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THEME 7
Transport including Aeronautics

Future prospects on TRansport evolution and innovation challenges for the competitiveness of Europe

FUTRE Project

FUture prospects on TRansport evolution and innovation challenges for the competitiveness of Europe
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EXECUTIVE SUMMARY

The European transport sector faces several challenges for which innovation may play an important role. The main objective of the FUTRE project is to assess the effects of future challenges, demand drivers and upcoming innovations on the competitiveness of the European transport sector. This assessment will be the basis for developing strategic options for transport related research activities.

The current deliverable summarizes the work developed in work package 2 of FUTRE, concerning the EU transport innovation systems and the current state of the competitiveness of the EU transport sector.

This work package is the starting point of the project and of a particular importance for the FUTRE concept, since it develops criteria for the assessment of innovation and competitiveness, focusing on the European transport sector.

It further summarizes the EU main transport related policies and innovation programmes. The European innovation system in transport is characterized by identifying the key actors per mode of transport and per technology field. Additionally a summary of the main drivers and barriers to innovation is performed.

By applying the concepts and methods developed in this deliverable, the EU transport sector is characterized in terms of its innovation capacity and competitiveness.

The main outcomes are summarized below:

EU transport policies, research programmes and the EU innovation systems in the transport sector

The analysis shows that the transport industry is experiencing a time of change. In most transport modes the European industry has a global competitive position to defend and there is a clear sense that the best way to do so is by investing in research and innovation. In most analysed modes of transport the challenge is twofold: ensure competitiveness of the European industry while reducing the societal impacts (especially environmental) of that mode of transport. These two objectives are not contradictory in nature: if legislation and regulation is properly designed at European and international level, addressing societal challenges would pay-off in terms of competitiveness.

A quick identification of barriers and drivers for market uptake of transport innovation was also performed. This showed that most barriers are market and finance related. One may take two conclusions from this observation:

- First, it may show that technological platforms are/have been effective networks for promoting research agendas that help to address the technological and organisational aspects of transport research;
- Second, that the focus of policy makers on transport research and innovation shall shift towards incentivising market experimentation and exploitation on the one hand,

and adopting regulation and legislation that rewards innovative transport solutions on the other.

As noted in the STTP process the transport industry is shifting from a cost-based competitive advantage to one based on high value-added, linked to innovation in the conception, production and operation of complex systems and services with lower carbon content. The analysis performed in the framework of FUTRE shows that to move in this direction there is a need to further exploit the work of technological platforms – a key structure for intra-industry discussion – together with an increased role for policy makers in reviewing regulation and legislation.

Innovation capacity of the European transport industry

The business sector is the main R&D investor in the EU. In the EU the Manufacture of motor vehicles trailers and semi-trailers is responsible for the highest share of expenditure, followed by the manufacture of air and spacecraft and related machinery.

Across member states, four countries spend the highest share of R&D in transport-related sectors. These are Germany, France, the United Kingdom and Italy. By transport sub-sectors, Germany dominates the R&D expenditure on manufacture of motor vehicle trailers and semi-trailers, railway locomotive and rolling stock. France is the main contributor on the manufacture of ships and boats as well as air and spacecraft, and related equipment.

R&D investments made by the key European companies are significantly high in the automotive and civil aviation industry. In terms of R&D intensity, the air industry followed by the ITS sector are the sectors investing a higher share of their net sales on R&D.

Patent analysis revealed that within the EU Germany and France have the highest shares of patent applications on mobility. Germany has a larger share of applications in rail-bound, hybrid-drive, electric drive and navigation, while France has a higher share of patents in aviation technologies. In other EU countries, other prominent areas with respect to patent shares are bio-fuel for the Netherlands, navigation for Italy, Sweden and Finland, aviation for Great Britain and mobility concepts for Austria.

Competitiveness of the European transport industry

Within the EU two sectors present the highest value added, turnover and production value. These are the 'Transportation and storage' and the 'Manufacture of motor vehicles, trailers and semi-trailers'. The automotive manufacture together with the air industry are characterised as specialized sectors, offering high quality jobs, which is reflected in higher average personnel costs and apparent labour productivity as well as high R&D expenditure. World market shares revealed that these two European sectors are in a good position to compete in international markets as they lead international exports.

Across countries, Germany dominates the automotive sector, while France and UK are in a good position regarding the aerospace equipment manufacture. The manufacture of ships and boats are of similar importance (in terms of value added and world market shares) in UK, France, Germany and Italy, while the manufacture of railway and tramway locomotives and rolling stock is dominated by three countries: Germany, France and Spain. Regarding the transport service providers, Germany, France and the United Kingdom have registered the highest profitability.

In general, the EU is the world leader in many of the transport sectors analysed, especially in the manufacture of motor vehicles, trailers and semi-trailers and manufacture of railway locomotives and rolling stock. However there is a fierce competition in the manufacture of air and spacecraft and related equipment between the EU and the US, with the US performing better in some of the analysed indicators (e.g. value added). The EU also lost its leading position (share of exports) in the manufacture of ships and boats, which is now dominated by China.

Regarding innovation the EU is above R&D expenditures of other regions, in all transport sectors except in the manufacture of air and spacecraft and related machinery which is dominated by the US. The EU is also leading the share of patent applications on mobility-related technologies. However, looking into specific technologies, we found that Japan and Korea are world leaders in the most dynamic technologies: electric motors, battery, and fuel cells while the US ranks particularly well at aviation related technologies.

The higher innovation capacity of the EU transport sector is generally in line with selected competitiveness indicators such as higher value added, turnover and market shares. There are still many areas where transport sectors need to improve their international competitiveness. These are mainly in the aviation and in the shipbuilding sector, where the EU is lagging behind the US and China, respectively, for some indicators. Innovation is needed to improve the competitive position of the EU transport sectors, providing more efficient ways of organizing production and increasing the quality and the range of its products.

Contents

List of figures

FUTRE
Future prospects on TRansport evolution and innovation challenges for the competitiveness of Europe

List of tables

Table of acronyms

EU: European Union
AT: Austria
BE: Belgium
BG: Bulgaria
HR: Croatia
CY: Cyprus
CZ: Czech Republic
DK: Denmark
EE: Estonia
FI: Finland
FR: France
DE: Germany
EL: Greece
HU: Hungary
IE: Ireland
IT: Italy
LV: Latvia
LT: Lithuania
LU: Luxembourg
MT: Malta
NL: Netherlands
PL: Poland
PT: Portugal
RO: Romania
SK: Slovakia
SL: Slovenia
ES: Spain
SE: Sweden
UK: United Kingdom
US: United States
RoW: Rest of the World

R&D: Research and development
CIS: Community innovation survey
NACE: Statistical classification of economic activities
ISIC: International standard industrial classification of all economic activities
ICB: Industry classification benchmark
NABS: Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets
GBAORD: Government budget appropriations or outlays for R&D
BERD: Business enterprise research and development
IPC: International patent classification
EPO: European patent office
GDP: Gross domestic product
ITS: Intelligent transport systems
ICT: Information and communication technologies
OEM: Original equipment manufacturer
AM: After-market
SME: Small and medium enterprises
(E)TP: (European) Technological platforms
SRA: Strategic research agendas
JTI: Joint Technology initiatives
ERA: European research Area
PPP: Public private partnership
STTP: European strategic transport technology plan

1. Introduction

The importance of the transport sector in the European Union (EU) is widely acknowledged in many policy documents as it is considered an important pillar for the economic growth and quality of life of European countries. The White Paper on Transport, which is the main policy document on transport policy for the European Commission, starts by saying:

> *"Transport is fundamental to our economy and society. Mobility is vital for the internal market and for the quality of life of citizens (…) enables economic growth and job creation (…)".(COM, 2011d, pg. 3)*

Nowadays several threats are imposed to transport and these will probably get tight in the future:

- Environmental constraints: the EU has set a target to reduce greenhouse gas emissions by 80-95% below the 1990 levels by 2050 and 60% of this reduction should come from the transport sector;
- Competition from fast developing world transport markets. The EU companies are world leaders in many transport sectors. However, other countries have launched coordinated and ambitious plans to promote certain transport sectors, leading the EU to loose competitiveness and face the delocalization of major companies to more competitive markets.
- Scarcity of resources: the EU transport sector depends on oil and oil products for 96% of its energy needs. Since oil will become scarcer in the future, transport will need to decarbonize so as to avoid oil price increase and deterioration of people's ability to travel.
- Security of passenger and goods.
- Congestion: certain transport infrastructures face important delays that represent a barrier to transport and lead to economic loss for companies and citizens.

Innovation in the form of new technologies or more efficient use of existing resources will be the key to address those threats without curving mobility. An innovative transport sector will also be the pillar to sustain the economic competitiveness of European countries across the world.

In this sense the main objective of FUTRE is the assessment of the effect of future challenges, demand drivers and upcoming innovations on the competitiveness of the European transport sector. This assessment will be the basis for developing strategic options for transport-related research activities, which may contribute to a more competitive transport system.

The first work package of FUTRE aims to develop a better understanding of the present innovation and competitiveness of the European transport sector. This will be done following specific objectives:

1. Lay down the concepts and methods related to innovation, the transport sector, market structure and competitiveness.

Chapter 2 of this report is entirely devoted to accomplish this objective. The main concepts and methods to measure innovation are described. Based on the literature review we will define innovation and describe its main characteristics. This chapter also highlights the importance of the *lead market* concept for assessing the future developments in the competitiveness of the European transport sector. Furthermore, several measures of innovation are selected and presented. There are several measures of innovation in the literature, however not all are available at a sectorial level of disaggregation. The list presented here only refers to those measures that offer an overview of the transport sector.

Secondly, based on the literature review, the concept of competitiveness will be presented, as well as the common variables used to measure it. The concept of competitiveness entails several definitions and its measurement differs according to the aim of the study. Here, a list of measures available to characterize the competitiveness of different transport sectors will be presented.

Finally, we will define the transport sector and propose a subdivision with the intention to capture all actors performing innovation in the transport sector. We will describe the market structure of each transport sub-sector and discuss how this market structure relates with their competitiveness and innovation capacity.

2. Perform a strategic review of the European transport policy, innovation programmes and the European transport systems.

Chapter 3 describes different European transport policies, focusing on how they address the most important societal challenges and respective targets and objectives laid down by the EU. Then an overview of existing innovation programmes is presented, which includes the ERA-NETs, the European Technology Platforms and the Joint Technology Initiatives. The European innovation system of transport is described as a whole and by transport mode, giving a brief overview of the key-players and the main challenges they may face in the future. Finally, specific drivers and barriers to innovation that are faced by the transport sector are presented.

3. Measure the present R&D investments performed by EU Member States, EU FP7 and corporate

R&D (research and development) is one of the main measures of innovation and the longest-standing area of data collection. R&D in the transport sector is performed mainly by private business but an important amount is also performed by the Member States and the EU, under the FP7 budget. In chapter 4 we measure the R&D efforts made by businesses, governments as well as the amount of budget under the FP7 programme that is devoted to transport related research. This assessment is based on official data sources.

Official statistics offer R&D data by transport sector or economic objective, by country and for several years, however in many cases, data is incomplete. Additionally, classification systems used by those data sources are not entirely suitable to characterize the transport subsectors defined in FUTRE. For these reasons and to complement the existing data sources, we undertake a bottom-up approach that estimates the R&D investment of the main corporate within each transport subsector.

R&D is not the only measure of innovation and in some cases it is not even the most important one. Thus, when available, other measures of innovation are being presented (e.g. innovation expenditure).

4. Perform a patent analysis

Patents are the outcome of an invention and a protection right that gives monopoly benefits to inventor(s) who decide the conditions on its commercialization. Patents are an indicator of the technological dynamism of countries and economic sectors. The patent analysis will be used to assess the competitiveness of the EU transport sector, looking at patent dynamics and specialization. This will be performed focusing on differences across countries, transport sectors and transport technologies. Regarding transport technologies, the analysis concentrates on key innovations. Patent analysis is presented in chapter 5.

5. Assessment of global competitiveness of European transport

The global competitiveness of European transport sectors is based on measures presented in chapter 2. Firstly, the EU transport sector competitiveness is characterized comparing differences among transport sectors. Then a similar analysis is performed at Member State level in order to draw conclusions about differences across countries in the EU. Finally, the competitiveness of the EU transport sectors is compared with major non-European regions, which will help to position the European transport sectors in the global context. This assessment is presented in chapter 6.

2. Methodological aspects of transport, innovation and competitiveness

This chapter lays down the relevant concepts and methods applied in this study. First a literature on innovation is reviewed and the main concepts and methods to present and measure innovation are summarised. Then we review the main concepts and methods to analyse competitiveness. A selection of indicators is being done, based on the existing statistics, which is applied on the following packages. Finally, the transport sector and its market structure is described. The market structure of transport sectors is especially important because it reflects their competitiveness and determines the innovation capacity of transport sectors.

2.1 Definition of innovation and how it can be measured

This section reviews some definitions for the innovation concept, looking at the literature to differentiate between types of innovations. It also reviews the innovation process that is how innovation starts, develops and finally diffuses among users. Subsequently, the most important measures used to characterise innovation activity are presented. We concentrate on those measures that can be used under the FUTRE project to represent the transport sector and that are currently available at this sectorial level from official databases. These include R&D measures, patents and innovation surveys.

2.1.1 Definition of innovation and main characteristics

Several reference studies on innovation issues have been reviewed. This review shows a disparity of definitions, which, however, have many common aspects. Rogers (1995) gives a broad definition of innovation as 'an idea, practice or object that is perceived as new by an individual or other unit of adoption'.

In its seminal work, Schumpeter (1934) distinguishes between invention and innovation. While the first one is the occurrence of an idea, innovation is the process of implementing the idea. Usually, innovations come after inventions and in places different from where inventions took place. Implementing an idea usually requires a combination of factors such as production of knowledge, skills and facilities, market knowledge, distribution system, financial resources. In this sense we can say that invention is more related with the achievements of individuals, while innovation is more of a collective process that nowadays is associated with organizations or firms.

Innovation requires learning in order to transform technologies and access markets in a more qualitative way and/or at a lower price of production. According to O'Sullivan (2000) this learning characteristic of the innovation process is uncertain, cumulative and collective. Uncertain because all the possible outputs from investing in learning are visible only after the process has progressed or has been finalised. Cumulative because learning requires a long-run investment on knowledge and cannot be done all at once. Collective because innovation is made possible by the collaborative learning of different people.

From the previous definition we can conclude that innovation is characterised as a novelty that requires the implementation of an idea and this implementing process is usually a collective task, requiring different knowledge along the production and market sale segments.

Schumpeter (1934) categorizes innovations as "incremental" or "marginal" innovations, "radical" innovations and "technological" revolutions:

- "Incremental" or "marginal" innovations relate to improvements that occur to a product or service, during its market diffusion.
- "Radical" innovations are totally new products or processes.
- "Technological" revolution refers to a cluster of innovations that have a high impact on society.

Schumpeter (1934) believed that radical and technological revolutions have the highest impacts. However, other authors (Lundvall, 1992) argue that incremental innovations are as important and in some cases even more important than radical innovations, since generally the greatest economic benefits come from improvements made to the original form of innovations.

Schumpeter (1934) distinguishes between five types of innovation:

- New product: the introduction of a new good
- New methods of production: the introduction of a new process within a firm
- New sources of supply: new raw materials or half manufactured goods
- The exploitation of new markets: the opening of a new market that is new to the company.
- New ways to organize business: the carrying out of the new organization of an industry. An example within the transport sector is the way airlines are now organized following a 'hub-and-spoke' structure.

Much attention has been paid to the first two types of innovation. However more and more studies recognize the importance of other types of innovation. The Community innovation survey (CIS) of 2008, introduced the concept of non-technological innovation such as organisational or marketing methods. The CIS defines organizational innovation as new organizational method in a firm's business practice, workplace organization or external relations not previously used by the firm. Mergers and acquisitions are excluded. Marketing innovation is defined as the use of a new marketing method that changes significantly the product design or packaging, product placement, product promotion or pricing. This excludes seasonal, regular and other routines in marketing methods.

Successful countries are leading the global economy because they have been able to organize production and distribution in an innovative way, giving place to companies that are able to operate in the global market. Chandlers (1990) emphasises that one of the most important organizational innovations have occurred in distribution with great impacts to the globalized economy. The development of ICT technologies wouldn't be possible without important organizational and institutional innovations.

Vernon (1996) suggested that some of these different types of innovation seem to be related with the “product-life-cycle". According to his theory, the industrial growth following an important product innovation was seen as composed of five different stages: introduction, growth, maturity, saturation and decline. Vernon states that the ability to do product innovation mattered most at the early stage, characterized by many different and competing versions of the product on the market. In the following stages, the product was assumed to be standardized, and this was accompanied by a greater emphasis on process innovation, new sources of supply, exploitation of new markets and new ways to organize business. Firms would adapt in terms of conditions and location of production, moved by a search for economies of scale and cost-competition, which leads to a transfer of technology from the innovator country (high income) to countries with large markets and/or lower costs.

The innovation process

Rogers (1995) defined the process of innovation development according to the following six main phases, usually in this order and including or not all stages:

1) Recognizing a problem or a need, which triggers the research and development activities to solve it. This need may be identified by scientists in academia or by firms and it may be part of a political agenda to solve specific societal problems.

2) Basic and applied research: Most innovations are supported by scientific research. Sometimes it derives from basic research, which in principle was not developed to solve any practical problem, or from applied research that is intended to solve practical problems.

3) Development: Rogers argues that research and development can be considered as distinct phases in the innovation process. He defines *Development* as 'the process of putting a new idea in a form that is expected to meet the needs of an audience of potential adopters' (p.137). The development process faces a high degree of uncertainty that requires the exchanges of information between developers and the other social actors (users, legal entities, competitors) in order to accomplish as much as possible the needs of everyone. But sometimes economic aspects such as profitability of companies shape the form of innovation that is further commercialized. Technological transfer is very important at this stage, so that users can understand the benefits of innovation and generate commercial products. This transition between research and development is known as the *valley of death*, as many technologies fail to pass this step.

4) Commercialization: this process consists of converting the innovation into a product or service for sale in the market.

5) Diffusion and adoption: the decision of whether or not to begin diffusing an innovation to potential adopters is very important. This decision process, also known as *innovation gatekeeping*, is controversial. On the one hand there is a pressure to start diffusion as soon as possible, but on the other hand companies need to make sure that only beneficial innovations are diffused because their reputation is at stake. During this process reinvention may occur, meaning that innovations may be changed. (See also box 1)

6) Consequences: this is the final phase of the innovation development process and represents the consequences for individuals or the society of using or rejecting innovation.

Widely deployed innovations create a *'path dependency'* that is difficult to abandon and represents a barrier to competing innovative technologies. This phenomenon is also known as the *lock-in effect*, which hampers innovations that lie outside of the currently dominant design. Path dependency and lock-in effect explain in part why certain innovations are more successful than others, especially in the transport sector. As Crozet (2010) pointed out, in a sector where infrastructure bears a heavy share of expenditure, innovation usually focuses on the best way of improving what already exists. Crozet gives the example of high-speed trains and their ability to use the existing railway tracks. This represents a comparative advantage in relation to magnetic levitation trains.

While the innovation development reflects the supply side of innovation, Rogers also developed a model of innovation decision that is much more related with the demand for innovation. The innovation decision process "is the process through which an individual (or other decision–making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers, 1995, p. 163). The innovation decision process is then composed of the following stages:

1) Knowledge: when individuals are exposed to the existence of an innovation and understand how it functions. This exposure may be accidental or may result from an individual’s search of innovations that fulfil particular needs.

2) Persuasion: when an individual forms a positive or negative attitude towards the innovation. At this stage individuals are more involved with innovation and actively seek for specific information.

3) Decision: represents the choice of adoption or refusing the innovation. Sometimes individuals may try the innovation prior of its final adoption/rejection. Innovations that can be trialled are usually adopted earlier.

4) Implementation: when the innovation is put into practice. As in the diffusion phase of the model of innovation development, during implementation, innovation may be reinvented, since users may find different usages for existing innovations.

5) Confirmation: when individuals reinforce the decision by finally adopting or rejecting it.

According to Rogers, innovations have different rates of adoption, defined as the relative speed with which an innovation is adopted by members of a social system. Different rates of adoption can be due to the specific characteristics of an innovation and emphasize on the following determinants:

- The relative advantage - of a particular innovation in economic terms, social prestige, etc.

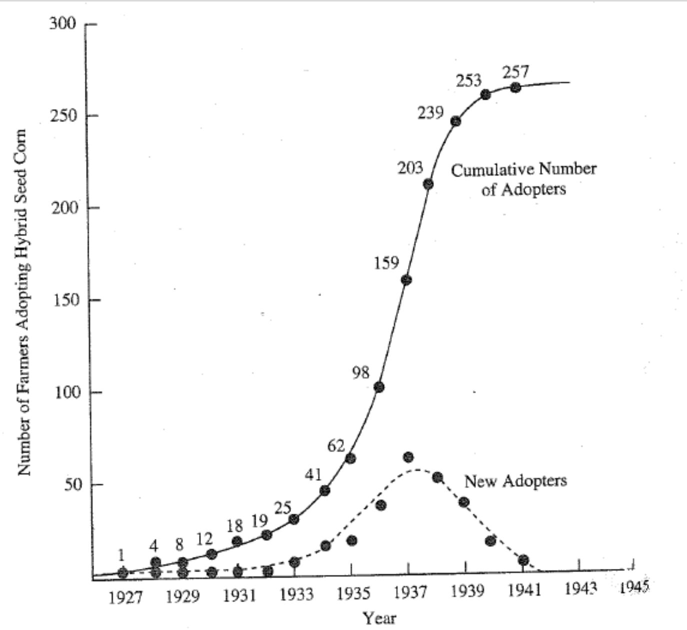
- Compatibility - with existing values, experiences and needs of different users.

- Complexity - innovations that are difficult to understand have a lower rate of adoption.
- Triability - the ability to try innovations on a limited basis encourages the diffusion process.
- Observability - as the degree to which the results of innovation are observed by others, has an impact on the rate of adopting an innovation.

Box 1. Innovation diffusion

Once an innovation comes out to the market, a diffusion process starts. Everett M. Rogers is the key author when it comes to explaining the process of innovation diffusion. In 1962 he developed a theory of diffusion of innovations which seeks to explain the processes involved in innovation diffusion, the causes that lead to this process and the rate at which innovations spread into the society. According to his theory the adoption of an innovation follows a normal, bell-shaped curve when plotted over time on a frequency basis and an S-shape curve if the cumulative number of adopters is represented (Figure 1).

Figure 1 - New adopters and the cumulative number of adopters of hybrid seed corn in two Iowa communities



Source: Rogers (1995)

The S-shape curve shows that there are fewer adopters at the beginning (what he called early adopters) and then rises till a maximum when the half of the population has adopted the new idea. Then the adoption process slows down since fewer individuals adopt the innovation (these are called the later adopters). The normality of the innovation distribution is explained by the cumulative nature of adopting a new idea. More and more individuals adopt an innovation due to the exchange of information with other members in the system. Somewhere in this distribution there is a point when critical mass is reached, meaning that enough individuals have adopted an innovation so that the innovation becomes self-sustainable. Rogers also alerts that the normality and the S-shape curve of adopters distribution is especially true for successful innovations, but not all innovations follow this pattern, mainly because they do not reach the critical mass point.

2.1.2 The Lead Market concept

The subsection will briefly introduce the concept of lead markets and the related discussions. It is not the intention to give a broad or even exhaustive overview of the field. Instead it highlights the importance of the concept for assessing the future developments in the competitiveness of an industrial sector. The relevance for FUTRE will have to be further discussed in deliverables 4 and 5 of the FUTRE-project. In these deliverables, the impact of specific developments on the competitiveness of the European transport sector will be analyzed.

The discussion about lead markets is in general strongly related to the impacts of environmental regulations. Environmental innovations often face the challenge of positive externalities by bearing high costs to the innovator and having the society benefit from them, eventually discouraging the innovator to actually innovate; this applies to the invention as well as to the diffusion phase of the innovation and is therefore referred to as the double-externality problem. Therefore, it is argued that policy measures are necessary to stimulate the development as well as the adoption of environmental innovations (Beise and Rennings, 2005; Zubaryeva et al, 2012).

The lead markets thesis argues that such policy measures can have positive impacts on the innovativeness and as well on competitiveness. In doing so, it contradicts the perspective that environmental regulations have only negative impacts on the economic performance of a firm or an industrial sector in a region or country. It is argued that environmental regulations induce, intentionally or not, the development of innovations. Firms have to develop and/or to adopt products, processes and services that enable them to cope with the new regulations. The main idea of the lead markets approach is that other countries implement similar regulations, which then lead to new markets for those who produce the eco-efficient innovations. It is argued that in this way, national (environmental) regulations can create lead markets, which enable local firms to export innovations. A critical point for the creation of lead markets is that the new regulations are adopted in other countries since these countries face similar challenges. Only when such a diffusion of policies is taking place, there will be similar market conditions at home and abroad (Beise and Rennings, 2003). The lead market develops in the country where the regulations where implemented first. These domestic markets then become reference markets for others. The lead markets provide a first mover advantage for the domestic industries: “Countries that are first in adopting an internationally successful innovation can be called lead markets, the following countries the lag markets.” (Beise and Rennings, 2003, 3).

The concept is linked to the so-called Porter hypothesis (Porter and van Linde, 1995) which states that environmental regulations can stimulate environment-related technological innovations. These innovations can lead to increased competitiveness in the market (see also Arimura et al., 2007). In literature, different variants of the Porter hypothesis are discussed (see Jaffe and Palmer, 1997). The weaker version of the thesis is just saying that environmental regulations, as any other regulation, can induce innovations since firms try to cope with the new situation in the most efficient way. Others argue that the choice of policy instruments is actually the important factor to stimulate environmental innovations (see Arimura et al., 2007). In this context it is asserted that flexible environmental regulations give firms more incentives to innovate than prescriptive regulations such as technology-based standards. Another interpretation argues that regulations, by providing information, can result in the realization of commercial opportunities (ibid.). Linked with the latter point, Porter and van Linde (1995) argue that also without an international diffusion of the environmental regulations, strict regulations may exert pressure on firms and induce eco-efficient innovations which may improve the competitiveness of domestic firms: “The logic behind this is that efficient use of natural resources is at least partly a private good since firms have to pay for the use of water, production of waste, etc. Thus natural resource efficiency can be regarded as a part of the total efficiency and competitiveness of a firm.” (Beise and Rennings, 2003, 9).

The linkage from environmental regulations to competitiveness is often called the “strong version” of the Porter hypothesis (see Ambec et al., 2011). Ambec et al. (2001) carried out a literature review, which indicated that not much evidence for the strong Porter hypothesis could be found (see also Rennings, Cleff, 2011; Rexhäuser, Rammer, 2011). However, there is also evidence pointing at the relevance of the lead market approach. Beise and Rennings (2003) discuss the lead market approach on the basis of two case studies:

- Fuel efficient passenger cars from Germany (based on Diesel-High-pressure-direct-injection);
- Wind energy from Denmark.

In both cases, the lead market became a large exporter of the technology. In the case of wind energy a combination of strict regulations and an international diffusion of such policies are the most important success factors. The authors argue that for fuel efficient cars the Porter effect is less important since environmental regulation is to date still outweighed by consumer preferences that steer diametrically into the opposite direction. The authors conclude: “The importance of the Porter effect depends on its relation to global demand and regulatory effects. If national regulation is supported by global demand or regulatory trends, a strong effect can be identified, as was shown in the cases of wind energy in Denmark and Diesel-High-pressure-direct-injection in Germany. If it is not supported, the market remains idiosyncratic, as could be seen in the failure of the [sic!] Golf Ecomatic.” (Beise and Rennings, 2003, summary). The Golf Ecomatic switched the motor off when it was not in use and was able to reduce fuel consumption significantly. The car won several prices but it was not accepted by the users.

Based on their work in this field Beise and Rennings (2005) identify 6 country-specific success factors for lead markets:

- Price advantage
- Demand advantage
- Transfer advantage
- Export advantage
- Market structure advantage and
- Regulation advantage

The authors argue that a good performance of these factors on the national level increases the probability of the market becoming a lead market (Rennings, Cleff, 2011, 4).

A prominent example to illustrate that also "second movers" can be successful and regulations do not necessarily lead to persistent lead markets is the feed-in tariff for renewable policies in Germany. The regulation brought the German market quickly into a demand advantage position which was not necessarily accompanied by advantages for the German industry. For example, most modules for photovoltaic are imported from Japan or China (ibid, 21). Rennings and Cleff argue that in the field of electric mobilitiy German policy is following a broader approach, taking more lead market factors into account. The strategy is not only demand-oriented (as it was characteristic for the case of renewable energies) but includes a broad range of technology push measures (e.g. extensive R&D activities). Rennings and Cleff further conclude: "It can be ascertained that the successful innovator is not necessarily the first but very often one of the early movers within the competition of different innovation designs." (ibid, 25).

Based on an examination of an extensive data set from German firms, Rexhäuser and Rammer (2011) conclude that the 'strong' version of the Porter hypothesis does not hold in general but strongly depends on the type of environmental innovations: "We find that innovations which reduce environmental externalities reduce firms' profits, as long as they are induced by regulations. However, innovation that increases a firm's material or energy efficiency in terms of material or energy consumption has a positive impact on profitability." (Rexhäuser, Rammer, 2011, 0).

The lead market approach is an important issue at European level. Slightly modified but still based on the concept of policy-induced innovations as it was described above is the Commission's activity in this context. In its lead markets initiative the Commission aims at "identifying areas where concerted action through key policy instruments and framework conditions, coherent and coordinated policy making by relevant public authorities, as well as enhanced cooperation between key stakeholders can speed up market development, without interfering with competitive forces." (CEC, 2007a).

The Commission defines a lead market as follows: "A lead market is the market of a product or service in a given geographical area, where the diffusion process of an internationally successful innovation (technological or non-technological) first took off and is sustained and expanded through a wide range of different services" (CEC 2007b). The lead-market initiative has applied a number of criteria (demand-driven markets, broad market segments, strategic societal and economic interest, added value of policy instruments, no 'picking of the winners') to identify potential European lead markets: eHealth, protective textiles, sustainable construction, recycling, bio-based products, renewable energies. This proves the recognition of the lead market concept's relevance at the level of European policy actors; and it may be useful to broaden the application of the concept to include innovations in the European transport sector.

Also José Manuel Barroso in a speech underpins the relevance of environmental regulations for competitiveness. Related to the European energy and climate change package he states: "It will encourage innovation and it will increase competitiveness. It is a mistake to oppose the fight against climate change to the competitiveness of European industries. The Union should lead the global efforts to tackle climate change. And European industries should continue to be world leaders. At the same time, we will also create new markets and new jobs, and make sure that we have the "first mover advantage" in many sectors." (Barroso, 2008).

This quote indicates that positive effects of environmental regulation seem to be taken for granted by many politicians. But the Porter hypothesis as well as the related lead markets concept is still subject of controversies. However, many observers consider the lead markets concept as being important for the competitiveness of an industrial sector in a country or a region. For the FUTRE project it will be essential to be aware of this discussion and to consider such impacts in the analyses of the future competitiveness of the European transport sector.

For the FUTRE project it is important that

- The lead markets concept is particularly relevant for policy-induced innovations, such as those stimulated by stricter environmental regulations or labels. Whereas in theory the concept could actually be related to any regulation, in praxis it is mostly discussed in context of environmental policy and corresponding environmental regulations. Environmental regulations are highly relevant for the developments in the European transport sector. Examples are the regulations for CO_2 emissions of cars (90g CO_2/km fleet average), for particulate matter emissions or the environmental zones that are implemented in German cities.
- Several case studies could prove that regulatory requirements result in the release of innovative potential in sectors where the double-externality problem applies (see

Jacob et al., 2004). For example it may happen that national 'strict' regulations in relation to quality control for public works will force constructing companies to comply with a highly demanding regulatory framework (e.g. high safety standards) which in the end may lead to competitive advantage in the international market for the companies. In this case the need for regulation compliance leads to high expertise, which in turn could lead to competitive advantage.

- The Commission's white paper sets a series of goals and targets (see CEC, 2011) that can only be fulfilled by incentives and regulations; some of these regulations will be strongly related to environmental issues. It will be crucial to anticipate to what extent these regulations might be adopted by other countries and if there are factors that point at a potential policy diffusion. A driving force for such policy diffusion might be countries recognizing similar challenges and pressures as the European countries do. Following the lead markets concept, a diffusion of European policies could make Europe or specific European countries an exporting lead market and provide a basis for improved worldwide competitiveness.
- Several roadmaps in the transport sector (e.g. by the several technology platforms) anticipate such regulations; they are crucial for the future development of innovation and thus need to be taken into account in FUTRE.
- It was stated above that there are good reasons to take the international diffusion of European policies into account for assessing the competitiveness of the European transport sector. But the same is true vice versa: there is a need to take the diffusion of policies from abroad into account. Early adoption of policies in countries outside Europe that later diffuse into European regulations could lead European markets to lagging behind, loosing competitiveness in the respective sectors.
- FUTRE explicitly aims at linking the supply and demand sides of the transport system by integrative scenarios and a systemic perspective on policy recommendations. The lead markets concept is an important element to link the supply and demand sides. It is a good example which shows that (transport) innovation does not take place isolated from the rest of the world, but shows a co-evolution with other elements of the (transport) system instead. The lead markets concept therefore highlights the importance and appropriateness of FUTRE's integrated approach.

2.1.3 How to measure innovation

Measuring innovation is not an easy task mainly because some aspects of innovation cannot be captured with current level of data provided by official statistics. There are two broad areas of indicators used to measure innovation: R&D and patent applications. However in recent years new indicators of innovation inputs and outputs have emerged. In this section we review some of the most important ones. This is not an exhaustive review of measures, instead the most appropriated measures have been selected considering the availability of data sources to characterise the transport subsectors defined in section 2.3.1.

Research and Development (R&D)

R&D is by no means the most important innovation input and the longest-standing area of data collection. The Frascati Manual (OECD, 2002) is one of the most important references worldwide for collection of R&D statistics. Within this manual R&D includes both the production of new knowledge as well as new practical applications of knowledge. It covers basic research, applied research and experimental developments. According to this manual for an investment be considered as R&D there should be an appreciate element of novelty. In that sense education and training for general purposes are not considered as R&D, nor market research, acquisition of product and licenses, product design, trial production, training and tooling up unless they are a component of research.

R&D can be defined as intramural and extramural:

- *Intramural* R&D are all expenditures for R&D performed within a statistical unit (eg. firm) or sector of the economy.
- *Extramural* R&D covers payments for R&D performed outside the statistical unit or sector of the economy.

R&D expenditures are performed by different sectors which in official statistics are defined as:

- Business enterprise sector (BES): includes all firms, organisations and institutions whose primary activity is the market production of goods and services for sale. Generally this sector is further broken down by economic sectors (e.g. Eurostat uses the European classification NACE).

- Government sector (GOV): refers to all departments, offices and other public bodies provided by governments. This sector do not sell to the community.

- Higher education sector (HES): covers all universities, colleges of technology and other institutions of post-secondary education. It also includes all research institutes, experimental stations and clinics controlled by higher education institutions.

- Private non-profit institutions (PNO): represents non-market, private non-profit institutions serving households. It also represents private individuals or households.

R&D expenditures may have different *sources of funds*, since in many cases the sector performing and the sector of funding differs. One example are private companies receiving funding from the Government or from universities to perform R&D activities.

Eurostat data offers differentiation between sectors of funding which include the above four sectors (BES, GOV, HES, and PNO) plus the '*Abroad sector'*. This sector consists in all institutions and individuals located outside the political borders of a country as well as all international organisations (except business enterprises) including facilities and operations within the country's borders.

Crossing information on performing and funding R&D sources gives interesting insights about the R&D transferences between different sectors. For example it is possible to look at the amount of public funded R&D that was performed by business enterprises or about the amount of businesses' R&D that was funded by foreign institutions (Abroad sector).

Public R&D is sometimes presented as *Government budget appropriations or outlays for R&D (GBAORD).* This is another type of R&D indicator that shows the government intentions to allocate money to R&D. This figure may be a forecast (budget proposals or initial budget appropriations) or a retrospective (final budget outlays). In any case this is not a real expenditure figure, since it is derived from national budgets.

R&D figures are usually expressed in relative terms as the ratio of R&D expenditure and some measure of output such as sales in case of firms, value added in case of an industry or GDP when is referred to a country. This is known as *R&D Intensity*. This indicator is perhaps more useful than R&D expenditures when it comes to compare different companies strategies or characterize industries in terms of high technology activities. As for countries it is used to analyse the level of technological progressiveness. One of the EU targets in terms of innovation policy (stated in the Lisbon strategy and the Europe 2020 Strategy) is to reach a R&D, GDP ratio of 3%.

R&D measures have some limitations in representing innovation activities and the most important one is that R&D is only one part of innovation spending. R&D usually accounts between one-half to two-thirds of all innovation expenditure while the other part is devoted to tangible and intangible assets (OECD, 2010). In this sense innovation expenditure (see description on CIS survey below) gives a more complete definition of innovation.

Patents

A patent is a legal property right over an invention that gives monopoly rights limited in time and geographical area to the applicant for the use of the invention. In contrast, the inventor discloses detailed information about the invention. The patent is granted by national patent offices and the patent system is aimed as an incentive for the creation of new knowledge and to spread information.

Patent statistics are often used as an indication of invention activities which reflects the technological dynamism of a country, an economic sector or a firm. They are also used as an indicator on the direction of technological change. However patents cannot directly be interpreted as an indicator of innovation since they represent only the start of the innovation process that is related with the invention. Some patents never achieve to be fully developed and commercialized. Another drawback of patents as a statistical indicator of innovation is that their economic impact differs enormously from one another. Furthermore many innovations are not reflected in a patent invention.

The major sources of patent data are the US Patent Office (USPTO) and the European Patent Office (EPO), providing freely available data for long periods. Patents are classified according to a detailed classification system of technological fields (International Patent Classification, IPC). Databases usually provide patent data broken down by economic sectors, by specific technology fields (High-tech, ICT, Biotechnology, Navigation per satellite, Energy technologies, Nanotechnology), by countries and even by regions. Information is also provided reflecting the 'Ownership of inventions' (such as the 'foreign ownership of domestic inventions' and 'domestic ownership of foreign inventions').

Patent statistics are subjected to home bias which means that firms tend to file patents first in their home country. This bias is particular important when it comes to comparison of patent figures of different countries. One solution for this problem is the use triadic patents defined as those patents applied for at the EPO, the Japan Patent Office (JPO) and the USPTO. The use of triadic patents has the additional advantage that patents are usually of higher value.

An important index based on patent statistic is the *Index of revealed technological advantage* which shows the country's specialization in a particular technology field.

The Community Innovation Survey (CIS)

The CIS collects international measures of innovation outputs at a firm level and it has been undertaken for seven times since it was created in 1993. Data is collected in a four early basis and the latest one was launched recently and contains data for 2010. All EU Member States (except Greece) participated in the 2010 survey plus Iceland, Norway, Croatia, Serbia and Turkey. The CIS is undertaken for all firms with 10 or more employees belonging to core sectors defined by the European Commission[1]

CIS questionnaires have evolved over time but since 2008 the statistical indicators cover several topics related to:

- Product, process, on-going and abandoned innovation
- Innovation activity and expenditure
- Intramural research and experimental development (R&D)
- Effects of innovation
- Public funding of innovation
- Hampered innovation activity
- Patents and other protection methods
- Other important strategic and organizational changes in the enterprise.

[1] The core sectors were defined in Commission Regulation No 973/2007

Common indicators extracted from CIS survey are:

Share of innovative enterprises in the economy. These enterprises can be further disaggregated by those who have introduced new or significantly improved products/process/organizational/marketing innovations which per se reveals the mix modes of innovation or the complementary innovation strategies of firms. Enterprises can be further distinguished between those who introduced an innovation that is "new to the market" or only "new to the enterprise"

Enterprises with co-operation arrangements on innovation activities. Cooperation on innovation activities is a trend within enterprises and this is also true for the transport sector. Cooperation on innovation has the potential to leverage the investment and extent the scope of a project. Co-operation with foreign companies is at least as important as the cooperation with national firms. The CIS differentiates between enterprises co-operating with other enterprises within the enterprise group and those who co-operate with suppliers.

Enterprises indicating high importance of selected sources of information. Sources of information included are: the company itself or the enterprise group, the suppliers, the customers, the competitors, external R&D performers (both private and public), conferences, journals and professional associations.

Innovation expenditure. This is a broader definition of innovation compared to R&D expenditure. Enterprises report their expenditure in innovation activities which comprises intramural and extramural R&D, expenditures for the acquisition of innovative machinery, equipment and software, and expenditures for the acquisition of other knowledge (eg. patents, trademarks, licenses). For most countries as well as for some sectors the main cost component of innovation expenditure is the acquisition of machinery followed by intramural R&D.
Sales of new or improved products as a percentage of total turnover. It is also possible to distinguish between products that are new for the enterprise and new for the market. Generally large enterprises have a higher share of turnover of new or improved products than smaller ones. Furthermore this share is usually higher in industry than in services.

