Sector Overview and Competitiveness Survey of the Railway Supply Industry

Within the Framework Contract of Sectoral Competitiveness Studies – ENTR 06/054

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Final report

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Client: European Commission, DG Enterprise and Industry

Ecorys

Rotterdam, May 2012
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Preface

Railways play an important part in securing transport in Europe. Millions of people use train, tram or metro as a means of (daily) transport. The rail sector is a major provider of jobs and economic growth in Europe. The wide range of economic activities are tied to the overall rail sector and provided by a variety of actors, ranging from railway undertakings, to rail infrastructure managers, rolling stock leasing companies to the railway supply industry.

This report analyses the competitive position of the railway supply industry and its future challenges. The railway supply sector is not only essential in making railway transport possible in Europe, but is also a major exporting industry, thus fostering economic growth and prosperity in Europe.

During the assessment we have spoken to a large number of people from many different organisations and companies. We would like to express our gratitude to all people who have shared their valuable insight with us on the matter.

The study has been carried out by an independent team. It should be noted that this report represents the views of the consultant, which do not necessarily coincide with those of the Commission.

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Summary

Background

The general background to this study is the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on “An Integrated Industrial Policy for the Globalisation Era – Putting Competitiveness and Sustainability at Centre Stage”. This communication calls for a refreshed approach to industrial policy to set the appropriate framework conditions to optimise the competitiveness and performance of the European industry in an increasing global world. As an important component of Europe’s manufacturing industry the study should shed light on the competitive position of the railway supply industry, its strengths, weaknesses and future challenges.

Objective of the study

The main objective of the study is, against the background of the Communication “An Integrated Industrial Policy for the Globalisation Era”, to:

- define clearly the railway supply industry (RSI), its company distribution, its situation vis-à-vis the world competitors, its challenges and future perspectives.

As such the study aims to assess the competitive position of Europe’s supply industry and the critical factors that influence this position.

The Railway Supply Industry in Europe

The Railway supply industry in Europe is an important industry representing a total production value of some 40 billion Euro (2010), with gross value added being around 30% of the production value.

In production value, the rolling stock and locomotives market is the most important market, practically equalled by the market segment for rail infrastructure. The segment of signalling and electrification follows at a distance. In terms of trade the rolling stock and locomotives market is by far the largest and most globalised market.

The rolling stock (and locomotives) industry in Europe employs some 160,000 people. The world rolling stock industry market has traditionally been dominated by three major players, Bombardier (Canada/Germany), Alstom (France) and Siemens (Germany). Industry data show that these employ approx. 78,000 people of which 9% are located outside the EU. However, the Chinese rolling stock manufactures have grown substantially and are now ranked third and fourth in the world in terms of turnover. The EU still accounts for most locations worldwide, although the cumulative capacity of Asians plants is highest in the world.

For rail infrastructure a high degree of specialisation is encountered, among the largest companies are three major EU companies (Voestalpine, Delachaux and Vossloh). Limited data are available on employment. The available data indicate a total direct employment of 50,000 employees. The

1 COM(2010)614
enterprises are mainly located in EU, a high number of components is being produced locally (e.g. rails, fastenings, sleepers), only high value components mainly produced in EU.

The world market for signalling is rather fragmented and served by various companies. Large companies that act on the signalling market include Alstom, Ansaldo, Bombardier, Invensys, Siemens, Thales and Toshiba. Regarding the market for electrification, the large electrification companies are located in countries with large electrified networks, Alstom, Balfour Beatty, Bombardier and Siemens are the main players acting worldwide. Employment figures are hard to assess as activities are interwoven in other activities performed by the companies that are active in this market.

The competitive position of the EU RSI

The EU is in the lead as a top exporter accounting for 21 per cent of railway total trade. In addition, the EU is the most important producer of railway products making 46 per cent of the combined output of the five analysed countries. The good performance of the EU RSI indicates noteworthy improvements in competitiveness. In contrast, the US and Japanese RSI have lost market share in relation to total output and total exports. In addition to these developments, the EU RSI has improved its gross operating rate and productivity levels during the period analysed.

The ECI reveals the relative improvement of the EU RSI vis-à-vis the US and Japanese RSI. Even though, EU RSI is lagging behind US and Japanese railway manufacturers, the gap has been narrowing over time. Regarding China, the EU RSI still has an overall comparative advantage although China is quickly catching up. This current comparative advantage of the Eu over China can also be seen in the trade data, where China runs a trade surplus in railway products with all the countries except for the EU. Korean RSI, nonetheless, is more competitive than its European counterparts. In recent years, there has been an important investment in railway technology in Korea, improving its competitiveness and helping to develop a mature railway industry. However, Korean output and export are much lower than the EU RSI.

The EU has a low import ratio. This is also the case for the US, Japan, Korea and China. Even though, the EU is a major exporter in those markets. With the exception of Japan the EU commands surpluses bilateral trade with all competing economies under investigation and is number 1 of their RSI imports with the exception of the US. This indicates a strong position in international competition. In particular the trade surplus with China reveals the strength of the EU in the RSI market. China itself has become a strong exporter and commands a surplus on average for all trading partners, but not for the EU. A division of the global railway market is made, depending on the indigenous capacity to produce railway products.

China is the most important foreign market for the European RSI. EU manufacturers have already invested in the market and will be setting up even more production sites to benefit from the large domestic market. This will have an impact on trade relations in the long-run and the division of labour between both of these economies will intensify. This incorporates the potential to increase EU exports of high-tech components and imports of low end products from China.

The EU RSI has a number of key strengths which provide a comparative advantage in non-EU countries. A great advantage of European rail electrification industry is the deployment of the European Rail Traffic Management System (ERTMS). The ERTMS is being implemented outside

\(^2\) http://www.raillogkorea.com/e/sub/sub_01_03_2.html
the EU. Another selling point is relates to high integrated solutions, i.e. merging of vehicle
technology with intelligent track/signalling and optimum operations and service management. In
addition, EU suppliers have high qualified key components like brakes delivered by specialized,
long term experienced suppliers. In infrastructure the EU is leading in developing special long-life
steel for rail, fastening systems and turnouts and high quality concrete or plastic sleepers to keep
maintenance cost within limits and to guarantee safe operation. The main competitor in this
segment is Japan.

The EU RSI spends significant amounts of resources in R&D ranging between 4 and 10 per cent for
the more technologically advanced market segment of locomotives and rolling stock and signalling
and electrification. For the infrastructure segment this R&D expenditure is much lower at 2 per cent
due to different R& requirements. The level of profitability in the industry may have affected the
amount of resources committed to R&D. In this regard, the lower gross operating rate of the EU
RSI’s limits the ability to raise the necessary funds for R&D activities to maintain its technological
lead. In spite of its bright performance in international markets over the past decade the EU RSI is
challenged to stay on the leading edge of technology to secure future success in railway markets.

Concerning labour force and skills, two factors are distinguished driving demand for railway
engineers: on the one hand the trend to more sophisticated railway technologies (e.g. ERTMS,
signalling, etc.) and the growing need to replace retiring engineers. Some EU countries (UK,
Germany) report chronic shortages of railway engineers. The next decade will be crucial in
determining the future of the rail industry in Europe.

The harmonisation and interoperability of EU railways through the implementation of several
Directives is gradually creating a single market in the EU for railway supply. The EU market will
become easier accessible through standardised products for non-EU companies. Better
functioning markets is expected to spur efficiency in EU RSI companies (economies of scales,
reduction of certification, testing and common standards reduce the number of variants to be
produced. This growing efficiency increases productivity (reducing the productivity gap against US
and Japan) and contributes to growing welfare in the Community

The anticipated competitive advantages from harmonisation within the Single Market for EU
companies likewise contribute to a reduction of non-tariff barriers in third markets. The EU is in the
vanguard of creating harmonized and transparent rules for railway operators and the RSI.
Numerous non-EU countries follow suit with the adoption of ERTMS.

Different non-tariff barriers to enter non-EU markets exist. Of importance are barriers above all in
major competing economies. In China barriers are in place related to standardisation and technical
regulations. Further barrier are insufficient IPR enforcement and heavy certification procedures.
The Japanese market access is not only constraint by the industry structure but by the lack of
transparency of the Japanese government procurement system. Japan Rail, the incumbent
operator, although recently privatised, falls under public procurement. This aggravates further
market access. The European Commission has openly complained about the lack of symmetry in
market access in relation to public procurement.
Recommendations

The study on the competitiveness of the EU RSI reveals that the position of Europe strong and as many other competing countries fed by a strong domestic market. In global trade Europe holds a lead position. Especially in the delivery of more complex technological solutions the position the Europe’s RSI is strong.

Key strengths of the European RSI as indicated in the study are its leading position in advanced technologies (e.g. ERTMS, ATO/UTO, CBTC etc.), the well-developed design and production methods, the high level of quality and quality control processes leading to a high reliability, the ability to smartly integrate services into product delivery and the long experience in general in improving operational and maintenance processes.

Seen over a longer time the EU has succeeded in improving its competitive position vis-à-vis Japan and the US, but China and to a lesser extent Korea a gradually positioning themselves as stronger competitors. Market access in Japan and China still faces some hurdles, in the latter country aimed at building up a more competitive industry. Especially China is expected to further improve its position worldwide. At the same time the harmonisation of the European market may create additional market entry for external competitors as it will reduce national fragmentation.

These changes find place in environment in which demand is expected to grow, although the regional focus will shift to growing, emerging economies in the Americas and Asia. To the extent that this growth materializes in countries with a strong own production base, it is expected that especially domestic suppliers will profit from this growth, as figures show that in these countries, including the EU, import penetration is relatively low.

In the future demand may also change to a certain extent. Especially the demand for higher energy efficiency, but also safety and security of transport will receive high and increasing attention. EU RSI unique position to profit from this development by further exploiting its technological advanced position.

Thus a number of challenges and opportunities are observed that form the basis for the recommendations. These recommendation address four areas:

- Continued innovation
- Safeguard access to skilled labour
- Continue to promote a level playing field and market access
- Stimulate a modal shift towards environmentally friendly rail transport

**Strategy 1: Continued innovation**

Maintaining the technological advanced position of Europe is key in retaining its future competitive positions. Recommendation can be made both with respect driving innovation from the demand side as well as the supply side. The following specific recommendation are made:

- The developments on the home market create a strong base for future exports. Progressive regulation driving innovation and market adoption of innovations in Europe can be powerful instruments as shown by the introduction of ERTMS in Europe which is now developing into a de facto world standard. Progressive regulation can for example be introduced in the field of safety and security, but also in improved energy efficient rail transport. This not only triggers innovation but also enhances the replacement demand on the home market;
- On the supply side continued attention to RTD in railway technology which answers to the market trends is essential. Again these can address societal trends towards an enhanced safe, secure and energy efficient rail transport but may also be related to technological intervention.
that create their own market access, e.g. by lowering the operational cost or maintenance of railway infrastructure and locomotives and rolling stock or improve the reliability of the rail system. As indicated earlier operating margins of European operators are relatively thin creating a risks towards future innovation. Continued R&D support is therefore deemed to be effective in safeguarding the technological advance of the European industry. As also raised by sector stakeholders this could possible take the form of a Joint Technology Initiative as this combines different actors across the value chain and would enable to bridge the gap between pre-competitive research and market uptake, whilst at the same time creating direct industry commitment.

**Strategy 2: Safeguard access to skilled labour**

As in most technical engineering sectors the supply of technical engineers may become a bottleneck in maintaining the competitive position of EU RSI on the long term. Especially in view of the ageing population it can be expected that a significant cohort will retire. In this respect the following recommendations are made:

- Intensify cooperation of companies with universities and enhance visibility to the public
- Start image campaigns to strengthen the brand of high-technology sectors such as RSI;
- Continuous adaption of curricula of training and education programmes to address new technological developments and trends such as the drive towards higher energy-efficiency
- Continued promotion of technical education in general, including attempt to increase the share of women in technical professions
- Develop progressive formal career paths by companies and their associations and improve the skills of medium qualified labour (e.g. through the introduction of apprenticeships or similar vocational schemes)
- Improve labour mobility by regular monitoring of supply and demand across Europe

**Strategy 3: Continue to promote a level playing field and market access**

Creating a level playing field and open market access is essential in maintaining the competitive position of the EU RSI. This leads to the following recommendations:

- Continuously monitor address barriers to market access, in particular non-tariff barriers and procurement strategies, as these forms a significant impediment for EU RSI actors. In particular situation the possibility of sanction should be considered if compliance with trade agreements it not reached;
- Monitor and encourage competing countries (in particular China) to introduce the necessary measures to protection IPR.
- Stimulate early relationship building with countries that are expected to face a significant market demand but do not have their own production capacity. This could imply a variety of measures, including training exchanges with students in these countries, to trade promotion and general international relation building activities. In some situation it may also related to development cooperation activities;

**Strategy 4: Stimulate a modal shift towards environmentally friendly rail transport**

Rail transport is an important mode of transport in greening Europe’s transport system. Various initiatives are already undertaken by national governments and the EU to promote more sustainable transport systems. It is recommended to:

- actively implement the investment strategy for the establishment of the TEN-T rail network;
- introduce measures that aim to internalise the external costs of transport thus improving the competitive position of rail;
- actively pursue the ongoing intervention that aim at increasing the relative competitive position of rail transport vis-à-vis other modes of transport.
1 Introduction

The European Commission (EC DG ENTR) has commissioned ECORYS under the Framework Service Contract for Sectoral Competitiveness Studies (ENTR 06/054) to carry out a study describing the current situation and the future outlook of the railway supply industry (RSI), comprising the manufacturing sector of rolling stock and locomotives; signalling and electrification equipment and some other components used by railways.

1.1 Context and background

The general background to this study is the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on “An Integrated Industrial Policy for the Globalisation Era – Putting Competitiveness and Sustainability at Centre Stage”\(^3\). This communication calls for a refreshed approach to industrial policy to set the appropriate framework conditions to optimise the competitiveness and performance of the European industry in an increasing global world.

1.2 Study Objective

In general, the railway supply industry is seen as one of the industrial areas that is addressed by the Communication in building a competitive Europe. As such this study aims to contribute to the overall objective of the Communication, on reinvigorating Europe’s industrial policy towards its manufacturing industry, by shedding light on the competitive position of the railway supply industry, its strengths, weaknesses and future challenges.

The specific objective of the study is to contribute to the objectives of the Communication on an integrated industrial policy for the globalisation era on defining clearly the railway supply industry (RSI), its company distribution, its situation vis-à-vis the world competitors, its challenges and future perspectives.

In particular, the study aims to explore the decisive factors influencing the competitiveness or the European RSI, its capabilities to innovate, to adapt to changes, to conquer new markets, etc.

1.3 Methodological issues

1.3.1 Definitions of the sector and its sub-sectors

In general, the railway supply industry groups the manufacturers of rolling stock and locomotives, electrification, signalling, telecommunication and track equipment. Included are the manufacturers of constituents of the railway line, suppliers of telecommunication systems, control command, providers of maintenance for infrastructure and locomotives and rolling stock and other companies in the supply chain of the railway industry.

\(^3\) COM(2010)614
Excluded are companies that do not produce a physical product (operators for rail freight and passenger transport services), companies that provide civil engineering services or designers of the infrastructure, etc.⁴.

When using databases and nomenclatures such as HS, NACE, and PRODCOM, a selection of statistical codes has been made that captures the railway supply industry.

Due to data limitations, two different definitions of the railway sector have been included in this study. A first definition of the railway supply industry has been constructed in order to describe the EU railway supply industry regarding the structure of the industry as well as the interrelation with third markets through imports and exports. The nomenclatures used to this aim were Prodcom and Combined Nomenclature. A full description of the product codes, level of disaggregation and the compatibility of the product codes can be found in Annex B. A second definition of the railway supply industry is used when the EU RSI is compared with the RSI in the US, Japan, Korea and China. The explanation for this second definition stems from the need to find a common definition of RSI for the five countries. A full description of the data can be found in Annex C.

The first selection differentiates and includes the three main types of railway supply products i.e. infrastructure, rolling stock and locomotives, signalling. The second definition includes mainly rolling and locomotives stock. This explains the lack of full compatibility between some sections. This limitation was necessary in order to ensure international comparability of the EU RSI. The use of the two definitions is explicitly acknowledged in the subsequent sections.

1.3.2 Methodological issues concerning data availability

In general, the distinction between passenger and freight is most difficult in the segment of locomotives. Eurostat does only partly allow such distinction. Hence secondary data, based on literature and expert interviews, have been applied to estimate what percentage can be labelled as freight, passenger, or (very) high speed rail.

The Eurostat Structural Business Statistics only exist for the NACE rev. 1 codes. Besides, reliable data only exists for the subsector Manufacture of railway and tramway locomotives and rolling stock. These data for this subsector are, however, not consistently available to construct timelines for every indicator, e.g. for personnel costs. Furthermore, no indication can be provided on size of company (SME vs. large corporation). Equally so, valuable data on the R&D expenditure in the sector, e.g. the total intra-mural R&D expenditure and total number of R&D personnel, cannot be retrieved from Eurostat. Other sources have been used for this purpose.

Another shortcoming of the Structural Business Statistics is the availability of data for ascertaining the development of the manufacture of railway and tramway locomotives and rolling stock. The data is only available for the years 1999 until 2008. In some cases, however, the data exists only until 2007. In light of the current economic crisis, this lack of recent data presents a challenge to establish a proper overview of the state of the RSI and all its activities. Extrapolation and estimation as well as reliance on sector sources have been used at various points throughout this report to try to accommodate for the data gap in cases where Eurostat's published data have proved insufficient.

⁴ Nevertheless, it is acknowledged that the RSI should be also seen as a part of the railway sector and working together with the managers of the infrastructure and the railway undertakings (operators).
PRODCOM data are incomplete and insufficiently available at individual EU Member State level, hence one can only work with aggregated data, which makes individual country output predictions and subsequent analyses difficult.

1.3.3 Literature review
As already mentioned this study relies on information from a great variety of sources that has been used to complement the information from various statistical sources. An extensive review of relevant literature has been conducted, ranging from academic studies to commercial market reports and trade magazine clippings. Annex A provides a list of sources consulted. Where information from these sources is used in the report references are made.

1.3.4 Forecasting developments
For the medium outlook of the RSI the development of a number of indicators has been forecasted. The forecasting exercise is conducted with the E3MG model. This model has been developed by Cambridge Econometrics and includes features of short and medium term econometric methods and methods of the CGE models. This combination of different features improved the ability of the model to forecast economic variables in the short and medium term.

1.3.5 Competitor countries
To assess the competitiveness of the EU27 RSI towards its competitors a selection is made of main competing countries. Based on the current market the main competing countries are:

- China
- Japan
- Korea
- US

Although also competition may exists between Member States within the EU27, the relative competitive position between the different EU Member States is not further elaborated as the competitive position RSI in the EU27 as a whole is assessed. This also implies that intra-European trade patterns are not analysed. However, at times data are presented for individual Member States, partly due to data limitations at an EU27 level but also to show to show regional clusters and concentrations in the RSI in Europe.

1.4 Structure of this report
This study report is divided into the following chapters:

Chapter 2 defines the sector and subsectors and describes key structural data and performance of the sector and subsectors including market segments, employment, production and internal consumption. In addition, the chapter looks into the overall development and current situation of the RSI in terms of production.

Chapter 3 includes an assessment of the production characteristics of the EU rail supply industry. The structure of the sector is described (number of enterprises, production locations, consolidation in the sector, employment, added value, etc.), as well structural changes in the sector.

Chapter 4 contains an analysis and assessment of the competitive position of the EU RSI. Several indicators for competitiveness are considered including business conditions, various input indicators, which can be assumed to affect the competitive performance of the construction sector, as well as process, output and performance indicators. It also addresses key framework and
regulatory conditions that have a direct influence on this competitive position. This includes an analysis of the openness of international markets.

Chapter 6 provides the strategic outlook for the EU RSI and draws a number of recommendations to improve and safeguard its competitive position.
2 Key aspects of the sector

2.1 The EU rail sector

Railways play a key role in the European economy in providing valuable transport backbone. The EU current rail network consists of some 230.865 km of rail lines, out of which 121.108 km electrified\(^5\). Millions of people use train, tram or metro every day. There were 367.3 billion passenger-kilometres travelled on national railway networks within the EU-27 (excluding the Netherlands) in 2008; this figure was considerably higher than the 20.4 billion passenger-kilometres travelled on international journeys\(^6\). In overall terms, modal share of rail, trams and metro the in inland passenger transport in the EU was 7.3%.

The total performance of rail freight transport in the EU-27 was estimated at 389 billion tonne-kilometres in 2010\(^7\). In recent years, in Europe, the share of rail in freight transport has stabilised at around 16% (measured in ton-km and excluding short-sea shipping). This marks the end of an era where the market share of rail freight declined continuously from a level of 35% in 1970 in a context of a 3% yearly expansion of the overall freight market\(^8\).

The rail sector is a major provider of jobs and economic growth in Europe. The wide range of economic activities are tied to the overall rail sector and provided by a variety of actors, including:

- Rail Undertakings that run rail passenger and line services
- Rail infrastructure managers that are responsible for the safety, planning, construction, operation, management and maintenance of the rail infrastructure
- Rail vehicle leasing companies or Rolling stock companies (ROSCOs) that own the actual trains that run on the rails and lease these out to the rail transport operator
- Rail Regulatory and Safety bodies that are responsible for promoting and/or enforcing competition and health and safety on the railway.
- Rail supply industry which encompassed manufacturers of all products for the railway operation – i.e. manufacturers of vehicles, control and safety technologies, infrastructure as well as the suppliers and service companies belonging to them.

Goods and services provided by these actors are included in several economic subsectors, ranging from transportation, public administration and civil engineering to support service activities and manufacturing.

The study is focussed on the section of the Railway Sector that is the Railway Supply Industry. The following section provides a general description and segmentation of this industry.

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\(^5\) UIC, 2010  
\(^6\) Eurostat, September 2011  
\(^7\) Eurostat, October 2012  
\(^8\) ERA (2010)
2.2 The Rail Supply Industry

2.2.1 Rail Supply Industry

In general, the railway supply industry groups the manufacturers of rolling stock and locomotives, electrification, signalling, telecommunication and track equipment. Included are the manufacturers of constituents of the railway line, suppliers of telecommunication systems, control command, providers of maintenance for infrastructure, rolling stock and locomotives and other companies in the supply chain of the railway industry.

Excluded are companies that do not produce a physical product (operators for rail freight and passenger transport services), companies that provide civil engineering services or designers of the infrastructure, etc.

In this study, the rail supply market is defined and devised into three main dimensions:

- Geographically
- Transport segments
- Product segments

Geographical breakdown

The world market for the RSI is frequently divided into the following geographical markets:

- Europe, sometimes sub-divided in the EU15 and the EU27, or Western Europe and Eastern Europa
- Asia and Pacific
- NAFTA
- Rest of the America’s
- Africa and Middle East

In this report data will be presented for these markets depending on the availability. In the analysis of trade patterns data for the EU27 will be compared with specific countries instead of wider markets. These are countries that are considered main competitors, as well as (potential) markets for the European RSI, such as China, Japan, USA, and Korea.

2.2.2 Transport segmentation

In this report, we distinguish several types of rail: very high speed rail (VHS); mainline & regional rail; dedicated freight rail; and urban rail (metro, light rail and trams).

(Very) high speed rail (VHS)

Specific definitions for high speed rail by the European Union[^9] relate to both rail infrastructure and rolling stock and locomotives, which characteristics should be compatible. Both infrastructure and rolling stock and locomotives should be designed to facilitate speeds of the order of 200 km/h for upgraded track and at least 250 km/h on lines specially built for High Speed, while enabling speeds of more than 300 km/h to be reached in appropriate circumstances.

Other countries use slightly different definitions, for example:

- In Japan, trains on the Shinkansen network operate at speeds with maximum of 240 km/h up to 300 km/h, on a network that is almost completely separated from conventional rail lines trains

[^9]: Directive 96/48/EC
In China, there are two grades of high speed lines: Firstly, slower lines running at speeds of between 200 and 250 km/h (124 and 155 mph) which may comprise either freight or passenger trains. Secondly, passenger dedicated high speed rail lines operating at top speeds of up to 350 km/h (217 mph).

In the United States, the U.S. Department of Transportation defines it as "reasonably expected to reach sustained speeds of more than 125 mph (201 km/h)" and having a speed above 110 mph (177 km/h) by the United States Federal Railroad Administration.

According to the country, high-speed lines may be strictly dedicated, or open to fast regional trains or even freight trains.

Maximum commercial speed is about 300 km/h for the majority of national high speed railways (Japan, China, Taiwan, France, Germany, Spain, Italy, UK), although some lines reach higher commercial speeds up to 320 km/h. Maglev trains can run at speeds around 400 km/h (249 mph). The minimum distance between VHS stations is some 50 kilometre whilst HSR is best suited for journeys of 2 to 3 hours (about 250–900 km).

**Mainline & local (commuter) rail**

Most mainline rail networks facilitate both passenger and freight transport services. The passenger transport services on the main network mainly consist of **Intercity rail services** - express passenger train services connecting larger cities, covering longer distances than commuter trains, but can also accommodate **commuter rail**, depending on the country.

The distance of an intercity rail journey is usually at least 50–100 km, although in many large metropolitan areas commuter and regional services cover equal or longer distances. Speeds on intercity rail lines usually range from 100 km/h\(^{11}\) up to 180 km/h in smaller countries up to 200–250 km/h on newly-constructed or improved tracks in bigger countries. In case of the latter intercity rail could fall into the category of high-speed rail.

Most European intercity passenger trains run on the local standard gauge track and are powered by all electric, or in some cases, electro-diesel (diesel-electric configurations complemented by a connection to the power grid).

**Commuter rail**, is a passenger rail transport service that primarily operates between a city center, and outer suburbs and commuter towns. The general range of commuter trains' distance varies between 15 and 200 km. Most such trains run on the local standard gauge track and are powered by either electricity from overhead lines (or third rails) or by diesel engines.

Commuter rail trains are usually composed of multiple units. Their ability to coexist with freight or intercity services in the same right-of-way can drastically reduce system construction costs. However, frequently they are built with dedicated tracks within that right-of-way to prevent delays, especially where service densities have converged in the inner parts of the network.

**Dedicated freight rail**

Rail freight transport can take place on the main network as well as on infrastructure dedicated exclusively for freight transport. There is a large variety of wagon types hauled by locomotives powered by diesel or electric engines. In the analysis of market segments, products employed for freight operations are in the freight segment. However for the infrastructure market, mainline and

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\(^{10}\) [US Code Title 49Sec. 26105, 1/07/2011 (111-383)]

\(^{11}\) Although speeds can be as low as 50 km/h depending on the circumstances.
regional rail and (exclusive) freight are often considered as one segment and included in the mainline segment.

**Urban rail**
The urban rail segment considers products manufactured for metro, light rail and trams. Urban rail transport typically provides passenger transport services in urban areas.

**Metro** transport systems are primarily used short-distance passenger transport within urban areas. Metro usually operates with frequencies, using infrastructure with exclusive right of way. Speeds are typically less than 130 km/hr. Power supply is electric, using electric multiple units.

**Light rail** or light rail transit (LRT) systems are typically used to refer to rail systems with rapid transit-style features that usually use electric rail cars[1] operating mostly in private rights-of-way separated from other traffic although some systems share streets with car traffic. Trains usually include 1-4 railcars, carrying up to 220 passengers and traveling up to 100 km/hr. LRT mostly uses electric multiple units but can use diesel multiple units.

**Tram or streetcar** systems are to provide passenger transport services on tracks along public urban streets and also sometimes on separate rights of way. Vehicles are lightweight, typically consisting of 3-body cars with capacity of up to 180 passengers. Electricity is most often provided by overhead lines. The distinction between light rail and streetcar or tram systems is sometimes difficult to draw. There is a significant amount of overlap between the technologies, many of the same vehicles can be used for either. Therefore trams could also be seen as a subtype of light rail rather than as a distinct type of transportation.

2.2.3 **Product segmentation**
Within the RSI three main segments have been distinguished:
- Infrastructure;
- Rolling stock (including locomotives);
- Signalling and electrification technology.

**Infrastructure**
Railway infrastructure broadly breaks down into permanent way, civil engineering, power supply and signalling. The major manufactured components of the permanent way include rails (including switches and crossings), ballast, sleepers and fastenings.

The major components for the electrification sub-system are substations, overhead contact wire, catenary wire and supporting fixtures, insulators, masts or portals, transformers.

