and retail activities by companies which, in turn, have been affected by the economic downturn. As a result, sales in Europe in the last 6 years have dropped dramatically, from more than 2.2 million units in 2007 to 1.43 million units in 2013, with an annual decrease of more than 7%.

EU manufacturers, which retain more than 74% of EU LCV sales in terms of units, have been affected differently, somehow in line with the trends of their national economies. Whereas German manufacturers have managed to contain sales drops (e.g. Volkswagen -10% and Daimler -17% over the last 5 years), French ones have faced heavier consequences (with Renault recording 22% and PSA 24.5% sales decreases from 2008 to 2013). Fiat has been the most affected among large EU manufacturers with -52% over the last 5 years.

In summary in the case of LCVs the RDI exclusive expenditure is substantially lower since technologies are highly transferable from cars to LCVs. The usage of LCVs also limits the applicability of technically possible innovations. These limitations apply to all manufacturers, EU and from other regions hence should a regulation impose stringent targets we expect sales will be impacted depending on the price elasticity of professional end users. OEMs with competitive prices due to low development costs and economies of scale may have an advantage. Collaborations may also arise as a result of market accessibility and technological advantages lying distinct in the hands of respectively EU and non EU OEMs.

### 11.5 Component manufacturers - Innovation capacity and innovation competitiveness impact

From a technological innovation viewpoint OEMs are dependent on first tier component manufacturers. These on their side strive for cutting edge technology advances in terms of commodities and system integration to avoid commoditisation and sustain constant price pressures from the OEMs. Regulatory pressure is considered the main driver of innovation. Component manufacturers have been increasingly redirecting or boosting their R&D efforts on powertrain electrification and hybridisation. There are component manufacturers in Europe that have increased their R&D budgets in absolute terms. Nevertheless currently Asian component manufacturers benefit from a ‘first mover’ advantage and are better placed in AFV and EV technologies particularly considering that the highest share of the total value is in the battery (with the great majority of manufacturers in Japan and some in Korea, the US, Canada).

Component manufacturers’ innovation capacity is directly positively impacted by the regulation. Innovation activity of first tier component manufacturers and their suppliers is further stimulated in response to legislation in their major markets also beyond Europe. Given that EU component manufacturers’ R&D
portfolio is wide-ranging a legislative push towards a more narrow range of technologies would give a competitive advantage to component manufacturers with a competitive edge in those specific technologies at least in the short term, the case of Japanese component manufacturers for electric components vs. the diesel based innovations of EU component manufacturers. Moreover due to the value of the battery and the dominance of Japanese component manufacturers a large share of the value would shift outside of Europe. Therefore, such a technologically biased regulatory push may cause negative innovation competitiveness impacts in the short term as a result of the different innovation capabilities of EU component manufacturers compared to component manufacturers from other regions. In the medium to longer term and depending on the strategies of EU component manufacturers in response to the technological mix implied by the post 2020 legislation increased innovation in EV technologies may occur with EU component manufacturers benefiting from a higher ‘speed to market’.

In summary component manufacturers act in anticipation of regulations and are particularly responsive to regulations particularly due to the important role they play in the realisation of technological innovations. First tier component manufacturers provide beyond components, system integration which differentiates them from other component manufacturers focused exclusively on commodities. The portfolio of component manufacturers tends to be diverse with a leading position in fuel injection technologies and an increasing emphasis on powertrain electrification and hybridization. Japanese component manufacturers are however clearly leading in the field. A regulation with an emphasis on electrification will inevitably impact EU component manufacturers should OEMs currently focused on diesel reconsider their product mix.

11.6 Energy Providers - Innovation capacity and innovation competitiveness impact

By Energy providers we refer to fuel distributors and refineries. In the case of fuel distributors no emphasis is placed on R&D and innovation activities. In the case of refineries a significant part of R&D and innovation resources goes to improving environmental performance also as a consequence of tightening fuel product norms and emissions standards included in the EU’s Fuel Quality Directive. The impact of CO2 legislation on their capacity to innovate is considered negligible. However increasing shares of AFVs, may require innovation by suppliers of alternative fuels (e.g. electricity and hydrogen). Nonetheless as most of these companies are only competing on the EU market this is not expected to affect innovation competitiveness with non EU fuel distributors.

11.7 Professional End users

By professional end users we refer to companies that use cars and vans, either to provide transport services to clients or as part of their own operations. The impact of CO2 legislation on their capacity to innovate is considered negligible. Increased share of AFVs may require some innovation in fleet operation but as most EU end-users of LDVs are not in competition with companies from outside EU this is not expected to affect innovation competitiveness.
11.8 Key conclusions

Key conclusions synthesize most relevant findings of the impact analysis of the LDV CO\textsubscript{2} legislation on R&D and Innovation. To do so we go back to our theoretical framework and in particular our propositions and the innovation competitiveness impact matrix.

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Differences ((\Delta s))</th>
<th>Key conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposition 1:</strong> The regulation impacts innovation strategy and RDI investment choices by influencing OEMs business strategy, notably related to product and service innovation.</td>
<td>(\Delta) RDI activities</td>
<td>RDI investment choices for automotive manufacturers are impacted particularly as regards product innovation and the prioritisation of R&amp;D expenditures. A regulatory push to electrification poses less need for adjustment to those automotive manufacturers from other Regions who are ‘first movers’ in this segment of the market and EU automotive manufacturers cross-subsidizing losses through overseas markets. That said, given the significantly below expectations market growth of EVs in Europe a push to electrification would put significant stress on profit margins particularly of mass production automotive manufacturers.</td>
</tr>
<tr>
<td><strong>Proposition 2:</strong> By creating the need for specific R&amp;D skills, the regulation influences the needs of RDI personnel of OEMs.</td>
<td></td>
<td>Component manufacturers act in terms of RDI investment in anticipation of regulations and are particularly responsive to regulations due to the important role they play in the realisation of technological innovations. First tier component manufacturers provide beyond components, system integration which differentiates them from other component manufacturers focused exclusively on commodities. The portfolio of component manufacturers tends to be diverse with a leading position in fuel injection technologies and an increasing emphasis on powertrain electrification and hybridization. Japanese component manufacturers are however clearly leading in the field. A regulation with an emphasis on electrification will inevitably impact EU component manufacturers should automotive manufacturers currently focused on diesel reconsider their product mix.</td>
</tr>
<tr>
<td><strong>Proposition 3:</strong> The regulation impacts the design and implementation of innovative products.</td>
<td></td>
<td>In the case of LCVs the RDI investment is substantially lower since technologies are highly transferable from cars to LCVs. The usage of LCVs also limits the applicability of technically possible innovations.</td>
</tr>
<tr>
<td><strong>Proposition 4:</strong> The regulation impacts the</td>
<td></td>
<td>Services are primarily driven by market conditions. Increasing potential appears to be linked to the development of services linked to electrification. In Europe with EVs being a niche market and given the lack of the necessary infrastructure competitiveness impacts related to this segment are not yet prominent. The increasing demand for people with either basic engineering skills or specific R&amp;D skills is being met through global recruitment due to a shortage of the desired skills in Europe. The same applies for automotive and component manufacturers vs. Automotive and component manufacturers from other regions. The declining expertise in Europe is posing a threat to Europe’s competitiveness altogether and not strictly on global industries like the automotive industry.</td>
</tr>
<tr>
<td><strong>Proposition 5:</strong> The regulation impacts the prioritisation for both automotive and component manufacturers, increasing capacity in some R&amp;D centres at the expense of other R&amp;D centres, or relocate R&amp;D may be considered irrespective and in anticipation of the regulation with an eye to future global market trends.</td>
<td></td>
<td>Depending on the local conditions in terms of supply of the right set of skills and R&amp;D prioritisation for both automotive and component manufacturers, increasing capacity in some R&amp;D centres at the expense of other R&amp;D centres, or relocate R&amp;D may be considered irrespective and in anticipation of the regulation with an eye to future global market trends.</td>
</tr>
<tr>
<td><strong>Proposition 6:</strong> The regulation impacts the</td>
<td></td>
<td>The design and implementation of innovative products is not directly influenced by the regulation but is a consequence of the chosen compliance strategy (i.e. product mix). It is also linked to the coherence between CO2 regulation and other regulations. Services are linked to products and are thus indirectly influenced by the regulation.</td>
</tr>
<tr>
<td><strong>Proposition 7:</strong> The regulation impacts the</td>
<td></td>
<td>Business models have been shaped by regulation over many years considering the emphasis towards sustainable business models predominantly centred on product, ranging for</td>
</tr>
<tr>
<td>Propositions</td>
<td>Differences ($\Delta s$)</td>
<td>Key conclusions</td>
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<tr>
<td>Proposition 5:</td>
<td>$\Delta$ Innovation strategies and strategic partnerships</td>
<td>Externalisation of some R&amp;D activities by either shorter term or longer term collaborations to bring down development costs have been occurring as a response to shrinking profit margins. Regulations implying products already available in the market by some automotive manufacturers or component manufacturers does imply collaborations as the fastest “catch up” strategy and may hence result in a further intensification of this trend. Moreover in the specific example of electrification the product can be characterised as a “high learning product” with long introductory phases particularly in Europe. Given growth expectations in other non-EU regions further consolidation in an already highly consolidated industry (including thus R&amp;D) may also be unavoidable. On the other hand automotive manufacturers with either their local markets in regions where electrification has picked up faster or with presence in those markets do have a competitive advantage and some may be less inclined to form collaborations in the absence of a favourable outcome to them.</td>
</tr>
<tr>
<td>Proposition 6:</td>
<td>$\Delta$ RDI outputs and results</td>
<td>IPR strategies are linked to decisions on R&amp;D externalisation and strategic co-operations. Automotive manufacturers may thus develop technologies in house and hence patent or decide to purchase patents or directly collaborate with automotive manufacturers in possession of the patents linked to their strategy of compliance. Automotive manufacturers and component manufacturers in possession of those patents deemed necessary have a competitive advantage either financially due to the possibility to sell or license their patents or in terms of negotiating power. Currently the great majority of automotive manufacturers and component manufacturers in possession of patents related to electrification are from regions outside of Europe.</td>
</tr>
<tr>
<td>Proposition 8:</td>
<td></td>
<td>The low profit margins for particularly mass production automotive manufacturers heightens the need for alternative forms of access to finance for either innovations linked to the regulation or other innovations that may as a consequence of the regulation become less of a priority but are considered either strategic for their future competitiveness or are required for their compliance with other regulations.</td>
</tr>
</tbody>
</table>

Notes: For Energy providers and Professional end users no relevant conclusions are drawn for either their capacity to innovate or competitiveness impacts (no references were made during the interviews).

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38 For example the innovative process of making a car using carbon fibre as material makes a car lighter and hence more efficient in its fuel consumption (plus makes the option of 3D printing possible). Moreover it impacts compliance to safety requirements posing hence higher R&D costs. In terms of the CO2 regulation assuming weight is part of the utility function lighter cars decrease OEMs’ target, which is not desirable for a manufacturer. While hence in the specific case not desirable as a compliance strategy it is a forward looking approach with a shorter term effect on fuel efficiency, a critical factor for the consumer.
12. Impacts on international competitiveness

12.1 Introduction

The first important element in defining the impact of the CO\(_2\) regulation on the international competitiveness position in the automotive and related sectors is to clarify the definition of international competitiveness. For an individual firm, competitiveness means securing a higher market share than its competing firms while maintaining positive profits margin or, vice versa, achieving a higher than competitors’ profit margin without a loss of market share. National (or supranational, like the EU) competitiveness means higher productivity than in competing countries or stronger international trade and investment position (net exports and the FDI stock). This definition fits the suggested indicators of the international competitiveness in the EU Competitiveness Toolkit, namely the export volumes, trade balance, revealed comparative advantage and inward and outward FDI stock.

The definition of the international competitiveness of the automotive sector is inherently ambiguous due to the global nature of the sector looked at either from a manufacturer (EU companies vs. competing companies from other regions) or manufacturing (by the place of production – Europe vs. other regions) perspective.

The international competitiveness indicators of the Competitiveness Toolkit are close to the manufacturing definition characterized by the location of production facilities notwithstanding the ownership of these facilities. For example, foreign-owned companies located in Europe employ mostly EU workers and produce value added which is counted as the EU GDP consequently raising the overall productivity measure (GDP per capita). In the same vein, the exports of the foreign-owned companies are counted as EU exports with a positive effect on the trade balance. The FDI which the foreign-owned companies receive, for instance, from their parent countries improve the EU investment position.

12.2 The analysis of current trade position of the EU

The ten main trade partners of the EU in passenger vehicles (classification code HS8703) are presented in the Annex 4 tables.

The U.S., Canada and Korea appear on both the list of ten largest export destinations for the EU exports and of ten largest origins of the EU imports. Developing countries, such as Mexico, India and China are among the most active exporters to the EU. Mexico and India, contrary to China, export the makes produced by the automotive majors.

The two important, and mutually related, trade competitiveness indicators are the trade balance (net exports) and the revealed comparative advantage (RCA) index. The trade balances of the cars, light commercial vehicles and auto components are presented in the Annex tables.

The EU has a strong positive trade balance in passenger vehicles, which increased by one-third from 2011 to 2012. However, the EU had a trade deficit with Korea, India and Japan.
Trade in light commercial vehicles and the related trade balance are just small fractions of the respective figures for passenger vehicles. The EU does not have a stable positive trade balance in this product group. The net exports were negative in 2011 but turned very slightly positive in 2012. For the trade of automotive components, we observe a strong trade position of the EU reduced by a sharply negative trade balance with Japan.

The revealed comparative advantage coefficient presented below is the simple Balassa index, which is the ratio of the proportion of the exports of a certain good in the total EU exports to the proportion of the world exports of the same good in total world exports. An index value above one designates a comparative advantage (or export specialization) in the commodity in question. An index value close to zero means the lack of comparative advantage in this commodity.

<table>
<thead>
<tr>
<th>Table 20 - The revealed comparative advantage coefficient in passenger vehicles</th>
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<tr>
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<tr>
<td>EU-27</td>
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<tr>
<td>Japan</td>
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<tr>
<td>Rep. of Korea</td>
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<tr>
<td>Turkey</td>
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<tr>
<td>USA</td>
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<tr>
<td>India</td>
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<tr>
<td>Canada</td>
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<tr>
<td>China</td>
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<tr>
<td>Mexico</td>
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<tr>
<td>Russian Federation</td>
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</table>

Note: The Balassa RCA index.

<table>
<thead>
<tr>
<th>Table 21 - The revealed comparative advantage coefficient in light commercial vehicles</th>
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<tr>
<td></td>
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<tr>
<td>EU-27</td>
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<tr>
<td>Canada</td>
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<tr>
<td>China</td>
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<tr>
<td>Japan</td>
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<td>Mexico</td>
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<td>Norway</td>
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<td>Rep. of Korea</td>
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<td>Russian Federation</td>
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<tr>
<td>Switzerland</td>
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<td>Turkey</td>
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</table>

Note: The Balassa RCA index.

We, again, observe a strong export specialization of the EU in passenger vehicles. This table is comparable with the table on net exports above. However, Japan, Korea, Canada and Mexico specialize even more strongly in passenger vehicles. Mexico’s strong export specialization emerged from the maquiladora
industry, which fostered the relocation of the U.S. auto plants into Mexico, especially after the conclusion of NAFTA in 1994.

In light commercial vehicles, the EU does not have a comparative advantage, which is consistent with the unstable EU trade position in light commercial vehicles. Mexico (again) and Turkey appear strongly specialized in this export.

The EU specializes in the exports of automotive components. Mexico and Japan possess an even higher comparative advantage than the EU while Turkey and the U.S. exhibit a marked export specialization slightly below the EU level:

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
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<tbody>
<tr>
<td>EU-27</td>
<td>1.35</td>
<td>1.36</td>
</tr>
<tr>
<td>China</td>
<td>0.46</td>
<td>0.47</td>
</tr>
<tr>
<td>India</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Japan</td>
<td>3.25</td>
<td>3.06</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.55</td>
<td>2.52</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.22</td>
<td>1.42</td>
</tr>
<tr>
<td>USA</td>
<td>1.15</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Note: The Balassa RCA index.

**12.3 The impact of the prospective EU CO\textsubscript{2} emission regulations on trade flows, trade competitiveness and cross-border investment flows in the automotive sector**

The international trade indicators (net exports, trade balance, revealed comparative advantage) depend on the change in export and import flows of cars and light commercial vehicles as a result of the new regulations. The determining factor of the changes in the direction of trade flows is the changes in the relative production costs of vehicles assembled, respectively, in Europe and overseas. Two types of costs should be considered:

- the costs of achieving the EU targets by, respectively EU and foreign producers, and
- the costs of achieving the targets established in the overseas markets by, respectively EU and foreign producers.

If the cost of achieving the targets are higher for the EU than for the foreign producers, then the EU trade balance will have the tendency to degenerate and the RCA index to decline.

Chapter 4.2 of this report compares and contrasts the EU CO\textsubscript{2} emission regulations with those in other regions. The chapter shows that in absolute values the current targets in Europe and Japan are lower than in
America and the rest of Asia, which all appear more or less similar. However, the targets may gradually equalize in the post-2020 perspective.

**Effects of post 2020 regulation on international competitiveness of EU car manufacturing**

Chapter 5 on cost competitiveness established that the change in costs results from a multitude of factors, including various specific targets for manufacturers affected by aspects of the regulation; compliance mechanisms used by the manufacturers; and the factors determining the costs of implementation of these mechanisms. A large number of pathways were qualitatively described, each of which can have either positive or negative sign of impact, which cannot be determined with any accuracy at this point. The overall conclusion is that modalities of the regulation as such do not strongly suggest either a positive or negative impact on relative costs for both cars and light commercial vehicles, hence we can posit that the regulation will probably be neutral for the trade balance and RCA. This overall conclusion, however, can be adjusted when more is known about the future target levels, utility parameter, the slope of the target function, the relative stringencies of the EU and overseas regulations, production factors (components, labour costs, labour requirement by labour type to meet the regulations, volumes of sales, capital goods requirements etc.).

The relocation of production is also not expected. The main factor of such relocation would be an advantage in labour costs resulting from the regulation. The impact of the regulation on labour cost competitiveness is possible if new technologies require more/less labour or have a higher/lower share of (manual) labour in assembly / production. This impact is of unknown sign and size but is expected to be rather small. Chapter 11 concludes that there might be an impact of the regulations on the location of R&D centres due to a different pace of regulations in the EU and abroad. However, the differences in the pace of regulations are uncertain and the impact is likely to be small.

Import tariffs if kept unchanged are unlikely to play a role in changing international competitiveness. The tariffs are currently higher in the EU than in partner countries. The EU tariff for cars is 10 per cent while it is 2.5 per cent in the U.S. and 0 per cent in Japan. Unless all non EU manufactured vehicles are just at the point where they would be imported (which is an unlikely situation) any change isn’t going to make a big difference.

This reasoning was generally supported by the interviews. Survey questions were as follows:

1. Does the EU CO₂ legislation for light duty vehicles lead to different “relative” levels of stringency of the targets imposed on EU and non-EU OEMs? If so, why? What elements of the legislation are causing this difference?

2. Are there differences in the costs for EU and non-EU OEMs of complying with similar targets? Are these the result of EU and non-EU OEMs choosing different compliance mechanisms with different cost implications to meet similar targets? Or are they the result of costs for similar compliance mechanisms being different for EU vs. non-EU OEMs? And if the latter is the case, what are the reasons for these differences in costs.

3. Would EU OEMs and suppliers or their non-EU competitors benefit from EU LDV CO₂ regulations being more stringent than in other regions / markets? If there would be similar LDV CO₂ regulations in different
markets / regions, would the economies of scale resulting from that benefit EU OEMs and suppliers or their non-EU competitors?

4. If future targets would require OEMs to sell significant shares of very efficient vehicles (ICEVs, BEVs, PHEVs and FCEVs), would you consider the EU automotive industry to be in a better / equal / worse position compared to non-EU competitors to apply that compliance mechanism? Why?

The responses point to some second-order effects which could have an effect on cost competitiveness and trade balances but whose magnitude is currently hard to assess. The responses to the first and second questions indicated that there is some difference between the EU and non-EU manufacturers in relation to stringency of the legislative targets due to the difference in vehicle portfolios. Namely, there appear to be some disadvantage for non-EU manufacturers that are mainly focused on gasoline, unless they are strong on hybrid, while the EU is primarily a “diesel market” and the targets can be achieved mainly through increasing the efficiency of ICEs\textsuperscript{39}. In this case, we might expect (a slight) improvement in the competitiveness of EU OEMs in the EU market. For the same reason, the cost of compliance of the non-EU manufacturers would be higher than EU manufacturers, with a similar effect on competitiveness.

On the third question, respondents think that more stringent EU regulations would not benefit EU OEMs on other markets. On the contrary, they think this would result in a decrease of the EU market share abroad, with a negative effect on the revealed comparative advantage index. Respondents do not expect significant variation of CO\textsubscript{2} emission legislation across major markets. On the fourth question, respondents believe that both EU and non-EU manufacturers would be affected similarly if future targets would require OEMs to sell significant shares of very efficient vehicles (i.e. there will be no change in relative competitiveness). However, they point to a possible negative consumer reaction whose acceptance of very fuel-efficient vehicles remains low. This will lead to loss of profitability of all OEMs and a slower fleet renewal.

In 2011, the outwards stock of FDI (investment out of the EU-27) in the sector “Manufacture of motor vehicles, trailers and semi-trailers” stood at 65,139 million euro with the inward FDI stock of the EU in the same sector at 28,740 million euro. Thus the ratio of outward to inward FDI stock equalled 2.27, i.e. the EU invested more abroad than it received investments from abroad.

The prospective regulations are likely to require additional investment of foreign-owned OEMs into their R&D and production facilities. While the former are located in their host countries, the EU plants will probably require updates in equipment and production processes. Some inwards FDI flows, which compensate the financing gap when EU-generated revenues are not enough, might result but the magnitude of these flows will be probably quite modest.

Effects of post 2020 regulation on international competitiveness of automotive (component) suppliers

Overall, cost differences among regions are not expected to be affected by the legislation. No marked changes in trade competitiveness or business relocation will likely result.

\textsuperscript{39} It should be mentioned however that the (unrelated to this study) Euro 6-2 regulation will somewhat reduce the advantage of the diesel engine by increasing development and production costs related to Euro 6-2.
Effects of post 2020 regulation on international competitiveness of EU component manufacturing

Chapter 7 concludes that the post 2020 EU LDV CO$_2$ legislation is unlikely to have a direct impact on the cost competitiveness of EU component manufacturing. A limited number of possible indirect impacts have been identified, including access to materials; the relative stringency of the legislation; the share of new (sub)components for advanced ICEVs and AFVs produced in the EU; regional differences in labour costs in combination with a distinctly higher/lower share of labour and differences in the costs of capital goods. The overall sign and size of these effects cannot be determined at this stage but we do not have solid reasons to assert a systematic change in international competitiveness and the location of the production facilities. In our survey, the respondents indicated somewhat lower prospective costs for Asian manufacturers in some components (e.g. electric cars) and for EU manufacturers in other components (e.g. diesel).

Effects of post 2020 regulation on international competitiveness of the energy supply industry

EU refineries may face reduced profitability as a result of the legislation. This means that the international competitiveness of EU refineries may be reduced and imports of petroleum products produced at low-cost or new state-of-the-art refineries in Russia, India and the Middle East might increase. However, since refineries are mostly owned by large global companies competing on various regional markets, the strategic decisions of these companies with respect to production locations may have an effect on the international competitiveness of EU refineries. However, these decisions are impossible to foresee at this time.

Regarding different product streams, the EU is currently a net importer of diesel and a net exporter of petroleum. Assuming that:
- the regulation does not alter the petrol-diesel share in the passenger car market;
- the net demand for diesel by HGVs will not reduce in the coming decades as a result of freight transport volume increases compensating efficiency improvements,
post-2020 LDV CO$_2$ legislation will lead to an increase of the diesel-to-petrol ratio in the demand from the EU transport sector. If the volume of fuel production in the EU is not adjusted to the overall lower demand, this will lead to a decrease in diesel imports and an increase in petrol exports. Given that rising motorization of the developing countries will create extra world market demand for petrol, this will lead to an improvement in trade balance and revealed comparative advantage for both petrol and diesel. If the volume of fuel production in the EU is reduced in accordance with the reduced demand from the EU transport sector, the ratio of diesel imports and petrol exports would remain at the current level with small changes in overall volumes.

Companies that operate fuel distribution infrastructure and filling stations in the EU do not and will not have a significant exposure to international markets and their international competitiveness position is irrelevant.

Effects of post 2020 regulation on international competitiveness of (professional) end users

Competitiveness impacts for professional end-users of LDVs will be insignificant, since the delivery services with LDVs are mostly provided locally, within the EU.
12.4 Key conclusions

- EU-based manufacturers currently hold strong competitive positions in passenger vehicles and auto components but not in light commercial vehicles.
- As a result of CO₂ emission legislation, the trade competitiveness of EU manufacturers of vehicles, automotive components and end users is not expected to change to a great extent. The regulation is likely to be trade-neutral. However, there are likely to arise some second-order effects, although quite small. For instance, the international competitiveness of EU-based gasoline vehicles may increase. Contrary to that, the competitiveness of EU-manufacturers may suffer if the EU targets are too stringent exceeding those of the competitors by a large margin.
- The competitiveness of the energy supply industry might be negatively affected by post-2020 CO₂ legislation as reduced demand leads to reduced profitability of refineries, but future strategic decisions of the global energy supply companies may alter this effect. In addition, however, the legislation may lead to an improvement in trade balance and revealed comparative advantage for both petrol and diesel.
- Some extra inward FDI flows may result but their magnitude is probably small.
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation
13. Conclusions and recommendations

13.1 Conclusions on possible cost competitiveness impacts

For assessing cost competitiveness impacts on the affected sectors automotive manufacturing industry, automotive supply industry and energy supply industry and end-users it is useful to separate the analysis into two cases:

- EU companies vs. competing companies from other regions;
- EU manufacturing / production vs. manufacturing / production in other regions.

The two perspectives are complementary. OEMs for instance compete for market shares in the EU market as well as on markets in other regions. This competition is strongly determined by the price and quality of their products and how these are valued by customers in the different markets. Price and quality of vehicles may be affected by legislative demands that are in place in different markets. This competition is affected by manufacturing costs, which depend among other things on whether the vehicles are manufactured in the EU or in other regions. Based on developments in this competition, combined with a range of other factors, OEMs may decide to increase or decrease their production capacity in the EU or in other regions.

Competitiveness impacts have been assessed from these two perspectives for the car manufacturing sector as well as the automotive supply sector. For the energy supply sector and professional end-users, the other two affected sectors included in this study, the two perspectives are less distinct. Within the energy sector oil companies are in global competition, but fuel supplied to the EU market is largely produced in the EU. Other affected energy suppliers (e.g. for electricity) are largely not competing with companies from other regions. Especially for end-users many of the possibly affected EU companies are not competing with non-EU companies, and if they are the impact of a change in costs of operating passenger cars and vans is likely to be a very small part of their cost of operations.

**Effects of post-2020 regulation on cost competitiveness of EU automotive manufacturers and manufacturing**

Possible competitiveness impacts of the post-2020 EU LDV CO$_2$ legislation have been assessed for EU OEMs vs. non-EU OEMs as well as for the EU automotive manufacturing industry (which includes production facilities of non-EU OEMs in the EU) vs. automotive manufacturing outside the EU.

**Competitiveness impacts from the perspective of car manufacturers**

Assessing cost competitiveness impacts on OEMs requires identifying whether and how the EU post-2020 LDV CO$_2$ legislation could lead to:

- different levels of stringency of the targets imposed on EU and non-EU OEMs;
- differences in the costs for EU and non-EU OEMs of complying with similar targets, which in turn may be the result of:
  - EU and non-EU OEMs choosing different compliance mechanisms with different cost implications to meet similar targets;
  - costs of similar compliance mechanisms being different for EU vs. non-EU OEMs.
The latter two are strongly related to the capabilities and resources of different companies. Analysing whether and how differences in capabilities and resources can be attributed to companies or manufacturing activities being EU or non-EU, and determining whether such differences lead to differences in the cost of compliance is the main challenge of the assessment of possible cost competitiveness impacts.

But even if targets and compliance costs are on average similar for affected OEMs from different regions, and direct competitiveness impacts are therefore unlikely, there may still be non-negligible second order impacts. If the increased costs of manufacturing vehicles for the EU market would lead to lower margins and thus reduced profits for sales on the EU market, EU manufacturers may still have different abilities than non-EU manufacturers to deal with such impacts, e.g. as they cannot recover losses on the EU market by profits in other markets in the same way as non-EU manufacturers can. The ability to deal with competitiveness impacts on the EU market may not so much relate to OEMs being EU or not, but maybe more to OEMs being premium manufacturers or not. OEMs selling premium models in the EU market first of all have higher profit margins in that market and customers with a higher willingness-to-pay (lower price-elasticity). But it is also the EU manufacturers of premium brands that are selling a lot of cars in foreign markets.

In view of the second aspect, i.e. costs of similar compliance mechanisms being different for EU vs. non-EU OEMs, the essential question is whether cost curves for efficiency improvement in ICEVs and costs of manufacturing AFVs are different for EU and non-EU manufacturers. This question is difficult to answer quantitatively, but possible origins for cost differences have been explored with the help of qualitative and quantitative sectorial information.

From an analysis of ways in which the regulation may affect the price and quality of products the following things can be concluded:

- Specific targets for manufacturers are affected by various aspects of the regulation;
- For meeting a given target a large number of compliance mechanisms are available;
- The costs for implementing these compliance mechanisms are determined by a large number of factors.

As a result of this there are a myriad of possible impact pathways that might have negative as well as positive impacts on the competitiveness of EU manufacturers. This makes it appear less likely that the post 2020 EU LDV CO\textsubscript{2} regulation as a whole would lead to net impacts on competitiveness of EU manufacturers. Nevertheless choices with respect to specific elements of the legislation could enhance the possibility of specific competitiveness impacts to occur. For that reason first an assessment was made of the general consequences of different aspects (modalities) of the legislation on the competitiveness of EU vs. non-EU OEMs.

It is concluded that the modalities as such do not directly lead to pronounced competitiveness impacts. However, for various modalities it is possible that they lead to, or at least contribute to competitiveness impacts depending how they are implemented in combination with specifics of the market (e.g. positions of EU and non-EU manufacturers in terms of sales distribution):

- The target level strongly determines the extent to which differences in the costs for similar technologies between EU and non-EU OEMs affect their competitiveness. Whether the EU target is more or less strict
than that in other regions, together with the market shares of EU and non-EU OEMs on the EU and other markets, determines economies of scale for CO$_2$ reducing technologies;

- If sales distributions over different vehicle segments are different for EU and non-EU OEMs, the utility parameter and the shape and slope of the target function determine the relative (average) stringency of targets for these groups of OEMs. For footprint as utility parameter, choices with respect to the shape and slope of the target function are less likely to lead to impacts on competitiveness;

- Other modalities, such as a joint legislative target for cars and vans, including mileage weighting, super – credits, eco-innovations, pooling and trading may lead to different abilities for EU and non-EU OEMs to meet their targets and might thus affect competitiveness.

Resources of OEMs, defined by their financial position, knowledge position, facilities for R&D and manufacturing, supplier base and their product portfolio and customer base determine their capability to implement compliance mechanisms for meeting future CO$_2$ targets. An analysis of possible regional differences in these resources and capabilities, based on a qualitative analysis augmented with sectorial data and input from stakeholder consultation, revealed the following possible impacts:

- The capability of EU OEMs to develop advanced ICEVs and AFVs may be less than that of non-EU OEMs, especially if powertrain electrification becomes an important compliance mechanism. Origins for this are the fact that the financial position of EU OEMs is more heavily affected by the economic crisis than that of non-EU OEMs, the technological focus of EU OEMs on diesel technology rather than hybrid/electric propulsion and a possible shortage of skilled R&D personnel;

- With respect to the ability to manufacture vehicles with CO$_2$-reducing technologies at competitive costs, various cost factors might lead to competitiveness impacts but for most of them the likeliness, sign and size of these impacts are difficult to judge. Japanese OEMs appear in a better position to scale up production of electric and hybrid vehicles and to benefit from their lead in this technology, but EU OEMs are catching up fast. EU OEMs may have a possible advantage to achieve cost reductions for integration of different powertrains due their advanced platform approach;

- The ability to sell at competitive prices is not only determined by the additional costs of manufacturing vehicles with CO$_2$-reducing technologies, but also by e.g. the amount of R&D costs to be earned back per vehicle, the ability to cross-subsidize within the product portfolio, and the ability to absorb losses. Concerning the latter the current financial position of EU OEMs, if continued over the next years, could cause negative competitiveness impacts;

- The ability to sell vehicles with new technologies on the EU market seems better for (some) EU OEMs due to their stronger position in premium segments of the market. Concerning the latter, stakeholder inputs as well as a decomposition of pathways seems to suggest that whether an OEM is a premium or volume manufacturer may be a stronger determinant for its ability to deal with the impacts of CO$_2$ legislation than whether it is EU or not.

Timing of the legislation, specifically the lead time between announcement of the target and the target year is expected to affect the above impacts. A short lead time leads to higher costs for developing and marketing new technologies, which are more difficult to bear for OEMs with a less strong financial position.
Competitiveness impacts from the perspective of automotive manufacturing

For the case of competitiveness impacts on EU car manufacturing the focus is on identifying possible impacts of the LDV CO₂ legislation on the cost of manufacturing or the cost of doing business. The main cost components that determine the costs of manufacturing cars are material costs, costs of purchased components, labour costs, capital costs (machines, tooling, etc.), and costs of overheads (such as management, marketing, logistics and R&D). The competitiveness of EU car manufacturing is determined by the total average costs of manufacturing per unit of production in the EU compared to those in other regions.