2.2. Competitiveness: concept and measures

This section is structured in two parts, the first one overview the concept of competitiveness and it political and economic relevance. Furthermore we explore the relationship between innovation and competitiveness, based in the literature review. The second part reviews the main studies assessing competitiveness at European and world level, then some measures of competitiveness that can be used to characterise the current situation of transport sub-sectors are proposed.

2.2.1 The concept of competitiveness and the role of innovation

There is no consensus about a unique definition for the concept of competitiveness. At a firm level a broad definition of competitiveness refers to the inclination and skills to compete and to gain a favourable position in the market, increasing the market share and profitability as well as succeed commercially. However for a country, competitiveness is much more related with increased standards of living and welfare.

The European Commission defines competitiveness as

> *(…) 'a measure of an economy's ability to provide its population with high and rising standards of living and high rates of employment on a sustainable bases.' (COM, 2012d, p.4)*

Similarly, the Organisation for Economic Co-operation and Development (OECD) defines competitiveness as the

> *(…)'the ability of companies, industries, regions, nations, and supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis' (Hatzichronologou, 1996).*

Productivity growth and competitiveness is related with the existence of a vigorous competition in a supportive business environment (COM, 2012d). This link between high productivity levels and competitiveness is present in many definitions of competitiveness. The World Economic Forum defines competitiveness as

> *(…) 'a set of institutions, policies and factors that determine the level of productivity of a country'. (World Economic Forum, 2012a, p.4)*

In Eurostat we find the following definition of competitiveness:

> *'Competitiveness is a measure of comparative advantage or disadvantage of enterprises, industries, regions, countries or supranational economies like the EU in selling its products in international markets. It refers to the ability to generate relatively high income and employment levels on a sustainable basis while competing internationally'.*

Following the definition provided by Eurostat, in FUTRE we define the competitiveness of the EU transport sector as the comparative advantage or disadvantage of the European transport sector in selling its products in national and international markets, while generating high income and employment levels.

Competitiveness is gaining more political relevance in the EU where it is considered a priority, closely related with the realization of the Europe 2020 Strategy on growth and jobs.

Coming out of the 'Europe 2020 strategy' the Flagship initiative 'An industrial policy for the Globalisation era' puts industrial competitiveness at the centre of EU policy. This flagship sets out the strategy to boost growth and jobs by supporting a diversified and competitive industrial base in EU.

Although not easily measured, the literature review points at an implicit relationship between innovation and competitiveness since most developed countries are also the places where the main innovation centres are located. Innovation centres on the other hand have been changing over time both in location and sector. For a long time UK was the main innovation centre and the productivity and income level was the highest in Europe. Then at the beginning of twentieth century, following its industrial revolution, Germany hosted the worldwide centre of innovation especially for the chemical and electric technologies. After the World War II, US have become the main centre of innovation enjoying the highest productivity and living standards in the world, mainly due to the exploitation of economies of scale and scope and mass production and distribution (Chandller, 1962, 1990).

At a firm level, technological competiveness is an important driver of economic development. In the short run, productivity and labour costs are important competitiveness factors, but in the long run the innovation activities are crucial factors of firm's competitiveness. Firms that are not able to innovate will be lag behind while innovative firms have higher possibilities for new business and future innovations and are key players for a more competitive economy.

Some studies evidence the role of public R&D investment on increasing productivity over time. Guellec and van Pottelsberghe (2003) using panel data across 16 OECD countries, studied the productivity effects of public sector R&D. They used total factor productivity and distinguish among, domestic business-performed, foreign business-performed and public R&D (performed in the higher education sector and government sector). They found higher elasticities for the public sector R&D and a time-lag of three years for the initial impact of this investment. This was interpreted as higher long run impact of R&D when it is performed by the public sector. The importance of public R&D in promoting technical change and innovation is widely recognized (Acz Audretsch and Feldman, 1992; Jaffe, 1989 and Nelson 1989).Furthermore, public R&D expenses are important for product or process developments, without which substantial delay would hamper the competitiveness of firms (Mansfield, 1991; Beise and Stahl, 1999).

Considering the importance of innovation on competitiveness, the EU established a target of 3% of the EU's GDP to be invested in R&D as a strategic objective to achieve a smart sustainable and inclusive economy, in its Europe 2020 strategy. Accordingly it was also launched a flagship initiative called 'Innovation Union' aiming at facilitating the conditions for access and finance of research and innovation so to promote the creation of growth and jobs.

2.2.2 Measures of competitiveness

Competitiveness is a multifaceted concept that can be applied both at micro (e.g. companies) and macro levels (e.g. countries). Its measurement depends on the unit of analysis since there is not a unique formula for measuring competitiveness. Previous definitions show that several factors need to be considered in order to measure competitiveness, while the selection of factors will depend on the unit of analysis

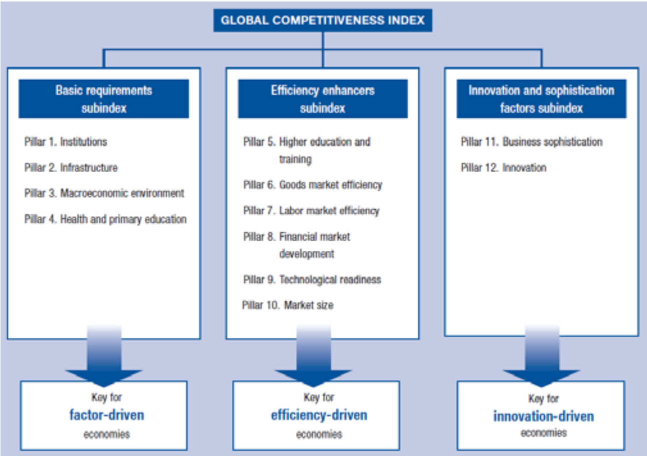
Measures of competitiveness are often categorized as price and structural measures. Structural measures link competitiveness with concepts of economic specialisation, technological innovation, quality of distribution networks. All these aspects raise productivity while lowering prices. On the other hand price measures of competitiveness are usually evaluated by price differentials such as production, export and import prices.

All these aspects are included in the European competitiveness report which every year addresses different key policy questions for the EU, with a special focus on economic sectors. In its 2004 edition, chapter four was devoted to the automotive industry regarding its competitiveness, challenges and future strategies. Competitiveness was assessed by looking at factors such as value added, employment, labour costs and labour productivity, production, expenditure on R&D, prices competitiveness and the performance in national and international markets.

Also since 2012, the EU launched the 'Industrial performance scoreboard' which monitors the competitiveness of Member States in five key areas: manufacture productivity, exports performance; innovation and sustainability; business environment and infrastructure, and finance and investment. Additionally, the 'EU industrial structure report' shows the efforts of the EU to understand the drivers and barriers of competitiveness and ways of promoting it.

The World Economic Forum produces the Global competitiveness report on a yearly basis since 2008, assessing competitiveness of 144 world economies. Competitiveness is measured by a composite indicator named ' Global Competitiveness Index' that aggregates many components that define the competitiveness of a country. These components are grouped into twelve pillars (see Figure 2).

Figure 2 - The Global Competitiveness Index framework



Source: World Economic Forum, 2012a

Pillars are grouped into three subindexes, each critical to a particular stage of development. The 'Basic requirements subindex' groups pillars most critical for countries at early stages of development that are basically factor-driven since they compete based on their natural resources (mainly low-skilled labour and natural resources).

The 'Efficiency enhancers subindex' includes the critical pillars for countries at an efficiency-driven stage of development. These countries are more competitive with higher levels of productivity and increased wages. Aspects such as efficiency and product quality became more important.

Finally the 'Innovation and sophistication subindex' includes critical pillars for countries at highest level of development, called the ' innovation-driven stage'. Those countries have high standards of living and high wages and business compete essentially with new and unique products, services, models and processes.

Similar to this approach, the Directorate-General for regional Policy produces the '*EU Regional Competitiveness Index'* (Dijkstra, L. et al., 2011) which provides a synthetic vision of the territorial competitiveness at NUTS 2 level of the EU 27 Member States. It is based on eleven pillars, grouped in three categories: Basic, Efficiency and Innovation.

Also for the EU the World Economic Forum produces the '*Europe 2020 Competitiveness Index'* (World Economic Forum, 2012b) based both on a survey and external quantitative data. The index is organized across seven pillars and each pillar is organized in three sub-indexes that in turn are the three axes of the Europe 2020 strategy:

- Smart growth: aggregating the pillars of enterprise environment, digital agenda, innovative Europe, education and training
- Inclusive growth: composed of labour market and employment, social inclusion pillars
- Sustainable growth: environmental sustainability pillar

Proposed measures of competitiveness in transport sectors

Previously we have defined the competitiveness of the EU transport sector as the comparative advantage or disadvantage of the European transport sector in selling its products in national and international markets, while generating high income and employment levels.

According to our definition of competitiveness we have selected a set of indicators that can be categorized into: labour cost and productivity, innovation, output measures and international competition.

Labour costs and productivity as well as innovation are factors that determine the comparative advantage or disadvantage of the European transport sector. Labour costs represent an important factor of price competitiveness but it also depends crucially on labour productivity. Innovation on the other side, both private and publicly funded, increases the range of products and their quality, which improves the capacity of selling them in national and international markets.

Output measures such as value added, production value or turnover are used to compare performances among transport sub-sectors and among different countries, while international competition is evaluated by looking at world market shares. Market shares reflect the ability of transport sectors and countries to compete in international markets.

Labour costs and productivity

Labour costs: low production costs are an important factor of international competitiveness of a firm. Labour costs, on the other hand, are a major source of difference in production costs between firms. Labour costs will be measured as total labour compensation (personnel costs) and average labour costs per employee.

Unit labour cost. Unit labour cost measures the average cost of labour per unit of output and is calculated as the ratio of total labour costs to real output. This is a measure of cost competitiveness and they show the relative increase of nominal wages compared to productivity.

They should be interpreted with caution, since they are not an exhaustive measure of cost competitiveness, as only labour costs are taken into account. In sectors where capital expenditure costs play a larger role, unit labour cost are lower and they are also affected by the degree of outsourcing, which decrease unit labour costs.

Gross operating surplus (GOS): is the surplus generated by operating activities after the labour factor input has been recompensed. It is related with the cost of inputs as well as with the attractiveness of products produced. Industries with higher share of labour costs have generally lower GOS. It can also be defined as value added minus personnel costs[2].

Gross operating rate: is defined as gross operating surplus divided by turnover; the result is expressed as a percentage. It can be considered a measure of cost competitiveness and is used to measure the competitiveness and the success of firms/sectors.

Labour productivity. It is measured as value added per hour worked or per number of persons employed. This indicator is directly linked with competitiveness and is considered to be indirectly connected to innovation, as it measures the outputs of the research and innovation systems. Labour productivity is related with technology levels since the introduction of new technologies increase labour productivity. It is also related with wages, as increasing of wages, other things being equal, will also increase labour productivity. Labour productivity is the ultimate source of economic growth (European Commission, 2011).

Innovation measures

Firms with high labour costs can only compete against low cost industries if their products are of superior quality or contain an element of differentiation that gives them a higher value. Innovation is at the heart of the competitiveness of firms and economic sectors. It can be used to reduce the costs of production and increase the quality and range of products and services that are sold by companies. That is why generally the most innovative companies are the most competitive ones. Innovation will be measure by:

R&D expenses: business expenditure on R&D statistics will be used to compare transport subsectors within EU countries and between the EU and its main counterparts. Additionally, public R&D will be analysed.

Output measures

Production value: measures the amount actually produced by firms within a sector, based on sales, including changes in stocks and the resale of goods and services

Value added: Value added equals the difference between an industry's gross output (consisting of sales or receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semi-finished

[2] This is the way Eurostat defined GOS in the context of structural business statistics.

goods, and services that are purchased from all sources). For an industry it represents its contribution to the overall GDP. Value added is a measure of output that over production measures has the advantage of being available to all sectors, while production is only available for manufacturing sectors. Value added excludes the intermediate consumption made by an individual sector, while this is included in the production measure.

Sector turnover: is the total invoiced by a sector in a reference period which corresponds to market sales of goods or services supplied to third parties.

International competition

World market shares: this represents the weight of exports of a given country in a certain transport subsector, measured as a percentage of world exports in that particular sector. Thus market share 'MS' of country 'j' on sector 'i' in world markets is defined as:

$$MS_{j,i} = Exp_{j,i} / \sum_{j=1}^{n} Exp_i$$

Where Exp represents the exports.

Previous indicators offer an overview of the current competitiveness of the transport sector. However one of the main challenges in FUTRE is the understanding of how this competitiveness will evolve in the future. For that purpose it is necessary to foresee the evolution of transport demand and how this evolution may impact the preferences for mobility services and products both in the passenger and freight markets. This will be the central aim of WP3 which will study, in a more qualitative way, the impacts of a set of possible demand pathways in the future competitiveness of transport.

FUTRE will also approach future changes of competitiveness within the transport sector that can arrive from the supply side. This will be done by identifying the most important up-coming innovations and analyse their potential impact on the transport sector. WP4 will analyse this aspect while evaluating the importance that each pointed innovation will have in the future competitiveness of transport sector.

2.3. Definition of transport sector and its market structure

In this section we propose a definition of the transport sector that will be used in further qualitative and quantitative analysis within FUTRE. Transport comprises highly heterogeneous sub-sectors covering the entire value-chain, going from manufacturers, suppliers, infrastructure construction and service providers. After defining each transport subsector we will briefly review their market structure and how this structure has an impact on their competitiveness and innovation capacity.

2.3.1 Definition of the transport sector and sub-sectors

The transport sector is defined here as the manufacturers of transport equipment and their suppliers, the constructors of transport infrastructure, the transport service providers, and Intelligent Transport Systems (ITS) companies. In total we consider seven transport subsectors:

- Automotive industry: comprising manufacturers of passenger cars, commercial vehicles and component suppliers.

- Civil aeronautics/aviation: Manufacturers of aircrafts and component suppliers for civil purposes.

- Waterborne: Shipbuilders and marine equipment manufacturers of maritime and inland waterway ships.

- Rail: Manufacturers and component suppliers of the rolling stock, including trams, metro, regional trains, locomotives, high speed trains

- Infrastructure construction: Companies that construct and maintain transport infrastructure as well as companies that produce construction equipment for transport infrastructure.

- Transport service providers: Logistics and freight transport service providers, passenger transport service providers, as well as the providers of infrastructure such as harbours

- ITS: Intelligent transport systems are solutions based on Information and Communication Technologies (ICTs) and electronic tools that aim to provide innovative services for transport applications. Such a subsector is not easy to define, since non-transport companies are involved in general production of ICT. Furthermore other transport subsectors (above mentioned) are likely to dedicate important parts of their R&D to ITS applications. Only a limited number of companies can be identified as specialised in ITS solutions (e.g. TomTom, Kapsch TrafficCom, Thales) will used

2.3.2 Market structure of transport sub-sectors. Differences in terms of innovation and competitiveness

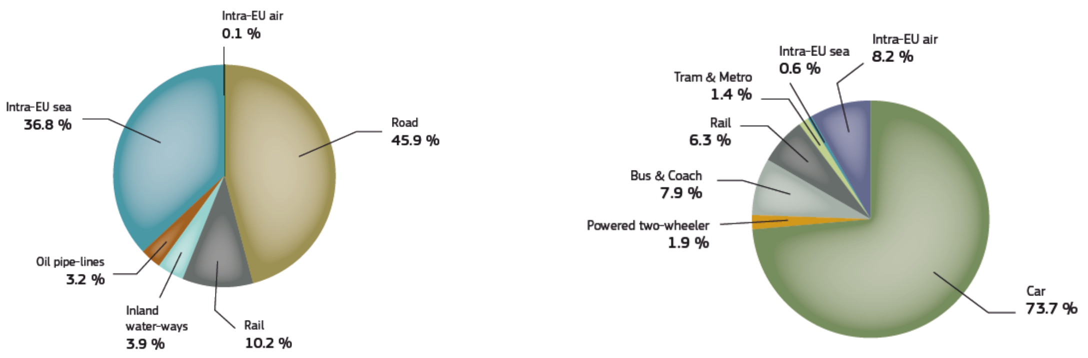
This section briefly reviews the market structure of the previously defined transport sub-sectors. Market structure differs among these subsectors and even within each sub-sector, increasing the difficulty of characterizing the market structure in very heterogeneous sub-sectors. We will see the main characteristics if their markets, with a special focus on the supply side. Then different forms of competition that characterizes each sector will be related with their capacity to innovate.

Automotive industry

In 2010 road sector is still the most important transport mode for freight intra-EU traffics (45.9%), followed by the maritime mode (36.8%) and rail (10.2%). However this picture is much more imbalanced regarding the transport of passenger inside the EU, where 73.7% of trips are done by car, 8.2% are done by air and only 6.3% is done by rail. (Figure 3)

In the Transport White Paper (COM, 2011d) the Commission proposed two highly important modal shift targets: 30% of road freight should go by rail or inland waterways by 2030 and 50% by 2050; and rail should account for the majority of intermediate-distance passenger travel by 2050.

Figure 3- Modal split intra-EU freight (left) and passenger (right) transport in 2010



Source: European Commission, 2012d

Due to this modal split distribution the automotive sector is, among the manufacture sector of transport vehicles, the one generating the highest value added, production value and higher employment levels. This sector is of strategic importance for the EU industry and economy, providing quality employments to millions of workers in the EU (Cars 21High Level Group, 2012).

It is characterized by a structure that is dominated by enterprises belonging to a few very large enterprise groups. These are supported by partners and contractors who deliver systems, parts and accessories. These partners are divided in original equipment manufacturers (OEM) that supply directly to motor vehicle manufacturers and that for the after-market (AM) as used for the upkeep, repair and modification of vehicles. Larger vehicle parts suppliers tend to cluster around their major customers.

Suppliers of OEMs are increasingly located outside the EU, as components and subsystems are more and more sourced from other parts of the world. Car assembly however remains in general, located close to the market. Around 85% of cars sold in the EU are also assembled there (Cars 21High Level Group, 2012). Successful European companies in many third markets (e.g. South America and China) locate assembling affiliates there. However the success of those companies in those markets contributes to investments in R&D in the EU.

According to ACEA[3], Europe is the world's largest vehicle producer, with an output of over 17 million passenger cars, vans, trucks and buses per year or 26% or world vehicle

[3] ACEA: European Automobile Manufacturers' Association

production. This study also shows that regarding passenger cars, the main EU's competitors are Japan, US, South Korea and Turkey, which in terms of car imports (in EUR million) represent 27%, 19% and 14%, respectively.

The economic crisis has had a negative impact on the EU's automotive sector sales which was more acute in the commercial vehicle segment than in the passenger car market. However globally, sales in the automotive sector are reaching record levels due to the development of emerging economies. EU's production was not so affected by the economic downturn thanks to growing exports to third markets (Cars 21High Level Group, 2012).

Rail

The rail sector as it is defined in FUTRE represents the manufacturers of locomotives and rolling stock, which includes both the OEMs also categorized as Tier 1, and Tier 2 companies which supply the OEMs. Tier 1 consist of a small number of large manufacturers that provide the shell (body), design, and final assembly of rail vehicles – locomotives, rail cars, and both diesel and electrical multiple units. The Tier 1, also known as system integrators represent large companies such as Alstom, Bombardier or Siemens. These companies have the higher-value roles, such as design, engineering and system integrations and they usually locate near the headquarters or near the largest market they serve.

Tier 2 companies can be divided into three systems: propulsion (e.g. electric generator, engines or brakes), electronics (e.g. communication systems, security auxiliary power unit) and body interior (e.g. window, lightning or seating flooring). Tier 2 suppliers work closely with Tier 1 companies in order to ensure a safe and efficient integration of their products during assembly. Sometimes Tier 2 companies are also active as Tier1, but this occur in a limited number of cases.

The rail sector is a key player in the EU as Europe remains the main market for railway equipment followed by Asia/Pacific regions and NAFTA (UNIFE, 2012). According to ERRAC[4], European railways run the fastest passenger trains on rail, have the largest high-speed network and are constructing the longest tunnel in the world[5]. It is also characterized by offering an attractive and efficient metro and light rail system and by implementing, in a continental scale, a unique integration of long distance high speed, regional, urban and freight networks.

Civil aeronautics/aviation

Aircraft production has become more complex in time. The increasing project volumes and shrinking abilities to execute them within national borders, has lead firms to evolve by collaborating with each other, both nationally and internationally. Consortiums were created between European companies and companies from other parts of the world so to develop new engines and other technologies that require very high technology and financial efforts. This

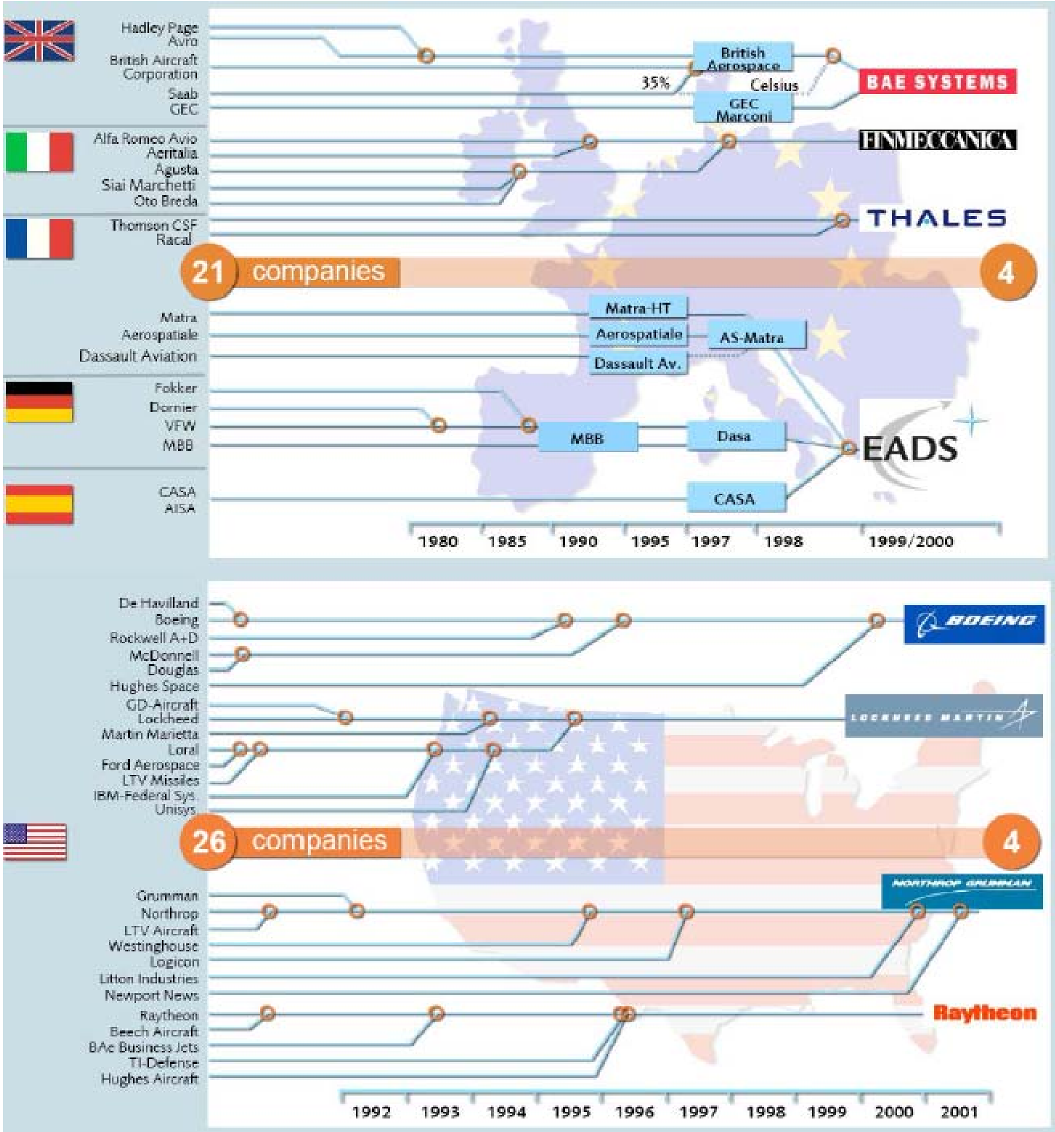
[4] European Rail Research Advisory Council
[5] The Gotthard tunnel will cross the Swiss Alps, with a length of 57km and is expected to be opened in 2016.

led the industry into integration (Figure 4), particularly after 1995 when the sector came out of the early 90s crisis.

The aviation sector is dominated by a small number of major manufacturers worldwide which are especially concentrated in the EU and US. The market for large civil aircraft is characterised by the rivalry between Boeing and Airbus. The A380 broke the monopoly in large long-rang aircraft and both companies are now competing in the long range, medium size wide body market.

Manufacturers work with suppliers of small and medium size as to outsource activities and reduce costs. Nowadays China and Russia is the base of important suppliers for the European aviation industry with increasing know-how which is putting additional competitive pressure on the European industry.

Figure 4: Consolidation in the European and American aerospace industry



Source: EADS web page

Waterborne

The waterborne sector aggregates shipbuilding industry (shipyards) and maritime equipment (shipyard supply industry). The European shipbuilding was dominating the world market till the 50s, when Japanese competitors gradually took over, mainly due to a rapid growth of Japanese economy and to a coordinated shipping and shipbuilding program. South Korea became an important player during the 70s due to lower wages and after defining shipbuilding as a strategic industry. The increasing role of China within this industry became clear since the last 10 years and nowadays it is the world leader within this sector.

The shipbuilding industry is dominated by a few large shipyards, manly based in Korea, Japan and China. Notwithstanding the overall dominance of the previous countries, Europe is the leader in a few specialized segments such as cruise vessels, offshore vessels and luxury yachts. All these segments are characterized by a high degree of specialization and high tech qualities, complex production processes and reduced number of units of the same type to be built. Within Europe, four countries dominate the field in ship construction: Germany, Italy, the Netherlands and Romania.

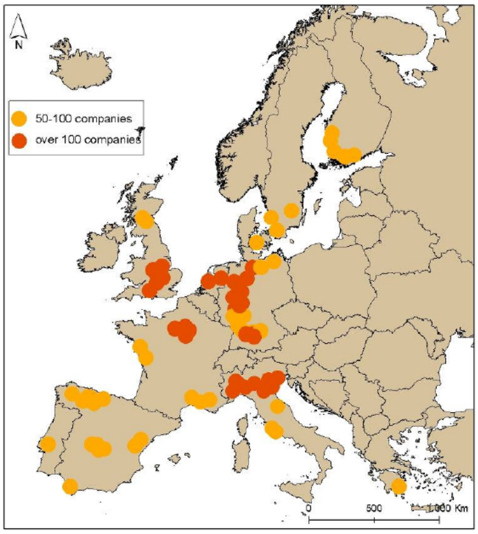
This sector is characterized by a strong globalization, with the ownership of European players moving to foreign hands (especially Korean) and the most important yards investing in facilities in countries with high skilled and relatively low cost of labour such as India, Vietnam, Philippines and Brazil. These four countries are becoming important in the last years, and nowadays they are already above some European countries.

Regarding the EU maritime equipment industry and according to Waterborne TP (2012), it is the favourite supplier of world shipbuilding and offshore operations. Some of the key areas in Europe are mechanical engineering including engines, electrical engineering/electronics and steel products. The most important companies in the maritime equipment in the EU are located mainly in Germany, Italy, the Netherlands, United Kingdom, Spain, Sweden and Finland (Figure 5).

The role of maritime equipment manufacturers has become more evident over time as originally most of the shipbuilding work was carried out at shipyards themselves. Recently a study from ECORYS (2009) stated that the share of maritime equipment is assessed at 50%-70% of the product value and can be 70%-80% in more specialised segments.

The maritime equipment subsector is highly heterogeneous and consists of many relatively small companies (between 5,000 and 9,000 according to ECORYS, 2009) with many of those being active in other business areas such as automotive and aircraft industry.

Figure 5 - Geographical distribution of marine supply companies (2000)



Source: ECORYS (2009)

Infrastructure construction sector

Companies working in the sector of transport infrastructure are in most of the cases also working in other type of infrastructure not directly related with transport (e.g. buildings, dams). This economic sector can be further subdivided into construction and maintenance transport infrastructure and manufacturing of construction material. Transport infrastructure is promoted at different Government levels thus sales under the construction and maintenance sector are dependent on public need for transport infrastructure. While the demand for infrastructure is decreasing in the EU, it is booming in emerging markets due to economic growth, increasing urbanization and demographic developments. This constitutes an opportunity for the infrastructure construction sector.

The infrastructure construction sector is characterized by either few but very big, multinational companies or a large number of very small contractors. However they do not compete for the same projects, as multinational are involved mainly in constructions and maintenance of infrastructures of national strategic interest while small firms are generally involved with specific local projects.

Intelligent Transport Systems

Intelligent transport systems use information and communication technology to improve people's travel experience. ITS technologies (such as satellite navigation) enable a more efficient use of transport networks (e.g. by reducing congestion and optimizing routes), increase safety and decrease environmental externalities (e.g. reduction of emissions). They are instruments that can be used for different purposes and they can be applied in every transport mode (road, rail, air, water).

ITS can be integrated into vehicles in a variety of ways. Systems can be categorised by their positioning (Institution of Mechanical Engineers, 2012):

1. In-vehicle: These are technologies within the vehicle, such as sensors, information processors, on-board units or displays providing information to the uses. They may also automate with some part of the driving task.
2. Infrastructure-based: these technologies can be subdivided into information via roadside messages or management of traffic flows. This is sometimes referred as infrastructure to infrastructure communication.
3. Co-operative: this involves communication between infrastructure and vehicles (this is known as V2I) or between different vehicles (V2V).

The ITS sector is strongly interlinked with other transport sectors and some industries outside the transport sector. Many companies work within this sector without this representing its main activity. Few companies are completely devoted to ITS business. This sector aggregates companies as diverse as car manufacturers, electronics suppliers, system integrators, map makers, telecom operators and suppliers, service providers, highway operators, etc. This sector, although very heterogeneous is characterized by very high turnover, low capital intensity and high innovation intensity.

Transport service providers

Transport service providers, as it is defined in this study, aggregates all transport modes for both goods and passenger transport. The UE is taking serious steps to increase competitiveness of transport services by opening-up national monopolies. One example is the regulation on cabotage that has been promoted by the EU[6]. Cabotage means that transportation of goods within one country can be performed by a haulier from another country. New regulations allow cabotage within EU countries with temporal restrictions, for example a hauler discharging a cargo from Bucharest to Vienna could pick up a load from Vienna to Budapest in order to optimize capacity.

Another example is the EU legislation liberalizing the rail operations by opening up competition within Member States, in a cross border sense. Rail freight has been completely liberalized in the EU since 2007 for both national and international services. This means that every licensed EU railway company that accomplish all safety certifications, can apply for operate in national and international markets. However in the passenger rail market, only international rail passenger services have been liberalized (since 2010) while domestic rail passenger services are not yet being opened to EU-wide competition. The Fourth Railway package launched in January 2013 (COM, 2013d) goes on this direction.

The aviation market has been gradually liberalized through three successive packages of measures adopted at the EU level which covers air carrier licensing, market access and fares. Previously it was characterized by a highly regulated industry, dominated by national flag carriers, operating under national monopolies and state-owned airports. Thanks to the liberalization airliners can operate air services on any desired route within the EU. Consolidation is another consequence coming out of this liberalization. Many national companies from different countries have merged (fully or partially), they have formed alliances in order to extend the network and include other services, among other formulas of cooperation. After the deregulation, low cost companies emerged and a large number entered in the market since then. All these aspects derived in a significantly decrease of prices on the most popular routes, increasing the demand for air transport. There are around 150 scheduled airlines and over 400 airports and 60 air navigation service providers (DLR, 2008).

Similar regulations have been promoted by the EU in the maritime shipping business in order to increase the range of services and achieve competitive prices. Shipping companies from one country are able to transport passenger and goods to any port or off-shore installation of a Member State[7]. Also cabotage rules[8] have been approved for the provision of maritime transport services, meaning that national connections can be offered by companies of other Member States.

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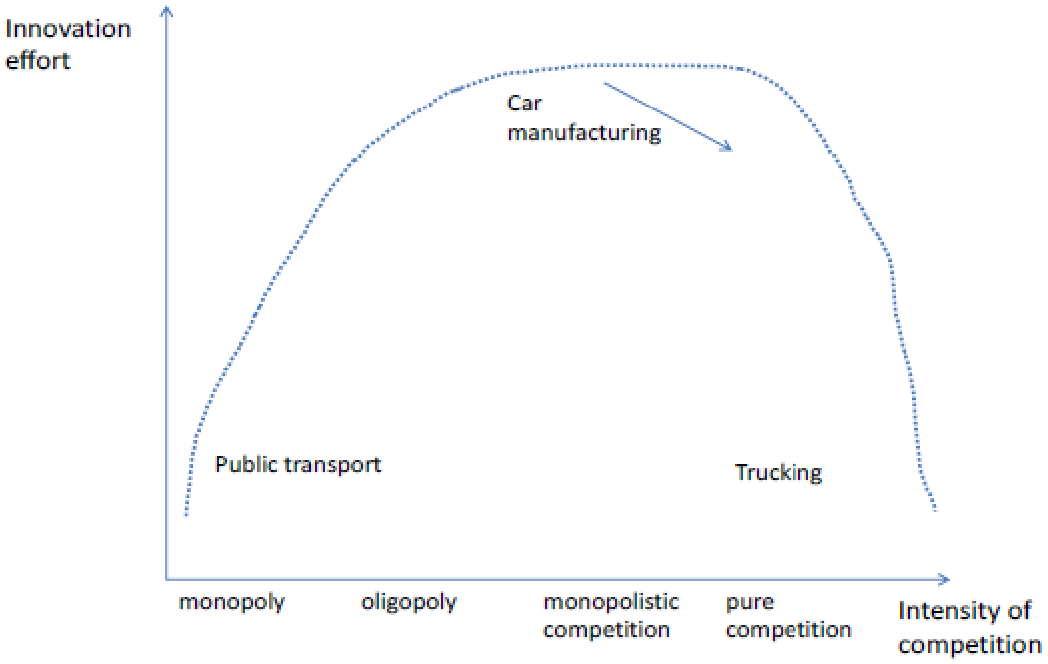
[6] Regulation (EC) 1072/2009
[7] Regulation (EEC) No 4055/86
[8] Regulation (EEC) No 3577/92

An interesting study about transport and innovation and the role of public policy, undertaken by the ITF (ITF, 2010) states that the innovative capacity of each transport sector is related with the competition intensity in a market and this relation can is described as an inverse U. Those sectors operating under near-monopolistic situations have lower incentives to innovate (Figure 6). This is the case of public transport operators, such as urban transport operators, since a monopolist has no need to innovate. On the contrary, under very strong competition conditions, profit margins are small and this results in a limited capacity to innovate. This is the case of the trucking sector or small transport infrastructure providers where many small firms operate at small margins that are not able to cope with the costs of innovation.

In between these two extremes, the incentives to innovate increase, large scale entities, or even partnerships dominate the market. This can be described as an oligopoly or a monopolistically competitive industry. Manufacturers of transport vehicles, such as the automotive or rail locomotive manufactures, are a good example of this type of market structure. A few companies within each sector compete by putting big efforts on innovation that respond to consumer demand. A substantial size and the increasing returns that come from it, seems to be important factor to face innovation costs.

Figure 6 - Market structure and innovation effort



Source: ITF 2010

3. European Union & Member States' transport policies, innovation programmes and the European innovation systems in the transport sector

This chapter aims to perform a strategic review of the European transport policy, summarizing the most important societal challenges and respective targets and objectives to be analysed in the project. It provides an updated overview on existing innovation programmes, which looks at both national and pan-European programmes and actors, including relevant ERA-NETS, Technology Platforms as well as the JTIs Hydrogen and Clean Sky.

Further sections will look at the European innovation system for transport as a whole, outlining the key-players of transport research and the main challenges per mode of transport and – where possible – per technology field. Drivers and barriers to innovation will be discussed using data of relevant surveys (e.g. CIS).

3.1. Strategic review of the European transport policy

In this section a review of the main European policy aspects which may influence the transport sector, the competitiveness of the transport industry and research & innovation is provided. In detail it aims to:

- Review policies, major goals and objectives
- Identify societal challenges and their importance for future transport research
- Gather information about relevant policy initiatives (until 2020), which may influence future developments on transport and innovation sectors and the institutional capacities

3.1.1 The Europe 2020 Strategy

In general the various European policies (e.g. transport, innovation, industry) are anchored in the **Europe 2020 Strategy**, which is presented as *the EU's growth strategy for the coming decade* (COM, 2010a). This document presents the view of the European Commission on the challenges and priorities for the EU in the decade finalizing in 2020.

Being developed at a time of crisis, the Europe 2020 Strategy devotes substantial attention to **conceive a strategy that enables the EU to come out stronger from the crisis**. The European Commission recognizes that the world is moving fast and long-term challenges – globalisation, pressure on resources, ageing – are intensifying. It also notes that even before the crisis there were many areas where Europe was not progressing fast enough relative to the rest of the world, justifying a structurally lower growth rate. As a result these areas need to be addressed in parallel to efforts to restore economic growth. Amongst these structural issues that need to be addressed, Europe 2020 Strategy specifically identifies the *differences in business structures combined with lower levels of investment in R&D and innovation, insufficient use of information and communications technologies, reluctance in some parts of* *our societies to embrace innovation, barriers to market access and a less dynamic business environment*. So, issues related with innovation policy are amongst the key areas where the strategy foresees the need to take structural action to improve Europe's competitiveness.

In addition to the challenges at European level changes at global level also impact European strategic options and policy priorities. Amongst other factors noted in the Europe 2020 Strategy, the **increasingly interlinked economies** and the **climate and resource challenges** are important for the transport industry and its innovation system. The European industry will face intensifying competition from developed and emerging economies, such as China or India, that are investing heavily in research and technology in order to move their industries up the value chain and "leapfrog" into the global economy. However, while this puts pressure on some sectors of Europe's economy to remain competitive, these countries development will open up new markets for many European companies.

Regarding the issues related with climate and resource challenges, strong dependence on fossil fuels, such as oil, and inefficient use of raw materials expose consumers and businesses to harmful and costly price shocks, threatening economic security and contributing to climate change. The expansion of the world population from 6 to 9 billion will intensify global competition for natural resources and put pressure on the environment. Here the EU is committed to continue its outreach to other parts of the world in pursuit of a worldwide solution to the problems of climate change, while at the same time the EU will implements its own agreed climate and energy strategy across the territory of the Union, with obvious impacts on the transport sector and the transport industry.

In its vision of where Europe wants to be in 2020, the **Europe 2020 Strategy** takes into account both these internal structural aspects and the international changes that shape today's world. It summarized the view in the goal statement of **"smart, sustainable and inclusive" growth**, putting forward three mutually reinforcing priorities:

- Smart growth: developing an economy based on knowledge and innovation;
- Sustainable growth: promoting a more resource efficient, greener and more competitive economy; and
- Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.

These priorities, which are of great importance in the framework of FUTRE (e.g. they are all relevant when reflecting on future challenges for the European transport industry competitiveness) may be seen as reflecting three engines for achieving growth in Europe: (i) knowledge and innovation; (ii) greener and more efficient use of resources and (iii) higher employment combined with social and territorial cohesion (Gros & Roth, 2010).

The priorities are broken down into five targets to be achieved by 2020, of which three are relevant for transport, industrial and innovation policies[9]:

- 75 % of the population aged 20-64 should be employed;

[9] The other two targets presented in the Europe 2020 Strategy are:
- The share of early school leavers should be under 10% and at least 40% of the younger generation should have a tertiary degree; and
- 20 million less people should be at risk of poverty.

- 3% of the EU's GDP should be invested in R&D; and
- The "20/20/20" climate/energy targets should be met.

In order to achieve these targets, the European Commission has proposed a work plan anchored across seven **flagship initiatives**. Although these initiatives aim to engage both the EU and the Member States, the Commission commits to make the necessary proposals to steer action and advance the initiatives. As a result these are a primary orientation towards sectorial policies in the areas they focus. In the framework of FUTRE it is worth focusing on three flagship initiatives[10]:

- "Innovation Union", which aims to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs.
- "Resource efficient Europe" focusing on helping to decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise the transport sector and promote energy efficiency.
- "An industrial policy for the globalization era" aiming to improve the business environment, notably for SMEs, and to support the development of a strong and sustainable industrial base able to compete globally.