**Rolling stock and locomotives**
Rolling stock and locomotives comprises all the vehicles that move on a railway, although in several countries the term is usually used to refer only to non-powered vehicles; specifically excluding locomotives. There is a wide range of types of rolling stock, which can be broken down in various segments:
- **(Very) high speed trains** run at speeds of at least 220 km/h. The trains can consist of multiple units or can be a single carriage, with a driver's cab at one or both ends.
- **Locomotives** provide the motive power for a train. Locomotives have no payload capacity of their own, and their sole purpose is to move the train along the tracks. In contrast, some trains have self-propelled payload-carrying vehicles. A further classification of locomotives is based on their power source, mainly diesel or electricity.
Multiple Units are self-propelled carriages that consist of more than one carriage, coupling several similar carriages, and that are controlled by one driving cab. Multiple units are classified by their power source and are of two main types: electric multiple unit (EMU) or diesel multiple unit (DMU). They are primarily used for passenger transport. Sometimes a further differentiation is based on speed and/or the type of lines they serve (eg. Intercity, regional, local).

Coaches are passenger railway vehicles other than passenger railcars, and also include sleeping cars, saloon cars, dining cars, etc.

Freight wagons are railway vehicles intended for transport of goods.

Metro vehicles including two specific types of metro vehicles, those using rubber tyre wheels or those using automation.

Light rail vehicles (including trams) including both powered units and trailers

All rolling stock is built from a series of progressively more complex assemblies and subsystems that may be manufactured in-house or purchased from other railway rolling stock companies. The key process in manufacture is the final assembly but the extent to which suppliers manufacture or buy in individual components in order to do this, varies considerably. The typical main subsystems are:

- Traction equipment (for locomotives and powered rolling stock)
- Bogies/wheelsets and suspension.
- Body structures.
- Braking systems.
- Control and diagnostic systems.

Spare parts

Obviously products in this market may consist both of final end products and individual components (for example in the delivery of spare parts). This market is substantial. An indication can be found in the spending patterns of railway operators which report to spend up to 30% of their annual budgets on spare parts. Although not the specific focus of this study more information on the sub-market of spare parts has been added in Annex D.

Signalling, control and electrification

The signalling and control segment includes electro-mechanical or electrical signalling, safety or equipment for railways or tramways. Typical components include level crossing equipment, train operation and protection systems, like ETCS; train supervision and station operation systems, and rail telecommunication systems. The equipment can be part of the on-board equipment of rolling stock and locomotives, part of the infrastructure, or both.

2.3 Production process

The railway supply industry comprises three basic levels:

1. Systems, i.e. a complete railway or tramway network
2. Sub-systems include complete locomotives, vehicles, track, electrification equipment, signalling and communication

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12 Self-propelled passenger railway vehicle constructed for the conveyance of passengers. The term "railcar" is usually used in reference to a train consisting of a single carriage, with a driver's cab at one or both ends. The term is sometimes also used as an alternative name for the small types of MU.
14 According to industry figures of the EU railway operators. See also Speech of Rüdiger Grube, CEO Deutsche Bahn at the European Parliament on 8th February 2012
15 European Train Control System
3. Components are all parts required to build the subsystems

The production processes that occur in each segment or sub-sector are described here.

2.3.1 Locomotives and Rolling stock

Locomotives and rolling stock are typically complex products containing many individual components. A recent study in the USA\textsuperscript{16} identified a general structure of the value chain for rolling stock and locomotive using questionnaires for 159 (tier 2) firms in-depth interviews with 11 (tier 1) firms. They concluded that Tier 1 consists of large and small original equipment manufacturers\textsuperscript{17} (OEM) firms that, at a minimum, provide the shell (body), design, and final assembly of passenger rail vehicles—locomotives, rail cars, and both diesel and electrical multiple units (DMUs/EMUs). The Tier 1 companies are also known as system integrators and represent the large companies such as Alstom, Bombardier, Kawasaki or Siemens. These system integrators tend to keep the high-value roles, such as design, engineering, and systems integration near their home headquarters, or at least near the largest markets they serve.

Tier 2 is divided into three systems: propulsion, electronics and body and interior. Each of these systems includes several major components, which are listed in the figure below. The Tier 2 manufacturers integrate parts (e.g., steel plates, frames, couplers, brake components, wheels) and assemblies (e.g., communications gear, engines, motors, transmissions, trucks) into systems. Suppliers of major systems, such as air brakes and engine controllers, work with locomotive and rail car manufacturers to assure safe and efficient integration of their products during assembly. A limited number of manufactures within Tier 2 are also active in Tier 1 and provide their own subsystems (mainly propulsion systems) and in some cases supply them to other OEMs.

Tier 3 includes firms that supply parts and materials to companies in the top two tiers.

\textsuperscript{16} Marcy Lowe, Soari Tokuoka, Kristen Dubay and Gery Gereffi, “U.S. Manufacture of Rail Vehicles for Intercity Passenger Rail and Urban Transit, A value chain analysis, Center on globalization, June 24th 2010

\textsuperscript{17} Original equipment manufacturers, or firms at the end of the supply chain that assemble the final product.
2.3.2 Infrastructure

Concerning the infrastructure segment, a distinction is made in raw material, basic products and assembling. The raw material consists of steel, concrete and ballast, which are manufactured in rails, fastenings and spikes, track components and equipment, base plates and mats and sleepers.
The railway infrastructure segment is, as mentioned before, characterised by local production of raw material (steel, concrete, ballast) as well as some of the base products. The reason being costs, transport costs of these products make them uncompetitive compared to locally (or at least as close as possible to the location) produced products.

In the infrastructure segment two elements provide high added value, namely ballast less track and points and crossings. These are specialised products, in particular the points and crossings for (very) high speed rail. Vossloh Gogifer (France) is one of the worldwide leaders in points and crossings for (very) high-speed railways, heavy-haul railways, metros and tramways.

Signalling, control and electrification

The signalling and control segment is closely linked to the rolling stock and locomotives segment. Electrical equipment is needed in both the vehicles and the infrastructure. The main sub-systems are train protection equipment, train operation equipment and train supervision equipment. Typical components are now electronic products, including complex software with high levels of safety integrity; radio based communications and advanced forms of display screen used for signalling control, information and communication systems.18

Many of the applications and components used in this segment are also extensive used in other industries, ranging from very high industries to basic industry. However, the high level of safety plus the special interface issues associated with railway applications means that despite this there is still a large degree of specialisation.19

18 Interfleet, 2007
The large EU (e.g. Siemens and Bombardier) and international (e.g. Hitachi) system integrators also provide electric components. The main added value components are the software development, testing and verification.

Railway electrification provides traction energy to trains. There is a wide variety of electric traction systems around the world, which have been built according to the type of railway, its location and the technology available at the time of the installation. The energy is usually generated in large-scale generating stations and conveyed to the trains by transmission lines to the railway. Transmission of power is always along the track by means of an overhead wire or at ground level, using an extra, third rail laid close to the running rails. Through a (continuous) contact conductor energy can be transferred to trains.

Electrification systems are classified by three main parameters: Voltage, Current and Contact System:

**Voltage**

There are many different voltage systems used for railway electrification systems around the world. The nominal voltage of the six most common electrification systems are 600 V, 750 V, 1500 V, 3 kV, 15 kV and 25 kV. In Europe, some locomotives are equipped to operate under four voltages - 25 kV AC, 15kV AC, 3,000 V DC and 1,500 V DC.

**Current**

Electrification systems use either DC (direct current) or AC (alternating current), the former being, for many years, simpler for railway traction purposes, the latter being better over long distances and cheaper to install but, until recently, more complicated to control at train level.20

**Contact System**

There are two main contact systems: overhead line (catenary) and third rail. In the case of overhead systems the contact conductor is usually a contact wire suspended in a catenary wire system to maintain accurate registration of geometrical position. The trains have a pantograph mounted on the roof, which supports conducting strips held in contact with the contact wire by a spring system.

The third rail system uses a "shoe" to collect the current on the train. Third rail systems can be designed to use top contact, side contact or bottom contact (see figure above). Third rail is

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20 Railway technical webpages, april 2012.
more compact than overhead wires and therefore more often used in inner urban areas where part of the track runs underground.

AC systems always use overhead wires, DC can use either an overhead wire or a third rail; both are common. Most third rail systems use DC.

Few companies manufacture solely for the rail industry and solely for electrification. Some RSI companies in electrification offer complete systems, turn key or BOT (built operate transfer), but act only as a contractor to the client. Components for the whole system might come from smaller companies, specialized in specific products, like copper cables, transformers, switchgear, poles and other equipment. These specialized small or medium sized companies usually serve the public power supply market as well and normally do not show the portion of rail products within their total activity.

2.4 Rail supply industry market volume

2.4.1 Global market

World wide, the installed base of rail track has now reached approximately 1.6 million kilometres—i.e. 40 times the circumference of the earth—with an estimated 5.2 million units of rolling stock deployed on this network. In addition, there are currently some 400 light rail systems with more than 44,000 rail vehicles in operation. As the figures below illustrate, the general trend in both rail freight and passenger transport over the past decade, is one of growth.

The economic recession of 2009 that affected large parts of the world, had a negative impact on rail transport and the rail supply industry that - after the rail supply market boom years of 2007 and 2008 – showed a decline. In particular the demand for rail freight transport dropped, resulting in fewer rolling stock and locomotives orders, especially in the US, Europe, and CIS. Nevertheless,
the demand for both rail transport and rail supply recovered quicker than expected from the economic crisis and is expected to continue to grow in coming years. To facilitate this demand, large investments are required to maintain and replace rail infrastructure and rolling stock and expand the rail network and rolling stock numbers.

Estimates on the current and future market for the rail supply industry vary across various sources, mainly depending on the differences in definitions used and differing market assessments.

Consecutive studies ordered by UNIFE in 2008 and 2010 estimated that the total rail supply market grew from 122 billion euro to 136 billion euro, comparing three-year averages for 2005–07 and 2007–09 (see figure 2.5).

Figure 2.5 World market for rail supply industry by product segments, billion euro and compound annual growth [%].


It is noted that the UNIFE studies, also distinguish ‘services’ as a separate segment. The services segment covers all labour and parts required to install the systems and maintain the infrastructure and rolling stock. In contrast to the UNIFE studies, this report adopts infrastructure, rolling stock and locomotives, signalling & control as the main rail product segments. A similar breakdown is also used in another recent rail supply market study. In this study the current RSI market was estimated at 131 billion Euro in 2010, consisting of 42 billion Euro of infrastructure, 74.3 billion Euro of rolling stock and locomotives and 14.7 billion Euro signalling and control systems.

Apart from market size, access to markets for industry players is important. Depending on trade and non-trade barriers, some geographical markets are only partly inaccessible to producers from other trading blocs. In further sections of this report, more detailed information on these barriers is provided.

Given the large installed base of rail infrastructure and rolling stock and locomotives, it is not surprising that service, replacement, and renewal are key drivers of the global rail supply market.

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22 The Compound Annual Growth Rate (CAGR) is the year-over-year growth rate and is calculated by taking the ‘n’th root of the total percentage growth rate, where n is the number of years in the period being considered.

An estimated 39% of the market in 2007–09 was in services. In addition, an estimated 58% of the infrastructure and 44% of the rolling stock and locomotives segment were replacement orders.

For decades, the maintenance of rolling stock and infrastructure was carried out by the maintenance divisions of the state railways. Still some 70% of the total market is accounted for by rail companies, who maintain their own vehicles. However, with the increasing degree of liberalisation and the disintegration of the incumbent railway operators, the number of actors in the railway sector has multiplied. In addition, railway operators and infrastructure managers are increasingly concentrating on their core business. As a result maintenance activities are becoming outsourced to third parties instead of relying on in-house maintenance divisions. With new rolling stock the maintenance is increasingly performed by the original manufacturer that hold contract for both the delivery and maintenance of rolling stock.

In terms of growth, infrastructure has shown the biggest growth in the past few years, just slightly higher than rolling stock and locomotives. The main drivers are the increased investment in various rail networks around the world, most importantly the massive orders for the build-up of the Chinese VHS, mainline and urban rail networks. China’s market for rail equipment, including trains, components, signalling systems and other equipment is expected to quintuple from an average of $10bn a year in the period between 2004 and 2008 to more than $50bn a year between 2009 and 2013, according to estimates from McKinsey24.

Apart from growing investments by China and other countries, various economic stimulus packages, introduced by various governments around the world to counter the economic crisis, have contributed to the growth of all product segments. For example, Germany’s stimulus funds to counter the economic crisis injected some $1.8 billion in rail transport on a one-time basis. This was on top of the annual investments in rail infrastructure that increased from slightly less than $5 billion in 2008 to $5.6 billion in 2011. At the same time in the USA, the Obama administration’s 2009 economic stimulus bill provided a one-time boost of $17.7 billion25.

Looking at transport segments, the figure below shows that mainline and freight are by far the largest segment. It also shows that Very High Speed (VHS) rail is the fastest growing segment. In the past decade several countries in Europe and Asia have invested heavily in the expansion of their VHS system. Japan, followed by France, Spain and Germany had the largest VHS systems in 2008. However China is rapidly overtaking the leading position in the high speed segment. In the past two years, hundreds of kilometres of new high speed line have been opened and China is seeking to expand its network even further with the goal of linking all provincial capitals with bullet trains.

25 Worldwatch Institute, 2010.
The figure below shows the current market volumes per region, as well as the expected growth until 2015. Here, Western Europe is still the largest market in 2010, marginally bigger than Asia/Pacific. In the earlier mentioned study by BCG for UNIFE\(^26\) it is estimated that Asia/Pacific has already overtaken Western Europe as the largest market.

It is expected that the overall market will grow up to 160 billion Euro in 2015 and annual growth of some 4.1\(^27\). These predictions are somewhat higher, but still in the same order of magnitude as the forecasts made for UNIFE that expect the rail supply market to continue to grow at 2.0\% to 2.5\%, resulting in an overall market volume of 153 billion Euro to 157 billion Euro in 2015.

\(^{26}\) BGG, 2011.  
\(^{27}\) SCI Verkehr 2010
Asia/Pacific is expected to be the largest market in 2015. The growth is mainly driven by the large investments in VHS systems particularly in China. By 2015, the number of VHS trainsets in operation worldwide is expected to rise by 70 per cent, to 3.725. Listed in order of their track-building ambitions between now and 2025, the front runners include China, Spain, France, Japan, Turkey, Germany and Italy\textsuperscript{28}.

Also growth in the Americas is largely caused by investments in VHS and the introduction of PTC that are expected to take place in the US towards 2015 as part of the recent commitment of $8 billion in stimulus funds to HSR. At the same time Russia is expected to invest heavily to replace the enormous vehicle fleet (freight in particular) and in VHS connecting the host cities of the FIFA world cup tournament in Russia in 2018.

Looking at product segments\textsuperscript{29} rolling stock and locomotives remains to be the largest product segment, followed by infrastructure and signalling and control. Rolling stock and locomotives is largely a replacement market, particularly in Europe, Russia and the US. In terms of growth rates, growth in the infrastructure segment is expected to be 1-2\% lower than for rolling stock and locomotives and signalling and control systems that are expected to grow around 2-3\% annually up to 2015. As orders for rolling stock and locomotives and particularly signalling and control systems usually lack behind orders for infrastructure by a couple of years, growth rates for these products are expected to be higher than those for infrastructure.

2.4.2 RSI Production

The previous section described the global distribution of the demand for the rail supply industry. This section provides an estimate of the production within the geographical markets that takes place to fulfil this demand. At a world wide level, comparable data for production is only available for locomotives and rolling stock\textsuperscript{30} and not for the signalling or infrastructure market segments.

\textsuperscript{28} Worldwatch Institute, 2010.
\textsuperscript{29} See annex for more details on expected growth by product segments.
\textsuperscript{30} Using data from NACE Rev 1 section 35.2 and UN COMTRADE
The table below provides the overview of production and consumption of locomotives and rolling stock in various geographical markets. It shows that the EU is the largest manufacturer of rolling stock and also had the largest domestic market (consumption), followed by China.

### Table 2-1 World wide production of locomotives and rolling stock (2009)

<table>
<thead>
<tr>
<th></th>
<th>Production (bn €)</th>
<th>Consumption (bn €) (a)</th>
<th>Export intensity (%) (b)</th>
<th>Import Penetration (%) (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>22,2</td>
<td>19,5</td>
<td>18%</td>
<td>6,4%</td>
</tr>
<tr>
<td>US</td>
<td>9,3</td>
<td>8,6</td>
<td>16%</td>
<td>8,8%</td>
</tr>
<tr>
<td>Japan</td>
<td>2,9</td>
<td>2,4</td>
<td>24%</td>
<td>6,3%</td>
</tr>
<tr>
<td>Korea</td>
<td>1,7</td>
<td>1,6</td>
<td>12%</td>
<td>7,5%</td>
</tr>
<tr>
<td>China</td>
<td>17,8</td>
<td>18,2</td>
<td>4%</td>
<td>6,2%</td>
</tr>
</tbody>
</table>

Notes:

a) Consumption is calculated as (Production – Exports) + Imports.

b) Export intensity is calculated as (Exports / Production) *100.

c) Import penetration is calculated as (Imports / Consumption) *100

Source: COMTRADE

From the export intensities it also becomes apparent that domestic markets are by far the most important markets for the five countries and production largely takes place to fulfil the demand on domestic market. Depending on the country, 86% to 96% of the production is to supply the respective local markets. It also shows that in Japan and the EU export has a larger relative importance compared to China and Korea.

The import penetration ratios show the share of the domestic demand for RSI is being met by foreign producers rather than from domestic production. Import penetration is relatively low for all the countries. In the following sections and chapters the global spread of RSI production and trade is explored in more detail.

### 2.5 Rail supply trade patterns

Following the description of the global market and geographical distribution of production for the RSI, this section provides an overall analysis of global trade patterns for the EU. A more detailed assessment of the position EUs RSI in the global market is provided in chapter 4, comparing its position to main competing countries and assessing its competitiveness.

#### 2.5.1 EU external trade: exports and imports

**Overall Railway Supply Industry**

Figures 2.9 and 2.10 show the total value of exports and imports for the RSI in the EU. The figures demonstrate the overall growth in both exports and imports of the RSI in the EU throughout the major part of the past decade. The graph also shows the drop in export and import following the economic crisis in 2009.

It is clear that rolling stock and locomotives is the most important segment in EU trade. However, there are differences between exports and imports. Whilst rolling stock and locomotives represents around 70 per cent of EU railway exports across the period of analysis, for EU imports rolling stock constitutes a little less than half of the total import and has a more or less equal share in imports as
infrastructure. Also it should be acknowledged that on average and in absolute terms, EU RSI exports are two times bigger than imports.

The following sections provide a more detailed analysis of EU trade per segment.

**Figure 2.8 Distribution of EU railway industry exports: Total value (€ million)**

Source: UN COMTRADE

**Figure 2.9 Distribution of EU railway industry imports: Total value (€ million)**

Source: UN COMTRADE

**Locomotive and rolling stock**

The EU has increased its total trade - exports and imports - of locomotives and rolling stock. The level of exports has increased almost continuously between 2002 and 2010 reaching its peak in the last year. Imports have increased as well, although, at a lower rate. Even though, the economic crisis has affected trade in locomotives and rolling stock, decreasing the amount of exports in 2008, the additional years in the series – 2009 and 2010 – shows a positive development in exports. This is in contrast with EU imports which have declined since they peaked in 2008. As a result of these
changes in exports and imports, the EU shows a positive trade balance\textsuperscript{31} in 2010 for this segment vis-à-vis the rest of the world equal to 4161 € million.

**Figure 2.10 EU external trade in locomotive and rolling stock: Total value (€ million)**

Source: UN COMTRADE

**Infrastructure**

Regarding infrastructure, exports and imports have been following a close path during the analysed period, increasing together with the raise in overall demand for the railway within and outside Europe. From 2008, however, imports to the EU suffered a considerable drop whilst exports slowdown but at a lower rate and recovered faster in the last year reaching a peak in 2010. As a result, the trade balance in 2010 shows a positive surplus equal to 650€ million.

**Figure 2.11 EU external trade in infrastructure: Total value (€million)**

Source: UN COMTRADE

\textsuperscript{31} Trade balance is calculated as export minus imports.
**Signalling and electrification**

The EU recorded a marked increase in its exports of signalling and electrification during the period analysed. The Compound Annual Growth Rate (CAGR)\(^{32}\) for EU exports and EU imports is equal to 12 per cent and 8 per cent respectively. The level of exports peaked in 2010, however, imports reached its peak during 2008, but have remained subdued thereafter. Thus, trade balance in 2010 shows a positive surplus equal to 311€ million.

![Figure 2.12 EU external trade in signalling and electrification: Total value (€million)](image)

Source: UN COMTRADE

**2.5.2 EU external trade: origin of EU imports**

**Overall Railway Supply Industry**

Although the level of EU imports in the railway industry is much lower than EU exports, it is important to highlight the most significant source of imports outside the EU. In this regard, in 2010 the United States (24%), Switzerland (17%), Japan (12%), China (7%) and India (6%) were the most important source of railway imports. Even though, the US lost market share during the period still remains the most important source of imports. The remaining countries maintained relatively stable shares between 2002 and 2010.

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\(^{32}\) The CAGR refers to the year-over-year growth rate over a specific period of time. The mathematical formula used is the following: \(\text{CAGR} = \left( \frac{\text{Final year value}}{\text{First year value}} \right)^{\left(\frac{1}{\text{(Number of years)}}\right)} - 1\)
In 2010, the main supplier of locomotive and rolling stock to the EU are the United States (35%), followed by Switzerland (19%), Japan (17%), India (5%), and China (5%). These countries constitute 82 per cent of EU total imports in this segment. The United States, Switzerland and Japan are the most important suppliers maintaining their shares during the whole period.

Infrastructure
As it was mentioned before, EU imports in railway infrastructure declined significantly after the peak of 2008 and experienced a slight recover in 2010. In 2010, the main suppliers of railway
infrastructure to the EU were the United States (21%), Switzerland (19%), China (17%), Norway (15%) and Japan (13%). There is a surge in railway infrastructure imports from China to the EU between 2006 and 2008. This trend, however, changed in 2009 and Chinese imports remained flat in the following year.

**Figure 2. 15 extra-EU imports of infrastructure by main source country (€ million)**

![Graph showing extra-EU imports of infrastructure by main source country.](image)

Source: UN COMTRADE

**Signalling and electrification**

Switzerland is the most important supplier of signalling and electrification products. In 2010, 40 per cent of EU imports in this segment were supplied from this country alone. Swiss companies are integrated within the EU supply chain of signalling and electrification. This can be seen from the significant share of EU imports and exports in this segment. Other important suppliers are the United States (25%), China (5%), Canada (5%) and Turkey (5%).

**Figure 2.16 extra-EU imports of signalling and electrification by main source country (€ million)**

![Graph showing extra-EU imports of signalling and electrification by main source country.](image)

Source: UN COMTRADE
2.5.3 EU external trade: destination of EU exports

Overall Railway Supply Industry
The figure below shows the most important destinations for European railway exports. These are China (19%), the United States (12%), Switzerland (8%), Turkey (7%) and Brazil (6%) representing 52 per cent of EU exports in the railway industry. Especially the considerable increase of China is remarkable, becoming the first destination market of EU exports in the railway sector doubling its market share between 2002 and 2010. The other half of EU exports in the railway sector remains scattered across many different markets. Those markets are important for EU exporters, maintaining its share of around half of EU exports in the railway industry throughout the whole period.

Figure 2.17 EU exports in RSI by destination (€ million)

Source: UN COMTRADE

Locomotive and rolling stock
As mentioned in the previous section, locomotive and rolling stock represent the lion’s share of EU exports in the railway sector. China (21%) is the most important market for European producers, followed by the United States (13%), Switzerland (8%), Turkey (7%) and Australia (5%). In 2010, these countries made 54 per cent of the EU total exports in locomotives and rolling stock.
Figure 2.18 EU exports in locomotive and rolling stock by destination (€ million)

Source: UN COMTRADE

**Infrastructure**

In 2010, the main destination countries for EU exports in railway infrastructure were China (12%), Brazil (10%), the United States (10%), Switzerland (10%) and Turkey (8%). These countries represent half of the EU total exports in infrastructure. Within this group of five top-destinations, emerging economies such as China, Brazil and Turkey have become relatively more important whilst the United States and Switzerland have lost market share as a destination of EU exports in railway infrastructure. In addition, the other half of the EU exports remains scattered across other countries which have maintained its relative share during the analysed period.

Figure 2.19 EU exports in infrastructure by destination (€ million)

Source: UN COMTRADE

**Signalling and electrification**

In 2010, European producers of railway signalling and electrifications products exported mainly to China (20%), Turkey (9%), Saudi Arabia (9%), Brazil (8%) and Switzerland (6%), making half of EU exports in this segment. Since 2008, Turkey, Saudi Arabia and Brazil are important markets for EU
exports in signalling and electrification, however, other countries such as Switzerland and the United States have become relatively less important reducing its market share.

Figure 2.20 EU exports in signalling and electrification by destination (€ million)

Source: UN COMTRADE
3 EU Railway supply industry production characteristics

This chapter contains a further elaboration of the characteristics of the Railway supply industry in the EU27. The content of this chapter is based on data from official statistics, literature analysis, annual reports and expert interviews.

The previous chapter showed that the locomotive and rolling stock segment is, in terms of production volume, the most important segment. At the same time this segment is also the easiest identifiable product segment not only in data sources, but also in terms of companies. The other segments, such as signalling are quite often produced by companies which supply many other industrial sectors in society and are hence more heterogeneous. As a result the analytical part of this chapter has a focus on locomotive and rolling stock, in comparison to the other two key segments rail infrastructure and signalling and electrification.

3.1 Enterprises, employment and production locations

3.1.1 Locomotive and rolling stock

The number of enterprises in locomotives and rolling stock in the EU was 1,167 in 2007. Over the period 2000-2007 the number of enterprises has shown a steady increase.

<table>
<thead>
<tr>
<th>Year</th>
<th>EU27</th>
<th>EU25</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1071</td>
<td>690</td>
</tr>
<tr>
<td>2001</td>
<td>1100</td>
<td>779</td>
</tr>
<tr>
<td>2002</td>
<td>1120</td>
<td>837</td>
</tr>
<tr>
<td>2003</td>
<td>1071</td>
<td>900</td>
</tr>
<tr>
<td>2004</td>
<td>1100</td>
<td>943</td>
</tr>
<tr>
<td>2005</td>
<td>1120</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1167</td>
<td></td>
</tr>
</tbody>
</table>

Source: Eurostat – SBS

Geographically, in 2007, Poland (14%), the UK (13%) and Italy (13%) had the largest share of EU manufacturing enterprises on their territories, followed by Germany (10%), Spain (9%), Romania (8%), Hungary (7%), France (6%), Czech Republic (4%) and Sweden (4%) (see table 3.2). Together they cover more than 80% of all enterprises in the EU27. In the total number of enterprises manufacturing railway and tramway locomotives and rolling stock some 60% are located in the EU-15 countries.34

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33 Empty cells correspond to existing data gaps in Eurostat – SBS (2002 data intrapolated). No data at EU27 level are available for 2006, however for most Member States 2008 data are available. More recent data are available, however these exclude the production of tramway rolling stock, making them incomparable with the data presented above. For this reason they have not been included in the above overview.

