Environmental Innovation Dynamics in the Automotive industry

Case study for project “Assessing Innovation Dynamics Induced by Environment Policy, EU DG Environment, Specific Agreement, no. 07010401/2005/424497/FRA/G1

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Abstract

This paper addresses the innovation dynamics induced by environmental policy in the automotive industry. It examines car fuel efficiency programs in the EU, the US and Japan. It concludes that existing programs have not yet succeeded in promoting radical and breakthrough technologies, but that the European and Japanese programs have had more success in stimulating incremental innovations than the US program.
1. Introduction

This paper examines policy instruments that aim to promote fuel efficiency in passenger cars. It examines whether such programs in the EU, the US, and Japan have promoted environmental innovation in the automotive industry. Section 2 discusses the programs of the EU, US and Japan and their results in detail. Section Error! Reference source not found. interprets the results, while Section Error! Reference source not found. concludes.
2. Drivers and Policy Instruments

In this chapter, three different fuel-economy instruments are discussed. Section 2.1 discusses the European ACEA Agreement, Section 2.2 discusses the US CAFE program, and Section 2.3 discusses the Top Runner program from Japan.

2.1 ACEA Agreement – EU

One important element of the EU’s strategy to reduce CO₂ emissions from passenger cars and to improve fuel efficiency are the voluntary agreements that it concluded with the automobile industry to reduce total new passenger fleet average CO₂ emissions according to specific targets and timetables. The voluntary agreements were in 1998 concluded with the European Automobile Manufacturers’ Association (ACEA), the Japan Automobile Manufacturers Association (JAMA), and the Korea Automobile Manufacturers Association (KAMA). Henceforth we will label these agreements collectively as the ACEA Agreement. The target for new passenger fleet average CO₂ emissions are 140 g CO₂/km by 2008/9. The Community’s target for 2012 is 120 g CO₂/km. This longer-term target has not yet included in any formal agreement with the car industry. Table 2.1 below shows how these targets can be translated into fuel efficiency standards for petrol and diesel cars. The Commission has stated on several occasions that a failure of the car industry to meet the 2008/9 target might lead to mandatory regulation in the future.

<table>
<thead>
<tr>
<th>Target</th>
<th>Fuel consumption (ℓ) per 100 km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>petrol</td>
</tr>
<tr>
<td>120 gCO₂/km</td>
<td>5.1</td>
</tr>
<tr>
<td>140 gCO₂/km</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Source: Kågeson, 2005.

Figure 2.1 below shows average specific CO₂ emissions for each association and for the EU-15 as a whole for the period 1995-2003, and the final target for 2008/9.

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1 Other elements include fuel-economy labelling on cars, and the promotion of car fuel efficiency by fiscal measures (EC, 2005).
2 The target year is 2008 for ACEA and 2009 for JAMA and KAMA.
Figure 2.1 Average specific CO\(_2\) emissions of new passenger cars and target

![Graph showing CO\(_2\) emissions from 1995 to 2009, with ACEA, JAMA, KAMA, EU-15, and Target lines.]

Source: EC, 2005.

Over the period 1995-2003, overall specific CO\(_2\) emissions of new passenger cars on the European market fell by almost 12 percent. In the context of this study, three questions are of prime importance:

1) Is the reduction in specific CO\(_2\) emissions of new passenger cars due to technological improvements or are they due to ‘autonomous’ changes in market demand?

2) What technological improvements have contributed most to the observed reductions in specific CO2 emissions?

3) To what extent can these technological improvements be attributed to EU policies, i.e., the voluntary agreements with the car manufacturers’ associations?

A change in average specific CO\(_2\) emissions of new passenger cars can have different causes. It can be caused by changes in the composition of the fleet because of changes in consumer demand. Changes can also occur because of changes in the average weight of passenger cars due to increasing comfort and safety features.\(^3\) A notable change in

\(^3\) Average weight of passenger cars increased from 1.100 kg to 1.200 kg between 1995 and 2002. A number of safety features such as (additional) airbags and anti-block braking systems, contributed to this increase in average weight (DLR, 2004).
European car sales in the past decade is the increasing share of diesel cars. Diesel engines have lower specific emissions of CO₂ than petrol engines.

