

Achieving Economies of Scale and Scope in Automotive Research – The Automotive Industry and the Community Framework Programme for Research and Technological Development

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ABSTRACT

The EU automotive industry is a major European industry. Though it is internationally competitive, its favourable position is under threat. R&D is the main driver of competitiveness in an industry marked by intense global competition. Automotive research is expensive and complex, and thus characterised by economies of scale and scope, which can be achieved via collaborative research. The European Community Framework Programme supports collaborative automotive research on key research challenges concerning hydrogen and fuel cells, ICT, and new materials.

Key-words: Competitiveness, Research/R&D, Collaboration, Economies of Scale and Scope, Framework Programme, Joint Technology

THE AUTOMOTIVE INDUSTRY – ONE OF EUROPE'S MAJOR INDUSTRIES

The automotive industry is one of Europe's major industries, and this not just because of its being the producer of one of the most important consumer goods in terms of total household expenditure.¹ In 2002, it accounted for 2.2 million jobs in the EU-25, equivalent to 6.4 percent of EU-25 manufacturing employment (Table 1).² It generated a turnover of € 720.6 billion, or 12.4 percent of manufacturing turnover (Table 1). And it produced € 118.0 billion of value added, equivalent to 7.7 percent of manufacturing value added (Table 1).³ In addition, it was responsible for about twice the amount of automotive value added and about twice the number of automotive jobs in upstream industries via backward

economic linkages.⁴

The European automotive industry is geographically concentrated, as a result of which the industry is of greater than average economic importance in some countries. Germany accounts for 45 percent of total EU-15 value added in motor vehicle production, France for 17 percent, the UK for 11 percent, Italy for 7 percent, Spain for 7 percent, and Sweden for 6 percent. Together, these six countries account for about 93 percent of motor vehicle production within the EU-15.⁵ In 2002, the motor vehicle industry accounted for 11 percent of manufacturing employment in Germany, 10 percent in Sweden, 8 percent in the Czech Republic, 8 percent in Belgium, 7 percent in Spain, and 7 percent in France.⁶ In the same year, it accounted for 15 percent of total manufacturing value added in Sweden, 13 percent in Germany, 10 percent in France, 7 percent in Spain, 7 percent in Belgium, 6 percent in Austria, 5 percent in the UK, and 4 percent in Italy.⁷

¹ European Commission, *European Competitiveness Report 2004*, Luxembourg, Office for Official Publications of the European Communities, 2004, p. 156.

² EU-15 automotive employment declined by 2 percent between 2000 and 2002 (European Commission, *European Competitiveness Report 2004*, p. 156).

³ The share of motor vehicles in total manufacturing value added has been stable since 1991 in the EU-15 (European Commission, *European Competitiveness Report 2004*, p. 156).

⁴ European Commission, *European Competitiveness Report 2004*, p. 157.

⁵ European Commission, *European Competitiveness Report 2004*, p. 156.

⁶ European Commission, *European Competitiveness Report 2004*, p. 157.

⁷ European Commission, *European Competitiveness Report 2004*, p. 156.

The automotive industry generates sizeable net export earnings. In 2005, EU-25 extra-European exports of the broader category of 'vehicles other than railway or tramway rolling-stock, and parts and accessories thereof' amounted to € 109.8 billion, and imports to € 48.5 billion, resulting in a trade surplus of 61.3 billion.⁸ Automotive industry exports more narrowly defined amounted to € 72.7 billion, and imports to € 30.6 billion, resulting in a trade surplus of € 42.1 billion.⁹

The economic importance of the automotive industry also relates to its being a key driver of the development and the diffusion of new technologies. The automotive industry is itself a highly R&D-intensive industry. But it is also an important source of demand for innovations by other industries, to which it is linked (e.g. chemicals, plastics, electrical and electronic parts, ICT, etc.), and an effective channel for their rapid diffusion.¹⁰

THE EU AUTOMOTIVE INDUSTRY – INTERNATIONALLY COMPETITIVE, FOR NOW

The international competitiveness of a particular industry is usually assessed by analysing its performance in international markets, in particular its ability to defend or gain market share in those markets.¹¹ By that standard, the European automotive industry appears to be internationally competitive.¹² It has maintained, and even improved slightly, its share of global sales.¹³ Between 1995 and 2001, for instance, EU automotive companies' share of triad worldwide automotive sales increased slightly.¹⁴ The EU automotive industry's good worldwide sales performance is due in the first place to "*its dominance of a large, loyal, sophisticated and diversified home market*".¹⁵ Another important

factor is the increase in the EU automotive industry's share of global exports.¹⁶ Between 1991 and 2001, for instance, the EU-15 increased its share of total OECD automotive exports.¹⁷ A third factor is the EU automotive industry's strong position in emerging markets such as China and the Russian Federation.¹⁸

But the favourable position of in particular the EU-15 automotive industry is under threat. While the EU is the world's largest market for passenger cars, and the world's second largest market for commercial vehicles, in particular the EU-15 is a replacement market, and so has limited further growth potential.¹⁹ While the overall EU-15 share of global automotive exports has increased, the export performance of individual EU-15 Member States has been mixed.²⁰ EU-15 labour costs are high, and EU-15 labour productivity is low.²¹ All of this points into the direction of the (further) delocalisation of automotive production out of the EU-15 towards Eastern Europe and further away.

THE AUTOMOTIVE INDUSTRY – MARKED BY INTENSE GLOBAL COMPETITION

The EU automotive industry must safeguard its international competitiveness within a context of intense global competition. The automotive industry is an industry characterised by production economies of scale and scope.²² And the search for such economies has resulted in a comparatively small number of industry players, each with a large production capacity, and each active in most market segments in both mature and emerging markets. The number of car manufacturers in Europe, the US and Japan dwindled from 36 in 1970 to 30 in 1980, 22 in 1990, and 14 in 2003.²³ And the production per car company or group of car companies runs in the millions of units.²⁴

⁸ Eurostat (DS-016894 – EU25 Trade Since 1995 By H2-H4).