The total cost ratio between manufacturing in EU and other regions may change as a result of the EU LDV CO₂ legislation:

- if one or more cost factors change as a result of the LDV CO₂ legislation and this change is different in the EU than in other regions;
- if application of new technologies or other activities needed to comply with LDV CO₂ legislation affect the shares of different cost factors in the total production costs, and if ratios of these cost factors for EU vs. other regions are significantly different.

Post 2020 EU LDV CO₂ legislation has no direct impact on the cost competitiveness of EU car manufacturing. A limited number of possible indirect impacts, however, have been identified:

- The access to materials as well as the costs of these materials could be different for EU and non-EU OEMs. This especially relates to materials for electric powertrains and vehicle light-weighting;
- Possible positive or negative competitiveness impacts are identified in relation to regional differences in the cost of components for advanced ICEVs and AFVs, depending e.g. on the relative stringency of EU legislation compared to that in other regions or whether components are required for which suppliers are mainly located outside Europe;
- Regional differences in labour costs may have an impact of unknown sign and size as new technologies may require more/less labour or have a higher/lower share of (manual) labour in assembly / production.
- Furthermore some impact pathways have been identified that relate to differences in the costs of capital goods, transport costs and tariffs, and the volume of sales over which R&D costs can be divided. The size and sign of these impacts depend on the relative stringency of EU legislation, with in general positive impacts for the EU industry if the EU legislation is more stringent.

Conclusions seem to be quite generic and the same for the car and van regulation.

Possible cost competitiveness impacts on the automotive supply industry

Also for the automotive supply industry possible competitiveness impacts of the post-2020 EU LDV CO₂ legislation have been assessed for EU suppliers vs. non-EU suppliers as well as for the EU automotive component manufacturing vs. non-EU component manufacturers. Similar mechanisms are found as for OEMs, but with different conclusions on the likeliness, sign and size of some of the possible impacts.
Competitiveness impacts from the perspective of component manufacturers

Concerning possible competitiveness impacts associated with regional differences in resources and resulting capabilities of component suppliers the following conclusions have been drawn:

- The ability of EU suppliers to develop components for CO\textsubscript{2} reduction in passenger cars and vans appears likely to be less than that of non-EU competitors, specifically if the post-2020 regulation would increase demand for vehicles with electric powertrains. This is related to their technology position, their financial position as well as to foreseen shortages in skilled R&D personnel;
- With respect to the ability of EU suppliers to manufacture at competitive costs their weak position in electric powertrain technologies could be a drawback. Other factors such as the costs of labour, the costs of equipment, economies of scale associated with the customer base and the stringency of the legislation and the costs of materials could lead to impacts on competitiveness, but the sign and size of these impacts is difficult to estimate;
- The ability of EU suppliers to sell at competitive prices may be affected by their limited ability to absorb (temporary) losses. Other factors such as manufacturing costs, R&D costs per unit of product and the ability to cross-subsidize over the product portfolio could lead to impacts on competitiveness, but the sign and size of these impacts is difficult to estimate;
- Overall the limited ability to absorb losses appears to negatively affect the competitiveness of EU suppliers.

Compared to car manufacturers the likeliness of negative competitiveness impacts for EU suppliers seems somewhat higher.

Competitiveness impacts from the perspective of component manufacturing

As for car manufacturing, also for component manufacturing only a limited number of pathways seem to result in likely impacts on competitiveness of EU manufacturing. Where impacts are possible, they may be positive or negative. Conclusions seem to be quite generic and the same for the car and van regulation.

Post 2020 EU LDV CO\textsubscript{2} legislation has no direct impact on the cost competitiveness of EU component manufacturing. A limited number of possible indirect impacts, however, have been identified:

- The access to materials as well as the costs of these materials could be different for EU and non-EU suppliers. This especially relates to materials for electric powertrains and vehicle lightweighting. Sign and size of the effect cannot be determined at this stage, but effects are likely to be more pronounced for component manufacturing than for vehicle manufacturing;
- With respect to the costs of purchased components small positive impacts could occur if the EU has more stringent regulation than other regions or if a large share of new (sub)components for advanced ICEVs and AFVs are produced in the EU. Small negative impacts may occur if (sub)components for advanced ICEVs and AFVs are mainly produced outside the EU;
- Regional differences in labour costs may have an impact of unknown sign and size as new technologies may require more/less labour or have a higher/lower share of (manual) labour in assembly / production;
- Furthermore some indirect impact pathways have been identified that relate to differences in the costs of capital goods and the volume of sales over which R&D costs can be divided. The size and sign of these impacts depend on the relative stringency of EU legislation.

Conclusions seem to be quite generic and the same for the car and van regulation.
Possible cost competitiveness impacts on the fuel supply sector

The post-2020 LDV CO\(_2\) regulation does not directly affect the costs of producing petroleum-based transport fuels or alternative fuels or energy carriers for transport. Indirect impacts are very likely, though, as the legislation will affect the demand for different energy carriers and different companies may have different abilities to cope with this changing demand.

The energy supply sector can be divided into:

- producers of fuels and other energy carriers
  - the oil refining industry for petroleum based fuels
  - electricity generation
  - production of alternative (bio)fuels and energy carriers (e.g. hydrogen)
- distributors of fuels and other energy carriers
  - fuel distributors and operators of filling stations
  - operators of electricity distribution networks and operators of charging stations

Both sub-sectors contain large, medium-size and small companies. The analysis of possible competitiveness impacts has been done separately for the two sub-sectors.

For producers of fuels and other energy carriers the following pathways for possible competitiveness impacts have been identified:

- A declining demand for petroleum fuels, resulting from post-2020 EU LDV CO\(_2\) legislation, will put pressure on the prices of fuels. For fuel producing companies lower volumes mean that refinery utilisation rates are expected to go down, leading to an increase in costs per unit production. The combination of the two will strongly reduce profitability of EU refineries. This means that it will become more difficult for the products of these refineries to compete on the EU market with imports from Russia or new state-of-the art refineries being opened in India and the Middle-East.
- Refineries are mostly owned by large, often global companies competing on various regional markets. The ability of companies to deal with changes in the EU market may depend on the size of their EU activities and the share of these in their global activities. Impacts may also depend on the extent to which they produce in the EU for the EU market or also import and export to and from the EU. With the information available it is not possible to “predict” what the strategic decisions of such global companies will be in response to the effects of post-2020 EU LDV CO\(_2\) legislation on the demand for fuels in Europe.
- In decisions on (dis)investments in refining capacity, also the status of facilities may play a role as decommissioning refinery capacity is more costly for newer than for older facilities. It is likely that there are differences in this respect between different refineries in Europe, but this has not been assessed.
- Closing of refineries in the EU will lead to a loss of jobs and of value added within the EU. This is an economic impact that is likely to happen if EU LDV CO\(_2\) legislation is effective, but that could be amplified by the fact that EU fuel producers are affected more severely by the legislation than producers outside the EU which operate new facilities and have a large share of their sales in markets that are still growing.
Companies that operate fuel distribution infrastructure and filling stations in the EU operate locally or regionally, and are not directly competing with companies in other regions (apart from some cross-border competition between adjacent EU and non-EU countries). Reduced demand for petroleum-based fuels could lead to negative economic impacts on this sub-sector of the fuel supply sector, including a significant loss of jobs and value added, but these are not to be classified as competitiveness impacts.

Possible cost competitiveness impacts on professional end-users

For those companies that use passenger cars and vans, either to provide transport services to clients or as part of their own operations, the total cost of ownership (TCO) for using these vehicles is an element in their cost of doing business. If the post-2020 EU LDV CO\textsubscript{2} legislation affects the TCO of vehicles, it directly affects the costs of doing business for all companies that use LCVs (professional end-users). Changes in the cost of doing business for a company affect the price of its products and/or services, which may affect competition in the market and lead to a change in market shares. If prices change similarly for all competitors, an overall change in the volume of the market is likely to occur. This may lead to a change in the utilization of facilities of these companies and thus to a further change in the costs per unit product or service. If these effects work out differently for competing companies, e.g. as a consequences of differences in their resources and capabilities that are associated with the region in which they are based / operate, competitiveness may be affected.

Making ICEVs more energy-efficient generally leads to a higher vehicle price but lower fuel costs. The net effect on TCO depends on the amount of efficiency improvement, the related additional vehicle costs and the costs per unit of fuel. Already based on cost curves for 2020 emission reductions to levels that may come into view for the 2020-2030 period can be achieved with net negative costs to the end user. It is expected that new cost curves for the 2020-30 period will suggest higher reductions to be possible at lower costs, further increasing the reduction potential that is cost effective to the-end user. Alternative fuelled vehicles (AFVs) tend to be more expensive than ICEVs. The fuel costs per kilometre differ strongly for the different energy carriers. Currently most AFVs (without tax incentives) have a TCO that is higher than that of ICEVs. In the 2020-30 timeframe the TCO of most AFVs is expected to approach that of ICEVs.

In addition to a change in TCO the technologies applied to ICEVs as well as AFVs may have an impact on the reliability and operability of vehicles, which may affect the value of the product or services supplied. Implementing e.g. BEVs with limited range may affect the way in which end-users use their vehicles and may even require changes in their operations or way of providing services. This may be seen as a reduction in the value added by operating such cars. On the other hand, the use of electric powertrains is expected to lead to lower maintenance costs, which may improve the TCO of BEVs.

In view of the above the following conclusions can be drawn with respect to possible competitiveness impacts on professional end-users of LDVs:

- Competitiveness impacts for professional end-users of LDVs are only to be expected for EU companies that provide products or services that compete on the EU market or other markets against products and services from non-EU companies. Positive impacts are expected as the post-2020 EU CO\textsubscript{2} legislation is in principle expected to lead to a net reduction of end-user costs. If different regions have LDV CO\textsubscript{2}
regulations with similar levels of stringency, EU companies are expected to benefit more as fuel prices are generally higher in Europe. However, the size of this impact is expected to be small, as the costs of operating LDVs is generally only a small fraction of the cost of doing business.

- EU-based SMEs, which in their operations make extensive use of LDVs, will in general not be competing with non-EU companies, regardless of whether or not these LDVs are directly used for providing transport services. Companies competing on the EU market will be similarly affected by post-2020 LDV CO\textsubscript{2} regulations. For end-user SMEs, therefore no impact on their competitiveness is expected.

13.2 Conclusions on possible R&D competitiveness impacts

In Table 19 key conclusions on possible competitiveness impacts of the LDV CO\textsubscript{2} legislation on R&D and Innovation are summarized using the innovation competitiveness impact matrix.

In the case of LCVs the RDI exclusive expenditure is substantially lower since technologies are highly transferable from cars to LCVs. The usage of LCVs also limits the applicability of technically possible innovations. These limitations apply to all manufacturers, both EU and from other regions, hence should a regulation impose stringent targets we expect sales will be impacted depending on the price elasticity of professional end users. OEMs with competitive prices due to low development costs and economies of scale may have an advantage. Collaborations may also arise as a result of market accessibility and technological advantages lying in the hands of respectively EU and non EU OEMs.

**Suppliers** act in anticipation of regulations and are particularly responsive to regulations particularly due to the important role they play in the realisation of technological innovations. First tier suppliers provide beyond components, system integration which differentiates them from other suppliers focused exclusively on commodities. The portfolio of suppliers tends to be diverse with a leading position in fuel injection technologies and an increasing emphasis on powertrain electrification and hybridization. Japanese suppliers are however clearly leading in the field. A regulation with an emphasis on electrification will inevitably impact EU suppliers should OEMs currently focused on diesel reconsider their product mix.

With respect to other stakeholders, **Energy providers** and **Professional end users** no relevant conclusions are drawn for either their capacity to innovate or competitiveness impacts.
### Propositions

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Differences (Δs)</th>
<th>Key conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition 1: The regulation impacts innovation strategy and RDI investment choices by influencing OEMs business strategy, notably related to product and service innovation.</td>
<td>Δ RDI activities</td>
<td>RDI investment choices are impacted particularly as regards product innovation and the prioritisation of R&amp;D expenditures. A regulatory push to electrification poses less need for adjustment to those OEMs/Suppliers from other Regions who are 'first movers' in this segment of the market and EU OEMs cross-subsidizing losses through overseas markets. That said, given the significantly below expectations market growth of EVs in Europe a push to electrification would put significant stress on profit margins particularly of mass production OEMs. Services are primarily driven by market conditions. Increasing potential appears to be linked to the development of services linked to electrification. In Europe with EVs being a niche market and given the lack of the necessary infrastructure competitiveness impacts related to this segment are not yet prominent. The increasing demand for people with either basic engineering skills or specific R&amp;D skills is being met through global recruitment due to a shortage of the desired skills in Europe. The same applies for EU manufacturers vs. manufacturers from other regions. The declining expertise in Europe is posing a threat to Europe's competitiveness altogether and not strictly on global industries like the automotive industry.</td>
</tr>
<tr>
<td>Proposition 2: By creating the need for specific R&amp;D skills, the regulation influences the needs of RDI personnel of OEMs.</td>
<td></td>
<td>The design and implementation of innovative products is not directly influenced by the regulation but is a consequence of the chosen compliance strategy (i.e. product mix). It is also linked to the coherence between CO2 regulation and other regulations. Services are linked to products and are thus indirectly influenced by the regulation. Business models have been shaped by regulation over many years considering the emphasis towards sustainable business models predominantly centred on product, ranging for example from efficient ICEV to AFVs and EVs. Nevertheless designs of product-process-structure-business models are shaped by market conditions and other regulations as well. The same applies for EU manufacturers vs. manufacturers from other regions and no competitive advantage can be attributed given similar levels of regulatory stringency across regions.</td>
</tr>
<tr>
<td>Proposition 3: The regulation impacts the design and implementation of innovative processes.</td>
<td>Δ Innovation strategies and strategic partnerships</td>
<td>The externalisation of some R&amp;D activities by either shorter term or longer term collaborations to bring down development costs have been occurring as a response to shrinking profit margins. Regulations implying products already available in the market by some manufacturers does imply collaborations as the fastest 'catch up' strategy and may hence result in a further intensification of this trend. Moreover in the specific example of electrification the product can be characterised as a “high learning product” with long introductory phases particularly in Europe. Given growth expectations in other non-EU regions further consolidation in an already highly consolidated industry (including thus R&amp;D) may also be unavoidable. On the other hand OEMs with either their local markets in regions where electrification has picked up faster or with presence in those markets do have a competitive advantage and some may be less inclined to form collaborations in the absence of a favourable outcome to them.</td>
</tr>
<tr>
<td>Proposition 4: The regulation impacts the design and implementation of innovative processes, including changes to business models of OEMs.</td>
<td></td>
<td>Business models are shaped by regulation over many years considering the emphasis towards sustainable business models predominantly centred on product, ranging for example from efficient ICEV to AFVs and EVs. Nevertheless designs of product-process-structure-business models are shaped by market conditions and other regulations as well. The same applies for EU manufacturers vs. manufacturers from other regions and no competitive advantage can be attributed given similar levels of regulatory stringency across regions.</td>
</tr>
<tr>
<td>Proposition 5: The regulation leads to externalisation of OEM's RDI activities.</td>
<td>Δ Innovation strategies and strategic partnerships</td>
<td>Externalisation of some R&amp;D activities by either shorter term or longer term collaborations to bring down development costs have been occurring as a response to shrinking profit margins. Regulations implying products already available in the market by some manufacturers does imply collaborations as the fastest 'catch up' strategy and may hence result in a further intensification of this trend. Moreover in the specific example of electrification the product can be characterised as a “high learning product” with long introductory phases particularly in Europe. Given growth expectations in other non-EU regions further consolidation in an already highly consolidated industry (including thus R&amp;D) may also be unavoidable. On the other hand OEMs with either their local markets in regions where electrification has picked up faster or with presence in those markets do have a competitive advantage and some may be less inclined to form collaborations in the absence of a favourable outcome to them.</td>
</tr>
<tr>
<td>Proposition 6: The regulation impacts RDI processes by creating the need for alternative forms of co-operation with external partners</td>
<td>Δ RDI outputs and results</td>
<td>IPR strategies are linked to decisions on R&amp;D externalisation and strategic co-operations. OEMs may thus develop technologies in house and hence patent or decide to purchase patents or directly collaborate with OEMs in possession of the patents linked to their strategy of compliance. OEMs/Suppliers in possession of those patents deemed necessary have a competitive advantage either financially due to the possibility to sell or license their patents or in terms of negotiating power. Currently the great majority of OEMs/Suppliers in possession of patents related to electrification are from regions outside of Europe.</td>
</tr>
<tr>
<td>Proposition 7: The regulation impacts IPR strategies.</td>
<td>Δ RDI outputs and results</td>
<td>The low profit margins for particularly mass production manufacturers heights the need for alternative forms of access to finance for either innovations linked to the regulation or other innovations that may as a consequence of the regulation become less priority but are considered either strategic for their future competitiveness or are required for their compliance with other regulations.</td>
</tr>
<tr>
<td>Proposition 8: The regulation leads to the need for attracting risk capital.</td>
<td></td>
<td>The low profit margins for particularly mass production manufacturers heights the need for alternative forms of access to finance for either innovations linked to the regulation or other innovations that may as a consequence of the regulation become less priority but are considered either strategic for their future competitiveness or are required for their compliance with other regulations.</td>
</tr>
</tbody>
</table>

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40 For example the innovative process of making a car using carbon fibre as material makes a car lighter and hence more efficient in its fuel consumption (plus makes the option of 3D printing possible). Moreover it impacts compliance to safety requirements posing hence higher R&D costs. In terms of the CO2 regulation assuming weight is part of the utility function lighter cars decrease OEMs' target, which is not desirable for a manufacturer. While hence in the specific case not desirable as a compliance strategy it is a forward looking approach with a shorter term effect on fuel efficiency, a critical factor for the consumer.
13.3 Conclusions on possible international competitiveness impacts

- The EU-based manufacturers currently hold strong competitive positions in passenger vehicles and auto components but not in light commercial vehicles.
- As a result of CO₂ emission legislation, the trade competitiveness of EU manufacturers of vehicles, automotive components and end users is not expected to change to a great extent. The regulation is likely to be trade-neutral. However, some second-order effects are possible and may be of either positive and negative signs. The sign and the precise magnitude of these effects is not clear at this time but they are likely to be small.
- The competitiveness of the energy supply industry might be negatively affected by post-2020 CO₂ legislation as reduced demand leads to reduced profitability of refineries, but future strategic decisions of the global energy supply companies may alter this effect. In addition, however, the legislation may lead to an improvement in trade balance and revealed comparative advantage for both petrol and diesel.
- Some extra inward FDI flows may result but their magnitude is probably small.

13.4 Summary of conclusions on the basis of questions from the Competitiveness Proofing Toolkit

In Table 24 the above conclusions for the different sectors are summarized in the form of answers to questions on cost, R&D and international competitiveness impacts as stated in the Commission’s Competitiveness Proofing Toolkit.

<table>
<thead>
<tr>
<th>Question</th>
<th>Car manufacturing</th>
<th>Component manufacturing</th>
<th>Energy supply</th>
<th>Professional end-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the effect on cost and price competitiveness?</td>
<td>Maybe</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A. Does the assessed proposal cut or increase compliance costs of the affected sector(s)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Does the policy option affect the nature of information obligations placed on businesses, such as the type of data required, reporting frequency, the complexity of submission process, etc.?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A monitoring mechanism for the CO₂ legislation is already in place. Details of that, and resulting requirements for OEMs, may change.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Does it require the use of new equipment (e.g. to reduce pollution, or to register sales, or to measure the content of a substance in the final product, etc.)?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Applying CO₂ reducing technologies to ICEVs or manufacturing AFVs is likely to require new equipment for manufacturing or assembly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing advanced components for ICEVs or AFVs is likely to require new equipment for manufacturing or assembly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Would it require additional staff time or business services provided by the private or public sector (such as external accounting or</td>
<td>Maybe</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A monitoring mechanism for the CO₂ legislation is already in place. Details of that, and resulting requirements for OEMs,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Affected sectors

<table>
<thead>
<tr>
<th>Question</th>
<th>Car manufacturing</th>
<th>Component manufacturing</th>
<th>Energy supply</th>
<th>Professional end-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audit services, or conformity verification by authorized public or private sector entities, etc.?</td>
<td>May change.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Do compliance costs place certain enterprises or sectors at a disadvantage relative to their competitors (including by creating an uneven playfield)?</td>
<td>Yes, size and sign of impact unknown. Depends on a range of factors such as relative stringency of EU legislation for EU and non-EU OEMs, relative stringency of the EU legislation compared to legislation in other regions, the target level and modalities and the extent to which these promote the implementation of AFVs as compliance mechanism.</td>
<td>Yes, size and sign of impact unknown. Depends on a range of factors such as relative stringency of EU legislation for EU and non-EU OEMs, relative stringency of the EU legislation compared to legislation in other regions, the target level and modalities and the extent to which these promote the implementation of AFVs as compliance mechanism.</td>
<td>Yes, EU refineries may face increased competition from refineries in other regions.</td>
<td>No</td>
</tr>
<tr>
<td>5. How are SMEs affected in particular?</td>
<td>Maybe, depends on derogations for small volume and niche manufacturers in post-2020 CO&lt;sub&gt;2&lt;/sub&gt; legislation.</td>
<td>No, advanced components for ICEVs or AFVs is likely to be supplied by large component manufacturing companies.</td>
<td>No</td>
<td>No, costs of doing business may be affected by ΔTCO of cars and vans, but SME end-users are not in competition with companies from outside EU</td>
</tr>
<tr>
<td>B. Does the proposal affect the prices and cost of intermediate consumption?</td>
<td>1. by affecting the price or availability of natural resources including raw materials and other inputs (intermediate goods and services) used in production?</td>
<td>Maybe, components for advanced ICEVs and AFVs are likely to require new materials. The price of these materials may be affected if demand increases faster than supply.</td>
<td>Maybe, components for advanced ICEVs and AFVs are likely to require new materials. The price of these materials may be affected if demand increases faster than supply.</td>
<td>No</td>
</tr>
<tr>
<td>2. by introducing restrictions (or bans) on the use of hazardous materials?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3. indirectly, when changes in the cost of output of directly affected sector are passed on downstream, or shift of demand to substitutes bids prices up, and those substitutes are used in intermediate consumption?</td>
<td>Yes, a change in the costs of cars and vans is expected which will impact on professional end-users.</td>
<td>Yes, a change in the costs of components is expected which will impact on OEMs.</td>
<td>Yes, a change in the price of fuels is expected which will impact professional end-users.</td>
<td>Maybe, prices of products and services may be affected by the ΔTCO of cars and vans, but impact is expected to be small.</td>
</tr>
<tr>
<td>C. Does the proposal affect the cost of capital?</td>
<td>1. by increasing the prices of capital goods?</td>
<td>Maybe, prices of alternative equipment for manufacturing advanced</td>
<td>Maybe, prices of alternative equipment for manufacturing components</td>
<td>No</td>
</tr>
</tbody>
</table>
### Affected sectors

<table>
<thead>
<tr>
<th>Question</th>
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<th>Professional end-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICEVs and AFVs may be affected if demand increases faster than supply.</td>
<td></td>
<td>for advanced ICEVs and AFVs may be affected if demand increases faster than supply.</td>
<td></td>
<td>(partly) counteracted by lower energy costs.</td>
</tr>
<tr>
<td>2. by affecting availability and cost of financing (equity, bank loans and bonds)?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>D. Does the proposal affect the cost of labour?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. by changing e.g. retirement age, minimum wages, social insurance contributions, or other taxes on labour?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2. by changing accounting or reporting obligations?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3. by affecting labour mobility, employee protection legislation, or labour market rigidities and flexibilities as a side effect?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4. by changes leading to additional/new labour demand?</td>
<td>Maybe</td>
<td>Developing and manufacturing advanced ICEVs and AFVs will require specifically skilled labour. Temporary shortage of such skilled labour is considered possible and will affect costs.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5. by imposing additional compliance costs related to employment: e.g. higher standards for health and safety at work or additional reporting requirements about the company’s workforce?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>E. Does the proposal affect the cost of energy?</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td></td>
</tr>
<tr>
<td>6. Does the policy proposal affect consumer’s choice and prices?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. by affecting the availability of certain products on the market?</td>
<td>Yes</td>
<td>Not relevant</td>
<td>Maybe</td>
<td>No</td>
</tr>
<tr>
<td>Yes Purchase prices of cars and vans are likely to go up. The legislation does not directly affect the portfolio offered by manufacturers.</td>
<td></td>
<td></td>
<td>The number of brands for fuels may reduce.</td>
<td>The CO₂ legislation is not expected to change the products and services offered by end-users.</td>
</tr>
</tbody>
</table>
### Affected sectors

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>but indirect effects are likely as changes in the product portfolio (sizes, performance, propulsion technology, etc.) may help OEMs to reduce cost of compliance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. by banning or limiting the marketing (or advertising) of certain products?</td>
<td>No</td>
<td>Not relevant</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3. by regulating or otherwise affecting the prices consumers pay for the products of the affected sector?</td>
<td>Yes The legislation does not directly affect prices, but as a result of applying CO\textsubscript{2} reducing technologies purchase prices of cars and vans are likely to go up.</td>
<td>Not relevant</td>
<td>Yes The legislation does not directly affect prices of fuels and other energy carriers. Reduced demand for petroleum fuel in EU is likely to increase costs for production but also put pressure on margins. Net effect is difficult to predict.</td>
<td>No</td>
</tr>
<tr>
<td>4. by affecting the quality of the goods and services consumers buy?</td>
<td>No</td>
<td>Not relevant</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5. by affecting the transparency and comparability of information about quality and prices of products and services?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>G. Would the impacts above require a major restructuring of affected enterprises’ operations?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Would there be substantial adjustment costs for enterprises (incl. workforce)?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2. Would the sector need a major restructuring such as closing of production lines, substitution of technologies, substitution of skills, etc.?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3. May it lead to closing down of enterprises?</td>
<td>Maybe No direct impacts expected, but identified possible impacts on competitiveness may in principle lead to closing down of enterprises.</td>
<td>Maybe No direct impacts expected, but identified possible impacts on competitiveness may in principle lead to closing down of enterprises.</td>
<td>Yes Reduced demand for petroleum fuels in EU is likely to lead to closing of refineries,</td>
<td>No</td>
</tr>
<tr>
<td>4. Would SMEs have difficulty to meet the cost</td>
<td>Maybe Depends on derogations for Advanced components for</td>
<td>No Advanced components for</td>
<td>Yes In the fuel distribution sub-</td>
<td>No Costs of doing business</td>
</tr>
<tr>
<td>Question</td>
<td>Car manufacturing</td>
<td>Component manufacturing</td>
<td>Energy supply</td>
<td>Professional end-users</td>
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</tr>
<tr>
<td>of restructuring?</td>
<td>small volume and niche manufacturers in post-2020 CO\textsubscript{2} legislation.</td>
<td>ICEVs or AFVs is likely to be supplied by large component manufacturing companies.</td>
<td>sector (filling stations) SMEs may have difficulty to deal with decreased demand and increased price competition.</td>
<td>may be affected by (\Delta\text{TCO}) of cars and vans, but net effect expected to be small.</td>
</tr>
</tbody>
</table>

Does the proposal affect the enterprises’ capacity to innovate?\(^{41}\)

1. By affecting enterprises’ capacity to carry out R&D leading to innovation in its products

<table>
<thead>
<tr>
<th></th>
<th>Maybe</th>
<th>Yes</th>
<th>Not applicable</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDI investment choices are impacted particularly as regards product innovation and the prioritisation of R&amp;D expenditures, but not the total RDI spending.</td>
<td>Suppliers indicate that CO\textsubscript{2} legislation not only leads to shifts in prioritisation but also to increased (need for) R&amp;D investments.</td>
<td></td>
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<td></td>
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</tbody>
</table>

1a. By affecting enterprises’ capacity to carry out R&D leading to innovation in its products, which can be further traced to the impact of the proposal on:
(a) supply of skills needed by the sector, and

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>Yes</th>
<th>Not applicable</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislation will lead to an increasing demand for people with specific engineering R&amp;D skills. It is foreseen that this demand cannot be met within the EU. This negative impact is partly counteracted through global recruitment.</td>
<td>Same motivation as for car manufacturing.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1b. By affecting enterprises’ capacity to carry out R&D leading to innovation in its products, which can be further traced to the impact of the proposal on:
(b) the efficiency of protection of intellectual property rights?

<table>
<thead>
<tr>
<th></th>
<th>Maybe</th>
<th>Maybe</th>
<th>Not applicable</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPR strategies are linked to decisions on R&amp;D externalisation and strategic co-operations which are influenced by the regulation. OEMs may thus develop technologies in house and hence patent or decide to purchase patents or directly collaborate with OEMs in possession of the patents linked to their strategy of compliance. OEMs/Suppliers in possession of those patents deemed necessary have a competitive advantage either financially due to the possibility to sell or license their patents or in terms of negotiating power.</td>
<td>Asian companies appear to have a stronger patent position for electric propulsion technologies. This may hinder EU supply industry in developing the right innovations to meet the legislation.</td>
<td></td>
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</tbody>
</table>

2. By affecting the sector’s capacity to bring to the market new products or improve the features of the current ones (capacity for product innovation),

<table>
<thead>
<tr>
<th></th>
<th>Maybe</th>
<th>Yes</th>
<th>Not applicable</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Externalisation of some R&amp;D activities by either shorter term or longer term collaborations to bring down development costs have</td>
<td>The need of OEMs to innovate will spur demand for innovative products from component suppliers. Increased investments in</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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\(^{41}\) For the adaptation of the EC’s Impact Assessment Competitiveness Proofing Toolkit questions to the specific context of the study see Table 11 in chapter 11. The main reason for this approach was that the Competitiveness Proofing Toolkit questions were not well adapted to fit the needs of this study and have been consequently redefined in the form of propositions.
### Affected sectors

<table>
<thead>
<tr>
<th>Question</th>
<th>Car manufacturing</th>
<th>Component manufacturing</th>
<th>Energy supply</th>
<th>Professional end-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>which depends crucially on technical skills and application of new technologies?</td>
<td>been occurring as a response to shrinking profit margins. Regulations implying products already available in the market by some manufacturers does imply collaborations as the fastest “catch up” strategy and may hence result in a further intensification of this trend.</td>
<td>component innovation will improve the supply sectors capacity to innovate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. by affecting the capacity to innovate in processes and product related services, including distribution, marketing and after-sales services (process innovation), which depends on the supply of management and organizational skills and talents?</td>
<td>No</td>
<td>Maybe A change in the type of components supplied to OEMs may require changes in services and supply logistics.</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>The design and implementation of innovative products is not directly influenced by the regulation but is a consequence of the chosen compliance strategy (i.e. product mix). It is also linked to the coherence between CO2 regulation and other regulations. Services are linked to products and are thus indirectly influenced by the regulation. <strong>Business models</strong> have been shaped by regulation over many years considering the emphasis towards sustainable business models predominantly centred on product, ranging for example from efficient ICEV to AFVs and EVs. Nevertheless designs of product-process-structure-business models are shaped by market conditions and other regulations as well.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. by affecting the ability to access risk capital?</td>
<td>No</td>
<td>No Same motivation as for car manufacturing.</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Regulation impacts the need to access risk capital not their ability to access risk capital. The low profit margins for particularly mass production manufacturers heightens the need for alternative forms of access to finance for either innovations linked to the regulation or other innovations that may as a consequence of the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Car manufacturing</td>
<td>Component manufacturing</td>
<td>Energy supply</td>
<td>Professional end-users</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>regulation become less prioritary but are considered either strategic for their future competitiveness or are required for their compliance with other regulations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What might be the effect on the sector’s international competitiveness?

1. What is the likely impact of the assessed option on the competitive position of EU firms with respect to non-EU competitors?

   Maybe
   - Trade-neutral but with second-order effects of indeterminate sign.
   - Trade-neutral but with second-order effects of indeterminate sign.
   - No
   - No

2. What is the likely impact of the assessed option on trade and trade barriers?

   No
   - No
   - No
   - No

3. Does the option concern an area in which international standards, common regulatory approaches or international regulatory dialogues exist?

   No
   - No
   - No
   - No

4. Is it likely to cause cross-border investment flows, including the relocation of economic activity inward of outwards the EU?

   Maybe
   - Slight increase in inward FDI flows.
   - Slight increase in inward FDI flows.
   - No
   - No

13.5 General conclusions

Post-2020 EU LDV CO$_2$ legislation will not directly affect the competitiveness of the EU vehicle manufacturing, component manufacturing and fuel or energy supply industry. For professional end-users there may be direct competitiveness impacts as the legislation affects the costs of operating passenger cars and vans, which are part of their cost of doing business. However, for the type of EU companies that are in competition with companies from other regions the share of costs related to using cars and vans in their total cost of doing business will generally be small, so that this impact is not considered significant.

However, there are a large number of indirect pathways that could result in competitiveness impacts. The likelihood and size of these indirect impacts depends partly on the way in which the legislation is designed and partly on ways in which the resources and capabilities of EU companies and sectors may be different from those of their non-EU competitors. These determine the ability of companies and sectors to deal with the consequences of the EU legislation.
13.6 Recommendations

This report provides a structured approach to assessing possible competitiveness impacts of post-2020 EU CO\textsubscript{2} legislation for light-duty vehicles. This framework has been used to identify possible impact pathways with respect to cost competitiveness, R&D competitiveness and international competitiveness. However, for most of the identified pathways no conclusions could be drawn on the likelihood, sign and size of the impacts as a result of the following factors:

- Many impact pathways were found to depend on the relative stringency of LDV CO\textsubscript{2} legislation in the EU versus regulations in other regions or on the relative stringency of the EU legislation for EU and non-EU OEMs active on the EU market. Generally it appears likely that a more stringent EU legislation has net positive impacts on the cost competitiveness of EU OEMs;

- Various identified pathways might have been further explored using concrete sectorial information, e.g. on sales distributions, shares of production inside and outside the EU, or trade flows. However, in many cases such information was either not available to the consortium or could not be further collected or analysed within the time and budget available for this study.