Each of these three flagship initiatives touch a key area for the work of FUTRE: the “Innovation Union” focus on the research and innovation policy, which is certainly a key policy area for the future competitiveness of the European transport industry; the “Resource efficient Europe" is an overarching policy initiative that is framing the European transport policy for the next decade; and the “industrial policy for the globalisation era" is the flagship initiative that determines the EU industrial policy until 2020. Regardless of the numerous interlinks between these policies in each of the next three sub-sections, a detailed analysis of innovation, transport and industry policies is provided. The last sub-section summarizes the most relevant European policy objectives for the work of FUTRE and discusses the key societal challenges to be addressed by European policies in the future.

3.1.2. Innovation Policy

This section will look at the major developments on EU innovation policy with the view of identifying relevant trends for analysing the future competitiveness of the European transport industry. As noted above, Innovation Policy has been placed at the heart of the Europe 2020 strategy, being seen by the European Commission as a major pillar for achieving smart, sustainable and inclusive growth in Europe. Accordingly it comes as no surprise that shortly after the adoption of the strategy, the European Commission published its Flagship Initiative Innovation Union, e.g. its outlook for European innovation policy until 2020 (COM, 2010b).

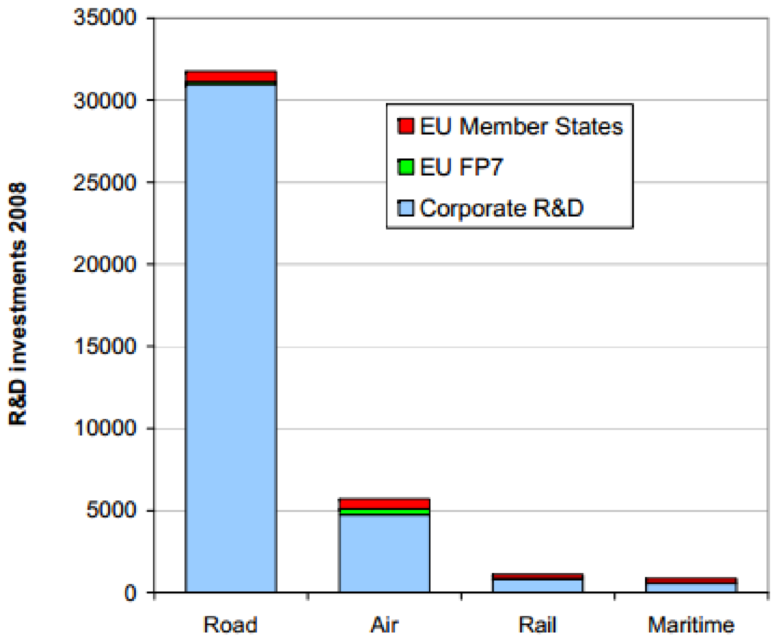
This prioritization of innovation at EU level is extremely important for the European transport industry. First, the industry in itself is the largest industrial R&D investing sector in Europe

[10] The other four flagship initiatives are: "Youth on the move", "A digital agenda for Europe”, "An agenda for new skills and jobs" and "European platform against poverty".

(Wiesenthal, T. et al., 2011) and accordingly, in principle, it has a lot to benefit from increased political attention to this field. Second, because there is a wide recognition that, in order to address the challenges of transport policy (to be addressed in the next section) and notably, to achieve a decarbonization of the transport sector, innovative solutions that go beyond business-as-usual developments will be needed (Hill, N. et al., 2012) making innovation in transport a key political priority. A third relevant reason for the importance of increased attention to innovation policy at European level relies in the fact that the competiveness of the European transport industry is increasingly dependent on developments in other areas. The transport industry has managed to remain at the forefront of technological innovation for various years and this leadership of European based companies in investment on R&D (IPTS, 2010, 2013) has certainly contributed to the sectors' competitiveness. However, there is an emerging consensus that the future competitiveness of the transport industry is going to be less dependent in its capacity to innovate exclusively in its core areas, but more and more in side aspects such as information and communication technologies (ICT) or on innovative business models. These aspects are to be addressed in more detail in Work Package 3, however one should note that the higher policy attention to innovation should be an opportunity to further explore mechanisms to incentivize synergies between R&D efforts from different industries.

One consequence of the relatively high private investment in transport research in Europe, as clearly indicated by the Innovation Scoreboards published annually by the European Commission (IPTS, 2010, 2013) is the fact that the share of EU public funding in this field is relatively small (see Figure 7).

Figure 7: R&D investments of EU-based companies and public funds by transport mode



Source: (Wiesenthal, T. et al., 2011)

Given these numbers one may question the extent to which the European Commission innovation policy may actually influence R&D activities in the transport sector. The Market-up project discussed this aspect and concluded that although the weight of the direct R&D investment by the European Union framework programme may be low it has a role in shaping the direction of research and there are other factors, such as regulation and standardization, where EU institutions are key players (Carvalho, D. et al., 2012). Accordingly it is important to analyse the main guidelines and priorities of the innovation union flagship initiative.

In the Communication on the Innovation Union flagship initiative the European Commission notes that Europe must develop its own distinctive approach to innovation which builds on its strengths and capitalises on its values, notably by focusing on innovations that address the major societal challenges identified in Europe 2020, pursuing a broad concept of innovation, and through the involvement of all actors and all regions in the innovation cycle (COM, 2010b). This was then welcomed by the European Council, which stressed that Europe should promote a broad concept of innovation, aiming at competitiveness while also addressing societal challenges (Council of the European Union, 2010a).

Accordingly, it is not surprising that the Proposal establishing Horizon 2020, the new Framework Programme for Research and Innovation in Europe, the European Commission assumes a strong focus on creating business opportunities out of Europe's response to the major concerns common to people in Europe and beyond, e.g. 'societal challenges' (COM, 2011a). These are defined as:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture, marine and maritime research and the bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, resource efficiency and raw materials; and
- Inclusive, innovative and secure societies.

While there is only one societal challenge that targets specifically transport, one can anticipate that links to transport policy will potentially occur across all six challenges. The table below gives examples of areas where there may be links between transport research areas and the identified societal challenges.

Table 1: Linking societal challenges to transport research and innovation

Societal Challenge	Example of links to transport R&D
Health, demographic change and wellbeing	Urbanization, megacities, health impact of transport (walking, cycling)
Food security, sustainable agriculture, marine and maritime research and the bio-economy	Biofuels
Secure, clean and efficient energy	Alternative fuels
Smart, green and integrated transport	All research in transport shall be linked to this challenge
Climate action, resource efficiency and raw materials	Reduction of GHG emissions from transport
Inclusive, innovative and secure societies	Accessibility for all (e.g. disabled); Transport security

Moreover, the European Commission has put sustainable development as an overarching objective of Horizon 2020, with a dedicated funding of at least 60 % of the total Horizon 2020 budget and around 35% of the Horizon 2020 budget will be climate related expenditure (COM, 2011a). This is a very clear signal of the Commission outlook on priority areas for research and development with important implications for the transport industry.

Another relevant aspect of the Commission's innovation policy is the strong focus on addressing the issue of market take-up of R&D results. There is a widespread recognition that while Europe remains a top player in terms of knowledge production and scientific excellence, it is losing ground as regards the exploitation of research results (COM, 2011b). This aspect was explored in other research projects for the concrete situation of transport research, such Market-up, which provided a deep analysis of the singular situation for transport. For example, while in general there is a problem of lack of private funding of R&D in Europe, which is seen as a problem in terms of market orientation of research results, this does not seem to apply to the transport sector where the issue of concentration of R&D efforts appears as more serious (Carvalho, D. et al., 2012). In any case, an innovation policy targeting the need to increase market take-up of research results will certainly have impacts on the transport sector, notably given the trend towards increased funding of closer to market activities, higher involvement of SMEs and unlocking access to venture capital.

3.1.3. Transport Policy

The European transport policy for the next decades is anchored in the Europe 2020 strategy through the "Resource efficient Europe" flagship initiative, which is focusing on helping to decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise the transport sector and promote energy efficiency (COM, 2011c). This initiative gathers a wide set of economic areas (e.g. transport, energy, industry or environment) to **agree on a coordinated long-term vision towards a resource efficient agenda for the European economy**. A notorious key aim of the document is *to increase certainty for investment and innovation by forging an agreement on the long-term vision and ensuring that all relevant policies factor in resource efficiency in a balanced manner* (COM, 2011c). Accordingly this strategic view is of great importance for FUTRE, as it outlines the direction for developing the European transport sector and its innovation system.

Within the “flagship initiative” the European Commission commits to *present a vision for a low-carbon, resource-efficient, secure and competitive transport system by 2050 that removes all obstacles to the internal market for transport, promotes clean technologies and modernises transport networks*. This was the basis of the Transport Policy White Paper (COM, 2011d), presented by the European Commission two months after the "Resource efficient Europe" flagship initiative. Amongst other, the Transport White Paper sets ambitious targets for the transport sector with the overall aim of reducing Europe's dependence on imported oil and cutting carbon emissions in transport by 60% by 2050.

The targets established in the White Paper put forward a clear vision for the development of the European transport sector, providing relevant messages for the industry and the research community. It notes that *despite technical progress, potential for cost-effective energy efficiency improvements and policy efforts* the transport sector has not fundamentally changed since the first big oil crisis 40 years ago and new technologies for vehicles and traffic management will be key to lower transport emissions in the EU as in the rest of the world (COM, 2011d). The paper also underlines the world leadership of European companies in infrastructure, logistics, traffic management systems and manufacturing of transport equipment, which *directly employs around 10 million people and accounts for about 5% of GDP*. If one considers these elements it does not come as a surprise that the focus of most targets in the Transport White Paper is on combining improved transport resource efficiency without compromising mobility and while enhancing industry competitiveness. In this vision transport research and innovation should support development and deployment of key technologies needed for a modern, efficient and user-friendly system, which will then ensure the future competitiveness of the European transport industry in the global markets.

In the framework of this discussion the White Paper sets *ten goals for a competitive and resource efficient transport system*, organised under three headings. These are presented in Table 2 (COM, 2011d).

Table 2: Transport Policy White Paper goals

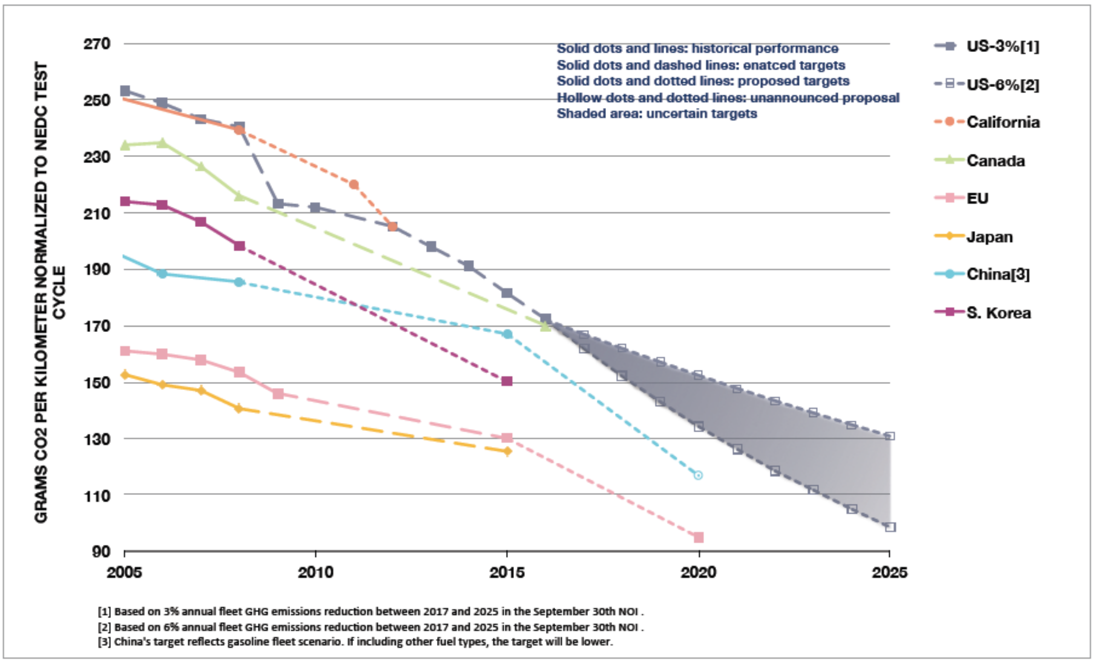
Developing and deploying new and sustainable fuels and propulsion systems
1. Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO2-free city logistics in major urban centres by 2030.
2. Low-carbon sustainable fuels in aviation to reach 40% by 2050; also by 2050 reduce EU CO2 emissions from maritime bunker fuels by 40% (if feasible 50%).
Optimising the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes
3. 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.
4. By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.
5. A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.
6. By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.
Increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives
7. Deployment of the modernised air traffic management infrastructure (SESAR12) in Europe by 2020 and completion of the European Common Aviation Area. Deployment of equivalent land and waterborne transport management systems (ERTMS, ITS, SSN and LRIT, RIS). Deployment of the European Global Navigation Satellite System (Galileo).
8. By 2020, establish the framework for a European multimodal transport information, management and payment system.
9. By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. Make sure that the EU is a world leader in safety and security of transport in all modes of transport.
10. Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport investments.

These goals clearly reflect the European Commission's perspective that the European transport system needs to experience a substantial technological change. The first major change regards its energy supply, which should change towards *sustainable fuels and* *propulsion systems.* The second area of change is also energy-related, as it regards the shift towards using energy-efficient modes of transport. While goals in this area seem to be less technology oriented the true is that it will necessarily imply major investments in those energy-efficient modes of transport and deployment of technologies that facilitate its use (e.g. multimodal transport information, management and payment system). The third area is related with the application of financial instruments and which is strongly related with the use of intelligent transport system technologies.

When looking to these goals one necessarily concludes that the European Commission is pushing for a shift away from the use of fossil fuels in transport and to apply information and communication technologies to improve efficiency and facilitate behavioural change. However, implementing such changes and achieving these goals is an unprecedented challenge, especially for a sector which has experience little progress over the last 40 years (as noted in the White Paper). The question that remains is how the Commission will implement a strategy that ensures that such challenges are properly addressed? This is not only a fair question but a particularly relevant one, especially in those cases where the European Commission have little direct influence in the policy areas that the goals are targeting (e.g. within urban areas the subsidiary principle is a constrain to EU intervention).

Regardless of these doubts it is important to note that relevant action is already underway. In July 2012 the Commission presented a Proposal establishing a new target to reduce CO2 emissions from new passenger cars (COM, 2012a), which is now going through the co-decision process. This Proposal is a follow-up to a Regulation adopted in 2009 which established CO2 emissions performance requirements for new passenger cars sold in the EU. In that regulation original equipment manufacturers (OEMs) were requested to ensure that he average CO2 emissions for their new passenger cars sold in the European market shall not exceed 130 g CO2/km by 2015. This Regulation was seen as the result of increasing consumer preferences toward vehicles with a lower carbon footprint, which led Governments throughout the world to imposing stringent environmental regulations (KPMG, 2010). The Regulations adopted in 2009 made Europe (together with Japan) leaders in the promotion of stringent passenger vehicle greenhouse gas and fuel economy standards (KPMG, 2010) but the Proposal for revision put forward by the European Commission in July, which includes a target of 95 gCO2/km for 2020, may turn the EU into the clear world-leader in this area (see Figure 8).

Figure 8: comparison of historical fleet performance and stringency of forthcoming regulations on CO2 emissions by passenger cars.



Source: International Council on Clean Transportation, 2011.

While these regulatory actions focus mostly on reducing oil dependency and CO2 emissions by increasing fuel efficiency, the European Commission had recently showed a great signal of commitment to fostering the deployment of alternative fuels in transport through the publication of an *alternative fuels strategy* (COM, 2013a). It is presented as a strategy *for the transport sector to gradually replace oil with alternative fuels and build up the necessary infrastructure could bring savings on the oil import bill of € 4.2 billion per year in 2020, increasing to € 9.3 billion per year in 2030* which is expected to boost growth and a wide range of jobs in the EU. This strategy covers all modes of transport, recognizing that for the Union to meet the long-term needs of all transport modes it must build on a *comprehensive mix of alternative fuels*. The table below provides an overview of the alternative fuels for which EU-wide availability and common technical specifications is foreseen.

Table 3: which EU-wide availability and common technical specifications for alternative transport fuels

Fuel	Mode / Range	Road-passenger			Road-freight			Air	Rail	Water		
		short	medium	long	short	medium	long			inland	short-sea	maritime
LPG		■	■	■	■	■	■			■	■	
Natural Gas	LNG	■	■	■	■	■	■		■	■	■	■
Natural Gas	CNG	■	■	■	■	■						
Electricity		■			■				■			
Biofuels (liquid)		■	■	■	■	■	■	■	■	■	■	■
Hydrogen		■	■	■	■	■			■	■		

Source: (COM, 2013a)

This strategy was already accompanied by concrete legislative action and a proposal for a "Directive on the deployment of alternative fuels infrastructure" (COM, 2013b) was adopted simultaneously. This proposal established obligations on the Member States to ensure certain levels of infrastructure to provide alternative fuels to road (Electricity, Natural Gas), Maritime Transport (Natural Gas) and Inland Waterways (Natural Gas), being seen as a step towards solving the "chicken and egg" problem where alternative fuel infrastructure is not available. Moreover the Commission also notes that it has initiated work towards a comprehensive strategy on LNG (Liquefied natural gas) for shipping and for developing common technical specifications (which are also addressed in the proposed Directive) (COM, 2013a).

When taking a broader look to transport policy it appears that the European Commission is serious about promoting 'resource efficiency' as the motto for the next years. This, to some extent, represents a change from a *status quo* where infrastructure provision and market opening were the main priorities of the EU transport policy. These topics do remain important and are covered not only in the White Paper on Transport Policy but are also resulting in concrete policy action[11], however it is clear that 'resource efficiency' will dominate transport policy agenda for the next years. This is a very important message for the industry as it will certainly impact priorities within the EU but also influence standards and regulations to be adopted at European or National level.

3.1.4. Industrial Policy

The European Industrial policy is a third key element to be considered in FUTRE. The main policy document guiding it is the Communication "Europe 2020 Flagship Initiative: An integrated Industrial policy for the globalisation era – Putting competitiveness and sustainability at centre stage" (COM, 2010c) which establishes a strategy to boost growth and jobs by maintaining and supporting a strong, diversified and competitive industrial base in Europe. It has a clear focus on strengthening industrial competitiveness while enabling a transition to a low-carbon and resource efficiency economy, which aligns it with the spirit of the Europe 2020 strategy.

Essentially this strategy is based on the perception that industry plays a key role in Europe's economy and must be at centre stage of the new growth model for the EU economy proposed on the Europe 2020 strategy. A vibrant and highly competitive EU manufacturing sector is seen as necessary to provide the resources and the solutions for the societal challenges, such as climate change, health and the ageing population.

Innovation also appears at the core of this strategy. The Commission notes that 80% of all private sector research and development efforts are undertaken in industry, which is key to meet the challenges of global competition and increased sustainability. The Communication proposes to have a new industrial innovation policy to encourage the much faster development and commercialisation of goods and services and to ensure that EU firms are

[11] For example, in January 2013 the European Commission adopted a forth railway package which is proposing *far reaching measures to encourage more innovation in EU railways by opening EU domestic passenger markets to competition, as well as substantial accompanying technical and structural reforms* (http://ec.europa.eu/commission_2010-2014/kallas/headlines/news/2013/01/fourth-railway-package_en.htm).

first onto the market. Without such innovation, Europe's industry will be unable to compete successfully in the global market, both in technology-driven and traditional industries.

Although all sectors are deemed as important, the strategy proposed in the flagship initiative presents sector-specific initiatives, having identified "motor vehicles and transport equipment industries" as determinant players to develop solutions for sustainable mobility, and sectors which are most promising in meeting the other future societal challenges of climate change, health, and security and where value-chain considerations are particularly important for the implementation of the proposed strategy.

Within sustainable mobility the Communication is well aligned with the European transport policy noting that developing and deploying clean and energy-efficient vehicle technologies are an opportunity to have a substantial impact on greenhouse gas emissions, air pollution and noise, and reinforce the market leadership of Europe's automotive sector.

This Strategy was welcomed by both the European Council and the European Parliament. In its Conclusions on the topic, the Council underlined the necessity to develop strong synergies between the industrial policy flagship and other relevant flagship initiatives and to mobilise all EU policies, such as competition, trade, transport, energy, environment and climate action, social and employment, education and training, cohesion, and consumer-protection policies in order to achieve the objectives of the Europe 2020 strategy (Council of the European Union, 2010b). In addition the Council recalls that industrial competitiveness is increasingly relying on intangible factors such as knowledge, entrepreneurship and skills and calls for new initiatives bringing together businesses, research, education, training, life-long learning, public authorities and social partners across Europe with a view to develop closer coordination and share best practices, in particular on science, technology, engineering and mathematics graduates. The European Parliament also addresses this topic but focus a substantial part of its resolution to stress that, in the face of the global challenges, it is essential that energy and resources efficiency are at the basis of the European industrial renewal and that a significant increase in R&D investment, both private and public, is essential for EU industry to remain a technology leader and retain global competitiveness in areas such as renewable energy and transport efficiency (European Parliament, 2011).

Following these reactions and the aggravation of the crisis in Europe this Communication was recently followed-up by a new Commission industrial policy update on "A stronger European industry for growth and economic recovery" (COM, 2012b). This paper reflects the mindset that the speed of innovation and technological development has put the world on the edge of an industrial break-through and that Europe needs new industrial investment not to be left behind. It proposes to reverse the declining role of industry in Europe as the only way to deliver sustainable growth, create high value jobs and solve the societal challenges that we are facing.

The document puts forward a *comprehensive vision* of what is needed to achieve this, clearly noting the focus on innovation as a key pillar. This is organised along *priority action lines*, in which the Commission says to be ready to *bring into play policy levers to support the reindustrialisation of Europe by mobilising all instruments at its disposal in an integrated way*. Following the identification of green energy, clean transport, new production methods, novel materials and smart communication systems as areas where industrial break-through may be close, all of which closely related with the transport industry, it is not surprising that clean vehicles are amongst the six priority action lines identified. **Within this Communication the European Commission sets an ambitious target of reversing the declining role of industry in Europe from its current level of around 16% of GDP to as much as 20% by 2020**.

It is worth noting that the Commission recognises that the strategy put forward in the Europe 2020 Flagship Initiative remains valid for achieving the long-term objectives. However, the harsh impact of the economic crisis and frequent calls for action from the European Council made the presentation of a Mid-term review of the industrial policy more urgent, leading to the adoption of a new Communication in less than two years.

Indeed, while the investment outlook is bleak, Europe needs to keep up with investment in the adoption and diffusion of new technologies, such as green energy, clean transport or new production methods, otherwise its future competitiveness will be seriously compromised. In order to revitalise investment the European Commission proposes to act along four pillars: (1) innovation; (2) better market conditions; (3) access to capital; and (4) human capital and skills.

For the purpose of FUTRE the most relevant aspect refers to the approach to facilitate investment in new technologies and innovation, which is related with the first pillar. R&D is certainly the most important instrument of company innovations, being a priority outline in the Innovation Union flagship initiative. However, the industrial policy update notes the need to translate a certain scientific leadership into an industrial advantage, which is often a weakness of the European innovation system. The Commission suggests that in order to address this weakness, European companies shall aim to benefit from the first mover advantage, by investing in the early stages of the adoption and diffusion of new technologies. However, the stakeholder consultation that was prepared before this update of the European Industrial Policy shows that uncertainties about the future evolution of new markets often adversely affect business confidence and hold back investment. **It is thus essential to dispel the uncertainties in new markets through the creation of a simple, stable and predictable long-term framework of Internal Market technical rules, standards and other legislation**. Six areas have been identified for priority action, which are highly correlated with the areas of investment of the Cohesion policy, including one area which is transport-centred: “Clean vehicles and vessels”.

Under the framework of this priority action line, the Commission anticipated a legal proposal on alternative fuel infrastructures, which was discussed in the previous section, and noted the **need for R&D and demonstration projects** to be developed under Horizon 2020, using Cohesion and Structural Funds, and also getting funding by Member states, in combination with European Investment Bank loans.

In short the European Industrial Policy seems to be at a crossroad. There is widespread agreement on the need to push for a new industrial regeneration in Europe as key for achieving the Europe 2020 objectives and that innovation is a key pillar of such process. However, trends show a decline of industrial activity in Europe and that most Member States are failing to achieve objectives on innovation policy indicators. To reverse this, substantial attention is needed by policy makers however, while the Council has in general been supportive of the European Commission’s Europe 2020 strategy the recent negotiations on the budget have resulted in mixed signals regarding Heads of State willingness to increase funding for R&D in Europe (Science Insider, 2013).

3.1.5. European Policy Objectives and Societal Challenges

The linkage between competitiveness and research and innovation is at the top of the policy agenda at European level. This priority is well reflected in the Europe 2020 Strategy which, being the overarching document guiding EU policies for this decade, influences sectorial policies on transport, innovation and industry. In all these three areas there are very important insights to consider in FUTRE.

The first aspect is that **innovation policy is clearly moving towards addressing societal challenges**. This is not only reflected in policy papers, but is already stamped in concrete policy action, notably in the framework of the new rules governing EU investment in R&D through the Horizon 2020. This will affect transport research and innovation in many ways. First, since transport is a cross-cutting issue for all societal challenges, one can see this as an opportunity to increase EU spending on transport research. Second, by tying EU research money to the societal challenges the EU is sending a very strong signal about its willingness to address them.

This second aspect is of high importance for FUTRE. While one can argue on Europe's ability to *really* influence transport research priorities through its spending, the message behind it is that the Commission is serious in tackling these societal challenges and accordingly the ability of market players to address them will be crucial for competitiveness in the future.

On what regards transport policy, the most important message for FUTRE is the **focus on resource efficiency**. After many decades where European transport policy was dominated by market liberalization and infrastructure investment, the motto has now shifted towards resource efficiency and decarbonisation. This is well reflected in the Transport Policy White Paper which proposes a set of targets mostly addressing GHG emissions and a new energy paradigm for transport.

While in some areas EU action is already underway to achieve these targets it seems clear that fully achieving them will require a deep transformation of the transport system. There are obvious links here with the new innovation policy framework and the focus on addressing the societal challenges, but still many questions remain to be answered.

Still, when thinking about the future competitiveness of transport industries, the White Paper is of great importance. It puts forward clear objectives for the transport sector for 2030 and 2050, which is important for industry to get certainty of how it shall develop and where it should concentrate its R&D efforts. However, in order to give early movers competitive advantages there is a need to translate such targets into Legislation and to make relevant legislation (e.g. on road charging, vehicle standards or fuel standards) reflect them while establishing binding long-term objectives.

Regarding industrial policy, the first important insight is that the main focus is on the **re-industrialization of the EU**. The Commission has put forward the target of reversing the declining role of industry in Europe from its current level to 20% by 2020. In what concerns the longer-term there are two aspects of the European industrial policy worth noting. The first refers to the recognition that investment in R&D is critical to guarantee the competitiveness of the European industry. The second refers to the perception that regulation and standards need to be developed in a way that rewards innovation while limiting the administrative burden.

In conclusion we have observed that innovation must be placed at the top of transport industrial leaders priorities for the next years. The view for re-industrialization of Europe is based on increased use of research and innovation to position EU's industry ahead of their competitors, while meeting the policy targets identified on the transport policy White Paper will certainly require developing and bringing to the market new solutions. However, two key questions emerge: In which areas should the transport industry invest? How will early movers be rewarded by their investment in R&D? To answer the first question, the European Commission is suggesting a focus of research and innovation investment in a set of areas, called "societal challenges". Answering the second question is more difficult, but examples of standards and legislation that put forward long-term targets and reward earlier adoption of innovation already exist and probably will become more common in the next years.

3.2. Overview of existing innovation programmes

In this section an analysis of innovation programmes relevant for the work of FUTRE is provided. Given the character of the project the focus is not on describing the innovation programmes but on analysing how such programmes may affect the future of transport research. Three different types of "innovation programmes" are considered: ERA-NETs, Technology Platforms (TPs) and Joint Technology Initiatives (JTIs).

The ERA-NETs target primarily authorities in the Member States responsible for research and innovation activities. Its main objective is to support public authorities in the Member States to work towards increased coordination of research activities. Within transport some ERA-NETs were created, leading to the establishment of research agendas and opening of transnational calls using national funds.

The Technology Platforms (TPs) are established to gather stakeholders in the definition of Strategic Research Agendas (SRA). Unlike the ERA-NETs they are content focused, aiming to identify the challenges relevant for research and innovation in a specific technological area.

Finally, the Joint Technology Initiatives (JTIs) are public-private partnerships (PPPs) which combine public authorities, industry players and research organisations in the implementation of SRA in given areas.

Following these lines we will look in more detail into the role and potential contribution for the future of transport research and industry competitiveness for each of these programmes.

3.2.1. ERA-NETs

When European leaders met in Lisbon in a summit aiming at formulating a response to the economic and social challenges the EU was facing, research activities and resources were known to be fragmented and research and innovation policies as being pursued largely independently at national, EU and regional levels. In response to this, the concept of a

European Research Area (ERA) emerged. It was seen as a powerful concept created to facilitate the progress towards a better organisation of research activities and policies in Europe (Matrix insight, 2009).

This process has been at the onset of several initiatives characterized by stronger interaction between EU Member States and Associate Countries on the implementation of research programmes and activities. It seems consensual that, at least it led to an increase in research policymakers' willingness to support European research cooperation and initiatives.

The ERA-NET is an example of such initiatives. Implemented as a part of the Sixth Framework Programme for Research and Technological Development (FP6) it was initiated as a specific programme "Integrating and Strengthening the European Research Area". Essentially it is a scheme for coordination and cooperation of national and regional programmes and as such, it aims at the national and regional programme makers and managers. It is implemented via an Open Call for proposals, welcoming proposals for coordination actions in any field of science and technology.

The ERA-NET scheme was the principal means for FP6 to support the cooperation and coordination of research activities (e.g. programmes) carried out at national or regional level. It envisaged financing networking of research activities, including their 'mutual opening' and the development and implementation of joint activities. It was designed to cover all fields of science and technology, being implemented using a 'bottom-up' approach, giving no preference to one research topic over another. The idea was that ERA-NET could function as a platform for open debate of actors and stakeholders which should help forming a vision of how the European Research Area could develop further.

The result from this FP6 novelty was the implementation of 71 co-ordination actions through the ERA-NET scheme (Matrix insight, 2009). For transport 4 ERA-NETs were created[12]:

- ERA-NET ROAD - Coordination and Implementation of Road Research in Europe

- ERA-NET TRANSPORT

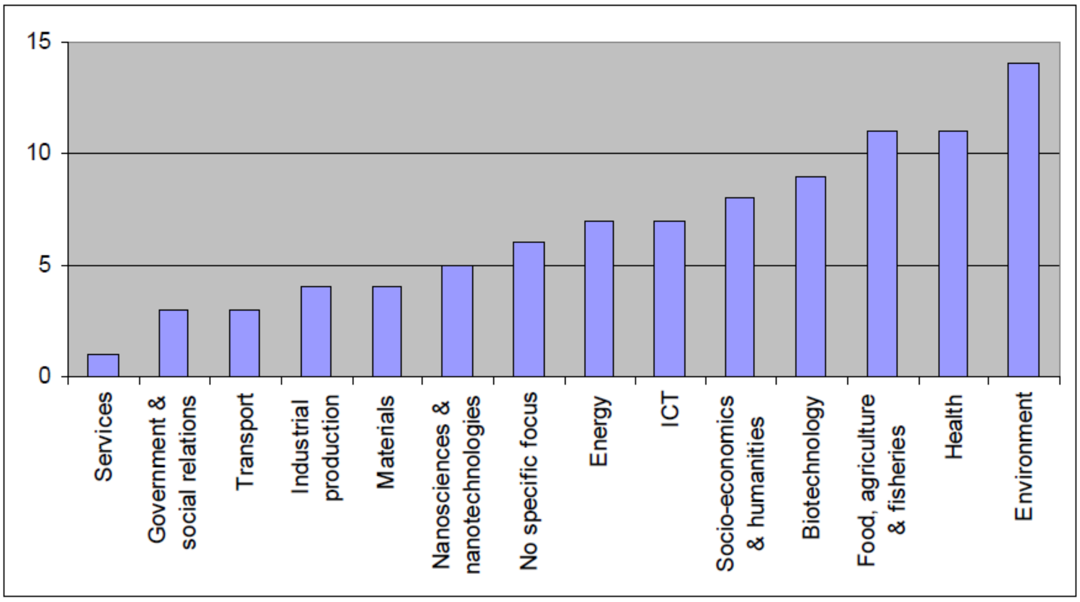
- Aeronautics ERA-Net as one of the key enablers of the prosperous development of Aeronautics in Europe

- MARTEC - Maritime Technologies

Follow-up projects within FP7 were also promoted and an ERA-NET on electromobililty was also initiated. Although these initiatives cover important parts of transport research we can conclude that transport is not amongst the main areas where ERA-NETs were developed, as one may see in the figure below.

[12] http://ec.europa.eu/research/fp7/index_en.cfm?pg=eranet-projects&mode=keyword#results

Figure 9: Research fields covered by the ERA-NET according to ERAWATCH classification



Source: Pérez, S. (2010)

Some questions emerge from this observation. What impact did the ERA-NETs have so far in European transport research and innovation? To what extent they have contributed towards improved coordination of research activities across Europe? What is the importance of the work of transport ERA-NETs for the future of transport?

All transport related ERA-NETs managed to bring together several official transport research bodies on their specific areas of activity and managed to promote transnational calls. To some extent these entities have been effective at driving a collaboration pattern between Member States on specific research topics. In general these projects had to start from a very low base, as there was a certain lack of cooperation between Member States in this field. For example, the ERA-NET TRANSPORT started from the European Platform for Co-operation and coordination of Transport Research, which was an informal structure for exchange of information or experience in workshops and seminars. However, the ERA NETs had to start by introducing Transport Research Agendas to guide action at Member State level, which later led to the issuing of joint calls.

Getting back to the questions raised above we can conclude that ERA-NETs were crucial in raising cooperation between Member States on transport research. This had a very important impact, especially considering that in most areas the starting point were informal gathering platforms. The extent to which ERA-NETs may influence the future of transport is more difficult to measure based on this review. The sense is that the ERA-NETs are rather instrumental in their nature: their aim is to foster cooperation between national decision-makers on transport research and innovation. Accordingly, they are not likely to assume a leadership role in terms of tailoring the future of transport and its research. The continuation of the ERA-NETs activities will certainly have an impact, notably in terms of improved Member State coordination, but it seems unlikely that the ERA-NETs will be relevant in terms of the content and future orientations of European transport research policy.

3.2.2. European Technology Platforms (ETPs)

The European Technology Platforms (ETPs) are industry-led stakeholder fora, charged with defining research priorities in a broad range of technological areas[13]. In other words these platforms are industry-based groups which get together to discuss where European research and innovation investment shall be focused. Accordingly, the ETPs are of great importance for the work of FUTRE as they reflect the areas where industry feels investment in research shall be made and consequently, provide a good indication of future expectations of industry experts.

In practice, ETPs bring together companies, research institutions, and other organisations, to define a common strategic research agenda (SRA) for the respective areas. By gathering these relevant stakeholders there is the expectation that it fosters the mobilization of a critical mass of national and European public and private resources. In that sense they may be seen as complimentary to the ERA-NETs.

The European Commission has supported the development of ETPs and has carried out a facilitation role. However, the ETPs are bottom-up, industry-led initiatives and the Commission participation is normally limited to an observer role (COM, 2009). There are more than thirty technological platforms, with five focusing on transport related research areas:

- Advisory Council for Aeronautics Research in Europe – ACARE
- European Rail Research Advisory Council – ERRAC
- European Road Transport Research Advisory Council – ERTRAC
- Waterborne ETP – Waterborne
- European Space Technology Platform – ESTP

The work of the ESTP is strongly focused on space technologies and accordingly is not considered in detail in FUTRE. As a result we have the transport technological platforms organized according to the modes of transport: one for road, one for rail, one for aviation and one for waterborne, covering both inland waterways and maritime transport.

The EPTs have first been very important in shaping FP7 and later continued to contribute with their suggestions to the yearly work programmes. Their work is very important to shape the actual content of calls and accordingly is important for FUTRE. In the next sections we will look into some detail to the relevant ETPs working on transport.

Advisory Council for Aeronautics Research in Europe (ACARE)

ACARE is the technological platform focusing in the air transport sector. This industry makes a significant contribution to the prosperity of Europe, both as a manufacturing sector and as an enabler of the effective transfer of people and goods (COM, 2009). However it is also responsible for approximately 2.1% of global CO_2 emissions in the mid-2000s, and expected to growth over the coming decades with a resultant increase in CO_2 emissions by 2050, despite mitigation efforts through technology, operations, and usage of low-carbon fuels (Lee, D.S., et al., 2013a). Accordingly it is one of the areas for which reversing the current upward trend on emissions shall be at the core of a strategy to boost competitiveness.

[13] http://cordis.europa.eu/technology-platforms/home_en.html

ACARE was established in 2001 with the main aim of establishing and carrying forward a SRA that will influence all European stakeholders in the planning of research programmes in the aeronautics industry, particularly national and EU programmes. To this end it brings together a large number of stakeholders, including representatives from the manufacturing industry, airlines, airports, service providers, regulators, the research establishments/academia and representatives from Member States and the Commission (COM, 2009).

In addition to the issue related with CO_2 emissions mentioned above, the sector faces enormous challenges, ranging from safety to infrastructure scarcity, while there is an expected tripling of passenger demand over the next 20 years. A second SRA was issued in 2004 and an addendum adopted in 2008, reflecting the dynamic character of the sector. This addendum to the SRA is intended to bridge the time between the last issue of the SRA and a full review of aeronautics, its direction and goals, which is expected to take place in 2010. The addendum focuses on three priorities: the environment, alternative fuels and security. It also includes a review of business models, international collaboration, infrastructures and education for aeronautics (COM, 2009).

The platform has been interacting with the ERA-Net project Air Transport Net (AirTN), especially through its Member States' Group.

European Rail Research Advisory Council (ERRAC)

ERRAC is the ETP that gathers stakeholders active on rail transport research and innovation. Established in 2001, ERRAC aims to reach consensus on priorities for European railway research and to guide research efforts towards a common strategy. To achieve this ERRAC brings together railway undertakings and infrastructure companies, public transport operators, the manufacturing industry, and representatives of the EU Member States, European Commission, customer groups, consultants and academic institutions.

The 2020 strategic rail research agenda, which includes a vision for innovations in the European railway industry for the next 20 years, was updated in 2007 and highlights the critical enabling technologies which will need to be developed.

While the share of rail transport in the EU has been decreasing over time, the European Commission is keen on making it work. The challenge is to ensure structural change to enable rail to compete effectively and take a significantly greater proportion of medium and long distance freight (and also passengers – see below). Considerable investment will be needed to expand or to upgrade the capacity of the rail network. New rolling stock with silent brakes and automatic couplings should gradually be introduced (COM, 2011d).

European Road Transport Research Advisory Council (ERTRAC)

Road transport plays a vital role in the European economy and society, and has a major impact on the quality of our daily lives, since it is a primary means for accessing our workplace, services and social activities. As such, it creates linkages that are essential for the development of social, regional and economic cohesion in Europe (COM, 2009).

However the sector is confronted with major challenges. Congestion is a major concern and implementing a downward trend on environmental impacts, such as CO_2 emissions will require massive changes to the s*tatus quo*. This happens at a time when, despite efforts to rationalise the need for transport, growth in the demand for mobility of people and goods is still expected by 2020.

Launched in June 2003 ERTRAC has involved all the stakeholders in the road transport sector, including end-users, vehicle manufacturers, road infrastructure operators, intelligent transport actors, component suppliers, energy and fuel suppliers, research institutes, cities and regions as well as other public authorities at both European and national level (COM, 2009).
Based on the 'Vision 2020', the ERTRAC SRA, published in June 2004 and subsequently extended and detailed through research implementation documents. Due to the complexity of the issues and the number of stakeholders involved with road transport, ERTRAC has structured the discussion and development of the ERTRAC vision for 2020 and the strategic research agenda around four pillars:

- mobility, transport and infrastructure,
- environment, energy and resources,
- safety and security,
- design and production systems.

European Technology Platform Waterborne

Europe has always been a maritime superpower and modern Europe would not be one of the world's most powerful regions without the performance of waterborne transport and operations, with world leaders in shipping, shipbuilding, marine equipment manufacturing and off shore services, following a continuous flow of innovations resulting from investments in a wide array of advanced R&D (COM, 2009).

The Waterborne technological platform was established in 2005 and gets together all parties involved in the areas of shipping and shipbuilding, off shore industry and leisure craft, ports and infrastructure development, and equipment manufacturers and systems suppliers. Its main objective is to bundle the research efforts of the European waterborne actors, in order to remain champions in maritime transport, in the production of efficient and safe vessels as well as the related systems and equipment, in providing infrastructure and logistics for ports and waterways, in off shore technology and leisure craft, and in creating high qualification employment opportunities in Europe.