⁹ Eurostat (DS-016894 – EU25 Trade Since 1995 By H2-H4); 8702 (Motor vehicles for the transport of >=10 persons, incl. driver); 8703 (Motor cars and other motor vehicles principally designed for the transport of persons, incl. station wagons and racing cars (excl. motor vehicles of heading 8702)); 8704 (Motor vehicles for the transport of goods, incl. chassis with engine and cab).

¹⁰ European Commission, *European Competitiveness Report*, p. 155-156.

¹¹ European Commission, *European Competitiveness Report 2004*, p. 168-169.

¹² European Commission, *European Competitiveness Report 2004*, p. 191.

¹³ European Commission, *European Competitiveness Report 2004*, p. 191.

¹⁴ European Commission, *European Competitiveness Report 2004*, p. 175-176.

¹⁵ European Commission, *European Competitiveness Report 2004*, p. 191.

¹⁶ European Commission, *European Competitiveness Report 2004*, p. 191.

¹⁷ European Commission, *European Competitiveness Report 2004*, p. 171-172.

¹⁸ European Commission, *European Competitiveness Report 2004*, p. 191.

¹⁹ European Commission, *European Competitiveness Report 2004*, p. 191 and 219-220.

²⁰ European Commission, *European Competitiveness Report 2004*, p. 174 and 191.

²¹ European Commission, *European Competitiveness Report 2004*, p. 191-195 and 220.

²² European Commission, *European Competitiveness Report 2004*, p. 163.

²³ European Commission, *European Competitiveness Report 2004*, p. 163-164.

²⁴ European Commission, *European Competitiveness Report 2004*, p. 161.

Such intense global competition results in high levels of investment in fixed capital, plant and equipment, especially in emerging markets, and sometimes over-capacity. In the manufacturing sector, the automotive industry capital intensity (investment per person employed) is inferior only to that in mining,²⁵ oil refining, chemicals, paper, and basic metals.

It also gives rise to a constant restructuring of the automotive value chain. Car manufacturers concentrate increasingly on core tasks, and occupy an ever smaller part of the overall automotive value chain, which is clear from decreases in car manufacturers' shares of total automotive value added and employment. The basic evolution is from car manufacturers assembling a high number of individual parts either procured internally or from a large number of external suppliers, to car manufacturers concentrating on engines and car bodies, and assembling a limited number of modules developed by or in cooperation with a limited number of external partners.²⁶

In spite of industry consolidation, high levels of investment, and value chain restructuring, levels of profitability in the motor vehicle industry are relatively low. The estimated operating margin fell between 1 and 2 percent in Europe in 2001.²⁷

R&D AND INNOVATION - DRIVERS OF COMPETITIVENESS IN THE AUTOMOTIVE INDUSTRY

The intensity of global competition in the automotive industry stimulates innovation. It drives the search for product innovation, which allows for escaping pure price competition, and for process innovation, which allows for controlling production costs.²⁸

The research challenges in terms of product innovation in the automotive sector are many. Recent foresight analyses point to important advances to be made in areas such as hydrogen and fuel cells, ICT, and nanotechnology (Boxes 1 and 2).

The urgency of meeting those research challenges explains why the automotive industry is one of Europe's most R&D-intensive industries. R&D expenditure accounted for 38 percent of total

motor vehicle industry expenditure in the EU-15 in 2000.²⁹ The share of motor industry R&D expenditure in total manufacturing R&D expenditure is on the rise in Europe. Between 1995 and 2000, for instance, this share increased by twenty percent.³⁰ By 2003, business enterprise R&D expenditure in the automotive industry, which accounted for most R&D expenditure by far in the automotive industry, amounted to PPS 18.8 billion, or 20.5 percent of manufacturing business enterprise R&D expenditure, and 16.6 percent of total business enterprise R&D expenditure (Table 2).

Table 2 shows that Germany accounted for most automotive industry business enterprise R&D expenditure in 2003, followed by France, the UK, Sweden, and Italy. It also shows that in a number of European countries, the automotive industry accounted for much larger than average shares of manufacturing and total business R&D expenditure. In the Czech Republic, for instance, automotive industry business enterprise R&D expenditure accounted for 43 percent of manufacturing business enterprise R&D expenditure in 2003, in Germany for 34.9 percent, and in Sweden for 26.8 percent.

The European automotive industry is also R&D-intensive from an internationally comparative perspective. The EU increased its share of motor industry R&D expenditure in Europe, the US and Japan from thirty-four to thirty-eight percent between 1995 and 2000.³¹ And EU-15 companies among the top 300 international firms by R&D expenditure spent substantially less on R&D than their US counterparts in 'Pharma & biotech', 'IT hardware', and 'Software & computer services', but maintained a substantial lead in 'automobiles & parts' in 2002.³²

The 2006 EU Industrial R&D Investment Scoreboard also provides an interesting insight into how European and foreign (US and other) automotive companies compare in terms of R&D expenditure. The Scoreboard lists 44 companies in the 'Automobiles & Parts' sector as part of the top 1000 European companies by R&D investment (Table 3), and 52 companies in the 'Automobiles & Parts' sector as part of the top 1000 non-European companies by R&D investment (Table 4). The data show that the

²⁵ European Commission, *European Competitiveness Report 2004*, p. 157.

²⁶ European Commission, *European Competitiveness Report 2004*, p. 165-167.

²⁷ European Commission, *Key Indicators on the Competitiveness of the EU's Automotive Industry*, Memo/05/7, Brussels, 13 January 2005, s.p.

²⁸ European Commission, *European Competitiveness Report 2004*, p. 168.

²⁹ European Commission, *Key Indicators*, s.p.

³⁰ European Commission, *European Competitiveness Report 2004*, p. 158.