Furthermore various possible competitiveness impacts on EU OEMs and component suppliers were found to relate to the economic / financial situation of the EU automotive industry, which appears to be more strongly affected by the economic crisis than the industry in other regions, due to the fact that the EU economy, and as a consequence the car market in the EU, has stagnated more strongly than in other regions. It is to be expected that this will be an important issue in the discussion on post-2020 targets. At the same time, however, this is in principle a temporary situation that may change in the coming decade. To enable a more objective discussion on this issue, it is recommended that a more in-depth analysis is made of the current economic situation of the EU automotive sector and its possible development in the coming years, and on how this may affect their ability to deal with different levels of stringency for the post-2020 CO\textsubscript{2} legislation in the EU.
14. Literature

[AEA 2008] Impacts of regulatory options to reduce CO₂ emissions from cars, in particular on car manufacturers, study carried out by CE Delft, TNO, Öko-Institut and AEA under a framework contract (nr. ENV/C.5/FRA/2006/0071) led by AEA, ED05315010 - Issue 1, December 2008


[ICCT 2014] From laboratory to road: A 2014 update, by Peter Mock, Uwe Tietge, Vicente Franco, John German, Anup Bandivadekar (ICCT), Norbert Ligterink (TNO), Udo Lambrecht (IFEU), Jörg Kühlwein (KISU), and Iddo Riemersma (Sidekick Project Support), ICCT, 2014

http://www.theicct.org/sites/default/files/Phase_1_2_Summary%20080713B_Trans.pdf


[IEEP 2007] Possible regulatory approaches to reducing CO₂ emissions from cars, Study on the detailed design of the regulation to reduce CO₂ emissions from new passenger cars to 130 g/km in 2012, carried out by IEEP, CE Delft and TNO on behalf of the EU Commission (DG ENV, contract nr. 070402/2006/452236/MAR/C3) in 2007

http://ec.europa.eu/clima/events/articles/0103_en.htm
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation


[TNO 2013a] Consideration of alternative approaches to regulating CO₂ emissions from light duty road vehicles for the period after 2020, Service request #4 for Framework Contract on Vehicle Emissions (Framework Contract No ENV.C.3./FRA/2009/0043) by TNO, AEA, CE Delft, and Ricardo on behalf the EU Commission’s DG CLIMA, October 2013


Final Report
Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIIP), TNO for DG CLIMA
ANNEXES
Annex 1. Current CO₂ legislation

Regulation (EC) 443/2009 establishes CO₂ emissions performance requirements for newly registered passenger cars for 2015 setting an overall target of 130 g/km. In March 2014 Regulation (EU) 333/2014 has been approved which defines the modalities for further reducing CO₂ emissions from new passenger cars to 95 g/km by 2021. Similar legislation for light commercial vehicles (also named LCVs or vans) is laid down in Regulation (EU) 510/2011, setting a target of 175 g/km for 2017, and Regulation (EC) 253/2014, defining the modalities for reaching a target of 147 g/km by 2020. The EU Commission is currently starting up preparatory work for the development of proposals for regulation of the CO₂ emissions of light duty vehicles beyond 2020. New legislative proposals are expected to be made by the Commission in 2015.

A1.1 CO₂ regulation for passenger cars

Some important elements of Regulation (EC) No 443/2009 are:

- **Target and limit value curve:** In 2015 the fleet average CO₂ emission, as measured on the EU type approval test using the New European Driving Cycle (NEDC), to be achieved by all cars registered in the EU is 130 grams per kilometre (g/km). A so-called limit value curve implies that heavier cars are allowed higher emissions than lighter cars while preserving the overall fleet average. Manufacturers will be given a target based on the sales-weighted average mass of their vehicles.

- **Phasing-in of requirements:** In 2012 65% of each manufacturer’s newly registered cars had to comply on average with the limit value curve set by the legislation. This rose to 75% in 2013, 80% in 2014, and is 100% from 2015 onwards.

- **Super-credits:** In calculating the average specific emissions of CO₂, each new passenger car with specific emissions of CO₂ of less than 50 g/km are counted as 3.5 cars in 2012 and 2013, 2.5 cars in 2014, 1.5 cars in 2015, and 1 car from 2016.

- **Excess emission premiums:** Manufacturers that fail to comply with their specific target must pay excess emission premiums increasing from 5 €/vehicle for the first g/km above target, 15 €/vehicle for the second and 25 €/vehicle for the third g/km above target, and 95 €/vehicle for every g/km that the manufacturer’s average is more than 3 g/km above their specific target.

- **Pooling:** The formation of manufacturers’ pools is allowed as a way of meeting the emissions target.

A number of implementing measures, detailing various provisions and procedures of the CO₂ legislation for cars, have been adopted. These implementing measures cover issues relating to:

  - These are technical measures applied to vehicles which reduce the energy consumption and CO₂ emissions under real-world driving conditions but that do not affect the CO₂ emissions as measured on the type approval test. Examples are waste heat recovery, solar roofs and LED lighting;
  - The total contribution of those technologies to reducing the specific emissions target of a manufacturer may be up to 7 g/km.

- Derogations for niche and small volume manufacturers and for market entrants, defined in Commission Regulation (EU) No 63/2011 of 26 January 2011;
A method for the collection of premiums for excess CO₂ emissions from new passenger cars defined in Commission Decision 2012/100/EU of 17 February 2012;

Provisions for monitoring CO₂ emissions and other features (e.g. mass and footprint) from newly registered light duty vehicles, defined in Commission Regulation (EU) No 1014/2010 of 10 November 2010. The rules on how to calculate the phase-in, eco innovation super credits, pooling and specific emission targets have been established in 2010 by Commission Communication COM(2010) 657 final.

Some important elements of Regulation (EC) No 333/2014 are:

- A target value of 95 g/km is set for 2020. However, due to a one-year phase-in period, requiring 95 percent of new car sales to comply with the target in 2020 and 100 percent from the end of 2020 onwards, the 95 g/km target effectively applies from 2021 onwards.
- De minimis clause excludes manufacturers registering less than 1000 vehicles from the effect of the Regulation.
- Vehicle weight is retained as the utility parameter for differentiating targets using a linear limit value curve.
- Super-credits for low-emission vehicles: In calculating the average specific emissions of CO₂, each new passenger car with specific emissions of CO₂ below 50 g/km shall be counted as 2 passenger cars in 2020, 1.67 passenger cars in 2021, 1.33 passenger cars in 2022, and 1 passenger car from 2023 onwards. The use of super-credits is subject to a cap of 7.5 g/km over the 2020-2022 period for each manufacturer.
- Test procedure: In order to ensure that specific CO₂ emissions quoted for new passenger cars are brought more closely into line with the emissions actually generated during normal conditions of use, the new WLTP test procedure should be applied at the earliest opportunity. When the test procedures are amended, the limits should be adjusted to ensure comparable stringency for manufacturers and classes of vehicles.
- Eco-innovations: Arrangements in the 2015 regulation are continued.

### A1.2 CO₂ regulation for light commercial vehicles

Some important elements of Regulation (EU) No 510/2011 are:

- Target and limit value curve: The fleet average CO₂ emissions to be achieved by all light commercial vehicles registered in the EU in 2017 is 175 grams per kilometre (g/km). As with passenger cars a mass-based limit value curve implies that heavier vans are allowed higher emissions than lighter vans while preserving the overall fleet average. Manufacturers will be given a target based on the sales-weighted average mass of their vehicles.
- Phasing-in of requirements: The EU fleet average of 175 g/km will be phased in between 2014 and 2017. In 2014 an average of 70% of each manufacturer’s newly registered vans must comply with the limit value curve set by the legislation. This proportion will rise to 75% in 2015, 80% in 2016, and 100% from 2017 onwards.
- Eco-innovations, through a similar provision as in the regulation for cars.
- Excess emissions premium, through a similar provision as in the regulation for cars.
Since then additional provisions have been implemented defining procedures for dealing with excess premiums (Commission Implementing Decision 2012/99/EU of 17 February 2012) and monitoring (Commission Implementing Regulation (EU) No 293/2012 of 3 April 2012 and Commission Delegated Regulation (EU) No 205/2012 of 6 January 2012). Detailed provisions on derogations and eco-innovations for light commercial vehicles have not yet been published.

Some important elements of Regulation (EC) No 253/2014 are:

- A target value of 147 g/km is set for 2020.
- De minimis clause excludes manufacturers registering less than 1000 vehicles from the effect of the Regulation.
- Vehicle weight is retained as the utility parameter for differentiating targets using a linear limit value curve.
- Eco-innovations: Arrangements in the 2017 regulation are continued.
- Test procedure: In order to ensure that specific CO\textsubscript{2} emissions quoted for new passenger cars are brought more closely into line with the emissions actually generated during normal conditions of use, the new WLTP test procedure should be applied at the earliest opportunity. When the test procedures are amended, the limits should be adjusted to ensure comparable stringency for manufacturers and classes of vehicles.
- Excess emissions premium continued.
Annex 2. Detailed market and sectorial overview

The global automotive industry is undergoing profound change. Vehicle sales in the more mature markets have mostly plateaued and the emerging markets are driving growth due to their rapidly growing economies and their larger, younger and growing populations. This has led automakers to increasingly shift their attention, and plant location towards these regions. The growth of the automotive industry is influenced by a series of factors, principally: the need for significant capital investment, the impact of the legislation including the environmental one, and strong competition for material, human, and natural resources. The next sections are devoted to analysing the market structure of the global automotive industry and related sectors and represent the baseline supporting the analysis of competitiveness impacts of post-2020 CO2 legislation. An assessment of the EU's current position compared to other regions illustrates its relative strengths and weaknesses. The examination of industry KPIs further enriches the market overview. Market projections provide a deeper understanding of the industry’s future trends.

A2.1 Overview of the automotive industry

A2.1.1. Industry structure

The automotive industry is a capital intensive industry with a relatively high capital-to-labour ratio. In many countries the majority of the vehicles produced are exported. More recently production has been increasingly shifted towards lower wage costs, emerging economies moving from regions such as Western Europe (i.e. EU 15) to Central and Eastern Europe (i.e. EU 13 plus Ukraine, Serbia and Belarus) and Turkey, from North America to Mexico, and in Asia towards China and India. For instance, between 2000 and 2007, the share of Japan and the United States in global production fell by 10% while the share of the non-OECD areas increased from 10% to 20%42 (OECD, 2009). Market saturation in mature regions, tariffs and high shipping costs and efforts by automakers to gain market share by placing production where sales are growing are some of the reasons for this trend. Simultaneously, the minimum efficient scale of production has grown, encouraging incumbents to pursue mergers and acquisitions in order to improve economies of scale.

Alliances and partnerships have also become fundamental at both horizontal and vertical levels. OEMs and suppliers have formed buyer-supplier relationships on a global scale. Interregional trade of parts and vehicles is substantial, but capped by operational and political considerations. Intraregional trade of finished vehicles and parts has become a relevant operational pattern, whereas domestic production is still very strong for the majority of markets. At local level, a phenomenon related to collaboration in the automotive industry is the emergence of clusters where companies along the value chain dealing with different activities (e.g. design, component manufacturing, and assembly) tend to be geographically close. The automotive industry is one where competitors cooperate both vertically and horizontally for different purposes including engine development, joint design or platform sharing. This phenomenon is known in management literature as co-opetition. Even though the automotive industry is highly competitive, there are occasions where combining both technical and financial resources can help the industry to move in new directions. The Ford-Daimler-Nissan alliance is a great example of co-opetition, with the joint aim to bring a hydrogen vehicle to

market within four years. In other cases, companies buy equity stakes in other companies (e.g. Renault, Nissan and Daimler).

In the EU automotive market competition is intense. Many factors have affected the industry including declining real prices for new cars, successful new entries, shortened life cycles, changes in market shares and demand-side changes. Competition is expected to increase mainly due to the entry of companies from emerging countries in the EU market. The EU industry has responded to these trends and to the recent crisis through consolidation and cooperation. The situation is not that different in other mature markets such as the United States. In the EU, Jaguar and Land Rover were bought by Tata Motors and Volvo by Geely, whereas in the US the acquisition of Chrysler by FIAT gave the latter the possibility to establish a global presence. The figure below provides an illustrative example of the automotive ties existing between European and Japanese companies belonging to the automotive sector.

A driver for further consolidation and alliances will be overcapacity in a price competitive market, which is likely to lead to as much cost optimisation as possible. Many manufacturers already co-operate in both production and R&D (e.g. in form of automotive clusters), which could provide a platform for further restructuring or consolidation in the industry. Restructuring also concerns automotive suppliers who are currently in the process of consolidation accelerated by the recession.

A key feature of the automotive sector is its tiered structure encompassing a relatively small number of large, multinational motor vehicle manufacturers that produce passenger cars, light and heavy commercial vehicles, tier 1 suppliers of main systems, components and tyres, along with a larger number of smaller tier 2 and tier 3 suppliers of individual components. In the aftermarket segment there are two main distribution channels: authorised ones linked to the OEM and independent manufacturers and traders of spare parts. Finally there are the providers of maintenance and repair services.

In the past OEMs manufactured almost the entire vehicle on their production lines. Now large parts of value-added are outsourced, assigning a much larger role to part suppliers than in the past. This was made possible via modularisation and the design of common under-body platforms. In this way producers benefit from economies of scale as they can build more car models using the same platform, a trend which has been strengthened by the recent industry consolidation.

Regarding automotive components, the European Association of Automotive Suppliers (CLEPA) state that around 75% of each vehicle is made by automotive suppliers, which supports the thesis that OEMs are increasingly relying on outsourcing. Tier 1 suppliers deliver some of the largest components or sub-systems for cars (e.g. powertrain systems, suspension assemblies, transmission and steering systems). These suppliers are large firms with multiple production plants and usually pursue diversification into other sectors such as electronics, plastics, metals or information technology among others. Tier 2 suppliers typically provide components to tier 1 suppliers (e.g. electric motors, pump units) and are generally small and medium-sized companies. Upstream from tier 1 suppliers are raw material suppliers which are also considered as tier 3 suppliers, although in some cases they supply directly to OEMs. Geographical proximity to OEMs has traditionally been key to tier 1 suppliers’ development and growth. This is important in terms of
operations management as it gives tier 1 suppliers the chance to pursue just-in-time production strategies. Tyre manufacturers are considered tier 1 suppliers. The tyre industry is quite concentrated, with ten tyre producers representing almost the 70% of the total tyre production. Three of these firms, representing 1/4 of world tyre production, have their headquarters in the EU.

Figure 34 - Automotive ties between European and Japanese companies

Source: JAMA

OEMs are car, truck and bus original equipment manufacturers. In 2012, there were 16 major OEMs in Europe and 177 vehicle assembly and engine production plants in 16 different Member States. The main car producers in the European market are Volkswagen, Toyota, FIAT, PSA, Renault, Daimler, BMW, Ford, GM, Nissan, Honda and Hyundai. The five main producers for the European light commercial vehicle market are Volkswagen, Ford, PSA, Renault and FIAT. In addition to the large OEMs, there are a number of

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specialised niche manufacturers that produce sports cars or special purpose vehicles (e.g. ambulances and taxis).

**Figure 35 - Automotive industry value chain**

Despite the negative trend of the past few years, the automotive industry is still a major EU manufacturing and service industry, as highlighted by the European Commission in a recent study which states: “the automotive industry is one of Europe’s key industrial sectors, and its importance is largely derived from its linkages within the domestic and international economy and its complex value chain” (EC, 2009). The 839 billion euro turnover generated by the automotive sector represents 6.9% of EU GDP. The automotive industry has ripple effects throughout the economy, with a supply chain involving industries such as metals, plastics, chemicals, textiles and electronics. Cars and commercial vehicles generate a wide variety of business services: sales and after-sales, insurance and finance, roadside assistance, leasing and rental, distribution and logistics, infrastructure and maintenance to name a few. The table below provides a synthesis of the major indicators that are used in the following sections to assess the current status and the future prospects of the EU automotive industry vis-à-vis the major markets outside the EU.

The industry's growth is related to the business and economic cycles, with overall economic growth influencing the demand for new vehicles. This trend can be observed in the medium term for passenger cars and is very evident for LCVs: the 4.5% decrease in EU (real) GDP in 2009 resulted in a dramatic drop (-29.5%) in LCV registrations. The trends in recent years are shown in the chart below.
A2.1.2. Vehicle manufacturing

In 2005 66.5 million passenger cars and commercial vehicles were produced globally, by 2013 production reached 87.3 million vehicles. The table below shows worldwide vehicle production from 2000 to 2013.

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Source: ACEA, VDA, AAA, IHS Global Insight, Eurostat
Source: Internal elaboration of ACEA and Eurostat data
Over this time, Asia has maintained its leadership in car and LCV production, in front of Europe and the Americas. China is now the largest producer of vehicles, followed by the EU (23% of cars and 8.5% of LCVs) and Japan, as reported in the table below.

<table>
<thead>
<tr>
<th>Production by area (2012)</th>
<th>Cars, units</th>
<th>Cars, % of global production</th>
<th>LCVs, units</th>
<th>LCVs, % of global production</th>
<th>Cars and LCV, units</th>
<th>Cars and LCVs, % of global production</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU manufacturing</td>
<td>14,693,534</td>
<td>23.19%</td>
<td>1,435,990</td>
<td>8.48%</td>
<td>16,129,524</td>
<td>21.88%</td>
</tr>
<tr>
<td>Other European manufacturing</td>
<td>665,574</td>
<td>1.04%</td>
<td>503,078</td>
<td>2.97%</td>
<td>1,159,652</td>
<td>1.87%</td>
</tr>
<tr>
<td>(incl. Turkey)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian manufacturing</td>
<td>34,006,727</td>
<td>53.67%</td>
<td>5,291,266</td>
<td>31.23%</td>
<td>39,297,993</td>
<td>50.65%</td>
</tr>
<tr>
<td>NAFTA manufacturing</td>
<td>4,105,853</td>
<td>6.48%</td>
<td>5,955,087</td>
<td>35.15%</td>
<td>10,060,940</td>
<td>23.45%</td>
</tr>
<tr>
<td>Others</td>
<td>9,896,304</td>
<td>15.62%</td>
<td>3,757,750</td>
<td>22.18%</td>
<td>13,654,054</td>
<td>17.42%</td>
</tr>
</tbody>
</table>

Vehicle manufacturing in the EU
Vehicle manufacturing is a strategic industry in Europe, with vehicle production being around 16 million cars and LCVs per annum. Consolidation has been pursued to improve industry profitability, as larger companies are better able to cope with high model development and launch costs, as well as benefiting from keen supplier prices. Partnership in production activity and shared use of plants is common in the industry, with several plants producing vehicles for different manufacturers.

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46 Source: Statista
47 Source: own elaboration of OICA data for the year 2012
Automobile manufacturers operate some 226 vehicle assembly and production plants in the EU and 27 additional plants in Turkey, Ukraine, Serbia and Belarus. However, the number of plants and total production in Europe is concentrated in a few Member States, as shown below.

Figure 38 - Automotive assembly and production plants in Europe

Around 40% of total turnover comes from Germany, and around 10% from France, while all other countries each account for less than 10% (Eurostat, 2013). A large share of LCV manufacturing for the EU market is located in Turkey, due to the positive combination of manufacturing and logistics costs, as well as free trade agreements.

The figure below shows the volume of vehicle production and the number of production plants in each Member State. Germany dominates (35% of total production in 2010), while other important producers include Spain (14%), France (13%), and the UK (8%), as well as the Czech Republic, Poland and Italy. The same countries are also the main producers of parts and components, despite Central and Eastern European Member States such as Slovakia, Slovenia, Hungary and Romania gradually gaining a higher share of total production, particularly regarding parts and components.

Figure 39 - Vehicle production and number of production plants per Member State, 2010

48 Source: own elaboration on ACEA data, May 2014. Non-EU Europe includes Turkey (15 plants), Ukraine (5), Serbia (2) and Belarus (1)
49 Source: ACEA
Despite some plant closures in recent years, the European automotive industry has been experiencing significant overcapacity (AEA, 2012). However, certain manufacturers have opened new manufacturing sites in Europe (mainly in Central and Eastern Europe) to take advantage of the lower production costs and the proximity to the Western European markets. Currently, approximately one European vehicle out of five is produced in Eastern Europe, reaching a total annual capacity of 3 million vehicles according to Roland Berger. For instance, the number of vehicles produced in Romania increased by 21% compared to the previous year, reaching 400 thousand units in 2013, the fastest increase of any country in the world. While the majority of sites belong to European OEMs, overseas investors have also invested in new plants in the Czech Republic (Hyundai), Hungary (Suzuki) and Poland (Toyota).

In spite of these developments, the location of production currently remains primarily in Western Europe for all major manufacturers selling vehicles in the EU. The table below shows the distribution of plants producing vehicles of different OEM groups by area. Companies with EU headquarters manufacture mainly in the country of their headquarters (plants in Germany for German manufacturers account between 40 and 52% of the total, French plants for French manufacturers between 42% and 50%, Italian plants for Fiat (incl. Iveco) 53%, Geely (Volvo) has 50% of its plants in Sweden). Non-EU based companies that acquired EU brands in Western Europe (General Motors) or have signed production partnerships (Nissan) exhibit similar figures for the geographical split of production plants, whereas non-EU based players such as Hyundai and Toyota exhibit a markedly higher share of plants outside Western Europe, suggesting that “legacy” factors have a long-term influence on the distribution of plants.

<table>
<thead>
<tr>
<th>Share of plants</th>
<th>Geely</th>
<th>BMW</th>
<th>Daimler</th>
<th>Volvo</th>
<th>wagen</th>
<th>Fiat</th>
<th>PSA</th>
<th>Renault</th>
<th>Ford</th>
<th>GM</th>
<th>Hyundai</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Others (European)</th>
<th>Others (non-European)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HQ</td>
<td>CN (SE Volvo)</td>
<td>DE</td>
<td>DE</td>
<td>DE</td>
<td>IT</td>
<td>FR</td>
<td>FR</td>
<td>US</td>
<td>US</td>
<td>KR</td>
<td>JP</td>
<td>JP</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EU Western</td>
<td>100%</td>
<td>100%</td>
<td>88%</td>
<td>71%</td>
<td>83%</td>
<td>74%</td>
<td>79%</td>
<td>67%</td>
<td>53%</td>
<td>0%</td>
<td>100%</td>
<td>50%</td>
<td>61%</td>
<td>64%</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>EU Central and Eastern</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>21%</td>
<td>10%</td>
<td>11%</td>
<td>14%</td>
<td>17%</td>
<td>18%</td>
<td>40%</td>
<td>0%</td>
<td>30%</td>
<td>12%</td>
<td>14%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Other Countries</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
<td>7%</td>
<td>7%</td>
<td>16%</td>
<td>7%</td>
<td>17%</td>
<td>29%</td>
<td>60%</td>
<td>0%</td>
<td>20%</td>
<td>28%</td>
<td>21%</td>
<td>16%</td>
<td></td>
</tr>
</tbody>
</table>

A2.1.3. Vehicle sales

The global automotive industry has been in a difficult situation for some years. The ‘big three’ in the US (GM, Ford and Chrysler) were particularly hit by the recession because of their specialisation in larger vehicles. The rise in oil prices up to mid-2008 drove material costs higher and shifted consumer preferences toward smaller vehicles. High debt burdens, huge fixed capital and labour costs further exacerbated the negative effects of the downturn. Other actors along the value chain have also been hit by the crisis. Suppliers have been particularly exposed to the recent crisis due to their close links to vehicle manufacturers, smaller size, lower diversification and their substantial role in vehicle production. Put differently, if a vehicle production site cuts capacity, co-located suppliers with strong ties to the site itself often have little choice but to follow suit.

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50 Kawecka-Wyryzkowska, E. (2009). New Member States of the euro zone. First experiences and lessons for Poland. Pacific Rim Conference, March 24-27, Kyoto, Japan
51 Source: own elaboration of ACEA data on production, 2014. Russia in not included among other countries
A recovery in global vehicle sales began in mid-2009. In 2012, sales increased in every region except Europe. The EU has been losing competitiveness in recent years due to both industry-related factors (such as overcapacity and production delocalisation) and external factors (such as recession and lower consumption) which has favoured production in emerging regions. Interviews with OEM professionals confirm this trend by indicating that for most OEMs competition is not confined to a single area and that the natural consequence of losing competitiveness in one region (i.e. Europe) is for delocalisation to areas (Eastern Europe and Asia in particular) with more suitable conditions (such as lower production costs and better financing). Yet, the EU still has a major role in both production and sales accounting for 23% and 18% of production and sales of passenger cars respectively.

The figure below represents the number of cars sold worldwide from 1990 through 2013 and presents a forecast for 2014. Global passenger car sales increased from 57 million units in 2010 to 65 million in 2012 and are forecast to exceed 70 million in 2014. Increased demand for cars in Asia and North America is forecast to offset declining sales volumes in Western Europe.

Figure 40 - Number of cars sold worldwide from 1990 to 2014 (in million units)\textsuperscript{52}

\textsuperscript{52} Source: Statista (**2014 forecast) and ACEA Pocket guide 2013; \textsuperscript{1} America includes LCVs;
OEMs such as General Motors or Volkswagen are enjoying rising sales across all Asian markets, and Ford expects Asia Pacific to contribute around 40% of its vehicle sales in four or five years’ time. It is expected that OEMs will undertake investment programs to grow their businesses in China, India and other emerging markets. For commercial vehicles, Asia is the largest market, with China alone accounting for 46% of the global market. The EU share of global sales has decreased to around 13% following the economic downturn of 2007/2008.

**Vehicle sales in the EU**

In the Western EU market, new car sales consist largely of replacement demand with a significant element of discretion on the timing of vehicle replacement. New vehicle sales depend on a broad range of factors such as consumer confidence, utility of change and the availability of finance. In New EU Member States, demand has been driven more by new motorisation than by replacement. In total the EU new-car market has shrunk every year since peaking at 16 million units in 2007, declining a further 8% to 12 million in 2013. This negative trend is mainly attributed to the 2007-08 financial crisis that has led to a dramatic decline in consumption. Industry analysts believe the industry will not see a return to pre-crisis sales before the end of the decade. In view of this, some have advocated making capacity reductions. On the other hand, the three premium German OEMs have managed throughout the crisis to avoid overall declines in their EU sales. These OEMs have added shifts or shortened vacation periods at their European plants in recent years to keep pace with strong demand for their models in countries such as China and the United States. While global sales are projected to continue growing reaching almost 100 million in 2020, the EU share of global car sales will decline because of the expanded share from developing countries such as China.

![Passenger car sales in EU27, 2009-2013](image)

In the aftermath of the 2008 crisis, manufacturers proved unable to lower production as fast as sales declined, leading to over-production. Moreover, the crisis increased the pressure on margins, also because the strong competition in the EU market prevents manufacturers (in particular “volume” ones) from increasing vehicle prices. To respond to the downturn generated by the crisis and to take advantage of existing opportunities, EU manufacturers have:

- further relocated part of their vehicle production for the EU in Central and Eastern Europe, as well as outside the EU borders (e.g. Turkey);

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53 Source: own elaboration on ACEA and National Associations data, EU27 + EFTA
Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation

- increased their presence (in terms of sales and consequently production facilities) in emerging markets, given that a substantial amount of future growth will come from extra-EU regions. Most European car manufacturers have significantly invested in new capacity in emerging markets such as China, for instance by opening car assembly plants.

Yet, Europe still holds a relevant role in the automotive industry as approximately one out of five cars are produced and sold in Europe. At the same time, EU manufacturers face competition also within the EU as Asian OEMs are expanding their market shares by introducing new products (e.g. Hyundai) or through mergers and acquisitions (e.g. Tata).

In the light commercial vehicles segment, EU sales have dropped significantly over the last 6 years. New LCV sales are correlated with business investments and retail activities by companies which, in turn, have been affected by the economic downturn. As a result, sales in Europe have dropped from more than 2.2 million units in 2007 to 1.43 million units in 2013, an annual decrease of more than 7%.

![Figure 42 - LCV sales in Europe, 2007-2013](image)

EU manufacturers, which retain more than 74% of European LCV sales in terms of units, have been affected differently, in line with the trends of their national economies. German manufacturers have suffered limited sale decreases over the last 5 years (e.g. Volkswagen -10% and Daimler -17%), over the same time French ones have faced larger drops (Renault -22% and PSA -24.5%), while Fiat has been affected the most of all large EU manufacturers (-52%).

A2.1.4. Vehicles sales and production by groups of manufacturers

With more than 8 million passenger cars sold worldwide Toyota, including its premium brand Lexus and Daihatsu, is the global market leader closely followed by General Motors and Volkswagen. The South Korean OEM Hyundai has gained significant market shares in recent years (+7% in sales in 2012 compared to 2011) mainly due to demand increases from Europe and North America. Worldwide, despite the fact that EU and US players are still in leading positions, the centre of gravity is shifting towards the east with 12

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54 Source: own elaboration on ACEA and National Associations data, EU27 + EFTA
Chinese, Indian and Russian groups in the top 30 manufacturers by units produced worldwide, along with 9 from Japan and Korea, against 6 from the EU and 3 from North America. An overview of the key EU and worldwide figures for the Top 30 groups is provided below.

Table 28 - Top 30 groups: Europe sales and world production figures\(^{55}\)

<table>
<thead>
<tr>
<th>Group</th>
<th>HQ Country</th>
<th>Registrations of cars Europe (units, 2013)</th>
<th>Registrations Europe % change last 5 years</th>
<th>Cars Europe MKT SHARE (units, 2013)</th>
<th>Registrations lCV Europe (units, 2013)</th>
<th>Registrations lCV Europe % change last 5 years</th>
<th>LCV Europe MKT SHARE (units, 2013)</th>
<th>World production Cars (units, 2012)</th>
<th>Cars Production Share</th>
<th>World production LCV (units, 2012)</th>
<th>LCV Production Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLKSWAGEN</td>
<td>Germany</td>
<td>3,042,143</td>
<td>0.63%</td>
<td>24.7%</td>
<td>204,853</td>
<td>-9.8%</td>
<td>14.27%</td>
<td>8,576,964</td>
<td>13.00%</td>
<td>486,544</td>
<td>3.36%</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Japan</td>
<td>543,115</td>
<td>-8.70%</td>
<td>4.4%</td>
<td>30,909</td>
<td>-50.62%</td>
<td>2.15%</td>
<td>8,381,968</td>
<td>12.71%</td>
<td>1,448,107</td>
<td>10.00%</td>
</tr>
<tr>
<td>HYUNDAI (incl. KIA)</td>
<td>South Korea</td>
<td>765,143</td>
<td>3.92%</td>
<td>6.2%</td>
<td>3,220</td>
<td>-73.62%</td>
<td>0.22%</td>
<td>6,761,074</td>
<td>10.25%</td>
<td>279,579</td>
<td>1.93%</td>
</tr>
<tr>
<td>GM</td>
<td>US</td>
<td>964,865</td>
<td>-5.52%</td>
<td>7.8%</td>
<td>74,770</td>
<td>-46.26%</td>
<td>5.21%</td>
<td>6,608,567</td>
<td>10.02%</td>
<td>2,658,612</td>
<td>18.35%</td>
</tr>
<tr>
<td>HONDA</td>
<td>Japan</td>
<td>138,703</td>
<td>-10.71%</td>
<td>1.1%</td>
<td>216</td>
<td>-76.85%</td>
<td>0.02%</td>
<td>4,078,376</td>
<td>6.18%</td>
<td>32,481</td>
<td>0.22%</td>
</tr>
<tr>
<td>NISSAN</td>
<td>Japan</td>
<td>422,036</td>
<td>2.76%</td>
<td>3.4%</td>
<td>45,202</td>
<td>-32.39%</td>
<td>3.15%</td>
<td>3,830,954</td>
<td>5.81%</td>
<td>1,022,974</td>
<td>7.06%</td>
</tr>
<tr>
<td>FORD</td>
<td>US</td>
<td>918,539</td>
<td>-6.67%</td>
<td>7.5%</td>
<td>166,683</td>
<td>-29.13%</td>
<td>11.61%</td>
<td>3,123,340</td>
<td>4.73%</td>
<td>2,394,221</td>
<td>16.53%</td>
</tr>
<tr>
<td>PSA</td>
<td>France</td>
<td>1,342,410</td>
<td>-6.57%</td>
<td>10.9%</td>
<td>301,308</td>
<td>-24.49%</td>
<td>20.99%</td>
<td>2,554,059</td>
<td>3.87%</td>
<td>357,705</td>
<td>2.47%</td>
</tr>
<tr>
<td>SUZUKI</td>
<td>Japan</td>
<td>152,099</td>
<td>-9.45%</td>
<td>1.2%</td>
<td>805</td>
<td>-58.59%</td>
<td>0.06%</td>
<td>2,483,721</td>
<td>3.77%</td>
<td>409,881</td>
<td>2.83%</td>
</tr>
<tr>
<td>RENAULT</td>
<td>France</td>
<td>1,096,210</td>
<td>-4.06%</td>
<td>8.9%</td>
<td>230,066</td>
<td>-21.99%</td>
<td>16.03%</td>
<td>2,302,769</td>
<td>3.49%</td>
<td>373,457</td>
<td>2.58%</td>
</tr>
<tr>
<td>BMW</td>
<td>Germany</td>
<td>794,693</td>
<td>2.33%</td>
<td>6.5%</td>
<td>1,734</td>
<td>-2.36%</td>
<td>0.12%</td>
<td>2,065,216</td>
<td>3.13%</td>
<td>261</td>
<td>0.00%</td>
</tr>
<tr>
<td>SAIC</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>1,523,398</td>
<td>2.31%</td>
<td>190,848</td>
<td>1.32%</td>
</tr>
<tr>
<td>DAIMLER</td>
<td>Germany</td>
<td>688,436</td>
<td>0.13%</td>
<td>5.6%</td>
<td>136,648</td>
<td>-16.81%</td>
<td>9.52%</td>
<td>1,455,650</td>
<td>2.21%</td>
<td>257,496</td>
<td>1.78%</td>
</tr>
<tr>
<td>FIAT</td>
<td>Italy</td>
<td>740,565</td>
<td>-10.01%</td>
<td>6.0%</td>
<td>187,988</td>
<td>-51.82%</td>
<td>13.10%</td>
<td>1,501,979</td>
<td>2.28%</td>
<td>498,984</td>
<td>3.44%</td>
</tr>
<tr>
<td>MAZDA</td>
<td>Japan</td>
<td>147,005</td>
<td>-6.95%</td>
<td>1.2%</td>
<td>260</td>
<td>0.02%</td>
<td>0.02%</td>
<td>1,097,861</td>
<td>1.66%</td>
<td>91,622</td>
<td>0.63%</td>
</tr>
<tr>
<td>MITSUBISHI</td>
<td>Japan</td>
<td>81,267</td>
<td>-5.53%</td>
<td>0.7%</td>
<td>15,276</td>
<td>1.06%</td>
<td>1.06%</td>
<td>980,001</td>
<td>1.49%</td>
<td>127,435</td>
<td>0.88%</td>
</tr>
<tr>
<td>GEELY</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>922,906</td>
<td>1.40%</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CHANGAN</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>835,334</td>
<td>1.27%</td>
<td>166,727</td>
<td>1.15%</td>
</tr>
<tr>
<td>TATA</td>
<td>India</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>744,067</td>
<td>1.13%</td>
<td>314,399</td>
<td>2.17%</td>
</tr>
<tr>
<td>FUI</td>
<td>Japan</td>
<td>38,687</td>
<td>-2.23%</td>
<td>0.3%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>734,959</td>
<td>1.11%</td>
<td>18,361</td>
<td>0.13%</td>
</tr>
<tr>
<td>CHRYSLER</td>
<td>US</td>
<td>629</td>
<td>-58.42%</td>
<td>0.0%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>656,892</td>
<td>1.00%</td>
<td>1,702,235</td>
<td>11.75%</td>
</tr>
<tr>
<td>AVTOVAZ</td>
<td>Russia</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>553,232</td>
<td>0.84%</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CHERY</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>550,565</td>
<td>0.83%</td>
<td>13,384</td>
<td>0.09%</td>
</tr>
<tr>
<td>DONGFENG</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>519,845</td>
<td>0.82%</td>
<td>245,641</td>
<td>1.70%</td>
</tr>
<tr>
<td>GREAT WALL</td>
<td>China</td>
<td>464</td>
<td>0.0%</td>
<td>0.0%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>487,704</td>
<td>0.74%</td>
<td>136,722</td>
<td>0.94%</td>
</tr>
<tr>
<td>FAW</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>480,442</td>
<td>0.73%</td>
<td>52,983</td>
<td>0.37%</td>
</tr>
<tr>
<td>MAHINDRA</td>
<td>India</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>429,101</td>
<td>0.65%</td>
<td>173,083</td>
<td>1.19%</td>
</tr>
<tr>
<td>BRILLIANCE</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>231,527</td>
<td>0.35%</td>
<td>231,862</td>
<td>1.60%</td>
</tr>
<tr>
<td>BAIC</td>
<td>China</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>83,033</td>
<td>0.13%</td>
<td>285,081</td>
<td>1.97%</td>
</tr>
<tr>
<td>ISUZU</td>
<td>Japan</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>32,309</td>
<td>0.22%</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Large EU OEMs (Volkswagen, PSA, Renault, Daimler, Fiat and BMW) retain significant shares of the EU market, accounting for more than 62% of car sales and for 74% of the LCV market. The largest part of the remaining market shares is held either by US based groups (with Ford and General Motors together accounting for 15% of car sales and 17% of LCV sales) or by Japanese and Korean players. Toyota, Hyundai, Nissan and other groups together hold 18.5% of EU cars and 6.5% of EU LCV sales. The rest of the EU market is supplied mainly by smaller EU brands with players from other regions having substantially

\(^{55}\) Source: Own elaboration of ACEA and OICA data

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Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIIP), TNO for DG CLIMA

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failed to date to enter both the car and LCV markets without buying European Companies (e.g. Volvo being now part of Geely and Jaguar Land-Rover now part of Tata).