Based on the common medium and long-term vision for the year 2020, 'Vision 2020', the Waterborne SRA was developed to address the innovation challenges over the next 15 years, summarised under three pillars:

- Safe, sustainable and efficient waterborne operations
- A competitive European maritime industry
- Manage and facilitate growth and changing trade patterns

Waterborne is engaged in dialogue with the ERA-NETs MARTEC (Maritime Technologies) and TRANSPORT. Particular attention has been given to reinforcing the existing national maritime forums (in Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, Slovenia and Spain) and establishing or developing new national forum platforms (the so-called emulation process, under which Cyprus, Greece, Ireland, Romania, Turkey and the United Kingdom are considering the creation of a national platform).

3.2.3. Joint Technology Initiatives (JTIs)

Joint Technology Initiatives (JTIs) are a means to implement the Strategic Research Agendas (SRAs) of a limited number of European Technology Platforms (ETPs). In these few ETPs, the scale and scope of the objectives is such that loose co-ordination through ETPs and support through the regular instruments of the Framework Programme for Research and Development are not sufficient. Instead, effective implementation requires a dedicated mechanism that enables the necessary leadership and coordination to achieve the research objectives. To meet the needs of this small number of ETPs, the concept of "Joint Technology Initiatives" has been developed14.

JTIs were a major novelty of the Seventh Framework Programme. Five JTIs have been set up under FP7: Innovative Medicines initiatives (IMI), Advanced Research and Technology for Embedded Intelligence and Systems (ARTEMIS), Aaeronautics and Air Transport (Clean Sky), European Nanoelectronics Initiative Advisory Council (ENIAC) and Fuel Cells and Hydrogen (FCH). Accordingly from the five JTIs two of them - Clean Sky and FCH – are transport related.

Several platforms have participated in the launch of a JTI, a public–private research partnership established in order to implement all or part of their strategic research agendas. As a result, two of them (innovative medicines and fuel cells and hydrogen) have ceased to exist as ETPs and focused on implementation through their JTIs. Other platforms see the JTI as one of several objectives and will continue operating their ETP in parallel.

For the purpose of FUTRE we will focus the analysis on the two transport-related JTIs.

Clean Sky Initiative

The Clean Sky Initiative is a PPP which objective is to develop innovative technologies with low environmental impact for all flying segments of the Air Transport System, allowing substantial reduction of noise, fuel consumption and emission of noxious gases in line with the targets set by the ETP for Aeronautics, ACARE. It became autonomous on 19 November 2009, meaning that it has the operational capacity to implement its own budget (COM, 2011e).

After the first 2.5 years of operation, members in Clean Sky have performed activities for a cumulated value of € 232 million across all programme areas and the first flight tests of innovative technologies have been accomplished. In addition to the members' activities, seven Calls for Proposals have been launched so far for additional € 63 million of funding (€97.5 million total scope of activities), engaging some 374 partners in 201 projects with an average duration of three years (COM, 2011e).

Fuel Cells and Hydrogen Initiative

The Fuel Cells and Hydrogen (FCH) Initiative was established in 2010 with the objective of accelerating the market introduction of fuel cells and hydrogen these technologies, realising their potential as an instrument in achieving a carbon-lean energy system. The FCH Joint Undertaking (FCH JU) is a public-private partnership that has as members the European

[14] http://ec.europa.eu/research/jti/index_en.cfm?pg=about

Union represented by the European Commission, the fuel cell and hydrogen industries represented by the "NEW" Industry Grouping and the research community represented by the "N.ERGHY" Research Grouping.

Three annual calls for proposals have already been completed up to date and a balanced portfolio of projects has been selected. Those from the first two calls for proposals (44 projects already on-going) will receive grants for a cumulative value of ~ 100 million Euros, engaging some 250 different partners. The negotiations for projects of the 2010 call for proposals (estimated 43 grants for a value of ~ 89 million Euros) should be completed by the end of July 2011. The 2011 call was published on 3rd of May 2011 (COM, 2011e).

3.3 European transport innovation system

This section provides an overview of the European transport innovation system, with the aim of giving useful background information for the development of FUTRE activities. It is important to note that mapping competences and transport research infrastructure in Europe is a very ambitious task which clearly falls outside the scope of FUTRE. What this chapter outlines are the key-players of transport research and the main challenges per mode of transport. This information will then be interpreted with the view of discussing drivers and barriers to innovation.

This work was based on the information collected and presented in the previous chapters and a review of the work conducted in other projects and activities. To that purpose we underline the importance of the following sources of information:

- **The European Strategic Transport Technology Plan** (STTP)[15]: The European Commission strategic framework for transport research, innovation and deployment, based on the White Paper's vision for an integrated, efficient, safe, secure and environmentally friendly European transport system by 2050. It was adopted in September 2012 and includes a *Scientific Assessment of Strategic Transport Technologies* and a *Mapping innovation in the European transport sector*, both developed by the EC Joint Research Centre.

- **The Market-up Project**[16]: it was a FP7 developed between October 2010 and September 2012 which aimed to identify barriers (both social and technical) and drivers for the market uptake of transport research results along Aeronautics, Air, Road, Rail and Waterborne transport. As part of its activities it included a *mapping of competences on transport research and innovation*.

- **The GHG-TransporD Project**[17]: aimed at developing an integrated European strategy that links R&D efforts with other policies and measures to achieve substantial GHG emission reductions in transport, in line with the overall targets of the EU. As part of this strategy, the project proposed GHG reduction targets for transport as a whole as well as for each transport mode for 2020 and 2050.

15 http://ec.europa.eu/transport/themes/research/sttp/
16 http://www.market-up.org/
17 http://www.ghg-transpord.eu/ghg-transpord/index.php

There is a very large amount of information on research challenges, actors, barriers and drivers for the transport sector. Given the objective of this document – to gather important information for the purpose of discussing the future of transport research in Europe and how it may affect competitiveness – it will be structured along the main modes of transport, which are also the way industrial sectors are organised.

3.3.1 Road Transport

In the framework of the STTP process a status and vision for research and innovation in different modes of transport was provided (Aparicio, A., et al, 2012). For Road Transport, which is the largest corporate R&D investor in transport in Europe (Leduc, G., et al., 2010), investment in R&D is seen as crucial to maintain the corporations' competitive position. This investment needs to cover both incremental improvements in products and services and step-change technologies that could significantly change the future performance and operational aspects of the road transport system (Aparicio, A., et al, 2012). These step changes are seen as crucial to meet the targets expressed in the Transport Policy White Paper, but also the main goals defined by the European Road Transport Research Advisory Council (ERTRAC) in its Strategic Research Agenda (SRA), outlined in the table below.

Table 4: Main goals for European Road Transport R&D activities, according to ERTRAC SRA

Overall goal	Indicator	Objective
Decarbonisation	Energy efficiency in urban passenger transport	+80% (pkm/kWh)*
	Energy efficiency in long-distance freight transport	+40% (tkm/kWh)*
	Renewables in energy mix	Biofuels: 25% Electricity: 5%
Reliability	Reliability of transport schedules	+50%*
Safety/ Security	Fatalities and severe injuries	-60%*
	Cargo lost to theft and damage	-70%*

*versus 2010 baseline

Source: (Aparicio, A., et al, 2012)

These goals suggest there are six areas were road transport R&D actors should focus their efforts: (i) vehicles; (ii) propulsion technologies; (iii) biofuels; (iv) intelligent transport systems; (v) improvement of infrastructures; and (vi) safety. These priorities are largely reflected in the fields of focus of Research and Innovation activities identified in the framework of STTP (COM, 2012a):

- Field 1 (Clean, efficient, safe, quiet and smart road vehicles) shall cover activities on vehicles, propulsion technologies, biofuels and safety;

- Field 5 (Smart, green, low-maintenance and climate-resilient infrastructure) shall cover the work on improvement of infrastructures; and

- Field 6 (Europe-wide alternative fuel distribution infrastructures) shall cover the infrastructure related aspects if new propulsion technologies and biofuels;

More importantly, some of these areas are touched by European regulatory action. Road transport vehicle technologies are highly regulated at European level and the role of the Regulation on CO2 emission standards for passenger cars and vans on improving the energy and carbon efficiency of vehicles seems undisputable. Regarding biofuels the European targets for renewable energy also played an important role for promoting them. A new element worth underlining regards alternative fuel distribution infrastructures for which the European Commission has recently adopted a proposal which provides mandatory targets for Member States in this field.

Regarding research capacities the Market-up project noted that automobile is a well-structured industrial sector, which is responsible for a considerable share of the total effort in R&D across Europe. The industry has a mature structure in manufacture, characterised by competition between a few main manufacturers. Firms based in the EU are: VW-Audi, PSA Peugeot Citroën, Renault, Fiat, Daimler, BMW. Smaller brands are owned by other international companies, with the US and Japan dominating (Market-up Project, 2012a). The most important actors and stakeholders are represented in the Table 5.

Table 5: Main actors and stakeholders of European road transport research

Organisations creating international policies serving the needs of road transport stakeholders	Political systems dealing with transport questions	Infrastructure for education and innovation	Research systems including automotive suppliers, OEM:s and road management and construction companies
United Nations European Commission ERTRAC (European Road Transport Research Advisory Council) with its members: CLEPA, CONCAWE, EARPA, ACEA (EUCAR), ERTICO, FEHRL,FIA and others	European Commission Ministries of Transport in all EU countries The national road administrations usually organised under the ministries mentioned above CEDR (Conference of European Directors of Roads)	European Commission National road research centres in partnership (FEHRL) Independent Vehicle research centres in cooperation (EARPA) Automotive suppliers and OEM:s CEDR	OEM:S organised under ACEA (EUCAR) and independent OEM:s Automotive suppliers organised under CLEPA or under other organisations Independent national and international road construction companies Independent national and international road maintenance companies

Source: Market-up Project, 2012a.

The funding for road transport R&D activities mainly comes from industry (estimated to 65% of the funding) while the remaining 35% can be traced to EU, national and regional funding. Most of these research funds cannot however be specifically located to road transport activities, since research in areas of energy transfer (use of biofuels and fuel cells) can be applied in all the transport mode areas (Market-up Project, 2012a).

3.3.2 Rail Transport

Rail transport has a relatively good environmental and energy performance which has made modal shift from other modes towards rail an important EU transport policy objective in the past. However, in spite of these advantages, rail has been losing market in most European countries, a trend which seems to have been reversed in some countries in the last few years due to a combination of technological development (high speed rail), increased cooperation with other modes of transport and reform of the regulatory framework increasing competition for rail services (Aparicio, A., et al, 2012).

In this framework it is not surprising that ERRAC's vision for the future of rail is aiming to increase railways' role in the European transport system, with a focus on the commercial attractiveness of this mode of transport. The Strategic Rail Research Agenda 2020 (SRRA) identifies key research objectives to ensure that rail remains at the heart of Europe's transport system over the next decade and a half. More specifically it adopts a long-term framework for the SRRA that sets out seven research priority areas for the next decade (ERRAC, 2007):

- **Intelligent mobility**: A European-wide intelligent infrastructure is needed to support customer information systems to provide compatible technology between Member States and across transport modes;

- **Energy and environment**: New standards and regulations must not only increase the level of environmental protection but also safeguard the commercial competitiveness of the mode while reducing dependence on fossil fuels, reducing exhaust emissions, improving design and offering a systematic approach to noise and vibration;

- **Personal security**: Identify new methods of improving security for customers and staff in relation to both terrorism and the more common problem of vandalism;

- **Test, homologation and security**: The spread of European homologation and acceptance procedures requires the speeding up of product approvals while squeezing out risk through improved safety management;

- **Competitiveness and enabling technologies**: Increasing the competitiveness of the rail sector can be achieved by improving product attractiveness for customers and reducing life cycle costs through modern technology on all aspects of railway operation including rolling stock, maintenance procedures, ticketing systems and infrastructure;

- **Strategy and economics**: New accounting and planning models will provide a better understanding of the costs of operating and maintaining rail infrastructure and how these costs vary according to changes in the frequency and types of train service;

- **Infrastructure**: Cost efficient maintenance, and maintenance-free interoperable infrastructure systems will be developed that yield increases in traffic capacity, loading and track stability.

For FUTRE the most important element from the analysis of ERRAC's SRA is its clear focus on increasing rail transport competitiveness. Unlike other modes there is a clear perception that environmental and safety aspects are actually a competitive advantage of rail.

The analysis of actors and stakeholders performed in the framework of the Market-up project shows that rail transport represents a mature industrial sector, with its main infrastructure being based on routes constructed in the 19th century. In terms of the industrial structure, there is a particularly strong link between infrastructure and train operations, because train control comes from the infrastructure operator. Infrastructure and operations are often part of the same firm, which in most of the EU is usually a national railway (Market-up Project, 2012b).

A certain diversity of technologies is observed across Europe. Western and Central Europe generally has well maintained and well developed railway networks, which cannot be said for Eastern and Southern Europe, struggling with coverage and infrastructure problems. This diversity is best showcased with electrified railway networks, which operate at different voltages AC and DC varying from 750 to 25,000 volts, and signalling systems vary from country to country. 15 kV AC is used in Germany, Austria, Switzerland, Norway and Sweden since 1912, while the Netherlands use 1500 V DC, France uses 1500 V DC and 25 kV AC, and so on (Market-up, 2012b).

All this makes not only the construction of truly pan-European vehicles a challenging task but also constituting a barrier to innovation. As a result it is also one of the main threats to the sector's competitiveness.

Regardless of this diversity, that is well reflected in research capabilities across Member States, Market-up identified the most important actors on rail transport research at European level.

Table 6: Main actors and stakeholders of rail transport research

Political System	Education and Research System	Innovation Infrastructure	Industrial System
European Railway Agency (ERA) DG MOVE DG RTD	European Rail Research Advisory Council (ERRAC) EUropean rail Research Network of Excellence (EURNEX)	International Association of Public Transport (UITP) EUREKA European Commission – Joint Research Centre	Union of European Railway Industries (Unife) Association of European Rail Agents (AERA) ERFA (European Rail Freight Association) Community of European Railway and Infrastructure Companies (CER) European Rail Infrastructure Managers

Source: Market-up, 2012b

Rail is far from being a powerhouse in terms of investment in R&D. Total R&D investment in rail in 2008 amounted to €1.1 billion, most of it emanating from corporations (€845 million), while public EU FP7 holds a much smaller share (€ 20 million). Around 20% of the total funds allocated to rail research are geared toward emission reduction. Other important issues are energy efficiency, regenerative braking systems, weight reduction and hybrid technologies (Leduc, G., et al., 2010).

3.3.3 Aviation and Aeronautics

Aeronautics and air transport is not only a sector vital for Europe's economy and society but is also an area where European public and private actors provide world leadership in many areas. The air transport industry has emerged from a niche sector and to be a highlight of high tech research, developing and manufacturing in Europe (Aparicio, A., et al, 2012).

However, air transport is also a sector where great challenges remain to be addressed. Environmental protection and security issues are examples of areas where recent improvements have failed to meet societal needs. On GHG emissions, for example, the sector is amongst the fastest growing sources of emissions in the EU: a wide range of projections and scenarios shows that aviation emissions are likely to grow over the coming decades with a resultant increase in CO2 emissions by 2050, despite mitigation efforts through technology, operations, and usage of low-carbon fuels (Lee, D.S., et al., 2013b).

As a result the air transport and aeronautics sector is currently focusing on achieving two objectives: meeting society needs and winning global leadership. This calls for a safe, reliable, affordable and quiet future for air transport, with a zero emission balance, well informed customers and good links with other modes of transport. The Advisory Council for Aeronautics Research in Europe (ACARE) Strategic Research Agenda (SRA) establishes a vision for 2020 which was then complemented by the European Commission publication "Flightpath 2050: Europe's vision for aviation" as major documents detailing future views for air transport. Both keep the dual approach: address societal challenges while maintaining global leadership (Aparicio, A., et al, 2012).

As noted in the Market-up project, the aviation is traditionally a high technology industry in which many of the major developments have come from military applications. It is also peculiar in the sense that since it is an international industry, an international regulatory authority – the International Civil Aviation Organization (ICAO) agrees standards of operation and international policy (Market-up Project, 2012c). This has allowed the industry to develop global standards and avoid some of the problems previously discussed for rail, but has also made it more difficult to adopt legislation to address societal challenges (e.g. Europe's difficulty to implement the inclusion of aviation activities in the EU Emissions Trading Scheme).

The industry is dominated by a very few airframe and engine manufacturers, who all compete in a global market. EADS (including Airbus), Boeing, Dassault, Finmeccanica (Alenia), Bombardier and Embraer are the main airframe manufacturers, with Russian and Chinese manufacturers mainly active in their internal markets. Rolls-Royce, General Electric and Pratt & Whitney are the main manufacturers of turbofan engines for large civilian aircraft. Thus the industry is highly concentrated in a few large firms, who usually have both civilian and military products (Market-up Project, 2012c). The most important actors and stakeholders of aviation research in Europe are presented in the table below.

Table 7: Main actors and stakeholders of air transport and aeronautics research

Political System	Education and Research System	Innovation Infrastructure	Industrial System
ICAO ECAC European Commission[1] EASA EUROCONTROL	EATRADA - the European ATM Research And Development Association DLR - German Aerospace Center NLR – Netherlands National Aerospace Laboratory JRC – Joint research Centre	ACARE FP 7 EU CleanSky EU SESAR TEN-T funding for investments in air navigation services EUREKA	Aircraft Manufacturers ASD, Airbus/EADS Alenia Augusta-Westland Engines and System Components ASD, Rolls-Royce, MTU ,SNECMA Airports ACI Airlines IATA, AEA, EBBA, ELFAA

Source: Market-up Project, 2012c

Overall R&D investments in air transport in 2008 (civil aeronautics only) have been estimated to reach some €5.7 billion, most of which arising from Corporate R&D investment (€4.75 billion). Public EU FP7 financing amounts for €350 million while national public R&D investment from Member States is estimated to be around €620 million (Leduc, G., et al., 2010). Aeronautics and Air Transport (AAT) is the most important programme line within FP7, focusing on reduction of emissions, work on engines and alternative fuels, air traffic management, safety aspects of air transport, and environmentally-efficient aviation. The AAT line covers roughly 2.3 billion Euros, e.g. more than 50% of the total direct investment in transport research in FP7 (Leduc, G., et al., 2010).

3.3.4 Waterborne Transport

The waterborne transport sector gathers three very different and diverse forms of transportation: international shipping, short-sea shipping and inland navigation. In all these sectors some elements are worth noting for the purpose of FUTRE. First, European industry has a leading role at global level. Second, they all have relatively good environmental performance, justifying the willingness to promote modal shift from other modes. Third, the fact that for these modes of transport freight transportation is actually relatively more important than passenger transportation.

Maritime is and will continue to be the most important cargo transport mode. It accounts for approximately 90% of EU external trade and for 40% of EU internal trade and it is growing (Aparicio, A., et al, 2012). This has attained attention to the societal impacts of maritime transport: regardless of its much better environmental performance international shipping suffers for some of the governance problems of aviation and if current projections of emissions from shipping are placed in the context of an overall global 2°C emissions reduction pathway, shipping might contribute between approximately 6% and 18% of median permissible total CO2-equivalent emissions in 2050, up from around 3.2% of global CO2 emissions in the mid-2000s (Lee, D.S., et al., 2013b).

New technologies to tackle the environmental impacts of shipping are now available, ready to use and with proven results and their market uptake is expected to benefit from new fuel regulations and the Energy Efficiency Design Index that was recently adopted by the International Maritime Organisation (Aparicio, A., et al, 2012).

For inland navigation the situation is somewhat different. Currently it is an underutilized mode of transport, having a great growth potential that is hampered by several organisational and technological barriers. In the coming year the focus on inland navigation shall be in improving the connections with the other modes of transport and on the introduction of alternative fuels/energy sources (LNG, bio-fuels, fuel cells and electricity). Another aspect of major importance is the need to address the vulnerability of inland waterways to climate change (Aparicio, A., et al, 2012). In it is “vision for 2025” the Waterborne Technological Platform also refers to these issues (Waterborne TP, 2012).

In what refers to actors and stakeholders the shipbuilding industry has four main sectors: commercial (bulk cargo, container, ferry and cruise), military, offshore energy and leisure (sail and motor yachts). EU shipyards have concentrated on either military or specialist ships or marine systems, being mature and concentrated for large ship construction. The large shipbuilders have access to an extensive and effective innovation infrastructure, mostly within the companies themselves or through established industry consultancies (Market-up Project, 2012d).

A particular feature of shipping is the complex pattern of ownership and insurance. Indeed ships are often not built for a shipping line, but for leasing intermediaries and all have to be insured for each voyage. This has had a major historical influence on innovation, because a classification society system was adopted, under which classification societies in the major shipbuilding countries specify standards of construction and maintenance. A further important feature of standards setting is the International Maritime Organisation (IMO). Since shipping is an international activity, the IMO agrees on standards for operation and also applies international environmental policy. In the maritime sector therefore, there is a regulatory (sub) system which forms an important and distinct part of the innovation system (Market-up Project, 2012d). As a result the Waterborne Community is composed of representatives from Industry (Manufacturers, Users & Service Providers), Society (Regulatory, Research & Education Organisations, Unions) and Public Authorities (Commission & Members States), which are summarized in the Table 8.

Table 8: Main actors and stakeholders of maritime transport research

Political System	Education & Research Systems	Innovation Infrastructure	Industrial System
European Commission EMSA IMO National Research Programmes	Research Institutes Maritime Universities Testing Centres	FP7 (Various Programmes) TEN-T MARTEC ERA-NET Life + Marco Polo II TEN-E Leonardo Di Vinci CIP IEE	Marine Equipment Waterborne TP Shipyards Ship-owners Inland Shipping Classification Societies Trade Unions Ports & Terminals Dredging Leisure Craft Offshore Renewables

Source: Market-up Project, 2012d

In the FP7 covering the years from 2007 to 2013, the Transport theme amounts to € 4.2 bn for all transport modes. Assuming a funding of € 1.3 bn to € 1.4 bn for surface transport and an equal allocation of these funds over the modes, this provides around €0.450 bn for waterborne transport over the entire period e.g. around €70 M per annum. From different reports (including ERA.Net MARTEC) and sources, it appears that the EU27 members' national funding of maritime research could amount up to €260 M per annum. Assuming that €1.7 bn needs to be financed every year for the implementation of the ambitious Waterborne Strategic Research Agenda, we estimate that European funds are predominantly used to support Pre-Competitive, Fundamental and Scientific Research, while Applied Research "close to market" is largely financed by private equity. Recent work by the European shipbuilding industry points to Research, Development & Innovation expenditures in the range of 9-11% of the turnover. An estimated 1 to 2 % is spent on the "R" (basic and industrial research), involving the maritime universities and research institutes as well. In the offshore industry this part is likely to be higher, as well as in major parts of the marine equipment sector and the naval sector (Market-up Project, 2012d).

3.4 Drivers and Barriers to Innovation

The analysis of the most important drivers and barriers to innovation will be based on the work developed in the Market-up Project, which identified barriers and drivers to transport innovation based on the work of Bergek, *et al* (2008), and on the Eurostat CIS Survey 2010. Table 9 presents the most important drivers and barriers for transport research market-uptake identified in the project and which are also expected to be relevant in the framework of FUTRE.

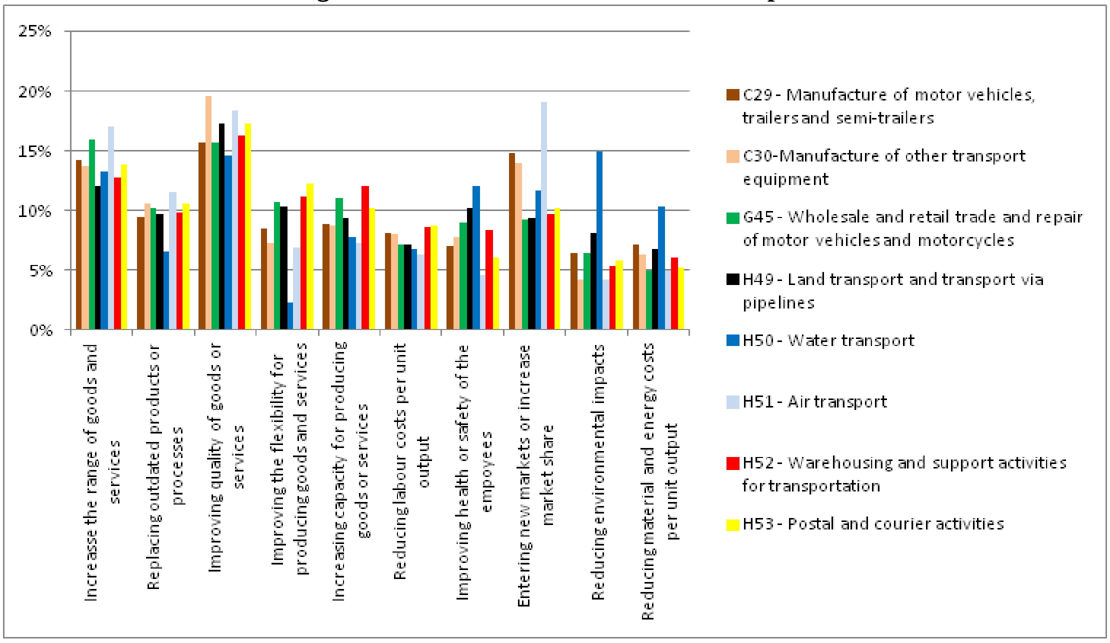
Table 9: Drivers and Barriers for the market uptake of transport research and innovation

Barrier name	Nature
Economic outlook	Market
Uncertain market demand	Market
Uncertain ROI	Market/Financial
Long lead times	Financial
Lack of funds	Financial
Insufficient access to subsidies	Financial
Legal background lacks incentives to innovate	Legal
Lack of external financing	Financial
Lock-ins	Technological
Lack of qualified personnel, technology	Organizational
Domination of established enterprises	Market
Limited access to information, tech support	Technological
Lack of business partners	Market
Lack of cooperation	Market
Lack of the mutual recognition of standards	Legal
Driver name	**Nature**
Economic outlook	Market
Expected energy price increases	Market
Current high energy prices	Financial
Current high material prices	Financial
Good business partners	Market
Secure or increase market share	Legal
Access to subsidies, incentives	Financial
Technological and management capabilities	Organizational
Increased green product demand	Market
Expected new regulations	Legal
Existing regulations	Legal
Future material scarcity	Market
Access to information, tech support	Technological
Limited access to materials	Market
Good cooperation	Market

Source: Bergek, A., et al., 2008

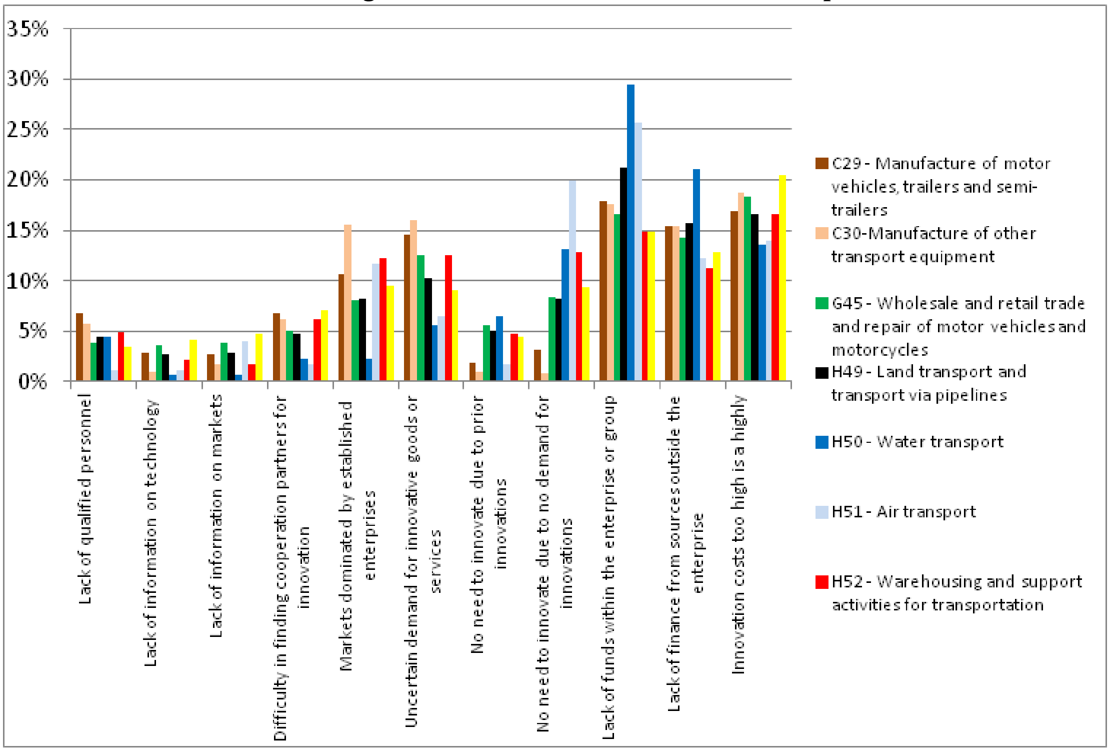
Most of these Drivers and Barriers are also identified in the CIS results for the transport related categories. Figure 10 and Figure 11 present the results on both barriers and drivers obtained at CIS survey 2010.

Figure 10: Drivers for innovation in transport



Source: IPTS, from CIS 2010 data

Figure 11: Barriers for innovation in transport



Source: IPTS, from CIS 2010 data

A first comparison between the table and the figures shows that drivers presented by the CIS would fit in the "secure or increase market share" category in Market-up.

Drivers and barriers can be classified according to their nature: market, financial, legal, technological or organisational. Given the purpose of FUTRE and its focus on the Future of Transport Research in Europe, technological and organisational barriers and drivers are identified in the Table 10, also taking into account inputs from CIS. A quick overview of the table, and a comparison with the graphs, shows that most barriers identified are market or financial related. This suggests a need to look both into the financing of research and development in Europe and to European regulation and legislations as privileged mechanisms to overcome barriers and capitalise drivers for transport innovation.

In order to ascertain more information on the barriers and drivers, a basic ranking system was created, providing a better understanding of the relative importance of the different inducement and blocking mechanisms identified in the transport sector.

Table 10: Ranking of Barriers for the market uptake of transport research and innovation

Impact duration	Short	Long
Impact severity		
Low	• Uncertain market demand • Uncertain ROI	• Lack of qualified personnel, technology • Long lead times • Lack of business partners • Lack of cooperation
High	• Economic outlook • Legal background lacks incentives • Limited access to information, technological support	• Lack of funds • Insufficient access to subsidies • Lack of external financing • Lock-ins • Domination of established enterprises • Lack of the mutual recognition of standards

Source: Market-up Project (2012e)

It is clear from the ranking that most of the barriers that have both considerable and long-lasting impacts are financial in nature. The most important barriers are in the bottom right, with severe and lasting impacts. Absent or inaccessible monetary resources and external funds have the capacity to cripple the development and the uptake of new ideas. Lock-ins and the domination of incumbents (often leading to inefficient monopolies) are hard to break, especially because of the conflict of interest with the well-established and leading institutions in the transport sector. Last but not least, the interoperability problems and the lack of unified standards have a profound impact on transport innovation and is difficult to address. This is perhaps the best area where policy efforts should be concentrated to achieve considerable gains across Europe (Market-up Project, 2012e).

Table 11: Ranking of Drivers for the market uptake of transport research and innovation

Impact duration / Impact severity	Short	Long
Low	• Secure or increase market share • Existing regulations	• Economic outlook • Good business partners • Technological and management capabilities • Expected new regulations • Good cooperation
High	• Current high energy prices • Current high material prices • Access to information, tech support	• Expected energy price increases • Access to subsidies, incentives • Increased demand for green products • Future material scarcity • Limited access to materials

Source: (Bergek, A., et al., 2008)

As the table above shows, most drivers have longer impact periods. Drivers with low duration and impacts include the current regulatory framework, which, by it definition is expected to change in the foreseeable future. The most powerful drivers are mostly related to the need to change current unsustainable operational practices across all areas, although the transport sector is perhaps even more affected than others. Peak oil, the scarcity of energy and materials will drive a profound change in the way we live, travel, and innovate. Designs will have to be modified to reflect the changes that have taken place since the industrial revolution, while consumers, becoming increasingly aware of the situation, will be increasingly driven towards more sustainable products and services, generating demand and innovations in this area. This fundamental change in mindsets should be taken advantage of when designing policy instruments to facilitate transport research in the future (Market-up Project, 2012e).

4. Present R&D investments

This chapter presents the current R&D efforts made both from the public sector, namely the EU and Member States, and the transport business sector regarding. The analysis will combine different data sources collecting data on innovation and R&D expenses. Furthermore a bottom-up approach, based on companies annual reports and the EU Industrial R&D investment Scoreboards (also generally named here as the Scoreboard), will be undertaken. However the analysis focused on those technological fields relevant for the competitiveness of the transport sector, that was mention in the work programme, will not be able to perform at this stage. Companies provide no clear information about the amount of R&D expenses by technologies, so these insights can be better captured from patent analysis (Chapter 5).

4.1 Data sources used in the current analysis

Data sources used in the current analysis vary in scope, regional allocation and detail provided and are summarizes in Table 12.

Table 12- Overview of database used and main characteristics

Database	Private/public	Main subject covered	Classification
EU Industrial R&D Investment Scoreboard	Private	R&D investments	ICB
BERD (Business enterprise research and development)	Private	R&D expenditures	NACE
GBAORD (Government budget appropriations or outlays on R&D)	Public	R&D appropriations	NABS92
Community Innovation survey (CIS)	Private mainly	Innovation-related topics	NACE

The last EU industrial R&D Investment Scoreboard (2012) collects data on R&D investments for the top 1000 EU-based and top 1500 world companies[18]. Companies are categorized following the ICB classification[19]. The Scoreboard follows the criteria of allocating the total R&D investment of a company to the country where it has its registered office, which may differ from the operation or R&D headquarters in some cases.

The BERD (Business enterprise research and development) database contains data on the business enterprise sector's expenditure in R&D following the NACE classification of economic sectors[20]. Expenditures are also classified by source of funds, disaggregated into business enterprise sector (BES), government sector (GOV), higher education sector (HES), private non-profit sector (PNO) and abroad (ABR). The BERD database uses the NACE classification of economic activities and allocated R&D investment of business to the country where the reporting company operates.

GBAORD (Government budget appropriations or outlays on R&D) contains all the appropriations allocated to R&D in central government or federal budgets. It may also include provincial or state budgets when the contribution is significant. Figures in this database are

[18] This includes also EU companies. In previous versions of EU industrial R&D Investment Scoreboard data was offered for the 1000 EU-based and 1000 non-EU based companies.
[19] See Annex I for a detailed description of the selected sectors under ICB classification
[20] See Annex II for a detailed description of the selected sectors under NACE classification

not real expenses but just budgets devoted to R&D. Data can be broken down into socio-economic objectives following the NABS classification. A major drawback of this data source is that transport-related investments often rank as a subcategory for which data are not explicitly collected.

The Community Innovation survey (CIS) is a survey on innovation activities in enterprises located in the EU as well as in Iceland and Norway. Eurostat is responsible for this survey which is conducted every 4 years. The latest CIS available refers to 2010 and was launched at the end of 2012.

Data provided by previous data sources is not comparable, mainly due to the following issues:

- Different geographical coverage and time horizon: Although databases hosted by Eurostat comprise all EU Member States, not all countries report data in all transport sectors and for all the years.
- Different approaches: Eurostat collects budget data in its GBAORD statistics, expenditure data in GERD and BERD. The EU Scoreboard uses data from companies' annual audited reports.
- Different sectorial classifications[21]: The BERD follows an institutional nomenclature (NACE), while the Scoreboard classifies companies' economic sectors according to the ICB classification. GBAORD follows the classification NABS.
- Different geographical allocation: The Scoreboard refers to all R&D financed by a particular company from its own funds, regardless of where that R&D activity is performed (Azagra Caro and Grablowitz, 2008). BERD refers to all R&D activities performed by businesses within a particular sector and territory, regardless of the location of the business's headquarters, and regardless of the sources of finances (Box 1).

4.2 Public funding of R&D: Member states and EU FP7

The endogenous growth theory holds that the long run growth rate of an economy depends on policy measures, such as subsidies and R&D. Accordingly, R&D is fundamental for technical progress and this is an endogenous factor of economic growth.

Public intervention is especially needed there were there is a market failure. This is the case of external effects (e.g. pollution) and public goods (e.g. environment) on which public intervention is certainly required – both by R&D spending or through regulation- since the private sector –either firms or households- would not bear the cost of actions that would benefit the whole community. This section presents the efforts made by the Member States and by the EU in financing R&D activities related with the transport sectors.

[21] Some data sources allow for a categorisation of their data according to a secondary socio-economic classification .

4.2.1 Member States

Public funding of R&D is under control of governments, who decide how much should be allocated in each socioeconomic objective. Eurostat GBAORD (Government Budget Appropriations or Outlays in R&D) database contains all appropriations allocated to R&D in central government or federal budgets. Generally provincial or state funds are also included while local government funds are excluded to avoid double counting.

GBAORD is broken down into socio-economic objectives following the NABS[22] classification. Transport is included under the category of 'Transport, Telecommunications and other infrastructure' which also includes non-transport infrastructure such as water and electricity infrastructure. Unfortunately transport-related investments are not explicitly collected.

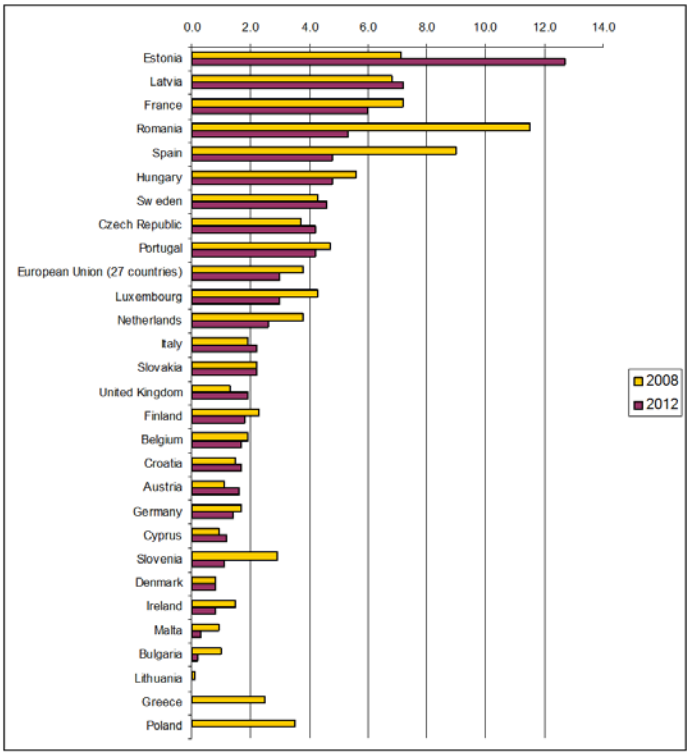
For the category of 'Transport, Telecommunications and other infrastructure' evidences show that the share of R&D budget (GBAORD) in total government expenditure has progressed on 9 Member States between 2008 and 2012. Estonia is the country were the share of R&D budget devoted to 'Transport, Telecommunications and other infrastructure' category has increased the most. Estonia is also the country investing a higher share of its total budget under this category, more than 12% in 2012. Other countries also dedicate higher share of budget under the transport-related category, these are Latvia (7.2%), France (6%), Romania (5.3%) and Spain (4.8%). However Romania and Spain are also the countries recording the highest decrease in the share of budget devoted to transport category during this period.

On average in the EU-27, the share of R&D budget under 'Transport, Telecommunications and other infrastructure' in total government expenditure has decreased around 20% between 2008 and 2012, mainly due to the sharp decrease observed in Romania and Spain.

From the figure bellow we can conclude that generally Member States with stronger private business sector such as the United Kingdom Germany, Austria, Finland or Denmark are characterised by a low involvement of the public sector in the financing of domestic R&D activities as a consequence of a higher participation of the private sector.

[22] Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets.