³¹ European Commission, *European Competitiveness Report 2004*, p. 199.

³² European Commission, *Towards a European Research Area – Science, Technology and Innovation – Key Figures 2003-2004*, Luxembourg, Office for Official Publications of the European Communities, 2003, p. 33-34.

European companies account for 41 percent of combined European and non-European R&D investment, and are slightly more R&D-intensive than non-European companies when R&D intensity is expressed through the R&D/net sale ratio, but slightly less R&D-intensive when R&D-intensity is expressed through R&D per employee (Table 5).

The immediate objective for the automotive industry is not only to spend more on research, but also to do so more efficiently. That is why, for instance, the search is on for better design systems. A recent foresight analysis on the automotive industry listed as an important economic driver and key determinant of the future of the sector, design systems significantly reducing development time and raising value (introduction of more sophisticated virtual engineering tools for all aspects of vehicle design).³³

But that is also why more and more automotive R&D is undertaken collaboratively.³⁴ Collaborative R&D allows for achieving critical mass and economies of scale.³⁵ It allows for the pooling of competences, important given the variety of the research challenges listed above. And it reduces risk as it spreads research investment over more partners and fosters the wider acceptance of proposed solutions and product standardisation.³⁶

ACHIEVING RESEARCH ECONOMIES OF SCALE AND SCOPE IN AUTOMOTIVE RESEARCH ON KEY ISSUES THROUGH THE COMMUNITY FRAMEWORK PROGRAMME

The European Community's Framework Programmes for Research and Technological Development are multi-annual programmes in support of European S&T and industrial competitiveness. They provide support for research which cannot be provided at regional or

national levels. The Framework Programmes support research projects by trans-national and mixed-actor (firms, universities, research institutes) consortia, contain schemes in support of pan-European researcher mobility (Marie Curie), facilitate the establishment of and access to large European research infrastructures, and promote the coordination of national research programmes.

So far, six Framework Programmes have been implemented over a period of a little over twenty years. The overall Framework Programme objective being extremely permissive, the specific focus of each programme has evolved over time.³⁷ The rationale for the 1st Framework Programme was the perceived technology gap.³⁸ The 2nd Framework Programme (1987-1991) was intended to strengthen the research base of European industry in response to fierce Japanese competition. Developing information and communication technologies was high on the political agenda. The 3rd Framework Programme (1990-1994) was developed against the background of efforts to integrate the European market. The conceptualisation of the 4th Framework Programme (1994-1998) took place during the period of the Maastricht Treaty (1992) and the White Paper on Growth, Competitiveness and Employment (1993). The 5th Framework Programme (1998-2002) put increased emphasis on socio-economic values. And the 6th Framework Programme (2002-2006) was designed to help build the European Research Area (Table 6).³⁹

Together with its rationale, the Framework Programme's content has also evolved. The number and content of Specific Programmes has changed from one Framework Programme to the next. The number of thematic priorities has multiplied. And new instruments have been introduced.

The Framework Programme budget has grown over time and reached about € 19 billion (at 2004 prices) for the four-year period 2002-2006 under the 6th Framework Programme (Figure 1). In 2006, research accounted for 4 percent of the EU budget (Figure 2).⁴⁰ The Framework Programme

³³ *Foresight Vehicle Technology Roadmap 2020 – Technology and Research Directions for Future Road Vehicles*, Foresight Brief No. 6 (www.emfn.info).

³⁴ A recent foresight analysis on the automotive industry called for "collaborative research on nanotechnology and its applications on the sector" (Logotech SA, *Perspectives of National and Regional Research and Innovation Systems in an Enlarged EU 2015: Specialisation, Complementarity and Competition*, June 2006, p. 49).

³⁵ Logotech SA, *Perspectives*, p. 49; Emmanuelle Maincent and Lluís Navarro, *A Policy for Industrial Champions: From Picking Winners to Fostering Excellence and the Growth of Firms*, Industrial Policy and Economic Reforms Papers No. 2, April 2006, p. 16-17.

³⁶ Logotech SA, *Perspectives*, p. 49.

³⁷ Erik Arnold, *What the Evaluation Record Tells Us about Framework Programme Performance*, May 2005, p. 3-4.

³⁸ Stefano Breschi and Lucia Cusmano, *Unveiling the Texture of a European Research Area: Emergence of Oligarchic Networks Under EU Framework Programmes*, CESPRI Working Paper No. 130, July 2002, p. 5.

³⁹ European Commission, *Five-Year Assessment of the European Union Research Framework Programmes 1999-2003*, 15 December 2004, p. 4.

⁴⁰ European Commission, *General Budget of the European Union for the Financial Year 2006 – The Figures*, Luxembourg, 2006, p. 13-15 (Sum of commitment

also accounts for about 6 percent of EU-15 non-military governmental RTD expenditure.⁴¹ This share increases to almost 25 percent when public support for research is more narrowly defined.⁴²

Collaborative research under the 6th Framework Programme centred on six thematic priorities: (1) 'Life Sciences, Genomics and Biotechnology for Health'; (2) 'Information Society Technologies'; (3) 'Nanotechnologies and Nanosciences, Knowledge-based Multifunctional Materials and New Production Processes and Devices'; (4) 'Aeronautics and Space'; (5) 'Food Quality and Safety'; (6) 'Sustainable Development, Global Change and Ecosystems'; and (7) 'Citizens and Governance in a Knowledge-based Society'. The thematic priority 'Sustainable Development, Global Change and Ecosystems' contained the three sub-priorities of 'Sustainable Energy Systems', 'Sustainable Surface Transport', and 'Global Change and Ecosystems'.