The best-selling car models worldwide reflect to some degree the top OEMs. The table below shows the situation in 2013. During that year, Ford's Focus sold approximately 1.1 million cars. One Chinese manufacturer is included in this top 10, in line with the recent trend of emerging countries assuming an increasingly central role in the automotive industry.

**Figure 43 - Bestselling car models worldwide in 2012 (in 1,000s)**

<table>
<thead>
<tr>
<th>Car Model</th>
<th>Sales (in 1,000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford Focus</td>
<td>1,020,41</td>
</tr>
<tr>
<td>Toyota Corolla</td>
<td>872,77</td>
</tr>
<tr>
<td>Ford T-Series</td>
<td>785,63</td>
</tr>
<tr>
<td>Wuling Ziqiang</td>
<td>768,87</td>
</tr>
<tr>
<td>Toyota Camry</td>
<td>729,79</td>
</tr>
<tr>
<td>Ford Fiesta</td>
<td>723,13</td>
</tr>
<tr>
<td>VW Golf</td>
<td>699,15</td>
</tr>
<tr>
<td>Chevrolet Cruze</td>
<td>661,33</td>
</tr>
<tr>
<td>Honda Civic</td>
<td>651,19</td>
</tr>
<tr>
<td>Honda CR-V</td>
<td>624,98</td>
</tr>
</tbody>
</table>

**A2.1.5. Differences among OEMs**

**Positioning**

In the automotive industry, OEMs are usually segmented as “premium” or “volume” manufacturers. The value proposition of “premium” brands relates to the provision of high performance technology, higher quality equipment, improved comfort, stylish design, as well as other features that convey the idea of prestige and high status. The value proposition of “volume” brands is based instead on value for money, efficiency, “smartness” and reliability, often combined with a specific style which is meant to increase the appeal of the vehicle to specific end user segments (e.g. young people, women).

For OEM groups, this distinction may become blurred as each manufacturer and brand competes on different vehicle segments (e.g. mini, small, different “medium” rangers, luxury, sport, etc.) by offering vehicles with very different positioning (as in the case of Fiat, offering both the Panda and the 500 in the mini segment). Nonetheless, the average vehicle price by manufacturer and, to a lesser extent, their average weight provide a clear indication of the differences between OEMs, as shown in the figure below.

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56 Source: Statista
Seven groups (Ford, General Motors, Hyundai, Nissan, PSA, Renault and Toyota) out of the 12 considered have a very similar positioning regarding price and weight, with average prices ranging from 19,200 to 22,500 Euro and average weight from 1680 to 1890 kg (the bubble size indicates the magnitude of yearly EU sales). Thus, they are clustered in this study as “volume” manufacturers. In 2012 Fiat was an outlier in the lower end of the market; however the positioning of the group has been changing thanks to the acquisition of Chrysler and the change in brand strategy, which started focusing on models such as the 500 and the Freemont.

The average pricing and weight of BMW, Daimler and Geely (Volvo) vehicles clearly show a different positioning with respect to the majority of manufacturers – they are considered “premium” groups in the study.

In the case of Volkswagen, the average pricing and weight can be better understood by analysing the individual brands within the group. Figure 45 below shows that whereas the Volkswagen brand is positioned on the (very) high end of the “volume” cluster, Skoda and Seat occupy lower-end positions within the same cluster. In contrast Audi clearly shares a similar positioning with other premium groups (and brands).

The analysis at brand level shows that the Renault group can also be split into Renault (in the middle of the “volume” cluster) and Dacia, which has an extremely aggressive positioning regarding price. In the figure above, a further split is not provided for PSA (with brands Peugeot and Citroen) and General Motors (with Opel and Vauxhall) due to the brands showing very similar characteristics.

Source: VVA elaboration based on ICCT data, year 2012
The distinction between premium and volume manufacturers is relevant to competitiveness impacts of CO\textsubscript{2} legislation due to a characteristic of the automobile market described by interviewed OEMs: the product innovation driven by CO\textsubscript{2} legislation is more likely to meet user acceptance (and willingness to pay) by end users of “premium” vehicles, as innovation is a key part of the selling proposition of vehicles. In contrast, end users purchasing “volume” brand vehicles are less willing to pay a premium price for greener vehicles. This issue has been reported by stakeholders to have a differential impact on the profitability of different OEMs based on their positioning, also due to the fact that Europe is a very competitive market with low margins for OEMs. While it is not possible in this study to compare directly the profitability in Europe of “premium” brands or groups vis-à-vis “volume” ones\textsuperscript{59}, available data from a selection of OEMs confirms that the profitability of the European market is currently the lowest among the regions covered, also an effect of the recession. In 2013, the EBIT of Fiat in EMEA was worth \(-520\) EUR million, i.e. -3\% of total revenues, vis-à-vis +5\% in both NAFTA and South America and +9\% in the Asia-Pacific Region. General Motors showed somewhat similar figures, with the EBIT being -4\% of revenues in Europe, +8\% in North America, +2\% in South America and +6\% in Asia-Pacific\textsuperscript{60}.

**Engine types in Europe**

In the past decade, the EU has gradually become a “diesel market”, as opposed to other regional markets where petrol is the main fuel for cars. The chart below depicts the share of cars sold by engine type in EU-27, showing that the share of diesel car sales rose from 35\% in 2001 to 55\% in 2012. On the contrary, petrol has progressively declined, whereas natural gas (in particular LPG) experienced a brief peak in 2009 and 2010, due to the combination of fiscal incentives by Member States such as Italy and strategic choices by certain manufacturers (e.g. Fiat).

\textsuperscript{58}Source: VVA elaboration based on ICCT data, year 2012

\textsuperscript{59}Profitability is not detailed at regional level in the Yearly Financial Reports of premium groups

\textsuperscript{60}Source: Annual Reports of the Groups.
As confirmed by interviewed manufacturers, the choice of increasingly relying on diesel engines represents one of the compliance mechanisms by OEMs in order to meet the targets of the current legislation. When looking at the breakdown of sales by individual brands or groups, however, it is possible to observe differences between OEMs, as shown in the figure below.

The figure below clearly shows that the brands of groups with EU headquarters (or sold recently to international groups, such as Volvo) exhibit a higher share of diesel engine sales (Fiat is an exception due to its choice to focus on natural gas for domestic reasons). Among them, the premium brands (e.g. Audi, BMW, Mercedes-Benz and Volvo) are the ones focusing the most on diesel. In contrast, brands of non-EU groups (Vauxhall, Opel, Hyundai, Kia, Toyota and to a lesser extent Nissan and Ford) tend to exhibit higher shares of petrol engines. Within this group, Toyota and Ford both represent unique situations, due to their choices to focus on hybrid propulsion and on the EcoBoost petrol engine respectively.

Such differences are mainly due to companies selling most of their vehicles in the EU having specific competences in diesel engines, which, according to some of the interviewed stakeholders, currently represents not only a key compliance mechanism with current CO₂ legislation (in particular for premium and heavier vehicles) but also a source of competitive advantage. Stakeholders remarked, in this sense, that the

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61 Source: VVA elaboration based on ICCT data, year 2012
62 Source: VVA elaboration based on ICCT data, year 2012
Euro 6-2 legislation will reduce this advantage by raising the costs of diesel engines and thus contributing to reducing their sales, in particular for the medium car segment and for the “non-premium” models.

**Share of sales in the EU**

All major OEMs can be considered as global companies, which serve several different regions in addition to the one of their headquarters through local production facilities, sales and distribution channels. Nevertheless, individual OEMs are influenced in their business by the distribution of their sales, with higher shares in a given region/country increasing the possible impact of changes in its market, competitive, economic and/or legislative scenario.

The table below presents the major groups in the world based on their share of sales in Europe. Companies headquartered in France remain the most “European”, with almost 60% of their sales being in Europe in 2013. German-based groups all show a similar share of around 40% of European sales. Another commonality among German groups is their progressive penetration of Asian markets, with 37% of Volkswagen's sales being in Asia-Pacific, 29% of BMW's and 25% of Daimler's (Mercedes-Benz only).

### Table 29 – Share of European sales of major automotive groups

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>HQ Country</th>
<th>% of sales in Europe</th>
<th>Total sales 2013 worldwide (x1000)</th>
<th>Manufacturer</th>
<th>HQ Country</th>
<th>% of sales in Europe</th>
<th>Total sales 2013 worldwide (x1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renault</td>
<td>France</td>
<td>59%</td>
<td>2,125</td>
<td>Nissan</td>
<td>Japan</td>
<td>14%</td>
<td>4,825</td>
</tr>
<tr>
<td>PSA</td>
<td>France</td>
<td>58%</td>
<td>2,189</td>
<td>Tata</td>
<td>India</td>
<td>11%</td>
<td>1,192</td>
</tr>
<tr>
<td>BMW</td>
<td>Germany</td>
<td>44%</td>
<td>1,964</td>
<td>Suzuki</td>
<td>Japan</td>
<td>13%</td>
<td>2,857</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>Germany</td>
<td>43%</td>
<td>9,729</td>
<td>Toyota</td>
<td>Japan</td>
<td>9%</td>
<td>8,871</td>
</tr>
<tr>
<td>Daimler (Mercedes-Benz)</td>
<td>Germany</td>
<td>41%</td>
<td>1,565</td>
<td>Hyundai</td>
<td>Korea</td>
<td>9%</td>
<td>4,622</td>
</tr>
<tr>
<td>Fiat</td>
<td>Italy</td>
<td>23%</td>
<td>4,330</td>
<td>Fuji</td>
<td>Japan</td>
<td>6%</td>
<td>724</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Japan</td>
<td>23%</td>
<td>1,257</td>
<td>Honda</td>
<td>Japan</td>
<td>4%</td>
<td>4,323</td>
</tr>
<tr>
<td>Geely (incl. Volvo cars)</td>
<td>China</td>
<td>23%</td>
<td>977</td>
<td>Isuzu</td>
<td>Japan</td>
<td>4%</td>
<td>639</td>
</tr>
<tr>
<td>Ford</td>
<td>US</td>
<td>21%</td>
<td>6,330</td>
<td>Dongfeng</td>
<td>China</td>
<td>0%</td>
<td>2,567</td>
</tr>
<tr>
<td>General motors</td>
<td>US</td>
<td>16%</td>
<td>9,715</td>
<td>Changan</td>
<td>China</td>
<td>0%</td>
<td>2,120</td>
</tr>
<tr>
<td>Mazda</td>
<td>Japan</td>
<td>16%</td>
<td>1331</td>
<td>Brilliance</td>
<td>China</td>
<td>0%</td>
<td>207</td>
</tr>
</tbody>
</table>

63 Source: VVA analysis based on financial statements for the year 2013
Following the acquisition of Chrysler, the focus of Fiat's sales has shifted to the Americas and is similar to Ford's and General Motors' (European sales between 16% and 23% and sales in the Americas between 50 and 70%). The remaining groups are Asian OEMs which are mainly active in Asia. Within this group, Japanese OEMs exhibit on average higher EU shares of sales, whereas Chinese and Indian OEMs currently only compete in Europe following the acquisition of European brands (as in the case of Tata with JLR and Geely with Volvo). Nonetheless some Chinese groups record very large global sales (e.g. Dongfeng, Changan) but do not currently sell their vehicles in Europe.

A2.1.6. The vehicle component sector

Automotive suppliers vary significantly in size and some of them are present in other businesses besides automotive. These suppliers usually serve more than one OEM which makes them less dependent on the performance of a single OEM. At the same time, OEMs do not depend on a single supplier and, in Europe for example, around 50 component suppliers are typically involved in the manufacture of single model.

<table>
<thead>
<tr>
<th>Component sub-division</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine parts</td>
<td>Pistons, piston rings, fuel delivery systems, engine valves, carburettors (largest components)</td>
</tr>
<tr>
<td>Electrical parts</td>
<td>Starter motors, spark plugs, electric ignition systems (EIS), generators, distributors, voltage regulators, ignition coils, flywheel magnetos</td>
</tr>
<tr>
<td>Drive transmission and steering parts</td>
<td>Steering systems, gears, axles, wheels, clutches</td>
</tr>
<tr>
<td>Suspension and braking parts</td>
<td>Leaf springs, shock absorbers, brakes, brake assemblies, brake lining</td>
</tr>
<tr>
<td>Equipment</td>
<td>Switches, electric horns, headlights, halogen bulbs, wiper motors, dashboard instruments, other panel instruments</td>
</tr>
<tr>
<td>Others</td>
<td>Sheet metal parts, pressure die castings, plastic moulded components, fan belts, hydraulic pneumatic equipment</td>
</tr>
</tbody>
</table>

The vehicle component sector is highly fragmented. Out of the ca. 20,000 companies belonging to NACE code 29 in the EU-27 in 2011, almost nine out of ten were component and part manufacturers. However, in recent years, consolidation has also started to take place among suppliers, which is leading to the creation of mega-suppliers, leaving less space for small and regional suppliers. Mega-suppliers are able to provide local support by building factories close to OEMs but they also have an international presence which gives them the possibility to better mitigate regional recessions. These players are also better positioned to exploit the automotive industry's increasing use of global platforms. Among the automotive suppliers that can be classified as mega-suppliers are companies such as Robert Bosch GmbH, the world's biggest supplier with USD 36.8 billion sales, Johnson Controls Inc. with USD 22.5 billion, and Yazaki Corp. with USD 15.8 billion in 2012.

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64 According to IHS Automotive, by 2019, global platforms will account for 74% of worldwide light vehicle production which may further push toward the creation of mega-suppliers.
Research and development is another key aspect for automotive suppliers as they represent a significant source of innovation in the automotive industry. In particular, tier-one suppliers are playing an increasingly prominent role in innovation and technological development. Moreover, the ongoing supplier consolidation will give rise to stronger OEM-supplier relationships as the former are becoming more dependent on their suppliers. This trend is not necessarily negative from the OEM standpoint as it means part of R&D expenses is shifting from the OEMs to suppliers, allowing OEMs to learn from upstream partners and decrease costs by leveraging on economies of scale for the component suppliers (in case their R&D are shared between components supplied to different OEMs). There is ample literature showing that producers combining their own critical expertise with that of their supply-chain partners may provide a competitive advantage. By developing intense relationships based on mutual trust, both OEMs and suppliers can increase their knowledge base and become more innovative. The figures below illustrate the described trends and demonstrate that the development of vehicles and components is becoming an increasingly shared task between OEMs and suppliers. In 2015, about 70% of R&D value creation will be generated by suppliers and engineering service providers.

The importance of tier-one suppliers in innovation and product development will grow. For instance, according to company sources, Bosch allocated 9% of its revenues in 2012 for all company-wide research. These companies are already playing a larger role in innovation in the areas of power train, interior design, and chassis components — historically the R&D domains of OEMs. In addition, the determinants for differentiation are shifting toward connectivity and active-safety features, in which tier-one suppliers have substantial expertise. The OEMs that construct the most effective collaboration models, encouraging and rewarding supplier R&D investment, are likely to build a long-term advantage.

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65 Source: own elaboration on Automotive News data
The EU-27 motor vehicle, trailer, and semi-trailer manufacturing sector generates EUR 141 billion of value added almost 40% of which is by vehicle component manufacturers. The latest data available indicate that the EU-27 motor vehicle, trailer, and semi-trailer manufacturing sector turnover was EUR 740.5 billion around 30% of which was generated by vehicle component manufacturers. In terms of value added and employment, the motor vehicle, trailer, and semi-trailer manufacturing sector was the fourth largest NACE division in the EU 27 manufacturing sector (Section C), accounting for 7.2% of the manufacturing workforce and 8.9% of manufacturing value added for the year 2010.

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67 Source: own elaboration on Oliver Wyman data
68 Eurostat
69 Source: own elaboration on Eurostat data
Faced with increasing pressure, component suppliers are implementing production outsourcing in the same way as OEMs. A projection by PricewaterhouseCoopers suggests that in the future, only 20% of the demand from German producers for components will come from Germany. This projection can be viewed as a consequence of the increasing delocalisation of German suppliers. For instance, Bosch has built a new plant in the western Chinese city of Chengdu, and plans to invest a further 100 million Euros there. By 2018, the company intends to shift the production of starters and alternators from Hildesheim (Germany) to Miskolic (Hungary). Headquartered in the United States, TRW Automotive Holdings Corp. has opened three new plants in China (Shanghai, Qingdao, and Wuhan) reaching a total of twenty plants. These factories account for 15% of TRW’s global sales which summed up to USD 14.1 billion in 2012. Another international supplier, Johnson Controls, is also closing plants or reducing production in Germany while opening a new plant located close to Daimler’s facility in Kecskemét (Hungary). The company will also open eleven new plants in China, all close to international OEM plants. These developments are a sign of the changes underway in the industry’s value chain that will be addressed in Section A2.8.

### A2.2 Employment and labour productivity in the automotive industry

#### A2.2.1 Employment

The latest data available from OICA indicate that more than 8 million people worldwide were directly employed in 2005 to make vehicles and their components, representing more than 5% of the world’s total manufacturing employment. It is estimated that the total workforce related either directly or indirectly to the automotive industry is more than 50 million.

In the EU, the data available on employees show a general equilibrium in the distribution of the workforce among the three NACE 29 segments (Divisions 29.1, 29.2, and 29.3). There were more than 2 million people

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70 Source: own elaboration on Eurostat data
employed in the EU-27’s motor vehicle, trailer, and semi-trailer manufacturing sector, almost half of which were employed in the manufacture of parts and accessories for motor vehicles.

Table 33 – EU-27 indicators for different segments of automotive manufacturing

<table>
<thead>
<tr>
<th>Activity</th>
<th>NACE code</th>
<th>Number of enterprises</th>
<th>Employees (in thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>29</td>
<td>20,029</td>
<td>19,720</td>
</tr>
<tr>
<td>Manufacture of motor vehicles</td>
<td>29.1</td>
<td>2,070</td>
<td>2,260</td>
</tr>
<tr>
<td>Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers</td>
<td>29.2</td>
<td>7,559</td>
<td>7,100</td>
</tr>
<tr>
<td>Manufacture of parts and accessories for motor vehicles</td>
<td>29.3</td>
<td>11,400</td>
<td>10,500</td>
</tr>
<tr>
<td>Manufacture of electrical and electronic equipment for motor vehicles</td>
<td>29.31</td>
<td>1,857</td>
<td>1,714</td>
</tr>
<tr>
<td>Manufacture of other parts and accessories for motor vehicles</td>
<td>29.32</td>
<td>9,543</td>
<td>8,786</td>
</tr>
<tr>
<td>Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres</td>
<td>22.11</td>
<td>1,806</td>
<td>1,641</td>
</tr>
</tbody>
</table>

Key categories of employees according to skill include mechanics, electricians, engineers, IT expert, together with sales and marketing specialists and product managers, accountants, business and financial specialists.

In terms of geographical spread Germany alone accounts for 36% of the total employment generated by the manufacture of motor vehicles (including both vehicles and parts), with more than 800,000 people employed. Other large EU Member States each account for 6 to 10%.

Figure 50 – EU employment in the manufacture of motor vehicles, 2012

71 Source: own elaboration on Eurostat data
72 Source: own elaboration of Eurostat data “Number of persons employed - Manufacture of motor vehicles, trailers and semi-trailers”. Data for France and Ireland refers to 2011
Before the crisis, there had been a trend of increasing employment, especially in new Member States. The decline in demand and production since mid-2008 and the resulting restructuring of the industry have brought a significant number of job cuts, hitting, among others, the United Kingdom (-42% in 2011), France and Spain (-20% and -19%), Hungary (-13%) and Italy (-7%) all compared to 2007. In the same period, some Central and Eastern European countries experienced a steady growth, including Bulgaria (+54%), Slovakia (+20%) and Romania (+18%). In 2012, figures improved slightly with Central and Eastern European countries continuing their growth, Germany growing quite significantly (+4%) and Member States hit the most by the crisis remaining at 2011 levels.

Focusing only on the employment in the manufacture of parts and accessories for motor vehicles, the EU workforce is more distributed across Member States than the direct one. Germany still accounts for the majority of the total (25%, vis-à-vis 36% of direct employment), whereas Central European countries such as Romania and Poland account for around 10% of indirect employment, whereas Italy, Spain, France and the UK retain between 9% and 4%. Even though data is not available for all Member States, overall trends suggest that, after strong decreases due to the economic downturn in 2007-2008, employment has slowly recovered in the following years. As for direct employment, the decrease in employment in Western European countries has been compensated by the growth in Central and Eastern European Member States.

Similarly to the situation in the EU, in other countries automotive employees also represent a significant share of the total workforce. In Japan, according to the Japanese Automotive Manufacturers Association (JAMA), auto-related employment amounts to 5.48 million people, equal to 8.8% of the country’s workforce. After a period of downturn following the 2008 crisis, employment in the US automotive industry is growing again. Data from the Bureau of Labour Statistics (BLS) show motor vehicle and part manufacturing employment to be at its highest in over four years, reaching 789,800 in March 2013. Combining vehicle production, sales, repair and vehicle maintenance, auto-related workforce reaches a total 4.7 million jobs.

73 Source: own elaboration of Eurostat data “Manufacture of parts and accessories for motor vehicles”. Data for France, United Kingdom and Ireland refers to 2011
A2.2.2. **Labour productivity**

Labour costs and labour productivity represent an important aspect of an industry’s ability to remain effective. Increased competition is pushing car producers to aggressively pursue cost optimisation. Since competition is particularly intense for small-sized cars, producers of lower segment cars have moved, or are moving, a great part of their production to countries with lower production costs. On the contrary, premium segment cars are still largely assembled on traditional sites. The new facilities for volume segment cars have been built with the latest technology, making these sites attractive for both lower labour costs and productivity reasons.

The fact that the cost of components are influenced by a series of specific factors (degree of automation of plants, efficiency and production competences of the manufacturer, type of vehicle produced, labour productivity based on skills, etc.) makes it extremely difficult to compare the different impacts of labour costs on vehicles.

As a rough estimation based on existing literature, however, suggests that around 25 to 40 hours of work are necessary per vehicle to produce a subcompact car, some hypotheses can be made, as reported in the table below. Under the hypotheses formulated above, mid-range vehicles produced in Turkey have a labour cost lower by 550 to 1,000 Euro than the average cost in western countries. Also Central and Eastern European countries also show significantly lower figures.

<table>
<thead>
<tr>
<th>Estimated labour costs</th>
<th>Germany</th>
<th>Belgium</th>
<th>Austria</th>
<th>Denmark</th>
<th>France</th>
<th>Italy</th>
<th>United Kingdom</th>
<th>Spain</th>
<th>Estonia</th>
<th>Hungary</th>
<th>Poland</th>
<th>Turkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcompact cars</td>
<td>€ 1,194</td>
<td>€ 1,184</td>
<td>€ 931</td>
<td>€ 887</td>
<td>€ 857</td>
<td>€ 746</td>
<td>€ 708</td>
<td>€ 651</td>
<td>€ 228</td>
<td>€ 220</td>
<td>€ 192</td>
<td>€ 91</td>
</tr>
</tbody>
</table>

The hypotheses formulated above have been confirmed by stakeholders within the panel of OEMs that have commented on labour cost figures. Focusing on the latter, important differences exist between countries within the same region for all the major markets. In the EU, countries such as Poland, Slovakia and Hungary offer personnel costs 5 times lower than West European countries such as Germany, France and Italy. Hungary still offers relatively low wages on all hierarchy levels, particularly in the blue-collar sectors. In addition to Central and Eastern European countries, Turkey is extremely competitive in terms of labour costs – this is one of the reasons leading many OEMs (Ford, Toyota, Fiat, Hyundai among others) to invest in production facilities in Turkey.

Similar trends can be observed both in North America and Asia. In Mexico, General Motors, Ford, Fiat, Toyota and Volkswagen, to name a few, have established production facilities serving the internal market, North America and increasingly South America, thanks to the favourable combination of skills, low labour costs and growing economy. In Asia, at the start of the last decade China had an extremely competitive market in terms of labour costs, which were ten times lower than Japanese and Korean ones. However, since the mid-2000s’ the booming economy has led to wages increasing by 20% or more every year.

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74 Source: own elaboration of VVA
resulting in a partial loss of competitiveness to countries such as Vietnam and India. The labour costs for a selection of countries are provided below.

### Table 35 – Automotive manufacturing labour costs

<table>
<thead>
<tr>
<th>Country</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>48.07</td>
<td>49.43</td>
<td>43.16</td>
<td>47.95</td>
<td>46.05</td>
</tr>
<tr>
<td>Belgium</td>
<td>NA</td>
<td>59.44</td>
<td>57.42</td>
<td>61.72</td>
<td>58.52</td>
</tr>
<tr>
<td>Denmark</td>
<td>45.16</td>
<td>44.12</td>
<td>43.45</td>
<td>44.82</td>
<td>43.87</td>
</tr>
<tr>
<td>Estonia</td>
<td>NA</td>
<td>12.00</td>
<td>10.25</td>
<td>11.44</td>
<td>11.29</td>
</tr>
<tr>
<td>France</td>
<td>44.97</td>
<td>43.16</td>
<td>41.70</td>
<td>44.86</td>
<td>42.36</td>
</tr>
<tr>
<td>Germany</td>
<td>59.46</td>
<td>57.30</td>
<td>54.35</td>
<td>60.42</td>
<td>59.04</td>
</tr>
<tr>
<td>Greece</td>
<td>28.44</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Hungary</td>
<td>11.51</td>
<td>10.26</td>
<td>9.73</td>
<td>10.88</td>
<td>10.87</td>
</tr>
<tr>
<td>Ireland</td>
<td>30.89</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Italy</td>
<td>37.93</td>
<td>37.03</td>
<td>36.26</td>
<td>39.00</td>
<td>36.88</td>
</tr>
<tr>
<td>Netherlands</td>
<td>42.33</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Poland</td>
<td>10.67</td>
<td>8.68</td>
<td>9.34</td>
<td>9.90</td>
<td>9.49</td>
</tr>
<tr>
<td>Slovakia</td>
<td>11.65</td>
<td>12.53</td>
<td>11.27</td>
<td>12.60</td>
<td>NA</td>
</tr>
<tr>
<td>Spain</td>
<td>34.42</td>
<td>34.33</td>
<td>32.90</td>
<td>34.51</td>
<td>32.19</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>37.33</td>
<td>32.86</td>
<td>32.71</td>
<td>34.87</td>
<td>35.00</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.98</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>United States</td>
<td>37.36</td>
<td>38.10</td>
<td>37.35</td>
<td>37.90</td>
<td>37.38</td>
</tr>
<tr>
<td>Mexico</td>
<td>8.70</td>
<td>8.01</td>
<td>7.96</td>
<td>8.16</td>
<td>7.79</td>
</tr>
<tr>
<td>Brazil</td>
<td>14.50</td>
<td>13.98</td>
<td>16.89</td>
<td>20.01</td>
<td>18.80</td>
</tr>
<tr>
<td>Japan</td>
<td>32.82</td>
<td>35.66</td>
<td>37.21</td>
<td>42.37</td>
<td>41.65</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>20.83</td>
<td>18.79</td>
<td>23.67</td>
<td>23.26</td>
<td>25.87</td>
</tr>
<tr>
<td>Taiwan</td>
<td>9.54</td>
<td>8.60</td>
<td>8.78</td>
<td>9.89</td>
<td>10.20</td>
</tr>
<tr>
<td>China</td>
<td>NA</td>
<td>NA</td>
<td>4.02</td>
<td>NA</td>
<td>6.91</td>
</tr>
<tr>
<td>India</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>3.10</td>
</tr>
<tr>
<td>Australia</td>
<td>36.76</td>
<td>35.05</td>
<td>42.73</td>
<td>51.67</td>
<td>54.34</td>
</tr>
<tr>
<td>New Zealand</td>
<td>21.46</td>
<td>19.72</td>
<td>23.40</td>
<td>25.99</td>
<td>27.97</td>
</tr>
</tbody>
</table>

Labour costs are only a partial indicator of a country’s attractiveness, as the most relevant indicator behind the choice of an OEM on a manufacturing location is labour productivity. In the EU, Germany’s automotive workforce remains the largest by far due to its productivity and skills, despite its high hourly cost: nearly 80% of the workforce has formal vocational training or an academic degree thanks to its unique dual education system. Labour productivity is also high in countries such as Hungary, which has been praised for the qualification level of its workforce. This has been one of the factors mentioned by Daimler behind the decision to use Hungary as a production base. Looking at EU labour productivity figures (table below), it is evident that the distances between West and East (and Central) European countries are smaller than what emerges solely from a comparison of personnel costs.

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75 Source: own elaboration of US Bureau of Labor Statistics, HRBS Manufacturing Labour Cost Survey 2012, EY’s surveys on country attractiveness (India and Turkey), IHS

Table 36 – Automotive manufacturing: labour productivity by country

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>€ 57,545.51</td>
<td>€ 98,000</td>
<td>170%</td>
</tr>
<tr>
<td>Belgium</td>
<td>€ 54,598.97</td>
<td>€ 74,200</td>
<td>136%</td>
</tr>
<tr>
<td>Denmark</td>
<td>€ 43,968.59</td>
<td>€ 61,600</td>
<td>140%</td>
</tr>
<tr>
<td>France</td>
<td>€ 54,446.46</td>
<td>€ 60,000</td>
<td>110%</td>
</tr>
<tr>
<td>Germany</td>
<td>€ 67,309.02</td>
<td>€ 97,800</td>
<td>145%</td>
</tr>
<tr>
<td>Hungary</td>
<td>€ 16,750.18</td>
<td>€ 46,800</td>
<td>279%</td>
</tr>
<tr>
<td>Ireland</td>
<td>€ 38,121.55</td>
<td>€ 55,200</td>
<td>145%</td>
</tr>
<tr>
<td>Italy</td>
<td>€ 41,827.27</td>
<td>€ 58,600</td>
<td>140%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>€ 50,701.19</td>
<td>€ 94,000</td>
<td>185%</td>
</tr>
<tr>
<td>Poland</td>
<td>€ 13,589.43</td>
<td>€ 32,900</td>
<td>242%</td>
</tr>
<tr>
<td>Slovakia</td>
<td>€ 16,231.73</td>
<td>€ 31,100</td>
<td>192%</td>
</tr>
<tr>
<td>Spain</td>
<td>€ 42,013.89</td>
<td>€ 60,500</td>
<td>144%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>€ 46,218.88</td>
<td>€ 98,400</td>
<td>213%</td>
</tr>
</tbody>
</table>

Central Europe deserves attention as it has attracted a number of European and non-European OEMs. A major strength of this region is its qualified and inexpensive workforce. Low labour costs coupled with rapidly growing labour productivity are a unique combination which strongly supports the competitiveness of car producers in the region. The labour cost advantage of Central Europe is present across a wide variety of segments. As a result, car production in this region also encourages the relocation of R&D centres from Western Europe.