Figure 12 – R&D appropriations of the NABS 07 04 class 'Transport, telecommunication and other infrastructures' as a % of total, 2008 and 2012(1)



Data source: Eurostat GBAORD
(1) 2011 data is used for the EU 27, BE, EE, SP, FR, CY, LV, LT, HU, SE, UK, HR

4.2.2 EU FP7

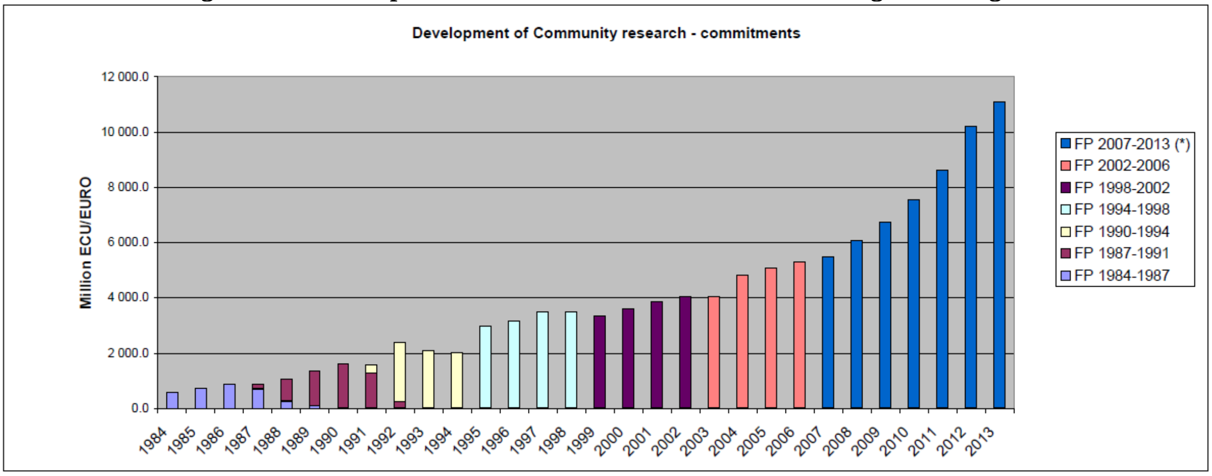
Complementary to Member States' public funding of R&D are European funds. The Research Framework Programme is the key source of R&D financing on new transport technologies. The EU has now almost 30 years investing in Research and Innovation through seven Framework projects. Figure 13 shows how the budget has grown over this 30 years period, from 1984 and 2013.

Launched in 2007, the Seventh Framework Program (FP7) has a total budget of EUR 50.5 billion[23] over the period 2007-2013, broken down into four main programmes (Cooperation, Ideas, Capacities, People) as well as JRC contribution. Under the cooperation programme (32.4 billion), the ' Transport' theme includes all transport modes and aeronautics and has been allocated around EUR 4.2 billion (Figure 14).

Transport research project under FP7 cover all modes of transport, both people and goods and they reflect the objectives and research priorities defined by the strategic agendas of relevant technology platforms such as ERTRAC for road, ERRAC for rail, WATERBORNE TP for waterborne transport or ACARE for air transport as well as the contribution of EIRAC for intermodal transport and logistics).

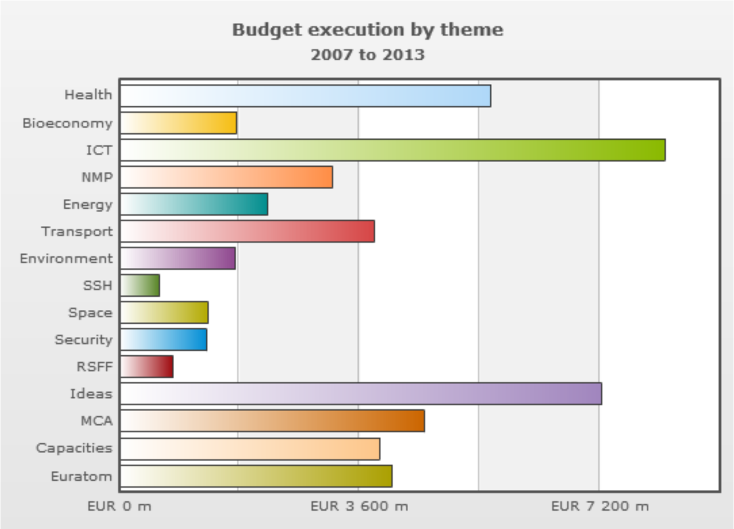
[23] Plus EUR 2.75 billion for nuclear research through Euratom.

Figure 13 – Development of EU research commitments through FP budgets



Source: DG Research and Innovation

Figure 14 – FP7 Budget execution by theme (2007-2013)



Source: DG Research and Innovation

4.3 Private R&D investments

This section analyses the private efforts on innovation made by companies operating in the transport sectors. This will be done by looking at official statistics provided by Eurostat, namely the BERD database which provides R&D expenses and the CIS which provides innovation expenditures. However previous data sources use a rigid classification of economic sectors that are not fully suitable to our definition of transport sector and subsectors. Thus section 4.3.2 presents a bottom-up approach that enables the estimation of R&D efforts of the most important companies within each transport sub-sector. Results from this bottom-up approach will be presented in the last part of this chapter.

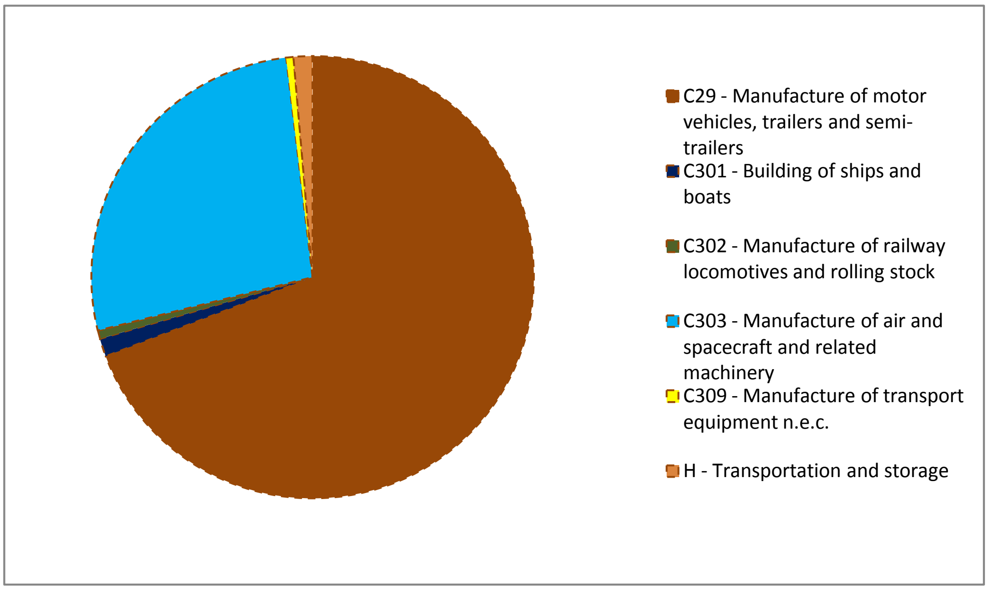
4.3.1 Business R&D investments by transport sector and Member States

The current assessment is based in to main data sources, namely the Eurostat BERD (Business Enterprise R&D) and the Community Innovation Survey (CIS). The BERD database contains data on the business enterprise sector's expenditure in the R&D for different economic sectors following NACE[24] classification. Additionally, expenditures also given by sources of funds, namely business sector (BES), government (GOV) and abroad sector (ABR). We will analyse R&D data from all sources of funds but our main interest in this section is the assessment on funds from the business enterprise sector, specifically those stemming from transport related sectors.

At an EU-27 level, most Member States present a higher industrial R&D investment under the Manufacture of motor vehicles trailers and semi-trailers category (Figure 15) which amounted around EUR 20 billion in 2010. Following this category, although in a lower extent, is the manufacture of air and spacecraft and related machinery. For the EU-27 BERD figures shows a R&D investments around EUR 8 billion. Other transport categories invested much less: rail (EUR 177 million), waterborne (EUR 391 million), manufacture of other transport equipment (EUR 158 million) and Transportation and storage (EUR 407 million).

Manufacture of air and spacecraft, the shipbuilders and the manufacture of other transport equipment (e.g. motorcycles) have increased their R&D investments between 2008 and 2010, especially in 2010 where R&D investment levels were around 20% higher than in 2008 (Figure 16). However the rail and the manufacture of motor vehicle present a decrease of its R&D expenses in 2009 (more acute in the rail sector) followed by a shy recovery in 2010.

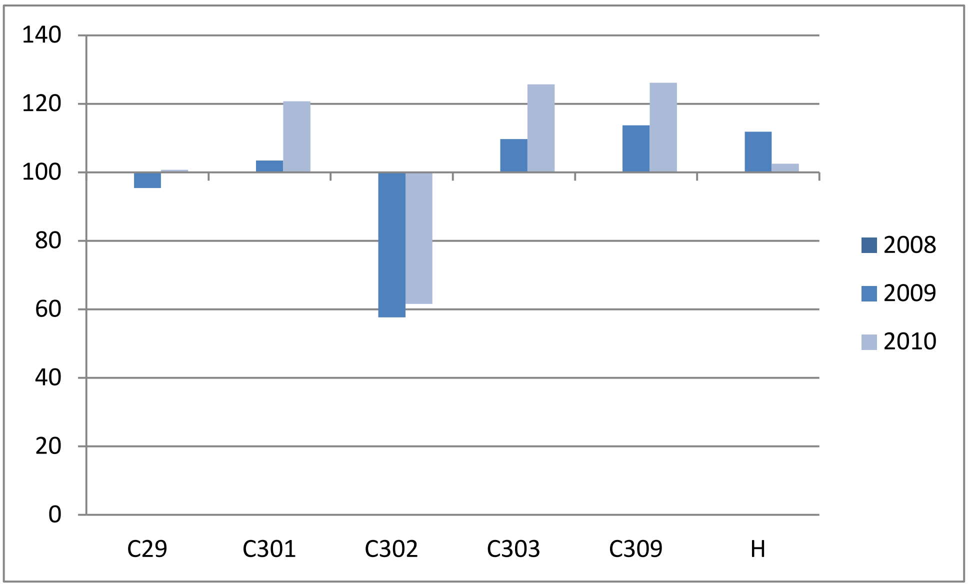
Figure 15 - Business R&D investments (BERD), EU-27 (2010[25]) under transport related categories.



Data source: Eurostat BERD

[24] European statistical classification of economic sectors. See Annex II for a detailed description of sectors used.
[25] Some gaps where filled with data from previous years (see Table 13)

Figure 16 – Evolution of business R&D investments under each transport category, EU-27 (2008=100)



Data source: Eurostat BERD

Most of R&D invested in each transport sector comes from the business sector (around 90 %, see Figure 17). However the R&D under the manufacture of air and spacecraft and related machinery receives a higher amount of funds from the Government sector (around 30%). A minor share of funds for R&D come from the 'Abroad sector', which represents institutions investing in the European transport sector. Although small, these funds represent a higher share under the manufacture of motor vehicles and the manufacture of air and spacecraft.

Germany is the country performing a great amount of R&D expenditure considering the total R&D invested in all transport sectors (see Table 13). France, the United Kingdom and Italy follow Germany but spending much less on R&D. The sum of R&D expenditure of these three countries is almost half the amount reported by Germany.

Germany spends around 86% of its total R&D expenditure devoted to transport in the manufacture of motor vehicles trailers and semi-trailers. Clearly is the highest R&D spender in this sector, followed by France (EUR 1.7 billion), United Kingdom (EUR 1.2 billion) and Italy (EUR 1 billion).

France reports more R&D expenditure in the manufacture of air and spacecraft and related machinery (EUR 2.8 billions), followed by Germany (EUR 1.3 billion) and the United Kingdom (EUR 1.3 billion). This is also the most important sector reported by France and by UK in terms of R&D expenses.

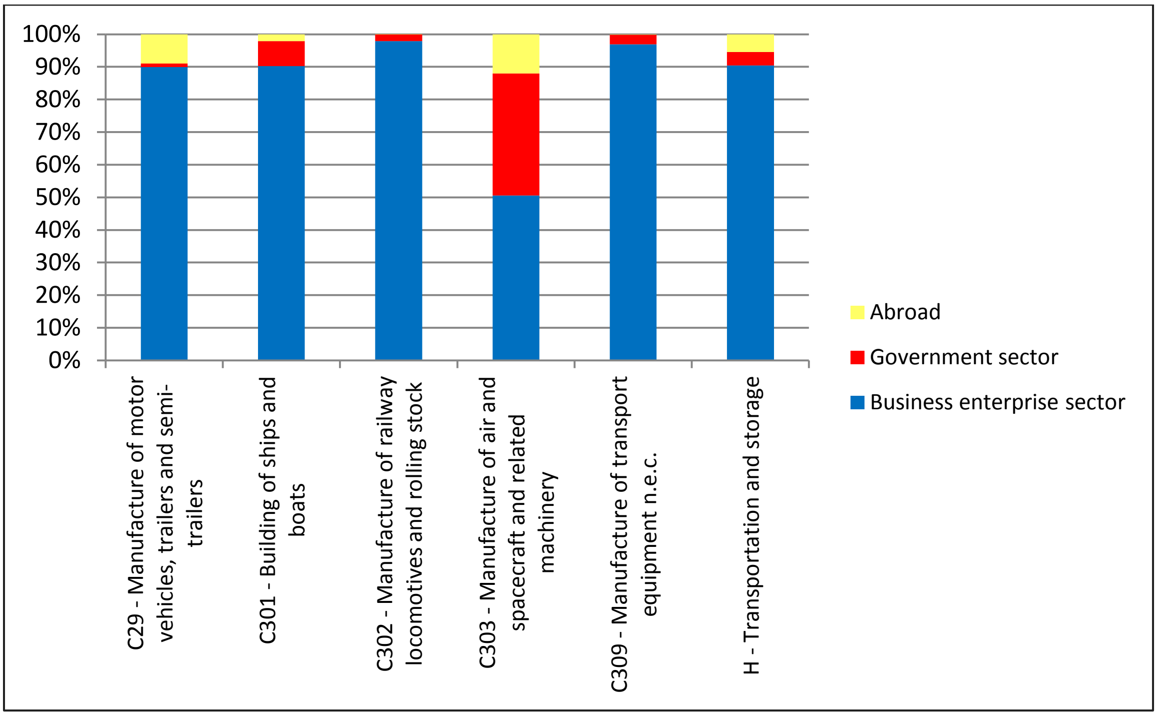
The manufacture of ships and boast invest higher amount of R&D expenditures in France (EUR 118 million), followed by Germany (EUR 95 million) and Spain (EUR 72 million). This may reflect a spatial mismatch between location of production and R&D centres, since countries such as the Netherlands and Italy, which are in the first places of the shipbuilding industry, are spending less on R&D than France or Spain.

The rail sector R&D expenditure is higher in Germany (EUR 69 million) Czech Republic (EUR 59 million), Austria (EUR 33 million) and Italy (EUR 21 million). This evidences a spatial concentration of rail manufacturers around central Europe. However many countries do not provide data for R&D expenditures in this sector and among them are France where many important companies are located (e.g.Alstom).

Italy is by far the country with the higher business expenditure in the manufacture of other transport equipment mainly due to its industry of motorcycles and companies such as Ducati Motor.

In the sector of Transportation and storage, the Netherlands is the EU country reporting the highest share of R&D investment (EUR 134 millions). This is also the most important transport sector in the Netherlands in terms of R&D expenditure and this may be related with the importance of Dutch ports (as the Rotterdam port) and logistic companies (e.g. TNT) that are among the most important companies in Europe.

Figure 17 - Industrial R&D under transport related categories by source of funds (2010)



Data: Eurostat BERD

Table 13 - Business enterprise R&D expenditure (BERD) in all transport categories, 2010[1] (Million EUR).

GEO/Transport sectors	*C29 - Manufacture of motor vehicles, trailers and semi-trailers*	*C301 - Building of ships and boats*	*C302 - Manufacture of railway locomotives and rolling stock*	*C303 - Manufacture of air and spacecraft and related machinery*	*C309 - Manufacture of transport equipment n.e.c.*	*H49-53 Transportation and storage*	Total
Belgium	84	0	0	**91**	1	24	*201*
Bulgaria	0	0	-	-	0	0	*0*
Czech Republic	**485**	0	59	20	1	0	*566*
Denmark	10	-	-	-	2	**95**	*107*
Germany	**15758**	95	69	2326	-	94	*18,342*
Estonia	1	0	0	0	-	1	*2*
Ireland	1	-	-	-	-	0	*1*
Greece	-	-	-	-	-	-	-
Spain	382	72	-	**398**	8	134	*994*
France	1789	118	-	**2782**	8	39	*4,736*
Italy	**1076**	54	21	942	118	41	*2,252*
Cyprus	0	0	0	0	0	0	*0*
Latvia	-	-	-	-	-	-	-
Lithuania	1	-	0	-	-	0	*1*
Luxembourg	0	-	-	-	-	6	*6*
Hungary	65	-	0	-	-	1	*66*
Malta	3	0	0	0	0	0	*3*
Netherlands	**71**	21	0	38	10	17	*157*
Austria	**369**	0	33	41	-	12	*454*
Poland	23	-	4	23	-	1	*50*
Portugal	**40**	2	0	0	1	41	*85*
Romania	**35**	5	1	1		0	*42*
Slovenia	**34**	5	0	1	0	2	*43*
Slovakia	**24**	0	-	-	0	0	*24*
Finland	**19**	-	-	-	-	11	*30*
Sweden	-	-	-	-	-	12	*12*
United Kingdom	1232	19	-	**1313**	7	65	*2,636*

Data: Eurostat BERD

[1] 2011 for CZ, DE (C29), SK (C29); 2009 for BE, BU (C29, H49-53), LX (C29, H49-53), AT, EE (C301), SK (C301, C309, H49-53), NL (C302, C309), HU (H49, H49-53), PL (H49-53), SE (H49-53). Bold numbers represent the most important sector within each country.
- not reported by the country

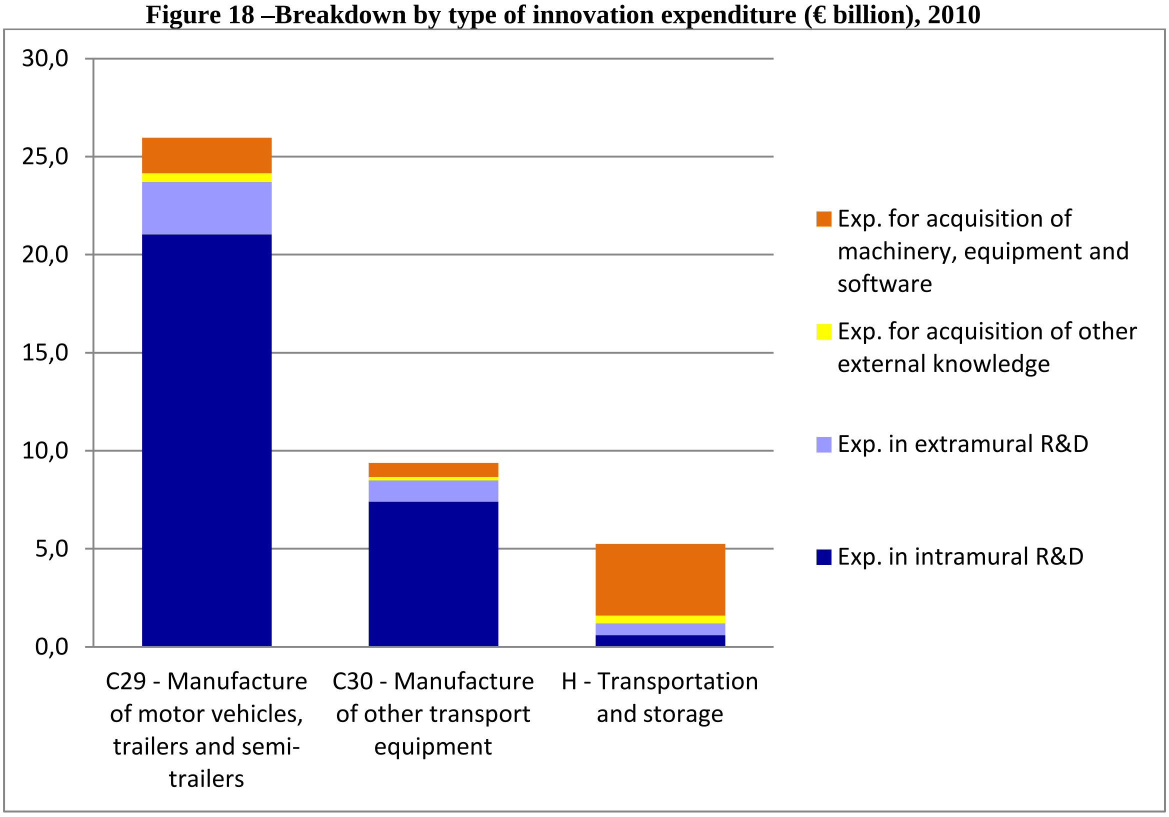
The CIS is a survey on innovation activities in enterprises covering the EU Member States, together with Iceland, Norway, Croatia, Serbia and Turkey. Some of its results can be disaggregated using NACE classification of economic sectors. However in this case there is no disaggregation for railways, aircrafts and ships manufacturers, as data is presented at a higher level of aggregation under the 'C30' category of 'Manufacture of other transport equipment'.

Several questions are ask about innovation in companies including how much they spend in innovation and about the type of innovation performed. Innovation expenditure is not only restricted to in-house R&D activities, besides that businesses innovate by acquiring innovative machinery, equipment and software, but also by acquiring other external knowledge (e.g. buying patents) or subcontracting other firms to perform R&D activities (extramural R&D).

The results of the last CIS for the year 2010 (Figure 18) show that, for the transportation and storage sector, the expenditure for acquisition of machinery, equipment and software is actually higher than intramural R&D. This sector is constituted mainly by service provider companies for which process innovations are more important than the product type of innovation. In this sense, service companies find it more beneficial to introduce innovations that have been developed by others, than developing it themselves. The total innovation expenditure of this sector is the lowest among the three analysed sectors (EUR 5.2 billion). As already noted in Wiesenthal, T. et al. (2011) these results are also in line with the considerations on the varying incentives to innovate across the diverse transport subsectors (see section 2.3.2).

Manufacturing industries, especially the manufacture of motor vehicles trailers and semi-trailers, report higher total innovation expenditures (EUR 26 billion). In both manufacture sectors, intramural R&D represents the higher share of innovation expenditure (81% for the Manufacture of motor vehicles trailers and semi-trailers and 79% for the Manufacture of other transport equipment).

Figure 18 –Breakdown by type of innovation expenditure (€ billion), 2010



Data: Eurostat CIS Survey 2010

Note: C29(no data for BU, DE, MT); C30 (no data for DE, IR, CY, LX, MT, and FI); G45 (data only available for DK, SP, IT, MT, and NL); H (no data for DE, LT). When available intramural R&D gaps were filled with figures from the Eurostat BERD database.

4.3.2 Corporate R&D investment by transport subsector (bottom-up approach)

Previous data sources offer an incomplete picture about R&D investment in the transport sectors defined in FUTRE. NACE classification includes companies that are not considered here as belonging to the transport sector (e.g. airspace industry under the category ' Manufacture of air and spacecraft and related machinery '), while sectors such as transport infrastructure providers and ITS are not treated separately. Furthermore some important countries are sometimes missing data for some sectors (e.g. France in the rail sector) or for some years. For these reasons we decided to perform a bottom-up approach, based on data offered by the EU Industrial R&D Investment Scoreboard. This section presents the methodology, followed by the results.

Methodology

The methodology is based on a bottom-up approach developed by Wissenthal et al. (2011). The main advantage is that we can analyse R&D investments in a systematic way, trying to approach all the transport sub-sectors that have a role along the innovation chain. We can also include companies that are classified outside the transport related categories by previous data sources, as their core activity is not related with transport. However some of these companies are among the biggest R&D spenders in the transport sector.

Previously Wissenthal et al. (2011) used the bottom-up approach to estimate R&D investments within transport sectors and disaggregated by technological fields. In our case only the disaggregation by transport subsector will be performed, since data on R&D by technological fields is rarely available. This approach consisted in of the following four steps (Figure 19):

Step 1: Identification of key industrial players by subsector.
Key industrial players and innovators in the transport sector were identified. Companies were selected one by one instead of relying on the classification by sector, allowing companies from ICB sectors that are not necessarily transport-related to be considered, such as industries that act in the supply chain. A total of 194 relevant companies have been identified. Note, however, that since the lists of key companies is not exhaustive, neglecting minor players that might provide a far greater R&D commitment, results tend to underestimate the total R&D efforts dedicated to transport subsectors.

Step 2: Gathering of information on R&D investments

The overall R&D investments in the year 2011 had to be identified for the companies selected. The most important data input are the companies' financial statements that are published in their annual reports. This information is collected in the EU Industrial R&D Investment Scoreboard, which is therefore used as the most important single data source. To the extent possible, gaps in the information of the EU Industrial R&D Investment Scoreboard have been filled through a systematic research of annual reports or other information for those companies that are not obliged to publish their financial statements.

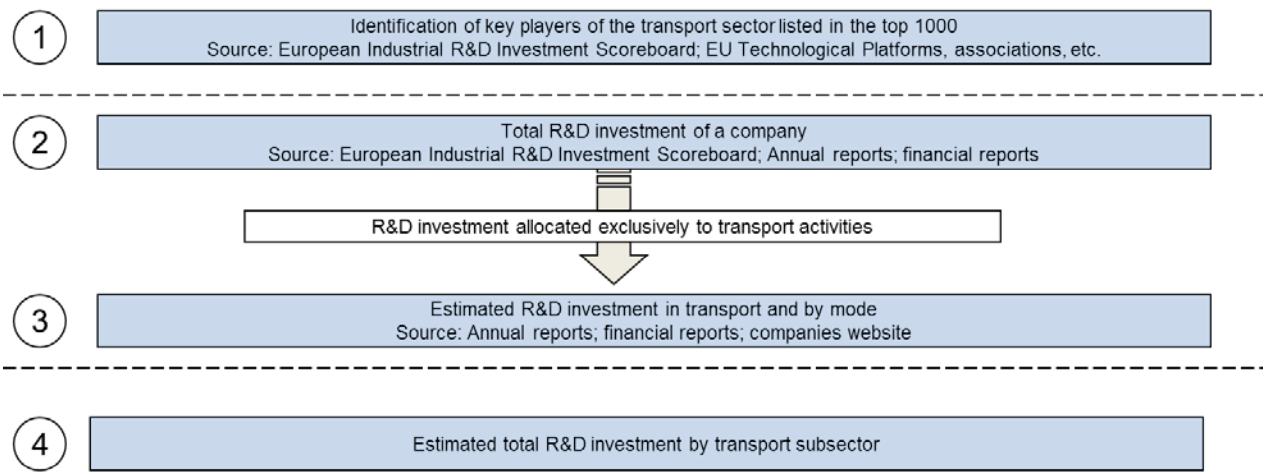
Step 3: Estimation of non-transport related R&D activities and breakdown by sub-sector.

Even though many of the companies identified are exclusively active in the transport sector, a number of large companies also have substantial activities in non-transport sectors. This is the case in particular for large supranational companies such as Bosch, Siemens, Alstom, etc. For those players, assumptions had to be made on the parts of their overall R&D activity that are directed towards transport. In a number of cases, this figure can directly be derived from official sources. In other cases, it was approximated by e.g. the turnover of the various branches, thus including some uncertainty to the results. Furthermore, for companies active in more than one transport sector, an allocation of R&D investments by sub-sector was performed. The following transport subsectors are considered:

- Automotive industry
- Civil aviation equipment manufacturing industry
- Rail transport equipment manufacturing industry
- Waterborne transport equipment manufacturing industry
- Transport service providers
- Transport infrastructure construction sector
- Intelligent transport systems sector

Step 5: The summing up of the individual companies' R&D investments by transport subsector.

Figure 19 – Schematic overview of the methodology

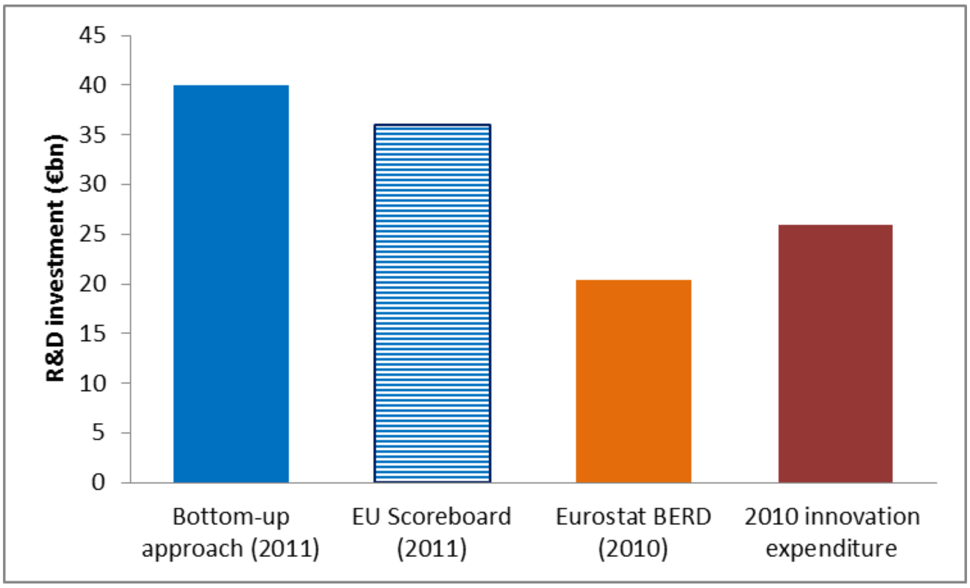


Results for the automotive industry

The automotive companies invested EUR 40.8 billion in R&D in 2011. This figure results from the assessment of 75 EU-based companies that are the key players in the sector. These companies sum around EUR 838 billion of sales in 2011, leading to a R&D intensity of 4.9%. It is worth noting that in 2008 Wiesenthal et al. (2011) found a R&D intensity of 5.2%. This lower figure in 2011 is the result of an increase in sales that is proportionally higher than the increase recorded in R&D expenses. The automotive sector presents the third largest R&D intensity among the transport subsectors.

Figure 20 summarizes private R&D investments reported by recent sources with regard to the automotive industry. The comparison between different sources must be done carefully due to discrepancies between data sources (methodology, geographical coverage or classification use). Despite all the differences, Figure 20 proves that our results are well supported by other sources. The amount estimated by this bottom-up approach overestimates slightly the one provided by the Scoreboard under the ICB category of automobile and parts, since now several companies outside this ICB category are included as they operate, at least partially, in the automotive sector. The overestimation is higher between our results and other data sources, such as the BERD and CIS, which estimated around EUR 20 and 26 billion respectively, for the category of 'manufacture of motor vehicles, trailers and semi-trailers. In addition to the use of a different classification, it must be recalled that these sources use a different geographical allocation of R&D funds. BERD and CIS data allocate all companies expenses to the country where the company operates, while the Scoreboard allocates the R&D expenses to the country where the company has its registered headquarters. In practical terms this means that in our bottom-up approach we are considering that all R&D reported by e.g. BMW are allocated in Germany (where it has its world headquarters) despite the fact that some share of this R&D is being spent in other countries, including outside the EU. Additionally both BERD and CIS figures refer to year 2010, since no data was available for 2011 (in the case of BERD only Czech Republic, Germany and Slovakia reported data for 2011) while the Scoreboard data refers to 2011.

Figure 20 – Innovation and R&D expenditure of the EU automotive industry



Results for the civil aviation equipment manufacturing industry

The Scoreboard reports EUR 8.8 billion for the ICB category 'Aerospace and defence' for the year 2011 within EU-based companies. This category includes research activities in aerospace (aeronautics and space) and defence segment.

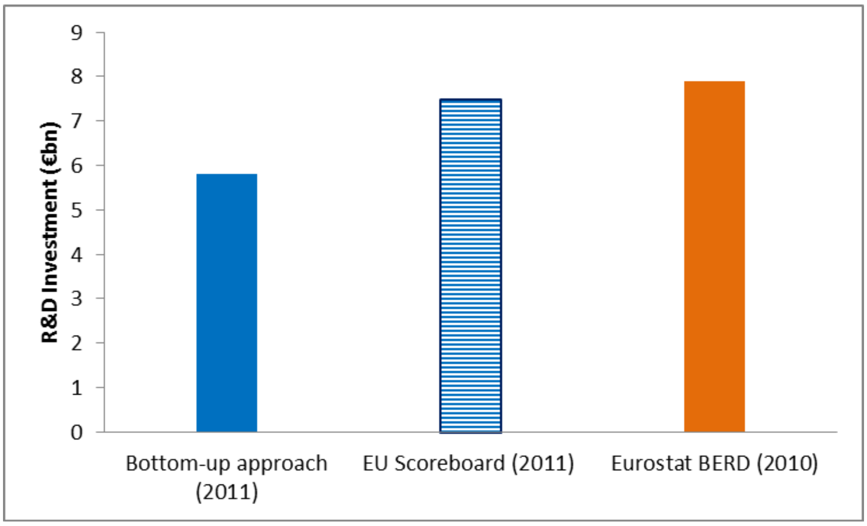
The bottom-up approach was used to estimate the R&D investments of EU-based companies working in civil aeronautics, thus excluding military and space-related R&D activities from the previous data source. The analysis was based on 25 companies that are the key players of the EU's civil aeronautics sector. Their sales exceeded EUR 89 billion in 2011 which represents a large fraction of the total turnover (EUR 93 billion) reported by Eurostat for the same year under the category of 'Manufacture of air and spacecraft and related machinery' (see section 6.1), despite discrepancies of categorization and geographical allocation schemes.

For the air transport sector, the present assessment estimates the total R&D investment in civil aeronautics to have reached EUR 5.9 billion in 2011. This is a lower estimate compared to the one provided by the BERD under the NACE category C303 'Manufacture of air and spacecraft and related machinery', which indicated a total of EUR 7.9 billion for 2010 (in 2011 only Czech Republic had reported data) (Figure 21).

The figure provided by the Scoreboard is, as we have seen previously, higher than our estimated value. This difference is due to the use of different classification (BERD and Scoreboard include spacecraft companies and the Scoreboard figures include companies working in the military sector) and to different geographical allocation scheme in the case of BERD.

The R&D intensity of civil aeronautics companies is the highest among the selected sectors, 6.5% on average, with some companies reporting more than 10% of R&D intensity, as Finmecannica (Italy, 13%) and Industria de Turbo Propulsores (Spain, 10%).

Figure 21 – R&D investment of the EU air transport industry according to different studies



Results for rail transport equipment manufacturing industry

In the rail sector Siemens and Alstom are by far the largest R&D contributors to the EU's rail transport equipment manufacturing industry. The analysis performed considered 18 EU-based companies that include several rail suppliers.

In 2011 the net sales of all these companies exceed EUR 26 billion a value that is not far from the Eurostat figure for the manufacture of railway locomotives and rolling stock (EUR 23 billion) for the same year despite the fact that several companies, not classified as belonging to the rail sector, are now considered in our bottom-up approach.

The analysis carried out leads to an estimate of EUR 921 million spent in R&D in 2011, implying a R&D intensity of 3.5%, two decimal points less than the estimated R&D intensity for 2008 (Wiesenthal et al., 2011).

The Eurostat BERD database reports, for the NACE category 'Manufacture of railway locomotives and rolling stock', an aggregate R&D investment of EUR 178 million which is far below our estimated figure. Several facts may explain this big difference: this figure is from 2010 since only Czech Republic had reported data for 2011. More important is that very few countries (14 of 27 countries) reported R&D data for this sector, including important players such as France or Spain. Additionally and as already mentioned, our estimate includes R&D investment from companies that are not categorized under the 'Manufacture of railway locomotives and rolling stock' but play an important role in this sector.

Results for waterborne transport equipment manufacturing industry

Main EU-based waterborne transport equipment manufacturing industries recorded a R&D investment around EUR 618 million in 2011. This figure results from the assessment of 20 EU companies. Even though the main EU companies have been considered, this figure is probably an underestimation of reality, since a number of smaller companies have not been included in the present analysis.
This sector presents a lower R&D intensity than the previous ones, an average of 3.2% among considered companies.
Eurostat BERD under the NACE R2 sector 'Building of ships and boats' reports a R&D investment of EUR 391 million for 2010 (data for 2011 was not available). However this is probably an underestimation owing the fact that only 13 EU Member States are covered. Our higher estimation is also due to the fact that we include companies that are not classified as 'Building of ships and boats' by the BERD (e.g. Rolls-Royce or ThyssenKrup).

Results for the transport service providers

For this transport subsector a diversified group of companies were considered. Some are listed in the Scoreboard as 'Industrial transportation' such as Deutsche Post, SNCF. Other companies are involved in the provision of passenger transport services, such as rail operators (e.g. Deutsche Bahn), providers of infrastructure services (harbours and highways operators) public transport operators (e.g. Veolia) and airliners (e.g. Lufthansa). In total 26 companies were assessed.

Smaller companies are excluded from the analysis thus leading to an underestimation of results. The aggregate R&D investment estimated for the sector 'Transport service providers' accounted for EUR 784 million. Our estimated R&D figure overestimates the one registered by the BERD data source which in 2010 is around 407 million. Despite the different geographical allocation of R&D funds and different year (no data was available for 2011) it is important to keep in mind that the BERD figure for the 'Transportation and storage' category, does not include infrastructure operators (such as highways operators or harbours), which are included in our definition of transport service providers.

Transport service providers are characterized for their low R&D intensity. The R&D intensity of this sector is the lowest among all assed transport sectors, around 0.3%. Among the companies considered TNT and NATS presented higher R&D intensities, 2.74% in both cases.

Results for the transport infrastructure construction sector

In order to extend the scope of this bottom-up approach to also include research on transport infrastructure, the level of R&D investments stemming from key infrastructure construction companies has been assessed. The collection of information focused on the R&D investments of 18 EU-based firms that are considered as key players on this domain (e.g. Bouygues, Balfour Beatty, Skanska), and form part of the Europe's 100 construction companies listed in Deloitte (2009). Their R&D investments and turnover have been taken from the EU Industrial R&D Investment Scoreboard database. Also some companies that produce construction equipment (e.g. Atlas Copco, Metso, Demag) have been considered. To the extent possible, only the R&D investments and net sales related to transport infrastructure, and to the manufacturing of equipment for infrastructure construction, have been taken into account.

The transport-related parts of the R&D investment of these companies amounted to almost EUR 325 million in 2011. In total, the R&D intensity of this group is rather limited (0.3%), even though important differences can be observed between construction companies with very low R&D intensities (below 1%) and the manufacturers of transport infrastructure construction equipment with R&D intensities in the order of 1% to 3%.

Results represent a slightly increase in R&D investment estimated by Wiesenthal et al. (2011), who found an R&D investment for this sector of almost EUR 300 million in 2008 with a similar R&D intensity.

Results for the intelligent transport systems sector

Intelligent Transport Systems (ITS) are solutions based on Information and Communication Technologies (ICTs) and electronic tools that aim to provide innovative services for transport applications. A wide variety of very different actors are pursuing research on ITS. These comprise non-transport companies involved in the general production of ICT (hard and software), many manufacturers and component suppliers of transport equipment and a number of companies dedicated specifically to ITS. Given the significant overlap of application of ICTs and the difficulty to allocate expenditures to end-uses, it is very difficult to identify with a sufficient precision the transport-related parts of the high total R&D investments of the ICT sector. In addition, the research activities of the European transport industry that concentrate on ITS solutions are also difficult to single out from the total R&D investments by transport subsectors.

For these reasons, the analysis carried out in this report cannot provide comprehensive figures on investment levels directed towards R&D on ITS. Instead, it gathered information from 12 dedicated ITS companies that are particularly involved in the development of ITS such as TomTom, Tieto, Kapsch Traficcom, Invensys, Indra Systems and Elektrobit. Their overall R&D investments reached € 625 million and an average R&D intensity of 5.2%. This is, however, a strong underestimation of the total ITS research activities considering the above.

Despite the limited number of companies in the ITS sector, the above results indicated a rather good performance of these companies in relation to R&D. In addition, the low capital intensive that generally characterises the ITS sector, further strengthens the identification of a strong innovation potential in the application of ITS to the transport sector.

5. Patent analysis

Competitiveness in technology-based economic sectors is to a large extent based on technical innovations. The more innovative a company, sector or economy is, the higher tends its competitiveness to be. Innovation, in turn, is the result of research activities and subsequent technology development in those sectors. Accordingly, research can be considered as an important precondition for competitiveness. In order to measure the intensity of research activities, it is possible to use both input indicators such as R&D expenditure, which describe the effort going into these activities, and output indicators such as patent applications, which measure inventions yielded by these activities.

5.1 Method

Since patents document the outcome of research, they are more closely linked to competitiveness than input-based indicators (Grupp 1997). This argument holds despite the fact that the application of patents may not always lead to the respective innovative product or process (cf. strategic patenting). Moreover, as patents and their contents are publicly accessible, it is possible to specify in detail who invented what and successfully applied for the respective patent where and when. This yields the opportunity to figure out how research and, with few years of delay, patenting activities in certain technology areas compare with each other, change over time and are split into different (national) economies or regions. In order to do so, the number of patent applications is counted for specific countries, years and technology areas. While the former two are identified in the patents (and in the respective database) quite easily, the assignment of a patent to a specific technology area is more challenging. Since the International Patent Classification (IPC) classifies inventions according to their functional (e.g. physical, chemical and so on) principles, it is basically well suited for this purpose. However, difficulties arise in the case of process innovations, which are based on implicit rather than codified knowledge, and specific product innovations, which are mapped by the existing IPC system too broadly or with an inadequate logic. The latter short-coming is accommodated by the combination of different IPC categories or of an IPC category with other attributes (e.g. keywords in the title or abstract) (see Legler et al. 2006).