The automotive industry has been a very active participant in the 6th Framework Programme. So far fifty-six major automotive firms have participated 292 times in the Programme through 129 different contracts (Tables 7 and 8). That means that on average, each major firm participated 5.2 times in the programme, and 2.3 different major firms participated in each contract. Most major firm participations were from Germany, followed by Italy, France, and Sweden.⁴³

The total Community financial contribution to the 129 contracts in which major automotive industry firms participated amounted to € 771.7 million (resulting in an average of € 6.0 million per contract). The total Community financial contribution to the major automotive industry firms' participations in those contracts amounted to € 124.1 million (resulting in an average of € 425 thousand per participation).

Most contracts and participations fell in the priority

area ICT, followed by sustainable development, and by nanotechnology and new materials. Most contracts took the form of STREPS, followed by IPs, and by NOEs. For participations, the ranking was different, since IPs and NOEs by definition involve a larger number of participants than STREPS. Most participations were in IPs, followed by STREPS, and by NOEs.

An analysis of all participations in contracts in which major automotive industry firms participated generated the following results. 1517 participants participated 2607 times in the aforementioned 129 different contracts. That means that on average, each participant participated 1.7 times in the programme and 20.2 participants participated in each contract.

Most participations were by German participants, followed by Italian and French participants, and then participants from the UK, Spain, Sweden, the Netherlands, Greece, Switzerland and Belgium.⁴⁴ Most participants were firms, followed by research institutes, and by higher education institutes.⁴⁵ The average Community financial contribution to the participations in those contracts amounted to € 293 thousand per participation. Most contracts and participations fell in the priority area ICT, followed by sustainable development, and by nanotechnology and new materials. Most participations were in IPs, followed by STREPS, and by NOEs.

As can be seen from Tables 9 and 10, these projects addressed important automotive industry research challenges, relating to, for instance, hydrogen and the development of fuel cells.

Like the 6th Framework Programme, the 7th will provide the EU automotive industry with ample research funding opportunities. The Commission presented its 7th Framework Programme proposal on 6 April 2005, and this proposal is now approaching its final approval.⁴⁶ The 7th

appropriations for 'Research' and for 'Research Framework Programme' under 'Enterprise', 'Energy and transport', 'Information society and media' and 'Direct research').

⁴¹ Court of Auditors, *Special Report No 1/2004 on the Management of Indirect RTD Actions under the Fifth Framework Programme (FP5) for Research and Technological Development (1998 to 2002), Together with the Commission's Replies (Pursuant to Article 248(4) Second Subparagraph EC) (2004/C 99/01)*, 23 April 2004, Paragraph 5.

⁴² Court of Auditors, *Special Report No 1/2004*, Paragraph 5: "However, if institutional funding is deducted, the budget for FP5 indirect RTD actions amounts to approximately a quarter of total funding for publicly financed research projects in the European Union".

⁴³ Germany: 117; Italy: 87; France: 35; Sweden: 33; Czech Republic: 6; United Kingdom: 5; Netherlands: 2; Belgium: 2; Austria: 2; Spain: 1; Switzerland: 1; Turkey: 1.

⁴⁴ Germany: 635; Italy: 343; France: 289; United Kingdom: 224; Spain: 160; Sweden: 129; Netherlands: 100; Greece: 90; Switzerland: 76; Belgium: 73; Austria: 66; Poland: 58; Finland: 50; Norway: 45; Portugal: 30; Hungary: 27; Ireland: 26; Czech Republic: 26; Denmark: 25; Israel: 19; Slovenia: 11; Romania: 9; Luxembourg: 8; European Union: 8; Turkey: 7; China: 7; Bulgaria: 7; Iceland: 6; Estonia: 6; Canada: 6; Australia: 6; United States: 5; Russian Federation: 5; Slovakia: 4; Lithuania: 4; Cyprus: 3; Brazil: 3; Ukraine: 2; Latvia: 2; Japan: 2; Undefined: 1; Singapore: 1; Malta: 1; Croatia: 1; Belarus: 1.

⁴⁵ Industry: 936; Research Institutes: 657; Higher Education: 610; Other: 404.

⁴⁶ European Commission, *Building the Europe of Knowledge*, Proposal for a Decision of the European Parliament and of the Council Concerning the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (2007 to 2013) – Proposal for a Council Decision

Framework Programme will run over seven years (2007-2013), and its budget will amount to € 48 billion (at 2004 prices), smaller than what was proposed by the Commission but by far the largest budget ever. The overall Framework Programme will consist of 4 so-called Specific Programmes: (1) 'Cooperation', concerning collaborative research; (2) 'Ideas', concerning frontier research; (3) 'People', concerning human potential; and (4) 'Capacities', concerning research capacities. Of most relevance to the EU automotive industry will be the 'Cooperation' Specific Programme, which among other things concerns 'Collaborative Research' and 'Joint Technology Initiatives'.

'Collaborative Research' is the traditional mainstay of all Framework Programmes so far, and is the kind of activity in which - as was described in detail above for the 6th Framework Programme - the EU automotive industry has been participating very actively. 'Collaborative Research' under the 7th Framework Programme will probably focus on 10 thematic priorities (instead of 7 under the 6th Framework Programme): (1) 'Health'; (2) 'Food, Agriculture and Biotechnology'; (3) 'Information and Communication Technologies'; (4) 'Nanosciences, Nanotechnologies, Materials and New Production Technologies'; (5) 'Energy'; (6) 'Environment (Including Climate Change)'; (7) 'Transport (Including Aeronautics)'; (8) 'Socio-economic Sciences and the Humanities'; (9) 'Security'; and (10) 'Space'. The 'Energy' thematic priority includes among others the activity 'Hydrogen and fuel cells'. The 'Transport' thematic priority includes among others the activity 'Surface Transport (Rail, Road and Waterborne)', which covers the areas 'The Greening of Surface Transport', 'Encouraging Modal Shift and Decongesting Transport Corridors', 'Ensuring Sustainable Urban Mobility', 'Improving Safety and Security', and 'Strengthening Competitiveness'.