Although changes in consumer demand that have influenced specific CO₂ emissions of new passenger cars have occurred over the period 1995-2003, a detailed investigation into the causes of changes in specific CO₂ emissions over that period found no evidence that “the observed total reduction of ACEA’s and JAMA’s CO₂ fleet average was significantly influenced by other factors than technological developments” (DLR, 2004:81). This strongly suggests that the observed emissions reductions were indeed primarily caused by technological developments. This conclusion seems to contrast somewhat with Kågeson’s claim that about 31 percent of the emissions reduction of ACEA was due to the sales shift towards diesel cars (Kågeson, 2005).

What kind of technological development have contributed most to emissions reductions? For petrol cars it was primarily the change from singlepoint to multipoint injection that improved fuel efficiency, for diesel cars it was the almost complete penetration of the direct injection/high pressure technology over the period 1995-2003. The share of direct injection in petrol cars is still very low (DLR, 2004).

Can these technological developments be (partly or totally) attributed to the Voluntary Agreements of the European Commission with the car manufacturers’ associations? In other words, what would have happened to car technologies without the voluntary agreements? This question is extremely difficult to answer. Since improved fuel efficiency is not only good for the environment, but also for the customer, and therefore for the competitiveness of the car manufacturer, the hypothetical “without” scenario seems almost impossible to estimate with any degree of certainty.

It is, however, possible to argue that car industry should have no difficulties to produce cars with average specific CO₂ emissions of 140 g CO₂/km in 2008 and 120 g CO₂/km in 2012 from a technological point of view (Kågeson, 2005). Kågeson (2005) argues that, under current rules, manufacturers, wholesalers and car dealers have no incentives to sell fuel-efficient cars. Their profit margins are better served by sales of larger and more fuel-consuming vehicles such as Multi-Purpose and Sport Utility Vehicles. Kågeson (2005) further argues that no individual manufacturer can afford to take a different route without the support of incentives.

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4 The complete quote is: “Overall, the investigation finds some evidence of the influence of non-technical factors on average CO2 emissions. Given the magnitude and mixture of negative and positive effects of these influences, however, no evidence could be found that the observed total reduction of ACEA’s and JAMA’s CO₂ fleet average was significantly influenced by other factors than technological developments.” (DLR, 2004:81).

5 Kågeson claims that by the end of 2002, the specific emissions reduction of ACEA was due to dieselisation (3.8%), technical innovations (8.3%), and changes in model mix (0.3%). (Kågeson, 2005).

6 In 1995, only Volkswagen/Audi offered some versions of its TDI. Now it is a commonplace engine technology for diesel cars (DLR, 2004).

7 For instance, Toyota’s hybrid car, the Prius, only emits 104 g CO₂/km. For overviews of technical options see, a.o., Kågeson (2005), Kampman and Boon (2005), and IEEP/TNO/CAIR (2005).
Kågeson also points to significant differences in average specific emissions between European countries, especially the high average specific emissions in Sweden (198 g CO\textsubscript{2}/km against an EU-15 average of 164 g CO\textsubscript{2}/km; see Figure 2.1). Kågeson argues that this difference can be largely explained by (the lack of) fiscal policies in Sweden.

Hence, although it cannot be excluded that the ACEA Agreement has contributed to technological innovation in the car industry, it can also be concluded that its contribution has been modest in terms of technological potential, and that its results are also highly dependent upon autonomous changes in market demand (e.g., dieselisation) and the general policy environment (e.g., Sweden).

### 2.2 CAFE – USA

In 1975, US Congress established Corporate Average Fuel Economy (CAFE) standards to conserve petroleum and to reduce US reliance on imported oil (Gerard and Lave, 2003). It has continued to enjoy public support, also as a means to reduce air pollution and to curb greenhouse gas emissions, although it has also been criticised by economists on the grounds that the aforementioned goals could be achieved with other instruments at less costs (see, for example, NAS, 2002).