A2.3 Trade performance and comparative advantages

Whereas in principle cars could simply be exported from mature to growing markets, cars are mostly assembled in the region where they are sold. In 2011 for instance, only around 11% of all produced passenger cars were traded between North America, Europe and South-East Asia. This trend is due to different reasons:

- **Trade barriers**: where Free Trade Agreements have not been signed, import duties prevent trade among markets. Non-tariff barriers Also have a role in reducing international trade;
- **Benefits of geographical presence and just-in-time production**: aside from economic evaluations, interviewed stakeholders suggested that geographical proximity to the clients provide a “soft” yet very relevant advantage, i.e. to be able to respond quickly to customers’ needs;
- **Transportation costs**: moving vehicles across different regions is expensive and time consuming.

The reasoning above has been confirmed for international trade between different regions by interviewed stakeholders. As mentioned above, trade tariffs play an important role in influencing international trade of goods. The level of trade tariffs applied by each country varies a lot, also depending on the type of good. The

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77 Source: own elaboration of US Bureau of Labor Statistics, HRBS Manufacturing Labour Cost Survey 2012, EY’s surveys on country attractiveness (India and Turkey), IHS
Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation

tariffs for the most recent available years for a selection of countries and goods (i.e. cars code HS8703, light commercial vehicles 870421, 31 and 90 and components 8708) are provided in the table below.

It can be noted that also non-tariff barriers (NTBs) have a significant role in reducing or hampering international trade. These include, for example, anti-dumping measures and countervailing duties. NTBs have increasingly been applied following the reduction of trade tariff levels by WTO activities and rules.

Table 37 – Overview of trade tariffs\textsuperscript{78}

<table>
<thead>
<tr>
<th>Reporter</th>
<th>Year</th>
<th>HS 8703</th>
<th>HS 870421, 870431 and 870490</th>
<th>HS8708</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>2012</td>
<td>35</td>
<td>35</td>
<td>15.35</td>
</tr>
<tr>
<td>Canada</td>
<td>2013</td>
<td>5.8</td>
<td>5.1</td>
<td>3.4</td>
</tr>
<tr>
<td>China</td>
<td>2011</td>
<td>25</td>
<td>25</td>
<td>9.8</td>
</tr>
<tr>
<td>EU Union</td>
<td>2013</td>
<td>9.7</td>
<td>12.3</td>
<td>3.8</td>
</tr>
<tr>
<td>India</td>
<td>2013</td>
<td>100</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>2013</td>
<td>8</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Mexico</td>
<td>2012</td>
<td>31.3</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>2012</td>
<td>1.7</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Turkey</td>
<td>2011</td>
<td>9.7</td>
<td>12.3</td>
<td>3.8</td>
</tr>
<tr>
<td>USA</td>
<td>2013</td>
<td>2.5</td>
<td>25</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Figure 52 - Flows of passenger cars in % of world production, 2011\textsuperscript{79}

The result of these factors is that a large share of cars is typically produced in the region where they are sold, as shown in the figure below. Roughly 82% of all cars manufactured in Europe are sold in Europe, with 9% exported to Asia and a similar share to Central and North America. Of all cars sold in Europe, 86% are manufactured in Europe, 9.5% in Asia and the rest in Central and North America. Trade from and to Asia exhibits similar figures to the European ones, whereas in Central and North America imports have a more

\textsuperscript{78} Source: WTO, Integrated Database (IDB) notifications. Most Favourable Nation applied tariffs

\textsuperscript{79} Source: OECD (2013)
prominent role. In 2011, 73.5% of cars sold in Central and North America were produced regionally, whereas 16% and 10.5% were imported respectively from Asia and Europe.

Trades within the same region are a common practice, when enabled by favourable combinations of geographical proximity, offset in labour costs and absence of trade barriers (as in the case of EFTA, Customs Union, NAFTA etc.). One interviewee reported shipping costs from Turkey to Germany to be around 300 Euro per vehicle, vis-à-vis savings in production costs in the order of 1,000 euros. Shipping from Asia to EU is reported to cost around 900 Euro per car.

A2.3.1. Free trade agreements
Where they are considered to be mutually beneficial, bilateral or regional Free Trade Agreements involving or excluding specific groups of goods are signed. The FTAs can have a significant impact on increasing the intensity of international trade, as exemplified by the recently signed FTA (Free Trade Agreement) with South Korea. According to the Annual Report on the Implementation of the EU-Korea Free Trade Agreement issued by the EU Commission in February 2014, EU exports of cars to Korea increased by 40% in value and 38% in units, compared to the year before the FTA was provisionally applied (i.e. two years before), as compared with an increase of 24% in value and 25% in units worldwide. Likewise, imports of cars from Korea increased by 53% in value and by 36% in units. The data suggest that FTAs can provide significant opportunities for EU exports, at the expense of increased internal competition, leading to the need of carefully considering advantages and drawbacks of FTAs on a case-by-case basis.

At the present stage, the EU has the following FTAs in place:
- Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama);
- Colombia and Peru;
- South Korea;
- Mexico (Comprehensive Free Trade Agreement);
- Economic Partnership Agreements with the Caribbean (fifteen CARIFORUM states), the Pacific (Papua New Guinea) and Eastern and Southern Africa (Zimbabwe, Mauritius, Madagascar, the Seychelles);
- South Africa (Trade, Development and Co-operation Agreement);
- Chile (Free Trade Agreement).

Moreover, FTAs are a core component of Association Agreements as well as Customs Unions (Andorra, San Marino, and Turkey). Hence the EU also has free trade deals in force with a number of countries in Europe (Faroe Islands, Norway, Iceland, Switzerland, the former Yugoslav Republic of Macedonia, Albania, Montenegro, Bosnia and Herzegovina, Serbia) and the Southern Mediterranean (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia) and three with African, Caribbean and Pacific countries (Caribbean, Pacific and Eastern and Southern Africa).

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81 Source: AALEP
A series of FTAs are **finished but not yet being applied**. These include:

- Eastern Neighbourhood – Deep and Comprehensive Free Trade Area (DCFTA) with Moldova, and Georgia, Ukraine
- Singapore – Free Trade Agreement (FTA)
- Five interim Economic Partnership Agreements with Cote d'Ivoire, Central Africa (Cameroon), the Southern African Development Community, Ghana and the East African Community.

**On-Going Negotiations** include:

- United States of America (The Transatlantic Trade and Investment Partnership (TTIP))
- Agreement on investment with China
- Canada (Comprehensive Economic and Trade Agreement (CETA))
- Japan (Free Trade Agreement)
- Association of Southeast Asian Nations (ASEAN): Malaysia, Vietnam and Thailand;
- Southern Mediterranean: Deep and Comprehensive Free Trade Agreement (DCFTA) with Morocco. The Commission has a mandate to start a similar process with Tunisia, Egypt and Jordan.
- India (Free Trade Agreement)
- Mercosur (EU-Mercosur Association Agreement)
- African, Caribbean and Pacific countries (ACP) – Economic Partnership Agreements (EPAs)

Of particular interest is the situation with **Japan**. EU-Japan FTA negotiations are ongoing for both vehicles and components – the EU does not envisage any exclusions. The negotiation involves both tariffs and NTBs:

- **Tariffs**: Japan has 0% tariffs on cars and most of the components. The EU has 10% duty on cars and Japan's objective is to eliminate this duty;
- **On NTBs** the objective of the EU is to encourage Japan to adopt and comply with the international (UNECE) standards. The EU has issued a list of NTBs some of which are related to cars. Several of the NTBs were already resolved during the first year of negotiations. A second list of NTBs is expected to be submitted in autumn 2014. Additionally, and in parallel with the discussions on specific NTBs, the EU has submitted to Japan an automotive annex which focuses on the elimination of NTBs and introduces mechanisms to prevent new NTBS from emerging.

**A2.3.2. Trade performance of the European automotive industry**

In spite of the barriers to trade caused by logistics costs and import tariffs, the European automotive industry is a global player delivering quality ‘Made in Europe’ products worldwide. The automotive sector contributes positively to the EU trade balance with trade surplus in the order of 100 billion euros when considering vehicle manufacturing (passenger cars and LCVs) and vehicle components[^82].

**Cars** account for the large majority of this surplus. The trade balance of cars with the main trade partners, shown in table 13, (NAFTA countries, EFTA countries, Middle East countries including Turkey, Russia, Korea, Japan, China and India) was positive and worth more than USD 81 million, a 34.5% growth compared to 2011.

[^82]: Data based on UN COM trade statistics, year 2012
Whereas the highest positive overall trade balances are with NAFTA, China, Russia and EFTA, high values of exports were also recorded for Japan and Turkey (respectively USD 8 million and USD 6 million).

Table 38 - EU-27 Balance of cars trade flows by area (USD million)$^{83}$

<table>
<thead>
<tr>
<th>Partner</th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAFTA</td>
<td>$26,909</td>
<td>$18,916</td>
</tr>
<tr>
<td>EFTA</td>
<td>$23,153</td>
<td>$12,381</td>
</tr>
<tr>
<td>Middle East</td>
<td>$7,758</td>
<td>$5,859</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>$11,269</td>
<td>$8,868</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>-$1,806</td>
<td>-$2,287</td>
</tr>
<tr>
<td>Japan</td>
<td>$746</td>
<td>$2,825</td>
</tr>
<tr>
<td>China</td>
<td>$24,322</td>
<td>$21,322</td>
</tr>
<tr>
<td>India</td>
<td>-$1,078</td>
<td>-$1,880</td>
</tr>
<tr>
<td>TOTAL Main Partners</td>
<td>$81,272</td>
<td>$60,354</td>
</tr>
</tbody>
</table>

Trade flows are different for light commercial vehicles. The magnitude of LCV trade flows is much lower than for passenger cars (both in absolute and relative terms). In 2012 car exports from the EU to key trade partners accounted for USD 110 billion and imports for USD 29 billion while both exports and imports of LCVs were worth around USD 3 billion.

The overall EU LCV trade balance was almost neutral (+USD 50 million) in 2012 and slightly negative in 2011 (-USD 1 billion). The main determinant of this are trade flows with Turkey, as imports from the country to the EU accounted for USD 3.5 billion in 2012 and USD 2.9 billion in 2011, against exports worth around USD 670 million in both these years.

Table 39 - EU-27 Balance of LCVs trade flows by area (USD million Dollars)$^{84}$

<table>
<thead>
<tr>
<th>Partner</th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAFTA</td>
<td>$355</td>
<td>$265</td>
</tr>
<tr>
<td>EFTA</td>
<td>$1,033</td>
<td>$1,034</td>
</tr>
<tr>
<td>Middle East</td>
<td>-$2,037</td>
<td>-$2,737</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>$751</td>
<td>$553</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>-$23</td>
<td>-$27</td>
</tr>
<tr>
<td>Japan</td>
<td>-$27</td>
<td>-$193</td>
</tr>
<tr>
<td>China</td>
<td>$2</td>
<td>$35</td>
</tr>
<tr>
<td>India</td>
<td>-$6</td>
<td>-$12</td>
</tr>
<tr>
<td>TOTAL Main Partners</td>
<td>$50</td>
<td>-$1,082</td>
</tr>
</tbody>
</table>

For components that can be associated with CO$_2$ reduction$^{85}$, the EU recorded a positive trade balance in both 2012 and 2011 (respectively worth around USD 20 billion and USD 15 billion). EU Member States

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$^{83}$ Source: Internal elaboration based on UN COMtrade statistics. The total can differ from the sum of rows due to rounding.

$^{84}$ Source: Internal elaboration based on UN COMtrade statistics. Note: Harmonized System Codes 870421, 870431 and 870490 were considered. Calculation of trade flows is lightly overestimated, as Harmonized System Codes do not perfectly match vehicles in scope of EU CO$_2$ legislation in terms of weight. The total can differ from the sum of rows due to rounding.
exhibit the most relevant positive trade balances with NAFTA countries and China. The only trade partner with significant net imports for the EU is Japan (yearly exports to Japan account for around USD 1 billion, whereas imports are worth USD 5 billion).

**Table 40 - EU-27 Balance of CO$_2$-related components trade flows by area (USD million)**

<table>
<thead>
<tr>
<th>Partner</th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAFTA</td>
<td>$10,688</td>
<td>$8,080</td>
</tr>
<tr>
<td>EFTA</td>
<td>-$10</td>
<td>-$125</td>
</tr>
<tr>
<td>Middle East</td>
<td>$2,662</td>
<td>$2,942</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>$3,994</td>
<td>$3,333</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>-$193</td>
<td>-$87</td>
</tr>
<tr>
<td>Japan</td>
<td>-$3,893</td>
<td>-$4,058</td>
</tr>
<tr>
<td>China</td>
<td>$6,007</td>
<td>$4,692</td>
</tr>
<tr>
<td>India</td>
<td>$476</td>
<td>$403</td>
</tr>
<tr>
<td>TOTAL Main Partners</td>
<td>$19,732</td>
<td>$15,180</td>
</tr>
</tbody>
</table>

**Comparative advantages**

An examination of the competitiveness of the EU automotive industry using the Revealed Comparative Advantage is provided below. The revealed comparative advantage coefficient presented below is the simple Balassa index, which is the ratio of the proportion of the exports of a certain good in the total EU exports to the proportion of the world exports of the same good in the total world exports. An index value above one designates a comparative advantage (or export specialisation) in the commodity in question. An index value close to zero means a lack of comparative advantage in this commodity.

**Table 41 - The revealed comparative advantage coefficient in passenger vehicles**

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU-27</td>
<td>1.71</td>
<td>1.69</td>
</tr>
<tr>
<td>Japan</td>
<td>3.26</td>
<td>2.93</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>2.07</td>
<td>2.04</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.06</td>
<td>1.33</td>
</tr>
<tr>
<td>USA</td>
<td>0.94</td>
<td>0.90</td>
</tr>
<tr>
<td>India</td>
<td>0.39</td>
<td>0.33</td>
</tr>
<tr>
<td>Canada</td>
<td>2.77</td>
<td>2.44</td>
</tr>
<tr>
<td>China</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.10</td>
<td>2.12</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0.05</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: The Balassa RCA index.

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85 Calculations consider both components that can be enhanced to reduce emissions and components whole sales might be influenced by CO$_2$ legislation. These include the following Harmonised System codes: 840733, 840734, 840820, 840991, 840999, 870840, 870850, 870870, 870892, 870893 and 870894. The total can differ from the sum of rows due to rounding.

86 Source: Internal elaboration based on UN COM trade statistics. The total can differ from the sum of rows due to rounding.
Table 42 - The revealed comparative advantage coefficient in light commercial vehicles

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU-27</td>
<td>0.68</td>
<td>0.67</td>
</tr>
<tr>
<td>Canada</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>China</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Japan</td>
<td>0.95</td>
<td>0.96</td>
</tr>
<tr>
<td>Mexico</td>
<td>7.51</td>
<td>7.19</td>
</tr>
<tr>
<td>Norway</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>0.92</td>
<td>1.02</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Turkey</td>
<td>5.09</td>
<td>7.61</td>
</tr>
</tbody>
</table>

Note: The Balassa RCA index.

We, again, observe a strong export specialisation of the EU in passenger vehicles. This table is comparable with the table on net exports above. However, Japan, Korea, Canada and Mexico are even more specialised in light commercial vehicles. Mexico’s strong export specialization emerged from the maquiladora industry, which fostered the relocation of the U.S. auto plants into Mexico, especially after the conclusion of NAFTA in 1994.

In light commercial vehicles, the EU does not have a comparative advantage, which is consistent with the unstable EU trade position in light commercial vehicles. Mexico (again) and Turkey appear strongly specialised in this export.

The EU specialises in the export of automotive components. Mexico and Japan possess an even higher comparative advantage than the EU while Turkey and the U.S. exhibit an export specialisation slightly below the level of the EU:

Table 43 - The revealed comparative advantage coefficient in automotive components

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU-27</td>
<td>1.35</td>
<td>1.36</td>
</tr>
<tr>
<td>China</td>
<td>0.46</td>
<td>0.47</td>
</tr>
<tr>
<td>India</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Japan</td>
<td>3.25</td>
<td>3.06</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.55</td>
<td>2.52</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.22</td>
<td>1.42</td>
</tr>
<tr>
<td>USA</td>
<td>1.15</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Note: The Balassa RCA index.
A2.4 Cost of capital and financial indicators

As analysed in the Impact Assessment on the modalities to achieve the 2020 targets, the implementation of the legislation does not directly affect the financial sector, however indirect impacts could take place in case of significant increases in the need for investment capital by OEMs, their suppliers and other affected sectors. For OEMs, these increases might be caused by the investments in developing and manufacturing innovative technologies required in order to fill the gap between the current average CO₂ emissions and the target. Supplier investments would be a consequence of the demand for enhanced or alternative components from OEMs.

The relevance of these impacts post-2020 depends on the level of ambition: if the target leads OEMs to invest heavily in alternative technologies (e.g. electric, plug-in hybrid or fuel cell vehicles), this might lead to a restructuring of the industry. The resulting uncertainty could increase the risk faced by financial institutions in providing capital, and eventually the cost of capital for automotive manufacturers and other affected sectors.

In this framework, competitiveness impacts (related to the cost dimension) result from different levels of the cost of capital for companies. At the beginning of 2014 the cost of capital for European OEMs was reported to be on average slightly lower than that of non-European competitors. This is mainly due to the combined effect of low after-tax costs of debt (3.24%) and high shares of debt over capital. The key figures of the car and commercial vehicle sectors are provided in the table below.

<table>
<thead>
<tr>
<th>Area</th>
<th>Cost of Equity</th>
<th>E/(D+E)</th>
<th>After-tax Cost of Debt</th>
<th>D/(D+E)</th>
<th>Cost of Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>12.97%</td>
<td>42.85%</td>
<td>3.24%</td>
<td>57.15%</td>
<td>7.41%</td>
</tr>
<tr>
<td>United States</td>
<td>9.42%</td>
<td>50.62%</td>
<td>6.71%</td>
<td>49.38%</td>
<td>8.08%</td>
</tr>
<tr>
<td>Japan</td>
<td>12.09%</td>
<td>57.11%</td>
<td>3.08%</td>
<td>42.89%</td>
<td>8.23%</td>
</tr>
<tr>
<td>China</td>
<td>10.63%</td>
<td>90.12%</td>
<td>3.38%</td>
<td>9.88%</td>
<td>9.92%</td>
</tr>
<tr>
<td>India</td>
<td>17.53%</td>
<td>78.62%</td>
<td>4.34%</td>
<td>21.38%</td>
<td>14.71%</td>
</tr>
<tr>
<td>Global</td>
<td>11.15%</td>
<td>55.59%</td>
<td>5.11%</td>
<td>44.41%</td>
<td>8.47%</td>
</tr>
</tbody>
</table>

As the sector is extremely concentrated, the average figures reported below depend on the cost of debts and the cost of equity of a restricted number of players. The cost of debt depends largely on the financial stability and the outlook of a company, which are summarised by their credit rating. The table below shows the (long-term) Standard & Poor’s credit rating for of a selection of OEMs.

The cost of equity reflects the return an OEM pays equity investors, i.e. shareholders, to compensate for the risk they undertake in investing their capital. It has more complex components than the cost of debt since, for each company, it depends on the increase of the firm market value as well as on the dividend payments made.

87 Source: Damodaran based on S&P Capital IQ data, January 2014
European automotive suppliers face higher costs of capital than non-EU competitors (11.77% against an average of 9.49%). The reasons behind this are a) the higher cost of equity for European firms (14% returns against around 10% both globally and in major trade partner markets), combined with the high weight of equity on total capital (around 80%) of the sector in all regions. The key figures of the automotive suppliers sector are displayed in the table below.

<table>
<thead>
<tr>
<th>Group or company</th>
<th>Headquarters</th>
<th>Long-term credit rating&lt;sup&gt;88&lt;/sup&gt;</th>
<th>Estimated spread&lt;sup&gt;89&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>Germany</td>
<td>A+</td>
<td>0.85%</td>
</tr>
<tr>
<td>DAIMLER</td>
<td>Germany</td>
<td>A-</td>
<td>1.30%</td>
</tr>
<tr>
<td>VOLKSWAGEN</td>
<td>Germany</td>
<td>A</td>
<td>1.00%</td>
</tr>
<tr>
<td>PEUGEOT</td>
<td>France</td>
<td>B+</td>
<td>5.50%</td>
</tr>
<tr>
<td>RENAULT</td>
<td>France</td>
<td>BB+</td>
<td>3.00%</td>
</tr>
<tr>
<td>FIAT (EXOR Spa)</td>
<td>Italy</td>
<td>BBB+</td>
<td>Slightly lower than 2%</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Japan</td>
<td>AA-</td>
<td>0.70%</td>
</tr>
<tr>
<td>GM</td>
<td>United States</td>
<td>BBB-</td>
<td>Slightly higher than 2%</td>
</tr>
<tr>
<td>FORD</td>
<td>United States</td>
<td>BBB-</td>
<td>Slightly higher than 2%</td>
</tr>
<tr>
<td>HYUNDAI (incl. KIA)</td>
<td>South Korea</td>
<td>BBB+</td>
<td>Slightly lower than 20%</td>
</tr>
<tr>
<td>NISSAN</td>
<td>Japan</td>
<td>A-</td>
<td>1.30%</td>
</tr>
<tr>
<td>HONDA</td>
<td>Japan</td>
<td>A+</td>
<td>0.85%</td>
</tr>
<tr>
<td>TATA</td>
<td>India</td>
<td>BB</td>
<td>4.00%</td>
</tr>
<tr>
<td>GEELY</td>
<td>China</td>
<td>BB+</td>
<td>3.00%</td>
</tr>
</tbody>
</table>

Aside from cost of capital, another factor affecting the financial situation of companies is the availability of investment capital for companies. Despite the fact that all OEMs and some component suppliers are global players, interviewed stakeholders remarked that:

- Local investments (e.g. in Europe) tend to be financed through local sources (i.e. European) of capital;
- Due to business culture differences, EU investors (e.g. banks, equity funds, etc.) have a lower risk acceptance than those in other regions, notably the United States;

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<sup>88</sup> Source: S&P, September 2014
<sup>89</sup> Source: Damodaran, 2014
<sup>90</sup> Source: Damodaran based on S&P Capital IQ data, January 2014
Consequently, interviewees claim that OEMs facing major investments in the EU might have a disadvantage compared to international competitors making similar investments in their own country.

A2.5 R&D and innovation

A2.5.1. R&D investment in new technologies

Baseline: Almost half of the world’s top 20 most innovative companies are car manufacturers according to a recent report by the Boston Consulting Group (BCG). More recently, according to the EU Commission’s 2013 EU Industrial R&D Investment Scoreboard, more than one out five companies ranked in the top 50 of the Scoreboard are from Automobiles and parts. In fact, Volkswagen, ranked as the world’s largest private sector R&D investor with 9.5 billion euros invested in R&D followed by Samsung Electronics (8.3 billion euros). This is the first time since 2004 that a company based in the EU leads the world R&D ranking.

The automotive sector is the largest investor in R&D in the EU with over 32 billion euros of expenditure and accounting for 25% of total R&D spending. In the Czech Republic, Sweden, France and Japan, the sector accounts for more than 15% of all R&D spending; in Germany its share exceeds 30%. EU OEMs and suppliers, led by German carmakers, show very high increases in R&D investment and sales (14.2% and 11.3% respectively). The R&D growth rates of Volkswagen (32.1%), BMW (17.2%) and Bosch (17%) determine a large portion of German and EU overall positive numbers. The R&D growth of FIAT (+51.5%) accounted for more than 36% of the R&D of the companies based in Italy. The opposite trend can be seen with US-based competitors, such as General Motors and Chrysler, which are still recovering from the crisis and the US government bail-outs. It is important hence to note that in many countries, the aggregate indicators depend to a large extent on the figures of a few firms.

The automotive sector is considered a medium R&D intensity sector opposed to high R&D intensity sectors such as software, pharmaceuticals, health, and technology hardware. The EU and Japan are stronger than the US in medium R&D intensity sectors like the automotive one.

One of the areas in which car manufacturers have invested the most in terms of R&D is safety. Since more than 90% of crashes involve some kind of driver error, a range of safety systems has been created to aid drivers in avoiding accidents. Driver assist systems include lane departure and blind spot warnings, adaptive cruise control and automatic braking. Another area of major development is represented by connectivity and the internet. In fact, the percentage of new passenger cars globally shipping with factory-installed telematics will increase from nearly 10% in 2010 to 62% in 2016 according to ABI Research. Moreover, companies along the automotive value chain are working to increase conventional vehicles’ fuel efficiency, by developing better hybrid and electric models, more efficient power trains and lighter car bodies.

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92 According to ACEA, the sector is the largest private investor in R&D in Europe representing about 4% of the industry’s turnover and 23% of EU industry’s total R&D expenditure.
A2.5.2. R&D investment in personnel (R&D centres)

Baseline: All top OEMs have R&D centres, the majority of them being located in the OEM’s country of origin. As products are becoming increasingly more complex from a technological standpoint, the automotive industry seeks to employ a highly skilled workforce. In particular given that EU automakers are increasing their investments in alternative technologies such as battery-powered hybrid vehicles, electric vehicles and hydrogen, their R&D departments are consequently witnessing a shift in competences from mechanical to electrical engineering. The workforce employed in R&D ranges in terms of an ‘R&D staff to Total staff ratio’ (see Table 47) of 1:5 concerning Opel to a 1:25 for Volkswagen. In terms of geographical location some OEMs tend to concentrate R&D resources in their base country where headquarters are located (e.g. Toyota and PSA), whereas others distribute R&D centres based on key markets (e.g. Volkswagen, Daimler and Honda, see Figure 54). To better understand the differences between OEMs, the context behind those figures is described below by OEM.

Figure 53 - R&D intensity by region, 2013

Source: own elaboration on 2013 EU industrial R&D Scoreboard

Figure 54 - R&D intensity most innovative OEMs, 2012 (Top 150)

Source: own elaboration on 2013 EU industrial R&D Scoreboard
OEMs – EU headquarters

Within the premium brands, German OEMs, BMW and Daimler are among the most innovative brands in the automotive industry. BMW’s research and development activities are located in three different continents, namely Europe, America, and Asia. Of the 11,359 employees belonging to the BMW Group’s global research and innovation network, the vast majority are employed at the BMW Group Research and Innovation Centre (9,200 employees). As one of the most innovative EU OEMs, BMW has recruited skilled staff specifically for the development and production of new technologies such as electromobility. As a result, the R&D staff represents approximately 10% of BMW’s total workforce as of December 2013. Daimler’s R&D staff is made of 14,700 employees over 16 locations in six different countries. The company’s major areas of research and development are related to design, safety and vehicle testing, telematics, and electronic mobility among others.

Other EU automakers that invest heavily in R&D activities, and thus need specialised staff, are FIAT, Opel, PSA, Renault and Volkswagen. According to the latest data available, the FIAT Group has a workforce of 18,700 employees in R&D, spread over 78 research centres. These are significant numbers, as innovation will be a major driver of growth not only for the premium brands but also for the more generalist automakers. The relatively recent investment in Chrysler is paving the way for the creation of a shared research and innovation plan. The main areas in which FIAT concentrates its R&D activities are the reduction of environmental footprint, safety and connected vehicles along with increasing the competitiveness of its products.

Another German company which is particularly investing in innovation is Opel, which is expected to introduce twenty-three new models and sixteen engines by 2016. A recent example of Opel’s innovativeness is the launch in 2012 of an Extended Range Electric Vehicle, the Opel Ampera. Sustainable mobility is one of the areas where Opel focuses its R&D activities through more eco-friendly engines and alternative propulsion systems. Opel’s workforce dedicated to engineering and development activities is made of approximately 6,800 employees. The most important centre is in Rüsselsheim where the company is also headquartered. In an effort to achieve the aforementioned goals, Opel’s parent company General Motors will invest 230 million euros in new facilities at the Rüsselsheim R&D centre.

Innovation is one of the key factors of the French PSA Peugeot Citroën’s strategy. PSA’s R&D staff counts 14,500 employees worldwide in six dedicated centres, four in France (Vélizy, Sochaux-Belchamp, La Garenne-Colombes and Carrières-sous-Poissy), one in Shanghai (China Tech Center) and one in Sao Paulo in South America. PSA Peugeot Citroën’s innovation policy is based on three key concepts: performance (cutting the time to market), openness (networking) and looking to the future (detecting any weak technological signals). PSA’s efforts in R&D also aim at cutting CO₂ emissions and improving connectivity between the driver and the vehicle. The PSA Group has its own style centre, the ADN (Automotive Design Network), which brings together the style studios of both brands and the innovation and vehicle architecture teams, totalling almost 1,000 people. Moreover, the China Tech Center also has its own style teams in order to better meet local needs. Finally, the Group operates vehicle test centres at Belchamp and La Ferté-Vidame in France.
The latest data available on the Renault Group explain that its overall workforce employed in R&D equals 16,426 employees. These figures are related to all of Renault's brands including Dacia and Renault Samsung Motors. Besides having invested heavily in electromobility, other priority areas in Renault's innovation strategy include innovative design, low CO\(_2\) emissions, autonomous vehicles and on-board multimedia services. R&D activities of the Renault Group are carried mainly in France. Renault Samsung Motor’s plant in Busan, South Korea, carries also R&D activities with an R&D staff of one thousand.

**OEMs – non EU headquarters**

Among the non-EU automakers, Nissan has a variety of research centres located across four continents and employing more than 16,000 people in R&D activities. The main areas in which Nissan is active are safety, CO\(_2\) emission reduction, driving experience and vehicle performance. More recently, Renault and Nissan have announced their intention to deepen their integration by strengthening cooperation in four areas, one of which is research and development. The two automakers are studying how to allocate research on next-generation technologies, accelerate the exploitation of common platforms, define and deploy a common powertrain strategy, and optimise test facilities globally.\(^93\)

Toyota has a large number of centres dedicated to a variety of research and development activities such as product planning, vehicle engineering and evaluation as well as design. The amount of staff working on R&D activities is equal to 14,000, the majority of which is employed in Japan (approximately 12,000). In R&D, Toyota focuses its efforts on three key areas: environment, safety and energy.

General Motors employs around 17,000 people in R&D activities in its eight R&D facilities. The main areas in which the GM group focuses are design and technology, environment, quality and safety. The largest facility is located in Detroit, Michigan (US), which accounts for more than 80% of the company’s R&D staff.

**Table 47 - R&D personnel, selected OEMs\(^94\)**

<table>
<thead>
<tr>
<th>Automaker</th>
<th>R&amp;D staff</th>
<th>R&amp;D staff Total staff ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW Group</td>
<td>11,359</td>
<td>1:10</td>
</tr>
<tr>
<td>Daimler</td>
<td>14,700</td>
<td>1:19</td>
</tr>
<tr>
<td>FIAT Group</td>
<td>18,700</td>
<td>1:12</td>
</tr>
<tr>
<td>General Motors(^95)</td>
<td>17,000</td>
<td>1:10</td>
</tr>
<tr>
<td>Nissan</td>
<td>16,120</td>
<td>1:10</td>
</tr>
<tr>
<td>Opel</td>
<td>6,800</td>
<td>1:5</td>
</tr>
<tr>
<td>PSA</td>
<td>14,500</td>
<td>1:13</td>
</tr>
<tr>
<td>Renault</td>
<td>16,426</td>
<td>1:7</td>
</tr>
<tr>
<td>Toyota</td>
<td>14,000</td>
<td>1:24</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>23,000</td>
<td>1:25</td>
</tr>
</tbody>
</table>


\(^{94}\) Source: own elaboration on OEMs annual reports and websites.

\(^{95}\) Not including Opel/Vauxhall.

Final Report
Valdani Vicari & Associati (VVA), Technopolis Group (TG), Joint Institute for Innovation Policy (JIP), TNO for DG CLIMA
A2.5.3. Service innovation

Baseline: Service based business models where OEMs other than the product also offer services around the product have emerged as a response to shrinking sales partly due to the financial and sovereign debt crises, and partly due to declining trends in car ownership\(^96\), or urbanisation trends\(^97\), among other reasons.

The most notable trend in service innovation has been car sharing. Last year, about 2.3 million drivers worldwide belonged to a car-sharing service, a number expected to increase to 26 million by 2020. The OEMs have joined in, through their own new ventures with possibly as main objective to hold onto existing customers and connect with future ones. E.g. Daimler and the rental company Europcar have joined forces to create Car2Go, while BMW has teamed up with the car-rental company Sixt to form DriveNow. Volkswagen, Citroën and Ford are among the other big manufacturers venturing into car-sharing. OEMs also use car-sharing vehicles to try out new technologies, like parking-space location, that will eventually be installed in the cars they sell or rent conventionally.\(^98\) Another business model in place in the sector is BMW’s comprehensive service package ‘360° ELECTRIC’ which is backing BMW’s product i8 with service innovation e.g. electricity contracts, applications locating charging stations, parking etc.