34 This share is based on figures of 2007, which is the latest complete set of figures available through Eurostat, Structural Business Statistics
Table 3.2: Number of enterprises in railway, tramway locomotive and rolling stock by main Member States ordered by rank in 2007³⁵

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>121</td>
<td>128</td>
<td>122</td>
<td>139</td>
<td>158</td>
<td>189</td>
<td>5,1%</td>
<td>10,2%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>126</td>
<td>151</td>
<td>158</td>
<td>161</td>
<td>156</td>
<td>n.a.</td>
<td>2,7%</td>
<td>1,1%</td>
</tr>
<tr>
<td>Italy</td>
<td>71</td>
<td>121</td>
<td>140</td>
<td>154</td>
<td>155</td>
<td>168</td>
<td>10,0%</td>
<td>8,6%</td>
</tr>
<tr>
<td>Germany</td>
<td>99</td>
<td>121</td>
<td>131</td>
<td>112</td>
<td>111</td>
<td>96</td>
<td>-0,3%</td>
<td>-5,6%</td>
</tr>
<tr>
<td>Spain</td>
<td>52</td>
<td>66</td>
<td>79</td>
<td>89</td>
<td>103</td>
<td>106</td>
<td>8,2%</td>
<td>12,6%</td>
</tr>
<tr>
<td>Romania</td>
<td>50</td>
<td>108</td>
<td>106</td>
<td>102</td>
<td>96</td>
<td>n.a.</td>
<td>8,5%</td>
<td>-3,9%</td>
</tr>
<tr>
<td>Hungary</td>
<td>16</td>
<td>88</td>
<td>83</td>
<td>85</td>
<td>87</td>
<td>89</td>
<td>21,0%</td>
<td>0,3%</td>
</tr>
<tr>
<td>France</td>
<td>65</td>
<td>61</td>
<td>59</td>
<td>60</td>
<td>72</td>
<td>n.a.</td>
<td>1,3%</td>
<td>5,7%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>63</td>
<td>60</td>
<td>55</td>
<td>52</td>
<td>51</td>
<td>n.a.</td>
<td>-2,6%</td>
<td>-5,3%</td>
</tr>
<tr>
<td>Sweden</td>
<td>28</td>
<td>52</td>
<td>49</td>
<td>43</td>
<td>49</td>
<td>n.a.</td>
<td>7,2%</td>
<td>-2,0%</td>
</tr>
<tr>
<td>Slovakia</td>
<td>11</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>18</td>
<td>n.a.</td>
<td>5,6%</td>
<td>13,1%</td>
</tr>
<tr>
<td>Austria</td>
<td>10</td>
<td>10</td>
<td>n.a.</td>
<td>n.a.</td>
<td>13</td>
<td>14</td>
<td>3,8%</td>
<td>8,8%</td>
</tr>
<tr>
<td>EU27</td>
<td>790</td>
<td>1.071</td>
<td>1.100</td>
<td>1.120</td>
<td>1.167</td>
<td>n.a.</td>
<td>5,0%</td>
<td>2,9%</td>
</tr>
</tbody>
</table>

Source: Eurostat – SBS

In terms of growth of the number of enterprises over the past 8-9 years³⁶ most countries have shown increases, with the exception of Czech Republic (where the number of companies reduced from 63 to 51) and Germany (which showed a stabilisation over the whole period). Some countries, viz. Italy, Spain, Hungary and Romania, showed a strong growth in the number of enterprises, pointing to an increase in rail based transport systems in these countries and possibly a shift of labour intensive activities towards lower-cost Member states. Another factor which is expected to play a role in this respect in the restructuring of rolling stock manufacturers in Member States (e.g. Czech Republic).

**Concentration worldwide within a limited number of large enterprises**

Whereas the total number of enterprises is relatively large and has shown a continuous increase, at the same time a process of consolidation has taken place (combining different enterprises in larger industrial companies), leading to a situation in which a number of large companies are clearly dominating the scene. As such the number of enterprises alone, only partially sets the scene as these enterprises may be part of a larger company.

Industry data show that the locomotives and rolling stock market is worldwide dominated by 30 to 40 and locomotives and rolling stock manufacturers who cover more than two third of the whole and locomotive and rolling stock production. In addition, thousands of small and medium-size companies operate along the supply chain as well, providing critical inputs such as brakes and articulation systems³⁷.

In 2005, the total sales of the three largest players at the time - Bombardier, Alstom, and Siemens - equalled roughly half of the world’s rail vehicle market³⁸. Turnover estimates for locomotive and rolling stock manufacturers from 2009 are presented below, showing that Bombardier and Alstom have maintained their leading positions, but Chinese manufacturers China South Locomotive and

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³⁵ Romania data for 1999 are 2000 data. Total number of enterprises EU27 on a EU27 level is estimated using data from 2000 where unavailable.

³⁶ For some countries this refers to 1999-2007 whereas for others this refers to 1999-2008 depending on data availability.

³⁷ Worldwatch Institute, 2010.

Rolling Stock Corporation Ltd (CSR) and China CNR Corporation Limited (CNR)\textsuperscript{39}, have now moved into third and fourth place, mainly through the strong growth of their home market.

**Figure 3.1 Top 10 rolling stock manufacturers by turnover**

![Figure 3.1 Top 10 rolling stock manufacturers by turnover](image)

\* not in 2008 top 10

Source: SCI Verkehr, the world market for railway technology, 2010

The total number of employees in the locomotive and rolling stock segment equals approx. 155,750\textsuperscript{40}. The overall figure has decreased with some 5\% in the period 2004-2007. For those countries for which 2008 data are available, 2008 showed again a relative strong growth of roughly 10\%, thus eliminating the decrease over the previous period\textsuperscript{41}.

| Table 3.3: Employment in the locomotive and rolling stock segment in selected EU-Member States\textsuperscript{42} |
|---------------------------------|--------|--------|--------|--------|--------|--------|
| Germany                         | 28,625 | 28,582 | 26,329 | 27,394 | 28,882 | 0,2\%   |
| Romania                         | 27,346 | 24,766 | 23,190 | 22,570 | n.a.   | -6,2\% |
| Poland                          | 17,367 | 17,484 | 17,449 | 18,372 | 18,788 | 2,0\%   |
| France                          | 14,297 | 13,952 | 13,465 | 13,723 | n.a.   | -1,4\% |
| Italy                           | 10,946 | 11,367 | 11,902 | 12,410 | 12,002 | 2,3\%   |
| Spain                           | 9,279  | 8,968  | 10,431 | 11,194 | 11,997 | 6,6\%   |
| Czech Republic                  | 10,327 | 10,628 | 10,794 | 11,065 | n.a.   | 2,3\%   |
| United Kingdom                  | 12,759 | 10,979 | 10,027 | 10,459 | n.a.   | -6,4\% |
| Hungary                         | 6,444  | 6,348  | 5,191  | 6,321  | 8,979  | 8,6\%   |
| Slovakia                        | 6,328  | 5,530  | 4,959  | 5,147  | 5,877  | -1,8\% |
| Austria                         | 4,930  | n.a.   | n.a.   | 4,671  | 8,536  | 14,7\% |
| Sweden                          | 4,888  | 4,627  | 4,515  | 4,631  | n.a.   | -1,8\% |
| EU27                            | 163,550| 160,600| 155,000| 155,750| n.a.   | -1,6\% |

Source Eurostat, SBS

Again patterns differ between countries, with some countries (e.g. Spain, Hungary, Austria) showing growth in employment whereas other (e.g. UK, Romania) show clear decreases.

\textsuperscript{39} Commonly known as CSR – formerly the China Northern Locomotive & Rolling Stock Industry (Group) Corporation

\textsuperscript{40} 2007 data, the latest year for which complete data coverage for the EU27 is supplied by Eurostat.

\textsuperscript{41} This conclusion should be treated with care as Eurostat does not produce figures for a number of major production countries (France, Czech, Romania, UK and Sweden).

\textsuperscript{42} EU Member States have been selected according to their total employment figures for 2007, since this year delivered a complete set of data. Some member states, e.g. Denmark, Belgium, the Netherlands, were not considered, since Eurostat – Structural Business Statistics does not show any records.
Apart from direct employment the rail supply industry generates indirect employment (mainly in the supply industry to the RSI). Data for Germany (being the main EU employer in RSI locomotive and rolling stock) provide an example for these indirect jobs. German industry data indicate direct employment in the rail industry of 45,000 in 2008. This is much higher than the data presented above, however this is explained by the fact that the definition of the rail industry used is much broader than only rolling stock. The German statistics show that the number of direct jobs has remained stable in the period 2009-2011. In addition, the number of indirect jobs is around triple the size of the direct jobs.

Table 3.4 Number of jobs in the rail industry – Germany

<table>
<thead>
<tr>
<th></th>
<th>first half year 2011</th>
<th>2010</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct jobs</td>
<td>48,100</td>
<td>45,800</td>
<td>44,800</td>
</tr>
<tr>
<td>Indirect jobs</td>
<td>approx. 150,000</td>
<td>approx. 150,000</td>
<td>approx. 150,000</td>
</tr>
</tbody>
</table>

Source: VDB, 2012

Data for the UK indicate that about 80,000 employees are working in the railway supply industry, defined as the suppliers of infrastructure, engineering and services in 2006. Again, this figure is much higher than official Eurostat statistics since it also includes services.

The average number of employees per enterprise for the EU27 equals 134 (based on 2007 data). Large differences exist between countries.

Figure 3.2 Average number of employees per enterprise by main Member State and EU27 (2007)

Source: Ecorys, based on Eurostat SBS data

In terms of employment, figures confirm the strong position of Europe in the global arena (see text box below).

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43 The size of these indirect jobs can not be explained from the information available.
44 Source: Skills Needs Assessment Sector Skills Agreement Stage I, Rail Industry, GoSkills Moving skills forward, 2006
Employment in non-EU countries

**Japan** has been a pioneer in high-speed rail development and continues to be a global leader. Some 25,000 people are employed in the production of rail equipment, parts, and signal and safety equipment in Japan, with many times more employed in component parts supply chains.

**China**’s two dominant rail manufacturing companies, CSR (China South Locomotive and Rolling Stock) and CNR (China Northern Locomotive and Rolling Stock) together employ more than 200,000 people directly.

**USA**
Manufacture of passenger and transit railcars and locomotives comprises an estimated 10,000 to 14,000 U.S. jobs. These represent a market that to date has been limited by much lower investments in passenger and transit rail than those of the nation’s economic competitors

Sources: Worldwatch Institute (2010), Center on Globalization (2010)

The above employment figures clearly reflect the location of the large production locations of Europe’s main players (see text box below). Major part of the production is carried out within Europe. It also shows that production locations are often spread across different European countries, whereas in a number of competing countries often production is more concentrated in a number of large manufacturing plants.

**Company data locomotive and rolling stock manufactures Bombardier, Siemens and Alstom**

**Alstom Transport (France)**
- Turnover: 6.000 mEuro
- Employees: 25.000
- Production locations: France (4.400 empl.), Germany (2.100), Italy (1.800), Poland (420), Spain (350), Switzerland (100), Brazil (1.200 ), USA (850)

**Bombardier Transport (Germany)**
- Turnover: 7.000 mEuro
- Employees: 35.000
- Production locations: Austria (450 empl.), Belgium (600), France (1.680), Germany (5.100), Hungary (700), Italy (500), Sweden (1.000), Switzerland (150), UK (2.000), Australia (300), Canada (870), India (1.000), Mexico (1.100), USA (480)

**Siemens (Germany)**
- Turnover: 6.500 mEuro
- Employees: 18.000
- Production locations: Austria (1.200 empl.), Czech Rep. (950), Germany (3.100), Slovenia (322)
  - India (n.n.), China (n.n.), Russia (n.n.), USA (n.n.)

This is also indicated if worldwide production sites are compared. Worldwide production takes place on some 330 sites, of which the top 50 companies operate 153 production sites for new vehicles worldwide. The figure below shows that with 66 production locations, the EU is still holds the largest number of production locations as compared to the other main market areas, North America and Asia.

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45 Source: annual reports, expert judgement on number of employees in rolling stock
46 Source: SCI Verkehr, the world market for railway technology, 2010
Whereas Europe (Western + Eastern Europe) is dominating in terms of production sites, Asia ranks first in production capacity\textsuperscript{47}. This is a clear indication for the stronger concentration in large scale production facilities in competing countries and the comparatively small-sized production at European rolling stock locations.

\textbf{3.1.2 Railway infrastructure}

Whereas Europe (Western + Eastern Europe) is dominating in terms of production sites, Asia ranks first in production capacity\textsuperscript{47}. This is a clear indication for the stronger concentration in large scale production facilities in competing countries and the comparatively small-sized production at European rolling stock locations.

Whereas Europe (Western + Eastern Europe) is dominating in terms of production sites, Asia ranks first in production capacity\textsuperscript{47}. This is a clear indication for the stronger concentration in large scale production facilities in competing countries and the comparatively small-sized production at European rolling stock locations.

Worldwide, in terms of number of enterprises, a total of 255 companies are currently operating in the market for railway infrastructure\textsuperscript{48}. These companies trade in various products (see figure 3.4). In general it is observed, that the rail infrastructure segment is characterized by a comparably high degree of product specialization. Half of the companies focus on providing just one product.

\textsuperscript{47} Based on consultants estimation production capacity. In terms of production capacity the US ranks above Western Europe.

\textsuperscript{48} Source: Railway directory and Innotrans database. Rail ballast suppliers are excluded here.
Europe’s dominance is clearly shown by the fact that the enterprises are mainly located in the Europe (64%), with 56% located in the EU15 member states, 5% in the EU12 member states and 3% in Switzerland. The NAFTA member countries and Asia can be considered as main competing grounds in terms of total enterprises. Concerning the location of production plants, it is noted that a large number of components is mainly being produced locally, e.g. rails, fastenings and sleepers. The high value components, such as ballast less track and points and crossings are mainly produced in the EU.
In terms of brands, these 255 companies can be allocated to 215 brands in the railway infrastructure.\textsuperscript{50} In terms of location and co-location centres, 12 of these brands are truly multinationals, i.e. they have production facilities in more than one country.\textsuperscript{51} Among the largest producers are Voestalpine/VAE, Delachaux/Pandrol, and Vossloh, which all trade in Europe, Asia and NAFTA.

\textbf{Vossloh – example of a global leader in rail infrastructure— operating from Europe}

Vossloh is headquartered in Germany and has 2 divisions: Rail Infrastructure and Transportation. 66\% of revenues from Vossloh come from the division Rail Infrastructure (892 m€). Key figures of the Rail Infrastructure Division (€ millions, business year 2010): Revenue 892, EBITDA 168, EBITDA margin 16\%, Employees 3155 (647 in Germany), revenue per capita: 283k. The Rail infrastructure division has 3 business units: Fastening systems (369 m€), Switch systems (439 m€) and Services (86 m€).

Vossloh has major rail fastening plants in Turkey and China. 70\% of revenues come from the European market, 18\% from Asia and 8\% from the America’s. In total, Vossloh’s rail infrastructure division showed a 29\% growth in 2010

In terms of employment, very limited data is available for the infrastructure segment.\textsuperscript{52}

\textbf{3.1.3 Signalling and electrification}

The signalling and electrification segment is further subdivided in separate signalling and electrification companies and electrification companies.

\textbf{Signalling}

Worldwide, the number of enterprises who are primarily active in the market of signalling is 22 (see figure below). In addition there are companies that supply small electronic component parts. In terms of size distribution, some 13 large players have been identified including companies as Siemens, Toshiba, Thales, Ansaldo STS and Invensys. These companies are also involved in feasibility, design and installation as well as manufacturing and also in production rolling stock and locomotives. Therefore it is difficult to split the figures due to manufacturing or supply of the signalling and electrification components only. Mergers and joint ventures within the last 2 decades shifted the international situation towards a few global players, resulting in smaller company names disappearing from the market.

\textsuperscript{50} according to www.railwaydirectory.net, Infrastructure: Track materials and equipment. Brands in that term means companies that can be identified by a clear product and are listed as separate companies in the railway directory, except for some Asian countries, such as China, with comparably little data recording. Due to Mergers & Acquisitions, or minority shares in other companies, however, the actual number of involved companies in rail infrastructure may be slightly higher. It would need further research on company websites to unveil company interlinkages.

\textsuperscript{51} www.railwaydirectory.net, Infrastructure: Track materials and equipment.

\textsuperscript{52} An very rough estimation has been carried out based on the world market for railway infrastructure (about €22 billion - UNIFE, 2010) and a revenue per employee €0,27 million (average over Voestalpine 2010/2011, Vossloh 2010 and Delachaux 2010) as a benchmark. This would imply that the infrastructure segment employs about 80.000 people worldwide. Based on the share of Europe in the total number of companies this would result in roughly 50.000 employees in this segment in Europe.
Regarding the employment figures, often only an overall figure for the group is given by the companies in their publicly available documentation. The two very large companies in the market segment (Siemens and Toshiba) skew the total number of employees because their global number of employees of over 200,000 includes those working in maintenance and in train production and design.

Regarding production facilities, it is observed that Siemens has a dominant position not only in Europe but also in America. The other (very large) company Toshiba, on the other hand, has its main foothold in Japan and in the Asian area. It has no production facilities in Europe. Among the large companies (>1000 employees) four have their HQ in France. Of these both Areva and Alstom also have a significant presence in America, Asia and the Middle East.

Regional representative offices are in most cases expanded to branch offices when construction works are carried out in a foreign country. Joint ventures are often created to create a certain percentage of local staff and productivity. Major design work, research and delivery of high sophisticated device in general come from the home country of the large manufacturers or from their subsidiaries. As the worldwide distribution of staff shows, Europe is the major centre of signalling and electrification industry.

Electrification

In electrification the number of enterprises is 29. The world leaders in electrification offer complete systems, turn key or BOT (built operate transfer), but act only as a contractor to the client. Components for the whole system might come from smaller companies, specialized in specific products, like copper cables, transformers, switchgear, poles and other equipment. These specialized small or medium sized companies usually serve the public power supply market as well and normally do not show the portion of rail products within their total activity. Large electrification companies are found in countries with large electrified networks. Mergers and joint ventures within the last 2 decades shifted the international situation towards a few global players, resulting smaller company’s names disappearing from the market, although still active under the brand name of a larger company.
Acting worldwide in the electrification market are Alstom, Balfour Beatty, Bombardier and Siemens, based in respectively Canada, UK, France and Germany but providing large branch offices around the world. Ansaldo-Breda, Spie Enertrans, Furrer & Frey, Flury, Elbro and others primary act at their local market (Italy, France, Switzerland, Germany), but contribute with their components to the international market.

The companies can be divided in companies working in the area of catenary design manufacture and installation; those who develop and manufacture components and subsystems and the two companies involved in maintenance. It is not always possible to identify the numbers of employees in each sector with an appropriate level of accuracy.

3.2 Production value of the EU27 railway supply industry

Production of the EU27 RSI has shown a trend of growth (see figure 3.8), although some impact from the economic crisis may be observed in 2009.
Locomotives and rolling stock have shown stable production in the recent years, also possibly reflecting the first phase of the economic and financial crisis. On the other hand infrastructure production value has been increasing since 2009, partly connected to economic stimulus packages that have been introduced as a result of the crisis. Electrification and signalling is at a relatively low level compared to the other two subsectors.

With the help of PRODCOM data, comprising all manufactured goods along pre-defined data codes, an assessment of the development of different product categories within these main market segments can be made for the EU27 (Tables 3.5 to 3.7).

### Table 3.5 Production of segment 'Locomotives and rolling stock' in EU27 markets

<table>
<thead>
<tr>
<th>Locomotive and rolling stock</th>
<th>PRODCOM code</th>
<th>Aggregated production 2005 - 2010</th>
<th>Total growth from 2005 (baseline) to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail locomotives &amp; tenders - powered from electric accumulators</td>
<td>30201300</td>
<td>459,758</td>
<td>140%</td>
</tr>
<tr>
<td>Rail traction compression-ignition internal combustion engines</td>
<td>28111320</td>
<td>724,055</td>
<td>98%</td>
</tr>
<tr>
<td>Rail/tramway passenger coaches, luggage vans and other coaches</td>
<td>30203200</td>
<td>15,976,627</td>
<td>95%</td>
</tr>
<tr>
<td>Reconditioning of rail &amp; tram locomotives &amp; rolling stock</td>
<td>30209100</td>
<td>4,855,321</td>
<td>83%</td>
</tr>
<tr>
<td>Rail locomotives - powered by electricity</td>
<td>30201100</td>
<td>8,842,136</td>
<td>56%</td>
</tr>
<tr>
<td>Railway &amp; tramway maintenance or service vehicles</td>
<td>30203100</td>
<td>3,185,304</td>
<td>47%</td>
</tr>
<tr>
<td>Rail/tramway goods vans and wagons</td>
<td>30203300</td>
<td>4,243,633</td>
<td>46%</td>
</tr>
<tr>
<td>Parts of locomotives or rolling-stock</td>
<td>30204030</td>
<td>31,823,660</td>
<td>37%</td>
</tr>
<tr>
<td>Diesel-electric locomotives</td>
<td>30201200</td>
<td>2,810,351</td>
<td>11%</td>
</tr>
<tr>
<td>Self-propelled rail or tramway coaches, vans, trucks</td>
<td>30202000</td>
<td>23,291,063</td>
<td>0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>96,013,908</strong></td>
<td><strong>37%</strong></td>
</tr>
</tbody>
</table>

Source: Eurostat Manufactured goods (Prodcom)

The table indicates that rail locomotives and tenders that have been powered from an electric accumulator have been experiencing strong growth, although it should be noted that these form a relatively small product category. This product category is followed by rail traction compression ignition internal combustion engines by 20% and coaches, i.e. including passengers as well as...
luggage, of 19%. Almost stagnating were diesel-electric locomotives and self-propelled rail or tramway coaches.

Table 3.6. Production of segment 'Rail infrastructure ' in EU27 markets

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>PRODCOM code</th>
<th>Aggregated production 2005 - 2010</th>
<th>Total growth from 2005 (baseline) to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screws and bolts for fixing railway track construction material, iron or steel</td>
<td>25941115</td>
<td>€ 1.869.076</td>
<td>58%</td>
</tr>
<tr>
<td>Railway material of steel</td>
<td>24107500</td>
<td>€ 11.359.429</td>
<td>34%</td>
</tr>
<tr>
<td>Rail/tramway sleepers of wood - non impregnated</td>
<td>16103200</td>
<td>€ 416.914</td>
<td>15%</td>
</tr>
<tr>
<td>Gravel and pebbles used for concrete aggregates, for road metalling or for railway</td>
<td>8121210</td>
<td>€ 25.445.052</td>
<td>11%</td>
</tr>
<tr>
<td>Crushed stone used for concrete aggregates for road metalling or for railway</td>
<td>8121230</td>
<td>€ 38.920.347</td>
<td>6%</td>
</tr>
<tr>
<td>Rail/tramway sleepers of impregnated wood</td>
<td>16101010</td>
<td>€ 404.847</td>
<td>-17%</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>€ 82.415.664</td>
<td>46%</td>
</tr>
</tbody>
</table>

Source: Eurostat Manufactured goods (Prodcom)

Overall production growth in the segment 'Rail infrastructure' has shown an increase of 46% in the 5-year period 2005-2010. The highest growth was achieved by screws and bolts for fixing railway track construction material, iron or steel (58%). Railway material of steel was growing at half the pace, i.e. 34%. The demand for wooden sleepers is reducing as these are increasingly replaced by more modern material.

A remarkable development can be observed in the development of the production value in the segment signalling and electrification. Other than the previous segments this segment has shown a decrease over the period 2005-2010.

Table 3.7 Production of “signaling and electrification technology” in EU27 markets

<table>
<thead>
<tr>
<th>Signalling &amp; electrification</th>
<th>PRODCOM code</th>
<th>Aggregated production 2005 - 2010</th>
<th>Total growth from 2005 (baseline) to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts of electric signalling, safety or traffic control equipment</td>
<td>27903330</td>
<td>€ 5.617.469</td>
<td>7%</td>
</tr>
<tr>
<td>Electrical signalling, safety or traffic control equipment for railway/tramway</td>
<td>27907010</td>
<td>€ 8.129.159</td>
<td>-14%</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>€ 13.746.628</td>
<td>-3%</td>
</tr>
</tbody>
</table>

Source: Eurostat Manufactured goods (Prodcom)

3.3 Value added of the EU27 railway supply industry

Next to the production value, which shows the total value of the production including supplies, parts and components that are purchased by companies for the manufacturing of the product, value added refers to the value that is added by the RSI in Europe. The value added analysis of the EU27 railway supply industry can only be given for the locomotive and rolling stock segment, since no Eurostat information or other (national) sources for the other segments is available.

Figure 3.9 plots the development of the gross value added over a period from 2000 to 2008. The development of RSI shows, apart from a dip in 2004, a continuous growth. This follows the overall growth pattern of the production value although.
The seven largest EU Member States in terms of value added were accountable for 72% of total value added in the EU27 in 2008. Especially Spain and Austria strengthened their position although also the share of France and the UK increased. In 2000 the share of these seven countries was much lower, either indicating a shift in production countries or tendencies of market concentration (economies of scale) or higher degree of specialisation and therefore focusing on high added value activities. It can be further explained by the fact of EU national locomotive / rolling stock manufacturers in a number of new member states in Eastern Europe countries have been acquired by other companies or closed down.

### Table 3.7: Value added of selected EU Member States compared to the total value added of the EU

<table>
<thead>
<tr>
<th>Value added at factor costs</th>
<th>% of total EU 2000</th>
<th>% of total EU 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>13%</td>
<td>16%</td>
</tr>
<tr>
<td>France</td>
<td>10%</td>
<td>14%</td>
</tr>
<tr>
<td>Spain</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>Austria</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>Italy</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>Poland</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total share</strong></td>
<td><strong>56%</strong></td>
<td><strong>72%</strong></td>
</tr>
</tbody>
</table>

**Development of value added in a global perspective**

In global perspective, a comparison of the relative development of gross added value in transport equipment in the period 1995-2006 between EU25, Japan and Korea has been made. This serves as a rough proxy of the developments as no comparable data are available for railway equipment alone are available. The gross added value in transport equipment as a whole shows a positive trend for EU25, which is in line with the specific trend for railway equipment. The figure below shows that the growth in gross added value of Korea outweighs the EU25 and that Japan shows a slightly lower increase compared to EU25.

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53 2008 missing data have been estimated using previous year data
3.4 Summary

The main finding regarding the characteristics of the EU Railway Supply Industry are:

- The Railway supply industry in Europe is an important industry representing a total production value of some 40 bn Euro (2010), with gross value added being around 30% of the production value.

- In production value, the locomotive and rolling stock market is the most important market, practically equalled by the market segment for rail infrastructure. The segment of signalling and electrification follows at a distance. In terms of trade the locomotive and rolling stock market is by far the largest and most globalised market.

- The locomotive and rolling stock industry in Europe employs some 160,000 people. The world locomotive and rolling stock industry market has traditionally been dominated by three major players, Bombardier (Canada/Germany), Alstom (France) and Siemens (Germany). Industry data show that these employ approx. 78,000 people of which 9% are located outside the EU. However, the Chinese locomotive and rolling stock manufactures have grown substantially and are now ranked third and fourth in the world in terms of turnover. The EU still accounts for most locations worldwide, although the cumulative capacity of Asians plants is highest in the world.

- For rail infrastructure a high degree of specialisation is encountered, among the largest companies are three major EU companies (Voestalpine, Delachaux and Vossloh). Limited data are available on employment. The available data indicate a total direct employment of 50,000 employees. The enterprises are mainly located in EU, a high number of components is being produced locally (e.g. rails, fastenings, sleepers), only high value components mainly produced in EU.

- The world market for signalling is fragmented and served by various large companies including (but not exclusively) Alstom, Ansaldo, Bombardier, Invensys, Siemens, Thales and Toshiba. Regarding the market for electrification, the large electrification companies are located in countries with large electrified networks, Alstom, Balfour Beatty, Bombardier and Siemens are the main players acting worldwide. Employment figures are hard to assess as activities are interwoven in other activities performed by the companies that are active in this market.
4 Assessment of the competitive position of the EU RSI

This chapter provides further analysis of the competitive position of the RSI in Europe. It first starts with an analysis of the position of the EU in international trade and an assessment of the particular strengths of the EU RSI in the specific product segments (4.1). This is followed by a further quantitative assessment of the competitive position of EU RSI (section 4.2). First the concept of competitiveness is defined, followed by the selection of a number of indicators to assess the competitive position of the EU vis-à-vis its main competitor countries resulting in an overall competitiveness index. Next, an assessment is made of a number of framework conditions that directly affect the competitive position of the EU RSI (section 4.3), in particular its performance in technological innovation and the availability of qualified labour. It concludes with a section (4.4) in which the openness of international markets is assessed including an assessment of the most important non-trade barriers. Finally the main conclusions on the competitiveness of the EU RSI are presented.

4.1 The position of the EU RSI in the world market

4.1.1 Production

The total production of the world market for RSI has grown continuously (see also chapter 2), and is expected to grow further in the coming years. Also production in the EU has shown a continuous increase. If the share of EU production is compared to its main competitors, we can observe that the EU has been able to maintain a share of around 50% in total production within this group of countries. Especially the increase of the production in China in the period is remarkable.

