4 Innovation and Competitiveness

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The ability of firms to compete in foreign and home markets crucially depends on innovative products which can be produced and sold at attractive prices. In the short run productivity and labour costs are important drivers of competitiveness. In the long run the ability of firms to innovate and invest in R&D and innovation are crucial determinants of competitiveness. Hence, this section looks at these factors driving competitiveness more closely. The analysis looks at the position of EU member states relative to the most important car producing countries. Hence, our approach focuses on countries and not firms. So, data and interpretations might differ from a company based view which looks at the company or brand no matter where the production takes place. The approach rests on the international comparison of both, levels (e.g. the labour cost comparison) and trends of different factors fostering competitiveness.

4.1 Labour Costs, Labour Productivity and Unit Labour Costs

4.1.1 Data

Data presented in this section mainly rests on the Groningen Industry Labour Productivity Database (ILPD) described in detail in O'Mahony and van Ark (Eds.) (2003). This database is updated – where necessary – for the years 2000-2001 using the most recent version of the OECD/STAN database (web-version March 2004) from which the main parts of ILPD are derived. Data for Japan and Korea are directly taken from STAN. In addition, the database is augmented with estimates for average working hours per person employed for Japan and Korea from national sources. Also, value added deflators – not contained in STAN – are updated for some countries (e.g. Portugal) for the period 1996-2001 using a mixture of national sources and aggregated sector level information (e.g. transport equipment). When possible the database is enlarged by data on the value of shipments and intermediate products in order to allow unit labour cost comparisons.

International comparisons of productivity levels crucially rest on an appropriate conversion of national currencies into a common currency. The preferable option is to use industry-specific conversion factors (industry PPPs) which take into account international differences in product specific taxes, specific production levies, and more importantly differences in the prices in the countries at hand. Price differences mainly rest on car quality differences, international differences in brand reputation but also pricing strategies.

However, we do not follow van Ark/O'Mahony in two important dimensions. We develop different conversion factors for the conversion of national currencies into USD. In addition, we use these conversion factors to derive EU-15 aggregates instead of using a national currency per euro conversion based on exchange rates.

Industry PPPs have been developed for the automotive industry by Baily and Gersbach (1995) for Japan, the US and Germany (see also MGI, 1993, for details). Their analyses point towards an industry PPP for the German automotive sector of 2.22 DM/USD (~1.13 EUR/USD) and for the Japanese car production of around 150 Yen/USD for the year 1990.[49] In a study of productivity of the automotive sector of France and Germany MGI (McKinsey Global Institute, 2002) report an industry PPP for final car production of 0.962 EUR/USD for cars produced in Germany for 1999. More recently, O'Mahony and van Ark (Eds.) (2003) published sectoral industry PPPs for the EU vs. the US. Referring to the study of van Mulligen (2003) they use a value for the EUR/USD relation of 1.47 for German and US cars for 1997. Van Mulligen derive industry PPPs based on hedonic regressions in various EU countries, the US and Japan. A closer inspection of the estimates and comparison with other studies using hedonic techniques for quality-adjusted car prices[50] makes us suppose that these estimates are severely upward biased with respect to the quality of US cars leading to quite unreliable industry PPPs.[51]

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49 Estimates of industry PPP are especially troublesome for industries with heterogeneous products. In addition, the automotive industry not only consists of heterogeneous final products but also includes a wide variety of intermediate products making international price comparisons in this industry much more burdensome and imprecise than price comparisons for manufacturing as a whole. See van Ark and Timmer (2002) for more details involved in the calculation of industry PPPs.

50 For an explanation of hedonic techniques see e.g. Triplett (1987, 2002). References for hedonic prices for car industries can be found in van Mulligan (2003).

51 This assessment is based on the following arguments: Reliable hedonic prices crucially depend on detailed information on quality characteristics of goods at hand and on a correct specification of the functional form of the underlying regression. Van Mulligen's estimates only rely on engine power and car size. Moch et al. (2002) show for the car market in Germany that engine power and engine size should enter the regression model in a non-linear form when car quality is controlled for by these variables only. The non-linearity implies decreasing elasticities for these two quality characteristics. Neglecting this non-linearity as it is done by van Mulligen leads to an overestimation of quality adjusted prices for cars with high-powered engines and large-sized cars. As US produced cars are typically larger (about 10% compared to Germany) and have more horse power (about 50%) resulting industry PPPs for the EU/US comparison are severely overestimated (as also shown by e.g. Moch et al. (2002) for Germany, Bode and van Dalen (2001) for the Netherlands (see also section 4.3.3). Van Mulligen's results suffer from omitted variable biases and a wrong specification of the functional form. Adding more quality characteristics (like ABS, engine type) to the hedonic regression model typically leads to a significant drop in the estimated impact of engine power and car size on quality adjusted prices. In addition, new car quality characteristics are often introduced earlier in Japanese and EU cars.

In addition, although these studies refer to different years it's not clear how to reconcile traditional industry PPPs estimates and hedonic estimates. Comparing price differentials of some selected cars (e.g. Mercedes Benz S-Class, BMW 5 series) in US and Germany we find a 50% difference of car quality in Germany and US quite unrealistic and hence base our estimates on MGI type of industry PPPs.[52] This also enables us to use comparable estimates for industry PPPs for the Japanese and Korean automotive sector derived also by MGI in another study (MGI, 1998).

To derive industry PPPs for all EU-15 member states we follow O'Mahony and van Ark (2003)[53] and use their benchmark values for the year 1997 to determine industry PPPs for European countries relative to Germany. Then we take the industry PPP for the German-US comparison to derive industry PPPs for conversion of national currency values to USD dollar for EU member states. An industry PPP for 1997 for DM/USD is gained by interpolation of the values found in the 1993 MGI study (referring to the year 1990) and the 2002 study (referring to 1999).

In addition, taking a closer look at productivity levels over time calls for the extension of PPP values of the benchmark year 1997 to other years. Such an extension becomes all the more problematic the longer the time period between the benchmarking year and the year for which the extension is performed because consumers will adjust the demanded bundle of goods due to the changes of relative prices. As a consequence the bundle of goods sold/produced in the base year may no longer be valid in other years. Hence, the industry PPP will change not only due to the changes in the relative prices but also because of shifts in the bundle of goods used for weighting. Despite this caveat we adjust industry PPPs derived for benchmark years by multiplying industry PPPs by the relation of indices of the value added deflators between the country at hand and the US (after rebasing the value added deflator in 1997 to 1).