'Joint Technology Initiatives' are completely new instruments, and so will be used for the first time under the 7th Framework Programme. 'Joint Technology Initiatives' are based on 'European Technology Platforms'. These are industry- or issue-based platforms, which focus on the development of comprehensive long-term strategic research agendas. So far, two 'European Technology Platforms' have been established concerning the EU automotive sector, namely ERTRAC (European Road Transport Research Advisory Council) and HFP (European Hydrogen and Fuel Cell Technology Platform).⁴⁷ Usually,

traditional 'Collaborative Research' will suffice to support the implementation of these research agendas. However, in a limited number of cases, the scale of a research or technological objective and the resources involved justify setting up long-term public-private partnerships in the form of 'Joint Technology Initiatives'. These initiatives will combine private sector investment and national and European public funding, including grant funding from the Research Framework Programme and loan finance from the European Investment Bank. Joint Technology Initiatives may be decided on the basis of Article 171 of the Treaty or on the basis of the Specific Programme Decisions in accordance with Article 166 of the Treaty. One of the 'Joint Technology Initiatives' to be launched in the rather short term and concerning the EU automotive industry is the one concerning hydrogen and fuel cells.

CONCLUSION

The EU automotive industry is a major European industry. Both directly and indirectly (via backward economic linkages), it accounts for many jobs, much turnover, and much value added, and this at overall Community level, but in particular in a number of Member States. The industry also generates a sizeable extra-European trade surplus, and is important as both a developer and diffuser of new technologies.

The international competitiveness of the EU automotive industry is clear from its high and rising share of global automotive sales. It is based on the EU automotive industry's dominance of the European home market, its strong export performance, and its strong FDI presence in emerging markets. At the same time, the EU automotive industry's favourable international position is under threat because of the limited potential for further home market growth, the weakening export performance of some Member States, high labour costs, and low labour productivity.

The EU automotive industry has to safeguard its international competitiveness within a context of intense global competition. The automotive industry is a concentrated industry consisting of a limited number of players active in all market segments and all markets. Automotive industry investment levels are high. The automotive value chain is under constant restructuring. Yet automotive industry profit levels are low.

The main driver of automotive competitiveness is R&D. Short- to medium-term research challenges relate to fuel cells and hydrogen, ICT, and nanotechnology. As automotive research is increasingly expensive and complex, requiring a mix of complementary competences, it is marked

Concerning the Seventh Framework Programme of the European Atomic Energy Community (Euratom) for Nuclear Research and Training Activities (2007 to 2011) (Presented by the Commission) (SEC(2005) 430 and SEC(2005) 431), COM(2005) 119 final, 6 April 2005.

⁴⁷ <http://www.ertrac.org> and www.hfpeurope.org

by economies of scale and scope. That is why the (EU) automotive industry is not only spending more and more on research, but is also trying to do so more effectively via, for instance, collaboration.

The Community Framework Programmes for Research and Technological Development have a long history of supporting collaborative research in the automotive sector. The sector was a very active participant in the 6th Framework Programme collaborative research scheme. The 7th Framework Programme, which will run from 2007 to 2013, and will have a much larger budget than the 6th Framework Programme, will also provide ample opportunities for EU automotive research, in particular via the long-standing instrument of collaborative research and via the new instrument of 'Joint Technology Initiatives'.

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Table 1: Key Economic Indicators on the EU-25 Automotive Industry

| Indicator | Manufacturing | NACE Branch 34 ⁴⁸ | Ratio |
|--|---------------|------------------------------|-------|
| Number of Persons Employed | 33 718 400 | 2 163 400 | 6.4% |
| Personnel Costs (Mio Euro) | 1 019 450 | 93 885 | 9.2% |
| Turnover (Mio Euro) | 5 798 577 | 720 579 | 12.4% |
| Value Added at Factor Cost (Mio Euro) | 1 528 982 | 117 983 | 7.7% |
| Gross Operating Rate (%) | | 3.3 | |
| Labour Cost per Employee (Unit Labour Cost) (Thousand Euro) | | 43.7 | |
| Gross Value Added per Person Employed (Apparent Labour Productivity) (Thousand Euro) | | 54.5 | |
| Share of Value Added in Production (%) | 28.7 | 23.0 ⁴⁹ | |

Source: Eurostat (Note: All figures for 2002, except 'Share of Value Added in Production' (2001))

⁴⁸ NACE Branch 34: Manufacture of motor vehicles, trailers and semi-trailers.

⁴⁹ 'Manufacture of Transport Equipment'.

Box 1: Technological Areas with Significant Potential to Deliver High Impact Technology Solutions to Meet Social, Economic and Environmental Goals

Engine and Power Train Technologies: These would lead to improved thermal and mechanical efficiency, performance, drivability, reliability, durability and speed-to-market, together with reduced emissions and cost.

Hybrid, Electric and Alternatively Fuelled Vehicle Technologies: Leading to new fuel and power systems, such as hydrogen, fuel cells and batteries to satisfy future social, economic and environmental goals. Activities are concentrating on reducing fuel consumption of conventional vehicles, together with developing alternative energy and power systems, such as hybrids, electric and alternatively fuelled vehicles. Hydrogen and fuel cells are of particular importance, although it is likely to be 15-20 years before such systems will become widely available.

Advanced Software, Sensor, Electronic and Telematics Technologies: Their development will lead to improved vehicle performance, safety, control, adaptability, intelligence, mobility and security. The content of electronics and software in new vehicles will continue to increase in areas such as control and intelligence, telematics, information and service provision, entertainment and user interfaces. Many of these functions will require parallel development of the infrastructure to enable communications and system level control. The development and agreement of international standards will be a key enabler.

Advanced Structures and Materials Technologies: These will lead to improved safety, performance and product flexibility together with reduced costs and environmental impact. Interesting new materials technologies include lightweight alloys and polymers, fluids, coatings, biotechnology and nanotechnology.