<table>
<thead>
<tr>
<th>Output</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>14.7</td>
<td>16.0</td>
<td>18.2</td>
<td>20.4</td>
<td>20.6</td>
<td>21.8</td>
<td>23.0</td>
<td>26.4</td>
<td>28.7</td>
<td>27.1</td>
</tr>
<tr>
<td>US</td>
<td>7.7</td>
<td>8.8</td>
<td>8.0</td>
<td>6.6</td>
<td>6.1</td>
<td>7.4</td>
<td>9.6</td>
<td>9.7</td>
<td>8.9</td>
<td>9.3</td>
</tr>
<tr>
<td>Japan</td>
<td>3.7</td>
<td>4.0</td>
<td>3.8</td>
<td>3.2</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
<td>3.4</td>
<td>3.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Korea</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.6</td>
<td>1.6</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>China</td>
<td>2.7</td>
<td>3.3</td>
<td>3.1</td>
<td>4.5</td>
<td>5.3</td>
<td>6.2</td>
<td>7.3</td>
<td>9.3</td>
<td>13.2</td>
<td>17.8</td>
</tr>
<tr>
<td>Total</td>
<td>29.9</td>
<td>33.3</td>
<td>34.3</td>
<td>35.7</td>
<td>36.8</td>
<td>40.4</td>
<td>44.9</td>
<td>50.4</td>
<td>56.4</td>
<td>58.8</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data
4.1.2 Trade

The value of global trade (sum of all exports) in the RSI was around €40.8 billion in 2010. The growth rate of growth of exports in the RSI between 2002 and 2010 was equal to 20 per cent, which almost double the rate of growth of exports in the machinery and transport equipment sector.

The EU is by far in the lead with a share of 21 per cent in 2010. In 2002, this figure was 18 per cent. This development was driven by strong export growth between 2002 and 2008. The largest share in exports was reached in 2009 where albeit the absolute reduction in exports for European producers, EU competitors suffered a deeper decline. In 2010, the US, Japan, Korea and China contributed with 11, 10, 2 and 8 per cent of total exports in the railway industry, respectively. The following table illustrates these developments.

Table 4.2 Key figures for global trade (total export volume) in the RSI

<table>
<thead>
<tr>
<th></th>
<th>2010 million €</th>
<th>Growth over the whole period (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>8,602</td>
<td>219%</td>
</tr>
<tr>
<td>US</td>
<td>4,534</td>
<td>155%</td>
</tr>
<tr>
<td>Japan</td>
<td>4,244</td>
<td>182%</td>
</tr>
<tr>
<td>Korea</td>
<td>950</td>
<td>389%</td>
</tr>
<tr>
<td>China</td>
<td>3,303</td>
<td>597%</td>
</tr>
<tr>
<td>Others</td>
<td>19,121</td>
<td>136%</td>
</tr>
<tr>
<td>World</td>
<td>40,755</td>
<td>176%</td>
</tr>
</tbody>
</table>

Looking at the different period exports in the railway industry grew fastest in the period 2002-2008 and slowed down in 2008-2010, due to a deep reduction in exports between 2008 and 2009. Korea and China increased their exports strongly between 2002-2008 becoming global competitors of European, Japanese and US RSI. The positive performance of trade in railway products is even more significant when we compare it with the level of production (output). World trade of railway product grew at an average rate of almost 20 per cent per year whereas the level of output of the five analysed economies grew by 7.7 per cent per year between 2000-2009.
Box 4.1 The strong growth of China

Production of railway production in China has grown rapidly, partly in line with massive investment in the Chinese railway network. The two biggest Chinese locomotive and rolling stock manufacturers CNR and CSR were created due to a political decision and bundle strong Chinese locomotive and rolling stock production activities each in the North (CNR) and in the South of China (CSR). Due to the enormous size of the Chinese market and the strong expansion of the Chinese rail transport during the last years, both producers have achieved rapid growth. Apart from covering the huge home market, the Chinese locomotive and rolling stock industry has become active on several international markets and has considerable successful sales. This includes amongst others, the Asian market, the more or less complete African market, the market in Middle East, and the Australian market. Chinese activities in Europe have been noticed in the field of freight wagons so far. Moreover, they start to offer passenger rolling stock and multiple units. CNR’s first plant outside China is located in Poland where they formed a joint venture with PKP Cargo. Chinese manufacturers have gradually expanded their delivery of locomotive and rolling stock to countries such as Brazil, Argentina, Tunisia, Iran, India etc. Their success in these markets has been strongly supported by beneficial funding conditions and additional offerings, such as the development of infrastructure.

Source figure: SCI Verkehr, the world market for railway technology 2010

Whereas the EU has a strong export position in RSI this particularly valid in the production of product with a higher level of technological complexity (see 4.1.3) that is triggered by a strong domestic market. In not all sub-segment the position of the EU is equally strong. This is illustrated by the market for rail freight locomotives and rolling stock (box 4.2).

Box 4.2 Competition in the market of rail freight locomotives and rolling stock

EU’s main competitors in terms of export volume in the rail supply industry are the US, Japan, Korea and China. A more specific picture exists for rail freight rolling stock (locomotives and rail freight cars), is presented. Traditionally, the US has been a global leader in exports of diesel-electric locomotives. The second largest exporter is Canada, followed by Spain, Ukraine and Germany.

Figure: Top five countries exporting diesel-electric locomotives
Concerning rail freight cars (wagons) Ukraine is the leading exporter for the entire period analysed. The majority of Ukraine’s exports went to Russia. Others in the top five include Romania, Slovakia, Mexico and China. China has shown the highest growth of exports over the period surpassing the US in export value in 2009. In contrast to locomotives, competition in freight cars is driven by price and not by know-how. The EU member states with a stake in this market are challenged by non-EU competitors.

4.1.3 Key strengths of the EU RSI

The key strength of the European RSI for each of the main product segments is described below.

Rolling stock and locomotives

European rolling stock manufacturers are especially successful with high speed system technology. This in particular relates to highly integrated solutions, i.e. combining vehicle technology with "intelligent track"/signalling and optimal operation- and service management. The EU RSI provide comprehensive service packages leading to a “one stop solution” for operators which is also reflected in the introduction of universal “design kit solutions” for standard rolling stock. The ability to deliver turnkey, integrated urban and suburban public rail transport systems is a competitive advantage

In addition, EU original equipment manufacturers (OEMs) procure use high performance key components delivered by specialized, long term experienced suppliers like Knorr, Faiveley and
Voith. These companies are also active in non-EU markets. Knorr for example provides braking systems for Chinese railways. EU manufacturers in the value chain enjoy a good reputation as suppliers of high performance products of outstanding reliability.

Finally, EU locomotive and rolling stock suppliers are leading in the production of locomotives and rolling stock adapted to specific applications manufactured in small numbers only, for instance special machines for track construction and maintenance.

**Infrastructure**

Running trains on rail infrastructure causes large mechanical stresses on the system and its components. The mechanical forces in high-speed operation demand high-quality infrastructure to ensure safety and to keep wear, noise and vibrations within acceptable limits. Development of special long-life steel for rail, fastening systems and turnouts and high quality concrete or plastic sleepers are of major importance to keep maintenance cost within limits and to guarantee safe operation. The EU supply industry is leading in the development of special products for railway infrastructure.

The introduction of high-speed rail traffic in Europe over the last 30 years has led to new track design and the development of full integration of the permanent way with civil support structures like tunnels and bridges. Special designs are developed for application on earth works. This so-called ballast-less track (slab track) has proved to be a reliable and cost-effective solution for (high-speed) railways. This European technology that also requires new designs for fastening systems, sleepers and switches is leading in the world. China has adopted this technology for the roll-out of its high-speed rail network. Ballast-less track is in general noisier than ballasted track but the transfer of vibrations to the environment is lower. Special materials and constructions are needed to reduce these phenomena. This becomes more and more important in high-density populated areas. Considerable experience has been gained in Europe and the associated solutions are adopted in various projects outside Europe.

Like in other industries, manufacturers strive for the supervision of their products over the life-cycle. Systems for monitoring and diagnosis have been introduced and will gain more importance. Bombardier's ORBITA is an example of such a product which allows the manufacturer to follow up its products and monitor performance throughout the life-cycle. This development is in line with the interest of OEMs to evolve from manufacturers towards service providers over the life cycle of their products. Beyond turnkey solutions, lifetime maintenance and repair the operation of railways for service providers and funding of projects have become new and promising business areas.

It is concluded that technological development for railway infrastructure is driven by Japanese and (Western) European R&D. The development and operation of high speed rail is an important driver for knowledge creation. Countries outside Europe are building extensive high-speed networks like Japan and China, but also Korea and Taiwan may be future competitors.

**Electrification and signalling**

Regarding electrification, the amount of new developments, new designs and construction methods as well as advanced operational concepts do exists, but face practical limitations in their implementation, as the client industries cannot easily carry out full system changes. Although the

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54 Rail supply manufacturers increasingly monitor the performance of their products and also supply monitoring equipment. The overall responsibility for monitoring and control of the performance of the entire rail system and operations is usually the responsibility of the infra manager.
potential is larger, in practice relatively small steps are taken towards energy savings, recuperation of braking energy on vehicles or in substations, reduction of electrical losses along the catenary and minimizing electrical disturbance to the feeding power supply grid indicate the efforts of the industry to improve electrification. These are long term aspects during the life cycle of the installation with small effects on the tendering of certain contractors.

A great advantage of European electrification industry is their long lasting experience in electrification and particularly high speed technology, offering proven technology to the world market. The quality standards are very high in Europe and this is helping to restrain competition from outside. However, Japan has similar experience and although at the moment China has a reputation for low quality this is changing and China is catching up with European standards, becoming a serious competitor in future.

Japanese railways were the first to introduce high speed systems across the country. Having used electric multiple units with several pantographs up per trainset, a very heavy and rigid catenary was developed, which is typical for the Japanese system. Developments in other countries showed that best performance is reached by a flexible, light weight catenary with an elasticity staying constant along the span length. The combination of a light-weight overhead line and light-weight pantographs have a proven better mechanical dynamic behavior at higher speeds, resulting in less wear of the contact wire and contact strips on the pantograph head. Therefore, European catenary design is state-of-the-art and has been introduced even in the Chinese network and on Korean high speed lines.

In signalling, the EU requirement for a standardized technology to replace various national signalling systems by a European Rail Traffic Management System (ERTMS), based on Directive 96/48 for Interoperability and following legislation, is a long lasting challenge for the European railways network operators. The development of the ERTMS became the Unique Selling Points for signalling companies in Europe. The development of this standard has contributed to the strengths of the EU companies. The extent of EU companies’ research budgets together with a long history of cooperation ensures a cross fertilization of ideas and innovations. These strengths are supplemented by close ties and co-operations with universities, research and testing bodies.

The success of ERTMS (Level 1 and 2) outside EU is shown in the following table and indicates the great opportunities for EU firms.

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55 See, example the FP6 funeced RAILENERGY project. UIC, 2010, RAILENERGY, Publishable Final Activity Report / Railenergy Brochure with an overview about the project and the final results (Deliverable D7.1.8)
56 See blogs.worldwatch.org/revolt/china's-rise-to-global-rail-leader
57 See: http://www.bbrail.com/connect-article/Growth-and-Prosperity
http://www.hochgeschwindigkeitszuege.com/korea/ktx.php
Table 4.3 Use and future development for ERTMS outside EU

<table>
<thead>
<tr>
<th>Country</th>
<th>Vehicles</th>
<th>Onboard Units</th>
<th>Route length</th>
<th>Track length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>0</td>
<td>0</td>
<td>426</td>
<td>852</td>
</tr>
<tr>
<td>China</td>
<td>290</td>
<td>580</td>
<td>3937</td>
<td>5862</td>
</tr>
<tr>
<td>India</td>
<td>77</td>
<td>119</td>
<td>234</td>
<td>508</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>0</td>
<td>0</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Libya</td>
<td>0</td>
<td>0</td>
<td>1250</td>
<td>1700</td>
</tr>
<tr>
<td>Mexico</td>
<td>20</td>
<td>40</td>
<td>35</td>
<td>70</td>
</tr>
<tr>
<td>Morocco</td>
<td>68</td>
<td>68</td>
<td>80</td>
<td>160</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0</td>
<td>0</td>
<td>175</td>
<td>350</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>23</td>
<td>15</td>
<td>2049</td>
<td>2849</td>
</tr>
<tr>
<td>South Korea</td>
<td>466</td>
<td>475</td>
<td>839,4</td>
<td>1678,4</td>
</tr>
<tr>
<td>Taiwan</td>
<td>811</td>
<td>811</td>
<td>1200</td>
<td>1800</td>
</tr>
<tr>
<td>Turkey</td>
<td>110</td>
<td>200</td>
<td>1109</td>
<td>1940</td>
</tr>
<tr>
<td>Total</td>
<td>1865</td>
<td>2308</td>
<td>11714,4</td>
<td>13869,4</td>
</tr>
</tbody>
</table>

Note: The figures indicate the lines and rolling stock in operation as well as contract signed as per September 2010. Route and track length are expressed in kilometres, and include frame contracts whenever mentioned. Source: UNIFE / www.ertms-online.com/facts-and-figures/development-statistics.aspx

4.2 Quantitative assessment of the competitive position of EU RSI

This section analyses the competitive position using a series of competitiveness indicators. These indicators are combined in a single Competitiveness Index. Firstly, competitiveness is defined from a theoretical angle. Many authors have struggled to provide a unique definition of this concept proposing different layers of analysis and indicators. Based on the existing literature, Ecorys has established its own framework to assess sectoral competitiveness. Within this framework, the Ecorys Competitiveness Index (ECI) has been developed.

4.2.1 Defining competitiveness

**Literature**

Michael Porter is the most important author in the analysis of sectoral competitiveness. Porter (1990) introduced a structural framework to identify and quantify the factors behind competitiveness. This framework was later adapted in the National Diamond model of the ‘Competitive Advantage of Nations’ (Porter, 1900). The diamond includes four forces of competitiveness: (i) factor conditions (skilled labour, capital, raw materials, etc.); (ii) demand conditions (size and expectations of the domestic market); (iii) related and supporting industries; and (iv) firm strategies, structure and rivalry. Porter’s work introduced competitiveness as a multidimensional concept determined by different forces changing over time.

Following the numerous literature reviews that have dealt with competitiveness (Cantwell, 2005; Siggel, 2006; Platenburg & Berden, 2008), we find consensus on two important issues. Firstly, competitiveness can be analysed at different levels of aggregation: from micro (firms) to macro (countries) with other conceptual layers of analysis (sector/industry) in between. Secondly, competitiveness is better understood when it is compared to a reference point. This tipping point

---

58 the ECI – Ecorys Competitiveness Index.
can be provided in relation to the same sector in different periods or in relation to the same sector in third countries (Buckley et al., 1992).

**The Ecorys framework to assess competitiveness**

Ecorys, together with its partners at the European Competitiveness and Sustainable Industrial Policy Consortium (ECSIPC, 2011) designed a framework to analyse sector competitiveness.

In this framework, sectoral competitiveness can be influenced by exogenous factors such as globalisation, technological change, climate change, economic shocks, market conditions, market institutions and regulations, and competitor performance. In addition, at the level of the firm, the capacity of the industry to respond to those shocks is conditioned upon the firm strategy and its business model, production process, innovation and technological development, and input factor utilisation, as well as, the supply and value chain relationships upstream and downstream. In addition, the firm operates within the economy and is dependent on factors such as infrastructure, labour force and skills, access to finance, energy, raw materials and knowledge.

The EU influences this framework, market and exogenous conditions, implementing regulatory and non-regulatory policies. At the EU-level, competition policy, consumer policy, trade policy, infrastructure policy, standardisation, energy policy and regional policy affect the industry performance.

The effects of these links determine sectoral competitiveness. Competitiveness, therefore, is reflected in the sector productivity, profitability, employment and environmental performance.

**The Ecorys Competitiveness Index (ECI)**

The Ecorys Competitiveness Index makes use of these outcome indicators to measure the level of competitiveness of the European RSI. The ECI is constructed in a way to provide policy-makers with an objective, comparable and easy to understand index that encompasses the different dimensions of competitiveness in a single number. Calculating the ECI for the railway sector in different periods, provides us with the necessary tools to assess the competitiveness dynamics in the EU RSI and to recognise future trends, which in turn represents relevant information for sensible policy shifts.

The ECI integrates different dimensions of competitiveness including several outcome indicators based on international trade, factor productivity, profitability and employment. These indicators measure the level of competitiveness for different dimensions of competitiveness. In addition, the index captures the relative nature of competitiveness within the sector in different periods of time and across different countries. Thus, a tipping point equals to one is created from which above (below) the EU RSI is competitive (uncompetitive) vis-à-vis the RSI in competing economies.

### 4.2.2 Assessing the competitiveness of the RSI

The assessment of the competitiveness of the European RSI is performed using a selection of the outcome indicators according to the economic literature and the Ecorys framework of competitiveness. These outcome indicators are analysed for the EU, the US, Japan, Korea and China. Finally, the ECI for the European RSI is calculated.

**Selection of the outcome indicators**

Based upon the description of Berning (2011), we group sectoral competitiveness measures in four main categories: (i) cost and price competitiveness; (ii) profitability; (iii) trade; and (iv) employment.
Cost and price competitiveness is a major driver of sector performance. An underlying factor behind costs and prices is factor productivity: capital, labour (Krugman, 1994) and natural resources (Porter, 2002). We use the unit labour cost and labour productivity to account for this measure. Competitiveness is also determined by the ability to set prices, which depends on the ability of the firm to supply with a unique product, through branding and product differentiation, and the market power exercised by the firm. In this regard, we make use of the gross operating rate that indicates the evolution of profitability of the sector once labour costs have been deduced. A third category is trade. An industry’s performance in third countries is an indicator of the level of competitiveness vis-à-vis domestic producers and other competing economies in the RSI market. An outcome indicator describing this external dimension of competitiveness is the Revealed Comparative Advantage (RCA). Finally, growth in employment, as an outcome of competitiveness, indicates a raising competitiveness of domestic production of goods and services in the sector.

Competitiveness is better understood in relative terms. Its interpretation becomes meaningful when it is conducted in comparison with other countries and therefore we need to choose a reference group in order to compare. The reference group has been chosen regarding its importance as competitors of the EU RSI. Within the reference group we include the US, Japanese, Korean and Chinese RSI.

The data set for this exercise is compiled from different data sources maintaining the same definition of railway industry. In chapter 1 an explanation is provided on all data and classifications used in this study including the data for the competitiveness analysis. The compiled dataset consists of the following variables:

- Output
- Value added
- Employees
- Wages & salaries

These variables have been adjusted to express in real terms and in constant prices using 2000 as the base year. Afterwards the variables have been transformed to be measured in Euros using the annual average exchange rate.

The dataset of ECI contains historical data until 2009. The next table provides key figures on the economic performance of the railway sector in the five selected countries for the year 2009. The evolution of these variables over a longer time period is analysed in the following section.
Table 4.4 Key figures on economic performance of RSI in the EU, US, Japan, Korea and China, 2009

<table>
<thead>
<tr>
<th>Variables</th>
<th>2009</th>
<th>Unit</th>
<th>EU</th>
<th>US</th>
<th>Japan</th>
<th>Korea</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td></td>
<td>Current prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bn. €</td>
<td>27.1</td>
<td>9.3</td>
<td>3.1</td>
<td>1.5</td>
<td>17.8</td>
</tr>
<tr>
<td>Value Added</td>
<td></td>
<td>Prices 2000 base year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bn. €</td>
<td>4.9</td>
<td>2.4</td>
<td>1.4</td>
<td>0.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Employees</td>
<td></td>
<td>Number</td>
<td>1000</td>
<td>160.7</td>
<td>27.8</td>
<td>16.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Labour productivity</td>
<td></td>
<td>Value added per employee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>€</td>
<td>30186</td>
<td>87344</td>
<td>82883</td>
<td>82516</td>
<td>13767</td>
</tr>
<tr>
<td>Gross operating rate</td>
<td></td>
<td>Share of Output</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.6</td>
<td>21.8</td>
<td>22.8</td>
<td>25.0</td>
<td>16.6</td>
<td></td>
</tr>
<tr>
<td>Unit labour cost</td>
<td></td>
<td>Labour cost per output unit</td>
<td>€/€</td>
<td>0.91</td>
<td>0.48</td>
<td>0.35</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Note: 2009 prices and exchange rate
Source: based on Eurostat & UN COMTRADE data

In 2009, the EU RSI was the largest producer within the group in terms of output and value added. However, European railway sector was lagging behind Korean, Japanese and US railway manufacturing in terms of labour productivity. Regarding the profitability of the railway and the unit labour costs, the EU RSI is also behind its main competitors. The US, Korean and Chinese RSI enjoy higher gross operating rates and lower unit labour costs than their EU counterparts.59

Analysis of the outcome Indicators

Gross operating rate
The gross operating rate is an indicator of the level of profitability in the sector and constitutes a major indicator of competitiveness. The reason for its relevance is that profitability is the main outcome in which companies measure its success. In addition, the current level of profits partly determines the future level of investment, which in turn influences its future competitiveness. Gross operating rate is defined in nominal terms and its formula reads as follow:

\[
\text{Gross operating rate (\%)} = \left( \frac{\text{Value Added} - \text{Wages & Salaries}}{\text{Output}} \right) \times 100
\]

Table 4.5 Gross operating rate

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>7.1</td>
<td>8.8</td>
<td>11.1</td>
<td>14.1</td>
<td>8.1</td>
<td>11.0</td>
<td>13.4</td>
<td>12.8</td>
<td>13.9</td>
<td>12.6</td>
</tr>
<tr>
<td>US</td>
<td>29.3</td>
<td>28.4</td>
<td>28.5</td>
<td>27.7</td>
<td>27.7</td>
<td>23.1</td>
<td>26.1</td>
<td>22.1</td>
<td>23.0</td>
<td>21.8</td>
</tr>
<tr>
<td>Japan</td>
<td>30.4</td>
<td>29.7</td>
<td>31.4</td>
<td>29.3</td>
<td>28.1</td>
<td>19.1</td>
<td>20.8</td>
<td>22.0</td>
<td>22.7</td>
<td>22.8</td>
</tr>
<tr>
<td>Korea</td>
<td>33.6</td>
<td>35.4</td>
<td>34.7</td>
<td>30.9</td>
<td>29.3</td>
<td>32.3</td>
<td>28.5</td>
<td>31.2</td>
<td>24.4</td>
<td>25.0</td>
</tr>
<tr>
<td>China</td>
<td>17.1</td>
<td>19.2</td>
<td>19.6</td>
<td>19.7</td>
<td>17.4</td>
<td>17.5</td>
<td>17.4</td>
<td>20.5</td>
<td>17.9</td>
<td>16.6</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data

59 The disadvantage of the EU as compared to other competing economies is a well-known phenomenon on a macroeconomic, as well as on the sectoral level. It is caused by a smaller margin of value added and labour costs. These discrepancies might be attributed to specifics in the structure of competing economies industries and differing statistical definitions. More important is the performance of the industries in course of the period under investigation that is analysed below.
Korean RSI is the most profitable, although, experiencing a declining trend. The US and Japan experience a declining trend as well. Chinese RSI have maintained a profit rate of nearly 20 per cent. The EU RSI has the lowest level of profitability, although, it increased from 2000 to 2003 almost reaching a 15 per cent peak, decreased in 2004 to fluctuated between 10 and 15 per cent for the rest of the period. Overall, gross operating rates were widely spread during the beginning of the period. However, the gap between the most and the least profitability has been reduced.

Although the EU is lagging behind all other competing economies the gross-operating rate has remained roughly stable. The EU RSI has performed better than its US, Japanese, Korean and Chinese competitors. It is concluded that the EU’s profitability has improved relative to both of these competing nations when compared with the year 2000.

**Labour productivity**

Labour productivity is a crucial factor for cost competitiveness. Labour productivity is measured with the following formula:

\[
\text{Labour productivity} = \frac{\text{Value added (real terms)}}{\text{Employees}}
\]

Value added is measured in real terms. In addition, all the figures are transformed into Euros using the exchange rate of each year in the series.

The formula is based on annual figures and calculates the ratio of the annual output as measured by value added and the average number of employees per annum. There are noteworthy discrepancies in the number of hours worked per employee that partly explain differences in the annual labour productivity. But here once more for the assessment of the competitiveness changes over the period under investigation are decisive for the assessment if the competitiveness has improved or worsened.
Table 4.6 Labour productivity (value added €/employee)

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>25021</td>
<td>25727</td>
<td>24250</td>
<td>24102</td>
<td>23100</td>
<td>27764</td>
<td>29606</td>
<td>31887</td>
<td>31687</td>
<td>30186</td>
</tr>
<tr>
<td>US</td>
<td>124674</td>
<td>131364</td>
<td>126339</td>
<td>103052</td>
<td>93090</td>
<td>86333</td>
<td>104540</td>
<td>92267</td>
<td>87438</td>
<td>87344</td>
</tr>
<tr>
<td>Japan</td>
<td>117057</td>
<td>111130</td>
<td>113479</td>
<td>91557</td>
<td>101550</td>
<td>83136</td>
<td>80566</td>
<td>78488</td>
<td>91189</td>
<td>82883</td>
</tr>
<tr>
<td>Korea</td>
<td>87138</td>
<td>81439</td>
<td>89512</td>
<td>81500</td>
<td>81534</td>
<td>122270</td>
<td>100520</td>
<td>108935</td>
<td>85244</td>
<td>82516</td>
</tr>
<tr>
<td>China</td>
<td>3344</td>
<td>4519</td>
<td>4674</td>
<td>5887</td>
<td>5137</td>
<td>6071</td>
<td>7247</td>
<td>10638</td>
<td>11717</td>
<td>13767</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data

Figure 4.3 Labour productivity

Source: Ecorys based on Eurostat and UN COMTRADE data

The US, Japanese and Korean RSI are at the top of the chart regarding labour productivity. In addition, for the US and Japanese labour productivity have experienced a decline in real terms. Labour productivity for Chinese RSI is far below from the group average, although, starting from a very low level it has improved continuously since 2000. The EU labour productivity has increased during the period and reaches its peak in 2007.

The low level of EU labour productivity vis-à-vis other countries is not a unique phenomenon of the railway sector. Previous studies have shown that this is also the case for the EU mechanical engineering and the aerospace industry.\(^{60}\) Hence, more important than the absolute values, which may to a certain extent be misleading, the development over the years is essential as this shows the relative development of Europe versus competing countries. The following table shows the growth of rate of labour productivity with respect to the previous year measured in real terms and in national currency.

\(^{60}\) As shown by the statistical data. To a certain extent this feels counter-intuitive and may be caused by different data interpretations by reporting countries. However this cannot be verified. Also structural differences between countries (e.g. different type of products may form part of the explanation).
Table 4.7 Changes in labour productivity (growth rates %)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>3%</td>
<td>-6%</td>
<td>-1%</td>
<td>-4%</td>
<td>20%</td>
<td>7%</td>
<td>8%</td>
<td>-1%</td>
<td>-5%</td>
<td>2%</td>
</tr>
<tr>
<td>US</td>
<td>2%</td>
<td>2%</td>
<td>-2%</td>
<td>-1%</td>
<td>-7%</td>
<td>22%</td>
<td>-4%</td>
<td>2%</td>
<td>-5%</td>
<td>1%</td>
</tr>
<tr>
<td>Japan</td>
<td>4%</td>
<td>11%</td>
<td>-10%</td>
<td>14%</td>
<td>-17%</td>
<td>3%</td>
<td>8%</td>
<td>10%</td>
<td>-22%</td>
<td>-1%</td>
</tr>
<tr>
<td>Korea</td>
<td>3%</td>
<td>12%</td>
<td>4%</td>
<td>6%</td>
<td>34%</td>
<td>-23%</td>
<td>15%</td>
<td>-1%</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>China</td>
<td>32%</td>
<td>9%</td>
<td>51%</td>
<td>-4%</td>
<td>17%</td>
<td>17%</td>
<td>53%</td>
<td>8%</td>
<td>9%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data

The analysis of labour productivity discloses a similar result as for the gross-operating rate. The productivities of the US and Japanese RSI are much higher than for the EU, but it declined for Japan and increases by 1 per cent for the US over the period under investigation whereas in contras the EU has enjoyed an improvement in the efficiency of labour input of 2 per cent. Only for China and Korea labour productivity had increased significantly. The growth of the Korean RSI was not only strong, but latest available figures indicate that it has matched labour productivities of the US and the Japanese RSI.

Unit Labour Cost

Unit Labour Cost (ULC) is another key component of cost competitiveness. ULC is approached by:

$$\text{Unit Labour Cost (EU)} = \frac{\text{Wages & salaries (nominal)}}{\text{Value added (real)}}$$

Wages and salaries are measured in nominal terms and transformed into euros using the average exchange rate of the Euro versus the national currency for each year. Value added is measured in Euros and in real terms with 2000 as the base year.