For testing the robustness of results we use three different conversion factors in our analyses. Here we follow van Ark (2002) who suggests to use both expenditure PPPs and industry PPPs to test for the sensitivity of results. Hence, we present two approaches:

1. Automotive industry PPPs as described above. We also use here the term automotive unit values in the Table 57.
2. Expenditure PPPs for GDP as published by the OECD and Eurostat. When referring to this concept we use the abbreviation PPP.

These new characteristics often become cheaper in later phases (see Moch et al., 2002). Thus, EU and Japanese cars might even have an "unmeasured quality" surplus against US cars (weighted by production shares). In conclusion, an EUR /USD industry PPP for Germany/US car production of 1.47 EUR /USD rests on a mis-specified regression model. An industry PPP of around 1 EUR /USD seems much more realistic.

52 This corresponds to a matched-model approach traditionally used in official statistics including an ad-hoc, expert based correction on quality differences.

53 Industry PPPs between EU countries and Germany are based on a matched-model type of approach (see Inklar et al., 2003).

Consequently, international productivity level comparisons should be interpreted with care. Indicators derived from the described database sometimes still show problems in international comparisons of productivity and labour cost levels for some years. These cases are marked in the tables where appropriate.
Data for the new member states differ due to data availability from the concepts described above. Three important differences should be kept in mind: (1) Value added in constant prices is not available for the new member states. Hence, we have to rely on production (value added + intermediate inputs) as an indicator of automotive industry output when calculating labour productivity. (2) Average annual working hours per employee at the level of NACE 34 (automotive industry) is also not available for the majority of new member states. (3) No estimates for unit values (or industry PPPs) are available for the automotive production and automotive value added. To overcome this lack of data we use as a proxy for automotive industry unit values the expenditure PPP for the capital goods. In addition, expenditure PPPs at the GDP level and capital goods expenditure PPPs are available for new member states for the year 1999 only. We use the 1999 values for the time period 1997-2001 and omit adjusting these values because of the short time period involved. Because such types of currency conversion factors change only gradually from year to year this will involve only a minor problem. The data for automotive industry in new member states stems from the WIIW sectoral database.

4.1.2 Labour Costs

Low production costs are one of the main sources of international competitiveness of an industry. High-cost countries can only compete against low-cost countries if their products are of superior quality. Given the increased openness and the increasing global presence of suppliers standardised intermediate products will be increasingly similar in price. Likewise, the international presence of major manufacturers and large scale suppliers will tend to equalise the costs of capital. Hence, international differences in labour costs are a major source of differences in production costs. In order to compare the level of labour costs one has to convert all data into the same currency. Exchange rates will do the job. But given the large fluctuations of currency exchange rates international labour cost comparison might give a misleading picture on structural differences when looking at a certain year. Hence, we used the purchasing power parity rates calculated by the OECD to convert national currency to dollar. Said simply, the PPP values are based on a bundle of goods contained in the GDP indicating the costs to the consumers of buying these bundles in different countries using the national currency. So, the following comparison of labour costs should be viewed from the perspective of the worker who earns the wages. However, instead of looking simply at wages our comparison also includes other elements of labour costs besides wages and salaries (e.g. employer's contribution to social security).

The following table gives the total labour compensation per hour in USD. In the short run, swings in exchange rates might also affect the ability of a country to sell products on the international markets. Hence, we also give information for the dollar values of labour compensation based on exchange rates.[54] The data refer to the year 2001 which is the most recent year available. In addition, to highlight the development of labour costs we include the years 1995 and 1990 in the table. The comparison over time also allows inferring the trend in labour costs in the EU-15 countries and the most important competitors in international car markets. It also highlights the differential impact of exchange rate fluctuations on international competitiveness in labour costs.

Table 20. International comparison of hourly labour costs in automotive industry

	Conversion to USD based on PPPs			Conversion to USD based on exchange rates		
	1990	1995	2001	1990	1995	2001
Korea	5.4	8.4	12.9	4.3	8.0	7.3
Japan	17.8	24.1	29.0	24.0	43.5	35.7
USA	25.4	34.3	33.8	25.4	34.3	33.8
EU-15	19.1	26.3	32.7	23.1	31.6	25.7
Austria	13.4	21.0	23.8	16.6	28.6	19.7
Belgium	20.7	27.9	31.5	24.4	34.7	25.2
Denmark	12.8	17.0	21.4	26.4	40.8	31.5
Finland	12.5	18.3	21.0	19.4	25.5	21.7
France	17.4	22.2	25.6	19.2	19.0	15.8
Germany	20.5	29.0	36.8	20.8	24.5	18.6
Greece	7.4	10.6	12.2	21.1	28.7	21.1
Ireland	9.5	13.1	17.5	6.5	9.3	8.0
Italy	17.0	21.4	23.9	10.9	13.3	15.6
Luxembourg	13.0	14.8	19.2	20.2	20.4	17.2
Netherlands	13.2	17.2	24.1	15.5	19.5	17.2
Portugal	8.1	14.7	18.3	15.7	21.8	19.7
Spain	17.9	19.4	23.3	5.9	11.7	11.1
Sweden	15.8	18.5	19.4	24.9	25.3	18.3
UK	17.9	22.3	26.2	19.2	23.0	24.2

Source: see text.

The most impressive result of this comparison is that EU-15 automotive industry has caught up with the US in terms of hourly labour compensation (based on PPP values). Now, the three most important production regions for automotive products (Japan, US, EU) are more similar with regard to labour cost than ever. One also should note that labour costs per hour in the US even in current values have stagnated in the last ten years. Hence, a positive impact on price competitiveness results from this development. When we convert currencies by relying on the exchange rate we arrive at a somewhat different picture. Due to the high valua-

[54] Average yearly exchange rates and PPP values are based on OECD data and are taken directly from MSTI 2003-2.

tion of the USD in 2001 we see declining nominal labour costs in the EU and also Japan. This also makes clear the price competitiveness of the automotive industry is crucially influenced by exchange rate. In addition, we can conclude that in the current situation with a high valuation of the euro the labour cost position of the EU as location for automotive production is under stress. Having said this it is also quite obvious that automotive producers try to absorb the impact of exchange rate fluctuations also by the international distribution of production locations and internationalisation of the supply chain.