\(^96\) A study of HIS showed that particularly young people are waiting longer to get their driving license in the US. A study of Michigan referenced in the report included figures of licensed drivers in the US recording a decrease of 10% between 1983 and 2008. This trend was also confirmed in other countries (in particular the UK, Sweden, Norway, Korea and Japan) (Available at: http://www.ihs.com/info/ecc/a/automotive-study.aspx)

\(^97\) Namely the expected growth of urban populations and the increasing positive attitude for public transport, cycling and walking in urban areas - as encouraged by policy makers and driven by a more environmentally conscious younger generation, or the increase in small and mini car use especially in urban areas. In fact, the European car use statistics shows that there was a steady growth of the market for ‘mini’ car models of 80% between 2003 and 2007 and a slight expansion for ‘small’ cars. Since the start of the financial crisis there has been a drop for both and a notable drop of 50% for mini cars (recorded in 2012).

\(^98\) http://www.nytimes.com/2013
A2.5.4. Strategic patenting

Baseline: The EU automotive industry is the origin of more than 53% of the patents submitted to the EU Patent Office, compared to the 21%, 15% and 0.4% of Japanese, US and Chinese manufacturers respectively (as measured in the year 2007) (Centre for Strategy and Evaluation Services, 2013). According to ACEA 56% of the world’s total automotive patents are filed in the EU. Technologies ranging from computerised driving aids and advanced transmission systems to lighter materials and improved engine technologies have put Europe at the cutting edge of automotive innovation.

Over the years the growth trends of electric and hybrid engine technology patenting were either lower or the same as the ones of traditional engine technologies. From the early 2000s however the “non-environmental” patenting rate dramatically declined while the “environmental” patenting continued to peak. Using patents on vehicle fuel efficiency and air pollution abatement, Volleberg (2010) showed empirically the increased dominance of R&D in alternative fuel vehicles, biofuel-driven, hydrogen-based or electric cars over the emission control, engine redesign, and other improvements (e.g. improvement of aerodynamics, tyre resistance, substitution of materials to decrease weight).

More recently, the electric and hybrid engine technologies (or “alternative powered vehicles” in Table 48) have been found to be the fastest growing segment of auto industry R&D with a 182% increase in patenting activity between 2006 and 2011, and 31% between 2012-2103 (Thomson Reuters, 2012; Thomson Reuters, 2014). The study compared innovation segments in technologies in the auto industry as measured by patent applications and granted patents (unique patents) in an attempt to identify those of growing attention by automotive innovators.

Geographically within the top 10 car manufacturers doing the most alternative power innovation Germany, France and the UK are the only EU countries on the list with a share of 7.8%, 1.7% and 0.6% respectively. Of those, only Germany ranks in the top five (being 5th) below frontrunner Japan with 35.2%, China 28.4%, USA 10.3% and S. Korea 9%.

<table>
<thead>
<tr>
<th>Technology areas</th>
<th>Volume 2013</th>
<th>% change 2012-2013</th>
<th>% change 2006-2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative powered vehicles</td>
<td>29,694</td>
<td>31%</td>
<td>182%</td>
</tr>
<tr>
<td>Transmission</td>
<td>15,236</td>
<td>28%</td>
<td>48%</td>
</tr>
<tr>
<td>Navigation Systems</td>
<td>15,050</td>
<td>30%</td>
<td>43%</td>
</tr>
<tr>
<td>Safety</td>
<td>14,306</td>
<td>39%</td>
<td>26%</td>
</tr>
<tr>
<td>Seat, Seatbelts and airbags</td>
<td>12,070</td>
<td>40%</td>
<td>42%</td>
</tr>
<tr>
<td>Steering Systems</td>
<td>9,030</td>
<td>32%</td>
<td>29%</td>
</tr>
<tr>
<td>Suspension Systems</td>
<td>8,321</td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>Pollution Control</td>
<td>8,180</td>
<td>13%</td>
<td>n.a</td>
</tr>
<tr>
<td>Security Systems</td>
<td>7,096</td>
<td>25%</td>
<td>54%</td>
</tr>
<tr>
<td>Engine Design and Systems</td>
<td>5,898</td>
<td>13%</td>
<td>24%</td>
</tr>
<tr>
<td>Braking Systems</td>
<td>5,441</td>
<td>28%</td>
<td>38%</td>
</tr>
<tr>
<td>Entertainment systems</td>
<td>3,495</td>
<td>28%</td>
<td>n.a</td>
</tr>
</tbody>
</table>

Source: Thomson Reuters
The leaders in alternative power patents during the 2006-2011 period identified in the study included Toyota, Honda, Denso (Japanese auto components manufacturer), General Motors and Panasonic. The leading position of Japanese companies in alternative power patents may be explained by their early and strong positioning in the electric vehicles global market. This is further supported by a cross-country trend comparison that showed that the non-EU companies have stronger relative specialisation on electric and hybrid car technologies (Aghion et al., 2012). In 2013 Bosch significantly strengthened its presence, ranking third after Toyota and Honda and far ahead any other EU OEM or supplier, but also markedly lower than Toyota.

Cooperation trends in the period 2002-2005 expressed by co-patenting investigated in the Sectoral Innovation Watch report on the automotive sector (2011), show that national cooperation is the most dominant form of cooperation and that OEMs are the most central in their networks compared to first tier suppliers. Nevertheless co-operations between OEMs, tier level suppliers and others have grown compared to earlier periods 1988-1991 and 1995-1998 creating a denser network, and international co-patenting has also increased primarily driven by Germany.

**Figure 56 - Top 10 assignees in alternative powered vehicles 2013**
A2.5.5. Strategic collaboration

Baseline: The innovation process in the automotive sector has shifted towards more integrated partnership with systems and component suppliers. According to CIS 499 data, 24% of automotive firms cooperate with suppliers, 19% with customers, 13% with universities and 8% with research institutions. Collaborations are therefore not a recent trend. First tier component suppliers and global mega suppliers increasingly coordinate the supplier and innovation networks, which entail the coordination of a network of other first tier suppliers and tier ‘n’ suppliers. OEMs on their end select first tier suppliers and try to retain influence in terms of project-organisation and development-expertise (Sectoral Innovation Watch – Automotive sector, 2011).

To put collaboration in the context of this study we look at EU vs. non-EU collaboration activities using Joint Ventures and Strategic Alliances (JVAs)100. Based on the available data on JVAs, during the period 1994-2014 (most recent data available in 08/214) EU OEMs and suppliers have participated in ca. 39% of all total (i.e. global) JVAs. In Europe the countries most active in JVAs are Germany with a significant distance from all the rest of EU countries (122 JVAs), France, Italy and the United Kingdom (see Figure 57). The most common countries with which these JVAs took place include China, the US, Japan, India and Russia (see Figure 57).

Figure 57 - Top EU countries engaged in JVAs (left) and top EU collaborators through JVAs (right)

Source: own elaboration based on Thomson One JVA data

Notes: JVAs have been sourced using Thomson Reuters’ SDC platinum database by querying for the following two SIC codes: Motor Vehicle Parts and Accessories & Motor Vehicles and Passenger Car Bodies. The data covers the period 1994-2014 (June).

99 The CIS 4 was implemented based on the reference year 2004.
100 Joint ventures and strategic alliances are agreements between businesses (or other organisations) to pursue a set of agreed upon objectives while remaining independent. Common objectives can be product developments, distribution channels, increasing manufacturing capability, project funding, capital equipment, knowledge, expertise, or intellectual property. Technology transfer constitutes often a part of joint ventures and strategic alliances.
With respect to collaborations of German stakeholders with non-EU stakeholders, we observe a shift towards more JVAs with Chinese stakeholders recording a growth of 25% between the periods 1994-2003 and 2004-2014. French stakeholders on the other hand have shifted towards more JVAs with Indian stakeholders, recording a growth of 83%. Italian stakeholders have substantially increased JVAs by ca. 600% with India and by 78% with China. UK stakeholders increased JVAs with China by 11%.

A2.5.6. Auxiliary baseline tables

### Table 49 - R&D investment in the motor vehicles sector

<table>
<thead>
<tr>
<th>Business &amp; R&amp;D expenditure (million €s)</th>
<th>% R&amp;D in turnover</th>
<th>% of R&amp;D in manufacturing total</th>
<th>% of country in total EU R&amp;D</th>
<th>R&amp;D investment /share of net sales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vehicles</td>
</tr>
<tr>
<td>EU -27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>40,240</td>
<td>4.5%</td>
<td>37%</td>
<td>74%</td>
</tr>
<tr>
<td>France</td>
<td>13,988</td>
<td>1.8%</td>
<td>12%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Italy</td>
<td>7,578</td>
<td>2.0%</td>
<td>14.1%</td>
<td>5.4%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6,958</td>
<td>2.3%</td>
<td>17.7%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Spain</td>
<td>3,346</td>
<td>11%</td>
<td>1.9%</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>353</td>
<td>6%</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>914</td>
<td>41%</td>
<td>1.9%</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Korea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Economisti Associati & CSES (2013)

### Table 50 - Share of innovative firms in motor vehicles and components sector

<table>
<thead>
<tr>
<th>Innovative enterprises</th>
<th>Product and process innovative enterprises only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing total</td>
<td>Manufacturing total</td>
</tr>
<tr>
<td>motor vehicles</td>
<td>motor vehicles</td>
</tr>
<tr>
<td>BE</td>
<td>67.9%</td>
</tr>
<tr>
<td>CZ</td>
<td>54.0%</td>
</tr>
<tr>
<td>DE</td>
<td>83.0%</td>
</tr>
<tr>
<td>ES</td>
<td>43.9%</td>
</tr>
<tr>
<td>FR</td>
<td>56.1%</td>
</tr>
<tr>
<td>IT</td>
<td>59.2%</td>
</tr>
<tr>
<td>HU</td>
<td>30.4%</td>
</tr>
<tr>
<td>NL</td>
<td>60.2%</td>
</tr>
<tr>
<td>PL</td>
<td>28.5%</td>
</tr>
<tr>
<td>PT</td>
<td>56.1%</td>
</tr>
<tr>
<td>RO</td>
<td>30.4%</td>
</tr>
<tr>
<td>SK</td>
<td>36.6%</td>
</tr>
<tr>
<td>SE</td>
<td>61.1%</td>
</tr>
<tr>
<td>UK</td>
<td>48.2%</td>
</tr>
</tbody>
</table>

Source: Eurostat, R&D and innovation statistics
A2.6 Overview of the fuel supply sector

A2.6.1. Overview of the fuel supply industry

The two main types of enterprises which will be affected in the fuel supply sector are filling stations and fuel refineries. In 2011 there were more than 70,000 enterprises classified as retail sale of automotive fuel in the EU-27, which comprise less than 10% of all enterprises in the wholesale and retail trade and repair of motor vehicles. These enterprises generated 203 billion euros in turnover, which resulted in 13.8 billion euros added value, again less than 10% of that of all enterprises in the motor vehicle trade and repair sector (Eurostat). The sector employed 400,000 people, 13% of the motor trades’ workforce.

Table 51 - Most innovative OEMs worldwide (Top 150), 2012

<table>
<thead>
<tr>
<th>World rank</th>
<th>Name</th>
<th>Country</th>
<th>R&amp;D</th>
<th>R&amp;D intensity</th>
<th>Sales</th>
<th>Capex</th>
<th>Capex int.</th>
<th>Profits</th>
<th>Profitability</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VOLKSWAGEN</td>
<td>Germany</td>
<td>9515</td>
<td>4.9</td>
<td>193000</td>
<td>10493</td>
<td>5.4</td>
<td>8333</td>
<td>4.3</td>
<td>525245</td>
</tr>
<tr>
<td>5</td>
<td>TOYOTA MOTOR</td>
<td>Japan</td>
<td>7071</td>
<td>3.7</td>
<td>193000</td>
<td>17288</td>
<td>8.9</td>
<td>11567</td>
<td>5.9</td>
<td>333498</td>
</tr>
<tr>
<td>11</td>
<td>DAIMLER</td>
<td>Germany</td>
<td>5639</td>
<td>4.9</td>
<td>114000</td>
<td>4837</td>
<td>4.2</td>
<td>9103</td>
<td>7.9</td>
<td>275087</td>
</tr>
<tr>
<td>12</td>
<td>GENERAL MOTORS</td>
<td>USA</td>
<td>5584</td>
<td>4.9</td>
<td>115000</td>
<td>6911</td>
<td>6</td>
<td>-23013</td>
<td>-20</td>
<td>213000</td>
</tr>
<tr>
<td>16</td>
<td>HONDA MOTOR</td>
<td>Japan</td>
<td>4906</td>
<td>5.6</td>
<td>86501</td>
<td>5490</td>
<td>6.1</td>
<td>4771</td>
<td>5.5</td>
<td>190338</td>
</tr>
<tr>
<td>23</td>
<td>FORD MOTOR</td>
<td>USA</td>
<td>4169</td>
<td>4.0</td>
<td>102000</td>
<td>4159</td>
<td>4.1</td>
<td>4768</td>
<td>4.7</td>
<td>171000</td>
</tr>
<tr>
<td>25</td>
<td>NISSAN MOTOR</td>
<td>Japan</td>
<td>4115</td>
<td>4.9</td>
<td>84326</td>
<td>10831</td>
<td>12.8</td>
<td>4477</td>
<td>5.3</td>
<td>160530</td>
</tr>
<tr>
<td>27</td>
<td>BMW</td>
<td>Germany</td>
<td>3952</td>
<td>5.1</td>
<td>76848</td>
<td>5236</td>
<td>6.8</td>
<td>8878</td>
<td>11.6</td>
<td>105876</td>
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<tr>
<td>34</td>
<td>FIAT</td>
<td>Italy</td>
<td>3295</td>
<td>3.9</td>
<td>83957</td>
<td>7534</td>
<td>8.9</td>
<td>3921</td>
<td>4.7</td>
<td>214836</td>
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<tr>
<td>48</td>
<td>PEUGEOT (PSA)</td>
<td>France</td>
<td>2481</td>
<td>4.5</td>
<td>55446</td>
<td>2279</td>
<td>4.1</td>
<td>-5087</td>
<td>-9.1</td>
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<td>58</td>
<td>RENAULT</td>
<td>France</td>
<td>1889</td>
<td>4.6</td>
<td>41270</td>
<td>2847</td>
<td>6.8</td>
<td>1028</td>
<td>2.5</td>
<td>127086</td>
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<tr>
<td>73</td>
<td>TATA MOTORS</td>
<td>India</td>
<td>1496</td>
<td>5.7</td>
<td>26149</td>
<td>1251</td>
<td>4.7</td>
<td>2391</td>
<td>9.1</td>
<td>62716</td>
</tr>
<tr>
<td>108</td>
<td>SUZUKI MOTOR</td>
<td>Japan</td>
<td>1044</td>
<td>4.6</td>
<td>22578</td>
<td>1436</td>
<td>6.3</td>
<td>1262</td>
<td>5.6</td>
<td>55948</td>
</tr>
<tr>
<td>119</td>
<td>HYUNDAI MOTOR</td>
<td>South Korea</td>
<td>934</td>
<td>1.6</td>
<td>59799</td>
<td>2689</td>
<td>4.5</td>
<td>5973</td>
<td>9.9</td>
<td>n.a.</td>
</tr>
<tr>
<td>143</td>
<td>MAZDA MOTOR</td>
<td>Japan</td>
<td>788</td>
<td>4</td>
<td>19312</td>
<td>612</td>
<td>3.1</td>
<td>448</td>
<td>2.3</td>
<td>37745</td>
</tr>
</tbody>
</table>

Source: own elaboration on 2013 EU industrial R&D Scoreboard
The evolution of filling stations in Europe shows that the number of stations has slowly declined over time (from 137,000 to 135,500), with each individual station dispensing on average more fuel in 2012 than in 2005 (3 million litres per site against 2.8 million litres in 2005).\(^{101}\)

The petroleum refining sector is likely to undergo significant change in the future. According to consultancy AT Kearney consultancy, over the next 10 years, operators at one in every three refineries in North America and Western Europe will need to reconsider their operating models and how they are integrated across the value chain.\(^{102}\) They project that the current trend of refinery closings will continue, with one in five refining assets being squeezed out of the market over the next five years in North America and Europe.

Similarly, a Lukoil report suggests that after a golden age between 2004 and 2008, the global financial crisis of 2008 left the European oil refining industry in a significantly changed environment. They point out that overcoming the European oil refining crisis will require shutting down an additional 1-1.5 mb/d of refining capacities in the region.\(^{103}\)

The distribution and density of filling stations across the EU varies from country to country. Italy has by far the most filling stations (around 22,500) followed by Germany with less than 15,000. A major trend in Europe has been the increasing importance of filling stations operated by supermarket chains, which has reduced the attractiveness of independent and oil company sites within the geographical sphere of influence of a supermarket forecourt. For stations operated by supermarket chains, “the performance of forecourt stores and other profit streams are increasingly important in order to keep them operating viably.”\(^{101}\)

CBRE researchers note that major oil companies (ExxonMobil, Shell, BP, Total and Chevron) now own just a third of Europe’s filling stations and instead the largest oil companies now place greater emphasis on upstream activities, namely exploration and production. For instance, Shell announced the potential divestment of its Italian service station portfolio and Esso recently sold 45 sites in the UK to Euro Garages.

According to CBRE research, independent fuel retailers, most of whom are SMEs, now own 20%, of all filling stations across Europe, compared to 16% in 2007. Across the same period major oil companies’ market shares decreased from 43% in 2007 to 32% today. Independent fuel retailers have the strongest foothold in Bulgaria, where they account for almost two thirds of filling stations at 64%. In Czech Republic the figure is 56%, and over a third of filling stations have been acquired by independents in Hungary, Belgium, Poland and Romania. Major oil companies retain a stronger presence in Europe’s more mature fuel markets including Denmark and France where just 6% and 13% of filling stations are owned by independents.


\(^{102}\) http://www.atkearney.co.uk/paper/-/asset_publisher/dVxv4Hz2h8bS/content/refining-2021-who-will-be-in-the-game/-10192

One aspect that is not reflected in the above statistics is the increasing importance of unmanned service stations in Europe, which has reached 7.7% of all service stations across the continent in 2011. Verdict research forecasts that by 2013 there will be 10,616 unmanned sites in Europe; a further upsurge of 3.7%. Countries with an increasing unmanned site count include Austria, Belgium, Denmark, France, Italy and Switzerland\textsuperscript{101}. According to Eurostat, wage-adjusted labour productivity for the automotive fuel retail sector was of 169% in 2011 compared to 133% in the overall motor vehicle sector. Oil price changes need to be taken into account when looking at these figures, as they directly affect revenues and thus labour productivity statistics.

Stripping out the impact of prices on the retail value of fuel, the figure below shows the evolution in EU demand for road fuel (by volume) and the mix between petrol and diesel. While demand for diesel fuel has increased steadily from 150 to 220 million tonnes per year between 2000 and 2013 (with a short plateau during the height of the financial crisis), petrol demand has been dropping from about 130 to just below 90 million tonnes per year.

On a country by country basis, there are significant differences both in terms of the overall fuel demand as well as the mix between different types of fuel (petrol / diesel). Despite diesel being the overwhelming source of road fuel in France, the majority of road fuel sold in Greece is petrol. In every other EU country diesel

\textsuperscript{104} Source: National Oil Industry association and FuelsEurope
represents the largest share of fuel demand; however the ratio varies among Member States, confirming that national markets for vehicles are dissimilar in terms of demand and preferences.

**Figure 60 - Road Fuel Demand in the EU in 2013**

Apart from filling stations retailing fuel, the other large sector in the fuel supply chain consists of refineries and fuel processing. According to Eurostat, in 2006 there were around 1,013 enterprises classified as concerned with manufacture of refined petroleum products in the EU 27. According to FuelsEurope there were 82 mainstream refineries in the EU in 2013 (plus 4 in Switzerland and Norway). Germany (11), Italy (11), Spain (9), France (8) and the UK (7) together accounted for almost 60% of the total. The manufacture of coke and refined petroleum products is one of the few manufacturing subsectors that are dominated by large enterprises.

Turnover in 2010 (latest available) was estimated to be around 497 billion euros with around 23 billion euros of value added. According to Eurostat, more than four fifths of EU-27 value added in the sector came from enterprises with at least 250 persons employed. Average personnel costs within the EU-27’s coke and refined petroleum product manufacturing sector are high, at 69.5 thousand euros per employee in 2010 compared to 35.8 thousand euros per employee for manufacturing as a whole. Over 121,000 people were employed in the sector with a wage adjusted labour productivity of 261% in 2010 (latest figures) significantly higher than in 2009 (170%) and 2008 (200%).

**A2.6.2. Competition of fuel producers on the EU market**

As can be seen from Figure 61 and Figure 62 the EU is a net importer of diesel and a net exporter of petrol. Diesel is mainly imported from the US and Russia. This situation is not so much a result of (price) competition between EU and non-EU fuel suppliers on the EU market, but is rather caused by the high share of diesel vehicles in the European LDV fleet, leading to a mismatch between the demand for petrol and diesel and the optimal production ratios of these fuels for European refineries. Oil companies need to strike a

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105 Source: WoodMacKenzie and FuelEurope
balance between optimising the operation of EU refineries and meeting the demands of the market. As a result of this there is competition between diesel from EU and non-EU refineries on the EU market.

Figure 61 – Major petrol and diesel trade flows to and from the EU in 2012 (source: https://www.fuelseurope.eu/dataroom based on Eurostat)

Figure 62 – EU trade balance for petrol and diesel (source: https://www.fuelseurope.eu/dataroom based on Eurostat)

According to FuelsEurope, in the near future EU refineries will see increasing competition from new, large refineries coming online in China, India and the Middle East. With domestic demand for high-quality fuels in these countries still low, these refiners are expected to turn to the EU to export their products. FuelsEurope states that upstream integration and cheap power supply, together with low labour costs, economies of scale
(due to the large size of many new facilities) and tax incentives will provide these refineries with a competitive edge over their European counterparts. While the local markets for these non-EU refineries continue to grow to a level where they can sufficiently absorb production, exports from Indian and Middle Eastern refineries are thus expected to at least temporarily add competitive pressure to the EU refinery system. A counteracting trend could be that fuel demand in China grows faster than its refining capacity, which makes Chinese companies look overseas for new refining opportunities, mostly to import back into China.

A2.6.3. R&D and innovation
Looking at innovation and R&D, the 2014 European competitiveness report points out that the coke and refined petroleum product sector is characterised by a high proportion of tertiary-educated employees (second highest manufacturing sector after pharmaceutical products and preparations). This also corresponds to Eurostat’s aggregations of knowledge-intensive activities. In addition the report finds that this sector (together with motor vehicles) features high investment ratios (37.8% in 2012 compared to a cross-industry average of 21.0%) which reflect a high proportion of capital-intensive firms.

While the R&D intensity of the coke and refined petroleum sector in Europe is low (2%) in comparison with other sectors, including motor vehicles (18%), the EU’s performance in this regard is better than that of the US in the same sector. At the same time, given the very low R&D intensity of this sector the 2014 European competitiveness report notes that “any differences between the EU and the US in R&D spending in such sectors are less important than other factors, such as differences in unit costs or productivity.”

A2.6.4. Trends in fuel demand

**Trends based on adopted policies and measures**
In the past, final EU energy demand in the transport sector has grown in line with the transport activity. However, the EU Reference Scenario shows that in the future fuel efficiency improvements driven by legislation adopted by the first half of 2012 are foreseen to stabilise energy demand by 2050, despite the projected upward trends in freight and passenger transport activities.

The most relevant driver of the reduction of average energy demand is policy, in particular at present for cars and LCVs. Regarding passenger road transport, the energy efficiency of vehicles is expected to improve by 21% by 2020 and 35% by 2030 with respect to 2005, leading to a decline in energy demand by 2030 and to stabilisation in the following two decades. The structure of passenger cars fleet in terms of engine and the trends in energy consumption are foreseen to experience:

- In the short-medium term a progressive reduction of the share of petrol, prolonging the trend of the last years;

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108 European competitiveness report, 2014

In the long term, the progressive erosion of diesel engine shares in favour of hybrid, plug-in electric and BEV.

**Figure 63 - Trends in transport activity and energy demand**

![Trends in transport activity and energy demand](image)

**Figure 64 - Structure of all passenger cars fleet and fuel consumption**

![Structure of all passenger cars fleet and fuel consumption](image)

Expected trends based on future policies

In order to keep climate change below 2°C, in 2011 the European Council reconfirmed the EU objective of reducing greenhouse gas emissions by 80-95% by 2050 vis-à-vis 1990 levels, in the context of necessary actions according to the Intergovernmental Panel on Climate Change by developed countries.

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110 ibid.
In particular, the Communication “A Roadmap for moving to a competitive low carbon economy in 2050”\textsuperscript{112} presents a Roadmap for possible action up to 2050 which could enable the EU to deliver greenhouse gas reductions in line with the agreed 80 to 95% target.

As an effect of the actions considered in the Roadmap, by 2050 the EU’s total primary energy consumption could be about 30% below 2005 levels:
- More domestic energy resources would be used, in particular renewables;
- Imports of oil and gas would decline by 50% compared to 2011.

Focusing on the transport sector, the Communication highlights that in 2005 greenhouse gas emissions increased by 30% in 2005 vis-à-vis 1990 levels (with transport being the only sector among those considered showing an increase). Upcoming measures are foreseen to bring emissions back to 1990 levels by 2030 (emission change will range from +20% to -9% compared to 1990 levels) and to bring marked reductions by 2050 (-54% to -67%).

A2.6.5. Fuel prices

Road transport energy consumption represents about 89% of total transport energy consumption, relying mostly on oil. In the past years, standards for fuel economy and vehicle CO\textsubscript{2} emissions have led OEMs to progressively reduce the amount of fuel required by vehicles per km driven. The extent to which these improvements are achieved by individual OEMs has an impact on their competitiveness, since it increases the value of their products for end users by reducing the Total Cost of Ownership (TCO) of the vehicle.

The significance of the impact on TCO depends on fuel price. In this regard the EU market offers very relevant opportunities due to the high fuel prices. May 2014 data suggest that, on average, unleaded 95 retail prices are in the range of 1.5 €/litre, diesel prices around 1.4 €/litre and LPG 0.75 €/litre, as shown in the table below.

These prices are significantly higher than those in most of the other major LDV markets, with EU retail prices being twice the US prices and significantly higher than the Chinese and Japanese ones. The figure below provides a visualisation of the price level difference among a subset of EU Member States and a selection of major international markets and trade partners, measured in the last year.

Fuel prices have slightly increased in recent years and dropped significantly in the last quarter of 2014. Figure 66 shows fuel price trends in Europe since 2005.

Notwithstanding the impact of price drops in the last quarter of 2014, since 2005 fuel costs have progressively become more important over time. The purchase price of cars has steadily reduced compared to average consumer prices. Over the same period the cost of fuel, which is covered under the operation of personal transport equipment, has increased (see Figure 67).

\textsuperscript{112} Brussels, 25.5.2011 COM(2011) 112 final/2
As a conclusion, medium-term fuel prices levels (assuming that existing differences will remain similar over time) suggest that improvements in the fuel efficiency of vehicles resulting from compliance with increasingly stringent targets will have a stronger impact on TCO for EU end-users than for users of similar vehicles in other regions. This effect will be further amplified in case post-2020 CO₂ targets set for the EU will be more ambitious than the ones that will be adopted in non-EU countries.

Table 52 - Fuel prices in the EU\textsuperscript{113}

<table>
<thead>
<tr>
<th>Member State</th>
<th>Unleaded 95</th>
<th>Diesel</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>€ 1.37</td>
<td>€ 1.30</td>
<td>€ 0.80</td>
</tr>
<tr>
<td>Belgium</td>
<td>€ 1.65</td>
<td>€ 1.44</td>
<td>€ 0.60</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>€ 1.28</td>
<td>€ 1.30</td>
<td>€ 0.60</td>
</tr>
<tr>
<td>Croatia</td>
<td>€ 1.41</td>
<td>€ 1.31</td>
<td>€ 0.75</td>
</tr>
<tr>
<td>Cyprus</td>
<td>€ 1.44</td>
<td>€ 1.43</td>
<td>-</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>€ 1.31</td>
<td>€ 1.32</td>
<td>€ 0.64</td>
</tr>
<tr>
<td>Denmark</td>
<td>€ 1.74</td>
<td>€ 1.53</td>
<td>€ 1.20</td>
</tr>
<tr>
<td>Estonia</td>
<td>€ 1.30</td>
<td>€ 1.28</td>
<td>€ 0.63</td>
</tr>
<tr>
<td>Finland</td>
<td>€ 1.63</td>
<td>€ 1.50</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>€ 1.52</td>
<td>€ 1.30</td>
<td>€ 0.86</td>
</tr>
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<td>Germany</td>
<td>€ 1.64</td>
<td>€ 1.43</td>
<td>€ 0.73</td>
</tr>
<tr>
<td>Greece</td>
<td>€ 1.61</td>
<td>€ 1.29</td>
<td>€ 0.88</td>
</tr>
<tr>
<td>Hungary</td>
<td>€ 1.37</td>
<td>€ 1.39</td>
<td>€ 0.81</td>
</tr>
<tr>
<td>Ireland</td>
<td>€ 1.55</td>
<td>€ 1.47</td>
<td>€ 0.78</td>
</tr>
<tr>
<td>Italy</td>
<td>€ 1.79</td>
<td>€ 1.67</td>
<td>€ 0.73</td>
</tr>
<tr>
<td>Latvia</td>
<td>€ 1.29</td>
<td>€ 1.26</td>
<td>€ 0.52</td>
</tr>
<tr>
<td>Lithuania</td>
<td>€ 1.31</td>
<td>€ 1.27</td>
<td>€ 0.64</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>€ 1.33</td>
<td>€ 1.19</td>
<td>€ 0.55</td>
</tr>
<tr>
<td>Malta</td>
<td>€ 1.44</td>
<td>€ 1.36</td>
<td>-</td>
</tr>
<tr>
<td>Netherlands</td>
<td>€ 1.82</td>
<td>€ 1.50</td>
<td>€ 0.87</td>
</tr>
<tr>
<td>Poland</td>
<td>€ 1.23</td>
<td>€ 1.21</td>
<td>€ 0.53</td>
</tr>
<tr>
<td>Portugal</td>
<td>€ 1.64</td>
<td>€ 1.40</td>
<td>€ 0.85</td>
</tr>
<tr>
<td>Romania</td>
<td>€ 1.41</td>
<td>€ 1.42</td>
<td>€ 0.70</td>
</tr>
<tr>
<td>Slovakia</td>
<td>€ 1.48</td>
<td>€ 1.36</td>
<td>€ 0.71</td>
</tr>
<tr>
<td>Slovenia</td>
<td>€ 1.48</td>
<td>€ 1.38</td>
<td>€ 0.75</td>
</tr>
<tr>
<td>Spain</td>
<td>€ 1.42</td>
<td>€ 1.34</td>
<td>€ 0.75</td>
</tr>
<tr>
<td>Sweden</td>
<td>€ 1.58</td>
<td>€ 1.54</td>
<td>€ 1.00</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>€ 1.61</td>
<td>€ 1.68</td>
<td>€ 0.88</td>
</tr>
<tr>
<td><strong>EU Average</strong></td>
<td><strong>€ 1.49</strong></td>
<td><strong>€ 1.39</strong></td>
<td><strong>€ 0.75</strong></td>
</tr>
</tbody>
</table>

\textsuperscript{113} Source: http://www.fuel-prices-europe.info, May 2014
Figure 65 - Fuel prices in the world\textsuperscript{114}

Unleaded gas prices, Liter, Euro

Diesel prices, Liter, Euro

Figure 66 - Fuel price trends (EU average), 2000-2014\textsuperscript{115}

\begin{itemize}
\item Source: \url{http://www.globalpetrolprices.com}
\item Source: oil bulletin prices history provided by Directorate-General Energy (DG-ENER).
\end{itemize}
A2.7 Overview of professional end users
It is possible to highlight many different categories of professional end users of vehicles, which could be indirectly impacted by CO\(_2\) and more generally by environmental legislation. Focusing on professional end users of cars, these include:

- **Rental companies and leasing companies**, although the latter can be considered intermediates for the real end-users;
- **Passenger transport services**, among which taxis represent the most relevant category;
- **Other categories**, such as companies operating large fleets of passenger cars for various professional services.

Professional users of LCVs include the following categories:

- **Postal and courier delivery companies**, using LCVs for picking orders and last mile deliveries;
- **A wide range of other companies**, including large companies operating (large) fleets of LCVs for retail distribution activities various professional services, SMEs using single LCVs or small fleets as well as Goods transport services.

Most of end users compete locally using the same type of vehicles, even if they are global players. The latter is the case of postal and courier delivery services and multinational companies using LCVs for the distribution of goods to retail stores. However, the net effect of their operating costs has an impact on the cost of doing business in the economy and therefore on overall EU competitiveness.

A2.7.1. Professional end users of cars

**Rental and leasing companies**

Vehicle leasing is the provision of a motor vehicle for a client to use for a fixed period of time, at an agreed amount of money for the lease. Dealers offer leasing solutions as an alternative to vehicle purchase. It is also used by companies to acquire vehicles without causing “peaks” in cash flows. Vehicle rental companies rent cars (or vans) for short periods of time (usually up to a maximum of few weeks). Major rental companies

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116 Source: EEA TERM report (2013). Real change in passenger transport prices, relative to average consumer prices based on the United Nations (UN) Classification of individual consumption by purpose (COICOP). Passenger transport by road includes exclusively transport of individuals and groups of persons and luggage by bus, coach, taxi and hired car with driver.
such as Europcar, Avis and Hertz are organised in local branches located in transport nodes (e.g. airports, stations but also busy city areas, which enable clients to pick vehicles easily and also to return them to different locations. Local branches are complemented by online reservation systems.

According to Eurostat, there are around 35,000 companies active in the renting and leasing of motor vehicles, generating a total turnover of more than 65 EUR billion. The United Kingdom is the largest market (14 EUR billion), followed by France (11.5), Germany (8.5), the Netherlands (6.5) and Italy (5.5). The sector employs some 160,000 people, with around 24% of them located in the United Kingdom, 16% in Germany and 11% in France.