As the focus of this analysis is on international competition and the underlying technical capacity, reference is made to patent applications filed to the World Intellectual Property Organisation (WIPO) via the Patent Cooperation Treaty (PCT) and to the European Patent Office (EPO). Both approaches enable simultaneous patent application in a wide variety of countries and thereby avoid as far as possible any bias towards specific patent issuing countries (Walz et al. 2008). The database used for the patent analysis is PATSTAT (version: December 2012), which allows for 2010 as the latest year with complete patent counts.

5.2 Technology areas

The aim of this study is the assessment of the competitiveness and, as a precondition, the technical capacity of the EU and its member states for the development and production of commodities related to mobility as a whole and different aspects of it. One evident way of distinction and specification is the mode of transportation: road and rail-bound, navigation and aviation. Since transportation is a major source of greenhouse gas emissions, a lot of innovation effort and respective technical capability is and will be needed to meet this challenge. At the same time, as climate and environment-friendly transportation will become an ever more important issue in the future, these innovative activities will raise the competitiveness in a rapidly expanding market. Therefore, types of drive trains responding to these challenges can be used as an additional criterion of distinction. Internal combustion engine (ICE), electric and hybrid drives as well as, for the latter two, batteries and fuel cells as power sources are prominent examples of relevant technology areas in this context. As the progress in the development of the ICE is considered as far-reaching today already, it is not expected to allow for major contributions to the competitiveness of car manufacturers in the future. Alternatively, bio-fuels are included in this analysis, because they can enable a very efficient ICE to become even more climate-friendly. Additionally, an important way of saving resources and mitigating greenhouse gas emissions in all transport modes is the design and construction of light-weight vehicles. Eventually, an important means of reducing the above-mentioned environmental impacts is the shift from more harmful (e.g. individual motorized) to less harmful (e.g. public or non-motorized) transportation. The related technical issues are summarized under the term 'new mobility concepts'.

The following list will provide an overview over the specific technical issues covered in the selected categories. This systematic list has been developed by Fraunhofer ISI in the course of several projects (e.g. Leduc et al. 2010) and specifically adjusted to the focus of this project (FUTRE).

- **Bio-fuels**. This category comprises a variety of processes for the reclamation of liquid or gaseous hydrocarbons from various sources of organic waste, the beneficiation of these hydrocarbons and their transformation into fuel.
- **Electric drive**. It includes energy efficient electric motors, their functional and mechanical integration into the vehicle (including power transmission between motors or between the motor(s) and axle or wheels); electronic devices for measuring and controlling one motor or a combination of electric motors; measurement and control of battery parameters.
- **Battery**. Functional principles, construction and design of all types Li ion and related secondary batteries; thermal control thereof.
- **Hybrid-electric drive**. Design and integration of motors of different types in one vehicle (common or alternative use), especially combustion engine-driven generators powering

electric motors; special control devices for hybrid-electric drives; recovery of break energy.

- **Fuel cell**. Functional and design principles, production of fuel cells with special reference to components occurring in PEM fuel cells (type prevailing in vehicles); integration of fuel cells into vehicle; devices for the transport and provision of hydrogen to the fuel cell.
- **Rail-bound** infrastructure incl. vehicles/coaches. Magnetic levitation train, suspension track, underground; various motors and combinations thereof including their functional integration and control; design and production of wheels, breaks and carriages.
- **Navigation**. Various ship propulsion systems (e.g. water or air-based propeller, wind-based, jet), various types of engines; drive control.
- **Aviation**. Various types of aircraft, construction and design elements (e.g. body, wings, steering) influencing stability (e.g. light-weight) and aerodynamics of the aircraft; propulsion principles and devices, construction thereof.
- **Material efficiency**. Focus on light-weight construction; special manipulation of (combinations of) of material (e.g. tailored blanks); special materials (e.g. aluminium and magnesium alloys, combinations of various materials); surface treatment leading to higher stability and reduced weight.
- **(New) mobility concepts**. Data processing the optimizing the operation and facilitating the use of public transportation; navigation systems (identifying the most efficient route).

It should be noted that the degree of specificity represented by the above categories is a compromise between the potential desire for an even more disaggregated assessment on the one hand and the need to identify a minimum number of patents in each of the categories in order to ensure statistical significance of the assessment results.

5.3 Research performance of the European Union and its member states

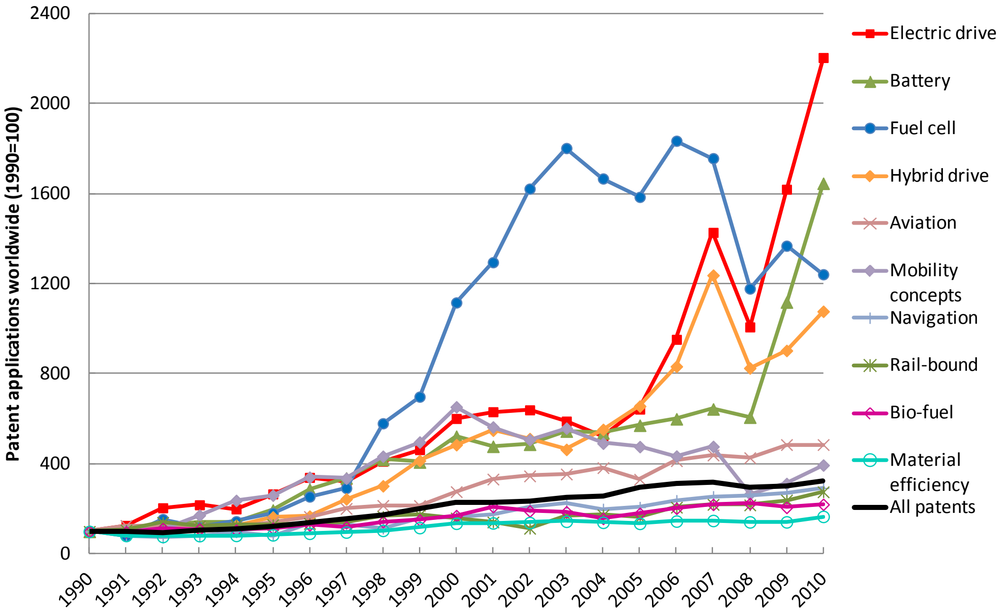
The major part of the assessment of the research performance of the EU and its member states comprises a comparison of their patenting activities with those of the leading patenting nations worldwide. For this purpose, patent shares as well as the patent specialization of the countries will be examined more closely. Before this is done, however, the analysis will start with an assessment of the general patenting dynamics in the different mobility-related technology areas specified in section 5.2.

5.3.1 Patenting dynamics

Patenting dynamics describes the changes in patenting activities and includes long-term trends as well as sudden changes. While the long-term increase in patent application reflects the general tendency of actors in specific technology areas to engage in patent application and the maturity of these areas in terms of technical progress, short-term changes often indicate changes in the basic conditions, for instance in the legal framework. So, patenting dynamics enables the identification of technology areas with a stronger increase in patent applications, which will show fierce competition in the future and depend more strongly on on-going and even increasing research activities.

As is evident from Figure 22, the technology areas show a high diversity in terms of patenting dynamics. While the number of patent applications increases more than 20-fold in the time period 1990 to 2010 for the area of electric drives, it does not even double for material efficiency.

Figure 22 Dynamics of the worldwide patenting activities in mobility-related technology areas (all patents for comparison)



Source: Fraunhofer ISI, own data assessment

There is a clear gap between the leading areas exceeding an index of 1000 in 2010 and those reaching not even 500 after starting from 100 in 1990. Technology areas of the former group are electric motors (reaching 2205), battery (1646), fuel cell (1242) and hybrid drive (1078), which all and exclusively represent components of new, alternative drive systems. Each of them shows a more moderate increase during the first part of the analysis period and then experiences a sudden strong increase at a certain point in time. For the fuel cell, this take-off takes place in 1998, for electric drive and hybrid drive around 2005 and for the battery technology in 2008. Remarkably, these were not the points in time when the technologies appeared for the first time, but when more than one company became interested in them (e.g. Toyota's Prius was first launched long before 2005).

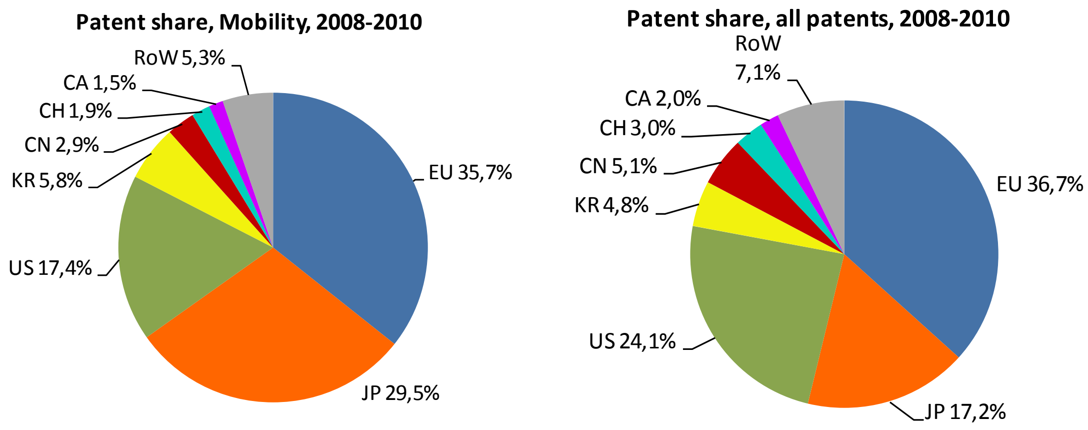
The next group of technologies were those representing broader aspects of transportation with aviation taking the lead (486), followed by (new) mobility concepts (395), navigation (293) and rail-bound technology (276). It can be argued that, to the extent that their curves lie above the curve representing the entirety of all patents, just the broadness of these technology areas can be a cause of their lower performance. This is so, because research activities tend to be distributed unequally over a variety of sub-areas and, accordingly, it would be much more unlikely for such a large compounded area to show high research performance in each of its parts. The fact that none of the broader areas shows the take-off phases described for the first group seems to further support this argument.

The final group of technologies are bio-fuels and material efficiency. Both are not or only partly associated with the transport sector. And with index values of 220 and 167, respectively, they show the lowest increases of patenting activities in 2010 – reaching only two thirds and one half, respectively, of the index value of all patents (326).

5.3.2 Patent shares

A first indication for the relative research performance of two countries is the ratio of the number of patents they hold. The larger a country's share of the worldwide patent applications, the higher it ranks in the respective performance list. For the patents issued in the whole area of mobility, Figure 23 (left part) shows the shares of all countries with shares greater than 1%. Evidently, the EU (its single member states are distinguished in Figure 24, below) figures first with 35.7%, followed by Japan (29.5%) and the US (17.4%). Other significant shares are contributed by South Korea, China, Switzerland and Canada. When these figures are compared with the shares of the same countries for patent applications in all technology areas (see Figure 23, right part), it turns out that the ranking order remains the same. Also the share of the EU is almost unchanged. However, Japan and Korea figure much more prominently in mobility than in all patents, whereas for all remaining countries the opposite is the case.

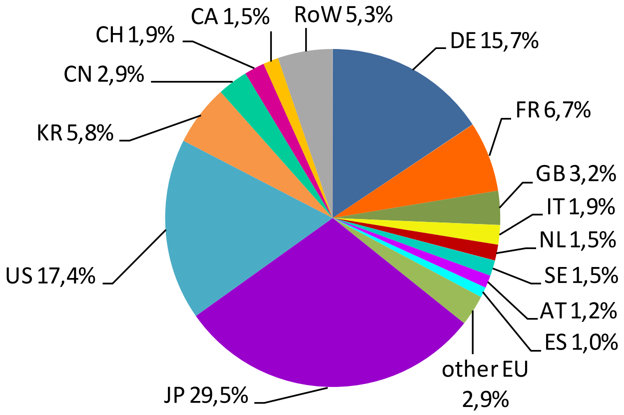
Figure 23 Comparison of the patent shares of the most relevant applicant countries (share > 1%) in 2008 to 2010 for mobility and all research areas.



Source: Fraunhofer ISI, own data assessment

When the patent share of the EU is further disaggregated for its member states (see Figure 24), it turns out that Germany and France hold around 40 and 20%, respectively, of all patents in the EU. So, Germany and France rank 3rd and 4th on the global scale, between the US and Korea. Moreover, Great Britain, Italy, the Netherlands, Sweden, Austria and Spain together hold about 30% of all mobility-relevant patents in the EU.

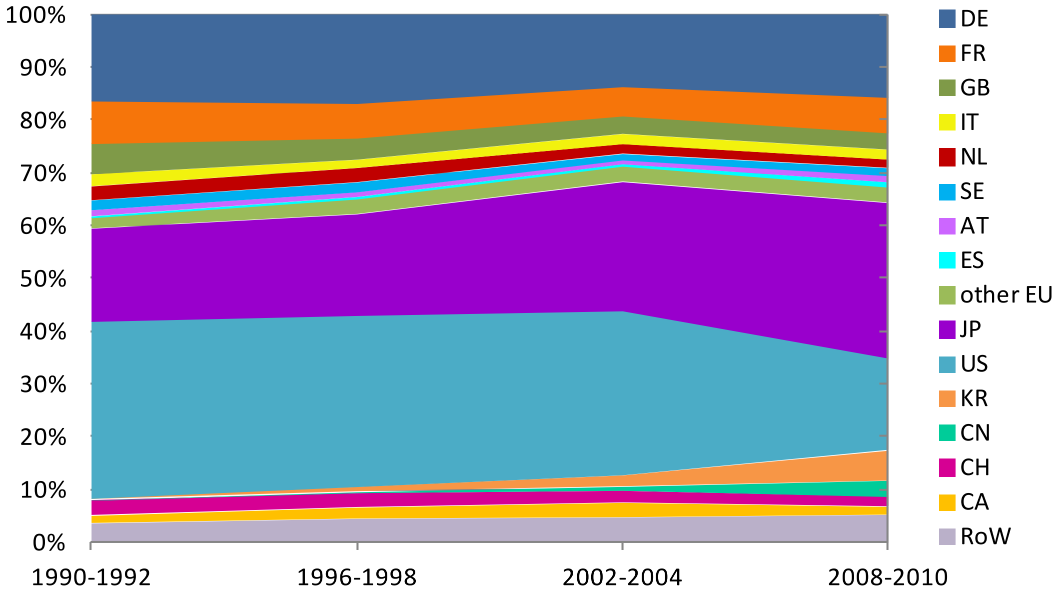
Figure 24 Patent shares for mobility of the most relevant applicant countries including EU member states (share >= 1%) in 2008 to 2010.



Source: Fraunhofer ISI, own data assessment

Putting the patent shares in a time perspective, a few important facts can be recognized. Between 1990 and 2003, Japan was able to expand its share significantly and essentially at the expense of the EU. Over the same time period, the US suffered only small relative losses, while Korea and China made gains of about the same size. After about 2003, the US experienced a 'collapse' with its patent share decreasing from 31.2% in around 2003 to a mere 17.4% just 6 years later. With the exception of Switzerland and Canada all other countries listed in Figure 25 could take advantage of this and at least maintain, but more often expand the share they held around 2003.

Figure 25 Change of patent shares of mobility-relevant countries during the time period 1990 to 2010.

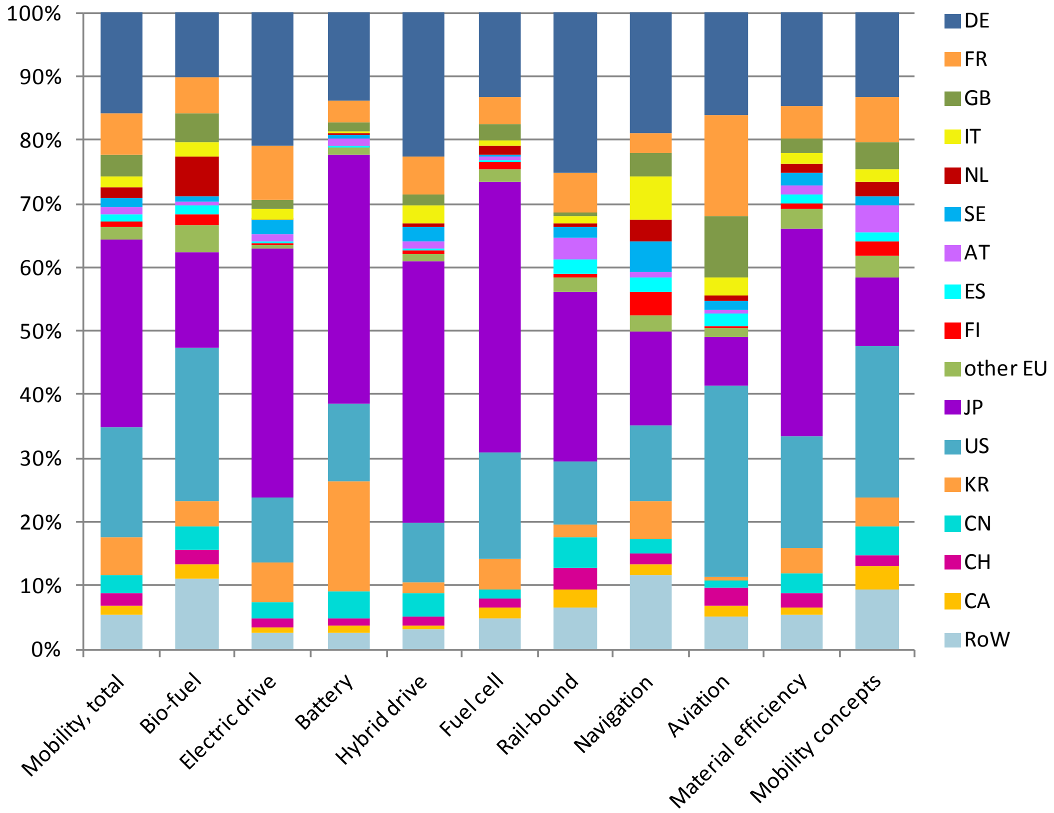


Source: Fraunhofer ISI, own data assessment

After identifying trends and shares for the application of mobility-relevant patents in general, the forthcoming analysis focuses more closely on the country shares in different specific technology areas. As is evident from Figure 26, the country profiles are quite different.

Looking at the EU countries first, Germany shows disproportionally (with respect to mobility in total) large shares in rail-bound, hybrid-drive, electric drive and navigation (in decreasing order). For France, aviation and, to a lesser extent, electric drive are above average. Other prominent areas with respect to patent shares are bio-fuel for the Netherlands, navigation for Italy, Sweden and Finland, aviation for Great Britain and mobility concepts for Austria. In two cases, battery and fuel cell, no EU country shows disproportionally strong patenting activities. It is not surprising that the EU as a whole does not play but a minor role in those cases. On the global level, by contrast, especially strong players in battery technology are Japan and Korea and in fuel cell Japan alone. Japan additionally takes the lead in electric and hybrid drive; so it dominates alternative drive technologies altogether. The US, by contrast, dominates the areas of bio-fuel, aviation and mobility concepts. The fact that Japan hardly plays a role in aviation well reflects the almost complete division of the global market between the EU (Airbus) and the US (Boeing).

Figure 26 Patent shares of the most relevant applicant countries (share >= 1%) for different mobility-relevant technology areas in 2008 to 2010.



Source: Fraunhofer ISI, own data assessment

Assessing the role of companies as patent applicants, it is hardly surprising that in this global comparison even multi-national companies cannot attain the patent shares typically achieved in national studies. Even in the technology area with the highest concentration of applicants, hybrid drive, the ten best performing applicants together are responsible for not more than 21.3%. The corresponding figures for electric drive, battery and fuel cell are between 10 and 20%; and for the remaining, broader technology areas, the cumulative share of the top 10 applicants even lies clearly below 10%. Nevertheless, if a country maintains an outstanding position in one or the other technology area, large companies associated with this country tend to rank highly in the list of applicants. In the case of bio-fuel, for instance, Shell is the leader and largely responsible for the relatively high share (see Figure 26) of the Netherlands. In hybrid and electric drives, Toyota (JP) is first and Robert Bosch (DE) second, followed by Aisin AW, Honda (both JP), Daimler and BMW (both DE). This reflects the leading roles of Japan and Germany. The relative large share of France is reflected by Renault and Peugeot being among the top 14 and 9, respectively, in the applicant lists. Japan and the US dominate the fuel cell with Toyota and Panasonic ranking first and second and UTC and Ford (both US) ranking fourth and sixth. Although Daimler is on third position, it is the only German company in the top 12. Research in battery technology is dominated by (South)Korea (LG, Samsung and SB LiMotive) and Japan (Panasonic, Toyota and Sanyo) on the top 6 ranks. The most relevant countries in rail-bound technology are represented by Siemens (rank 1), Bombardier (rank 2, both DE), Toyota and Mitsubishi (ranks 3 and 4, both JP). The relatively large shares of France (see Figure 26) and Austria (see also Table 14) are reflected by the companies Alstom (rank 4) and Siemens Austria (rank 9). Dominated by Germany (Siemens and ZF Friedrichshafen on ranks 1 and 3), relevant research in navigation is done in two smaller countries, Korea and Sweden, with the companies Daewoo (rank 4) and Rolls Royce AB (rank 10). Research in aviation is characterized by the US (General Electric, United Technologies and Boeing) and a European consortium formed around Airbus Industries with additional companies in France (e.g. Snecma), Germany (Siemens) and Great Britain (Rolls-Royce). There are no dominant companies (share less than1%) in material efficiency and new mobility concepts.

Assessing the research performance of small countries on the basis of patent shares alone is difficult, because the number of patents strongly depends on the availability of research-relevant resources and, thus, on the size of the economies. So, it is quite natural that shares readily become quite small for smaller economies or countries exhibiting lesser patenting activities. Moreover, it is known that smaller countries do not simply scale down their research activities proportionally in all technology areas. Instead, they often tend to specialize in some areas – increasing or at least maintaining their research activity there – while decreasing or giving up research in other areas. In this case, the specialization of countries for patent applications in specific research areas is the preferable performance indicator.

5.3.3 Patent specialization

Patent specialization is measured basically by relating the share of technology-specific patent applications (p_i) from all patents in one specific country (j) to the respective share of patent applications worldwide. The *Relative Patent Advantage* (RPA) is a specialization indicator, which makes use of exactly this relationship and undergoes a twofold transformation to allow for easier handling. As is shown in Equation 1, the logarithm leads to positive RPA values, if a country is specialized, while a negative RPA indicates a disproportionally low engagement of that country in the assessed technology area. Additionally, the *Tangens hyperbolicus* function limits the logarithm to values in the range between -1 and 1.

(1)

Following Equation 1, the RPA eventually lies in the range between -100 and 100, where 100 indicates complete specialization in a technology area, 0 indicates no specialization, exhibiting equivalent patent shares within the assessed country and worldwide, and -100 indicates no patenting at all in that country. RPA values exceeding 20 can be considered as significant specialization.

Calculating the RPA for all countries with patent shares above 1% and all technology areas reveals that only a small share of all RPA values indeed indicates significant specialization. All cases of significant specialization are listed in Table 14.

Table 14 Ranking of EU countries with highest RPA (patent specialization) in different mobility-related technology areas in the recent (2008 to 2010) or medium past (1996 to 2010; in parentheses)

Rank	Country	RPA	Rank	Country	RPA	Rank	Country	RPA
Biofuels								
1.	Slovakia	71 (78)	4.	Belgium	46 (53)	7.	Portugal	27 (53)
2.	Netherlands	66 (62)	5.	Greece	41 (3)	8.	Denmark	29 (23)
3.	Czech Rep.	64 (67)	6.	Poland	34 (43)		(India)	42 (36)
Electric drive								
1.	Germany	41 (31)	2.	France	39 (12)		(Japan)	68 (71)
Battery								
–				(Japan)	68 (66)		(Korea)	86 (62)
Hybrid drive								
1.	Germany	47 (36)		(Japan)	70 (73)			
Fuel cell								
–				(Japan)	72 (49)		(Canada)	-11 (54)
Rail-bound								
1.	Austria	85 (85)	3.	Germany	55 (64)		(Canada)	31 (7)
2.	Spain	56 (47)	4.	Czech Rep.	32 (74)		(Switzerland)	13 (40)
Navigation								
1.	Finland	84 (85)	3.	Sweden	70 (78)	5.	Germany	32 (8)
2.	Italy	78 (70)	4.	Spain	61 (52)		(Australia)	61 (78)
Aviation								
1.	France	78 (70)	3.	Spain	53 (35)		(US)	22 (27)
2.	Great Britain	72 (27)						
Material efficiency								
1.	Latvia	77 (84)	2.	Czech Rep.	56 (26)	3.	Austria	39 (38)
Mobility concepts								
1.	Finland	64 (38)	2.	Ireland	63 (60)		(Australia)	64 (41)
							(Canada)	55 (31)

Source: Fraunhofer ISI, own data assessment and calculation
Notes: RPA in () are average values for the period 1996 to 2010. Non-EU countries in () for comparison

For large countries with strong general patenting performance it is much harder to exhibit a significant specialization, because the corresponding technology-specific patenting would have to go on top of an already high baseline. Therefore, it is little surprising – and by purpose – that the list mainly contains countries with small patent shares, showing lower general patenting activity. However, exceptions to this 'rule' exist: Germany in the case of electric and hybrid drive and rail-bound technology and Japan for all alternative automobile drive technology areas. Interestingly, only very few other countries stand out in the latter technology areas: France for electric drive, Korea and Lithuania for battery technology, Canada for fuel cell and none for hybrid drive. This leads to the conclusion that the dominance of the large players in these areas is so big that smaller countries cannot easily stand out. By contrast, as more opportunities for focussing research exist in the broader technology areas, more smaller countries are able to show up here. Some of these countries, such as France, the Czech Republic and Spain show up in several areas, while most of them are especially successful in only one area.

The changes in patenting specialization indicated by the differences between RPA figures shown without or within parentheses, respectively, are often in the range of statistical insignificance (+/-20). This implies that the changes are due to statistical variability. If the changes are larger, this indicates that the patenting activities were raised or dropped significantly prior to the more recent period (2008 to 2010). Fuel cell technology provides a prominent example for the latter case: while Canadian companies had been pioneers during the 1990s, Japanese companies assumed this role during the last decade.

6. Assessment of global competitiveness of European transport

This chapter aims the analysis of global competitiveness of the EU-27 transport sector by comparing the EU-27 with its main competitors. The analysis will be performed also at the Member State level when data is available. A set of indicators representing the competitiveness of transport sector have been proposed in section 2.2.2. The data comes from available statistics that are provided by three main data sources: Structural Business Statistics (SBS) from Eurostat, Database for Structural Analysis (STAN) and BERD from OECD[26]. All these sources provide data at industry level, using a statistical classification of economic activities. We have used NACE Rev. 2 for Eurostat data and ISIC Rev.3 for OECD data.

We will star by overviewing the different transport sub-sectors in the EU-27 as a whole, and then this overview will be further disaggregated by Member States. Finally the competitiveness of the EU-27's transport subsectors will be compared with that from EU's main competitors.

6.1 EU-27's competitiveness: sectorial overview

The analysis of the EU-27's competitiveness is based on data provided by Eurostat under the SBS database. R&D figures refer to the BERD data provided by Eurostat while the world

[26] BERD OECD data sometimes differ from the BERD figures provided by Eurostat.

market shares are calculated based on OECD data provided under the STAN bilateral trade by industry and end-use.

The number of enterprises across the EU- 27 provides little information for the analysis of the relative competitiveness of the different transport sectors. Output measures such as value added and turnover are generally more meaningful when representing their economic importance. For the EU 27, during the year 2010, the 'Transportation and storage' category (H) and the 'Manufacture of motor vehicles, trailers and semi-trailers' presented the highest value added, generating EUR 471.6 billion and EUR 141 billion, respectively (see Table 15). These two sectors also reported the highest turnover for the year 2010, especially for the 'Transportation and storage' sector. The other transport categories recorded much less value added and turnover, with the air industry performing better that rail and the manufacture of transport vehicles such as motorcycles. Similar conclusions can be drawn by looking at the production value. The output of EU-27's transport sectors recorded an abrupt decrease in 2009 (see Figure 27) especially in the manufacture of motor vehicles trailers and semi-trailers and in the transportation and storage sector. After this year transport sectors registered a recovery except the transportation and storage sector which continue to decrease till 2011.

In employment terms, the importance of 'Transportation and storage' is in line with a higher number of enterprises and mentioned measures of output. This is a relatively high labour-intensity sector that employed 10.4 million people in 2009. The automotive industry is the second largest sector in terms of employment (938 thousand people), while the manufacture of transport vehicles such as motorcycles and rail manufacturers registered the smallest number of persons employed.

The large amount of labour in 'Transportation and storage' and automotive manufacturers justifies the important figures for personnel costs registered by these sectors (EUR 302 billion and EUR 95 billion, respectively). However in terms of average personnel costs 'Transportation and storage' presented the lowest expenditure (EUR 32 thousands per employee) together with the manufacture of transport vehicles such as motorcycles. Average personnel costs were higher in the air industry (EUR 59 thousands per employee) followed by the automotive and the rail manufacturers (EUR 44 thousands per employee in both sectors) which is in line with a higher specialization of the labour force that characterize these sectors.

Apparent labour productivity, which represents the value added per person employed, was especially high in the air industry (EUR 80 thousands per employee), followed by the automotive and rail manufacturers (EUR 65 and 61 thousands per employee, respectively). The less productive sectors, in terms of labour productivity, were the manufacture of transport vehicles such as motorcycles and the 'Transportation and storage'.

The gross operating surplus (value added at factor cost less personnel costs) measures the operating revenue that is left to compensate the capital factor input (such as providers of funds, taxes, self-financing investments), after labour costs have been deducted. Generally, although not always the case, the gross operating surplus will be higher for capital-intensive activities and lower for those activities with higher share of their costs devoted to personnel. The gross operating rate (gross operating surplus divided by turnover and expressed in percentage) can be regarded as one measure of profitability and an indicator of competitiveness. The highest level of profitability in the EU-27 was recorded by the 'Transportation and storage' sector (13.6%) which despite being a labour intensive sector, turns out to be quite profitable. The air industry (8.3%), rail (8.1%) and automotive manufacturers (6.2%) also present higher levels of profitability. Waterborne and the manufacture of transport vehicles such as motorcycles on the other hand, registered the lowest EU-27 gross operating rates (5.5% in both cases).

R&D expenditure in the business sector is considered as an important lever for companies' competitiveness. The automotive sector, as we have seen in previous sections, was by far the highest expender of R&D (EUR 20.4 billion) followed by the air industry (EUR 7.9 billion).

The bilateral trade provided by STAN database (OECD) was used to calculate the world market shares of particular industries and set of countries. Data is provided at industry level, using the ISIC classification of economic sectors. World market shares represent the share of exports of a particular country (or set of countries e.g. EU) in total world exports of a particular industry. We assume as total world exports, the sum of exports for the set of countries included in the database (64 countries).

The higher expenditure in R&D seems to be related with higher market shares since the European automotive and air industry recorded the highest world market shares among all sectors (around 50% of world exports). Market shares have been measured as the share of EU exports in global exports within each sector. Since we are using a database of exports of goods, 'Transportation and storage' sector could not be included under the market share indicator.

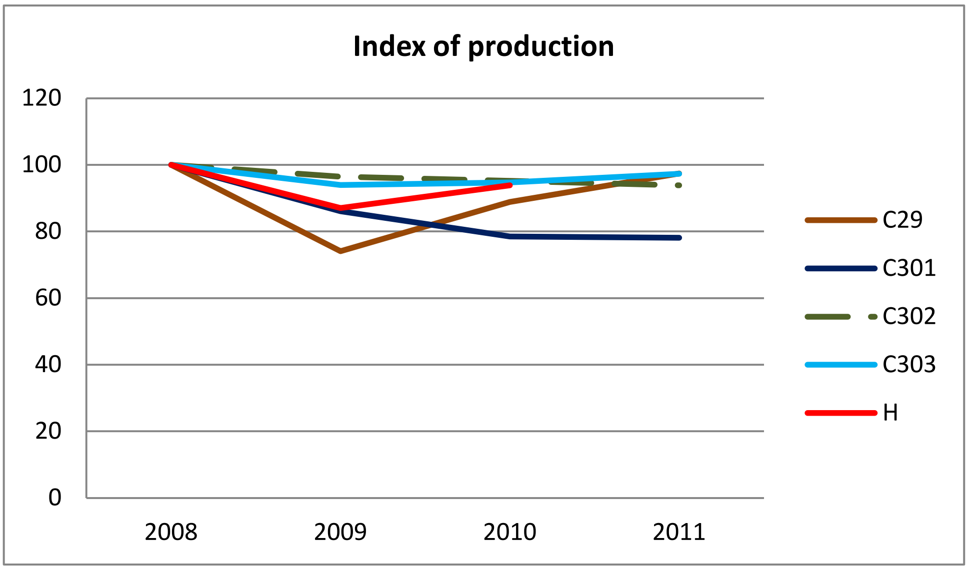
Table 15 – EU-27 transport sector, main competitiveness indicators (2010)[1]

	C29	C301	C302	C303	C309	H
Enterprises	20.5	8.7	0.9	1.5	3	1,122
Persons employed	938	182	104	242	54	10,433
Turnover	740,587	36,646	22,345	89,314	11,064	1,250,000
Production	636,518	34,154	22,262	89,952	10,188	1,155,297
Value added at factor cost	141,063	8,774	6,304	27,658	2,476	471,661
Personnel costs	95,269	6,776	4,495	20,232	1,868	302,588
Average personnel costs	44	38	44	59	32	32
Gross operating surplus	45,793	1,999	1,809	7,426	608	169,074
Apparent labour productivity	65	48	61	80	40	42
Gross operating rate	6.2	5.5	8.1	8.3	5.5	13.6
R&D expenditures	*20,455*	*391*	*178*	7,973	*158*	407
Market shares	*50.9%*	*19.0%*	*43.0%*	*52.3%*	-	-

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

1) 2009 for red values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

Figure 27 – Evolution of production, EU-27 (2007=100)



Data source: SBS (Eurostat)

6.2 Competitiveness of transport sub-sectors: Member State overview

Following the previous results, this section overviews the competitiveness of different transport subsector by Member States

6.2.1 Automotive industry

Following the definition of the automotive industry used in this project, this section analyses two distinct classes: 'manufacturers of motor vehicle, trailers & semi-trailers' and the manufacturers of vehicles such as bicycles and motorcycles (Table 16and Table 17). However statistics for 'manufacturers of other vehicles' category are missing many values when the analysis is performed at a country level.

Regarding 'manufacturers of motor vehicle, trailers & semi-trailers' Germany is by far the EU member state with the highest added value, accounting for almost 50% of EU-27 total and 20% of world market shares (Table 16).

The manufacture of motor vehicle, trailers & semi-trailers was particularly concentrated within the larger Member States. Germany, France (10%), the UK (8%) and Italy (7%) jointly represent 75% of the EU-27's value added in 2010. Accordingly these countries present the higher production value and higher turnover as well as the higher number of persons employed.

Italy is particularly successful in the manufacture of other transport equipment (in particular motorcycles and bicycles) with a production value and a turnover that is the highest in the EU-27 (Table 17).

In terms of average personnel costs there are significant differences among EU-27 Member States, where poorer countries such as Bulgaria registered EUR 5 thousands per employee and Germany recording the highest average value of EUR 64 thousands. For the other transport equipment similar patterns can be observed, although data is missing for some counties.

The highest levels of profitability within these sectors are registered by East countries such as Czech Republic, Estonia, Latvia, Lithuania, Hungary and Poland, where labour costs are not so high. On the other side, labour productivity is higher Austria (90), Germany (89) and the UK (84).

Countries were the industry is more developed are generally the ones investing more in R&D. This is the case of Germany, France, Italy and the United Kingdom with higher R&D investment and higher market shares and value added.

Table 16 – Manufacture of motor vehicles, trailers and semi-trailers (C29), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	0.5	0.1	1.4	0.2	2.9	0.0	0.1	0.3	2.0	2.0	2.3	0.1	0.0	0.0
Persons employed	19.0	0.0	33.3	0.3	464.4	:	0.2	1.1	63.4	137.6	68.5	0.0	0.1	0.1
Turnover	16,863	401	27,685	954	325,874	266	571	279	51,110	99,082	53,393	14	77	108
Production	16,205	398	27,280	867	281,750	245	516	303	47,581	62,664	45,180	14	78	107
Value added	2,679	81	5,213	313	66,839	79	132	127	8,111	14,029	10,457	6	24	31
Personnel costs	1,825	49	2,458	235	47,996	40	104	97	5,793	12,210	6,692	4	12	12
Average personnel costs	53	5	18	54	64	13	36	25	41	54	40	28	12	9
Gross operating surplus	855	32	2,755	78	18,843	39	28	36	2,318	1,819	3,765	2	12	19
Apparent labour productivity	77	8	37	71	89	26	45	30	58	63	61	27	24	24
Gross operating rate	5.1	7.9	10.0	8.2	5.8	14.5	5.0	12.8	4.5	1.8	7.1	12.3	15.6	17.5
R&D expenditures	84.2	0.0	375.9	10.3	14811.7	0.9	1.3	:	382.2	1788.8	1075.5	0.0	:	0.7
World market shares	*3.2*	*0.0*	*2.1*	*0.2*	*19.9*	*0.1*	*0.0*	*0.0*	*4.0*	*4.6*	*2.8*	*0.0*	*0.0*	*0.1*

	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	0.0	0.5	:	0.8	0.3	1.4	0.5	0.4	0.1	0.2	0.3	1.1	2.8	0.1
Persons employed	0.0	11.1	:	8.5	13.4	32.1	5.4	17.5	2.9	12.3	2.1	44.9	63.9	:
Turnover	:	13,731	:	6,551	11,827	24,520	5,957	7,768	2,895	13,371	1,188	21,955	53,998	124
Production	:	13,214	:	5,830	11,040	23,670	5,948	7,672	2,630	13,182	1,117	21,568	47,307	112
Value added	:	2,862	:	1,597	2,621	4,410	1,061	1,533	481	1,600	336	4,941	11,454	34
Personnel costs	:	968	:	946	1,585	1,880	645	899	278	778	253	3,744	5,740	23
Average personnel costs	:	15	:	48	55	13	22	8	22	15	39	59	43	12
Gross operating surplus	:	1,894	:	651	1,036	2,530	416	634	203	864	82	1,197	5,714	12
Apparent labour productivity	:	44	:	80	90	30	36	13	37	31	51	74	84	18
Gross operating rate	:	13.8	:	9.9	8.8	10.3	7.0	8.2	7.0	6.5	6.9	5.5	10.6	9.4
R&D expenditures	0.3	65.2	2.6	71.0	368.5	22.7	40.4	34.9	33.9	33.0	19.3	:	1231.9	6.3
World market shares	*0.1*	*1.3*	*0.0*	*1.2*	*1.5*	*2.2*	*0.5*	*0.6*	*0.3*	*1.2*	*0.2*	*1.4*	*3.6*	*0.0*

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

Table 17 - Manufacture of other transport equipment n.e. (C309), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	:	0	0	0	:	0	:	0	:	0	0.917	0	0	0
Persons employed	:	1	3	1	8	:	:	0	:	5	20	0	0	0
Turnover	:	65	154	88	1,583	:	:	30	:	1,002	4,115	0	0	50
Production	:	59	146	89	1,429	:	:	25	:	802	4,340	0	0	52
Value added	:	10	43	33	:	:	:	10	:	218	919	0	:	6
Personnel costs	:	3	28	27	:	:	:	6	:	228	748	0	0	5
Average personnel costs	:	3	12	52	:	:	:	27	:	45	37	:	:	9
Gross operating surplus	:	7	14	7	:	:	:	3	:	-11	172	0	:	1
Apparent labour productivity	:	10	16	63	:	:	:	38	:	42	43	:	:	11
Gross operating rate	:	10.3	9.2	7.4	:	:	:	11.5	:	-1.1	3.7	:	:	3.3
R&D expenditures	0.8	0.0	2.1	1.7	:	:	:	:	7.9	8.5	118.2	0.0	:	:
	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	0	0	:	0	0	0	0	0	0	0	0	0	0	0
Persons employed	:	1	:	3	2	6	1	1	0	0	0	2	:	0
Turnover	:	76	:	843	540	367	113	94	14	13	35	387	573	4
Production	:	69	:	756	530	344	109	94	13	7	36	364	517	2
Value added	:	9	:	166	77	95	29	12	1	1	11	123	151	2
Personnel costs	:	6	:	105	74	44	21	5	2	2	10	86	85	1
Average personnel costs	:	9	:	44	42	8	15	5	24	9	37	51	:	13
Gross operating surplus	:	3	:	61	3	52	8	7	-1	-1	0	37	65	1
Apparent labour productivity	:	13	:	66	44	17	20	13	15	4	37	68	:	33
Gross operating rate	:	4.4	:	7.2	0.5	14.1	6.9	7.4	-5.2	-6.7	1.1	9.5	11.4	20.4
R&D expenditures	:	:	0.0	10.0	:	:	0.7	:	0.5	:	:	:	7.3	0.0

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

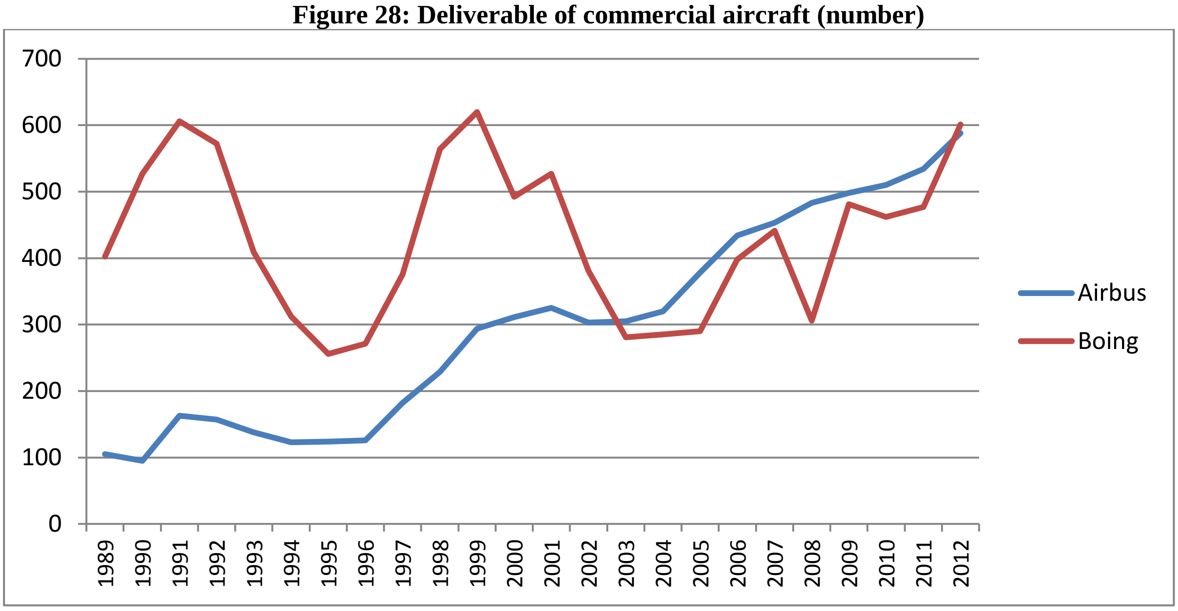
1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate is expressed as percentage

6.2.2 Civil aeronautics

This section refers to the production of aircraft that are used for the transport of passenger and freight as well as for military applications as it is given by official statistics under the NACE group 'Manufacture of air and spacecraft and relate machinery'. This sector is highly concentrated within the EU and US, as we have seen previously and is ruled by a few large manufacturers of aircrafts and engines that are at the top of the pyramid, these are supplied by medium size firms making systems, structural elements and components and by SMEs producing material software and services[27].