However, there are striking differences within Europe.[55] Germany is the most expensive country for automotive labour with labour costs per hour worked in the German automotive industry that are 8% above the US level in 2001. On the other hand, labour compensation per hour worked is below US and Japan in all other member states. E.g. labour costs in Portugal amount to only 54% of the US level. The high labour costs in Germany endanger the competitiveness at least if high labour costs are not matched with an above average labour productivity. In addition, given the currently low value of the USD labour costs in the EU are above US labour costs in a short run perspective. This currently puts the EU at a severe cost disadvantage against the US putting the cost competitiveness of EU produced cars against the US locations under pressure.[56]

Looking at the changes in labour cost in the 1990s Table 20 also makes clear that a significant cost advantage of Europe against the US diminished in the last decade. The catch-up in labour cost not only occurred in the high wage EU countries but even more in the low wage countries. As a rule hourly labour costs in low-cost countries show even a steeper increase there, than in the high cost countries (see e.g. Portugal or Greece). In the last decade differences in labour cost decreased within EU-15 and the wage increases become more and more uniform more recently.

Seen from the perspective of price competitiveness the change in labour costs relative to the increase in the product price is the more relevant indicator because it allows some conclusion whether – ceteris paribus – the industry is able to pass increased labour costs on to the customers. The growth of real product labour costs per hour is shown in Table 21. Ceteris paribus increasing price competitiveness is associated with negative values of this indicator. In addition, the table shows the difference between average annual compound growth rates of hourly labour productivity and hourly labour costs. Here, a positive value indicates that the increase in labour costs is overcompensated by the growth of labour productivity.

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55 Labour cost differences also reflect differences in skill composition of the labour force and also the composition of the automotive industry. Typically, labour costs per hour worked is lower in the automotive parts (suppliers) industry than in car assembly.

56 Using the average EUR/USD exchange rate for 2001 labour costs in EU-15 amount to 76% of the US level. The average EUR /USD exchange rate in 2001 was about 1.12, the PPP value 0.88 EUR /USD.

Table 21. Average annual compound growth rates of real product hourly labour costs (%) and growth rate differentials between labour productivity per hour and hourly labour cost (%) in automotive industry

	Growth of real product hourly labour costs			Difference between growth rates of value added per hour and hourly labour costs		
	1981-1990	1991-1995	1996-2001	1981-1990	1991-1995	1996-2001
Korea	13.6	12.1	3.2	-1.4	-2.4	1.6
Japan	4.5	5.0	1.4	-1.0	-2.9	1.3
USA	-0.5	-0.6	-1.5	1.3	4.4	2.8
EU-15	2.8	2.8	1.7	1.7	0.5	-1.3
Austria	1.2	6.6	-2.1	-2.0	2.8	3.4
Belgium	2.5	2.0	4.8	2.7	1.7	-0.7
Denmark	-0.3	1.5	3.0	3.0	-4.9	2.0
Finland	1.9	4.8	3.8	1.5	-3.3	0.0
France	0.2	4.2	3.4	4.5	-0.4	5.7
Germany	1.4	3.1	0.1	0.8	-0.1	-1.0
Greece	0.2	7.5	5.8	-5.8	-1.5	2.9
Ireland	0.3	1.7	3.3	4.3	0.5	-5.4
Italy	5.2	2.2	0.0	1.5	-0.9	1.0
Luxembourg	3.1	-2.6	2.6	2.5	-4.4	-2.9
Netherlands	1.5	5.6	5.3	1.9	0.2	0.0
Portugal	0.8	3.3	1.9	0.9	5.3	6.6
Spain	4.5	-3.3	2.0	2.2	7.0	-2.1
Sweden	0.1	4.9	3.1	1.3	4.4	0.6
UK	3.1	4.0	2.4	3.1	-0.6	-0.8

Source: see text.

A look at the real product labour costs growth rates[57] reveals that the international ranking of countries in terms of average hourly earnings is only partly influenced by the labour cost increases in the country itself. E.g. in the German case the rate of increase of real product labour costs was quite low compared to other countries in the second half of the 1990s. However, due to an increasing purchasing power of the national currency German's labour cost disadvantage even increased further. Moreover, labour cost growth in Germany was larger in the last period than labour productivity increase. Both implies that Germany's price competitiveness in the automotive industry is under pressure. On the other hand French automotive industry significantly improved price competitiveness since 1996. This increase also overcompensates with regard to price competitiveness the increase in labour costs.

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[57] Real product labour costs are defined as hourly labour compensation deflated by the country specific value added price index. The change in real product labour costs is equal to the change of value added based unit labour costs which refers to total labour costs divided by value added.

In EU-15 countries the growth of hourly labour costs regularly exceeds the growth of value added deflator whereas in the US the reverse is true. Taken together, labour cost development in the US strengthened the price competitiveness of the USA against Japan as well as against the EU. The position of the EU-15 with regard to price competitiveness strongly increased in the 1980s against the major other car producing countries. The first half of the 1990s shows a further positive development compared to Japan and Korea. In the last period (since 1996) EU is loosing against all other countries. The development within the EU was quite heterogeneous. Some countries improved their price competitiveness even further whereas others show a significant decline. As a consequence automotive industries in the latter countries are forced to reduce labour costs by increased international outsourcing of part of the value chain to other EU countries and in the last year to the new member states.

Unit labour costs relate labour costs to the value of production. Unit labour costs crucially depend on the composition of automotive industry. Usually, unit labour costs are larger in the supplier industry than in car assembly. Unit labour costs are also affected by the degree of outsourcing. So, labour costs are only one determinant of unit labour costs. In addition, unit labour costs also mirror the reaction of an industry to high wages e.g. via outsourcing. The table below show a wide variation of unit labour costs between countries. Unit labour cost is traditionally low in France. Low unit labour costs are also present in Korea, Ireland, Netherlands, Belgium and Spain. However, the reason behind these values is quite different. In the Belgium case unit labour costs are low despite high labour cost per hour because of a high labour productivity and an above average use of intermediate inputs from outside automotive industry. In the Netherlands, France, and Spain relatively high labour productivity helps to keep unit labour costs below average. Germany faces a strong decline in unit labour costs. This decline is mainly caused by increased outsourcing. This interpretation rests on the fact that the share of labour costs in value added has increased and intermediate inputs increase as well.