Despite the large number of companies, the European market is quite concentrated. Three large multinational companies control around 61% of the overall market. With almost 30% of the companies located in France, the country is the leader in terms of number of enterprises. Yet, it employs less people than the United Kingdom and Germany, showing that the concentration of the market is different across Member States. The main industry indicators are summarised in the tables below.

**Figure 68 - Key industry indicators for selected countries, 2009-2011**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Number of enterprises</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 27</td>
<td>31,855</td>
<td>33,691</td>
</tr>
<tr>
<td>Germany</td>
<td>4,136</td>
<td>4,055</td>
</tr>
<tr>
<td>Spain</td>
<td>2,986</td>
<td>2,555</td>
</tr>
<tr>
<td>France</td>
<td>6,910</td>
<td>8,128</td>
</tr>
<tr>
<td>Italy</td>
<td>2,250</td>
<td>2,394</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3,710</td>
<td>3,685</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countries</th>
<th>Turnover</th>
<th>Turnover per person employed</th>
<th>Personnel costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 27</td>
<td>59,000</td>
<td>59,900</td>
<td>63,247</td>
</tr>
<tr>
<td>Germany</td>
<td>8,487</td>
<td>7,525</td>
<td>7,684</td>
</tr>
<tr>
<td>Spain</td>
<td>4,489</td>
<td>4,649</td>
<td>4,444</td>
</tr>
<tr>
<td>France</td>
<td>10,546</td>
<td>11,132</td>
<td>10,454</td>
</tr>
<tr>
<td>Italy</td>
<td>5,741</td>
<td>6,142</td>
<td>5,196</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10,682</td>
<td>10,857</td>
<td>14,242</td>
</tr>
</tbody>
</table>

Source: own elaboration on Eurostat data

Around 30% of new vehicle registrations in Europe are done by leasing companies. Data from Lease Europe show that in 2009 approximately 5.5 million new vehicle registrations were for lease (4.79 million cars) and short term car rentals (704 thousand cars). In 2012 the European leasing industry registered 5.8 million new leases while the overall fleet consists of more than fifteen million vehicles. Due to the typical duration of leasing contracts (around 4 years), leasing plays an important role in the renewal of the car fleet.

**Passenger transport services (taxi)**

Eurostat data indicates that more than 400,000 people are employed in taxi operation, whereas according to IRU data, the European taxi industry employs more than one million people, representing 8% of employment.
in the European transport sector\textsuperscript{117}. Taxis complement other public transport modes, in particular in urban areas but also in suburban and rural ones thanks to their flexibility and availability.

Thanks to the particular usage conditions (namely urban transport, in areas with high availability of different types) fuel infrastructures, taxis are early adopters of green technologies, in particular when fiscal, administrative and operational incentives are available for environmentally friendly innovations.

A2.7.2. Professional end users of light commercial vehicles

Postal and courier delivery companies

Postal services gather, manage and deliver correspondence in a given territory, usually national. Each country has its own postal system, whereas national systems are coordinated with each other so as to enable deliveries globally. Parcel delivery can be distinguished from ordinary mail services by a series of added value features, including delivery speed, security, tracking, customisation, etc. Large couriers operating in Europe include DHL, FedEx, TNT, UPS, etc., which offer services worldwide through hub and spoke models with different levels of aggregation. According to Eurostat data, the postal and courier delivery sector includes 52,000 companies in the EU. Total turnover in 2012 was 110 billion euros, employees summed up to more than 1.8 million.

Postal and in particular express delivery companies use LCVs and other motor for ‘last mile’ deliveries in local areas. Even though data is not available at EU level, the express delivery industry worldwide operates and owns more than 200,000 trucks and delivery vehicles\textsuperscript{118}. Large individual companies publish statistics online - UPS declares that its delivery fleet includes 8,800 vehicles, including package cars, vans, tractors and motorcycles.

A2.8 Automotive industry: market projections to 2020 and beyond

The changes that will interest the automotive industry are not confined to a single geographical area. Distinctions between mature and emerging markets will remain but will become more subtle as the latter establish themselves as the engines of growth. These trends will also push to rethink the label “emerging” since the numbers reveal that it would be rather appropriate to define such markets as “establishing” (the stage between emerging and established). The interaction of two key forces underlies the growth predicted for the emerging markets (e.g. Brazil, China, India and Russia). These are the liberalisation of industrial and market regulatory policies and the increasing ability of large and underserved populations to purchase vehicles.

To serve these markets, characterised by younger populations, economic growth and low vehicle penetration, OEMs are already setting up local production and tailoring vehicles to the needs of local consumers. This opportunity could push aggregate sales to more than 1 billion light vehicles worldwide over a ten year period (2010-2020).

\textsuperscript{117} Source: International Road Transport Union
\textsuperscript{118} Oxford Economics Report - The Economic Impact of Express Carriers in Europe
According to LMC Automotive, in 2020 global light vehicle sales will reach approximately 117 million units annually, against the current level of around 70 million. Most of this growth will stem from emerging markets, above all Asia-Pacific followed by Eastern Europe and Latin America. By 2020 Asia-Pacific could account for almost half of global light-vehicle sales. McKinsey predicts the global share of sales of established markets will decline from 50% in 2012 to 40% in 2020 and are predicted to account for only 25% of future volume growth. Both KPMG and LMC predict that China will be the major automotive market, accounting for almost one-third of annual new vehicle sales globally followed by North America and Western Europe. India will enjoy an important sales growth (11% CAGR) while Iran will account for the largest portion of sales coming from the rest of the world with 1.8 million vehicles sold in 2020.

Chinese and Indian OEMs are in a favoured position compared to OEMs from other emerging countries. Despite the acquisitions of Jaguar Land Rover by India’s Tata Motors and Volvo by the Chinese Geely, the demarcation between established and establishing OEMs will remain clear up to 2020. Establishing OEMs will still play a minor role in established markets achieving less than a 2% market share by 2020.\(^{119}\)

The regulatory changes that have been implemented in Brazil, China, India and Russia will benefit the auto markets of such countries. These changes have attracted significant foreign direct investments and helped the development of export industries, which provide foreign currency reserves to help financial growth.

<table>
<thead>
<tr>
<th>Country</th>
<th>Light-vehicle sales in 2013 (in millions)</th>
<th>Light-vehicle sales in 2020 (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>21.5</td>
<td>34.6</td>
</tr>
<tr>
<td>United States</td>
<td>15.4</td>
<td>17.4</td>
</tr>
<tr>
<td>Japan</td>
<td>5.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.7</td>
<td>5.4</td>
</tr>
<tr>
<td>India</td>
<td>3.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Germany</td>
<td>3.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Russia</td>
<td>2.8</td>
<td>3.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: own elaboration on LMC Automotive data

One major growth opportunity is in smaller vehicles which already account for 30% of global sales and could reach 30 million units in 2020. More than 60% of this market is located in emerging economies, where sales are expected to grow by an annual 5-6% rate until 2020. Success in this key segment requires a low-cost business model characterised by a limited number of body types based on a single platform and a limited offer range. Modularity will thus become a fundamental success driver as most automakers are stretching their product lines, mainly through derivatives – products derived from standard models – to satisfy customer needs with respect to e.g. performance, style and uniqueness. Running more derivatives per platform creates complexity. To manage complexity while controlling costs and ensuring sufficient differentiation, OEMs will increasingly develop new global platform strategies including modular concepts. It is not excluded

\(^{119}\) KPMG (2013). Global automotive retail market
that strategic alliances between competitors will represent a viable alternative to in-house development. One recent example is the alliance between PSA and General Motors where the two OEMs will share the same platform for building future generations of their small cars. However, the most significant evidence of this trend is Volkswagen’s modular unit through which it plans to build 4 million vehicles along forty different models using one single platform called MQB. According to company sources, Volkswagen’s MQB platform will provide several benefits such as a reduction in production time by 30% and a reduction of parts and engineering costs by 20%\textsuperscript{120}.

In terms of production, although the triad (United States, Europe, and Japan) will no longer represent the centre of growth, three out of four vehicles sold globally in 2020 will still be made by established OEMs from these regions. The other fourth will be produced by an establishing OEM. As production of light vehicles is anticipated to increase, it is plausible that OEMs will expand their presence in regions where production costs are lower and demand is rising. Asia-Pacific, Eastern Europe and South America will lead this trend. The cost of labour in establishing markets will continue to be lower than that in the developed world, although the gap is expected to decrease over time.

![Figure 69 - Light vehicle production forecast (millions of units)](image)

The data also support the contention that automakers will increasingly prefer building production facilities near the markets where the demand for new cars will be higher. For example, China and South America will represent more than 50% of the growth in global light vehicle production\textsuperscript{121}. We use Bartlett and Ghoshal’s (1989) model as a starting point to propose that automotive production will move from the current local-for-global model to a local-for-local model which is more apt to increase efficiency and customise offerings to meet local taste\textsuperscript{122}. As noted in previous sections, this trend is already ongoing but it is expected to be much more evident in the near future.

\textsuperscript{120} [http://www.autoweek.com/article/20120412/CARNEWS/120419955](http://www.autoweek.com/article/20120412/CARNEWS/120419955)
\textsuperscript{121} CSM Worldwide (2009). CSM global light weight production summary, [http://automotiveforecasting.com](http://automotiveforecasting.com)
Table 54 - Global light vehicle production forecast\textsuperscript{123}

<table>
<thead>
<tr>
<th>Country</th>
<th>2013 (in millions)</th>
<th>2013 (share of total)</th>
<th>2020 (in millions)</th>
<th>2020 (share of total)</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia-Pacific</td>
<td>21.5</td>
<td>36%</td>
<td>34.6</td>
<td>42%</td>
<td>48</td>
</tr>
<tr>
<td>North America</td>
<td>15.4</td>
<td>26%</td>
<td>17.4</td>
<td>21%</td>
<td>16</td>
</tr>
<tr>
<td>Western Europe</td>
<td>11.9</td>
<td>20%</td>
<td>14.1</td>
<td>17%</td>
<td>18</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>6.8</td>
<td>11%</td>
<td>10.1</td>
<td>12%</td>
<td>48</td>
</tr>
<tr>
<td>South America</td>
<td>4.5</td>
<td>7%</td>
<td>6.5</td>
<td>8%</td>
<td>44</td>
</tr>
</tbody>
</table>

The link between economic growth and attention to the environment will become stronger as efficient mass production of modern vehicles might be among the most challenging manufacturing pursuits in the future. CO\textsubscript{2} regulation is likely to continue to tighten not solely in Europe as legal initiatives to reduce emissions have already been put in place in countries such as the US, Japan and China. OEMs will face additional manufacturing costs to comply with regulation, as described in detail in Chapter 4.

In Europe, the 2020 target is expected to be largely achieved by applying advanced technologies to conventional vehicles. Some OEMs argue it is necessary or beneficial to achieve part of the reduction through increased electrification. This will act as an incentive for OEMs to invest more in e-mobility, meaning electrical/hybrid powertrains, including batteries, as well as in lightweight and aerodynamic drag-reducing technologies. Electric vehicles (EVs) may be promising in the long term but will not achieve a major market penetration in the next six years. Internal combustion engines (ICEs) that burn petrol, diesel, or another combustible fuel accounted for 97\% of the passenger vehicles sold worldwide in 2013 while the remaining 3\% had alternative configurations (hybrid powertrain or full battery electric motor). This ratio will not change significantly in 2020 when LMC estimate that ICEs will account for about 95\% of sales whereas McKinsey estimate 90\% for traditional ICEs. Deloitte is very optimistic, stating that by 2020 electric vehicles and other

\textsuperscript{123} Source: own elaboration on LMC Automotive data

\textsuperscript{124} A broad definition of electrification is considered in the chart, including also hybridization
“green” cars will represent up to a third of total global sales in developed markets and up to 20% in urban areas of emerging markets.\textsuperscript{125}

Tackling environmental pollution is a theme that is strongly related to innovation and research and development (R&D). Alternative power will see continuous innovation even beyond 2020. For instance, lithium-ion technology will see considerable investment and growth. Micro, mild and full hybridisation is already undergoing extensive development and will continue to do so. A majority of the new vehicles in 2020 are expected to have some level of hybridisation.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure71}
\caption{Level of innovation in various aspects of the vehicle by 2020}
\end{figure}

Source: IBM Automotive 2020 global study

At the same time, the vehicle of 2020 will be characterised by several significant developments that will make it remarkably different from today. Innovation will be mostly concentrated on software, electrical systems, electronics, engine and auxiliary systems, and powertrain.

In 2012, the world’s top 17 OEMs spent more than 50 billion euros on R&D. It is likely that the automotive industry exceeds 100 billion euros in this area. This spending trend will continue as OEMs need to develop more efficient internal combustion engines in parallel with electromobility. On average, R&D accounts for 4-5% of OEMs’ total costs. According to some industry experts, it is possible that it will increase in the next years.\textsuperscript{126}

Another important aspect of car innovation is related to telematics and infotainment. Vehicles are being equipped with danger-warning applications, traffic information services as well as infotainment features. The number of networked cars will rise by 30% every year and by 2020 one out of five cars will be connected to the internet. Approximately half of these cars will be in the premium segment.

\textsuperscript{126} E.g. Oliver Wyman (2013). Automotive manager.
As OEMs are switching progressively to a local-for-local production model, it is expected that **suppliers** will also follow. In regions such as Asia, where production volumes are expected to rise to meet 70% of demand, it will be crucial to build a local supplier base. This requires the design of an enhanced supply chain as well as the full exploitation of supplier capacities. Another particular aspect in which the relationship between suppliers and OEMs is expected to be essential is the challenge of low carbon mobility. OEMs will need and depend on suppliers to manage the long-term transition from ICEs to EVs for both technology and logistics.

The maturity of the automotive **retail market** will be influenced by a variety of specific features and macroeconomic conditions such as new car demand, first car versus replacement car demand, used car demand, the used/new car sales ratio, car park density and income levels. By 2020, none of the establishing markets such as China, Brazil, and India will have reached a state of maturity that is comparable to current levels in North America, Western Europe and Japan. As auto mobility will undergo significant changes, established markets where demand is more mature, are expected to be in a “hard selling” period. This will lead to a consolidation and centralisation of the retail network. The centralisation process will not necessarily lead to fewer point-of-sale locations but will probably lead to fewer retail network owners (i.e. grid managers) managing the retail grid. In establishing markets, where vehicle penetration is still low, a rise in demand will lead to an “easy selling” period characterised by strong new car demand, leading to the development of a large and decentralised retail network structure.

Another major challenge dealers will need to face stems from the incredible amount of information on the web available to car buyers. The volume and breath of the material available through the internet is going to increase dramatically until 2020. In 2007, a potential car buyer would visit a dealer an average of five times before purchasing a car, whereas nowadays she/he is already well-informed since the first time she/he visits the point of sale, leaving the dealer fewer chances to turn the browser into a buyer. Embracing this challenge...
will require innovative retail strategies that may feature brand experience centres with high-tech digital, personalised visualisation tools or “pop-up” stores that advertise a specific product to create buzz.\textsuperscript{127}

A2.8.1. Business models in 2020

A recent study conducted by Arthur D. Little highlights the need for business model redesign in the automotive industry.\textsuperscript{128} The study reveals how the current and established business models may not be sustainable in light of the major trends shown previously. The models proposed are based on two variables. The first is the range of services which describes the scope of services that are directly linked to mobility (e.g. parking guidance systems) or otherwise overarching services which the customer can use during the actual mobility time (e.g. online shopping). The second variable is the link between product and mobility which ranges from physical ownership of a car to rejection of ownership in favour of alternative forms such as car-sharing. The table below provides an overview and synthesis of the four business model archetypes.

<table>
<thead>
<tr>
<th>Product Focused Manufacturer (PFM)</th>
<th>Service Focused Manufacturer (SFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This business model is the closest to today’s traditional OEMs</td>
<td>This business model provides mobility in the same way as the PFM through strong attachment to the automobile</td>
</tr>
<tr>
<td>Technological excellence, core competence in product and manufacturing technology</td>
<td>Moderate technology dominance, outsourcing of areas beyond their strategic competence</td>
</tr>
<tr>
<td>Main income stream primarily derived from selling physical products</td>
<td>Service portfolio with comprehensive offering around the core product that allows generating revenue opportunities across the product lifecycle</td>
</tr>
<tr>
<td>Premium vendors (e.g. Porsche) or volume manufacturers with leading market position, sufficient margins and optimal cost position (e.g. Tata)</td>
<td>Unique selling proposition through design and individuality</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic Mobility Provider (BMP)</th>
<th>Mobility Service Provider (MSP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This business model uncouples mobility from car ownership</td>
<td>This business model dissolves completely the link between car and mobility</td>
</tr>
<tr>
<td>The focus moves from the product (automobile) to the need (transport). Practicability and cost efficiency are of key relevance.</td>
<td>The core competence is the successful mastery and operation of complex customer relationships by integrating a cooperation network</td>
</tr>
<tr>
<td>The auto mobility share is covered by a standard car (no frills), while other mobility building blocks can be handled using public and non-individual means of transport</td>
<td>Similar to the SFM, the MSP offers a range of services that go beyond vehicle acquisition (e.g. online commerce, parking services)</td>
</tr>
<tr>
<td>Pay-by-use approach (e.g. Car2go)</td>
<td>Comfort, luxury and status are substituted by sustainable convenience</td>
</tr>
</tbody>
</table>

Source: adapted from Arthur D. Little (2009)

\textsuperscript{127} McKinsey (2012). The road to 2020 and beyond: what’s driving the global automotive industry?
\textsuperscript{128} Arthur D. Little (2009). Future of Mobility 2020. The automotive industry in upheaval?
A2.8.2. **An overview of the industry post 2020**

In the post 2020 era the automotive industry may look reasonably different from how it looks today. Here, we briefly summarise some of the most significant trends that will characterise the automotive industry.

OEMs and suppliers will face significant challenges which may impact buyer-supplier relationships. Make or buy evaluations may push some OEMs to backward integrate by acquiring some of their suppliers while others may increase their outsourcing activities. A competence shift is also highly likely as OEMs will focus on their core competences, leaving space for suppliers to capture additional value in production and R&D activities. The overall OEM share of global R&D value creation will decline from 60% today to 47% in 2025.129. OEMs will place the major focus of their innovation activities on environmental friendliness and fuel efficiency instead of comfort. Europe will retain its leadership as an R&D location. OEM R&D spending is expected to rise as automakers will need to develop smarter and more innovative solutions to meet more stringent environmental regulations. For example, according to industry experts, between 2010 and 2025 car CO₂ emissions will need to be reduced annually by 4.7% and in Europe by 3.9%.130 Engine downsizing as well as hybrid engines and electric powertrain replacing conventional engines, and new materials (e.g. composites) are all potential solutions requiring an effort in innovation. Accordingly, it is expected that R&D spending will double, accounting for 10% of OEMs’ total costs by 2025 compared to the current 4-5%.

Another important aspect is related to the growth of emerging versus established markets. The global automotive industry is expected to grow by about 3% per annum until 2025. By 2025, global automotive value creation will grow to 1.25 trillion euros compared with 840 million euros in 2012. As emerging countries will continue to experience higher and faster growth compared to the established markets, Asia will further expand its position as the dominant automotive region. By 2025, China is expected to be the most important vehicle producing country globally generating around 300 billion Euros in value.

Regional vehicle segments are also expected to change. China will benefit considerably from the premium segment’s growth until 2025, while Europe will maintain its supremacy in that segment. India will significantly increase its share in the small vehicle segment. At the same time, value creation by vehicle modules will be also subject to change. Electric drives will be the strongest growth sector in production, increasing by 20% per year in terms of value creation. If we consider the individual vehicle segments, the exterior and chassis sectors will show the highest growth for the small car segment. For the premium vehicle segment, value creation in the exterior sector will increase strongly by 2025 due to lightweight construction concepts, new materials, cost reductions and a strong focus on design.131

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130 Oliver Wyman (2013). Automotive manager
131 Ibid.
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation
Annex 3. Results from stakeholder consultation

This section provides a synthetic overview of the key outcomes of the interview to stakeholders along the value chain, organized by type of player and by question. Overall, the interview campaign included 12 interviews with automotive manufacturers, component suppliers and fuel suppliers. End users representatives were also contacted, but did not provide an answer.

Table 56 – List of interviewees

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of entity</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>Daimler</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>Ford (Europe)</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>Fiat</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>Toyota</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>BMW Group</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Company</td>
<td>Volkswagen</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Association</td>
<td>ACEA</td>
</tr>
<tr>
<td>Vehicle Manufacturer</td>
<td>Independent expert</td>
<td>Mr Luc Bastard</td>
</tr>
<tr>
<td>Component Supplier</td>
<td>Company</td>
<td>Robert Bosch</td>
</tr>
<tr>
<td>Component Supplier</td>
<td>Association</td>
<td>CLEPA</td>
</tr>
<tr>
<td>Fuel supplier</td>
<td>Association</td>
<td>Eurofuels</td>
</tr>
<tr>
<td>Fuel supplier</td>
<td>Association</td>
<td>Renault</td>
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</table>

The survey consisted of semi-structured in depth interviews. This choice was made due to the necessity to obtain the maximum information from stakeholders even in the absence of information regarding the targets and modalities of post 2020 CO2 legislation (which were not defined yet at the time the study was performed).

The tables below include the questionnaires submitted to manufacturers (left column), as well as a summary of the answers received (right column).

A3.1 Answers by vehicle manufacturers

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 1. In what way does current legislation affect competitiveness between competitors in the affected sector? By which part of current policy? Focusing on the target, how feasible and expensive will it be to comply with the 2020 one? | • Most manufacturers remarked that competitiveness is a general task (i.e. not related to one specific piece of legislation), and is thus affected by the whole regulatory framework in the EU  
• Concerning CO2 regulation, it was suggested that the target is the most influencing factor in terms of profitability. According to interviewees, achieving the targets set definitely had an impact on costs of operations within the EU and resulted in a loss of competitiveness in manufacturing in the EU in favour of other production sites outside the EU  
• A few interviewees discussed in detail the role of the slope. The slope has been reported to have an influence on competitiveness based on the relative positioning of OEMs (big/"premium" vs. small/"volume" vehicles) |
<table>
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<tr>
<th>Question</th>
<th>Answer</th>
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</table>
| It has been argued that the innovation led by CO2 legislation is more likely to meet user acceptance (and availability to pay) by end users of “premium” vehicles, where innovation is part of the selling proposition. Vice versa, end users purchasing “volume” brand vehicles are not willing to pay a premium for greener vehicles. This dynamic has been reported to have a differential impact on the profitability of different OEMs based on their positioning.  
Eco-innovations, super credits and other “flexibilities” have been reported to have a mitigating effect on competitiveness impacts by helping to make the target feasible for “non-premium positioned” vehicles manufacturers.  
The 2020 target was judged to be extremely challenging by interviewees, although costs were not quantified. |  |
| Does the EU CO2 legislation for light duty vehicles lead to different “relative” levels of stringency of the targets imposed on EU and non-EU OEMs? If so, why? What elements of the legislation are causing this difference? |  |
| It was reported that all manufacturers are global companies. From the perspective of manufacturers, competitiveness in the EU market must be always linked to global competitiveness. All OEMs operating in EU and producing here under similar costs structure across the EU and all have operations outside EU.  
It was reported that it is not possible to split competitiveness to one local area, as losing competitiveness in one leads to delocalisation to another area with more suitable conditions.  
While the stringency is the same the impact on the feasibility of reaching the target [considering that it has been reported to be expensive and to lower profitability], the only possible differences between OEMs depend on:  
- the financial resources available  
- the “weight” of EU sales vis-à-vis non EU sales, as OEMs with higher dependency on EU market have to cope with higher costs associated with production in the EU not being offset by revenues from third market. It was agreed that the EU market is less profitable than the foreign ones. This means that OEMs have to find external markets to finance EU innovation  
A stakeholder pointed out that some manufacturers are very distant from the target. This has been reported to be due to the fact that diesel engines are the main mechanism of compliance with current targets. Players with sales mainly in the EU have strong competences in diesel, whereas other players (not focusing on hybridization) are more focused on gasoline due to the characteristics of their internal market. It has been remarked that, in this sense, Euro 6-2 legislation is “doing a favour” to non-EU OEMs by raising costs of diesel engines and thus reducing their sales, in particular for the medium segment. |  |
| Are there differences in the costs for EU and non-EU OEMs of complying with similar targets? Are these the result of EU and non-EU OEMs choosing different compliance mechanisms with different cost implications to meet similar targets? Or are they the result of costs for similar compliance mechanisms being different for EU vs. non-EU OEMs? And if the latter is the case, what are the reasons for these differences in costs? |  |
| It was remarked that costs are depending on the production localisation: In general, production in Europe is more expensive to other possible production places due to high regulatory burden, but all OEMs have operations and production in the EU, there is no difference for EU and non-EU manufacturers. |  |
### Question 4
What strategies are being applied to comply with the legislation? Do you foresee that in the future (post-2020) the available strategies will remain the same? What are the policy elements with the largest effect? Why?

- It was remarked that strategies are up to individual OEMs and all OEMs are trying to cope with similar conditions on the EU market. Some similarities were noted however:
  - In general, up to 2020 the strategy is to focus on diesel and to downsize gasoline.
  - For post 2020, it should be noticed that the pace of technical progress on reducing CO2 emissions will slow down. Diverse range of low carbon technologies that include biofuels, CNG, LPG, clean diesel, hybrids, electricity and hydrogen are available.
  - Some of the manufacturers might resort to pooling as a “last resource” before paying fines.
  - OEMs are focusing on cost reduction and global approach how to stay and be further competitive on the EU market. Especially for volume manufacturers, part of this strategy includes delocalization of production site to (EU or neighbouring) countries with lower costs than Western EU countries.

### Question 5
Would EU OEMs and suppliers or their non-EU competitors benefit from EU LDV CO2 regulations being more stringent than in other regions/markets? If there would be similar LDV CO2 regulations in different markets/regions, would the economies of scale resulting from that benefit EU OEMs and suppliers or their non-EU competitors?

- Focusing on cars, it was remarked that imposing overly-ambitious targets for Europe as compared to other world would lead to non-profitable investments for manufacturers, with a heavier weight on those selling the largest share of their vehicles in the EU.
- Focusing on LCVs, on the one hand it was answered that LCV legislation is expected to be similar across different regions, on the other hand it was remarked that very ambitious targets can damage profitability: stringent CO2 targets accelerate the obsolescence of the vehicle. This pushes manufacturers to maintain prices competitive and/or to accelerate innovation (i.e. product lifecycles). In both cases, profitability drops.

### Question 6
If future targets would require OEMs to sell significant shares of very efficient vehicles (ICEVs, BEVs, PHEVs and FCEVs), would you consider the EU automotive industry to be in a better/equal/worse position compared to non-EU competitors to apply that compliance mechanism? Why?

- Focusing on cars, it was answered that there is an issue of acceptance by the market: the current market uptake of alternative powertrains is low.
- Besides this issue, most manufacturers stated that there is no difference between EU and non-EU manufacturers, as they will all be faced with the same problems and need to finance non-profitable operations due to the regulatory burden not being “transferrable” to end users through higher prices.
- In this frame, “premium” manufacturers would be better positioned due to lower price sensitivity of their customers.
- Focusing on LCVs, it was remarked that usually LCV customers don’t want to pay for the premium associated to AFVs. It is not possible for manufacturers to have a downsizing strategy for the vehicle because of the loss of load capacity – which is a key driver for purchase for customers in addition to price.

### Question 7
To what extent does the regulation influence the design and implementation of innovative products or services?

- Product Innovation
  - Regulation may impact the scope of innovation but not hugely the extent of the efforts; Regulatory pressure has led to incremental innovation.
  - Market acceptance is the main driver particularly the case of mass production OEMs; Profitability is a pre-condition for ambitious innovation strategies.
  - CO2 legislation was behind most of the efforts on ICEV.
<table>
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<tr>
<th>Question</th>
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<tbody>
<tr>
<td>▪ The more the target and the slope make targets stringent the bigger will be the push to AFVs and EVs.</td>
<td></td>
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<tr>
<td>▪ A significant share of OEMs R&amp;D expenses was already addressing CO2 reduction technologies. This is the case for both mass production and premium OEMs.</td>
<td></td>
</tr>
<tr>
<td>▪ Low hanging fruit related to ICEV innovation have been grabbed and the most resource intensive innovations are currently under development.</td>
<td></td>
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<tr>
<td>▪ Innovation is concentrated on powertrain-related innovation, engines, aerodynamics, affordable lightweight materials, catalytic converters</td>
<td></td>
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<tr>
<td>▪ Increasing efficiency of diesel engines is important for EU OEMs.</td>
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<tr>
<td>▪ Strategies on alternative fuel vehicles seem to vary across companies. Innovation in EVs and natural gas is in some cases no longer actively pursued nor is hybridisation.</td>
<td></td>
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<tr>
<td>Services Innovation</td>
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<td>▪ A number of OEMs got involved in car sharing initiatives. However the emergence of these business models/services was not driven by CO2 regulation, but rather it was a strategy to enter a new market and/or being prepared to potentially changing customer behaviours.</td>
<td></td>
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<tr>
<td>▪ Emerging trends like service innovation e.g. electricity contracts, applications locating charging stations, parking etc. is backing product innovation are occurring. Currently they are developed by premium OEMs and hence motivated by being on the cutting edge of innovation.</td>
<td></td>
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<tr>
<td>▪ Manufacturers that can differentiate their technology by product and market may have an advantage over premium manufacturers that apply technological innovations on all products.</td>
<td></td>
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<tr>
<td>8. Is the legislation likely to affect internal production process and/or organisational structure?</td>
<td>▪ Different views were expressed:</td>
</tr>
<tr>
<td>▪ The majority of manufacturers stated that these issues are affected by all various aspects of business life, not by a specific piece of legislation</td>
<td></td>
</tr>
<tr>
<td>▪ One manufacturer answered that no change was expected</td>
<td></td>
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<tr>
<td>▪ Two manufacturers stated that increasing price pressure will lead to further shift in the choice of production location, and that electrification will move a lot of value creation out of the industry and push towards players specialized in the production of electric motors and batteries. This trend towards decreasing role of production vis-à-vis assembly has been judged to be detrimental in the long term for the EU, as the creation and nurturing of competences would eventually damage exports</td>
<td></td>
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<tr>
<td>9. Is the legislation likely to affect value chains of product development and marketing? Does the regulation, for example, lead to externalizing R&amp;D activities or changing the R&amp;D partners? And would those changes affect the competitiveness of EU industry &amp; business vs. industry &amp; business in other parts of the world?</td>
<td>▪ Innovation strategies are only a part of all other strategies (product, service, marketing etc.). Cost optimization considerations do impact R&amp;D investments.</td>
</tr>
<tr>
<td>▪ R&amp;D activities are becoming more resource intensive because technology becomes obsolete more quickly (the case of cars and not so much vans).</td>
<td></td>
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<tr>
<td>▪ Innovation spending has increased and choices have to be made in terms of prioritising innovation efforts in different segments, which may lead to a competitive disadvantage in the longer term.</td>
<td></td>
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<tr>
<td>▪ Mass producing OEMs have not and will not most likely increase R&amp;D even further as they are already constrained and have had serious losses in last few years of economic crisis.</td>
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<tr>
<td>10. What is the impact of changes in innovation strategies on your overall costs of doing business? Are the required R&amp;D investments likely to require access to external equity, including risk capital? Do you foresee a positive impact on revenues counterbalancing compliance costs? What will be the effect in the long term? And would the impact on the cost of doing</td>
<td></td>
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<tr>
<td>Question</td>
<td>Answer</td>
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<tr>
<td>business be different for you than for your (non-EU) competitors?</td>
<td>• Finding people with the right set of skills in Europe is becoming increasingly difficult particularly in relation to EVs &lt;br&gt; • OEMs that are global are more profitable – because the EU market is less profitable than the foreign ones and can thus rely on external markets to finance innovation</td>
</tr>
<tr>
<td>11. What are possible strategies and actions for limiting possible negative competitiveness effects?</td>
<td>• It was answered that strategies depend on individual OEMs &lt;br&gt; • Brand management is important because of what said above (i.e. to gain premium positioning), but this is a difficult and resource-consuming strategy to pursue. Moreover, there is not just “space” for everybody to “jump” in the premium segment</td>
</tr>
<tr>
<td>12. At the lights of the points above, can you conclude that EU companies will in general be affected differently than companies from other regions? Why? Will possible competitive advantages or disadvantages be maintained also in the long term?</td>
<td>• It was answered that there is not a large difference as all OEMs are global companies. Possible differences could still exist along these lines: &lt;br&gt; • Looking to the short term Diesel-specialised manufacturers have an advantage vs. gasoline-specialised OEMs, but Euro 6-2 will reduce it &lt;br&gt; • Both in short and medium-long term, Premium-focused manufacturers have an advantage vs. non-premium-focused OEMs &lt;br&gt; • In the long term, in case of stringent targets leading to radical changes, it will be more a matter of incumbents in the automotive industry vs. new players. with large amount of resources and familiarity with the new technologies</td>
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<tr>
<td>13. What is the overall impact of implementing compliance strategies on vehicles’ prices? Does this impact the demand for new vehicles?</td>
<td>• In general, market prices have been relatively stable in recent years. Absorption of all costs is not converted into a price increase. &lt;br&gt; • For premium vehicles it is possible to advertise and sell quite easily the new technologies and put a premium price &lt;br&gt; • Some manufacturers underlined that in the future, more stringent targets might eventually oblige [in particular volume] manufacturers to increase prices, which would eventually reduce the demand. This could have a potential social equity impact, as well as slowing the achievement of CO2 emissions reduction due to slower fleet renewal</td>
</tr>
<tr>
<td>14. Focusing on components enabling to hit CO2 targets, it possible to estimate the share of CO2 related components purchased from EU manufacturers vis-à-vis international ones? What is the share of CO2 reducing components produced in-house per manufacturer?</td>
<td>• Most manufacturers answered that all the vehicle is impacted. Focusing on components, low prices will be the priority. This is again due to profitability issues. &lt;br&gt; • It was also suggested that components related to the diesel technology are purchased mainly by EU manufacturers, whereas electrification-related technologies are sourced mainly outside EU, from Japanese players Korean ones and in the future increasingly Chinese players</td>
</tr>
<tr>
<td>15. What impact do you think that compliance actions by OEMs will have on component manufacturers, e.g. in terms of sales? Do you think that EU component manufacturers are better positioned than non-EU ones for taking advantage of compliance actions? Why?</td>
<td>• With the push towards electrification there will be a general tendency towards moving out of Europe (at least in terms of some of the required technologies), therefore EU component manufacturers will need to be even more competitive. To this do this they might be required replicate the strategies pursued recently by OEMs, e.g. to form partnerships and joint ventures to pool resources for R&amp;D</td>
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</tbody>
</table>
### A3.2 Answers by component suppliers