Globally the main producers of civil aircraft are Boeing (US) an Airbus (EU) and their market are characterized as being cyclical. Figure 28 shows the amount of aircrafts delivered by Airbus and Boeing during the period 1989 and 2007 which clearly indicates the cyclical nature of this sector. Boing seems to be more sensitive to market cycles while Airbus shows a smooth increase of deliveries over the years.

Figure 28: Deliverable of commercial aircraft (number)



Source: Airbus and Boing webpages

As we have seen before, the EU-27's aerospace equipment manufacturing sector in 2010 consisted of 1.48 thousand enterprises which created EUR 27.6 billion value added and employed 242 thousand persons.

France reported a 27% share of EU-27 value added in this sector, the highest share among the Member States, followed by the United Kingdom and Germany (Table 18).

Average personnel costs range from EUR 77 thousand per employee in Germany and EUR 9 thousand per employee in Lithuania. The highest apparent labour productivity was EUR 156 thousand per person employed in Austria and in the most developed countries such as Germany and France (more than EUR 90 thousand per person employed) while East countries

[27] These SMEs are probably not accounted for within this category since their main activity lays outside the transport manufacturer sector

registered the lower values of apparent labour productivity (around EUR 20 thousand per person employed). On the other hand East countries present the highest operating rate, an indicator of high profitability which in this case is mainly due to the lower cost of labour force.

R&D investments are especially high under this transport sector as we have seen in previous sections. Countries recording higher expenditures on R&D within the manufacturers of air and spacecraft machinery are in this order France, Germany and UK which are also the countries with the highest value added and turnover. These three countries together had around 40% of world exports within this sector, for 2010.

Table 18 - Manufacture of air and spacecraft (C303), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	0.044	0.003	0.053	0.021	0.138	0.0	0.014	0.01	0.085	0.193	0.17	0.0	0.002	0.003
Persons employed	5.2	0.0	6.0	0.2	67.7	0.0	2.0	3.0	17.7	83.1	32.5	0.0	0.0	0.3
Turnover	1,139	1	443	24	18,837	0	345	146	4,549	27,941	7,822	0	:	14
Production	1,197	1	475	22	19,529	0	344	188	4,658	27,359	8,442	0	:	16
Value added	383	:	124	9	6,340	0	178	108	1,284	7,606	2,763	0	:	4
Personnel costs	326	:	106	10	5,198	0	122	152	958	5,860	1,724	0	:	2
Ave. personnel costs	63	:	18	55	77	:	61	51	54	71	53	:	:	9
Gross operating surplus	57	0	17	-1	1,142	0	56	-45	326	1,747	1,039	0	:	1
Apparent labour productivity	74	:	21	52	94	:	88	36	72	92	85	:	:	14
Gross operating rate	5.5	:	3.9	-2.1	6.1	:	16.1	-30.5	7.2	6.3	13.3	:	:	9.2
R&D expenditures	91.1	0.0	17.3	:	2326.1	0.0	:	:	397.8	2781.9	941.8	0.0	:	0.0
World market shares	*0.7*	*0.0*	*0.2*	*0.1*	*14.0*	*0.0*	*0.4*	*0.1*	*1.6*	*20.1*	*2.1*	*0.0*	*0.0*	*0.0*

	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	0.0	0.031	:	0.069	0.019	0.051	0.014	0.021	0.017	:	0.006	0.035	0.492	0.013
Persons employed	0.0	0.2	:	3.9	0.7	14.0	0.3	3.5	0.1	0.2	1.3	:	:	0.4
Turnover	0	10	:	:	202	650	10	117	10	15	147	:	24,589	12
Production	0	9	:	:	182	700	11	122	10	9	158	:	23,725	11
Value added	0	4	:	:	106	347	:	55	5	5	76	:	7,217	:
Personnel costs	0	2	:	:	44	198	:	37	3	:	67	:	4,755	:
Ave. personnel costs	:	11	:	:	65	14	:	10	25	:	52	:	:	:
Gross operating surplus	0	2	:	:	62	149	:	18	2	:	9	:	2,462	:
Apparent labour productivity	:	23	:	:	156	25	:	16	39	:	59	:	:	:
Gross operating rate	:	22.5	:	:	30.7	22.9	:	15.6	17.2	:	6.2	:	10.0	:
R&D expenditures	:	:	0.0	38.0	41.0	23.4	0.0	0.5	1.4	:	:	:	1312.9	0.0
World market shares	*0.1*	*0.0*	*0.0*	*1.1*	*0.4*	*0.5*	*0.1*	*0.1*	*0.0*	*0.0*	*0.2*	*0.3*	*10.0*	*0.0*

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

6.2.3 Waterborne

This sector is represented by the NACE group of 'building and repairing of ships and boats'. Official statistics report that the United Kingdom, France and Germany, followed by Italy and the Netherlands, were the largest producers in terms of value added within this sector (Table 19).

The United Kingdom registered the higher value added within this sector. Output however was higher in Italy and Germany. In the United Kingdom and France production has been decreasing for the period between 2008 and 2010, with an average contraction of 1.9% per annum.

In terms of employment the United Kingdom is the country with the highest number of workers, followed by Italy, France and Germany. Within this sector also other smaller countries registered an important number of workers. This was the case of Romania and Poland which indicates the significance of this sector in these countries that together employ around 30 thousand persons, more than one tenth of the EU-27's total.

As we have seen previously the EU-27's 'building and repairing of ships and boats' sector has one of the lowest average personnel costs (EUR 38 thousand per employee) and apparent labour productivity (EUR 48 thousand per employee) among transport sectors. Germany, the UK and the Netherlands are the countries in the EU-27 with the highest labour productivity. Average labour costs are higher in Germany and Sweden, followed by countries such as Belgium, Denmark, France and Austria, all above EU's average (more than EUR 50 thousand per employee).

Poland is the country with the highest gross operating rates together with the Baltic countries, evidencing higher cost competitiveness due mainly to lower personnel costs.

R&D investments were higher in countries where this sector is more developed such as France, Germany, and Italy. These countries are also the ones with the highest world market shares in terms of exports (4.2% for Germany, 3.3% for Italy and 1.7% for France). Other countries presenting considerable exports within this sector are Poland, the UK and the Netherlands, scoring 1.9%, 1.4% and 1.3% of world market share, respectively.

Table 19 - Manufacture of ships and boats (C301), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	:	0.0	0.1	0.0	0.4	0.1	:	0.4	0.5	0.5	1.6	0.0	0.0	0.0
Persons employed	0.2	2.6	0.5	2.5	19.5	0.6	:	4.3	12.4	20.1	28.3	0.0	0.8	0.5
Turnover	45	42	37	676	6805	49	:	436	3742	4594	7225	2	70	63
Production	41	37	25	669	5751	49	:	451	3574	4598	5792	3	:	55
Value added	17	25	4	140	1118	15	:	277	878	1172	1098	1	23	31
Personnel costs	:	15	5	174	1019	8	:	140	568	1029	1057	1	:	20
Average personnel costs	42	7	11	69	53	13	:	36	47	52	40	16	12	39
Gross operating surplus	3	-25	-1	-34	99	7	:	136	310	142	41	1	:	11
Apparent labour productivity	45	7	8	55	57	25	:	64	71	58	39	28	:	60
Gross operating rate	3.2	2.6	-1.8	-5.0	1.4	15.2	:	31.1	8.3	3.1	0.6	19.7	:	17.6
R&D expenditures	0.4	0.0	0.0	:	94.6	:	:	:	72.3	118.1	54.1	0.0	:	:
World market shares	*0.1%*	*0.0%*	*0.0%*	*0.6%*	*4.2%*	*0.1%*	*0.0%*	*0.1%*	*1.2%*	*1.7%*	*3.3%*	*0.0%*	*0.0%*	*0.1%*

	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	0.0	0.1	:	1.1	0.0	0.9	0.2	0.3	0.0	:	0.4	0.7	1.0	0.3
Persons employed	0.0	0.3	:	12.0	0.2	13.1	2.0	17.5	0.3	:	7.4	3.4	33.9	11.7
Turnover	0	8	:	4430	25	989	92	913	42	25	1095	502	4687	816
Production	0	6	:	4840	23	951	91	831	44	:	1094	481	4633	973
Value added	0	2	:	1106	7	377	24	310	10	:	240	158	1787	213
Personnel costs	0	1	:	578	5	175	44	169	7	:	259	146	1336	163
Average personnel costs	:	6	:	52	32	14	23	10	24	:	36	49	40	14
Gross operating surplus	0	1	:	528	2	203	-19	141	3	:	-18	12	451	50
Apparent labour productivity	:	8	:	92	37	29	12	18	32	:	32	47	53	18
Gross operating rate	:	9.8	:	11.9	6.7	20.5	-20.7	15.4	7.1	:	-1.7	2.4	9.6	6.1
R&D expenditures	:	:	0.0	21.0	:	:	2.3	5.0	4.7	:	:	:	18.9	0.2
World market shares	*0.0%*	*0.0%*	*0.0%*	*1.3%*	*0.1%*	*1.9%*	*0.0%*	*0.7%*	*0.0%*	*0.0%*	*1.0%*	*0.3%*	*1.4%*	*0.9%*

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

6.2.4 Rail

This section shows some statistics for the manufacture of railway and tramway locomotives and rolling stock. In the EU-27, Germany is the country generating the highest value added followed by France and Spain (Table 20). These three countries together represent 55% of EU-27's value added. Other countries also recording high value added within the sector are Italy and Austria. Other indicators of output such as turnover and production value show similar distribution between countries.

Additionally, some smaller countries have consolidated their position in the rail sector, this is the case of Poland and Romania, with a value added of EUR 185 million and EUR 115 million, respectively.

Regarding exports from this sector, Germany has the highest market share, exporting around 12% of world exports. Germany is followed by Italy and by Austria which are responsible for 6.6% and 4.2% of wold exports. Also France and Spain are in a good position regarding world exports within this sector.

The number of persons employed is also higher in those countries where the railway sector is more developed. This sector is characterized as being labour-intensive and by a high proportion of operating expenditure devoted to personnel costs. Central countries present higher personnel costs and average personnel costs which are above EUR 50 thousands. Belgium and France are the countries with the higher average personnel costs (EUR 68 thousands in both cases). Regarding labour productivity, Belgium (EUR 159 thousands) has one of the highest apparent labour productivity in EU-27, followed by Spain, France and Italy. The operating rate is especially high in Belgium (36.6%) but also in Poland (18%) and Romania (17%).

In terms of R&D investments central countries, with higher expenditure capacity, spend more in research and development. Unfortunately many countries do not present data on business R&D spending for 2010 (nor 2011 or 2009) including some of the most important countries within this sector, such as France or Spain.

Table 20 - Manufacture of railway locomotives and rolling stock (C302), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	0.0	0.0	0.0	0.0	0.1	0.0	:	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Persons employed	1.2	2.3	9.4	:	20.0	:	:	0.0	11.6	14.0	10.4	0.0	1.1	:
Turnover	267	52	920		5,226			0	3,183	3,842	2,233	0		
Production	271	76	1,171	:	5,140	:	:	0	3,659	4,131	2,925	0	:	:
Value added	184	21	367	:	1,224	:	:	:	1,113	1,158	851	0	:	:
Personnel costs	78	13	164	:	1,201	:	:	0	632	950	520	0	:	:
Ave. personnel costs	68	6	18	:	60	:	:	18	55	68	51	:	:	:
Gross operating surplus	106	8	203	:	23	:	:	0	481	208	332	0	:	:
Apparent labour productivity	159	9	39	:	61	:	:	1	96	83	82	:	:	:
Gross operating. rate	36.6	10.4	19.4	:	0.4	:	:	-193.2	13.4	5.0	13.4	:	:	:
R&D expenditures	0.2	:	38.9	:	69.3	0.0	:	:	:	:	20.9	0.0	:	0.0
World market shares	*2.0*	*0.2*	*1.8*	*0.3*	*11.6*	*0.3*	*0.0*	*0.0*	*2.6*	*3.1*	*6.6*	*0.0*	*0.1*	*0.2*

	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	0.0	0.0	:	0.0	0.0	0.2	0.0	0.1	0.0	:	0.0	0.0	0.0	0.0
Persons employed	0.0	3.6	:	0.3	3.0	7.9	0.1	8.8	0.1	3.2	:	2.0	5.0	1.2
Turnover	0	253		77	1,217	421	15	219	20	218		509	1,493	65
Production	0	315	:	74	1,352	525	14	293	24	251	:	514	1,498	89
Value added	0	118	:	26	619	185	6	115	:	:	:	155	:	23
Personnel costs	0	69	:	21	:	96	4	64	:	:	:	114	:	16
Ave. personnel costs	:	19	:	62	:	13	25	7	:	:	:	61	:	14
Gross operating surplus	0	48	:	5	:	89	3	51	:	:	:	42	-49	7
Apparent labour productivity.	:	33	:	77	:	24	42	13	:	:	:	79	:	19
Gross operating. rate	:	14.7	:	6.1	:	18.2	15.4	17.1	:	:	:	7.6	-3.9	9.1
R&D expenditures	:	0.4	0.0	:	32.6	3.6	0.0	1.4	0.0	:	:	:	10.4	2.1
World market shares	*0.1*	*1.0*	*0.0*	*2.2*	*4.2*	*1.4*	*0.4*	*0.5*	*0.2*	*0.7*	*0.1*	*0.9*	*2.5*	*0.1*

Data source: SBS (Eurostat) BERD (Eurostat) STAN (OECD)

1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

6.2.5 Transport service providers

Figures in this section refer to the NACE category of 'Transportation and storage' which aggregates land transport, water transport, air transport, warehousing and transport support activities for transportation and postal and courier activities. This is a very heterogynous sector, with many SMEs operating in the land transport, warehousing and transport support activities and some few big companies operating in the rail and air transport sector for example. In total there were around 1.1 million enterprises in the EU-27, which hired more than 10 million jobs in 2010 and generated a value added that was around EUR 471 billion.

Germany, France and the United Kingdom were the three bigger countries in terms of value added (Table 21). All these countries together make up to 50% of EU-27's value added within this sector. Germany ranks first in terms of value added but also in the number of persons employed. It also recorded the biggest turnover while in terms of production value, France presents a higher value.

Personnel costs were higher in France and Germany, followed by the United Kingdom, due to a combination of higher number of persons employed and higher wages, while average personnel costs were especially high in Denmark (EUR 57 thousands), Belgium and Luxembourg (EUR 52 thousands in both cases). Average personnel costs seem to be related with labour productivity since also Denmark, Belgium and Luxembourg have the greater apparent labour productivity. Gross operating rate was generally high in East countries, but also in countries were labour costs are not so low, such as the United Kingdom (scoring the highest value, 18%).

R&D expenditure within transportation and storage sector was higher in Spain (EUR 93.6 million), Germany (EUR 63 million) and Denmark (around EUR 48 million).

Table 21 – Transportation and storage (H), main competitiveness indicators (2010)[1]

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT
Enterprises	18	19	39	12	88	4	10	69	210	88	135	3	6	7
Persons employed	217	156	278	131	1,881	37	78	203	921	1,380	1,110	21	68	90
Turnover	46,797	4,691	20,060	44,666	236,524	4,085	13,437	14,354	99,535	192,174	144,372	1,837	4,008	4,956
Production	46,776	4,754	17,673	43,192	189,766	3,966	11,010	12,877	76,552	192,080	156,143	1,845	3,232	4,870
Value added	15,569	1,493	5,872	12,285	89,402	927	4,847	6,219	41,297	77,135	56,346	857	1,188	1,278
Personnel costs	10,477	750	3,628	7,036	54,300	430	3,437	3,925	24,768	58,315	36,197	544	588	716
Ave. personnel costs	52	5	15	57	30	12	50	32	34	44	39	25	9	8
Gross operating surplus	5,094	743	2,244	5,249	35,103	497	1,410	2,295	16,529	18,820	20,150	313	600	562
Apparent labour productivity	72	10	20	94	48	25	62	31	45	56	51	40	17	14
Gross operating rate	10.9	15.8	11.2	11.8	14.8	12.2	10.5	16.0	16.6	9.8	14.0	17.1	15.0	11.3
R&D expenditures	16.7	:	0.1	48.6	63.5	0.7	:	:	93.6	35.2	31.7	0.1	:	0.2

	LU	HU	MT	NL	AT	PL	PT	RO	SL	SK	FI	SE	UK	HR
Enterprises	1	31	:	30	14	139	24	33	9	14	23	29	66	11
Persons employed	23	220	:	407	208	728	163	319	51	115	148	269	1,211	77
Turnover	4,833	13,214	:	67,700	36,300	35,975	17,045	10,447	4,491	6,233	20,684	43,120	156,361	3,730
Production	3,780	9,128	:	66,730	21,291	32,714	17,730	10,691	4,344	5,978	20,427	42,967	155,118	3,683
Value added	1,594	3,624	:	25,111	12,964	11,839	6,025	3,835	1,732	2,082	7,412	12,734	68,243	1,709
Personnel costs	1,184	2,534	:	15,705	8,385	6,131	3,847	2,062	947	1,353	5,260	10,050	40,097	1,071
Ave. personnel costs	52	13	:	42	43	11	25	7	21	14	40	44	35	16
Gross operating surplus	410	1,090	:	9,406	4,579	5,708	2,178	1,773	785	859	2,152	2,684	28,146	638
Apparent labour productivity.	70	17	:	62	62	16	37	12	34	18	50	47	56	22
Gross operating rate	8.5	8.2	:	13.9	12.6	15.9	12.8	17.0	17.5	13.8	10.4	6.2	18.0	17.1
R&D expenditures	6.1	0.1	0.5	17.0	6.7	0.7	28.9	:	1.4	:	10.5	12.2	33.5	0.0

1) 2011 for blue values, 2009 for red values, 2008 for orange values. Values are in EUR million; number of enterprises and number of persons employed are given in thousands; average personal costs and apparent labour productivity are given in EUR thousands per person; gross operating rate and market shares are expressed as percentages

6.3 Comparison between EU-27 and its main competitors

In this section we will compare the EU with its main counterparts. For that purpose we will use mainly data taken from the OECD. When data is missing (mainly for the R&D data) we will use in the EU Industrial R&D Investment Scoreboard and Eurostat data. Figures in OECD database generally refer to OECD members who for the EU represent 21 of the 27 Member States[28] and usually only few countries present complete data series. Another drawback of OECD data is that, for some indicators, the most recent data is 2008.

In terms of value added the EU manufacture of motor vehicles, trailers and semi-trailers performed better than the US or Japan (C29 graph, in Figure 29) and this is particularly evident since 2002, when the US' value added started to decline while the EU's and Japan's remained quite stable. After 2007 all countries shown a decrease in their value added a situation that is probably accentuated after 2008 due to the well know effects of economic downturn within this sector. Unfortunately no data for the following years is available at the time of writing this report.

In terms of production, passenger car manufactures have been displaced to other countries with lower labour costs. A study performed by ACEA (2012) shows that the EU has been decreasing its share in world production of cars. In 2005 the EU was the world leader in passenger car production, but data from 2010 and 2011 shows a significant increase of car production in BRIC[29]. This was particular true for China which in 2011 almost reached the EU's level of car production. In terms of commercial vehicle production, this study shows that the US is the world leader while China has been catching-up and is now close to US' production levels, while the EU is performing much below these two countries.

The EU countries also dominate the rail sector (C302 of the same figure), which have increased the industry's value added, reaching more than EUR 10 billion in 2007. On the other side, US rail sector has decreased its value added along this period, losing the leadership in 2001 and almost reaching the level of EUR 6 billion in 2009. In the rail sector, Japan was always behind EU countries and US during the analysed period.

A similar ranking can be found in the waterborne sector (C301 of the same figure), with the EU presenting a higher value added than the US and Japan. Within this sector the US shows a decreasing value added while the opposite occurs with the EU countries and Japan. This figure shows how Japan is decreasing the gap with the US while the EU is enforcing its leading position overtime. However this picture is incomplete, since China and South Korea are excluded from this analysis due to missing data. These countries are world leaders within this sector, above European countries.

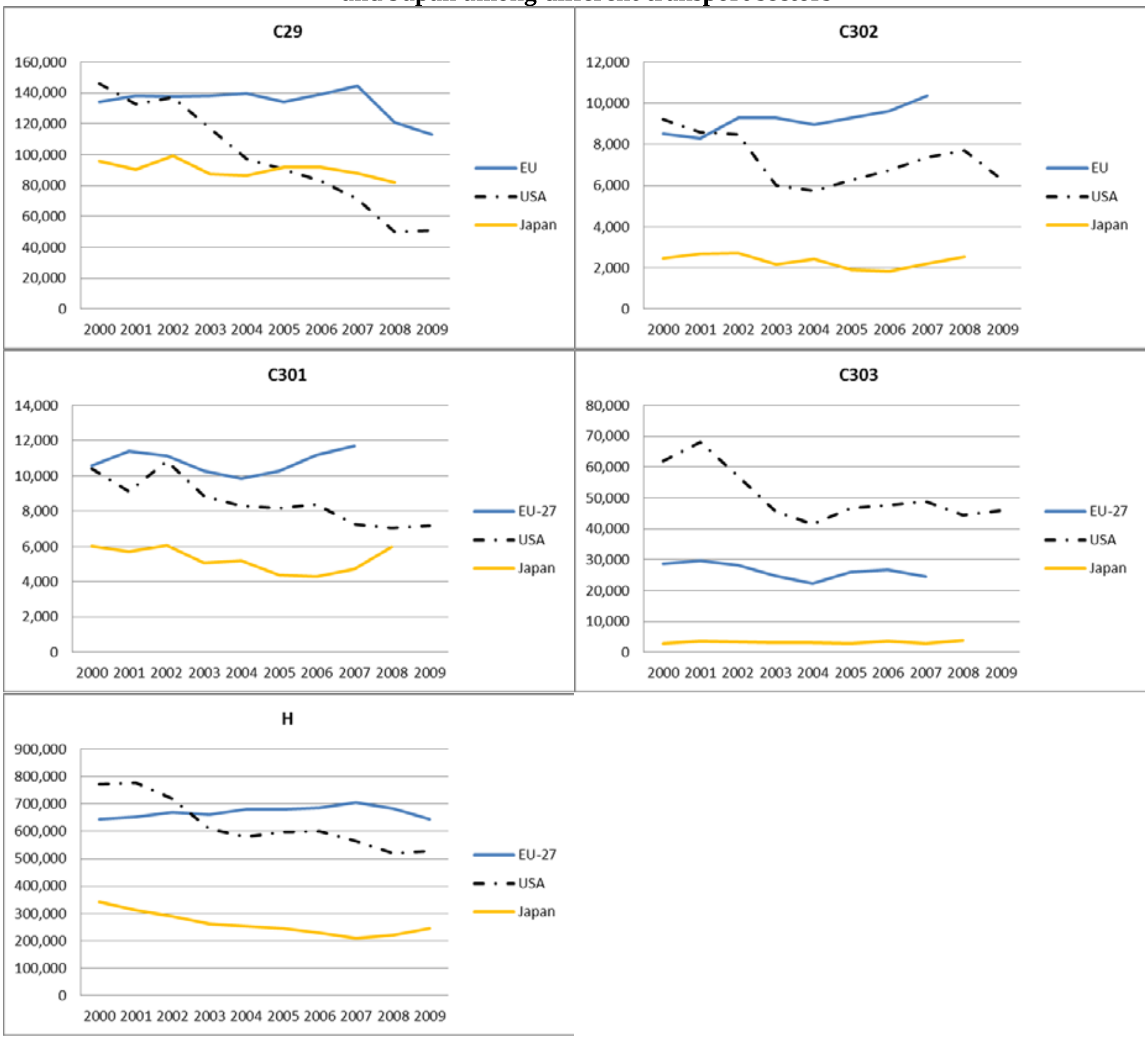
Within transport services providers (H of the same figure), the gap between the US and the EU is smaller and both countries perform better than Japan. EU countries are at the forefront of US and Japan regarding value added.

[28] EU member states considered in OECD data are: AT, BE, CZ, DK, EE, FI, FR, DE, EL, HU, IR, IT, LX, NL, PL, PT, SK, SL, ES, SE, UK

[29] Brasil, Russia, India and China

In the air and spacecraft industry (C303 of the same figure), the US is generating a higher value added than the EU and Japan, while maintaining this position all over the analysed period. The EU generates a value added in between that of the US and Japan's while the gap between EU and US is decreasing over time, mainly due to a sharp decrease of US industry's value added from 2001 till 2004, following the crisis installed in this sector after September 2001.

Figure 29 – Evolution of value added, (constant prices EUR 2005 million) comparison between EU[30], US and Japan among different transport sectors



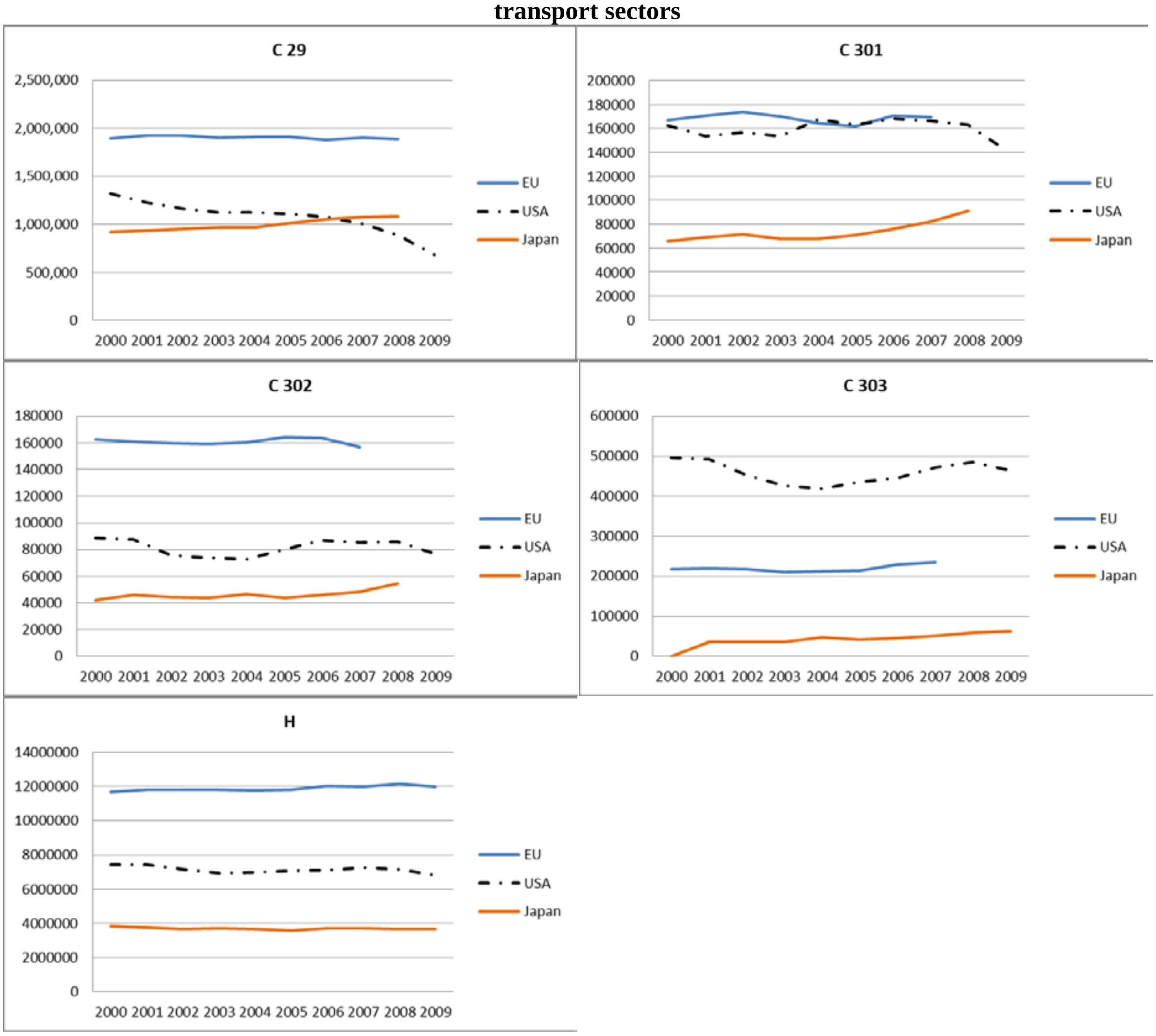
Data source: STAN (OECD)

Employment remained quite stable in the EU countries during the analysed period and among the selected transport sectors (Figure 30). The EU is above the US and Japan for the manufacture of motor vehicles, trailers and semi-trailers, for the rail sector and for the transportation and storage sector.

[30] EU value added is the sum of the EU countries value added listed in the OECD database

For the manufacture of ships and boats, levels of employment are very similar between the US and EU while Japan recorder lower employment levels, although increasing in the last analysed years. For the air transport, the US generates much more employment than the EU and Japan all along the analysed period. This is in line with previous results regarding value added

Figure 30 – Evolution of employment. Comparison between EU[31], US and Japan among different transport sectors



Data source: STAN (OECD)

EU's sector C301, C302 and C303 are underestimated as they have no data for EE, EL, LX, NL, PL, SK, SL and UK.

Unit labour costs represent a measure of cost competitiveness, measuring the average cost of labour per unit of output (value added in this case). As such they represent the link between productivity and the cost of labour in producing output. Unit labour costs generally range between 0.5 and 1 which means that average labour costs are below the value of a unit of output.

[31] EU employment is the sum of employment registered by EU countries in the OECD database

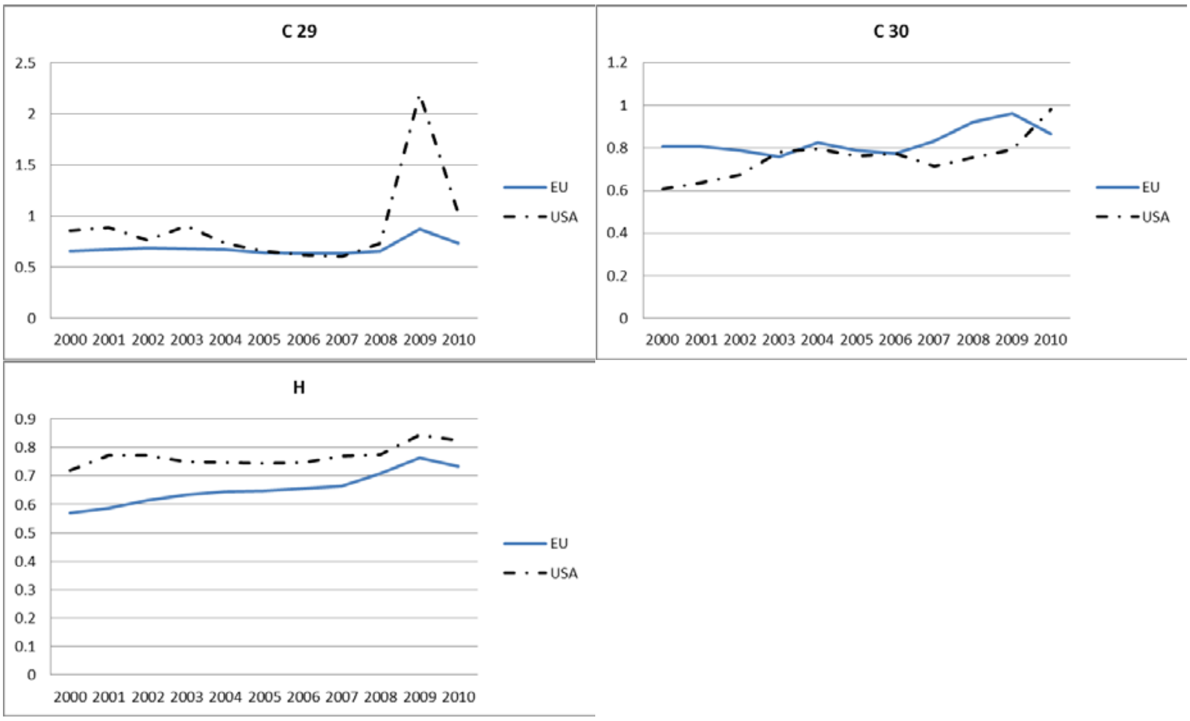
OECD STAN database contains data on unit labour costs. However it provides no data for Japan, or for subcategories of C30 which includes rail (C302), air (C303) and waterborne (C301) manufactures.

In the manufacture of trailers and semitrailers, the EU's unit labour costs were lower than in the US till the year 2005 (Figure 31). From 2001 till 2005 they were, on average, around 0.65 for the EU and 0.75 for the US. From 2006 till 2008 EU's unit labour costs slightly outweighed the ones from the US while in year 2009 the US's unit labour cost showed a dramatic increase probably due to the effects of the economic crisis which decreased the industry's value added more than in the EU. Unit labour costs remained quite stable along the analysed period, recording a slightly increase from 2008 onwards.

As for the C30 category, which aggregates the manufacture of aircrafts and spacecraft, railways locomotives and rolling stock and ships and boats and waterborne sector, unit labour costs are higher in the EU than in the US, in general terms. However for the last year (2010) this tendency was reverted. In both cases unit labour costs have been increasing since 2000, in overall terms.

For the category of transportation and storage, the EU registers lower unit labour costs than the US along the analysed period. Despite some fluctuations, the general tendency shows an increase of unit labour costs along the period 2000 and 2010

Figure 31 – Evolution of Unit labor costs among transport related categories. Comparison between the EU[1] and US

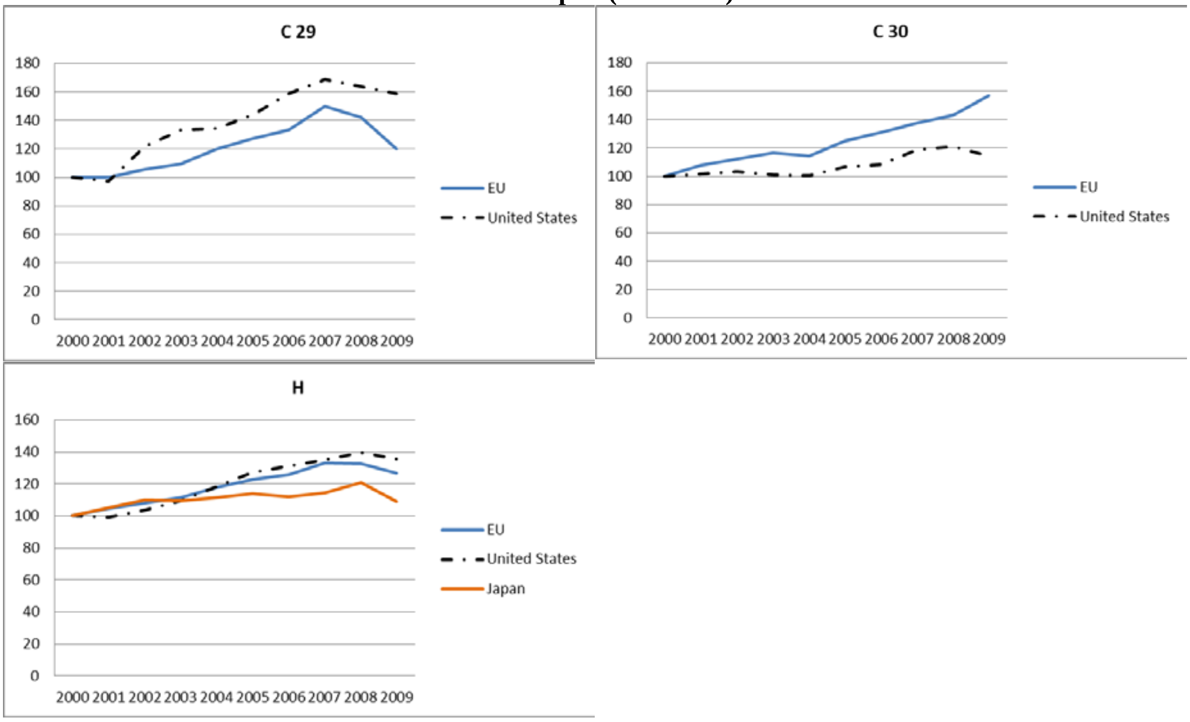


Data source: STAN (OECD)

1) EU unit labour costs are calculated as the average value of the EU countries listed in this source, which are AT, BE, CZ, DK, FI, FR, DE, HU, IT, NL, and SL

In overall terms, labour productivity has been increasing in all sectors among the EU, US and Japan (Figure 32), between 2000 and 2009. The US presented a higher increase in labour productivity in the automotive and the transportation and storage category, while the UE scored better in the aggregate category of other transport equipment (C30). In absolute terms EU's labour productivity is higher under the 'other transport equipment' category, while the US's presents a higher labour productivity in the automotive sector and the transportation and storage category.

Figure 32 Labor productivity index among transport related categories. Comparison between the EU[1] US and Japan (2000=100)



Data source: STAN (OECD)

1) EU for C29 an C35 is the average value considering the following set of countries AT, BE, CZ, DK, FI, FR, DE, EL, HU, IT NL, SK, SL, SP, and SE, for the H category the EU average additionally considers EE, LX, PL, PT, and UK.

The EU Industrial R&D Investment Scoreboard contains the R&D investment of the main companies, from which we extract those related with the transport sector. From this source we can compare R&D performed by EU companies with that performed by companies from other countries, namely from the US, Japan, Brazil, China and Rest of the World (RoW).