Unit labour costs strongly depend on the sectoral composition of the automotive industry. As a rule unit labour costs (based on gross production) are lower in car assembly than in manufacturing of car parts. Hence, the numbers given in Table 22 crucially depend on the share of assembly plants in total output of the automotive sector in a country. This notion is based on the different importance of intermediate inputs in different sub-sectors of the automotive industry. The decreasing trend in unit labour costs based on gross production is mainly due to increased outsourcing in automotive industry.

Hence, one can look at the ratio of total labour costs to value added. This ratio gives an impression about the relation of labour costs on the one hand and capital costs and capital enumeration on the other. Table 22 shows no clear trend. One can observe quite different developments within EU countries. In some countries the share of labour costs is increasing whereas in others it is decreasing. However,

Table 22. Unit labour costs in the automotive industry

	Total labour costs per gross production (%)			Total labour costs per value added (%)		
	1990	1995	2001	1990	1995	2001
Korea	14.4	16.7	12.2**	41.0	46.2	42.1
Japan	12.9	15.2	15.1*	52.0	60.2	55.6
USA	19.0	21.1	18.7	88.1	70.7	59.7
EU-15	n/a	n/a	n/a	75.0	73.2	78.9
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Austria	20.8	18.1	15.9	74.6	64.9	53.1
Belgium	n/a	13.4	12.5*	76.3	70.1	73.2
Denmark	21.2	28.3	26.5	56.2	71.9	63.7
Finland	21.6	28.0	28.6	64.5	76.2	76.2
France	14.9	14.2	10.0	63.8	65.2	46.4
Germany	26.3	25.6	21.7	74.8	75.3	79.7
Greece	n/a	27.5	25.8	94.6	102.1	86.0
Ireland	19.6	17.5	14.1	98.0	95.3	n/a
Italy	n/a	n/a	n/a	70.9	74.1	69.6
Luxembourg	n/a	n/a	n/a	58.3	72.8	86.5
Netherlands	14.8	14.7	13.7*	74.9	74.0	73.9
Portugal	n/a	n/a	n/a	98.5	75.5	50.8
Spain	22.9	14.9	13.5*	88.9	62.6	70.9
Sweden	21.1	15.9	n/a	73.7	59.2	56.9
UK	24.0	21.8	20.1*	75.2	77.6	81.5

* 2000; ** based on employees only.
Source: OECD/STAN Database, Internet Version March 2004.

there are some remarkable international differences between the EU, Japan, USA and Korea. In the US automotive industry value added based unit labour costs are declining in the 1990s and are now significantly smaller than in the EU. Also, Japan and even more so Korea has much smaller shares of total labour costs in value added than the EU-15 average. While some EU-15 countries are on the same level as the US and Japan some others are far above. This again confirms that the EU position on labour cost competitiveness is under stress. [58] One of the most important factors causing high labour costs per hour in the EU is the low range of effective working hours per employee in automotive industry.

Different trends prevail in the last decade in the major automotive producing regions. Most remarkably, average yearly working hours in the USA increased by about 1% p.a. in the last 15 years. In Japan, Korea and EU-15 we can observe a downward trend in annual working hours in the last two decades amounting to about -0.5% per year. As a result we see large differences in the average yearly working time in automotive industry. As shown in Table 22, Japan and the US

58 Unit labour costs not only depend on labour enumeration. Also, production technology plays a crucial role here. Firms can react to high wages by substituting labour inputs by capital inputs and hence reducing unit labour costs.

Table 23. Average yearly working hours in the automotive industry by country

	Hours worked per employee per year relative to US US = 100					Average working hours per year per employee
	1981	1985	1991	1995	2001	2001
Korea	140.8	130.0	129.8	121.7	121.1	2,460
Japan	114.8	112.3	115.6	98.4	99.6	2,023
USA	100.0	100.0	100.0	100.0	100.0	2,032
EU-15	90.9	84.0	84.6	79.7	77.9	1,583
Austria	97.6	91.1	92.9	81.5	80.0	1,626
Belgium	92.5	86.1	87.7	80.2	77.2	1,569
Germany	82.5	78.5	78.0	73.8	71.2	1,447
Denmark	92.1	85.0	84.8	80.7	79.2	1,609
Spain	102.8	92.3	94.2	88.6	89.3	1,815
Finland	90.0	86.3	84.4	76.9	80.8	1,641
France	101.1	87.3	84.6	79.1	77.4	1,572
Greece	104.4	96.8	98.7	93.9	94.9	1,929
Ireland	103.7	94.8	99.2	89.6	82.8	1,682
Italy	87.4	80.7	84.2	77.8	80.3	1,631
Luxembourg	89.6	82.1	84.6	76.5	76.8	1,560
Netherlands	92.1	84.3	93.9	77.9	76.4	1,552
Portugal	100.1	93.1	97.2	89.0	84.4	1,714
Sweden	77.6	75.0	79.1	83.1	83.5	1,697
UK	96.7	94.3	98.0	91.5	88.9	1,806

Source: US and EU-15 based on Groningen Growth Centre Industry Data Base (van Ark/Mahony CD ROM) which is derived from OECD/STAN. (For some countries van Ark and Mahony use hours worked per employee in the transport sector as an approximation for automotive sector. The levels were checked with national sources available for some countries. It turns out that the approximation of hours worked in the automotive sector by hours worked per employee in the transport sector is fairly reliable).
Korea: OECD/STAN + Employment Outlook (cross-checked with ILO data): The trend development is based on STAN; however the level in 2001 (and hence for the rest of the period) is adjusted based on employment outlook data. (STAN data contains information on manufacturing only. No separated data on hours worked per employee are available for the automotive industry.)
Japan: OECD/STAN. In this case STAN gives data at the level of the transport sector (automotive and other transport equipment). Therefore, data are crosschecked and some minor adjustments are made based on data from the Japanese ministry of health, labour and welfare which refers to the automotive sector only.

show a quite similar yearly working time amounting to around 2,000 hours per employee. Despite some recent shortening of working time, Korean automotive industry still shows the longest working time. The EU-15 reaches only about 75% of the US labour time. Again, there are significant differences within the EU.