Design and Manufacturing Process Technologies: These will provide improved industrial performance, considering the full vehicle life cycle from 'cradle to grave'. Newer, flexible manufacturing technologies have the opportunity to service different industry sectors and provide better returns on investment.

Source: *Foresight Vehicle Technology Roadmap 2020 – Technology and Research Directions for Future Road Vehicles*, Foresight Brief No. 6 (www.emfn.info)

Box 2: Major Issues Important for the Specialisation of Europe in the Automotive Industry

"The first is the concentration of both public and private forces for meeting the major future challenges. In the short to medium term, the challenge is to promote alternative clean technologies that could compete [with] the Japanese hybrid engine, while in the long run [it is] to develop **fuel cells** as standardised[d] products. Furthermore, collaborative research on **nanotechnology** and its applications on the sector, the development of a standardised **IT-backbone** across car models and software and hardware vendors, development and diffusion of intelligent transport systems across countries, are some of the issues where coordination between countries, car manufacturers and suppliers is necessary"

Source: Logotech SA, *Perspectives of National and Regional Research and Innovation Systems in an Enlarged EU 2015: Specialisation, Complementarity and Competition*, June 2006, p. 49 (emphasis added).

Table 2: Business Enterprise R&D Expenditure (BERD), 2003, Millions of PPS (Purchasing Power Standards)

| Country | All NACE branches [A] | Manufacturing [B] | NACE Branch 34 ⁵⁰ [C] | Ratio C/B | Ratio C/A |
|----------------|-----------------------|-------------------|----------------------------------|-----------|-----------|
| EU-25 | 113,437.00 | 91,793.00 | 18,784.00 | 16.6% | 20.5% |
| Germany | 34,192.59 | 31,092.19 | 10,860.73 | 31.8% | 34.9% |
| France | 20,434.42 | 17,633.34 | 3,013.32 | 14.7% | 17.1% |
| United Kingdom | 18,623.89 | 14,334.88 | 1,596.12 | 8.6% | 11.1% |
| Sweden | 6,602.95 | 5,304.90 | 1,421.75 | 21.5% | 26.8% |
| Italy | 7,059.48 | 5,209.39 | 731.34 | 10.4% | 14.0% |
| Czech Republic | 1,158.02 | 736.74 | 317.04 | 27.4% | 43.0% |
| Spain | 5,063.75 | 2,706.55 | 216.52 | 4.3% | 8.0% |
| Netherlands | 4,439.52 | 3,465.48 | 109.05 | 2.5% | 3.1% |
| Belgium | 3,500.09 | 2,749.79 | 75.23 | 2.1% | 2.7% |

⁵⁰ NACE Branch 34: Manufacture of motor vehicles, trailers and semi-trailers.

| | | | | | |
|-----------------|----------|----------|-------|-------|-------|
| Poland | 578.99 | 396.13 | 39.06 | 6.7% | 9.9% |
| Hungary | 452.27 | 348.14 | 38.81 | 8.6% | 11.1% |
| Greece | 357.79 | 235.17 | 16.99 | 4.7% | 7.2% |
| Portugal | 406.59 | 181.57 | 7.76 | 1.9% | 4.3% |
| Ireland | 900.01 | 557.75 | 4.93 | 0.5% | 0.9% |
| Slovenia | 277.89 | 237.40 | 4.67 | 1.7% | 2.0% |
| Estonia | 39.60 | 16.67 | 4.07 | 10.3% | 24.4% |
| Denmark | 2,509.32 | 1,528.61 | 2.32 | 0.1% | 0.2% |
| | | | | | |
| Bulgaria | 50.60 | 24.39 | 0.00 | 0.0% | 0.0% |
| Romania | 318.13 | 195.85 | 40.09 | 12.6% | 20.5% |
| | | | | | |
| Norway | 1,443.18 | 655.53 | 25.18 | 1.7% | 3.8% |

Source: Eurostat

Table 3: 'Automobiles & Parts' Companies among the Top 1000 European Companies by R&D Investment

| Country | Number of Companies | Names of Companies |
|------------|---------------------|--|
| ✓ Austria | ✓ 3 | ✓ EYBL International, Miba, Pankl Racing Systems |
| ✓ Finland | ✓ 1 | ✓ Nokian Tyres |
| ✓ France | ✓ 7 | ✓ Renault, Peugeot (PSA), Valeo, Michelin, Burelle, MGI Coutier, Gevelot |
| ✓ Germany | ✓ 16 | ✓ DaimlerChrysler, Volkswagen, BMW, Robert Bosch, Continental, ZF, Hella, Behr, Rheinmetall, ZF Lenksysteme, Eberspaecher, Grammer, Beru, Porsche, ElringKlinger, BBS Kraftfahrzeugtechnik |
| ✓ Italy | ✓ 6 | ✓ Fiat, Pirelli, IMMSI, Brembo, Ducati Motor, Carraro |
| ✓ Slovakia | ✓ 1 | ✓ Matador |
| ✓ Sweden | ✓ 4 | ✓ Autoliv, Trelleborg, Haldex, Opcon |
| ✓ UK | ✓ 6 | ✓ GKN, Avon Rubber, Wagon, Torotrak, ZYTEK, Antonov |