The Scoreboard uses an ICB classification, which for the transport sector the most relevant categories are 'Automobiles & parts', 'Aerospace and defence' and ' Industrial transportation'. When analysing the results of this data source it is important to keep in mind that figures are derived from a limited number of companies only. The Scoreboard contains for the transport related categories 79 EU-based companies and 102 non-EU-based companies for the year 2011 (respectively 104 and 101 in 2008[32]).

[32] It is important to notice that the EU Industrial R&D investment scoreboard for the year 2008 included the category of 'Commercial vehicles and trucks' that is no longer available in the Scoreboard 2011. This different categorization of companies justifies partially the smaller number of EU-based companies in the transport sector in the year 2011.

Table 22 – Corporate R&D investment related to the ICB transport-related categories (2008 and 2011)

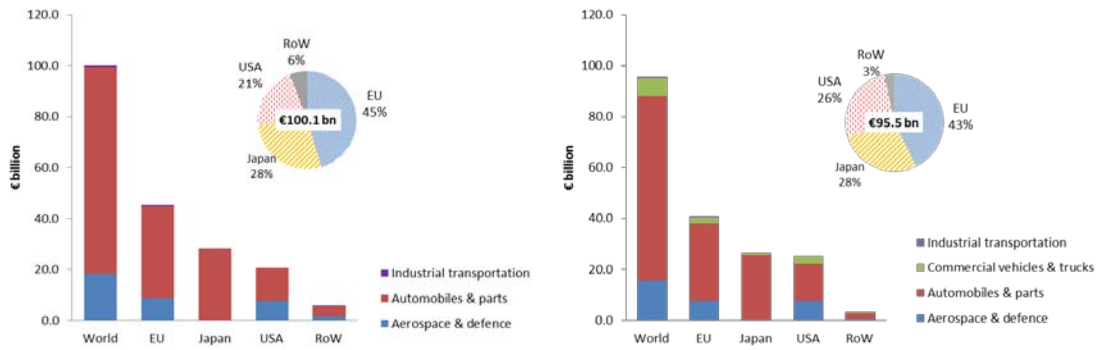
R&D investment (€ bn) Industry\Location	EU		Japan		US		Brazil		China		RoW		World	
	2008	2011	2008	2011	2008	2011	2008	2011	2008	2011	2008	2011	2008	2011
Aerospace & defence	7.5	8.8	0.1	0.1	7.4	7.6	0.1	0.1			0.4	1.6	15.6	18.1
Automobiles & parts	30.4	36.0	25.5	28.2	14.7	13.1			0.0	1.8	2.0	2.2	72.6	81.2
Commercial vehicles & trucks	2.4	*	0.9	*	3.0	*		*		*		*	6.8	*
Industrial transportation	0.4	0.6								0.1		0.1	0.4	0.7
Transport	40.8	45.4	26.4	28.3	25.1	20.7	0.1	0.1	0.1	1.8	2.9	3.8	95.5	100.1
All the industries	130.4	153.1	93.9	111.5	159.2	178.4	1.6	2.7	2.6	13.9	42.6	60.2	430.8	519.8
Share of Transport	31%	30%	28%	25%	16%	12%	9%	3%	6%	13%	7%	6%	22%	19%

Data source: EU Industrial R&D Investment Scoreboard (JRC-DG RTD, 2009, 2012)

Table 22 presents the R&D investment for the relevant transport categories for the year 2008 and 2011. Figures for 2008 come from the previous analysis performed by Wiesenthal et al. (2011).

In 2011, the 181 transport-related companies considered at the global level invested around EUR 100 billion (EUR 4.6 billion more than in 2008) thus accounting for 19.2% of the total industrial R&D investment. Within this total, EU-based firms show the highest contribution with and aggregated R&D investment accounting for 45% of the total companies considered around the world (43% in 2008, see Figure 33), followed by Japanese companies and US-based companies with 28% and 21%, respectively. Note that the share of other regions of the world (essentially South Korean and Chinese companies) in the total R&D investment has increased form 3% in 2008 to 6% in 2011.

Figure 33 – R&D investments in transport-related ICB sectors, 2011 (left figure) ad 2008 (right figure)



Data source: EU Industrial R&D Investment Scoreboard (JRC-DG RTD, 2009, 2012)

In Europe, the 79 top companies listed in the Scoreboard active in transport invested around EUR 45 billion in 2011. European based automotive manufacturers and suppliers invested approximately EUR 36 billion followed by aerospace and defence (EUR 8.8 billion). Hence, the EU transport sector represented 30% of the total EU industrial research in 2011 (31% in 2008). According to data in the Scoreboard, the transport sector accounted in 2011 for 25% of the total industrial R&D investment in Japan, 12% in the US, around 3.2% in Brazil and 13% in China, while in the RoW this share was around 6%.

Automotive manufacturers and suppliers invested EUR 81.2 billion in R&D in 2011, derived from the assessment of 114 companies worldwide. Almost 45% (EUR 36 billion) were due to companies with their headquarters in the EU (mainly Germany, France and Italy), 35% from Japan and 16% from US firms. At the world level, fifteen groups namely Toyota, Volkswagen, General Motors, Daimler, Honda, Nissan, Robert Bosch, Ford, BMW, Denso, Peugeot, Fiat, Renault, Continental, and Hyundai accounted for 75% of the total R&D investment within this sector. In the EU, seven car manufacturers and suppliers accounted for 77% of EU's total R&D expenses in the automotive sector, namely Volkswagen, Daimler, Robert Bosch, BMW, Peugeot, Fiat, and Renault. This sector has increased in all the analysed countries/regions between 2008 and 2011, except in the US where it decreased EUR 1.6 billion during this period.

The Aerospace and defence sector spent 18.1 in R&D in year 2011. This estimation is based in the assessment of 53 firms around the world among which EADS, Boing and Finmeccanica are the three largest investors accounting for around 44% of total R&D investment. In Europe, 60% of the 2011 R&D investment stems from EADS and Finmeccanica. It is worth noting that this sector has increased in all regions and selected countries during the period between 2008 and 2011.

The R&D investment of the ICB sector Industrial transportation reached EUR 714 million in 2011, based on data from 14 firms. Note that outside the EU, this ICB class only contains two companies for the year 2011 and none for 2008. The companies reporting higher R&D expenses were SNCF, Deutsche Post and CAE.

The innovation gap was calculated using the R&D investment performed by business. This data was taken from OECD BERD database. As mentioned in section 4.1, BERD database is not comparable with data from the Scoreboard. However both sources offer a complementary overview of R&D efforts of companies.

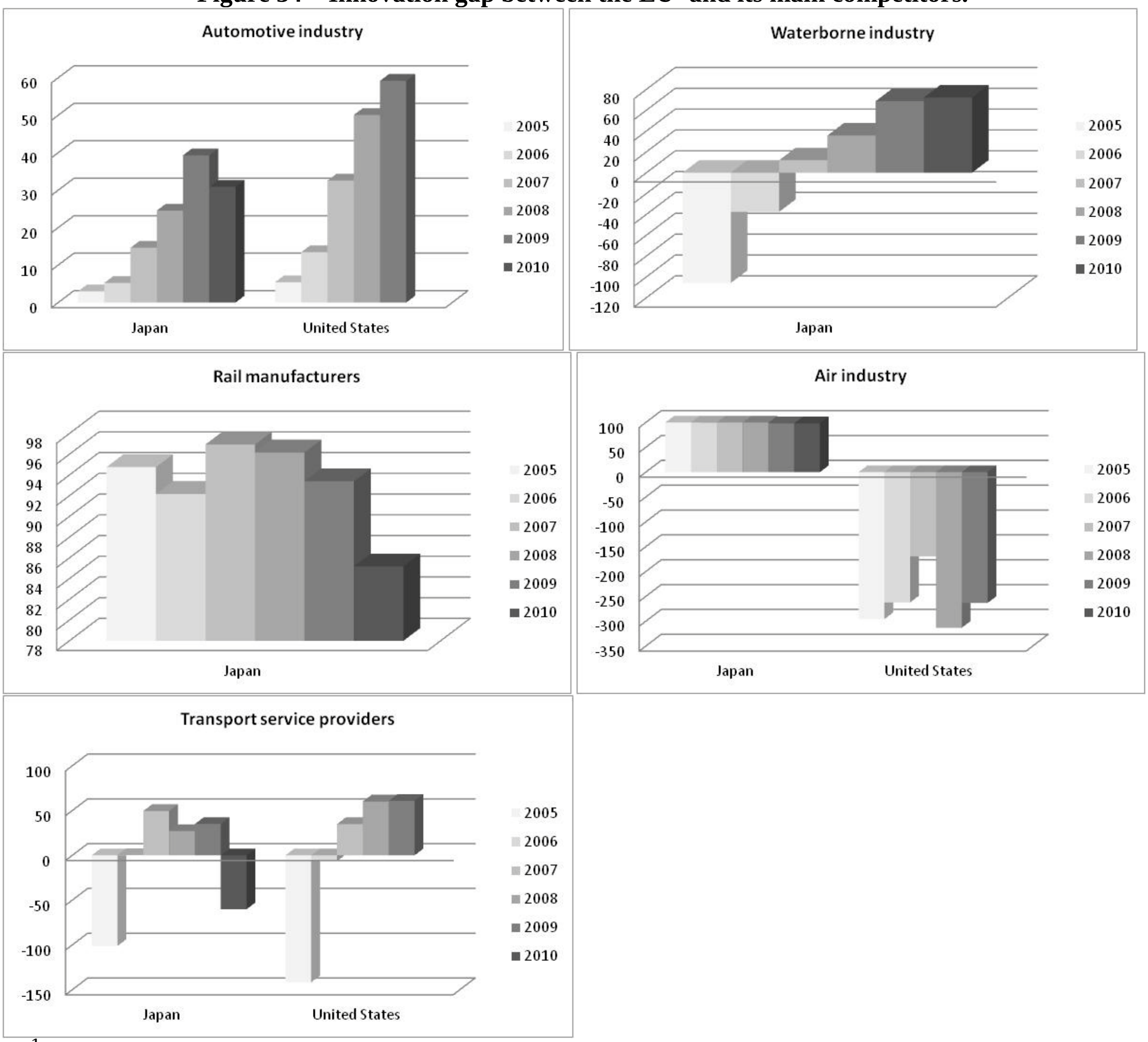
Innovation gap measures the distance in terms of R&D investment between European transport sectors and the equivalent sector in the US or Japan. An innovation gap of 60 between EU and US for a particular transport sector means that this European transport sector is 60% above that US's sector.

The European manufacture of motor vehicles, trailers and semi-trailers is above the Japanese and the US in R&D expenditure all along the analysed period (2005-2009) (Figure 34). This gap has increased over time which means that the European industry has been investing relatively more that its main competitors.

For the manufacture of ships and boats as well as for the manufacture of railways locomotives and rolling stock the analysis can only be done comparing the EU with Japan, since no data is available for the US. In the manufacture of ships and boats, at the beginning of the analysed period Japanese industry was investing more that European companies, however since 2007 the gap has been reverted and the European sector has been gaining relative position in terms of R&D investment. For the railway locomotive and rolling stock manufacturers, the EU presents a level of R&D investment that is always above 90 % of the Japanese companies, this gap seems to be decreasing slightly the last two year of the analysed period, with Japanese manufacturers catching up in terms of R&D expenses.

For the manufacture of aircraft and spacecraft the European companies perform an investment that is almost 100% above the one performed by the Japanese, but is much lower than the one registered by US companies. Finally, regarding the transportation and storage sector, European companies show a R&D investment generally higher than its main counterparts. This gap seems to be increasing between the EU and the US. Between the EU and Japan this is not so clear, as for 2010 this gap was -60, meaning that transport services in Europe invested 60% less than the Japanese counterparts.

Figure 34 – Innovation gap between the EU[1] and its main competitors.

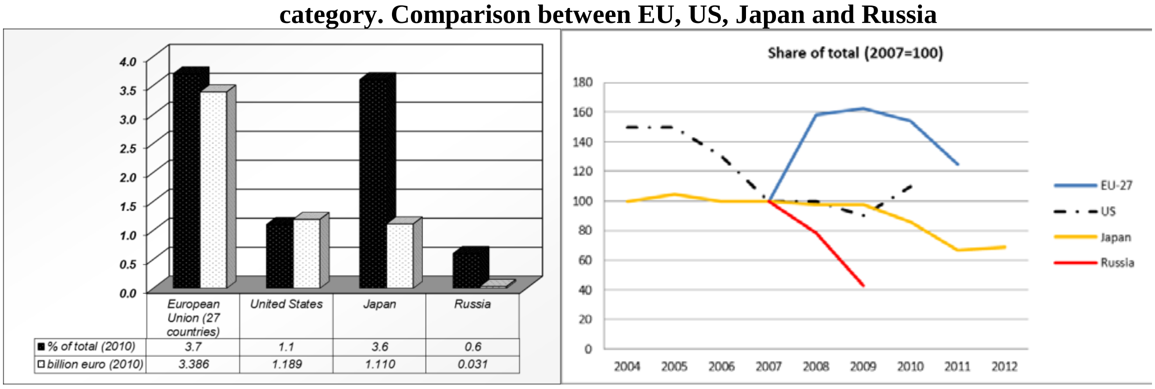


[1] Figures for EU combine data from OECD and Eurostat, for missing values in the first data source. For all countries, constant prices are considered (EUR 2005)

Public funding of R&D intends to support research activities performed by companies and research institutions. In previous section we have seen that this support varies considerable among countries. GBAORD data provided by Eurostat offers data series of public funding of R&D under the transport related category ('Transport, telecommunication and other infrastructure) for the EU-27, US, Japan and Russia. However for the EU-27 and Russia data is missing before 2007.

Public funding of R&D under the transport related category ('Transport, telecommunication and other infrastructure) is higher both in absolute terms and as a percentage of R&D budget in total government expenditure in the EU-27 (Figure 35). Japan is very close to the EU-27 in terms of share of R&D budget devoted to the transport related category, but in absolute terms it is investing much less. This share of R&D budget has increased considerably in the EU-27 from 2007 to 2008 (Figure 35) but it is decreasing since then. In the US this share is decreasing all over the period and slightly increased in 2009. On the contrary, Japan remained quit stable along the period and registered a decrease in the period 2009 - 2011. Finally for Russia and for the three year of available data the evidences show a sharp decrease in the share of R&D budget devoted to transport, telecommunication and other infrastructure.

Figure 35 – R&D budget (GBAORD) on 'Transport, telecommunication and other infrastructure' category. Comparison between EU, US, Japan and Russia



Data source: GBAORD (Eurostat)

The bilateral trade provided by STAN database (OECD) was used to calculate the world market shares of particular industries and set of countries. World market shares represent the share of exports of a particular country (or set of countries e.g. EU) in total world exports of a particular industry.

In the automotive industry, the EU Member States together export more than 50% of all exports within this sector. This share has been maintained quite stable along the analysed period with a slightly decrease in 2010-2011 (Figure 36). Regarding the EU's passenger car exports and the main destination countries are the US (21% of EU car exports, in 2011 EUR million), followed by China (18.5%) (ACEA 2012), while the most exported market segments were premium cars and heavy duty vehicles.

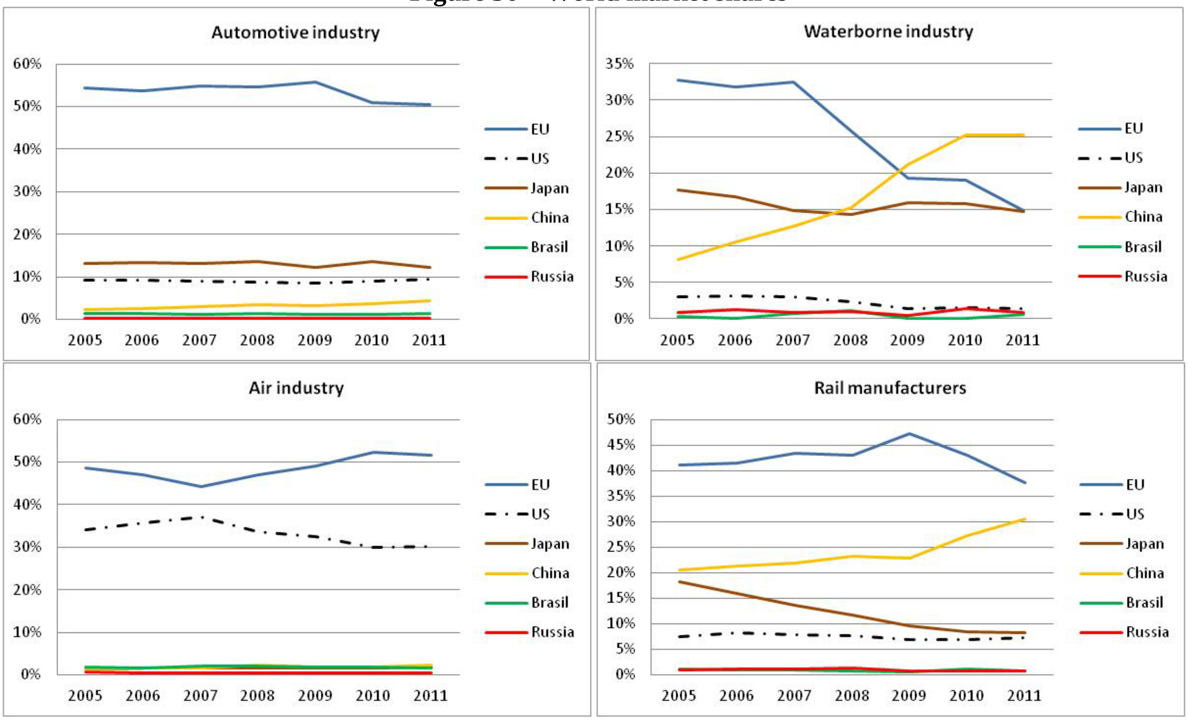
Japan's and US' market shares were lower and remained quite stable along the analysed period, close 10% in the case of US and around 15% for Japan.

Within the manufacture of ships and boats Japan and especially Europe dominated the world exports till 2008. The EU countries reached a market share close to 35% in 2007 but after that year the market share decreased abruptly. EU countries lost competitiveness for the Chinese manufacturers, who recorded a steep increase of their exports, overcoming Japanese market share in 2007 and the EU's in 2009. In 2011 Chinese market share was 25%, well above the EU and Japan (both around 15%).

In the air and spacecraft industry, EU countries and the US are the two clear players regarding world exports, with the EU countries summing a higher market share (around 50%) than the US (around 30%) while the other countries are performing much lower (less than 5%). This situation reflects the dominant position of the two world companies that are Airbus (EADS) and Boing. The gap between the EU and US increased at the end of the period, due to a relative increase of European exports and a decrease of US exports.

Regarding the railway locomotives and rolling stock manufacturers, the EU has the highest market shares along the period, reaching more than 45% of world exports in 2009 and decreasing thereafter till less than 40% in 2011. China is the world second player within this sector, with exports that are continuously growing, reaching the level of 30% in 2011. Japan is in the opposite situation, it started the period with similar market share than China (around 20%), but it lost position to China and Europe. In 2011 Japanese rail manufacturer's exports account for less than 10% of world market shares.

Figure 36 – World market shares[1]



Source: STAN (OECD)

[1] Market shares were calculated as the sum of exports of each transport sector within each country. For the EU, market shares refer to the sum of exports of all member states.

7. Conclusions

The European transport sector faces several challenges for which innovation may play an important role. Environmental constraints, competition from fast developing countries, scarcity of resources, security and increasing congestion, are pressing the EU transport sector to change and adapt in order to remain competitive. Additionally, the current economic downturn imposes a reduction of demand within this sector, increasing the costs incurred by companies and reducing their competitiveness. In this sense innovation may help to overcome the difficulties imposed to the sector, improving its cost efficiency and productivity as well as the quality and the rage of its products and services.

In this deliverable we aimed to develop a better understanding of the present innovation and competitiveness of the European transport sector. In order to achieve this objective, several specific objectives were established and the main conclusions are presented above these lines.

1. Lay down the concepts and methods related with innovation, the transport sector, market structure and competitiveness.

The present deliverable reviewed the main concepts and methods used to measure innovation and competitiveness, focusing on those measures that can be used to characterize the transport sector. Within innovation measures two broad areas of indicators were analysed: R&D and patent applications. However these are only partial measures of innovation, as they are not able to capture the entire innovation process. Fortunately in recent years new indicators of innovation inputs and outputs have emerged and can be used to differentiate transport sectors (e.g. innovation expenditures).

Regarding competitiveness it was acknowledge the difficulty to define and mainly to measure this concept, as the success of economic sectors depends on several factors and their selection depends on the unit of analysis. Measures of competitiveness are often categorized as price and structural measures. Structural measures link competitiveness with concepts of economic specialisation, technological innovation, quality of distribution networks. All these aspects raise productivity while lowering prices. On the other hand price measures are usually evaluated by price differentials such as production, export and import prices. Following this logic, here we have presented a set of indicators to characterize the competitiveness of transport sector, which can be classified as labour cost and productivity, innovation measures, output measures and international competitiveness.

2. Perform a strategic review of the European transport policy, innovation programmes and the European transport systems.

The role of the EU as a promoter of innovation activities within the European transport sector has been overviewed, looking at different transport-related policies. The following European policies were summarized: transport, innovation and industry, which are all anchored in the Europe 2020 strategy. All these policies aim to address societal challenges and goals on which transport may play an important role.

An overview of existing EU innovation programmes was presented, analysing how such programmes may affect the future of transport research. Three different types of innovation programmes are analysed: the ERA-NETs, Technology Platforms (TPs) and Joint Technology

Initiatives (JTIs). Within these innovation programmes some are directly linked with transport: 5 ERA-NETs (ERA-NET ROAD; ERA-NET TRANSPORT; Aeronautics ERA-Net; MARTEC and Electromobililty+), 5 TPs (ACARE, ERRAC, ERTRAC, Waterborne, ESTP) and 2 transport-related JTIs (Clean Sky Initiative and Fuel Cells and Hydrogen initiative).

Finally the European transport innovation system by transport mode is analysed. Results showed that transport industry is experiencing a time of change and the main challenge is to ensure competitiveness while reducing the societal impacts (especially environmental). A review of the main drivers and barriers to innovation in transport revealed that most barriers are market and financial related.

3. Measure the present R&D investments performed by EU Member States, EU FP7 and corporate

For this specific objective several official data sources were combined to conclude on the efforts made by national governments and the EU as well as those made by the business sector.

Regarding the contribution of Member states to the 'Transport, Telecommunications and other infrastructure' objective we concluded that some Governments had an active role financing R&D activities (e.g. Estonia, Latvia, France, Romania and Spain). Other countries, generally those with stronger economies and more liberal culture (e.g. UK, Germany or Austria), are less involved in the public financing of R&D activities. In the EU-27, the share of R&D budget under this objective has decreased around 20% between 2008 and 2012. At the EU level, the Seventh Framework Program (FP7) (2007-2013) which has a total budget of EUR 50.5 billion allocated around EUR 4.2 billion to the ' Transport' theme.

The business sector is the main R&D investor in the EU. In the EU the Manufacture of motor vehicles trailers and semi-trailers is responsible for highest share of expenditure (around 69% of total transport related expenditure) followed by the manufacture of air and spacecraft and related machinery (around 27%).

Across member states, four countries spent the highest share of R&D in transport-related sectors. These are Germany, France, the United Kingdom and Italy, while Germany is by far the higher investor (responsible for near 60% of total R&D investment in this sector).

By transport sub-sectors, Germany spent around 86% of its transport-related R&D expenditure, in the manufacture of motor vehicles trailers and semi-trailers. It is the main R&D investor among EU countries under this sub-sector, responsible for 73% of EU investment. Germany is also the main R&D investor regarding the manufacture of railway locomotive and rolling stock, followed by the Czech Republic. However this is a partial conclusion since, within this sector, important countries such as France do not report data.

Regarding the manufacture of ships and boats, businesses located in France are the main R&D contributors and this is also true for the manufacture of air and spacecraft and related equipment. The manufacture of other transport equipment (such as motorcycles) is dominated by Italy. Finally under the transportation and storage sector Spain registers the higher expenditure.

From official statistics we have observed that R&D investment performed by all transport sectors, was mostly funded by the business sector. This share was around 90% in all sectors, except in the manufacture of air and spacecraft and related machinery which was around 50%. The other 50% came mainly from the Government sector (around 38%) and from the abroad sector (international institutions). This reflects the strategic importance that this industry represented in the past and stills represents for the European countries, which have supported R&D activities performed by companies within this sector.

Intramural R&D represents the main innovation expenditure for most transport sectors. However for the transportation and storage sector, expenditure for the acquisition of machinery, equipment and software, constituted the highest share of innovation expenditure. This is mainly explained by the fact that this sector is formed by service provider companies, for which process innovations are probably more important than product innovation (See section 2.3.2). In that sense they benefit more when buying and introducing products that have been developed by others.

Additionally we have developed a bottom-up approach to assess the R&D investments made by the key European companies across all transport sectors. Our estimates are quite consistent with official statistics, showing that European companies operating in the automotive sector are by far the higher R&D performers. These were followed by those operating in the aviation industry. In terms of R&D intensity, the air industry presented a higher R&D intensity (6.5%, over total net sales) followed by the ITS sector (5.2%) and the automotive sector (4.9%). Companies operating under the waterborne and rail industry recorded an R&D intensity of 3.2% and 3.5%, respectively. R&D intensity was much lower in the transport service providers and in the transport infrastructure construction companies (0.3% of net sales).

4. Perform a patent analysis

Patent analysis was used to conclude about the dynamics and specialization of countries on certain technologies. A list of technologies related with mobility has been identified by Fraunhofer ISI as representative of main technical paths for the future in transport. These are categorized into: biofuels, electric drive, battery, hybrid-electric drive, fuel cell, rail-bound, navigation, aviation, material efficiency, and new mobility concepts.

The analysis of patent dynamics identified three main leading areas: electric motors, battery, and fuel cells. Electric drives applications increased more than 20-fold in the time period 1990 to 2010.

Considering the share of the worldwide patents applications on mobility, EU is above the US and Japan. Within the EU, Germany and France rank 3rd and 4th on the global scale, between US and Korea, while Japan holds the higher share of patents on mobility. The analysis by technologies showed that Germany has a larger share of application in rail-bound, hybrid-drive, electric drive and navigation (in decreasing order). France has a higher share of patents in aviation technologies. In other EU countries, other prominent areas with respect to patent shares are bio-fuel for the Netherlands, navigation for Italy, Sweden and Finland, aviation for Great Britain and mobility concepts for Austria. However EU countries are behind Korea and Japan regarding the main leading technologies (electric motors, battery, and fuel cells).

The index of patent specialization showed similar results. However for large countries with strong general patenting performance it is much harder to exhibit a significant specialization. Thus we have found countries with small patent shares but with high patent specialization, as it is the case of Austria for rail-bound technologies or Slovakia for biofuels.

5. Assessment of global competitiveness of European transport

We have assessed the current global competitiveness of the EU different transport sectors. This analysis was done firstly comparing differences within transport sectors in the EU, then comparing differences among Member States and finally comparing the EU with major non-European regions.

At the EU level 'Transportation and storage' and the 'Manufacture of motor vehicles, trailers and semi-trailers' presented the highest values regarding output indicators (value added, turnover and production value). Accordingly, these two sectors registered the higher employment levels and the higher labour costs. Average personnel costs and apparent labour productivity were higher in the air industry followed by the automotive and the rail manufacturers. The automotive sector registered the highest R&D expenditure, followed by the air industry. R&D expenditure seems to be related with higher market shares as these two sectors recorded the highest world market shares among all sectors (around 50% of world exports each).

The analysis by countries showed that Germany dominates the automotive sector, with higher value added, turnover, production value, employment levels, higher salaries, and labour productivities, higher R&D investments and higher world market shares. Italy on the other hand is well positioned in the manufacture of other type of vehicles, mainly due to the motorcycle industry.

France is in a good position regarding the aerospace equipment manufacturing, where the industry registered the highest value added, turnover and production value. It is also the country investing more on R&D within this sector and achieving a higher world market share. Also in the aerospace manufacturing, the UK achieves similar results as France in terms of output measures.

Regarding the manufacture of ships and boats the UK, France, Germany and Italy are the countries with higher value added and world market shares. Although in a lower extent, this sector reveals a significant presence in smaller countries such as Romania and Poland.

Germany, France and Spain together represent 55% of EU-27' value added under the manufacture of railway and tramway locomotives and rolling stock. These countries also show high employment levels and high apparent labour productivity. Germany has the highest world market share, exporting around 12% of world exports.

Regarding the transport service providers sector, Germany, France and the United Kingdom were the three main countries in many of the analysed variables (value added, production and turnover). Average personal costs and labour productivity is high in these countries but is even higher in Belgium, Denmark and Luxembourg.

Comparing the EU transport sectors with other regions in the world we can conclude that in terms of value added, the EU manufacture of motor vehicles, trailers and semi-trailers performed better than those sectors in the US or Japan. This is also the case of the manufacture of railway locomotives and rolling stock, the manufacture of ships and boats and the transportation and storage sector. The only exception was the air and spacecraft industry, which till 2009 showed the dominance of the US, followed by the EU. Unit labour costs and labour productivity are higher in the US than in the EU for the manufacture of motor vehicles, trailers and semi-trailers and the transportation and storage sector.

Regarding the R&D performed by the most important companies within transport sectors, we can conclude that EU firms show the highest contribution, accounting for 45% of the total R&D investment. EU companies were followed by Japanese and US-based companies. Companies under the automotive manufacturers and suppliers were the main R&D investors across all transport sectors, while almost 45% were from companies with their headquarters in the EU, 35% from Japan and 16% from US firms. EU companies under the Aerospace and defence sector registered a slightly higher R&D investment than their US's counterparts.

The innovation gap showed that the EU is above Japan and US in most transport sectors, since it is investing more on R&D than other regions. However it is below the US regarding the manufacture of air and spacecraft and related machinery. This results partly contradicts the previous conclusions on R&D expenditures of main companies listed under the Aerospace and defence sector. However we must keep in mind that these results are not comparable since they come from different data sources, refer to a different year and use a different classification system.

From the previous patent analysis we have seen that the EU has a higher share of patent applications on mobility-related technologies. However looking into specific technologies, we found that Japan and Korea are world leaders in the most dynamic technologies: electric motors, battery, and fuel cells while the US ranks particularly well at aviation related technologies.

Finally comparing the world market shares, we concluded that the EU has a higher market share in the manufacture of motor vehicles, trailers and semi-trailers, air and spacecraft industry, and in the railways locomotive and rolling stock manufacture. However in the sector of building ships and boats China has taken the lead in world exports since 2009.

Previous results offered an overview of the current competitiveness of the transport sector. However one of the main challenges in FUTRE is the understanding of how this competitiveness will evolve in the future. For that purpose it is necessary to foresee the evolution of transport demand and how this evolution may impact the preferences for mobility services and products both in the passenger and freight markets. This will be the central aim of WP3 which will study, in a more qualitative way, the impacts of a set of possible demand pathways in the future competitiveness of transport. FUTRE will also approach future changes of competitiveness that can arrive from the supply side. This will be done by identifying the most important up-coming innovations and analyse their potential impact on the transport sector. WP4 will analyse this aspect while evaluating the importance that each pointed innovation will have in the future competitiveness of transport sector.

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Annex I – Industry classification benchmark (ICB) classification

This table shows the transport-related sectors used in this deliverable.

ICB sector	ICB code	Relevance to transport R&D? (with ICB subsector when appropriate)
Aerospace & defense	**271**	2713 – Aerospace: Manufacturers, assemblers and distributors of aircraft and aircraft parts primarily used in commercial or private air transport. Excludes manufacturers of communications satellites, which are classified under Telecommunications Equipment. 2717 – Defence: Producers of components and equipment for the defense industry, including military aircraft, radar equipment and weapons.
Automobile & parts	**335**	3353 – Automobiles: Makers of motorcycles and passenger vehicles, including cars, sport utility vehicles (SUVs) and light trucks. Excludes makers of heavy trucks, which are classified under Commercial Vehicles & Trucks, and makers of recreational vehicles (RVs and ATVs), which are classified under Recreational Products. 3355 – Auto parts: Manufacturers and distributors of new and replacement parts for motorcycles and automobiles, such as engines, carburetors and batteries. Excludes producers of tires, which are classified under Tires. 3357 – Tires: Manufacturers, distributors and retreaders of automobile, truck and motorcycle tires.
Commercial vehicles & trucks	**2753**	Manufacturers and distributors of commercial vehicles and heavy agricultural and construction machinery, including rail cars, tractors, bulldozers, cranes, buses and industrial lawn mowers. Includes nonmilitary shipbuilders, such as builders of cruise ships and ferries.
Industrial transportation	**277**	2771 - Delivery Services: Operators of mail and package delivery services for commercial and consumer use. Includes courier and logistic services primarily involving air transportation. 2773 - Marine Transportation: Providers of on-water transportation for commercial markets, such as container shipping. Excludes ports, which are classified under Transportation Services, and shipbuilders, which are classified under Commercial Vehicles & Trucks. 2775 – Railroads: Manufacturers, distributors and retreaders of automobile, truck and motorcycle tires. 2777 - Transportation Services: Companies providing services to the Industrial Transportation sector, including companies that manage airports, train depots, roads, bridges, tunnels, ports, and providers of logistic services to shippers of goods. Includes companies that provide aircraft and vehicle maintenance services. 2779 –Trucking: Companies that provide commercial trucking services. Excludes road and tunnel operators, which are classified under Transportation Services, and vehicle rental and taxi companies, which are classified under Travel & Tourism

http://www.icbenchmark.com/ICBDocs/Structure_Defs_English.pdf

Annex II - Statistical classification of economic activities (NACE) revision 2

This table shows the transport-related sectors used in this deliverable.

NACE R2 section	Description
C29	**Manufacture of motor vehicles, trailers and semi-trailers** **29.1 Manufacture of motor vehicles** This includes the manufacture of passenger cars, manufacture of commercial vehicles (vans, lorries, over-the-road tractors for semi-trailers, dumpers for off-road use, etc.), manufacture of buses, trolley-buses and coaches, manufacture of motor vehicle engines, manufacture of chassis fitted with engines, manufacture of other motor vehicles (snowmobiles, golf carts, amphibious vehicles; fire engines, street sweepers, travelling libraries and banks, etc.) **29.2 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers** This division includes the manufacture of bodies, including cabs for motor vehicles, outfitting of all types of motor vehicles, trailers and semi-trailers, manufacture of trailers and semi-trailers (tankers, caravan trailers, etc.), manufacture of containers for carriage by one or more modes of transport. **29.3 Manufacture of parts and accessories for motor vehicles** This class includes the manufacture of diverse parts and accessories for motor vehicles (brakes, gear boxes, axles, road wheels, suspension shock absorbers, radiators, silencers, exhaust pipes, clutches, steering wheels, steering columns and steering boxes), manufacture of parts and accessories of bodies for motor vehicles (safety belts, doors, bumpers). This division also includes manufacture of inlet and exhaust valves of internal combustion engines.
C30	**Manufacture of other transport equipment** **30.1 Building of ships and boats** The sub-division 30.11 includes the building of commercial vessels (passenger vessels, ferry-boats, cargo ships, tankers, etc.), building of warships, building of fishing boats, construction of hovercraft, construction of drilling platforms, floating or submersible, construction of floating structures (floating docks, pontoons, coffer-dams, floating landing stages, buoys, floating tanks, barges, lighters, etc.), maintenance, repair or alteration of ships, shipbreaking. The sub-division 30.12 includes the building of inflatables, building of sailboats with or without auxiliary motor, building of motor boats, building of other pleasure and sporting boats (canoes, kayaks, skiffs). **30.2 Manufacture of railway and tramway locomotives and rolling stock** This includes the manufacture of electric and diesel rail locomotives, manufacture of self-propelled railway or tramway coaches, vans and trucks, maintenance or service vehicles, manufacture of railway or tramway rolling stock, not self-propelled (passenger coaches, goods vans, tank wagons, self-discharging vans and wagons, workshop vans, crane vans, tenders, etc.), manufacture of specialized parts of railway or tramway locomotives or of rolling stock (bogies, axles and wheels, brakes and parts of brakes; hooks and coupling devices, buffers and buffer parts; shock absorbers; wagon and locomotive frames; bodies; corridor connections, etc.) **30.3 Manufacture of aircraft and spacecraft** This class includes the manufacture of aeroplanes for the transport of goods or passengers, for use by the defence forces, for sport or other purposes, manufacture of helicopters, manufacture of gliders, hang-gliders, manufacture of dirigibles and balloons, manufacture of spacecraft and spacecraft launch vehicles, satellites, planetary probes, orbital stations, shuttles, manufacture of parts and accessories of the aircraft of this class (major assemblies such as fuselages, wings, doors, control surfaces, landing gear, fuel tanks, nacelles, etc., airscrews, helicopter rotors and propelled rotor blades, motors and engines of a kind typically found on aircraft, parts of turbojets and turbopropellers), manufacture of aircraft launching gear, deck arresters, etc., manufacture of ground flying trainers. **30.9 Manufacture of transport equipment n.e.c.** 30.91 Manufacture of motorcycles and bicycles (manufacture of motorcycles, mopeds and cycles fitted with an auxiliary engine; manufacture of engines for motorcycles; manufacture of sidecars; manufacture of parts and accessories for motorcycles) 30.92 Manufacture of bicycles and invalid carriages (manufacture of non-motorised bicycles and other cycles, including (delivery) tricycles, tandems, children's bicycles and tricycles; manufacture of parts and accessories of bicycles; manufacture of invalid carriages with or without motor; manufacture of parts and accessories of invalid carriages; manufacture of baby carriages)

	30.99 Manufacture of transport equipment n.e.c. (manufacture of hand-propelled vehicles: luggage trucks, handcarts, sledges, shopping carts etc.; manufacture of vehicles drawn by animals: sulkies, donkey-carts, hearses etc.)
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles This includes all activities (except manufacture and renting) related to motor vehicles and motorcycles, including lorries and trucks (wholesale and retail sale of new and second-hand vehicles, maintenance and repair, wholesale and retail sale of parts and accessories, activities of commission agents involved in wholesale or retail sale of vehicles, washing, polishing and towing of vehicles, etc.). This also includes retail sale of automotive fuel and lubricating or cooling products.
H	**Transport, storage** This includes activities related to providing passenger or freight transport, whether scheduled or not, by rail, pipeline, road, water or air, supporting activities such as terminal and parking facilities, cargo handling, storage, etc., postal activities and telecommunication, renting of transport equipment with driver or operator. **49 Land transport; transport via pipelines** 49.1 Passenger rail transport, interurban; 49.2 Freight rail transport; 49.3 Other land transport; 49.4 Freight transport by road and removal services; 49.5 Transport via pipelines **50 Water transport** 50.1 Sea and coastal passenger water transport; 50.2 Sea and coastal freight water transport; 50.3 Inland passenger water transport; 50.4 Inland freight water transport **51 Air transport** 51.1 Passenger air transport; 52.1 Freight air transport and space transport; **52 Warehousing and support activities for transportation** 52.1Warehousing and storage 52.2 Support activities for transportation **53 Postal and courier activities** 53.1 Postal activities under universal service obligation 53.2 Other postal and courier activities

Eurostat (2008)

Annex III - International standard industrial classification (ISIC) of all economic activities

This table shows the transport-related sectors used in this deliverable.

ISIC R3 section	Description
D34	**Manufacture of motor vehicles, trailers and semi-trailers** 341 Manufacture of motor vehicles 342 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 343 Manufacture of parts and accessories for motor vehicles and their engines
C35	**Manufacture of other transport equipment** 351 Building and repairing of ships and boats The sub-division 3511 Building and repairing of ships; The sub-division 351212 Building and repairing of pleasure and sporting boats. 352 Manufacture of railway and tramway locomotives and rolling stock 353 Manufacture of aircraft and spacecraft 30.9 Manufacture of transport equipment n.e.c.
G50	**Sale, maintenance and retail of motor vehicles and motorcycles; retail sale of automotive fuel** This division includes wholesale and retail sale of new and second hand motor vehicles, motorcycles and snowmobiles, maintenance and repair, sale of parts and accessories, activities of commission agents involved in the sale of the vehicles, washing, polishing and towing of vehicles, etc. Also included is the retail sale of automotive fuel and lubricating or cooling products.
I	**Transport, storage** These divisions include activities related to providing passenger or freight transport, whether scheduled or not, by rail, road, water or air and auxiliary activities such as terminal and parking facilities, cargo handling, storage. Division 64 includes postal activities and telecommunications. In particular renting of transport equipment with driver or operator for the different transport modes are considered to be transport activities and are therefore included in this section. 60 Land transport; transport via pipelines (601 Transport via railways; 602 Other land transport; 603 Transport via pipelines) 61 Water transport (611 Sea and coastal water transport; 612 Inland water transport) 62 Air transport (621 Scheduled air transport; 622 Non-scheduled t air transport) 63 Supporting and auxiliary transport activities; activities of travel agencies 64 Post and telecommunications (641 Post and courier activities; 642 Telecommunications)

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