German workers face the lowest working hours amounting to only 70% of the US level. The strongest decline in working time in the last two decades can be observed in France where the annual working time declines by about 1.1% annually. However, in some EU-15 member states the downward trend to shorter working time stopped in the last 10 years. Some countries like Spain, Finland, Italy and Greece even follow the US trend of increased working time.

4.1.3 Labour Productivity[59]

Labour costs are only one side of the coin. If high labour costs are met by high labour productivity no negative impact may occur. Hence, we look more closely at labour productivity as an factor determining competitiveness. According to O'Mahony and van Ark (2003),[60] European productivity growth in manufacturing has fallen behind growth rates in the United States in the second half of the 1990s. However, the authors argue that an in-depth analysis should be carried out for individual industries. They also report significant differences with regard to individual industries. Similar to O'Mahony/van Ark, we find that labour productivity measured as current value added per employee in the EU-15 currently lags behind the USA and Japan.

The EU-15 automotive industry shows a significant labour productivity[61] gap compared to the US and Japan. However, the EU-15 automotive industry exhibited higher cumulative growth rates in labour productivity during the 1990s than both the USA and Japan when we look at labour productivity in USD converted via automotive unit values. But — as shown by the following table — the catching-up process proceeds only gradually. Looking at the case where automotive unit value ratios (UVR) are used to convert national currencies to USD we find that the Japanese automotive industry is losing its competitive edge compared to the US. Not surprisingly, we find a steep increase in the labour productivity in Korea. However, there is still a considerable productivity gap between Korea and the other leading automotive producing regions.

The table shows that the picture of international productivity trends strongly depends on the way we convert national currencies to USD taking into account the trends in automotive prices. For example based on automotive unit values Japan is losing its leading position in labour productivity in the automotive industry. When we convert Yen to USD using purchasing power parities we find a lower labour productivity level in Japan in the 1980s and a catching-up process with the US later. These different trends in the Japanese-US comparison rest on an increasing

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59 We omit multi-factor productivity for two reasons: Data are only available for some EU countries. International productivity differences as well as productivity growth differentials in the automotive sector result mainly from the labour productivity part (see e.g. MGI, 2002, 2003).

60 See O'Mahony and van Ark (Eds.) (2003).

61 Labour productivity is defined here as value added per hour worked.

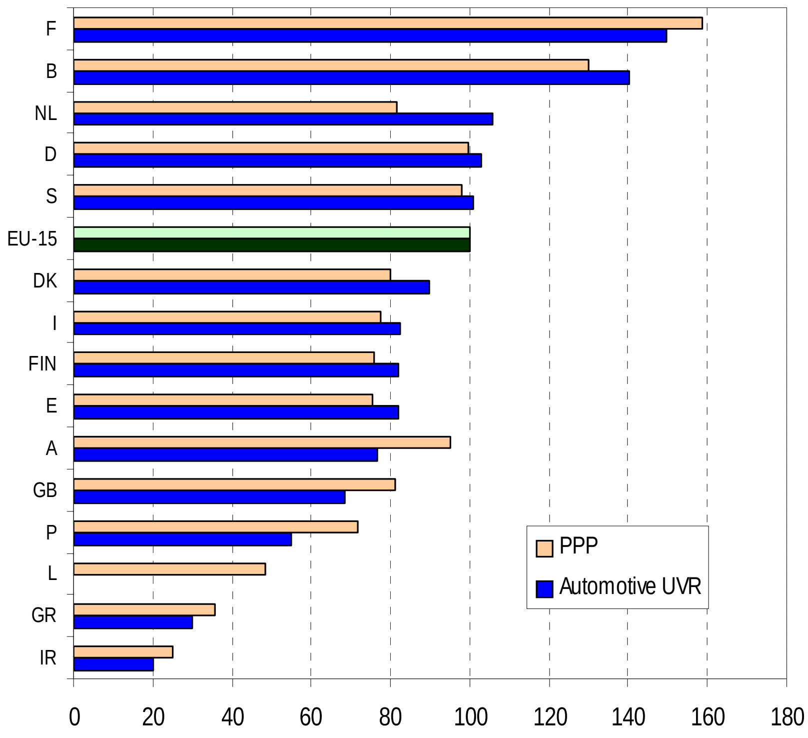
trend in the Yen/USD relation in the automotive unit value ratio and a decreasing trend in the Yen/USD relation in PPP conversion factors.

Table 24. Labour productivity in automotive industry relative to the US level (US=100)

	Based on automotive unit values			Based on PPPs		
	1990	1995	2001	1990	1995	2001
EU-15	59.6	65.9	75.2	71.7	69.0	75.3
Korea	19.4	32.3	33.7	36.4	37.6	46.0
Japan	131.8	110.8	108.8	78.4	82.4	101.7
USA	100.0	100.0	100.0	100.0	100.0	100.0

Source: See text.

Fig. 57. Labour productivity of EU-15 member states relative to EU-15 average 2001



Source: See text.

Within Europe, the picture is mixed with France showing high productivity growth rates, while Germany had a disappointing negative performance, albeit coming from a high level. Recently, France is leading in labour productivity not only in Europe but even with regard to Japan and US. This position is based on a variety of reasons. Leading French manufacturers produce more standardised cars than the German industry which increasingly pins its hope on product differentiation and offers a highly diverse set of cars. The French strategy makes it easier to exploit economies of scale. Also, French industry seems to have some strategic advantage with regard to the implementation of the outsourcing process with a more efficient way of managing outsourcing processes at the level of final producers (see MGI 2002). In addition, privatisation of Renault seems to stimulate productivity development in the French automotive industry. However, we should also note that German automotive industry invests heavily in R&D in the late 1990s whereas the R&D investment of the French automotive industry is comparably more modest. In the short run R&D investment hampers labour productivity growth because the returns to R&D lag R&D investment. In order to economise on the huge R&D investment the German automotive industry has to realise a more rapid productivity growth in the near future. However, it is still unclear whether the R&D-prone strategy of the German automotive industry will be successful. A recent study of MGI (2002) argues that there is significant potential in German automotive industry to increase the efficiency of R&D investment.

Figure 57 shows the ranking of EU-15 countries with regard to labour productivity in the automotive industry in the year 2001. France and Belgium show a significant lead. Belgian, Dutch and German automotive sectors are slightly above EU-15 average. Greece and Ireland show the lowest labour productivity.