Table 4.8 Unit labour cost

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>0,75</td>
<td>0,72</td>
<td>0,79</td>
<td>0,83</td>
<td>0,96</td>
<td>0,85</td>
<td>0,82</td>
<td>0,83</td>
<td>0,87</td>
<td>0,91</td>
</tr>
<tr>
<td>US</td>
<td>0,34</td>
<td>0,35</td>
<td>0,36</td>
<td>0,38</td>
<td>0,40</td>
<td>0,43</td>
<td>0,36</td>
<td>0,44</td>
<td>0,44</td>
<td>0,48</td>
</tr>
<tr>
<td>Japan</td>
<td>0,30</td>
<td>0,32</td>
<td>0,33</td>
<td>0,35</td>
<td>0,32</td>
<td>0,38</td>
<td>0,35</td>
<td>0,34</td>
<td>0,30</td>
<td>0,35</td>
</tr>
<tr>
<td>Korea</td>
<td>0,25</td>
<td>0,25</td>
<td>0,27</td>
<td>0,29</td>
<td>0,30</td>
<td>0,23</td>
<td>0,33</td>
<td>0,27</td>
<td>0,33</td>
<td>0,31</td>
</tr>
<tr>
<td>China</td>
<td>0,41</td>
<td>0,35</td>
<td>0,36</td>
<td>0,34</td>
<td>0,35</td>
<td>0,32</td>
<td>0,31</td>
<td>0,25</td>
<td>0,26</td>
<td>0,26</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data
Even though, ULC in the European railway sector has declined since 2004, the EU has the highest ULC in the reference group. Again especially the development of the indicator is important and in that sense the decline is a positive signal. From 2007, Chinese ULC declined making its RSI the most competitive regarding this outcome indicator. On the other hand, the US and Japan have seen their ULC raised, approaching the gap with the EU RSI. On the other hand, Korean RSI maintained its price competitiveness with lower ULCs than the European, US and Japanese railway manufacturing sector. Its ULCs have remained close to Chinese.

ULCs are not included in the overall Competitiveness Index. The ECI needs ‘positive’ indicators of competitiveness. Outcome indicators are divided between countries to calculate a ratio from which higher (lower) than the unity means the country is competitive (uncompetitive). For example, dividing EU’s ULC between Japan’s ULC provides a ratio higher than one whilst the EU has higher unit labour costs.

**Revealed Comparative Advantage (RCA)**

The RCA measures the external competitiveness of an industry. This indicator informs us about the level of a country’s competitiveness in exporting a specific product. The RCA index of country i for the RSI is measured by the product’s share in the country’s exports in relation to its share in world trade. The statistical definition of the RCA can be found below:

\[
RCA_{iRSI} = \frac{x_{iRSI}}{x_{RSI}} \cdot \frac{x_{wRSI}}{x_{wt}}
\]

Where:
- \( x_{iRSI} \): value of country i’s RSI exports
- \( x_{wRSI} \): value of world RSI exports
- \( x_{it} \): value of country i’s total exports of manufactured goods
- \( x_{wt} \): value world total exports of manufactured goods

A value of more (less) than one, implies that the country has a revealed comparative advantage (disadvantage) in the RSI (World Integrated Trade Solution - WITS, 2012).
Table 4.9 Revealed comparative advantage

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
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<td>1.61</td>
<td>1.63</td>
<td>1.72</td>
</tr>
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<td>2.36</td>
<td>2.48</td>
<td>2.57</td>
<td>2.51</td>
<td>2.52</td>
<td>2.85</td>
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<td>1.17</td>
<td>1.16</td>
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</tr>
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<td>2.62</td>
<td>2.57</td>
<td>2.83</td>
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</tr>
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<td>0.30</td>
<td>0.36</td>
<td>0.31</td>
<td>0.37</td>
<td>0.47</td>
<td>0.52</td>
<td>0.67</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data

The EU, Japanese and Korean economies are focusing on RSI exports. This is reflected in their RCAs being higher than one. The Korean economy has strongly expanded its presence in global markets. The RSI sector has been even more dynamic and the share of RSI exports of total exports of manufactured goods exceeds by far the shares of the competing economies’ RSI. Over the period under investigation the RCA has reached a value of more than 3 in 2007. The years after the RCA has been soaring, but this might be attributed to one time effects of large contracts. But generally speaking the growth of the RCA and the good performance of price and cost indicators add together to a growing competitiveness of the Korean RCA. This fits in the overall picture of Korea which is strongly pushing its export position globally as being the major motor for growth given the relatively small size of the country. Nevertheless the extremely strong development in 2008 en 2009 is also expected to be due to incidental large orders, as further investigation into the Korean RCA for the RSI shows that its RCA in 2011 is back to 2.5.

It is more difficult to assess the performance of the US RSI. Its RCA had steadily improved until 2007 and then plummeted. Nevertheless, it is well above two for the previous years, there is a significant reduction on railway exports in comparison with the growth rate of the other countries. US railway manufacturers are specialised in the production of freight locomotives and rolling stock. This market has been badly hit by the economic downturn.

The RCA for Chinese RSI was below 1 for most of the period under consideration, but growing. Only in 2009 it exceeded 1. This was the first year when the share of Chinese RSI exports of total exports was higher than on global average. This development indicates a growing specialization of China in the world market on RSI. An RCA value below 1 is a typical pattern for non-industrialized
and emerging economies. RSI is an industry that is characterized by a complex value chain with numerous specialized manufacturers. Therefore, a competitive RSI requires a well-developed manufacturing environment that usually is not available in catching up economies. The Chinese performance in foreign trade indicates beyond a growing strength in RSI a more general growth in technological and industrial competencies.

It should be noted that trade in railway products is characterised by the purchase of big orders. These big orders are expected to be partly responsible for the rapid fluctuation in the RCA of the US and Korean RSI.

Table 4.10 Total exports of railway products (€ billion)

<table>
<thead>
<tr>
<th>Year</th>
<th>EU</th>
<th>US</th>
<th>JP</th>
<th>KR</th>
<th>CH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1,64</td>
<td>1,38</td>
<td>0,40</td>
<td>0,09</td>
<td>0,20</td>
</tr>
<tr>
<td>2001</td>
<td>1,79</td>
<td>1,52</td>
<td>0,57</td>
<td>0,07</td>
<td>0,09</td>
</tr>
<tr>
<td>2002</td>
<td>1,84</td>
<td>1,02</td>
<td>0,43</td>
<td>0,11</td>
<td>0,19</td>
</tr>
<tr>
<td>2003</td>
<td>2,05</td>
<td>1,18</td>
<td>0,26</td>
<td>0,13</td>
<td>0,16</td>
</tr>
<tr>
<td>2004</td>
<td>2,03</td>
<td>1,28</td>
<td>0,30</td>
<td>0,17</td>
<td>0,29</td>
</tr>
<tr>
<td>2005</td>
<td>1,92</td>
<td>1,62</td>
<td>0,22</td>
<td>0,06</td>
<td>0,43</td>
</tr>
<tr>
<td>2006</td>
<td>2,25</td>
<td>1,96</td>
<td>0,54</td>
<td>0,17</td>
<td>0,53</td>
</tr>
<tr>
<td>2007</td>
<td>3,10</td>
<td>1,82</td>
<td>0,34</td>
<td>0,20</td>
<td>0,55</td>
</tr>
<tr>
<td>2008</td>
<td>2,98</td>
<td>1,92</td>
<td>0,56</td>
<td>0,34</td>
<td>0,80</td>
</tr>
<tr>
<td>2009</td>
<td>3,90</td>
<td>1,46</td>
<td>0,69</td>
<td>0,22</td>
<td>0,67</td>
</tr>
</tbody>
</table>

Table 4.11 Total exports growth rate with respect to the previous period (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>EU</th>
<th>US</th>
<th>JP</th>
<th>KR</th>
<th>CH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>9%</td>
<td>11%</td>
<td>43%</td>
<td>-25%</td>
<td>-57%</td>
</tr>
<tr>
<td>2002</td>
<td>3%</td>
<td>-33%</td>
<td>-23%</td>
<td>56%</td>
<td>117%</td>
</tr>
<tr>
<td>2003</td>
<td>11%</td>
<td>15%</td>
<td>-39%</td>
<td>27%</td>
<td>-16%</td>
</tr>
<tr>
<td>2004</td>
<td>-1%</td>
<td>9%</td>
<td>13%</td>
<td>27%</td>
<td>88%</td>
</tr>
<tr>
<td>2005</td>
<td>-5%</td>
<td>26%</td>
<td>-26%</td>
<td>27%</td>
<td>45%</td>
</tr>
<tr>
<td>2006</td>
<td>17%</td>
<td>21%</td>
<td>141%</td>
<td>-68%</td>
<td>24%</td>
</tr>
<tr>
<td>2007</td>
<td>38%</td>
<td>-7%</td>
<td>-36%</td>
<td>205%</td>
<td>5%</td>
</tr>
<tr>
<td>2008</td>
<td>-4%</td>
<td>5%</td>
<td>62%</td>
<td>20%</td>
<td>45%</td>
</tr>
<tr>
<td>2009</td>
<td>31%</td>
<td>-24%</td>
<td>24%</td>
<td>-36%</td>
<td>-17%</td>
</tr>
<tr>
<td>Average</td>
<td>-4%</td>
<td>24%</td>
<td>-1%</td>
<td>27%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Growth in employment

Growth in employment is another outcome indicator of sectoral competitiveness. Growth in employment is measured in thousands and it is calculated as follows:

\[
\text{Growth in employment} = \frac{\text{number of persons employed}_{t} - \text{number of persons employed}_{t-1}}{\text{number of persons employed}_{t-1}}\times 100
\]

In 2009, Chinese RSI employed around 320,000 workers while the EU RSI had a total workforce of 108,000. These two countries concentrated 90 per cent of the total number of employees in the reference group. The other countries account for 28,000; 15,000 and 5,000 thousand employees for the US, Japan and Korea respectively.

The following table and figure shows the evolution of employment in the RSI for the five countries.

Table 4.12 Employment (000’s)

<table>
<thead>
<tr>
<th>Year</th>
<th>EU</th>
<th>US</th>
<th>Japan</th>
<th>Korea</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>165</td>
<td>27</td>
<td>14</td>
<td>6</td>
<td>233</td>
</tr>
<tr>
<td>2001</td>
<td>168</td>
<td>27</td>
<td>15</td>
<td>6</td>
<td>221</td>
</tr>
<tr>
<td>2002</td>
<td>173</td>
<td>25</td>
<td>14</td>
<td>6</td>
<td>216</td>
</tr>
<tr>
<td>2003</td>
<td>175</td>
<td>24</td>
<td>14</td>
<td>5</td>
<td>249</td>
</tr>
<tr>
<td>2004</td>
<td>173</td>
<td>24</td>
<td>15</td>
<td>5</td>
<td>312</td>
</tr>
<tr>
<td>2005</td>
<td>170</td>
<td>26</td>
<td>14</td>
<td>5</td>
<td>302</td>
</tr>
<tr>
<td>2006</td>
<td>163</td>
<td>28</td>
<td>15</td>
<td>6</td>
<td>293</td>
</tr>
<tr>
<td>2007</td>
<td>160</td>
<td>29</td>
<td>16</td>
<td>5</td>
<td>271</td>
</tr>
<tr>
<td>2008</td>
<td>167</td>
<td>30</td>
<td>18</td>
<td>5</td>
<td>304</td>
</tr>
<tr>
<td>2009</td>
<td>161</td>
<td>28</td>
<td>17</td>
<td>5</td>
<td>320</td>
</tr>
</tbody>
</table>

Source: Ecorys based on Eurostat and UN COMTRADE data
Positive dynamics in terms of employment have been taking place in the five countries with the exception of Korea. While the US and Korea have maintained their level of employment, Chinese and Japanese RSIs have been able to increase the number of employees. The EU RSI was able to maintain its workforce during the period with a slight decline in the number of jobs equals to 5 thousand.

A further analysis of the level of employment in the RSI for the five countries needs to take into account the differences in economic size. The following table shows the level of employment in the RSI as a ratio of the level of output/production.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>11.2</td>
<td>10.5</td>
<td>9.5</td>
<td>8.6</td>
<td>8.4</td>
<td>7.8</td>
<td>7.1</td>
<td>6.1</td>
<td>5.8</td>
<td>5.9</td>
</tr>
<tr>
<td>US</td>
<td>3.5</td>
<td>3.0</td>
<td>3.1</td>
<td>3.6</td>
<td>4.0</td>
<td>3.5</td>
<td>2.9</td>
<td>3.0</td>
<td>3.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Japan</td>
<td>3.7</td>
<td>3.7</td>
<td>3.7</td>
<td>4.5</td>
<td>4.1</td>
<td>3.9</td>
<td>4.3</td>
<td>4.7</td>
<td>4.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Korea</td>
<td>5.1</td>
<td>5.2</td>
<td>4.7</td>
<td>5.4</td>
<td>5.3</td>
<td>3.6</td>
<td>3.7</td>
<td>3.0</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>China</td>
<td>87.3</td>
<td>67.0</td>
<td>69.0</td>
<td>54.9</td>
<td>58.5</td>
<td>48.4</td>
<td>39.9</td>
<td>29.3</td>
<td>23.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>

All countries, except for Japan, have reduced its amount of labour in relation to output. This is an indication of the productivity gains due to the industry’s ability to produce more output with less labour. It is the Chinese RSI, the one which has reduced its labour intensity in a greater degree. In addition, in comparison with the other countries, Chinese RSI still have the capacity to achieve further reductions.

**Output (production)**

Production and the share of production within a given area of total production are indicators of past competitiveness, as well as, a driver of future competitiveness. There are no data available for the global production. As a first approximation we use the production of the competing economies under consideration in this study. The following table shows in nominal terms and € billion of the

![Figure 4.6 Growth in employment](source: Ecorys based on Eurostat and UN COMTRADE data)
global production as measured by the output of the RSI for the five analysed countries between 2000 and 2009.

Table 4.14 Output for the RSI (€ billion)

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>14.7</td>
<td>16.0</td>
<td>18.2</td>
<td>20.4</td>
<td>20.6</td>
<td>21.8</td>
<td>23.0</td>
<td>26.4</td>
<td>28.7</td>
<td>27.1</td>
</tr>
<tr>
<td>US</td>
<td>7.7</td>
<td>8.8</td>
<td>8.0</td>
<td>6.6</td>
<td>6.1</td>
<td>7.4</td>
<td>9.6</td>
<td>9.7</td>
<td>8.9</td>
<td>9.3</td>
</tr>
<tr>
<td>JP</td>
<td>3.7</td>
<td>4.0</td>
<td>3.8</td>
<td>3.2</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
<td>3.4</td>
<td>3.9</td>
<td>3.1</td>
</tr>
<tr>
<td>KR</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.6</td>
<td>1.6</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>CH</td>
<td>2.7</td>
<td>3.3</td>
<td>3.1</td>
<td>4.5</td>
<td>5.3</td>
<td>6.2</td>
<td>7.3</td>
<td>9.3</td>
<td>13.2</td>
<td>17.8</td>
</tr>
<tr>
<td>Total</td>
<td>29.9</td>
<td>33.3</td>
<td>34.3</td>
<td>35.7</td>
<td>36.8</td>
<td>40.4</td>
<td>44.9</td>
<td>50.4</td>
<td>56.4</td>
<td>58.8</td>
</tr>
</tbody>
</table>

All countries, except for Japan, have increased their production level. In relative terms, the EU is the most important producer of RSI accounting for half of the railway production in the reference group. Although fluctuation occur their appear to be sign that the EU, Japan and the US have reduced their shares. Although still very high, the share of production in the EU has been gradually declining from 56% in 2003 to 46% in 2009. On the other hand, Chinese contribution to total output has increased strongly throughout the period becoming in 2009 the second most important producer in the reference group. The increasing production shares in Chinese RSI are due to a stronger growth in output during whole period in comparison with the other countries, especially between 2003-2004 and 2008-099.

The changes in production share over time better define competitiveness. production share changes in the reference group indicate a shift in performance. The ECI uses the following formula to assess the growth of market share (Berning 2011).

\[
\text{production growth} = \frac{\text{production value at } t}{\text{production value at } t-1}
\]

Calculating the Ecorys Competitiveness Index

Methodology

The ECI is calculated from five out of the six outcome indicators previously analysed i.e. gross operating rate, labour productivity, market share, growth of employment, and revealed comparative advantage. Due to the relative nature of competitiveness, we develop the ECI as outcome indicator country-pairs for the EU with all the other nations included in the reference group i.e. the US, Japan, Korea and China.

Following Berning (2011), the EU is referred as ‘source country’ (country i), and each country the EU will be compared is defined as ‘destination country’ (country j). The EU ECI for the railway supply industry is calculated as the EU score divided by the score of the destination country i.e. US, Japan, Korea and China in each of the outcome indicators. If the score of the indicator is bigger (lower) than the unity, the EU has a competitive advantage (disadvantage) in that outcome indicator. This procedure is repeated for every country pair, after which the average is taken to calculate the ECI of the EU in the railway sector for each of the output indicators during the analysed period. Finally, the ECIs are averaged again to calculate a unique index of competitiveness.
The creation of country pairs has two main advantages: (i) comparing two nations is in line with theoretical consensus that competitiveness is a relative concept; and (ii) using ratios eliminates the different units in which the indicators are expressed.

The five outcome indicators are Gross Operating Rate (GOR); Labour Productivity (LP); Production Growth (PG); Revealed Comparative Advantage (RCA); and Growth in Employment (GE).

The ECI score of a given country $i$ compared to a destination country $j$ in a specific year $t$ for sector $k$ – in our case the RSI - was obtained by adding up the 4 bilateral scores of country $i$ and divide it by the number of observations (i.e. 4). This is done for the five output indicators available for source country $i$, after which a simple average is taken in order to obtain the ECI score of that given year.

Expressed in a mathematical formula, the ECI reads as follows:

$$ECI_{i,k} = \frac{\sum_{j} \left( \frac{TP_{j,k} + LP_{j,k} + PG_{j,k} + RCA_{j,k} + GE_{j,k}}{5} \right)}{\text{number of reported output indicators}}$$

**Results**

The ECI for each of the outcome indicators and the final average can be seen in the table below and displayed in the following figure.

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average (2001-09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR</td>
<td>0.33</td>
<td>0.41</td>
<td>0.54</td>
<td>0.33</td>
<td>0.51</td>
<td>0.60</td>
<td>0.55</td>
<td>0.64</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>LP</td>
<td>1.61</td>
<td>1.47</td>
<td>1.22</td>
<td>1.31</td>
<td>1.36</td>
<td>1.26</td>
<td>1.01</td>
<td>0.95</td>
<td>0.82</td>
<td>1.22</td>
</tr>
<tr>
<td>PG</td>
<td>0.97</td>
<td>1.18</td>
<td>1.21</td>
<td>0.96</td>
<td>0.92</td>
<td>0.93</td>
<td>1.08</td>
<td>0.98</td>
<td>0.95</td>
<td>1.02</td>
</tr>
<tr>
<td>RCA</td>
<td>2.32</td>
<td>2.28</td>
<td>2.05</td>
<td>2.25</td>
<td>2.25</td>
<td>1.50</td>
<td>1.38</td>
<td>1.18</td>
<td>1.61</td>
<td>1.87</td>
</tr>
<tr>
<td>GE</td>
<td>1.01</td>
<td>1.07</td>
<td>1.01</td>
<td>0.93</td>
<td>1.02</td>
<td>0.90</td>
<td>1.02</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Average ECI</td>
<td>1.25</td>
<td>1.28</td>
<td>1.21</td>
<td>1.16</td>
<td>1.21</td>
<td>1.04</td>
<td>1.01</td>
<td>0.95</td>
<td>0.99</td>
<td>1.12</td>
</tr>
</tbody>
</table>

The average ECI shows that the EU RSI is above and equal to one regarding its overall competitiveness during the whole period. This final result needs to be interpreted within the reference group which is composed by the most important EU competitors in the railway sector. The ECI suffered a declining trend from 2005, the level of competitiveness goes to one in 2006 and remains in that position until the end of the period. Regarding its components, the EU competitiveness is positively influenced by its strong performance in third markets measured through the RCA. Labour productivity is above the average ECI until 2007, experiencing a declining trend. Production growth Market share and growth of employment fluctuates below and above one. Gross operating rate is the weakest outcome indicator of EU railway competitiveness, although, it has improved since 2004.

The ECI attaches the same weight to all the countries. This is a major detriment since we have included countries with different level of GDPs and industrial development. Korea has a low GDP in comparison with the other countries. Chinese RSI is catching up in terms of technology with the other countries. In contrast, the US and Japan are high-tech competitors of the EU RSI.

In order to overcome this issue, the ECI for the EU RSI is calculated against the performance of the different countries. Firstly the EU RSI is assessed against the US and Japanese RSI. Secondly, the same analysis is conducted for the Chinese and the Korean RSI.

The following table and figure provide the ECI for the EU RSI in comparison with the US.
Table 4.16 ECI for the EU RSI calculated against the performance of the US RSI

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average (2001-09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR</td>
<td>0.31</td>
<td>0.39</td>
<td>0.51</td>
<td>0.29</td>
<td>0.48</td>
<td>0.51</td>
<td>0.58</td>
<td>0.60</td>
<td>0.58</td>
<td>0.45</td>
</tr>
<tr>
<td>LP</td>
<td>0.20</td>
<td>0.19</td>
<td>0.23</td>
<td>0.25</td>
<td>0.32</td>
<td>0.28</td>
<td>0.35</td>
<td>0.36</td>
<td>0.35</td>
<td>0.27</td>
</tr>
<tr>
<td>PG</td>
<td>0.95</td>
<td>1.26</td>
<td>1.36</td>
<td>1.09</td>
<td>0.87</td>
<td>0.81</td>
<td>1.14</td>
<td>1.18</td>
<td>0.91</td>
<td>1.06</td>
</tr>
<tr>
<td>RCA</td>
<td>1.04</td>
<td>1.10</td>
<td>1.06</td>
<td>0.98</td>
<td>0.92</td>
<td>0.89</td>
<td>0.93</td>
<td>1.02</td>
<td>1.03</td>
<td>1.00</td>
</tr>
<tr>
<td>GE</td>
<td>0.79</td>
<td>0.70</td>
<td>0.72</td>
<td>0.73</td>
<td>0.75</td>
<td>0.53</td>
<td>0.52</td>
<td>0.63</td>
<td>3.53</td>
<td>0.98</td>
</tr>
<tr>
<td>Average ECI</td>
<td>0.66</td>
<td>0.73</td>
<td>0.78</td>
<td>0.67</td>
<td>0.67</td>
<td>0.61</td>
<td>0.70</td>
<td>0.76</td>
<td>1.28</td>
<td>0.76</td>
</tr>
</tbody>
</table>


Figure 4.8 ECI of the EU RSI calculated against the performance of the US RSI

The competitiveness of the EU RSI in comparison with the US RSI has improved over time. Even though, labour productivity and gross operating rate are lower than one, both variables show a positive trend. On the other side, growth in employment and production growth fluctuated around one. The revealed comparative advantage is over one during the whole period but jumped in 2009 due to the strong reduction in this outcome indicator for the US RSI.

The same analysis is conducted for the Japanese RSI in the table and figure below.
Table 4.17 ECI for the EU RSI calculated against the performance of the Japanese RSI

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average (2001-09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR</td>
<td>0.29</td>
<td>0.35</td>
<td>0.48</td>
<td>0.29</td>
<td>0.58</td>
<td>0.64</td>
<td>0.58</td>
<td>0.61</td>
<td>0.55</td>
<td>0.46</td>
</tr>
<tr>
<td>LP</td>
<td>0.23</td>
<td>0.21</td>
<td>0.26</td>
<td>0.23</td>
<td>0.33</td>
<td>0.37</td>
<td>0.41</td>
<td>0.35</td>
<td>0.36</td>
<td>0.30</td>
</tr>
<tr>
<td>PG</td>
<td>1.00</td>
<td>1.18</td>
<td>1.37</td>
<td>0.86</td>
<td>1.08</td>
<td>1.13</td>
<td>1.15</td>
<td>0.95</td>
<td>1.17</td>
<td>1.10</td>
</tr>
<tr>
<td>GE</td>
<td>0.93</td>
<td>1.07</td>
<td>1.02</td>
<td>0.93</td>
<td>1.03</td>
<td>0.94</td>
<td>0.91</td>
<td>0.92</td>
<td>1.04</td>
<td>0.98</td>
</tr>
<tr>
<td>RCA</td>
<td>1.96</td>
<td>1.78</td>
<td>1.71</td>
<td>1.64</td>
<td>1.82</td>
<td>1.40</td>
<td>1.39</td>
<td>1.27</td>
<td>0.93</td>
<td>1.59</td>
</tr>
<tr>
<td>Average</td>
<td>0.88</td>
<td>0.92</td>
<td>0.97</td>
<td>0.79</td>
<td>0.97</td>
<td>0.90</td>
<td>0.89</td>
<td>0.82</td>
<td>0.81</td>
<td>0.88</td>
</tr>
</tbody>
</table>


Figure 4.9 ECI for the EU RSI calculated against the performance of the Japanese RSI

The competitiveness of the EU RSI in comparison with the Japanese RSI has declined from 2005. However, even though, labour productivity and gross operating rate are lower than one, both variables show a positive trend. On the other side, growth in employment and production growth fluctuated around one. The revealed comparative advantage experiences a declining trend being below one in the last year of the analyzed period.

Regarding Chinese RSI, the same analysis is conducted in the table and figure below.
Table 4.18 ECI for the EU RSI calculated against the performance of the Chinese RSI

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average (2001-09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR</td>
<td>0.46</td>
<td>0.57</td>
<td>0.72</td>
<td>0.47</td>
<td>0.63</td>
<td>0.77</td>
<td>0.62</td>
<td>0.78</td>
<td>0.76</td>
<td>0.64</td>
</tr>
<tr>
<td>LP</td>
<td>5.69</td>
<td>5.19</td>
<td>4.09</td>
<td>4.50</td>
<td>4.57</td>
<td>4.09</td>
<td>3.00</td>
<td>2.70</td>
<td>2.19</td>
<td>4.00</td>
</tr>
<tr>
<td>PG</td>
<td>0.88</td>
<td>1.20</td>
<td>0.77</td>
<td>0.86</td>
<td>0.91</td>
<td>0.90</td>
<td>0.91</td>
<td>0.76</td>
<td>0.70</td>
<td>0.88</td>
</tr>
<tr>
<td>GE</td>
<td>1.07</td>
<td>1.06</td>
<td>0.87</td>
<td>0.79</td>
<td>1.02</td>
<td>0.99</td>
<td>1.06</td>
<td>0.93</td>
<td>0.92</td>
<td>0.97</td>
</tr>
<tr>
<td>RCA</td>
<td>5.75</td>
<td>5.97</td>
<td>5.08</td>
<td>5.98</td>
<td>5.70</td>
<td>3.54</td>
<td>3.11</td>
<td>2.43</td>
<td>1.63</td>
<td>4.35</td>
</tr>
<tr>
<td>Average</td>
<td>2.77</td>
<td>2.80</td>
<td>2.31</td>
<td>2.52</td>
<td>2.57</td>
<td>2.06</td>
<td>1.74</td>
<td>1.52</td>
<td>1.24</td>
<td>2.17</td>
</tr>
</tbody>
</table>


Figure 4.10 ECI for the EU RSI calculated against the performance of the Chinese RSI

The EU RSI is more competitive than its Chinese counterparts. However, the overall ECI has experienced a declining trend. Even though, the EU RSI deliver a better performance regarding labour productivity and export performance, the Chinese RSI have been catching up reducing the gap between both industries regarding these two indicators. On the other hand, gross operating rate for the EU RSI vis-à-vis the Chinese RSI has improved. Growth in employment and production growth have been close to one during the period.