Source: 2006 EU Industrial R&D Investment Scoreboard

Table 4: 'Automobiles & Parts' Companies among the Top 1000 non-European Companies by R&D Investment

| Country | Number of Companies | Names of Companies |
|------------|---------------------|---|
| ✓ Canada | ✓ 1 | ✓ Ballard Power Systems |
| ✓ India | ✓ 1 | ✓ Tata Motors |
| ✓ Japan | ✓ 26 | ✓ Toyota Motor, Honda Motor, Nissan Motor, Denso, Aisin Seiki, Mazda Motor, Suzuki Motor, Bridgestone, Yamaha Motor, Mitsubishi Motors, Fuji Heavy Industries, Toyota Industries, Calsonic Kansei, Toyoda Gosei, Koito Manufacturing, Sumitomo Rubber Industries, NGK Spark Plug, Yokohama Rubber, Toyo Tire, Akebono Brake Industry, Showa, Nissin Kogyo, Ichikoh Industries, Sanden, Exedy, Kayaba Industry |
| ✓ Malaysia | ✓ 1 | ✓ Proton Holdings Berhad |

| | | |
|----------------------|------|---|
| ✓ South Korea | ✓ 3 | ✓ Hyundai Motor, Hankook Tire, Hyundai Mobis |
| ✓ Taiwan | ✓ 1 | ✓ China Motor |
| ✓ USA | ✓ 19 | ✓ Ford Motor, General Motors, Delphi, Visteon, Johnson Controls, Goodyear, Dana, TRW Automotive, Harley-Davidson, ArvinMeritor, Lear, BorgWarner, Federal-Mogul, American Axle & Manufacturing, Polaris Industries, Tenneco, Modine Manufacturing, Stoneridge, Gentex |

Source: 2006 EU Industrial R&D Investment Scoreboard

Table 5: Comparison of EU and non-EU Top 'Automobiles & Parts' Companies by R&D Investment

| Indicator | EU Companies | Non-EU Companies |
|--|--------------|------------------|
| 2005 R&D Investment (€ 000) | 25 984.01 | 38 107.42 |
| Change in R&D Investment from 2004 to 2005 (%) | 3.6 | 6.7 |
| 2005 Net Sales (€ 000) | 577 655 | 942 475 |
| 2005 Employees (#) | 2 180 176 | 2 639 262 |
| 2005 R&D/Net Sales Ratio (%) | 4.5 | 4.0 |
| 2005 Operating Profit (% of Net Sales) | 4.5 | 4.1 |
| 2005 R&D per Employee (€ 000) | 11.9 | 13.4 |

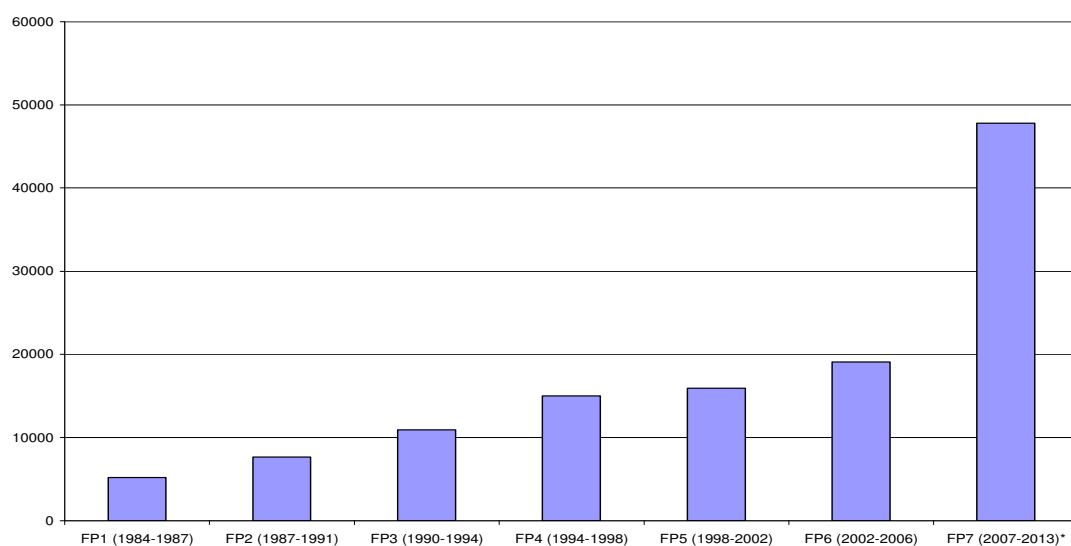
Source: 2006 EU Industrial R&D Investment Scoreboard

Table 6: The Evolution of the Framework Programme

| Periods | Main objective | Main priorities | New actions |
|--------------------|---------------------------------------|-------------------------|---|
| Before (1975-1983) | Ad hoc approach | Energy oriented | |
| FP1 (1984-1987) | Coordination of Community RTD actions | Energy and ICT oriented | Environment, international cooperation human capital and mobility |
| FP2 (1987-1991) | Information society | ICT oriented | Biotechnologies, marine resources, dissemination |
| FP3 (1990-1994) | Industrial competitiveness | Multiple priorities | |
| FP4 (1994-1998) | Industrial competitiveness | Multiple priorities | Transport and social sciences |
| FP5 (1998-2002) | Innovation and social needs oriented | Multiple priorities | Nanotechnologies |
| FP6 (2002-2006) | Instrument for ERA | Multiple priorities | New instruments |