Some more insight can be gained when looking at the development of trend values of labour productivity as well as the trends in labour productivity growth. Here we employ a Hodrick-Prescott filter to eliminate cyclical, short-term variation. The results are depicted in Figures 58 and 59.

The basic messages of these figures are:

- The speed of the catching-up process of EU-15 against the US and Japan is slow. This is especially true against the US since 1995. More recently, the catching-up process of EU-15 against Japan nearly came to a standstill. It can be supposed that this slowdown in catching-up should be attributed to the sluggish European car market in the 1990s.
- The most remarkable development in labour productivity in EU-15 is the French productivity miracle which takes place in the 1990s. However, since the end of the 1990s the trend productivity growth in France is declining and the German trend productivity growth rates are revitalised.
- Similar to France, we can observe an extremely positive development of labour productivity in the Dutch, Belgian, Austrian and Swedish automotive industries. However, productivity advance has lost momentum in recent years in these countries.
- Labour productivity developments in smaller automotive producing countries are more volatile than in countries with a significant automotive industry.

Fig. 58. Trend labour productivity by country 1981-2001 (USD; automotive UVR)

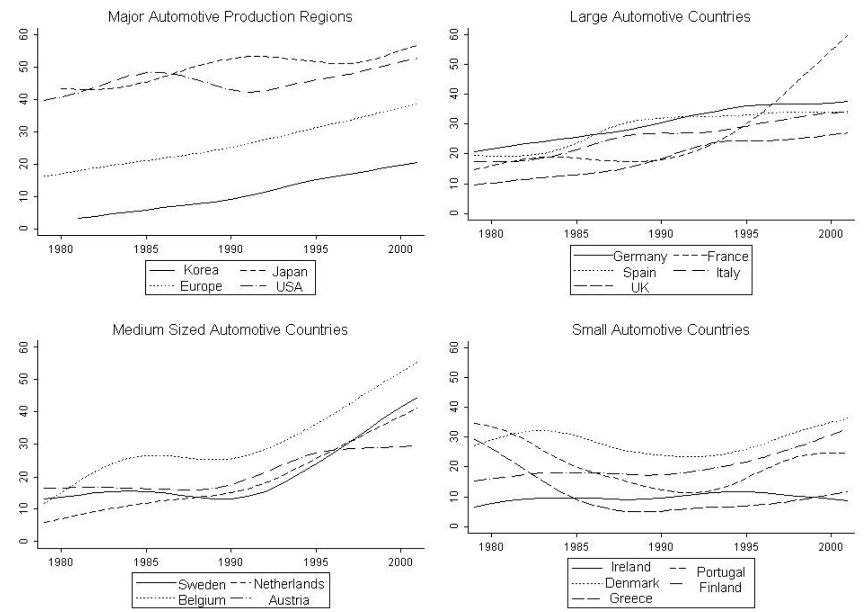
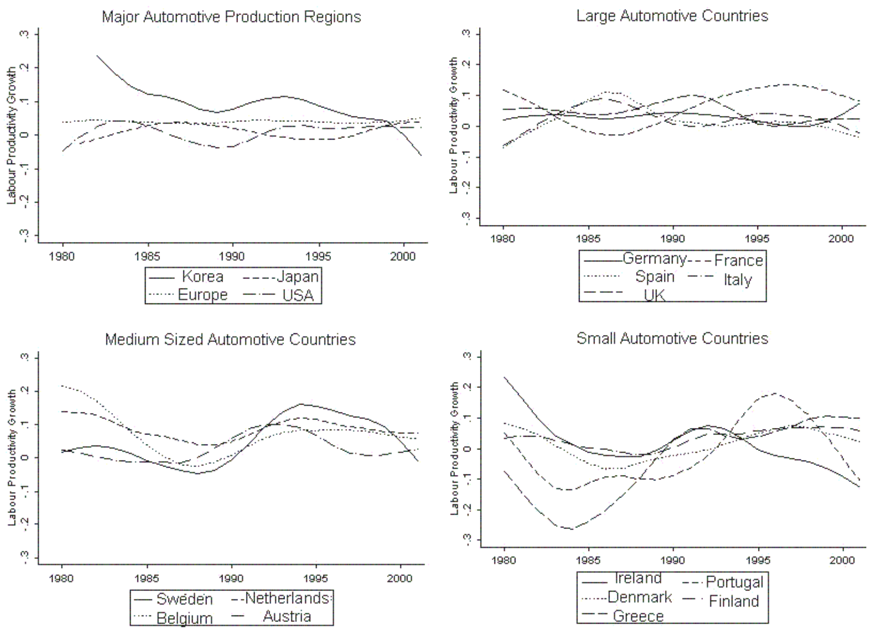


Fig. 59. Trend labour productivity growth by country 1981-2001



4.1.4 Special Focus on the New Member States

4.1.4.1 Employment

The role of the automotive industry as an employer is generally less prominent than as a producer, due to the capital-intensive character of the industry. However, in the NMS this difference is extreme. The difference is most prominent in Slovakia, with a production share of 17.2% and an employment share of 4.8%, pointing to a relatively high labour productivity (and capital intensity) in the Slovak automotive industry. This phenomenon is the consequence of a dramatic decline and labour shedding in the automotive industry during the first years of transition[62] and the emergence of a completely new industry, based on foreign direct investment thereafter. In most cases, the new owners either took over companies which had reached a low employment level already or set up new factories where they could make their employment decisions freely without bothering about existing staff and trade unions – at the same time having at their disposal a large skilled labour force, particularly in the field of engineering. Nevertheless, the automotive industry is one of the very few manufacturing industries in the NMS, where the number of employees has increased after 1995 (see Table 66), although limited to the countries with the fastest output growth (Czech Republic, Hungary and Slovak Republic) and to the production of bodies for motor vehicles (NACE 34.2) and parts and accessories (NACE 34.3).