Finally, Korean RSI has experienced a positive growth with an overall improvement in competitiveness. However, relative sizes matter at the time to compare. In 2009, Korean's RSI output was 5.6 per cent of European’s RSI output. The following table and figure show the competitiveness of the EU RSI vis-à-vis Korean RSI.
Table 4.19 ECI for the EU RSI calculated against the performance of the Korean RSI

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average (2001-09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR</td>
<td>0.25</td>
<td>0.32</td>
<td>0.46</td>
<td>0.28</td>
<td>0.34</td>
<td>0.47</td>
<td>0.41</td>
<td>0.57</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>LP</td>
<td>0.32</td>
<td>0.27</td>
<td>0.30</td>
<td>0.28</td>
<td>0.23</td>
<td>0.29</td>
<td>0.29</td>
<td>0.37</td>
<td>0.37</td>
<td>0.30</td>
</tr>
<tr>
<td>PG</td>
<td>1.07</td>
<td>1.07</td>
<td>1.34</td>
<td>1.02</td>
<td>0.82</td>
<td>0.88</td>
<td>1.11</td>
<td>1.04</td>
<td>1.04</td>
<td>1.04</td>
</tr>
<tr>
<td>GE</td>
<td>0.99</td>
<td>1.05</td>
<td>1.06</td>
<td>1.01</td>
<td>1.12</td>
<td>0.77</td>
<td>1.17</td>
<td>1.06</td>
<td>0.96</td>
<td>1.02</td>
</tr>
<tr>
<td>RCA</td>
<td>0.76</td>
<td>0.69</td>
<td>0.70</td>
<td>0.65</td>
<td>0.72</td>
<td>0.54</td>
<td>0.49</td>
<td>0.38</td>
<td>0.34</td>
<td>0.59</td>
</tr>
<tr>
<td>Average ECI</td>
<td>0.68</td>
<td>0.68</td>
<td>0.77</td>
<td>0.65</td>
<td>0.65</td>
<td>0.59</td>
<td>0.70</td>
<td>0.68</td>
<td>0.64</td>
<td>0.67</td>
</tr>
</tbody>
</table>


The EU RSI is less competitive than the Korean RSI. Even though, growth in employment and production growth fluctuate around one, the other output indicators are lower than one during the whole period. Labour productivity and gross operating rate, although, increasing during the period are fairly low. The performance of Korean RSI in third markets outpaced the EU RSI. This can be seen from the declining trend of this outcome indicator from 2005.

4.3 Other (framework) factors influencing EU RSI competitiveness

Whereas in the previous section an analysis is made of the current competitiveness of the EU27 RSI over the past period, in addition a number of framework condition are relevant to determine the overall competitive position. This section elaborates on the technological advancement of the EU RSI and the access to labour as two essential framework conditions for EU RSI. Regulatory conditions are being assessed in the next section which deals with the openness of markets.

4.3.1 Performance of the EU RSI in technological competition

The amount of resources allocated in research and development (R&D) and the ability of the industry to transform those resources into innovative products is a key aspect of the present and future competitiveness of the RSI. The importance of R&D, however, is difficult to quantify. Even though, we can measure the amount of resources committed to R&D, it is difficult to assess to what
extent those resources will end up being successful innovations. The trade-off between resources and continuous innovation depends on the quality of the institution and to some extent on certain degree of randomness.

All in all, the EU RSI has some peculiarities that need to be analysed in order to understand the effect of R&D expenditure on its competitiveness. In this regard, the success of European producers in third markets is highly reliant on its technological capabilities. Innovation is, however, driven by future demand of railway products and constrained by its relatively low level of profitability, as we have seen in the previous section regarding the EU RSI gross operating rate. In this section, we describe these elements and the performance of the EU RSI, analysed by means of expenditures on R&D.

The innovation process in the EU RSI
Innovation in the EU RSI is a mixture of supply and demand driven innovation. In each tender the operator defines the requirements and the industry competes to offer the best product with the most efficient technology. In order to accommodate the needs of the operator, the system integrators define products and technologies. RSI manufacturers have to balance investment expenditure and running costs to meet clients’ expectations and win contracts.

R&D is conducted by the system integrator and by the companies within its supply chain. It can be a vertical process where the system integrator asks its suppliers for a specific output. Yet it can take the form of a bottom-up process where a component of the RSI is designed or improved by an upstream company. Of special importance are innovations carried out by key component suppliers, for instance in the area of drive trains.

Innovation can be driven by new regulations and harmonisation requirements. In the signalling segment, there has been an intense R&D activity in order to meet the new EU requirements of a common European signalling system in the railway. This new standards have successfully become global standards, helping EU companies to exports their products in third markets.

Innovation in the RSI, stimulated by the need to win new contracts, is highly dependent on the demand of railway products. However, locomotive and rolling stock, and railway infrastructure are long-term assets with long depreciation periods. Therefore replacement of the old railway system only takes place at a slow pace, reducing the speed of dissemination of innovations. Thus, the capacity of the industry to remain competitive depends on the ability to supply new locomotives, railway infrastructure, and signalling in third countries which are investing in new railway.

In international tenders, the best technology and the proven capacity to implement the project throughout references are very important factors. This is a major advantage of the European RSI. EU companies have the experience and the advance technology. Even though, Japanese technology follows closely and Chinese companies are catching up, the EU RSI maintains the lead in this regard. Since technology is geared towards running costs, the EU RSI is able to offer the best value for money. This is a crucial factor to understand its leadership exporting these products.

The EU RSI has low margins in comparison with its main competitors. Even though, gross operating rate has increased since 2004, the EU is still at the bottom of the table regarding this outcome of competitiveness. The low level of profitability may have negative consequences in the ability of the EU RSI to invest in R&D and therefore in its future competitiveness and likelihood to win international tenders. In the past, however, the EU RSI, compared to the US, Japanese, Korean and Chinese RSI, has had the lowest level of gross operating rate but it has being able to maintain its strong position in international markets.
Measuring R&D expenditure in the RSI

Innovation efforts in the railway supply industry are measured by expenditures on R&D. For international comparisons, use has been made of the OECD database on industrial R&D expenditures for 32 OECD countries and 6 non-member economies\(^{61}\). No EU27 figure is supplied by OECD but expenditure in most important R&D expenditure Members States have been selected to assess the expenditure pattern in the European Union.

Total R&D expenditure

Total R&D expenditure is presented for selected EU Member States\(^{62}\), the US, Korea, China, Japan and Russia. Figure 4.11 shows the total expenditure in these countries for the years 2000 and 2009\(^{63}\).

Figure 4.11 R&D expenditure in railway equipment for selected countries (million USD in constant 2005 prices (PPP)), 2000 and 2008

Note 1: EU6 = Germany, France, Spain, Italy, UK, Austria.
Note 2: for France and Germany 2008 figures are based on 2007
Source: www.oecd.org/sti/anberd, data for category C352A9: Railroad equipment

The figures show that, according to OECD data, the US has the largest R&D expenditure in the sector “Railroad equipment” followed by the sum of the 6 selected EU Member States\(^{64}\). Total R&D

\(^{61}\) www.oecd.org/sti/anberd C352A9: Railroad equipment and transport equipment nec The ANalytical Business Enterprise Research and Development database (ANBERD) was developed to provide analysts with comprehensive and internationally comparable data on industrial R&D expenditures that address the problems of international comparability and breaks in the time series of official business enterprise R&D data (OFFBERD) provided to the OECD by its member countries through the joint OECD/Eurostat R&D survey. The ANBERD database includes a number of estimations

\(^{62}\) Member States with the highest R&D expenditure in the sector Railroad equipment have been selected.

\(^{63}\) This is the most recent year for which data are available for most selected countries

\(^{64}\) It is noted that this high R&D level apparently is not reflected in the number of patents of the US (see figure 4.12).
expenditure in Japan, Korea and China is much lower and comparable to some of the larger EU27 Member States, although it should be mentioned that for China only 2000 data were available. It is expected that current expenditure in China is much higher than in 2000. The figures also show a decrease in overall R&D expenditure in the EU countries between 2000 and 2008 in absolute terms although differences exist between countries.

**R&D intensity**
The same OECD database also presents indicators regarding the R&D intensity. Two different indicators are used: R&D expenditure as percentage of value added and R&D as percentage of total production value. Table 4.20 presents data for both indicators for selected countries for which data are available. Apart from 2000 the most recent available data are presented.

<table>
<thead>
<tr>
<th>Country</th>
<th>R&amp;D as % of value added</th>
<th>Most recent year</th>
<th>R&amp;D as percentage of production value</th>
<th>Most recent year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td></td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>9.6%</td>
<td>11.6%</td>
<td>2008</td>
<td>3.6%</td>
</tr>
<tr>
<td>Japan</td>
<td>9.4%</td>
<td>12.8%</td>
<td>2006</td>
<td>3.3%</td>
</tr>
<tr>
<td>Korea</td>
<td>10.1%</td>
<td>6.3%</td>
<td>2006</td>
<td>2.6%</td>
</tr>
<tr>
<td>France</td>
<td>9.9%</td>
<td>12.4%</td>
<td>2006</td>
<td>2.6%</td>
</tr>
<tr>
<td>Germany</td>
<td>17.3%</td>
<td>6.3%</td>
<td>2007</td>
<td>4.7%</td>
</tr>
<tr>
<td>Italy</td>
<td>4.0%</td>
<td>5.6%</td>
<td>2007</td>
<td>0.9%</td>
</tr>
<tr>
<td>Spain</td>
<td>6.1%</td>
<td>5.6%</td>
<td>2007</td>
<td>1.4%</td>
</tr>
<tr>
<td>Austria</td>
<td>8.5%</td>
<td>12.7%</td>
<td>2002, 2007</td>
<td>2.0%</td>
</tr>
<tr>
<td>UK</td>
<td>20.9%</td>
<td>2.8%</td>
<td>2006</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

Source: [www.oecd.org/sti/anberd](http://www.oecd.org/sti/anberd), data for category C352A9: Railroad equipment

Large differences exist between years, but the overall picture is that there are a number of countries in Europe with a relatively high R&D intensity (viz. France, Austria and Germany), whereas among competitor countries especially Japan and the US show a high research intensity and Korea a much lower R&D intensity. The latter is also in line with the relatively low absolute R&D expenditure in Korea.

In addition to the OECD data on a country level, direct industry information can be derived from annual reports and interviews with some of the sector players. This also gives further information regarding R&D in the different market segment that are discerned in this report.

In the locomotive and rolling stock segment, estimations for the major system integrators (Siemens, Alstom, Bombardier) reveal that around 5-10 per cent of turnover is invested in research and development.

The available information from Vossloh, VoestAlpine and Delachaux reveals that R&D in the market segment of railway infrastructure is much lower, approximating roughly 2 per cent for all three companies.

For R&D in signalling and electrification, the available information indicates R&D percentages between 4 and 10 per cent, with electrification in general hovering around 4 percent. The exception being Thales which states that it devotes some 20 per cent of its consolidated revenues – €2.5 billion in 2009 – to research and development. However it should be noted that the activities of Thales stretch a much wider domain than signalling and electrification in the railway sector alone.
It should be noted that these percentages are higher than the countries figures on R&D intensity as a percentage of production value as derived from OECD statistics. To some extent this might be explained by the fact that the sector reported by OECD does not fully correspond with R&D sector definition that is used in the annual reports.

**Direction of R&D expenditure in Europe**

To obtain a rough idea on the direction of research that is carried out in Europe an analysis has been made of the topics of FP7 R&D projects in the RSI domain. The current FP7 includes 65 research projects concerning the railway sector. These projects deal with all different aspects of the railway system and industry: passenger and freight, urban rail and high-speed, infrastructure, locomotive and rolling stock, and operations. Some of the research projects concern several modes of transport. The research projects are clustered in several categories. The number of research projects in each category and its share over the total number of projects is given in the table below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of projects</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ecological friendly transport (energy efficiency, noise,</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>greenhouse-gases and other emissions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maintenance and inspection</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>• Co- and intermodality</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>• Safety and security</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>• Social and spatial issues</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>• Interoperability</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>• Competitiveness of rail transport</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>• Electromagnetic compatibility</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>• Education and training</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>• Other</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>• Total</td>
<td>69</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: some projects are included in more different categories

R&D efforts towards more sustainable and safe railway transport, and towards maintenance & inspection and co-modality appears to be themes which are relatively strong represented.

**Patents**

R&D activities can also be measured by the outputs of R&D processes. The following statistics is based on the number of patents as an indicator for the R&D output of the rail supply industry.

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65 It is noted that FP7 research is pre-competitive research done at EU level in full collaboration with all rail stakeholders. In addition to this research in FP7, there are also national funded project and competitive R&D projects funded internally to the RSI companies without public support. Nevertheless the themes covered in FP7 research give a clear indication of the direction of overall research within the RSI.
The information is derived from an Australian study\textsuperscript{66} in which the number of patents for railways\textsuperscript{67} during the period of 1990-2009 was analysed. Patent data have been obtained from all major patent authorities. In terms of the number of transnational patents the EU-27 is more or less equal to Japan. Within Europe, Germany accounts for the major part of applications followed by France.

\textsuperscript{66} Innovation in the Railway Industry - Australia in a Global Market - presentation- Mark Pullen, Senior Associate, Watermark

\textsuperscript{67} IPC code B61, subdivided in 9 components.
4.3.2 Labour force and skills

This section provides an analysis of the labour force and skills needed in the railway supply industry sector. The focus is on recent trends in overall employment, as well as the qualification of staff needed and the match with actual labour skills.

Labour force

In chapter 3 the development of employment in the RSI in Europe has been analysed using Eurostat data. The overall figure for the locomotive and rolling stock segment is approximately 155,000 employees, and has decreased with some 5% in the period 2004-2007. The development differs between countries, with some countries showing growth in employment (e.g. Spain, Hungary and Austria) and other clear decreases (e.g. UK, Romania).

There is a number of national sources (e.g. Germany, UK) available indicating also the indirect employment of the RSI, though no trend analysis can be carried out.

Demographic changes in Europe affect the supply side of labour in the RSI. The number of ageing employees is increasing and a large number of workers will retire in coming years. This means the loss of substantial knowledge and experience. Competing countries Japan, Korea and the US are facing similar problems. In China the average age of workers is lower, and the labour force is expected to grow, not being affected by an aging population in the coming decade.

Labour skills

Recent studies show that the aging EU population in combination with available skills, in particular in engineering and other technical skills is a concern in the manufacturing sector68. Two factors are distinguished that drive demand for railway engineers: on the one hand the trend to more sophisticated railway technologies (e.g. ERTMS, railway signalling, etc.) and the growing need to replace retiring engineers. In addition, talent shortages are known, for example in the UK where 10 years ago there were 190 people competing for an engineering job, whilst now this number is reduced to only 1069.

On a more general level, some question the knowledge base of the locomotive and rolling stock industry. The lack of technical education for rail builders has been raised, as well as the notion that this skill is only transferred from generation to another70.

The rail engineering skills needed in future have been subject to a large investigation of the UK Institution of Mechanical Engineers and Lloyd’s Register which has been held end of 2011. Questions were addressed to today’s rail engineers and related to: where the industry is headed; how that should affect the decisions of new entrants looking to develop long-term careers in rail; and whether the industry’s approach to training and qualifications ensured an adequate supply of skills to meet future demand. The findings were compiled from 220 respondents.

The key findings from the survey were71:

69 Source: Mind the age gap, How is the rail industry engineering a solution to recruit younger engineers? 23 June 2011, Balfour Beatty
70 Quote form Angelo Caragiuli: CEEP- Chairman of working group on skills and training, published in the report “Public Services’ contribution to smart, sustainable and inclusive growth, Ecorys, June 8, 2008
71 http://www.allaboutshipping.co.uk/2012/03/13/industry-survey-finds-engineers-are-being-deterred-from-railway-careers-due-to-requirements-for-early-specialisation/
More than 80% of respondents agreed that current training and development encourages specialisation too early, a feature which can limit career paths and deter new entrants.

- The industry would be well counselled to break down ‘silos’ between disciplines and focus on providing new recruits with a wider level of knowledge and better understanding of system interfaces before they explore specialist interests.

- More than 70% respondents felt that, while reducing costs and increasing capacity will continue to preoccupy boardrooms, the skills in highest demand during the next 10 years are those in various fields of engineering (mechanics, electronics, material sciences etc) required to for research and design of more energy efficient rail systems.

- Future engineering leaders will need to demonstrate a more enterprising and innovative approach, and a willingness to challenge current practices.

Interestingly, the responses showed that designing skills and knowledge to increase energy efficiency will be in the highest demand, followed by skills that can be used to increase reliability, accessibility and maintainability and safety.

A slightly different angle of concern relates to the technical knowledge of railway systems. Already in 2006 suppliers of infrastructure, engineering and services in the UK reported to have concerns the lack of overall system knowledge of the railways. It is cited that the modern structure of the railway industry, namely highly technological advanced sub-systems, creates specialists following a narrow career path with less exposure to the broad range of occupations in the railway industry72. To a certain extent this can be attributed to a sophisticated academic education of engineers. Similar complaints have been reported from aerospace.

This problem should be overcome by curricula of senior engineers that are dedicated to bring together know-how from different areas. First attempts are being made already. Railway engineering programmes that include a focus on emerging technologies are common at German technical universities. Students who pass these programmes join different parts of the industry, such as railway infrastructure and train-operating companies, the signalling industry, railway consultants or railway engineering companies. Still there is a shortage of qualified locomotive engineers in Germany73.

Other developed economies face similar problems to the UK and Germany. For example, also the US is also reportedly suffering from a chronic shortage of railway engineers.

4.4 Openness of the EU and international markets

Geographically the global RSI market can be classified in two main groups of countries. On one hand, we find the major RSI producing economies which at the same time are the most important exporters and consumers of railway products. This group includes the analysed countries i.e. EU, US, Japan, Korea and China. The majority of their own consumption is served by domestic companies and import penetration is relatively low (see table 2.1 and the further analysis in this section). The second group is constituted by countries without a significant railway industrial base and, therefore, net importers of railway products. The first group of countries compete to supply railway products to the second group.

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72 Source: Skills Needs Assessment Sector Skills Agreement Stage I, Rail Industry, GoSkills Moving skills forward, 2006
73 Source: http://www.railway-technology.com/features/feature43038/
As the major consumption countries (the first group of countries) have also a strong local production base external competition through exports to these countries is limited as is shown by the import penetration figures. Although this may be due to procurement strategies or (non) trade barriers, the mere fact of a strong local production base itself has an impact on the competitive position.

For the position of EU RSI the openness of market is both relevant from the viewpoint of being able to enter external market, but also to the extent that competitors are able to enter the EU market.

Before getting into the openness of market first the trade balance of EU versus its main trading partners/competitor countries is analysed.

4.4.1 Bilateral trade with competing economies

The next table presents the trade figures between the EU and its major competing countries. The figures are presented from the viewpoint of the trade partner with the EU.

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74 This is understood by the definition of “accessible” markets as used in the UNIFE market reports (e.g. see BCG 2011)
Table 4.22 Global and bilateral EU trade in the RSI with major competing economies

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2002-05</th>
<th>2005-08</th>
<th>2008-10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US RSI Imports</td>
<td>Million €</td>
<td>3600,8</td>
<td>68,9%</td>
<td>19,8%</td>
</tr>
<tr>
<td>US RSI Exports</td>
<td>Million €</td>
<td>4534,2</td>
<td>63,2%</td>
<td>50,1%</td>
</tr>
<tr>
<td>US-EU RSI Imports</td>
<td>Million €</td>
<td>1092,9</td>
<td>37,5%</td>
<td>44,4%</td>
</tr>
<tr>
<td>US-EU RSI Exports</td>
<td>Million €</td>
<td>839,5</td>
<td>-3,9%</td>
<td>29,1%</td>
</tr>
<tr>
<td><strong>Trade balance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Imports</td>
<td>Million €</td>
<td>933,4</td>
<td>-609,5</td>
<td>-107,7</td>
</tr>
<tr>
<td>EU Imports</td>
<td>Million €</td>
<td>-253,4</td>
<td>-405,9</td>
<td>-733,4</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan RSI Imports</td>
<td>Million €</td>
<td>428,4</td>
<td>55,3%</td>
<td>89,4%</td>
</tr>
<tr>
<td>Japan RSI Exports</td>
<td>Million €</td>
<td>4243,5</td>
<td>51,8%</td>
<td>62,3%</td>
</tr>
<tr>
<td>JP-EU RSI Imports</td>
<td>Million €</td>
<td>127,6</td>
<td>23,3%</td>
<td>98,4%</td>
</tr>
<tr>
<td>JP-EU RSI Exports</td>
<td>Million €</td>
<td>449,4</td>
<td>66,1%</td>
<td>54,7%</td>
</tr>
<tr>
<td><strong>Trade balance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Imports</td>
<td>Million €</td>
<td>3815,1</td>
<td>1827,0</td>
<td>2805,5</td>
</tr>
<tr>
<td>EU Imports</td>
<td>Million €</td>
<td>321,8</td>
<td>247,6</td>
<td>416,7</td>
</tr>
<tr>
<td><strong>Korea</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea RSI Imports</td>
<td>Million €</td>
<td>623,3</td>
<td>76,5%</td>
<td>101,9%</td>
</tr>
<tr>
<td>Korea RSI Exports</td>
<td>Million €</td>
<td>950,4</td>
<td>17,2%</td>
<td>242,6%</td>
</tr>
<tr>
<td>KR-EU RSI Imports</td>
<td>Million €</td>
<td>246,9</td>
<td>70,8%</td>
<td>59,3%</td>
</tr>
<tr>
<td>KR-EU RSI Exports</td>
<td>Million €</td>
<td>35,4</td>
<td>-58,0%</td>
<td>462,2%</td>
</tr>
<tr>
<td><strong>Trade balance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Imports</td>
<td>Million €</td>
<td>327,2</td>
<td>-1,1</td>
<td>76,7</td>
</tr>
<tr>
<td>EU Imports</td>
<td>Million €</td>
<td>-211,4</td>
<td>-79,3</td>
<td>-153,9</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China RSI Imports</td>
<td>Million €</td>
<td>4353,5</td>
<td>61,0%</td>
<td>167,7%</td>
</tr>
<tr>
<td>China RSI Exports</td>
<td>Million €</td>
<td>3303,3</td>
<td>166,5%</td>
<td>159,1%</td>
</tr>
<tr>
<td>CH-EU RSI Imports</td>
<td>Million €</td>
<td>1580,0</td>
<td>12,3%</td>
<td>205,5%</td>
</tr>
<tr>
<td>CH-EU RSI Exports</td>
<td>Million €</td>
<td>220,4</td>
<td>305,0%</td>
<td>165,9%</td>
</tr>
<tr>
<td><strong>Trade balance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Imports</td>
<td>Million €</td>
<td>-1050,1</td>
<td>-374,6</td>
<td>70,3</td>
</tr>
<tr>
<td>EU Imports</td>
<td>Million €</td>
<td>-1359,6</td>
<td>-490,5</td>
<td>-640,9</td>
</tr>
</tbody>
</table>

The US has a trade deficit against the EU during the period analysed. However, US exports have grown faster than import reducing its trade imbalance. Similarly, US exports to the rest of the world increased at a faster rate than imports turning the US global trade balance in the railway industry into surplus. However the US has remained a net importer of EU RSI products.

Japan’s economy has traditionally been characterized by large trade surplus in manufactured goods. Regarding the railway sector, Japan enjoys a large surplus in trade with the world Japanese exports to third countries grew at an average rate of 20 per cent whereas imports grew at 12 per cent. Japan’s surplus in trade with the EU is less pronounced, due to the fact that the EU itself is a major manufacturer of RSI. However, Japan RSI industry is successful in the EU and recently won
a large contract in the United Kingdom. Bilateral trade, exports and imports, between the EU and Japan grew at a rate of around 9 per cent.

Total Korean exports in the railway sector have boomed in the last ten years with an growth rate of 43 per cent per year, driven by a very intense growth in the period of 2005-2008. In addition, Korean imports grew substantially at a rate of 24 per cent per year. In this regard, European railway exporters contributed to the overall increase in Korean imports. This increase was driven by a strong EU exports growth between 2005 and 2008. From 2008, however, European exports to Korea suffered an immediate reduction in parallel to the overall imports of RSI products. The steady Korean deficit in trade with the EU indicates a structural dependency on EU deliveries. The intense increase in Korean exports to the rest of the world, explains the change in trade balance from a trade deficit in 2002 to a consistent and growing trade surplus.

China maintained a deficit in the railway in total external trade. The trade deficit with the EU is even higher and has increased in recent years. Yet Chinese exports in third countries grew at a faster rate than imports. The contrary occurred in relation to the EU where imports grew at 31 per cent and exports at 25 per cent per year. China enjoys a trade surplus with non-EU economies that is more than outbalanced by the trade with the EU. The development of bilateral trade over the period under investigation indicates an excellent performance of the EU. It benefits from the large and growing Chinese market, as well as from Chinese success in third countries.

Overall, the EU maintains a positive trade balance with the US, Korea and China and a relative small trade deficit vis-à-vis Japan. The fact that the EU has this trade deficit against Japan could be an indication that the Japanese market is relatively less accessible to EU firms than vice versa, possible because of the existence of trade barriers. However it should also be noted that the Japanese RSI has a strong export rate (higher than the EU), which also explain this negative trade balance.

In general total trade, measured as the sum of imports and exports, has grown at a considerable higher speed between Japan, Korea and China and the rest of the world than between these countries and the EU. For the assessment of competitiveness of the EU RSI one has to have in mind that market access to competing economies’ markets is extremely difficult. There exist noteworthy non-tariff market access barriers, such as standards and safety requirements. Moreover, traditionally client industries have a preference for domestic suppliers even if they are fully privatised and independent in their investment decisions. As a consequence the trade surplus with three of the competing economies under investigation is valued as a strong position of the EU RSI in global markets. Especially, the surpluses with Korea and China, strongly growing emerging economies are understood as an advantage that incorporates growth opportunities to be exploited in coming years and decades.

4.4.2 Openness of inter national markets in RSI

There are some peculiarities within the railway sector that make it different from other manufacturing industries. Firstly, many countries have included the railway sector as part of their national industrial policies. The railway sector is seen as a strategic sector due to the significant downstream effects and its importance as a mean to integrate and connect different regions within countries. Thus, many regulations were designed at the national level and indigenous industries

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75 Different definitions of openness have been proposed in the economic literature. The most popular being the share of exports and imports over country GDP. In this case we use import penetration as a proxy of openness. However, low import penetration does not necessarily mean high tariff and non-tariff barriers. Low import penetration can be as a result of strong local RSI supplying the domestic market.
flourished under the support of national governments and the lack of competition from abroad. At the same time not all procurement is (directly or indirectly) accessible to third countries.

The table below shows the level of production, exports, imports, consumption and import penetration in the railway sector for the EU, US, Japan, Korea and China. The trade figures are compiled for the railway sector, defined in the NACE Rev 1 as 35.2 Railway/tramway locomotives & rolling stock. Therefore, exports and imports figures differ from the previous table used in the bilateral trade analysis. As previously mentioned, this is because our own classification of the railway sector includes products regarding railway infrastructure and signalling that are not included under NACE Rev 1 as 35.2 Railway/tramway locomotives & rolling stock. However, using the same definition of railway enables us to combine production data from our competitiveness dataset with international trade data from UN COMTRADE. It is above all this subgroup that is most open to international competition.

Table 4.23 Production and trade figures in 2009

<table>
<thead>
<tr>
<th></th>
<th>Production (bn €)</th>
<th>Exports (bn €)</th>
<th>Imports (bn €)</th>
<th>Consumption (bn €) (1)</th>
<th>Import Penetration (%) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>27,1</td>
<td>3,9</td>
<td>1,2</td>
<td>24,4</td>
<td>5,1</td>
</tr>
<tr>
<td>US</td>
<td>9,3</td>
<td>1,5</td>
<td>0,8</td>
<td>8,6</td>
<td>8,8</td>
</tr>
<tr>
<td>Japan</td>
<td>3,1</td>
<td>0,7</td>
<td>0,2</td>
<td>2,6</td>
<td>5,8</td>
</tr>
<tr>
<td>Korea</td>
<td>1,5</td>
<td>0,2</td>
<td>0,1</td>
<td>1,4</td>
<td>8,5</td>
</tr>
<tr>
<td>China</td>
<td>17,8</td>
<td>0,7</td>
<td>1,1</td>
<td>18,2</td>
<td>6,2</td>
</tr>
</tbody>
</table>

Note:
1) Consumption is calculated as Production – Exports + Imports.
2) Import penetration is calculated as (Imports/Consumption)*100

As described earlier the EU, followed by China, is the largest producer of railway products. European producers are the most important exporters, although, in relative terms the Japanese railway industry is more outward oriented since exports represent around 22 per cent of its total production. The EU and China are the most important importers of railway products. Yet, it is the US which has a higher share of imports in relation to the size of the domestic market.

Indigenous demand is by far the most important driver for the RSI sector in each of the five countries. For the EU, US, Japan and Korea exports are higher than imports and therefore consumption is lower than production. Only Chinese consumption of railway products is higher than internal production. Although import penetration is low, similar to the other competing economies, the high and strongly growing domestic Chinese demand is dependent on foreign deliveries and know-how. This has triggered the development of European railway companies entering into the Chinese market through FDI and JVs.