<table>
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<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What impact is the current CO2 legislation having on the automotive</td>
<td>• Legislation is a driver to spur innovations and new technologies; all regulations apply the same way to all the stakeholders; it thus spurs competitiveness.</td>
</tr>
<tr>
<td>supply industry? In what way does it eventually affect</td>
<td>• Looking to the impact on of the target, it depends mainly on its stringency and the distribution of capabilities: at the moment the EU industry is in a good position with respect to the injection equipment of diesel and ECU (electronic control units), and also for partition components and gasoline equipment.</td>
</tr>
<tr>
<td>competitiveness between automotive suppliers? By which part of</td>
<td>• In the field of electrification EU is not this strong. Looking to the volume of sales in future on electrification. The highest share of value is on the battery as the rest is commoditized. Here Asian players are in a very good position.</td>
</tr>
<tr>
<td>current policy? (probe for: Target; Utility parameter and utility</td>
<td></td>
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<tr>
<td>function (slope); Eco-innovations; Legal entity; Derogation, ...)</td>
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<tr>
<td>Focusing on the post-2020 CO2 legislation, what impacts do you</td>
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<tr>
<td>expect on the industry and on the competition between suppliers?</td>
<td></td>
</tr>
<tr>
<td>2. Does the European CO2 legislation for light duty vehicles lead to</td>
<td>• If regulation puts pressure on innovation it prevents commoditization with other suppliers. However, to take advantage of this the industry need to be in the right position and on the stringency of the target.</td>
</tr>
<tr>
<td>different “relative” levels of pressure on costs for European and</td>
<td>• With no or lean legislation there will be lower prices and competition on commodities from Asian players</td>
</tr>
<tr>
<td>non-European suppliers, due to requirements from OEMs caused by the</td>
<td>• “Medium” stringency will cause stable situation on prices</td>
</tr>
<tr>
<td>legislation? Can you map the causal reaction linking the legislation,</td>
<td>• High stringency will lead price to increase but will provide competitive advantage to Asian suppliers against EU ones</td>
</tr>
<tr>
<td>the compliance actions by OEMs and eventually the impact on suppliers?</td>
<td></td>
</tr>
<tr>
<td>3. What strategies are being applied by suppliers to satisfy the</td>
<td>• Strategies include combination of lightweight, downsizing, downspeeding. From a technical point of view, 2020 targets are expecting to be achieved with known technologies. However the continuation of the gradient of CO2 will progressively lead to electrification and increased demand for high-end powertrains.</td>
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<tr>
<td>demands from OEMs resulting from the EU LDV CO2 legislation? Do you</td>
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<tr>
<td>foresee that in the future (post-2020) the available strategies will</td>
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<tr>
<td>remain the same? Why?</td>
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<tr>
<td>4. Would European suppliers or, alternatively, their non-EU</td>
<td>• In the last decade EU regulation is in the leading position but in future more or less more or less the same levels across different regions is expected. For EU component suppliers, it was not a disadvantage in the past to have EU legislation more stringent as it avoided commoditization.</td>
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<tr>
<td>competitors benefit from EU LDV CO2 regulations being more</td>
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<tr>
<td>stringent than in other regions / markets? If there would be</td>
<td></td>
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<td>similar LDV CO2 regulations in different markets / regions, would</td>
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<tr>
<td>the economies of scale resulting from that benefit EU suppliers or</td>
<td></td>
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<tr>
<td>rather their non-EU competitors?</td>
<td></td>
</tr>
<tr>
<td>5. Do you expect the CO2 legislation to lead to more or less turnover</td>
<td>• Very stringent legislation is expected to lead to a disadvantage for the EU industry, meaning less turnover and jobs. To ensure competitiveness of suppliers and OEMs a better compromise is judged to be needed.</td>
</tr>
<tr>
<td>and more or less jobs in the European automotive supply industry?</td>
<td></td>
</tr>
<tr>
<td>Is that the result of European automotive supply companies gaining /</td>
<td></td>
</tr>
<tr>
<td>losing market share or of non-European suppliers relocating production</td>
<td></td>
</tr>
<tr>
<td>facilities to or out of Europe? Or is the labour intensity of</td>
<td></td>
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<tr>
<td>manufacturing CO2 reducing components different from the current</td>
<td></td>
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<tr>
<td>average?</td>
<td></td>
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<tr>
<td>6. To what extent does the regulation influence the design and</td>
<td>• Regulation is judged to be a main driver of change.</td>
</tr>
<tr>
<td>implementation of innovative products or services?</td>
<td></td>
</tr>
<tr>
<td>7. Is the legislation likely to affect internal production process</td>
<td>• To improve systems a change of the type of engineering, from component-based engineering to the systems engineering, is required. On the production side suppliers remarked the need to be close to customer and react to their needs.</td>
</tr>
<tr>
<td>AND/OR organisational structure?</td>
<td></td>
</tr>
</tbody>
</table>
8. Is the legislation likely to affect value chains of product development and marketing? Does the regulation, for example, lead to searching for new R&D partners, partners in design, new materials, engagement in new strategic alliances? Do these changes lead to new ways of protecting IPRs? And would those changes affect the competitiveness of European industry & business vs. industry & business in other parts of the world?

- In the future partnerships will be necessary, it will be also necessary to have different partnerships from the past, i.e. short-term partnerships.
- There is no easy answer to IP protection.

9. What is the impact of changes in your innovation strategies on your overall costs of doing business? And would the impact on the cost of doing business be different for you than for your (non-EU) competitors?

- R&D budget will be used with a focus on electrification. Different suppliers in Europe already changed (increased) the overall budget allocated to R&D.

### A3.3 Answers by fuel suppliers

In addition to the answers received to the specific questions, fuel suppliers emphasised that:

- any policy, and in particular policy related to progressive reduction of CO2 emissions from transport, should be technology neutral.
- the more that alternatives to fossil fuels are being including in transport CO2 emissions related policy, the more it is important to able to compare each fuel and/or technology on a comparable basis: this should be based on the emissions over the life cycle of the considered fuel, (i.e. well-to-wheel.)

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>1. If post 2020 CO2 legislation for light duty vehicles (LDVs) leads to more efficient internal combustion engine vehicles (ICEVs), as well as to the introduction of alternatives such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell electric vehicles (FCEVs), what are the main impacts on your business? Why?</td>
<td>The impact can be seen in reduced volumes of motor fuels, while the overhead cost and the other operational costs will remain approximately the same. These costs have to be spread over a smaller volume and so this will increase the price per litre (assuming taxes etc. remain the same). When the costs are too high compared to the turnover, this will result in a growing number of petrol stations that will be forced to stop the activities and a growing number of smaller petrol distributors that will be going bankrupt, not being able to cope with market pressures. Of course, this scenario will depend very much on the success of deployment and market buy-in of alternative fuels</td>
</tr>
<tr>
<td>2. Can you estimate the long-term impact of CO2 legislation on fuel demand and fuel prices?</td>
<td>The long term impact will be that prices will go up, as margins will increase and there will be less demand for oil-based fuels. Of course, this scenario will depend very much on the success of deployment and market buy-in of alternative fuels</td>
</tr>
<tr>
<td>3. To what extent are these effects impacting the competition between energy supply companies active on the European market? How would a shrinking fuel market in Europe affect competition between companies on the EU market? Are all companies active in Europe equally able to deal with the impacts of the CO2 legislation? And if not, is that related to them being European or non-European companies?</td>
<td>The shrinking market will increase competition in principle, if one assumes that EU legislation is applied in the same way in all countries.</td>
</tr>
<tr>
<td>4. Currently fuel suppliers and electricity suppliers are not generally seen as direct competitors. Will that change when post-2020 CO2 legislation for LDVs leads to large scale introduction of alternatives such as BEVs, PHEVs and FCEVs?</td>
<td>No, it will favour alternative fuels and not so much electricity providers, so they will not be direct competitors. However, the legislation will create unfair competition between fuel suppliers and alternative fuels suppliers.</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5. Will post-2020 CO2 legislation for LDVs lead to impacts on the number of jobs in your sector in Europe?</td>
<td>Yes, there will be a drastic impact on jobs in the fuel retail sector – drastic jobs reduction. Smaller firms will also be closed as they would not be able to cope with market pressures and larger firms in our sector will decrease in size too. Family enterprises will be closed, so there will be serious impact on SMEs.</td>
</tr>
<tr>
<td>6. Would the large scale introduction of alternatives such as BEVs, PHEVs and FCEVs foreseen to affect the business’ operations and structure? E.g. related to the installation, operation and maintenance of new energy supply infrastructures?</td>
<td>The key question is whether petrol stations will invest in alternative fuels infrastructure – some will do so and other will not, it will all depend on whether there is a business case for it or not. It will also depend on the kind of alternative fuel.</td>
</tr>
</tbody>
</table>
Annex 4. Trade tariffs, barriers and Free Trade Agreements

Trade tariffs play an important role in influencing international trade of goods. The level of trade tariffs applied by each country varies a lot, also depending on the type of good. The tariffs for the most recent available years for a selection of countries and goods (i.e. cars code HS8703, light commercial vehicles 870421, 31 and 90 and components 8708) is provided in the table below.

Table 57 – Overview of trade tariffs

<table>
<thead>
<tr>
<th>Reporter</th>
<th>Average of Ad Valorem Duties (%)</th>
<th>Year</th>
<th>HS 8703</th>
<th>HS 870421, 870431 and 870490</th>
<th>HS8708</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td></td>
<td>2012</td>
<td>35</td>
<td>35</td>
<td>15.35</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td>2013</td>
<td>5.8</td>
<td>5.1</td>
<td>3.4</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td>2011</td>
<td>25</td>
<td>25</td>
<td>9.8</td>
</tr>
<tr>
<td>EU Union</td>
<td></td>
<td>2013</td>
<td>9.7</td>
<td>12.3</td>
<td>3.8</td>
</tr>
<tr>
<td>India</td>
<td></td>
<td>2013</td>
<td>100</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td>2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td></td>
<td>2013</td>
<td>8</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td>2012</td>
<td>31.3</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td>2012</td>
<td>1.7</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td>2011</td>
<td>9.7</td>
<td>12.3</td>
<td>3.8</td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td>2013</td>
<td>2.5</td>
<td>25</td>
<td>1.3</td>
</tr>
</tbody>
</table>

It is also to be remarked that also non-tariff barriers (NTBs) have a significant role in reducing or hampering international trade. These include, for example, anti-dumping measures and countervailing duties. NTBs have increasingly been applied following the reduction of trade tariffs levels by WTO activities and rules.

Where considered to be mutually beneficial, bilateral or regional Free Trade Agreements involving or excluding specific groups of goods are signed. The FTAs can have a significant impact on increasing the intensity of international trade, as exemplified by the recently signed FTA (Free Trade Agreement) with South Korea. According to the Annual Report on the Implementation of the EU-Korea Free Trade Agreement issued by the EU Commission in February 2014, EU exports of cars to Korea increased by 40 % in value and 38 % in units, compared to the year before the FTA was provisionally applied (i.e. two years later), as compared with an increase of 24% in value terms and 25% worldwide. Likewise, imports of cars from Korea increased by 53 % in value terms and by 36 % in terms of units.

At the present stage, the EU has in place the following FTAs:

- Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama);
- Colombia and Peru;
- South Korea;
- Mexico (Comprehensive Free Trade Agreement);

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132 Source: WTO, Integrated Database (IDB) notifications. Most Favourable Nation applied tariffs
133 Source: AALEP
• Economic Partnership Agreements with the Caribbean (fifteen CARIFORUM states), the Pacific (Papua New Guinea) and Eastern and Southern Africa (Zimbabwe, Mauritius, Madagascar, the Seychelles);
• South Africa (Trade, Development and Co-operation Agreement);
• Chile (Free Trade Agreement).

Moreover, FTAs are a core component of Association Agreements as well as Customs Unions (Andorra, San Marino, Turkey). Hence the EU also has free trade deals in force with a number of countries in Europe (Faroe Islands, Norway, Iceland, Switzerland, the former Yugoslav Republic of Macedonia, Albania, Montenegro, Bosnia and Herzegovina, Serbia) and the Southern Mediterranean (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia) and three with African, Caribbean and Pacific countries (Caribbean, Pacific and Eastern and Southern Africa).

A series of FTAs are finished but not yet being applied. These include:
• Eastern Neighbourhood – Deep and Comprehensive Free Trade Area (DCFTA) with Moldova, and Georgia, Ukraine
• Singapore – Free Trade Agreement (FTA)
• Five interim Economic Partnership Agreements with Cote d'Ivoire, Central Africa (Cameroon), the Southern African Development Community, Ghana and the East African Community.

On-Going Negotiations include:
• United States of America (The Transatlantic Trade and Investment Partnership (TTIP)
• Agreement on investment with China
• Canada (Comprehensive Economic and Trade Agreement (CETA)
• Japan (Free Trade Agreement)
• Association of Southeast Asian Nations (ASEAN): Malaysia, Vietnam and Thailand;
• Southern Mediterranean: Deep and Comprehensive Free Trade Agreement (DCFTA) with Morocco.
• The Commission has a mandate to start a similar process with Tunisia, Egypt and Jordan.
• India (Free Trade Agreement)
• Mercosur (EU-Mercosur Association Agreement)
• African, Caribbean and Pacific countries (ACP) – Economic Partnership Agreements (EPAs.)

Of particular interest is the situation with Japan. EU-Japan FTA negotiations are ongoing for both vehicles and components – the EU does not envisage any exclusions. The negotiation involves both tariffs and NTBs:
• Tariffs: Japan has 0% tariffs on cars and most of the components. The EU has 10% duty on cars and Japan's objective is to eliminate this duty;
• On NTBs the objective of the EU is to encourage Japan to adopt and comply with the international (UNECE) standards. The EU has issued a list of NTBs some of which related to cars. Several of the NTBs were already resolved during the first year of negotiations. A second list of NTBs is expected to be submitted in autumn 2014. Additionally, and in parallel with the discussions on specific NTBs, the EU has submitted to Japan an automotive annex which focuses on elimination of NTBs and introduces mechanisms to prevent new NTBS from emerging.
Annex 5. Analysis of sales distributions

A5.1 Introduction

An important question for assessing possible competitiveness impacts of post-2020 CO₂ legislation is whether the legislation is likely to lead to targets of different stringency for EU manufacturers and non-EU manufacturers. In case the target is implemented on manufacturers using a utility-based target function, differences in the effective stringency of targets posed on individual manufacturer are the result of differences in the sales distributions of these manufacturers in relation to the utility parameter and the slope of the utility-based target function. As indicated in chapter 4, differences in the sales-averaged value of the utility parameter lead to significantly different targets if the target function has a finite slope. In this Annex sales distributions and average values for the utility parameters mass and footprint are assessed for EU manufacturers and non-EU manufacturers. The analysis is based on the 2013 monitoring database.

Different definitions of what are EU and non-EU manufacturers are discussed in section 2.5. Here analyses are presented for the following cases:

1. Current main association membership for the EU market:
   - Associations: ACEA, JAMA, KAMA, and other / unknown;
   - With Toyota (incl. Lexus) and Hyundai as member of ACEA;
   - Chrysler counts as ACEA member as it is owned by Fiat (since 2014);
   - Various GM brands counting as ACEA member (since 2014) through the Opel Group;
   - For large manufacturers this represents as European manufacturers all OEMs that manufacture a large share of their EU sales in the EU;
   - “Other / unknown” contains e.g. manufacturers from the US, China, India, and Malaysia;
   - Many small manufacturers are not member of ACEA, JAMA or KAMA and are also classified as other / unknown, without distinction of whether they are EU or non-EU. Due to their low sales this does not affect the overall picture.

2. Original association membership:
   - Associations: ACEA, JAMA, KAMA, and other / unknown;
   - With Toyota (incl. Lexus) as member of JAMA and Hyundai as member of KAMA;
   - “Other / unknown” contains e.g. manufacturers from the US, China, India, and Malaysia;
   - Many small manufacturers are not member of ACEA, JAMA or KAMA and are also classified as other / unknown, without distinction of whether they are EU or non-EU. Due to their low sales this does not affect the overall picture.

3. Location of headquarters / owner
   - Regions: Europe vs. Japan, Korea and other (including US);
   - Chrysler counts as European as it is owned by Fiat;
   - The region “other” then includes Ford and GM counted as having US-based ownership and Volvo and Landrover/Jaguar as owned by companies from China resp. India.

The fourth definition, based on the share of vehicles manufactured in the EU, could not be used in this analysis due to a lack of data.

For passenger cars a detailed list of how different brands/manufacturers are attributed to different regions according to the above definitions is given in Table 58. A similar list for LCVs is presented in Table 59.

Table 58 – Classification of different passenger car brands / manufacturers in the EEA 2013 monitoring database as European or non-European according to three different definitions (sales > 500)

<table>
<thead>
<tr>
<th>Brand</th>
<th>Sales</th>
<th>Main association for EU market</th>
<th>Original association</th>
<th>Owner/HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLKSWAGEN</td>
<td>1486615</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>FORD</td>
<td>891905</td>
<td>ACEA</td>
<td>ACEA</td>
<td>Other/ukn</td>
</tr>
<tr>
<td>RENAULT</td>
<td>793271</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>PEUGEOT</td>
<td>723889</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>AUDI</td>
<td>662318</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>BMW</td>
<td>608594</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>MERCEDES</td>
<td>594093</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>CITROEN</td>
<td>587649</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>OPEL</td>
<td>545451</td>
<td>ACEA</td>
<td>ACEA</td>
<td>Other/ukn</td>
</tr>
<tr>
<td>FIAT</td>
<td>535793</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>491902</td>
<td>ACEA</td>
<td>JAMA</td>
<td>Japan</td>
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<tr>
<td>SKODA</td>
<td>480740</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>NISSAN</td>
<td>409673</td>
<td>JAMA</td>
<td>JAMA</td>
<td>Japan</td>
</tr>
<tr>
<td>HYUNDAI</td>
<td>406286</td>
<td>ACEA</td>
<td>KAMA</td>
<td>Korea</td>
</tr>
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<td>KIA</td>
<td>338679</td>
<td>KAMA</td>
<td>KAMA</td>
<td>Korea</td>
</tr>
<tr>
<td>DACIA</td>
<td>289162</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>SEAT</td>
<td>280326</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>VAUXHALL</td>
<td>258868</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
</tr>
<tr>
<td>VOLVO</td>
<td>203431</td>
<td>ACEA</td>
<td>ACEA</td>
<td>Other/ukn</td>
</tr>
<tr>
<td>MINI</td>
<td>147247</td>
<td>ACEA</td>
<td>ACEA</td>
<td>EU</td>
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<td>SUZUKI</td>
<td>137188</td>
<td>JAMA</td>
<td>JAMA</td>
<td>Japan</td>
</tr>
<tr>
<td>CHEVROLET</td>
<td>136437</td>
<td>ACEA</td>
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<td>Other/ukn</td>
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<td>MAZDA</td>
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<td>LAND ROVER</td>
<td>98711</td>
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<td>ACEA</td>
<td>Other/ukn</td>
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<td>MITSUBISHI</td>
<td>70833</td>
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<td>Japan</td>
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<td>LANCIA</td>
<td>70791</td>
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<td>EU</td>
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<td>SMART</td>
<td>63384</td>
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<td>ALFA ROMEO</td>
<td>62237</td>
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<td>PORSCHE</td>
<td>40492</td>
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<td>EU</td>
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<td>SUBARU</td>
<td>27903</td>
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<td>JAMA</td>
<td>Japan</td>
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<tr>
<td>JAGUAR</td>
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<td>ACEA</td>
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<td>OTHER/ukn</td>
<td>Other/ukn</td>
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<tr>
<td>LEXUS</td>
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<td>Japan</td>
</tr>
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<tr>
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<tr>
<td>MAGYAR SUZUKI</td>
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<td>BENTLEY</td>
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</tbody>
</table>
Table 59 – Classification of different LCV brands / manufacturers in the EEA 2013 monitoring database as European or non-European according to three different definitions (sales > 500)

<table>
<thead>
<tr>
<th>Brand</th>
<th>Sales</th>
<th>Main association for EU market</th>
<th>Original association</th>
<th>Owner/HQ</th>
</tr>
</thead>
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<td>EU</td>
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<td>EU</td>
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<td>ASTON MARTIN</td>
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<td>LAND ROVER</td>
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<td>JAMA</td>
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<td>Japan</td>
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<td>JEEP</td>
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<td>EU</td>
</tr>
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<td>OTHER/ukn</td>
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</tr>
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<td>BMW</td>
<td>651</td>
<td>ACEA</td>
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</tr>
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<td>OTHER/ukn</td>
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</tr>
<tr>
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<td>OTHER/ukn</td>
<td>EU</td>
</tr>
<tr>
<td>GOUPIL</td>
<td>573</td>
<td>OTHER/ukn</td>
<td>OTHER/ukn</td>
<td>EU</td>
</tr>
</tbody>
</table>
A5.2 Passenger cars

A5.2.1. Mass

Figure 73 shows that in all three definitions the European, Japanese and Korean manufacturers have fairly similar distributions of sales over the range of mass values, with Korean OEMs having a somewhat more pronounced sales peak in the medium segment. In the definition based on association membership manufacturers in the category “Other/unknown” have peaks in their sales for vehicles with smaller than average and higher than average mass, as well as a wider spread towards higher masses. Based on the location of headquarters / owner, in which case e.g. Ford, GM and Volvo are categorised as “Other/unknown”, this category has a sales distribution that is more similar to that of OEMs from the EU, Japan and Korea.

In Figure 74 it can be seen that the average mass for EU manufacturers is not sensitive to the definition, which is to be expected given the high share of EU OEMs in the European vehicle sales. For OEMs from other regions the average mass and CO₂ value are somewhat sensitive to the definition used to categorise the OEMs, but sign and to a lesser extent size of the deviation from the average for EU OEMs remain largely the same for the three definitions. Sales volumes for the category “Other/unknown” are most sensitive to the definition of the categories.
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 73 – EU passenger car sales distributions as function of utility: mass
Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation

Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 74 – EU passenger car average CO\textsubscript{2} vs. utility: mass (The sizes of the bubbles indicate the sales volumes in the EU)
A5.2.2. **Footprint**

Figure 75 shows that in all three definitions the European and Japanese manufacturers have fairly similar distributions of sales over the range of footprint values, while both Korean OEMs and OEMs in the category “Other/unknown” have a more peaked distributions with large shares in small vehicles as well as vehicles with a footprint just above the average. These differences are less pronounced when OEMs are categorised on the basis of the location of headquarters / owner.

Figure 76 shows that also the average footprint for EU manufacturers is not sensitive to the definition. Contrary to the case of mass as utility parameter, however, for OEMs from other regions the average footprint and CO₂ value are quite sensitive to the definition used to categorise the OEMs. The average footprint of OEMs in the category “Other/unknown” is below average for the definitions based on association membership, but above average for the definition based on the location of headquarters / owner. The average CO₂ emissions of Japanese OEMs are above average if Toyota is categorised as European, but slightly below average if Toyota is categorised as Japanese.
Figure 75 – EU passenger car sales distributions as function of utility: footprint
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 76 – EU passenger car average CO₂ vs. utility: footprint (The sizes of the bubbles indicate the sales volumes in the EU)
A5.2.3. **Footprint vs. mass**

Figure 77 shows the average footprint vs. average mass for passenger car manufacturers from different regions based on the three different definitions for categorising the OEMs. This graph confirms that average footprint is more sensitive than average mass to how one defines the region to which an OEM belongs. On the other hand the differences between OEMs from different regions appear more pronounced for mass than for footprint, meaning that the relative stringency of the target for OEMs from different regions will be more sensitive to the slope of the target function when this is based on mass rather than footprint.
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 77 – EU passenger car average footprint vs. mass
(The sizes of the bubbles indicate the sales volumes in the EU)
A5.2.4. **Power-to-weight**

Power-to-weight is not a considered utility parameter for post-2020 LDV CO\(_2\) legislation, but an evaluation of sales distributions over this parameter gives insight into one of the origins of why OEMs with different average utility values may have different average CO\(_2\) emissions. Some manufacturers focus more on sportive or premium models within the different size segments. For such vehicles CO\(_2\) emissions are not only higher, but also applicable technologies for CO\(_2\) emission reduction and their costs may be different than for (volume) manufacturers of more mainstream vehicles.

Different associations, however, are found to have quite comparable sales distributions over the power-to-weight range, with distributions being most similar if the categorisation is based on location of headquarters / owner. Korean manufacturers show a more pronounced peak at below-average power-to-weight, but also have a shoulder in the distribution at above average power-to-weight values. If the categorisation is based on current main association membership for the EU market, OEMs in the category “Other/unknown” have a very wide distribution towards higher power-to-mass. In that case this category contains a large number of small European companies producing sports cars, which are not a member of ACEA. Striking to see is that European OEMs, although they dominate the premium segment of the market in the EU, show lower sales shares at above-average power-to-weight values than OEMs from other regions. This must be because the premium segment remains a relatively small share of the overall sales of EU OEMs.

Figure 79 shows that European, Japanese and Korean OEMs have quite comparable average power-to-weight, fairly independent of the definition for categorisation. Based on current and original association membership the OEMs in the category “Other / unknown” clearly have higher average power-to-weight as well as CO\(_2\) emissions. When Ford and GM are added to this category, based on the location of their headquarter / owner, the average power-to-weight drops to a value just below the average. Average CO\(_2\) also drops but to a lesser extent.
Assessment of competitiveness impacts of post-2020 LDV CO₂ regulation

Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 78 – EU passenger car sales distributions as function power-to-weight ratio
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 79 – EU passenger car average CO₂ vs power-to-weight ratio
(The sizes of the bubbles indicate the sales volumes in the EU)
A5.3 Light commercial vehicles

The graphs in this section analyze sales distributions and averages for European, Japanese, Korean and other manufacturers of light commercial vehicles. Some differences may be noted in the graphs for mass and footprint which are related to the fact that in the EEA database for LCVs not for all vehicles mass, footprint and CO₂ data are available.

A5.3.1. Mass

Compared to cars the sales distributions for LCVs show a more scattered picture, with a much wider spread of sales over mass and footprint as well as a less smooth distribution with several pronounced peaks. As far as mass is concerned, all distributions show a dip in the sales around 1700 kg, indicating a clear segmentation of the market into lighter and heavier vans. Due to this scattered distribution Figure 80 does not directly lead to clear conclusions on differences between OEMs from different regions and how these depend on the definition for categorisation.

Figure 81, however, which indicates total sales and the average mass and CO₂ for the various groups, provides a much clearer picture. First of all it is clear that the LCV market is much more dominated by EU manufacturers than is the case for passenger cars. Only when Ford and GM are counted as non-European does one see a significant share of sales from non-EU OEMs. This already indicates that the competition in the EU market is more between EU OEMs than between EU and non-EU OEMs. For Japanese and Korean OEMs the average mass and CO₂ value are found to be very insensitive to the definition of the categories. For the category “Other / unknown” average mass and CO₂ do depend on the definition. Differences in average mass between OEMs from different regions are quite significant so that the relative stringency of average targets will be quite sensitive to the slope of a mass-based target function.
Based on current main association membership for the EU market

![Graph showing sales distributions based on current main association membership.]

Based on original association membership / intuitive region of origin

![Graph showing sales distributions based on original association membership.]

Based on location of headquarters / owner

![Graph showing sales distributions based on location of headquarters.]

Figure 80 – EU LCV sales distributions as function of utility: mass
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 81 – EU LCV average CO₂ vs. utility: mass
(The sizes of the bubbles indicate the sales volumes in the EU)
A5.3.2. **Footprint**

Also for footprint the sales distributions for LCVs are much more scattered than for passenger cars. Compared to mass the distribution is somewhat more even. EU, Japanese and “other” OEMs still appear to show a dip separating segments of smaller and larger vans, while this dip is located at a higher average footprint for the Korean OEMs. Also here the scattered distribution makes that Figure 82 does not directly lead to clear conclusions on differences between OEMs from different regions and how these depend on the definition for categorisation.

As for mass, however, Figure 83, which indicates total sales and the average footprint and CO$_2$ for the various groups, provides a much clearer picture. For Japanese and Korean OEMs the average footprint and CO$_2$ value are found to be very insensitive to the definition of the categories. For the category “Other / unknown” average footprint and CO$_2$ do depend strongly on the definition. Average footprint is below the overall average for the definitions based on association membership and above the overall average for the definition based on location of headquarters / owner. Differences in average footprint between OEMs from different regions are quite significant so that the relative stringency of average targets will be quite sensitive to the slope of a footprint-based target function.
Based on current main association membership for the EU market

![Graph showing EU LCV sales distributions as function of utility: footprint based on current main association membership for the EU market.]

Based on original association membership / intuitive region of origin

![Graph showing EU LCV sales distributions as function of utility: footprint based on original association membership/intuitive region of origin.]

Based on location of headquarters / owner

![Graph showing EU LCV sales distributions as function of utility: footprint based on location of headquarters/owner.]

Figure 82 – EU LCV sales distributions as function of utility: footprint
Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation

Figure 83 – EU LCV average CO\textsubscript{2} vs. utility: footprint
(The sizes of the bubbles indicate the sales volumes in the EU)
A5.3.3. **Footprint vs. mass**

Figure 84 shows the average footprint vs. average mass for LCV manufacturers from different regions based on the three different definitions for categorising the OEMs. Contrary to passenger cars this graph suggests that average mass is more sensitive than average footprint to how one defines the region to which an OEM belongs. Similar to passenger cars, the differences between LCV manufacturers from different regions appear more pronounced for mass than for footprint, meaning that the relative stringency of the target for OEMs from different regions will be more sensitive to the slope of the target function when this is based on mass rather than footprint.
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 84 – EU LCV average footprint vs. mass
(The sizes of the bubbles indicate the sales volumes in the EU)
A5.3.4. **Power-to-weight**

Power-to-weight is not a considered utility parameter for post-2020 LDV CO₂ legislation, but for passenger cars at least - an evaluation of sales distributions over this parameter gives insight into one of the origins of why OEMs with different average utility values may have different average CO₂ emissions. For LCVs this is expected to be less the case as there is no distinction between volume and premium models and overall a more rational approach towards motorisation of the vehicles.

In the LCV market different associations are found to have quite different sales distributions over the power-to-weight range, as can be seen in Figure 85. Strong similarities, however, are apparent if the categorisation is based on location of headquarters / owner. This is especially the case for EU OEMs and the category “Other / unknown” which have strikingly coinciding sales distributions under this definition. It is tempting to seek the origin in the high level of platform sharing among various OEMs, e.g. Renault and Opel, but then one would expect this also to show up in the sales distributions as function of mass and footprint.

Figure 86 shows that European, Japanese and Korean OEMs have different average power-to-weight values, fairly independent of the definition for categorisation. The values for the category “Other / unknown” depend strongly on the definition. When Ford and GM are added to this category, based on the location of their headquarter / owner, the average power-to-weight becomes equal to the EU average, with average CO₂ some 20 g/km above the EU average.
Based on current main association membership for the EU market

Based on original association membership / intuitive region of origin

Based on location of headquarters / owner

Figure 85 – EU LCV sales distributions as function power-to-weight ratio
Figure 86 – EU LCV average CO₂ vs. power-to-weight ratio
(The sizes of the bubbles indicate the sales volumes in the EU)
Assessment of competitiveness impacts of post-2020 LDV CO\textsubscript{2} regulation
Annex 6. International competitiveness

Table 60 - EU-27 net exports of passenger vehicles, by trade partner (mil. U.S.$)

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<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
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<tbody>
<tr>
<td>NAFTA</td>
<td>26,910</td>
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<td>EFTA</td>
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<td>Middle East</td>
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<tr>
<td>India</td>
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<td>TOTAL Main Partners</td>
<td>81,272</td>
<td>60,354</td>
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</table>

Note: HS 8703.

Table 61 - EU-27 net exports of passenger vehicles, by trade partner (mil. U.S.$)

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
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<tbody>
<tr>
<td>NAFTA</td>
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<td>EFTA</td>
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<tr>
<td>TOTAL Main Partners</td>
<td>81,272</td>
<td>60,354</td>
</tr>
</tbody>
</table>

Note: HS 8703.

Table 62 - EU-27 net exports of light commercial vehicles, by trade partner (mil. U.S.$)

<table>
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Note: The light commercial vehicles are defined as trucks with gross weight under five tons. This definition differs from the definition used by the EU commission (trucks and vans with the gross weight under 3.5 tons). However, this is the closest definition that can be found in the Harmonized System coding system of international trade.
### Table 63 - EU-27 net exports of components, by trade partner (mil. U.S.$)

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### Table 64 - The revealed comparative advantage coefficient in passenger vehicles

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Note: The Balassa RCA index.

### Table 65 - The revealed comparative advantage coefficient in light commercial vehicles

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Note: The Balassa RCA index.
Table 66 - The revealed comparative advantage coefficient in automotive components

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<tr>
<td>USA</td>
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<td>1.12</td>
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Note: The Balassa RCA index.