4.1.4.2 Labour Productivity

Labour productivity, defined as gross output per employee (OUT/EMP) in the automotive industry,[63] is very high in the NMS compared to the manufacturing industry on average, due to the large amount of foreign direct investment and technology transfer as well as a relatively small number of persons employed. In Slovakia, the automotive industry reached 471% of the productivity level of the manufacturing industry on average. For the other big vehicle producers in the NMS, this ratio came up to 222% in the Czech Republic, 325% in Hungary and 187% in Poland in the year 2001 (see Table 67 and Table 68). Slovenia, which classifies as a small producer, but with a relatively high specialisation in the auto-

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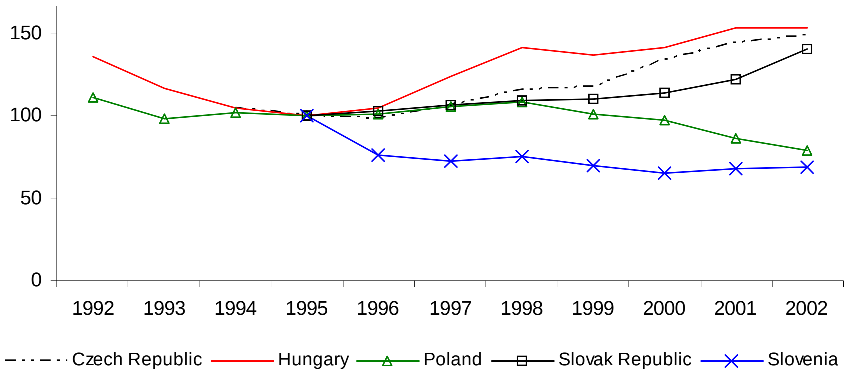
[62] Firstly, the car industry was underdeveloped in all demand economies as the emphasis was placed on mass transportation. Secondly, existing products were not internationally competitive and faced a severe blow due to the economies' opening-up. Altogether, the transport equipment industry and vehicle production in particular were among the big losers of the transformational recession, with a worse development than average manufacturing in all transition countries (see Hanzl, 1999 and Urban, 1999).

[63] Due to data availability we are forced to work with a different definition of labour productivity for the new member states. As mentioned above now data are available for value added at constant prices, working hours and automotive industry specific conversion rates for national currencies into euro.

motive industry, shows a very high productivity relative to total manufacturing, too (319%). In fact, the productivity lead of the automotive industry is far larger in the NMS than in the OMS where the industry reaches around 150% of manufacturing productivity on average only – although France and Spain, for instance, were showing a significantly higher margin of 195% in 2000.

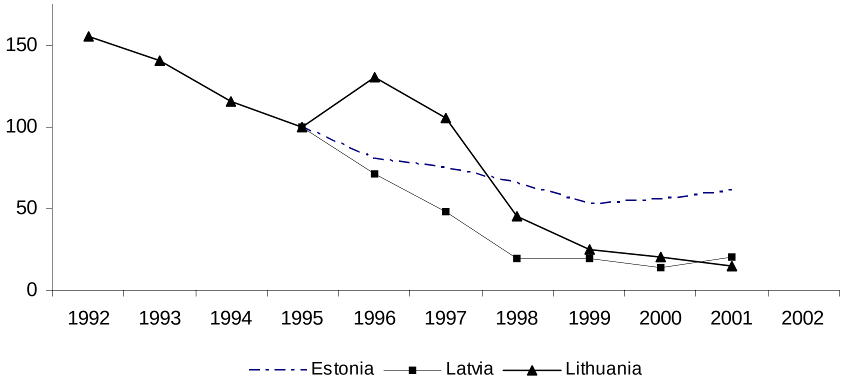
Nevertheless, because of the much lower overall level of productivity in the NMS, productivity in the automotive industry is still lower than in the OMS in most countries – although to a far lesser extent than in most other industries.

Fig. 60. Index of employment in the automotive industry (NACE 34) in the NMS (I)



Source: wiiw Industrial Database; Panorama of Czech Industries, Eurostat, New Cronos, SBS; 1995=100.

Fig. 61. Index of employment in the automotive industry (NACE 34) in the NMS (II)



Source: wiiw Industrial Database; Panorama of Czech Industries, Eurostat, New Cronos, SBS; 1995=100.

However, the exact size of this productivity gap is difficult to measure, as for cross-country comparisons output data in national currency have to be converted to a common currency, the result of which should reflect the real value of production in the countries compared. The use of market exchange rates is not appropriate for this purpose, in particular not for the NMS with their currencies still undervalued and exchange rates fluctuating strongly. As an alternative, we may use purchasing power standards (PPS), taking account of the relative price levels in the countries. However, PPS are comparing prices for different ‘baskets’ of goods, such as consumer goods, investment goods or the GDP as a whole, but in order to compare (real) output levels in the automotive industry properly, information on relative prices in this specific industry is needed. Unfortunately, so-called (industry-specific) *unit value ratios* (UVRs), which compare prices of representative industrial products in different countries, are only available for a few NMS and for selected years in the past[64]. We therefore had to resort to the ‘second best’ method, using purchasing power standards. In order to allow for a broader range of prices, we have taken two different kinds of PPPs for conversion. Thus, our first data set for labour productivity in Table 67 results from national productivity figures converted with 1999 standard purchasing power parity factors for the *whole gross domestic product* (PPP99), and the second data set in Table 68 uses purchasing power standards (PPS) for *gross fixed capital formation* (PPPCAP99) instead. The latter estimates for productivity are lower, because prices for investment goods in the NMS are higher in relative terms (excluding services but comprising a higher share of imports). For the rare cases, where UVRs were available for comparison, they showed a closer correspondence to the latter measure and thus productivity levels expressed at PPPCAP99 are probably closer to reality. Hence, we use both measures here.[65]

According to our estimates, labour productivity in the automotive industry ranked highest in the Slovak Republic and Hungary, probably even surpassing the average productivity level of the automotive industry in the EU-15, followed by Slovenia, the Czech Republic and Poland, reaching between 58% and 97% (at PPP99 conversion rates) and 43%-83% (PPPCAP99) of the respective EU-15 level. Even when taking the lower measure, Slovakia and Hungary ranked among the top productivity performers in Western Europe, just behind France and Belgium, but before, for instance, Germany, Italy, the UK and Spain. In Slovenia, productivity (measured at PPPCAP99) is only slightly lower than in neighbouring Italy. However, the Czech Republic and Poland range more at the lower end of the Western car producers with respect to productivity (see Table 67 and Table 68).