In contrast with the developments in manufacturing where global production chains have become prominent and in some cases exports and imports have grown faster than production, foreign imports in the railway sector are relatively small as compared to domestic demand. Import penetration measured as a percentage of total consumption displays a picture of the shrinking importance of foreign deliveries to domestic markets of Korea and the US. For Korea this decline is understood primarily as a growing self-sufficiency. However, with regard to the small size of the economy on the one hand and the typically broad value chain on the other hand the low import ratio is noteworthy. After the decline during the early years of the period under investigation it has stabilized between 5 and 10%. For the US the declining trend is driven by FDI of foreign manufacturers, eager to strengthen their position in this important market.
Import penetration is relatively low for the EU throughout the whole period and does not show any trend. The low market penetration could be explained by the size of the market and a high degree of self-sufficiency, especially in high-tech components. The EU has a very strong local RSI that mainly supplies the internal market. Also in low-tech products the EU has remained self-sufficient. Chinese import penetration fluctuates around 10 per cent, although it has been declining since 2006 to reach its lowest value in 2009. The only country that shows growing internationalization by imports is Japan. During the early years of the period under investigation the import penetration was between 2 and 3 per cent. During the latter years it steadily increased and exceeded the 5 per cent level in 2009. This development is understood primarily as a relocation of low-end products to China and other emerging economies and to a lesser extent as growing access of foreign manufacturers to the Japanese market.

European producers are the most important world exporters of railway products. In particular, the EU RSI is the most important foreign supplier for the Japanese, Korean and Chinese market and the second most important for the US. In this regard, European producers account for a very significant market share of railway total imports in the US (19%), Japan (50%), Korea (47%), and China (63%). However, in comparison with internal consumption, EU market share is significantly lower for all the countries, US (2%), Japan (3%), Korea (4%) and China (4%). But this is in line with the peculiarities of the RSI market that makes it difficult to tap into foreign markets by trade.

The lower share of foreign imports on total consumption can be an indication that tariffs and non tariff measures as well as client industries’ behaviour are hampering international trade. As
previously acknowledged, the railway sector is a special case within the manufacturing and transport equipment industry. Important buyers of railway products are national governments and privatized companies that prefer domestic purchases. Public procurement of railway products falls under Government Procurement Agreement (GPA) for signatory countries. This is the case for the EU, Korea, Japan, and the US, but not for China. Above a certain threshold, GPA signatory countries cannot discriminate foreign companies bidding for public contracts. However, the GPA contains certain provisions and exceptions reducing the effective amount of procurement falling under the agreement. In addition, the non-signature countries are not obliged to follow the principles of openness, transparency and non-discrimination in which the GPA is built.

**Accessible markets - procurement**

In the recent BCG study for UNIFE an analysis is made of the accessibility of markets. According to BCG “a market is considered accessible if it is open to any external supplier and not served by in-house railways. The term “external supplier” covers direct or indirect international bidders.” Market as Japan are defined as accessible to European supplier, although they are mainly served by local companies. Figure 4.15 shows the comparison of both the total market (domestic demand/consumption) and the accessible market. Approximately 70% of the total market is characterized as being “accessible”.

**Figure 4.15 Comparison between total and accessible market 2007–09**

![Comparison between total and accessible market](chart.png)


<table>
<thead>
<tr>
<th>Region</th>
<th>Accessibility ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia/Pacific</td>
<td>0.65</td>
</tr>
<tr>
<td>Western Europe</td>
<td>0.76</td>
</tr>
<tr>
<td>NAFTA</td>
<td>0.83</td>
</tr>
</tbody>
</table>

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76 China became an observer of the GPA in 2002. The Chinese Government submitted an initial offer for its inclusion into the GPA in December 2007 but it was considered insufficient by the members of the GPA. In July 2010, China submitted a revised offer to enter into the GPA.
Whereas Western Europe has an accessibility ratio which is higher than average, CIS has a very low ratio. Also Asia/Pacific with a ratio of 0.65 is slightly less accessible than average. According to BCG Japan, China and India show low accessibility for some product segments. The NAFTA market on the other hand is highly accessible in terms of procurement strategies.

The above picture fits in a reported tendency in non-EU countries to replace more and more the contractor's components by equipment locally produced. As a result EU manufacturers focus more on the production of key components for the manufacture of high-performance locomotive and rolling stock and tracks and system integration. Labour intensive, less know-how driven components and the assemblage are carried out locally in third markets.

**Non-tariff barriers**

This section highlights the most pressing non-tariff barriers (NTBs) regarding the RSI for the EU. The majority of these NTBs have been taken from the EU Market Access Data Base.

**China**

In general, the most prominent market access barriers persist in standardisation and technical regulations. Further barriers are insufficient IPR enforcement and heavy certification procedures. Due to the one-off costs for testing and standardisation requirements in the railway industry, particularly the increasing requirements for compliance with Chinese standards and certification procedures are hampering foreign competitors.

Moreover, due to governmental instructions for the purchase of new vehicles, conditions were created which allow local locomotive and rolling stock producers to access foreign suppliers’ know-how, in particular by obligations to invest in joint ventures. Thus, since the 90s, global players (Siemens, Bombardier, Alstom) have committed themselves, upon contract award, to cooperate with Chinese manufacturers who have to produce in each case the biggest part of the rolling stock series in China. A further limitation in this respect is that China has categorized the railway industry as a strategic sector requiring the establishment of joint ventures, instead of allowing 100 per cent owned foreign subsidiaries.

In addition, the Ministry of Railway together with another seven Chinese Ministries issued a notice to remind public authorities to the strict application of the Buy Chinese rules in the public procurement financed under the 4 trillions RMB stimulus package launched in 2008. The Chinese Government Procurement Law issued in 2003 giving preference to domestic goods and services, has been strengthening through several decrees, notices and opinions. These regulatory actions allow for a stricter interpretation of the Government Procurement Law limiting the access to foreign companies into the Chinese government procurement. This directly links to the definition of “accessible markets” as described above.

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79 Interfleet, 2007: Survey of Competitiveness of the EU Rail Supply Industry (Final Report), P. 65
In recent years it has become more difficult for manufacturers to tap into the Chinese market and compete independently with the governmental-controlled enterprises in China’s railway locomotive and rolling stock industry. There are high start-up costs for potential manufacturers and long established relationships between domestic producers and China’s railways to overcome. Research and development requirements and governmental regulations add further cost to production in China.

**Japan**

With a share of 2 per cent of EU exports in the railway sector in 2010, Japan is not a top destination for the EU RSI. However, Japan is a very important global market in terms of consumption of railway products. The previous trade analysis showed the low level of import penetration in Japan. Yet Japanese average weighted tariff for foreign manufacturing products is relatively low. The combination of low tariffs and a low import ratio has been described as the so-called Japanese conundrum (Copenhagen Economics, 2009). In the case of the RSI, the question of market access for foreign goods needs to be linked with the Japanese commitments in government procurement.

Japan Rail, the incumbent operator, although recently privatised, falls under public procurement. Thus, market access is not only constrained by the industry structure but by the lack of transparency of the Japanese government procurement system (Copenhagen Economics, 2009). The European Commission has openly complained about the lack of symmetry in market access in relation to public procurement. The EU argues that restriction to access contracts awarded by the railway and urban transport operators contributes to this asymmetry in market access (EC, 2011).

A common complaint made by the EU RSI regards the requirements on safety and technical standards for the procurement of railway products. It has been argued that European railway products are not adequate for the Japanese market due to lack of safety features in case of earthquake. This anecdotic example stems from the fact that the Japanese administration makes use of the ‘Operational safety clause’ excluding public contracts of rolling stock for safety reasons. The US Government made similar remarks urging the Japanese Government to ‘remove or narrowly apply the operational safety exception for railroad procurements’ (NTE 2011, USTR). However, the EU has been positive about the recent developments regarding this issue for which Japan has undertook commitments to apply the operational safety clause in railways procurement in a transparent and non-discriminatory manner (EC, 2012).

In December 2011, following intense negotiations, the EU and Japan jointly agreed on a specific exchange of letters on rail transport. The first months of 2012 are expected to be critical as pressure has mounted on Japan to establish more transparent tender procedures. In parallel, the Commission will present a communication on the use of “reciprocity instruments” by which Japanese suppliers could be excluded from the EU market, should the Japanese market remain close to European suppliers (UNIFE 2011).

**US**

No known non-trade barriers exist for the US. The Market Access Data base does not reveal any NTB for the US market and also UNIFE did not mentioned any specific complaint on the US market. Finally the WTO Trade Policy Review did not contain any complaint on the US regarding railways.

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80 Rolling Stock: Locomotives and Rail Cars, Industry & Trade Summary, March 2011, USA Office of Industries
81 Copenhagen Economics, 2009: Assessment of barriers to trade and investment between the EU and Japan, p. 233
4.4.3 Market access EU market

As indicated earlier a large part of the EU procurement market is characterised as being accessible (76%). This is above average, although it is still lower than in the NAFTA region. Still the import penetration in the EU market is relatively low. This is partly the result of the strong position of EU RSI which makes it hard to enter a home market, but it is also related to the traditional fragmentation of the EU in separate national market. The ongoing harmonisation in Europe will have a direct impact on this aspect. The following text briefly describes the regulatory conditions in the EU and their impact on the market.

EU Regulatory Conditions

The EC directives currently in place apply to a number of fields, namely: i) infrastructure and interoperability, ii) internal market, freight and passenger rights, iii) employment and working conditions and iv) railway safety. The implications for the railway supply industry mainly exhibit themselves in infrastructure and interoperability, and railway safety. The following sub sections explain the headlines of the regulatory framework in this respect.

The European Commission has issued various Directives, aimed at progressively creating a European rail network. Moreover, by setting standards as part of these Directives, the EC aimed to influence railway developments outside the EU and contribute to harmonizing standards of relevance for the global RSI market.

From a technical point of view, interoperability is at the core of the European Directives. The EC defines interoperability:\(^4\):

\[
\text{The ability of a rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance for these lines. This ability depends on all the regulatory, technical and operational conditions which must be met in order to satisfy the essential requirements.}
\]

Interoperability is aimed at gradually integrating the EU network through technical harmonisation, while guaranteeing a high level of safety. The directive concerning interoperability (2008/57/EC\(^5\)) applies to the European Economic Area, not just the EU. The phased approach poses requirements on structural and functional elements. The Directive outlines the concept of technical specifications for interoperability (TSIs), which describe the way in which different systems should be compatible and cooperate. The work related to the TSI is coordinated by the European Railway Agency (ERA). In its activities, ERA co-operates with the railway representative organisations and national safety authorities, as well as with the European standardisation bodies and notified bodies.

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\(^5\) This directive applies to both conventional rail and high-speed rail; previously, two separate directives dealt with these types of rail respectively. These directives were: 2001/16/EC concerning conventional rail and 96/48/EC concerning high-speed rail.
### Table 4.26 Overview of Interoperability directives

<table>
<thead>
<tr>
<th>Directive</th>
<th>Focus</th>
<th>Implications for railway supply industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>96/48/EC</td>
<td>Interoperability of the high-speed rail system</td>
<td>Created a more homogenous European market for high-speed rail, hence reducing barriers. This directive has a system focus and also indicates which general standards are to be followed.</td>
</tr>
</tbody>
</table>
| 2001/16/EC  | Interoperability of the conventional rail system | Created a more homogenous European market for conventional rail, hence reducing barriers. Specific areas concerned are:  
  - infrastructure  
  - energy  
  - maintenance  
  - control and command and signalling  
  - locomotive and rolling stock  
  - traffic operation and management  
  - telematics applications for passenger and freight services |
| 2008/57/EC  | Interoperability of the rail system         | Further homogenised the European market for high-speed and conventional rail, enhancing the effect of the previous directives |
| 2004/49/EC  | Safety of the EU rail system                | Lays down the safety requirements of the European rail system (which includes operations as well): common safety targets (CSTs) and common safety measures (CSMs). Its impact for the RSI is primarily indirect as the requirements are, in first instance, imposed upon infrastructure manager and railway undertakings. |

Compliance with the interoperability requirements is mandatory. The "Technical Specifications for Interoperability" (TSIs) describe these requirements for the fundamental elements of each sub-system, specifically those relevant to interoperability.

A case worth mentioning is the European Rail Traffic Management System (ERTMS). This system was developed to be used alongside national systems for traffic management, though it has become mandatory now for EU (co-)funded projects (Railway Gazette, 2009[^86]). In essence, it has made the European local markets more contestable for outside players. The introduction of ERTMS as a unified system, instead of national systems with their own particularities, increases the scope of the EU market for both EU and external players in the RSI, creating a more level playing field for the RSI. At the same time, with the uptake of ERTMS outside Europe there is ample scope for European companies to export their products. The development of the ERTMS in fact became the unique selling point for signalling companies in Europe. It has developed into a worldwide signalling standard, based on the philosophy and technology of (presently) eight EU signalling manufacturers. International companies from US and Japan look for partnership to the ERTMS industry[^87].

**Cross acceptance**

Implementation of directives may differ across countries. At Member State level it are the national competent (supervisory) authorities that are responsible for cross acceptance issues. At EU level, ERA ensures that despite such differences interoperability is not threatened. This is done by developing a common approach to the evaluation and acknowledgement of requirements and processes used by Member States for the authorisation to place in service locomotives and rolling stock and their subsystems. This is done through a “cross acceptance” process. Railway infrastructure is also included in the scope of TSIs. The 2004 Directives provide the current basis for ERA’s work in this respect.

[^87]: GE and Hitachi, see presentation “Aktueller Stand bei Zulassung und Inbetriebnahme von ETCS” DLR, 10. Nov. 2011
Other standards
The European Committee for Standardisation (CEN) has also issued standards for rail equipment. These include, but are not limited to:

- Wheels, axle-boxes, suspension systems
- Track and track elements
- Testing standards
- Fire protection (CEN/CLC/WG FPR)
- Beyond the scope of this study, but worth mentioning are standards for e.g. containers and tanks for the transport of dangerous goods.

In addition to this, CENELEC (European Committee for Electrotechnical Standardisation) develops standards for the electric and electronic aspects of railways. European Telecommunications Standards Institute (ETSI) develops standards for ICT applications in general, some of which pertain to the railways. While in Europe, the European standards prevail, other countries have sometimes also decided to follow these standards. Some other countries develop their own standards based on the European ones. China is one such example.

Impact
Previously, an integrated European rail network did not exist. Each country had domestic standards, with few features shared across networks. Therefore, production was local or, at least, very much customised. Interoperability has not made the national rail systems in the EU all alike, but at least ensures systems can be used alongside each other. For the RSI, however, interoperability has created a more homogenous market and thus created potential for economies of scale and scope: products can now be offered in a much larger market and products can be standardised to a higher degree. The more homogenous internal market has stimulated competition and contributed to structural changes. In particular manufacturers in regional markets face tougher conditions in sales markets and have to examine their current business model. As a consequence the initiatives to harmonize the RSI market have contributed to the competitiveness of the EU manufacturers.

To date technical standards have not yet been completely harmonized. For some specific areas of locomotive and rolling stock equipment (e.g. railway safety) manufacturers have to produce tailor-made rolling stock equipped with several systems to allow for interoperability and trans-national operation of vehicles. Further efforts taken by the EC and the RSI are necessary to further improve the effectiveness of the Single Market for EU manufacturers’ competitiveness.

4.4.4 Business strategy to address the openness of markets.
In order to overcome access barriers to local market companies have developed business strategies to get into these markets through foreign direct investment (FDI) and joint ventures (JV). Establishing manufacturing facilities in third countries allows companies to supply railway products locally. As indicated above, this is frequently an indispensable prerequisite to win a contract.

EU actors in non-European markets
Especially in countries where local production capacity exists, companies expand their market access by establishing a local foothold through mergers, acquisitions and joint ventures. All major EU rolling stock companies follow active strategies in this respect to enter into non-EU markets. Notwithstanding these strategies still by far the largest employment concentration of EU27 industry players is based in Europe.
Foreign strategy of three major EU locomotive and rolling stock manufacturers: Alstom, Bombardier and Siemens

Alstom Transport S.A.
Like Bombardier or Siemens, Alstom has been strongly active in expanding its business activities in the Asian and Russian area during the previous years. Alstom cooperates with several big Chinese companies as well as with the biggest Russian rolling stock manufacturer Transmashholding.

Bombardier
During the previous years, Bombardier especially expanded its activities on the Asian and CIS market. In these markets, Bombardier mainly focussed on its activities in the large emerging economies China, Russia and India. Especially in China, Bombardier is strengthening its high-speed competence. The Bombardier JV with its Chinese partner won large orders for the manufacture of high-speed trains.

Siemens Rail Systems
Siemens has expanded like the other competitors its Asian activities over years with cooperation for example together with its locomotive production in Dalian/China or the investment in the production of locomotives in Ekatarinenburg/Russia.

Source: Annual reports, Railway Gazette

In addition EU producers have established large research and development capacities in China in cooperation with local partners. China is a clear example which has a distinct policy to promote the development of the local industry. For example, UK based Balfour Beatty delivered 80 per cent of the electrification material from Europe, but the remaining 20 percent came from Chinese manufacturers.

This tendency creates questions of responsibility in all contractual aspects to both the contractor and the client. Accepting this, the product to be delivered is no longer a German, French, British or any other proven system but a mixture of individual components, fitted together. EU contractors deliver parts and act as system integrators. As a consequence the EU manufacturers become more service driven. The funding of large projects and the responsibility for the performance of supplied systems have become important factors in international competition.

Non-European actors on the EU market
The presence of non-European players on the EU27 market has remained limited until now, obviously influenced by the strong position of the European RSI, but also due to the originally fragmentation of the market in terms of technical, safety and other requirements. In view of the ongoing harmonisation of technical standards in the European market a tendency towards a further opening up of the market may be expected.

Although the share of non-EU player on the EU27 market is still small a number of anecdotic examples are presented here, as an illustration of these developments.

The Intercity Express Network (IEP) in the UK, which has been tendered in 2011, is amongst the largest orders of rolling stock in the world. The 4-5 € billion contract has been awarded to the Japanese rolling stock company Hitachi. The company will establish a rolling stock manufacturing and assembly centre in the UK. This investment will generate at least 500 new jobs, and major

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opportunities for the UK and European supply chain. There has been a debate concerning this award, since the number of jobs created with this delivery in the UK is supposed to be much lower in case a European supplier would have been awarded with the contract. The company responded to the concerns raised, stating that they came to the UK rail market in 2005, and have worked continuously with European suppliers to develop the Class 395 trains. The European suppliers provided 50 per cent of purchased components (by value) of this train type.

Also the joint venture of China’s CNR with Polish PKP Cargo can be seen as an example. Apart from this joint venture with PKP, Chinese manufacturers have not yet entered the EU market. One of the main reasons that is stated is that they still lag their European rivals in terms of quality and technology. Their main competitive advantages are their lower prices, catching-up technology, and financial support from Chinese state-owned banks. They are able to offer a global package, which is usually the result of combining technical solution with financing, making it easy for governments to purchase their products.

4.5 Summary

The EU is in the lead as a top exporter accounting for 21 per cent of railway total trade. In addition, the EU is the most important producer of railway products making 46 per cent of the combined output of the five analysed countries. The good performance of the EU RSI indicates noteworthy improvements in competitiveness. In contrast, the US and Japanese RSI have lost market share in relation to total output and total exports. In addition to these developments, the EU RSI has improved its gross operating rate and productivity levels during the period analysed.

The ECI reveals the relative improvement of the EU RSI vis-à-vis the US and Japanese RSI. Even though, EU RSI is lagging behind US and Japanese railway manufacturers, the gap has been narrowing over time. Regarding China, the EU RSI still has an overall comparative advantage although China is quickly catching up. This current comparative advantage of the EU over China can also be seen in the trade data, where China runs a trade surplus in railway products with all the other countries except for the EU. Korean RSI, nonetheless, is more competitive than its European counterparts. In recent years, there has been an important investment in railway technology in Korea, improving its competitiveness and helping to develop a mature railway industry. However, Korean output and export are much lower than the EU RSI.

The EU has a low import ratio. This is also the case for the US, Japan, Korea and China. Even though, the EU is a major exporter in those markets. With the exception of Japan the EU commands surpluses bilateral trade with all competing economies under investigation and is number 1 of their RSI imports with the exception of the US. This indicates a strong position in international competition. In particular the trade surplus with China reveals the strength of the EU in the RSI market. China itself has become a strong exporter and commands a surplus on average for

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89 Article: UNIFE alarmed by decision to award UK Intercity Express Programme to Hitachi, 03 Mar 2011 · by A. Samuel · in Business, Featured Rail News, Rolling Stock and Components

90 Article: Hitachi releases statement following UNIFE’s concerns over IEP, 09 Mar 2011 by A. Samuel · in Featured Rail News, High Speed Rail

91 Article “High-speed China changes rail landscape”, Financial Times, March 16, 2010, By Jamil Anderlini in Beijing

92 http://www.raillogkorea.com/e/sub/sub_01_03_2.html
all trading partners, but not for the EU. A division of the global railway market is made, depending on the indigenous capacity to produce railway products.

China is the most important foreign market for the European RSI. EU manufacturers have already invested in the market and will be setting up even more production sites to benefit from the large domestic market. This will have an impact on trade relations in the long-run and the division of labour between both of these economies will intensify. This incorporates the potential to increase EU exports of high-tech components and imports of low end products from China.

The EU RSI has a number of key strengths which provide a comparative advantage in non-EU countries. A great advantage of European rail electrification industry is the deployment of the European Rail Traffic Management System (ERTMS). The ERTMS is being implemented outside the EU. Another selling point is relates to high integrated solutions, i.e. merging of vehicle technology with intelligent track/signalling and optimum operations and service management. In addition, EU suppliers have high qualified key components like brakes delivered by specialized, long term experienced suppliers. In infrastructure the EU is leading in developing special long-life steel for rail, fastening systems and turnouts and high quality concrete or plastic sleepers to keep maintenance cost within limits and to guarantee safe operation. The main competitor in this segment is Japan.

The EU RSI spends significant amounts of resources in R&D ranging between 4 and 10 per cent for the more technologically advanced market segment of locomotives and rolling stock and signalling and electrification. For the infrastructure segment this R&D expenditure is much lower at 2 per cent due to different R& requirements. The level of profitability in the industry may have affected the amount of resources committed to R&D. In this regard, the lower gross operating rate of the EU RSI’s limits the ability to raise the necessary funds for R&D activities to maintain its technological lead. In spite of its bright performance in international markets over the past decade the EU RSI is challenged to stay on the leading edge of technology to secure future success in railway markets.

Concerning labour force and skills, two factors are distinguished driving demand for railway engineers: on the one hand the trend to more sophisticated railway technologies (e.g. ERTMS, signalling, etc.) and the growing need to replace retiring engineers. Some EU countries (UK, Germany) report chronic shortages of railway engineers. The next decade will be crucial in determining the future of the rail industry in Europe.

The harmonisation and interoperability of EU railways through the implementation of several Directives is gradually creating a single market in the EU for railway supply. The EU market will become easier accessible through standardised products for non-EU companies. Better functioning markets is expected to spur efficiency in EU RSI companies (economies of scales, reduction of certification, testing and common standards reduce the number of variants to be produced. This growing efficiency increases productivity (reducing the productivity gap against US and Japan) and contributes to growing welfare in the Community

The anticipated competitive advantages from harmonisation within the Single Market for EU companies likewise contribute to a reduction of non-tariff barriers in third markets. The EU is in the vanguard of creating harmonized and transparent rules for railway operators and the RSI. Numerous non-EU countries follow suit with the adoption of ERTMS.

Different non-tariff barriers to enter non-EU markets exist. Of importance are barriers above all in major competing economies. In China barriers are in place related to standardisation and technical regulations. Further barrier are insufficient IPR enforcement and heavy certification procedures.
The Japanese market access is not only constrained by the industry structure but by the lack of transparency of the Japanese government procurement system. Japan Rail, the incumbent operator, although recently privatised, falls under public procurement. This aggravates further market access. The European Commission has openly complained about the lack of symmetry in market access in relation to public procurement.
5 Strategic Outlook and recommendations

This final chapter presents a strategic outlook for the RSI and key trends and challenges. Based on these and the assessment of the current competitive positions of EU RSI, a number of recommendations is made.

5.1 Key trends and challenges

The main trends and challenges faced by the (EU) rail transport sector are described, which are expected to shape the market for railway transport, and thus, will be main drivers of long term developments in the EU RSI.

5.1.1 Key drivers affecting the (rail) transport sector

Energy, environment and climate issues
Rail is a relatively clean mode of transport that is far more energy-efficient than, for example, road transport. Nevertheless, there is still a growing urgency for the transport sector in general to mitigate its negative impact on the environment. Greenhouse gas emissions must be clearly reduced to keep the consequences of climate change at a minimum for humans and for nature. The EU has recently adopted a Climate and Energy package that sets a target of reducing GHG emission in the EU by 20% with respect to 1990.

This has two impacts on rail transport. First there will be continued attention to rail transport as it is, in comparison to other modes of transport, relatively environmentally friendly. Also rising costs of fossil fuels will trigger demand for rail based transport. Secondly energy efficiency improvement will be stimulated also in rail transport to decrease the energy consumption of rail transport. The rail sector has committed itself to clear targets for further reducing emissions and strives to increase energy efficiency, halving their specific final energy consumption from train operation by 2050 compared to the base year 1990.

Urbanisation and urban sprawl
Urbanisation has been a clear trend in the past decades and is expected to continue in Europe and most other parts of the world. By 2030, 80 per cent of the world’s population will already be living in cities. The further expansion of urban areas (urban sprawl) and rise of megacities is expected to continue. Providing (mass)transport to the increasing urban population with an increasing demand for transport is one of the major challenges for policy makers, planners and transport service providers. The limited availability of space and congestion negatively impact inter-urban travel, transport cost and the environment.

Population, economic growth and mobility
Population growth and greater economic development mean more mobility and more transport. Both are expected to grow in the coming decade, but at different growth rates across the globe. The table below shows expected population growth rates for different regions until 2020. Population growth will occur in Africa, Asia and Latin America, whilst growth in the EU and Northern America is modest. The world population is expected to exceed 9 billion by 2050.

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Table 5-1 Population change (thousand and %)

<table>
<thead>
<tr>
<th></th>
<th>Africa</th>
<th>Asia</th>
<th>Europe</th>
<th>Latin America &amp; the Caribbean</th>
<th>Northern America</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2015</td>
<td>24.616</td>
<td>42.246</td>
<td>774</td>
<td>6.471</td>
<td>3.022</td>
</tr>
<tr>
<td>2015-2020</td>
<td>26.577</td>
<td>38.008</td>
<td>422</td>
<td>5.949</td>
<td>2.951</td>
</tr>
</tbody>
</table>

Source: UN World Population Prospects: The 2010 Revision (medium variant)

Economic growth is even more important for the development of transport demand. Although it may be temporarily halted by economic crises predominantly in Europe, the US and Japan, economic growth in these regions is expected to recover in the coming years, whilst at the same time much stronger economic growth is expected in various developing countries. The figure below presents the development of GDP until 2025 for the EU 27 and major economies in RSI markets outside the EU.

Figure 5-1 Forecasted GDP development

There is a firm relation between GDP development and transport. As a result, transport outside Europe is expected to increase much more than inside Europe. EU external trade and transport are likely to keep growing rapidly in the coming years. It is expected that the need and investments for transport equipment and infrastructure will follow a similar pattern. More importantly, as transport markets outside the EU are continue to develop, it is expected that global competition will also increase. It is expected that this competition will come from China and other Asian countries in particular.

**Ageing**

A trend that will continue in the coming decades is the ageing of the European population. Both the median age and the share of people aged 65 or older are expected to grow. An ageing society will place more emphasis on the provision of transport services involving a high level of perceived security and reliability, and which feature appropriate solutions for users with reduced mobility.

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Also, as more people will retire from the workforce this may lead to a shortage of skilled workers in the transport and manufacturing industry.

5.1.2 EU policies for the railway sector

The European Commission’s efforts have concentrated on three major areas which are all crucial for developing a strong and competitive rail transport industry: (1) opening of the rail transport market to competition, (2) improving the interoperability and safety of national networks and (3) developing rail transport infrastructure.

The White Paper: A strategy for revitalising the Community’s railways is the most relevant policy document for the sector and completing the implementation of the rail packages. The European Commission adopted in 2010 a proposal to provide better rail services for passenger and freight users by: increasing competition on the railway market; strengthening the power of national regulators; and improving the framework for investment in rail. The proposal for a Directive establishing a Single Rail Area is an exercise in legislative simplification and consolidation with the merger of the three directives in force and their successive amendments into one coherent text. It also aims to tackle key problem areas undermining the effective functioning of the railway market.