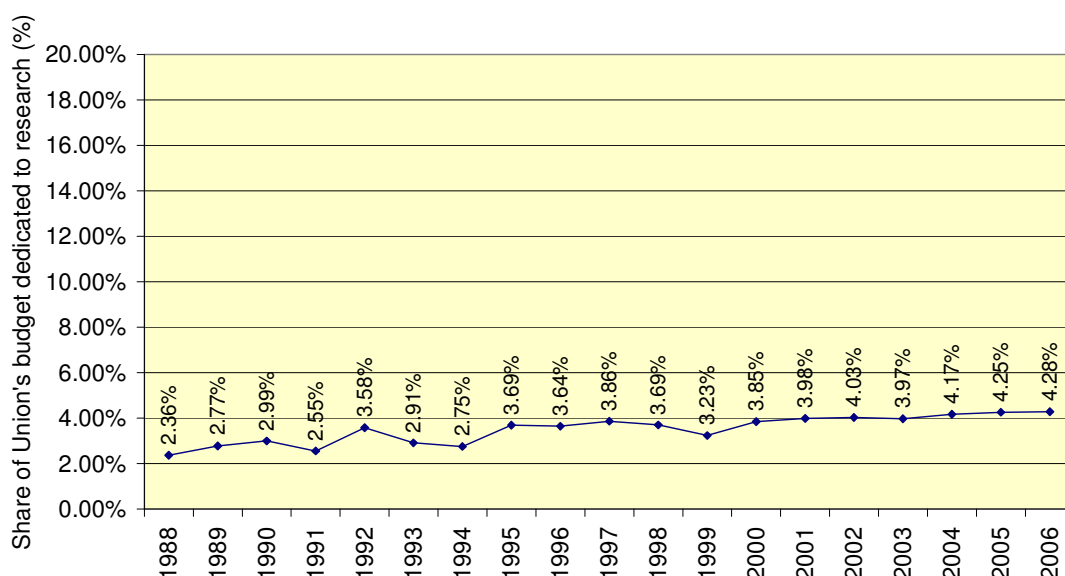
Source: DG Research

Figure 1: Evolution of the FP Budget (€ Million, 2004 Prices)



Source: DG Research - *: Provisional

Figure 2: Increasing Share of the Union's Budget Dedicated to Research



Source: DG Research - *: Provisional

Table 7: Key Data on FP6 Projects in which Major Automotive Industry Firms Participated

| | |
|---|-----------------|
| Total Number of Projects | 129 |
| Total EC Financial Contribution to All Projects | € 771.7 million |
| Average EC Financial Contribution per Project | € 6.0 million |
| Number of Projects by Priority Area | |
| ✓ Information Society Technologies | 57 |
| ✓ Sustainable Development, Global Change and Ecosystems | 42 |
| ✓ Nanotechnologies and Nanosciences, Knowledge-based Multifunctional Materials and New Production Processes and Devices | 30 |
| Number of Projects by Instrument | |
| ✓ Specific Targeted Research Projects (STREPs) | 68 |
| ✓ Integrated Projects (IPs) | 52 |
| ✓ Networks of Excellence (NoEs) | 9 |

Source: DG Research (Note: Data as of 17 July 2006)

Table 8: Key Data on Participations in FP6 Projects in which Major Automotive Industry Firms Participated

| Indicator | Participations by Major Automotive Industry Firms | All Participations |
|---|---|--------------------|
| Number of Participations | 292 | 2 607 |
| Number of Participants | 56 | 1 517 |
| Average Number of Participations per Participant | 5.2 | 1.7 |
| Average Number of Participations per Project | 2.26 | 20.2 |
| Total EC Contribution to All Participations | € 124.1 million | € 764.7 million |
| Average EC Contribution per Participation | € 424.9 thousand | €2 93.3 thousand |
| Number of Participations by Priority Area | | |
| ✓ Information Society Technologies | 130 | 1 193 |
| ✓ Sustainable Development, Global Change and Ecosystems | 123 | 898 |
| ✓ Nanotechnologies and Nanosciences, Knowledge-based Multifunctional Materials and New Production Processes and Devices | 39 | 516 |
| Number of Participations by Instrument | | |
| ✓ Integrated Projects | 163 | 1 521 |
| ✓ Specific Targeted Research Projects (STREPs) | 110 | 760 |
| ✓ Networks of Excellence (NoEs) | 19 | 326 |

Source: DG Research (Note: Data as of 17 July 2006)

Table 9: Examples of Hydrogen-related FP6 Projects in which Major Automotive Industry Firms Participated

| Instrument | Project Title | Total EC Financial Contribution to the Project (€) | Total Number of Participants in the Project |
|-------------------|--|---|--|
| IP | Development of a harmonised "European Hydrogen Energy Roadmap" by a balanced group of partners from industry, European regions and technical and socio-economic scenario and modelling experts | 4 000 000 | 34 |
| IP | Hydrogen and Fuel Cell Technologies for Road Transport (HYTRAN) | 8 811 143 | 19 |
| IP | Hydrogen for Clean Urban Transport in Europe | 18 986 145 | 31 |
| IP | Hydrogen Storage Systems for Automotive Application (STORHY) | 10 729 990 | 35 |
| IP | Lombardia & Rhein-Main towards Zero Emission: Development & Demonstration of Infrastructure Systems for Alternative Motor Fuels (Bio-fuels and Hydrogen) | 7 461 265 | 16 |
| IP | NOVEL EFFICIENT SOLID STORAGE FOR HYDROGEN | 7 499 999 | 22 |
| IP | Optimisation of hydrogen powered internal combustion engines (HYICE) | 5 008 316 | 10 |
| NOE | Safety of Hydrogen as an Energy Carrier (HYSAFE) | 7 000 000 | 25 |
| STREP | Handbook for Approval of Hydrogen Refuelling Stations | 1 900 000 | 25 |

Source: DG Research

Note: Data as of 17 July 2006; All projects fall under priority area "Sustainable Development, Global Change and Ecosystems"

Table 10: Examples of Fuel Cell-related FP6 Projects in which Major Automotive Industry Firms Participated

| Instrument | Project Title | Total EC Financial Contribution to the Project (€) | Total Number of Participants in the Project |
|-------------------|--|---|--|
| IP | Automotive High Temperature Fuel Cell Membranes | 8 299 693 | 29 |
| IP | Fuel Cell Hybrid Vehicle System Component Development | 11 197 200 | 25 |
| IP | Further Improvement and System Integration of High Temperature Polymer Electrolyte Membrane Fuel Cells (FURIM) | 3 999 000 | 13 |
| IP | Hydrogen and Fuel Cell Technologies for Road Transport (HYTRAN) | 8 811 143 | 19 |
| STREP | Compact direct (m)ethanol fuel cell for portable application (MOREPOWER) | 2 147 784 | 9 |

Source: DG Research

Note: Data as of 17 July 2006; All projects fall under priority area "Sustainable Development, Global Change and Ecosystems"