The CAFE standards set mandatory average fuel economy standards for automobile manufacturers for passenger cars and light-duty trucks. For passenger cars, the standards increased from 18 mpg (miles per gallon) in 1978 to 27.5 mpg in 1985 and have not been raised since. For light-duty trucks, the standard is 20.7 mpg.

Compared to the European targets, the CAFE standards are not very ambitious. The 140 g CO\textsubscript{2}/km target from the ACEA Agreement translates into a fuel economy standard of 5.9 ℓ/100 km (see Table 2.1). The US CAFE standard for petrol passenger cars is 22.1 ℓ/100 km and the light-duty truck standards for minivans, pickups and sport utility vehicles are even less ambitious.

Figure 2.2 below indeed shows that the average fuel economy of new cars in the United States has not improved since the mid-1980s. There are many reasons for this trend, perhaps most importantly the low US petrol prices. NAS (2002) remarks that there are many advanced technologies on the market, including direct-injection, direct-injection compression-ignition (diesel) engines, and hybrid electric vehicles that could improve vehicle fuel economy by 20 to 40 percent. With respect to diesel technology, that has, as discussed earlier, produced large fuel economy gains in Europe, the US has problems with emission standards of nitrogen oxides and particulates under the (1990 amendments to the) Clean Air Act. According to NAS (2002), if direct-injection gasoline and diesel engines are to be used extensively to improve fuel economy, significant technical developments concerning emissions control have to occur or adjustments have to be made to the Clean Air Act emissions standards (NAS, 2002: 5).
According to an econometric study by Goldberg (1998), the main effect of CAFE has been to stimulate the sales of small cars at the expense of larger cars. This effect has been partially undone, however, by the loophole that was provided by the lighter light-duty vehicles standards, that are applicable to large and growing segment of modern, larger passenger cars, including the minivans, pickups, and sports utility vehicles.

Moreover, Kågeson (2005) observed that the effectiveness of the CAFE program has also been undermined by the low level of compliance penalty fees, which according to him have not effectively stopped manufacturers from non-compliance.

Concluding then, CAFE did probably not stimulate environmental innovation in the US automobile industry very much. It is also probably not a good model for Europe, as it gives few incentives to manufacturers of small cars to improve fuel efficiency (Kågeson, 2005).

2.3 Top Runner – Japan

The Top Runner Program was introduced in Japan in 1999 as part of the revision of the Law on the Rational Use of Energy (Naturvårdverket, 2005). The objective of Top Runner Program is to address energy use in the transport, commercial and private sectors. One of the targetted sectors is the automobile industry. Among the targetted product groups (e.g., passenger cars), the most energy-efficient product (the “Top Runner”) becomes the basis of the standard in 3 to 12 year time, taking into account the potential for technological innovation and diffusion. The standards in the Top Runner Program are used in the Green Purchasing law and the green automobile tax scheme. There is also an annual award for the most energy-efficient products and systems.

The experience with the Top Runner Program has been good. For certain product groups – air conditioners, TV sets, and videotape recorders – the results have exceeded
expectation, and not only have manufacturers met standards on a weighted average basis but also on an individual model basis (Naturvårdverket, 2005). It is expected that cars will manage to meet the Top Runner standards prior to the target year (Naturvårdverket, 2005).

Naturvårdverket (2005) lists a number of stronger and weaker points of the Top Runner Program. Stronger points include that the program gives incentives for industry-wide environmental improvements, because the standards do not only look at the best product on the market, but also to the potential for other producers to realistically meet the standards. The mandatory nature of the program forces producers to meet the standards. The standards apply to individual companies, which probably gives more incentives to companies to comply than industry-wide standards such as the ACEA standards. The relationships of the standards with other policy instruments, public procurement, tax systems, is interesting. In Japan, the “name-and-shame” element of the program (with its annual awards) is also of great importance.