5.1.3 Implications and challenges for the RSI

Chapter 2 of this report already provided an outlook for the demand for rail supply industry for the period up to 2015 and 2020. Based on various markets forecasts it is expected that the rail supply market continues to grow at rates between 2% and 4% per annum in the period 2010-2015, with major growth manifesting itself in the Americas and Asia. The pattern that emerges is consistent with the “two speeds” development pattern of population and economic growth. Although Western Europe remains the largest RSI market, the growth rates in Latin America, Asia and CIS are much higher. The European market is largely a replacement market. As a result of the economic crisis investments in new rail supply is expected to slow down, especially in high speed rail.

Replacement orders for rolling stock in the UK, Germany and France will form the basis for RSI demand. For example, the UK has recently announced a 5.5 bln Euro Intercity Express Programme (IEP). The Programme seeks to replace the distinctive “Intercity 125” High Speed Train (HST) diesel fleet procured by British Rail during the 1970s and 1980s with a new, higher capacity, more environmentally friendly train. In Germany Deutsche Bahn recently reached agreement with Siemens, worth ‘around 6 bln. Euro, ‘to order up to 300 ICX trainsets to allow replacement of DB’s ageing fleet of locomotive-hauled InterCity and EuroCity coaches and later ICE1 fleet. The first batch of 120 trains is ordered of which first trains are due to enter service in December 2016.

Asia is overtaking Europe as the largest RSI market. Japan and Korea are considered relatively mature markets where demand will be mainly driven by replacement orders. Market growth in the region is spurred by economic growth in the region, with high demand for rail freight transport in China and India, but also with increasing investments in rail in Cambodia, Malaysia, Thailand and Vietnam. Apart from growing demand for rail supply for rail freight, RSI demand is increasing for passenger rail for city railway lines, metro and light rail in order to fulfil transport demand of Asia’s rapidly growing urban population.

Demand for rail supply in the United States will continue to be dominated by (replacement) demand for freight rolling stock and locomotives. Remediing the backlog and maintaining the existing fleet

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97 Department for Transport, press release 01 March 2011.
98 Railway Gazette, 21 April 2011
would require $5.8 billion annually over six years, or almost $35 billion\textsuperscript{99}. Foreign diesel-electric locomotive manufacturers do not compete for sales in the U.S. locomotive and rolling stock market; in large measure, this is likely tied to long-standing relationships between U.S. manufacturers and railroads, and U.S. railroad companies’ familiarity with U.S. manufacturers’ products\textsuperscript{100}. The market for passenger rail is relatively small and largely relies on non-US suppliers. The 11 bln. dollar stimulus funds contained in the American Recovery and Reinvestment Act of 2009 will positively contribute to growth in RSI demand in coming years. However, the U.S. government decided to scale back its ruling that makes it mandatory for freight rails to install new anticollision technology called “Positive Train Control.” The government decision will reduce demand for these technologies by approximately US$500 million\textsuperscript{101} \textsuperscript{102}.

5.2 Trends in technology development

The figure below relates some of the main trends (top layer) described in the previous section to the main operation challenges for the railway sector (middle layer) that in turn pose new challenges and functional demands on RSI subsystems and components (bottom layer). In order to meet these demand R&D is required to enhance the performance of rail supply.

Figure 5-2 Demand requirements for new technology development

![Figure 5-2 Demand requirements for new technology development](image)

Source: Hitachi

The prospects of purely technological advance also vary substantially by type of technology. For example vehicle design improvements can reasonably be expected to reduce mass, rolling resistance, drag coefficient. In engine design the focus will be on developing more efficient and less pollutant engines and developments in vehicle/infrastructure interface should increase the efficiency of movement, particularly in urban areas.


\textsuperscript{101} Zacks Equity Research (2012) Railroad Industry Stock Outlook, February 2012.

\textsuperscript{102} This reduction has not been accounted for in growth projections as depicted in figure 6.1
Regarding the expected R&D focus in Europe this is strongly influenced by the long term strategic rail research agenda as has been drafted by ERRAC. This agenda distinguished a number of different research priorities including:

- Intelligent mobility
- Energy and environment
- Personal security
- Test, homologation and security
- Competitiveness and enabling technologies
- Strategy and economics
- Infrastructure.

Against the background of this wider agenda a number of possible research themes have been identified by the rail experts in the consultant’s theme (see box below). These serve as possible directions and do not aim to present a complete overview.

**Box 5-1 Possible R&D directions per market segment (non-exclusive)**

<table>
<thead>
<tr>
<th>Rail Infrastructure</th>
<th>Signalling and ICT</th>
</tr>
</thead>
<tbody>
<tr>
<td>• New materials (e.g. high-quality steel for rails/switches and high quality plastics for sleepers)</td>
<td>• ERTMS for capacity improvement (level 3) and regional train operations;</td>
</tr>
<tr>
<td>• Ballast-less track for high-speed</td>
<td>• BCTC applications for metro</td>
</tr>
<tr>
<td>• Reduced vibration/noise</td>
<td>• Galileo/GPB systems in rail operations</td>
</tr>
<tr>
<td>• Intelligent infrastructure and control systems and remote monitoring of infrastructure and rolling stock</td>
<td>• Fully automated/unmanned metro operations (ATO/UTO)</td>
</tr>
<tr>
<td>• New technologies as maglev (high populated areas/corridors) and monorail (urban transport &amp; airport shuttles)</td>
<td>• Seamless e-ticketing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rolling stock</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>• New, energy friendly (hybrid) drive trains and renewable energy sources</td>
<td>• Intelligent control systems to reduce power consumption and allow energy regeneration</td>
</tr>
<tr>
<td>• Light-weight rolling stock and silent freight wagons (for higher value freight)</td>
<td>• Reduced electromagnetic emissions in urban areas (heavy traction current and HF radiation)</td>
</tr>
<tr>
<td>• Integrated IT systems for passengers, train operations and diagnostics</td>
<td>• Light weight catenary systems and pantographs for high-speed operation</td>
</tr>
<tr>
<td>• Automated/efficient machinery for track maintenance (yellow plant)</td>
<td>• Upgrading existing DC-systems to 25 kV AC-systems</td>
</tr>
<tr>
<td>• New RS technologies (see infrastructure)</td>
<td>• Linear drives for monorail and maglev</td>
</tr>
</tbody>
</table>

Source: expert input Lloyd’s Register

Since railway operators and infra managers are increasingly focussing on their key activities and become less involved in technology development, the RSI will become the main driver of R&D activities and new technology development in future.

For the commercial organisation, particularly in highly competitive markets such as rolling stock providers, survival depends primarily on the ability to maintain economic cost effectiveness in...
production and to improve product quality and attractiveness from the consumers’ point of view\textsuperscript{104}. As cost for R&D are high and immediate rewards often uncertain, there is the threat for a clear risk evading attitudes by all actors involved in the operation of rail transport. Therefore future R&D will focus on those elements that offer the best commercial opportunities for exploitation.

Government intervention by regulations or leading or supporting research might also be required to help promote R&D. Government intervention may also be required in supporting RTD initiatives as operating margin of European RSI are relatively thin. Consortium forming between RSI and RSI and railway managers and operators to conduct R&D will also continue to be important to spur R&D activities in certain areas.

5.3 Medium-term outlook

This section addresses the medium term growth potential of the RSI as well as the future development of a number of important competitiveness indicators for the European industry. Using the latest baseline in the E3MG model\textsuperscript{105} for ‘Other Transport Equipment’, indicative projections have been calculated for the development of the competitiveness of the RSI industry in the EU, US, Japan, Korea and China. In the following sections forecasts are presented for different indicator. These indicators have been calculated in real terms with 2000 as the year base. The average of the exchange during the period of 2000-2010 has been used to transform the values into euros.

Output

The following figure shows the development of value of output/production for the five countries between 2010 and 2015. RSI output will continue to grow for all countries, with especially China continuing to show fast growth. However, growth is slowing down for all five markets towards 2015 with a trend is towards converging growth rates for all markets. Based on the growth development it is expected that China eventually takes over the position of the EU as the largest producer of railway products.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5-2.png}
\caption{Output growth rate with respect to the previous period}
\end{figure}


\textsuperscript{105} see Annex D for a short description of the model
These predictions of future growth potential for RSI output are based on an assessment of the size of manufacturing as a share of GDP and, in turn, the size of RSI as a share of manufacturing. An analysis\textsuperscript{106} of data from UNCTAD shows that most countries have manufacturing shares of around 15% to 20% of GDP. China is a clear outlier with manufacturing accounting for more than 40% of GDP. Developments within each country have been quite stable in the last years, with a little more dynamics in the period of the financial crisis. Therefore long-term development of manufacturing shares is assumed to be stable, with shares expected to revert back to pre-crisis levels by 2012.

**Value added**

A similar evolution can be appreciated for the amount of value added by country. The next figure shows the changes in value added for the RSI. The increases in value added for the Chinese RSI are the strongest in the analysed group. Annual growth rate in value added are two digits for the Chinese RSI and much lower for the other countries. As in the case of output, the differences in the rate of growth are, nonetheless, decreasing.

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>2.0%</td>
<td>2.0%</td>
<td>2.0%</td>
<td>1.9%</td>
</tr>
<tr>
<td>US</td>
<td>3.4%</td>
<td>3.3%</td>
<td>3.2%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Japan</td>
<td>6.7%</td>
<td>6.3%</td>
<td>5.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Korea</td>
<td>8.8%</td>
<td>6.5%</td>
<td>7.6%</td>
<td>5.6%</td>
</tr>
<tr>
<td>China</td>
<td>17.9%</td>
<td>15.2%</td>
<td>15.8%</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

**Employment**

The EU27, the US and Korea are forecast to see little of no change in RSI employment between 2010 and 2015. However, Japanese and Chinese RSI employment is forecast to grow modestly over the period.

**Productivity**

Productivity is important to the sustainable growth and competitiveness of RSI moving forwards. In the past period China, coming from a low level of productivity has showed good progress with higher productivity growth than the other countries. Towards the future RSI productivity suggests that EU27 RSI productivity will grow at a modest and consistent pace up to 2015. Korean RSI productivity is expected to settle down and grow faster than EU 27 RSI productivity. China’s RSI productivity will continue to grow at a much faster rate than the other examined countries while the US and Japan will see a slight pick-up with modest growth.

Unit labor costs
After comparing outcomes for RSI in terms of economic growth and productivity it is also interesting to examine unit labour costs. In the past period productivity has grown at a similar pace as wages per employee for EU27 RSI. Unit labour costs for the EU27 RSI have remained fairly stable, a pattern that is forecast to continue through to 2015, similar to Japan. Chinese is expected to see a further fall in unit labor costs as a results of increasing productivity levels up to 2015.

5.4 Recommendations
The study on the competitiveness of the EU RSI reveals that the position of Europe strong and as many other competing countries fed by a strong domestic market. In global trade Europe holds a lead position. This is confirmed by the analysis of the competitive advantages of Europe, as expressed in the Competitiveness Index, which shows the comparative competitive advantage of
Europe. Especially in the delivery of more complex technological solutions the position the Europe’s RSI is strong.

Key strengths of the European RSI as indicated in the study are its leading position in advanced technologies (e.g. ERTMS, ATO/UTO, CBTC etc.), the well-developed design and production methods, the high level of quality and quality control processes leading to a high reliability, the ability to smartly integrate services into product delivery and the long experience in general in improving operational and maintenance processes.

Seen over a longer time the EU has succeeded in improving its competitive position vis-à-vis Japan and the US, but China and to a lesser extent Korea a gradually positioning themselves as stronger competitors. Market access in Japan and China still faces some hurdles, in the latter country aimed at building up a more competitive industry. Especially China is expected to further improve its position worldwide. At the same time the harmonisation of the European market may create additional market entry for external competitors as it will reduce national fragmentation.

These changes find place in environment in which demand is expected to grow, although the regional focus will shift to growing, emerging economies in the Americas and Asia. To the extent that this growth materializes in countries with a strong own production base, it is expected that especially domestic suppliers will profit from this growth, as figures show that in these countries, including the EU, import penetration is relatively low.

In the future demand may also change to a certain extent. Especially the demand for higher energy efficiency, but also safety and security of transport will receive high and increasing attention. EU RSI unique position to profit from this development by further exploiting its technological advanced position.

Thus a number of challenges and opportunities are observed that form the basis for the recommendations. These recommendation address four areas:

- Continued innovation
- Safeguard access to skilled labour
- Continue to promote a level playing field and market access
- Stimulate a modal shift towards environmentally friendly rail transport

**Strategy 1: Continued innovation**

Maintaining the technological advanced position of Europe is key in retaining its future competitive positions. Recommendation can be made both with respect driving innovation from the demand side as well as the supply side. The following specific recommendation are made:

- The developments on the home market create a strong base for future exports. Progressive regulation driving innovation and market adoption of innovations in Europe can be powerful instruments as shown by the introduction of ERTMS in Europe which is now developing into a de facto world standard. Progressive regulation can for example be introduced in the field of safety and security, but also in improved energy efficient rail transport. This not only triggers innovation but also enhances the replacement demand on the home market;

- On the supply side continued attention to RTD in railway technology which answers to the market trends is essential. Again these can address societal trends towards an enhanced safe, secure and energy efficient rail transport but may also be related to technological intervention that create their own market access, e.g. by lowering the operational cost or maintenance of railway infrastructure and locomotives and rolling stock or improve the reliability of the rail system. As indicated earlier operating margins of European operators are relatively thin creating a risks towards future innovation. Continued R&D support is therefore deemed to be
effective in safeguarding the technological advance of the European industry. As also raised by sector stakeholders this could possible take the form of a Joint Technology Initiative as this combines different actors across the value chain and would enable to bridge the gap between pre-competitive research and market uptake, whilst at the same time creating direct industry commitment.

Strategy 2: Safeguard access to skilled labour
As in most technical engineering sectors the supply of technical engineers may become a bottleneck in maintaining the competitive position of EU RSI on the long term. Especially in view of the ageing population it can be expected that a significant cohort will retire. In this respect the following recommendations are made:

- Intensify cooperation of companies with universities and enhance visibility to the public
- Start image campaigns to strengthen the brand of high-technology sectors such as RSI;
- Continuous adaption of curricula of training and education programmes to address new technological developments and trends such as the drive towards higher energy-efficiency
- Continued promotion of technical education in general, including attempt to increase the share of women in technical professions
- Develop progressive formal career paths by companies and their associations and improve the skills of medium qualified labour (e.g. through the introduction of apprenticeships or similar vocational schemes)
- Improve labour mobility by regular monitoring of supply and demand across Europe

Strategy 3: Continue to promote a level playing field and market access
Creating a level playing field and open market access is essential in maintaining the competitive position of the EU RSI. This leads to the following recommendations:

- Continuously monitor address barriers to market access, in particular non-tariff barriers and procurement strategies, as these forms a significant impediment for EU RSI actors. In particular situation the possibility of sanction should be considered if compliance with trade agreements it not reached;
- Monitor and encourage competing countries (in particular China) to introduce the necessary measures to protection IPR.
- Stimulate early relationship building with countries that are expected to face a significant market demand but do not have their own production capacity. This could imply a variety of measures, including training exchanges with students in these countries, to trade promotion and general international relation building activities. In some situation it may also related to development cooperation activities;

Strategy 4: Stimulate a modal shift towards environmentally friendly rail transport
Rail transport is an important mode of transport in greening Europe’s transport system. Various initiatives are already undertaken by national governments and the EU to promote more sustainable transport systems. It is recommended to:

- actively implement the investment strategy for the establishment of the TEN-T rail network;
- introduce measures that aim to internalise the external costs of transport thus improving the competitive position of rail;
- actively pursue the ongoing intervention that aim at increasing the relative competitive position of rail transport vis-à-vis other modes of transport.
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Eurostat, PRODCOM – production manufactured goods

Eurostat, COMEXT – trade data

UN, COMTRADE – trade data

OECD, ANBERD – R&D

## Annex B: First Definition of RSI: Data codes

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<thead>
<tr>
<th>Sector</th>
<th>Product Code (4)</th>
<th>Description</th>
<th>Product Code (6)</th>
<th>Description</th>
<th>Product Code (8)</th>
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<td>Rail locomotives powered from an external source of electricity or by electric accumulators</td>
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<td>Powered from an external source of electricity</td>
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<td>Powered from an external source of electricity</td>
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<td>Powered by electric accumulators</td>
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<td>8603</td>
<td>Self-propelled railway or tramway coaches, vans and trucks, other than those of heading 86.04</td>
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<td>86039000</td>
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ignition internal combustion piston engines (diesel or semi-diesel)
| Locomotive and rolling stock | 8604 | Railway or tramway maintenance or service vehicles, whether or not self-propelled (for example, workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles). | 860400 | Railway or tramway maintenance or service vehicles, whether or not self-propelled (for example, workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles). | 86040000 | Railway or tramway maintenance or service vehicles, whether or not self-propelled (for example, workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles). | 30203100 | Railway or tramway maintenance or service vehicles (including workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles). |

<p>| Locomotive and rolling stock | 8605 | Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04). | 860500 | Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04). | 86050000 | Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04). | 30203200 | Rail/tramway passenger coaches; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04). |</p>
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### Infrastructure 2517 Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, for road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated; macadam of slag, dross or similar industrial waste.

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<td>Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, for</td>
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<td>road metalling or for railway or other ballast, shingle and flint, whether</td>
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<td>road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated;</td>
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<tr>
<td>or not heat-treated; macadam of slag, dross or similar industrial waste.</td>
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<td>macadam of slag, dross or similar industrial waste.</td>
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### Limestone, dolomite and other calcareous stone, broken or crushed

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<td>Limestone, dolomite and other calcareous stone, broken or crushed</td>
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### Other

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<td>Of a weight per metre of 36 kg or more</td>
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<td>73021090</td>
<td>Used</td>
<td>2410T252</td>
<td>Railway material</td>
</tr>
<tr>
<td>730230</td>
<td>(-2001) Sleepers (cross-ties)</td>
<td>No code at 8 digits</td>
<td></td>
</tr>
<tr>
<td>73023000</td>
<td>Switch blades, crossing frogs, point rods and other crossing pieces</td>
<td>2410T252</td>
<td>Railway material</td>
</tr>
<tr>
<td>730240</td>
<td>Fishplates and sole plates</td>
<td>73024000</td>
<td>Fish-plates and sole plates</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------</td>
<td>----------</td>
<td>----------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>730290</td>
<td>Other</td>
<td>73029000</td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Infrastructure 8608**

| 860800 | Railway or tramway track fixtures and fittings; mechanical (including electromechanical) signalling and electrification, safety or traffic control equipment for railways, tramways, roads, inland waterways, parking facilities, port installations or airfields | 86080000 | Railway or tramway track fixtures and fittings; mechanical (including electromechanical) signalling and electrification, safety or traffic control equipment for railways, tramways, roads, inland waterways, parking facilities, port installations or airfields; parts of the for | 25992910 | Railway or tramway track fixtures and fittings and parts thereof |
| Infrastructure | 4406 | Railway or tramway sleepers (cross-ties) of wood. | 440610 | Not impregnated | 16101010 | Railway or tramway sleepers (cross-ties) of wood, not impregnated |
| Infrastructure | 440690 | Other | Railway or tramway sleepers (cross-ties) of impregnated wood |
| Infrastructure | 7318 | Screws, bolts, nuts, coach screws, screw hooks, rivets, cotters, cotter pins, washers (including spring washers) and similar articles, of iron or steel: | 731815 | Other screws and bolts, whether or not with their nuts or washers | 73181520 | For fixing railway track construction material | 25941115 | Other screws and bolts for fixing railway truck construction material, iron or steel |
| Signalling and electrification | 8530 | Electrical signalling and electrification, safety or traffic control equipment | 853010 | Equipment for railways or tramways | 85301000 | Equipment for railways or tramways | 27907010 | Electrical signalling and electrification, safety or traffic control equipment |
for railways, tramways, roads, inland waterways, parking facilities, port installations or airfields (other than those of heading 86.08).

<table>
<thead>
<tr>
<th>Control equipment for railways or tramways</th>
<th>853090</th>
<th>Parts</th>
<th>85309000</th>
<th>Parts</th>
<th>27903330</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts of electrical signalling and electrification, safety or traffic control equipment for railways, tramways, roads, inland</td>
<td>Parts</td>
<td>Parts</td>
<td>Parts</td>
<td>Parts</td>
<td>Parts</td>
</tr>
</tbody>
</table>
Annex C: Second definition of RSI

The data set for this exercise is compiled from different data sources maintaining the same definition of railway industry. The RSI is defined as NACE 35.2 Manufacture of railway and tramway locomotives and rolling stock, NACE Rev.2 NACE 30.2 Manufacture of railway locomotives and rolling stock, and ISIC 35.2 Railway/tramway locomotives & rolling stock. These three definitions are compatible.

The table below provides a summary of the data sources for the five different countries and the main assumptions under which the data set has been built.

<table>
<thead>
<tr>
<th>Country</th>
<th>Data source</th>
</tr>
</thead>
</table>
| EU      | 2002-2003
          | Wages & salaries are estimates by extending SBS series using implied growth rates in other data sets.
          | 2004-2009
          | Published data from Eurostat - NACE 35.2 Manufacture of railway and tramway locomotives and rolling stock (2000-07); NACE Rev.2 NACE 30.2 Manufacture of railway locomotives and rolling stock (2008, 2009) |
          | Extended UNIDO data with growth rates from OECD: Rolling stock is extended using series for 'Other transport equipment'.
          | 2004-2007
          | Raw data from UNIDO (Rolling stock is defined as ISIC 35.2 Railway/tramway locomotives & rolling stock) |
          | Extended UNIDO data with growth rates from OECD: Rolling stock is extended using series for 'Transport equipment' of Japan.
          | 2004-2007
          | Raw data from UNIDO (Rolling stock is defined as ISIC 35.2 Railway/tramway locomotives & rolling stock) |
| Korea   | 2000-2004 and 2008-2009
          | Extended UNIDO data with growth rates from OECD: Rolling stock is extended using series for 'Other transport equipment'.
          | 2005-2007
<pre><code>      | Raw data from UNIDO (Rolling stock is defined as ISIC 35.2 Railway/tramway locomotives &amp; rolling stock) |
</code></pre>
<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2008</td>
<td>Raw data from UNIDO (Rolling stock is defined as ISIC 35.2 Railway/tramway locomotives &amp; rolling stock)</td>
</tr>
</tbody>
</table>
Annex D: Spare parts

This Annex presents a further analysis of the sub market of spare parts. It includes an analysis of the evolution between 2002 of 2010 of trade in spare parts for the RSI. It includes a description of the trade in spare parts for the EU and the world including the most important destination markets and suppliers for EU producers.

Spare parts are defined under the product code 860719107. The description of the code is the following: ‘Parts of railway or tramway locomotives or rolling-stock, Other, including parts’

World trade in spare parts

The world trade in spare parts measured as World Exports, not taking into account intra EU trade, reached the value of some € 1,250 million in 2010. The evolution of trade is shown in the next figure and table.

Table 3 Spare parts total world exports (million euros)

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>485</td>
<td>449</td>
<td>621</td>
<td>876</td>
<td>1199</td>
<td>1112</td>
<td>1453</td>
<td>1083</td>
<td>1249</td>
</tr>
<tr>
<td>Exports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: COMTRADE

International demand (imports) and supply (exports) of spare parts

In 2010 the most important importers of spare parts railway supply products were the United States (12%); Russia (9%); Canada (8%); and the EU (7%).

In accordance with the client for his study, this code has been adopted for the analysis.
On the other hand, the most important exporters of spare parts railway supply producers were the United States (28%); the EU (28%); Ukraine (12%) and Japan (10%).

**EU Trade in spare parts**
The following table shows EU exports and imports in spare parts.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Exports</td>
<td>122</td>
<td>136</td>
<td>146</td>
<td>206</td>
<td>253</td>
<td>254</td>
<td>288</td>
<td>367</td>
</tr>
<tr>
<td>EU Imports</td>
<td>30</td>
<td>45</td>
<td>39</td>
<td>42</td>
<td>70</td>
<td>120</td>
<td>173</td>
<td>108</td>
</tr>
<tr>
<td>Trade balance</td>
<td>92</td>
<td>91</td>
<td>107</td>
<td>164</td>
<td>183</td>
<td>133</td>
<td>115</td>
<td>259</td>
</tr>
</tbody>
</table>

Source: COMTRADE
EU exports increased during the whole period, but suffered a small reduction in 2010. EU imports also increased until 2008 followed by a decrease afterwards. The different between exports and imports revealed a positive and increase trade surplus in this particular sub-segment.

**Competitiveness of spare parts**

The EU is an important supplier of railway spare parts products. The Revealed Competitive Advantage indicator provides insight in the competitiveness in exporting these particular products. The next table shows the RCA values for the five countries analysed in the study in spare parts.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Union</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>United States</td>
<td>2.4</td>
<td>2.8</td>
<td>3.2</td>
<td>3.3</td>
<td>3.2</td>
<td>2.7</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Japan</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Korea</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>China</td>
<td>0.3</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.7</td>
<td>0.6</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The EU, US and Japan have a competitiveness advantage exporting these products whilst Korea and China have competitiveness disadvantage.

**Interoperability of spare parts in the railway supply industry**

Interoperability of spare parts is important for the railway operators, as they spend up to 30% of their annual budgets spare parts. Improved interoperability is expected to lead to potential cost savings for them.

In general, interoperability in the railway sector has shown significant progress. In particular the markets for rolling stock, CCS and infrastructure interoperability are increasing. Progress in terms of increasing authorisations has also been recorded for most subsystems. Examples for the latter are particularly interoperable train sets, wagons and infrastructures. The number of EC Certificates issued by the notified bodies for rolling stock subsystems increased 400% over the years 2010 to
As a rule, interoperability on the exchange of hardware parts is more difficult than the exchange of data. Major EU-funded projects (FP7), such as the TrioTrain project\textsuperscript{109} provide a platform for both the Railway Supply industry as well as the railway operator industry in increasing harmonisation and interoperability.

**Industry initiatives towards interoperability**

Based on a voluntary cooperation between UNIFE and UIC on rail standardisation, a series of standards called Technical Recommendations (TecRecs) have been introduced.\textsuperscript{110} TecRecs are non-binding in nature and suggested in particular for:

- Product and interface standards such as standardisation of component interfaces
- Publication of results of common research programs
- Acceleration and better influence over the European Standardisation works

Pending the publication of a European standard a TecRec will serve as a common comprehensive standard, approved by UIC and UNIFE and therefore serve as a voluntary sector standard. Topics for TecRecs are selected according to well defined criteria under the supervision of the joint UIC/UNIFE TecRec management co-ordination group (TMT). The partners will agree on a topic and will seek to develop those that are founded on a solid business case. ERA indicated in their earlier study that these voluntary initiatives are relatively effective and formal technical specifications for interoperability (TSIs) are not the appropriate means of support.


\textsuperscript{109} [http://www.triotrain.eu/TRIO_generalbackground.htm](http://www.triotrain.eu/TRIO_generalbackground.htm). The project aims at promoting interoperability by increasing the use of virtual certification for testing processes, through simulation and field testing.

\textsuperscript{110} [http://www.tecrec-rail.org/introduction](http://www.tecrec-rail.org/introduction)
Annex E: The E3MG model

E3MG\textsuperscript{111} is a detailed model of over 40 sectors. This model, developed by Cambridge Econometrics, combines features of short and medium term sectoral estimated by econometric methods with the detail and methods of the CGE models. Thus, the E3MG can be sued for forecasting of long-term outcomes. It is essentially a dynamic simulation model estimated by econometric methods.

The E3MG has a complete specification of the long-term solution. The method utilises developments in time-series econometrics, with specification of dynamic relationships defined from a error correction model (ECM) which allow for long-term convergence of the parameters.

In comparison with other models, the E3MG has three main comparative advantages.

Model disaggregation: The detailed nature of the model allows it to represent fairly complex scenarios and for specific countries and sectors.

Econometric pedigree: The econometric grounding of the models provides a better representation and forecast of the short to medium run.

The following figure describes the main economic interactions in the model.

Figure XXX: The Economic Model: European Example

The economic module is solved as an integrated global model. The module includes three loops of economic interdependence: export loop, output-investment loop and income loop.

\textsuperscript{111} The description of the model is based on the following document: ‘E3MG: A global Energy-Environment-Economy Model. A non-technical description’ (2012). This document can be sent to DG Enterprise upon request.
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