Weaker points include that the “realistic” levels of the standards (see above) may not stimulate radical or break-through innovations, and that the differentiation of standards within product groups ensures the availability of a wide range of products, which may not all be preferable from an environmental or sustainability perspective. The Top Runner Program for cars, for example, differentiates between weight classes (see Table 2.2).

Table 2.2 Top Runner Fuel Economy Standards (km/ℓ)8

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 703</td>
<td>21.2</td>
<td>18.9</td>
<td>15.9</td>
</tr>
<tr>
<td>703-828</td>
<td>18.8</td>
<td>18.9</td>
<td>14.1</td>
</tr>
<tr>
<td>828-1016</td>
<td>17.9</td>
<td>18.9</td>
<td>13.5</td>
</tr>
<tr>
<td>1016-1266</td>
<td>16.0</td>
<td>16.2</td>
<td>12.0</td>
</tr>
<tr>
<td>1266-1516</td>
<td>13.0</td>
<td>13.2</td>
<td>9.8</td>
</tr>
<tr>
<td>1516-1766</td>
<td>10.5</td>
<td>11.9</td>
<td>7.9</td>
</tr>
<tr>
<td>1766-2016</td>
<td>8.9</td>
<td>10.8</td>
<td>6.7</td>
</tr>
<tr>
<td>2016-2266</td>
<td>7.8</td>
<td>9.8</td>
<td>5.9</td>
</tr>
<tr>
<td>&gt; 2266</td>
<td>6.4</td>
<td>8.7</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Source: (Naturvårdverket, 2005).

Concluding then, the Top Runner Program has interesting features. It provides for dynamic incentives to improve energy efficiency and it affects companies directly. It may not, however, provide incentives for radical innovations and some of its success factors may by culturally-determined and not directly exportable to Europe.

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8 x km/ℓ is equivalent to 100/x ℓ/100km. The highest fuel efficiency standards are for small gasoline cars, they are 4.7 ℓ/100km. Note that the fuel efficiency standard for small diesel cars is 5.3 ℓ/100kg, which is comparable to the average ACEA 140 standard.

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3. Summary and Conclusions

The three fuel-efficiency instruments discussed in Chapter 2 all have different elements and specific features. The ACEA program in Europe and the Top Runner program in Japan are clearly more ambitious in their targets than the CAFE program in the US. A further difference is that the Japanese and US programs are mandatory, while the EU program is voluntary. Finally, while the EU and US programs set industry-wide standards, the Japanese system sets company standards.

With respect to innovation, the EU and Japanese policy instruments perform better than the US CAFE program. This is not surprising, given the large gap between the stringency of fuel-efficiency standards in Europe and Japan on the one hand and the US on the other. None of the standards, however, is expected to give incentives for radical or break-through innovations. Both ACEA and Top Runner seem to be focusing more on the rapid diffusion of new technologies and incremental innovations. As yet, however, the ACEA agreement has not been extremely successful in stimulating promising technologies such as direct injection in gasoline cars and the production of hybrid cars.

It is not yet clear whether the mandatory or voluntary nature of the policy instruments makes much of a difference. It is not known yet whether the car industry will meet the final ACEA standards in 2008, and how the European Commission will react on a possible failure. The US CAFE program has mandatory standards, but it also has legal loopholes and according to some observers the non-compliance penalties are too small to make a big impression on automakers.

One interesting distinction between the European ACEA approach and the Japanese Top Runner approach is that ACEA sets standards at the industry level, while Top Runner sets standards at the company level. Perhaps this latter approach has the advantage that companies are more directly involved in the process. It is, for example, remarkable that only half of the European automakers mentioned the ACEA standard and progress towards this standard in their annual reports (WRI, 2005).9

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9 Only BMW included information in its 2003 annual report on its strategy to meet the ACEA standard (WRI, 2005).
4. References


WRI (2005). Transparency Issues with the ACEA Agreement.