The dramatic process of productivity catching-up in Slovakia, Hungary and the Czech Republic is clearly demonstrated in Figure 62, showing output growth and employment growth between 1995 and 2002. Productivity growth is indicated by the difference between the production and the employment line[66]. This figure also

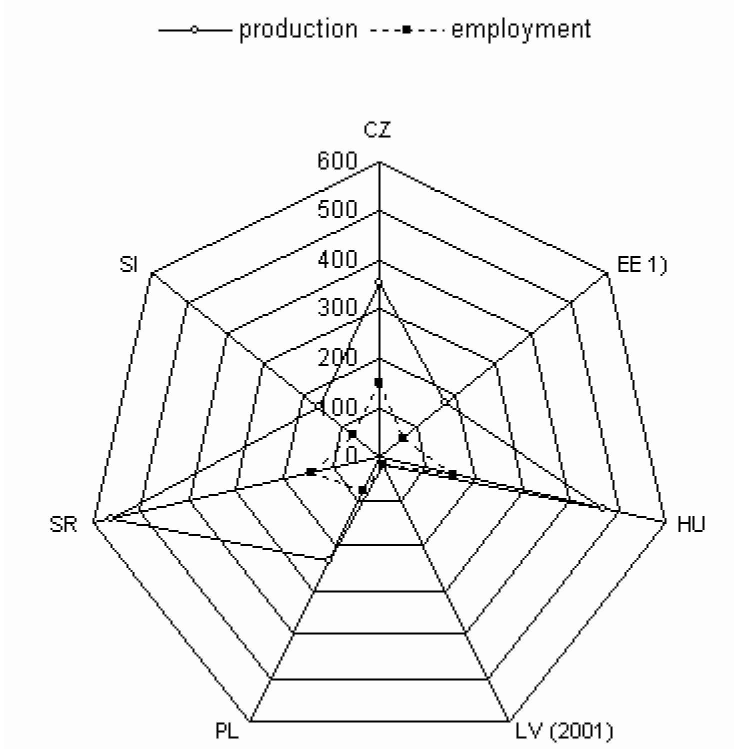
64 UVR estimates for the year 1996 are available for the Czech Republic, Hungary and Poland relative to Germany from a joint research project by WIIW and the University of Groningen (Monnikhof and van Ark, 2000).

65 See, for instance, Dollar and Wolff, 1993.

66 Productivity = Output/Employment. For small changes we may thus assume: d Productivity = d Output – d Employment.

shows the relatively slow productivity growth in the automotive industry in Poland, Slovenia and particularly in Latvia.

Fig. 62. Motor vehicles labour productivity 2002 (1995=100)



Source: wiiw.

4.1.4.3 Wages

Despite substantial wage increases in the past, wage levels in the NMS still stay significantly below those of the OMS. Wages in the automotive industry are generally higher (due to higher labour productivity) than in the manufacturing industry on average and this is true for most NMS as well, with wages in this industry varying between 145% and 115% of manufacturing average in the major vehicle producing countries. However, if converted in euros (at market exchange rates), in 2001, wages in the automotive industry reached only between 6% (Lithuania) and 30% (Slovenia) of the average wage level in the EU-15 automotive industry (see Table 69). Wages for Malta and Cyprus are available for some years only; they are higher than in the Central and Eastern European countries, but are staying significantly below EU-average.

Table 25. Unit labour costs 1997-2002 for automotive industry (NACE 34) (PPP99 conversion rates; calculated with gross wages)

	1997	1998	1999	2000	2001	2002	in % of total manufacturing 2001	in % of EU-15 2001 (EU 2000)
Czech Rep.	2.66	2.86	2.82	2.68	2.71	3.09	55.6	20.5
Estonia	5.74	6.54	5.19	5.42	4.79		68.7	36.3
Hungary	1.78	1.43	1.26	1.27	1.57	1.87	41.1	11.9
Latvia	8.75	4.75	15.28	5.58	8.61		116.4	65.3
Lithuania	27.27	8.99	10.58	6.55	2.47		46.6	18.7
Poland	3.98	3.66	3.78	3.78	4.46	3.97	61.6	33.8
Slovak Rep.	1.88	1.12	1.08	1.13	1.17	1.24	33.6	8.8
Slovenia	4.90	4.12	4.21	3.84	3.98	4.07	33.4	30.2
EU-15				13.19				

Source: wiiw Industrial Database; Panorama of Czech industries, Eurostat, New Cronos, SBS; unit labour cost, PPSGDP 99, 1997-2002; (calculated with gross wages) in %.

Table 26. Unit labour costs 1997-2002 for automotive industry (NACE 34) (PPPCAP99 conversion rates; calculated with gross wages)

	1997	1998	1999	2000	2001	2002	in % of total manufacturing 2001	in % of EU-15 2001 (EU 2000)
Czech Rep.	3.83	4.12	4.07	3.87	3.90	4.46	55.6	29.6
Estonia	9.83	11.19	8.88	9.28	8.20		68.7	62.2
Hungary	2.65	2.13	1.87	1.90	2.35	2.79	41.1	17.8
Latvia	14.38	7.80	25.10	9.16	14.15		116.4	107.2
Lithuania	47.93	15.81	18.59	11.51	4.35		46.6	33.0
Poland	5.33	4.91	5.06	5.07	5.97	5.31	61.6	45.2
Slovak Rep.	3.21	1.90	1.84	1.93	1.99	2.11	33.6	15.1
Slovenia	5.77	4.85	4.95	4.52	4.68	4.79	33.4	35.5
EU-15				13.19				

Source: wiiw Industrial Database; Panorama of Czech industries, Eurostat, New Cronos, SBS; unit labour cost, PPSCAP 99, 1997-2002; (calculated with gross wages) in %.

In Table 70, total labour costs, including direct and indirect wage costs are given as well, which may be more relevant for international cost comparisons, but were not available for all countries. Compared to the EU-15, total labour costs seem to be relatively higher than wages, but not much.

High productivity in the automotive industry combined with low wages gives the NMS a clear competitive (cost-)advantage in this field, which can be measured by so-called unit labour costs.

4.1.4.4 Unit Labour Costs

Unit labour costs (ULC)[67], in the automotive industry are typically *much* lower in the NMS than in the OMS, indicating a very large competitive cost advantage of the NMS in this industry. According to the lower measure, using PPPs as a converter for output, ULCs ranged between 9% of EU-15 average in Slovakia and 65% in Latvia in 2001. When we base conversion on the price of fixed investment (PPPCAP99), the range was between 15% and 107% of EU-15 average. As can be seen from Table 25, apart from Slovakia, Hungary shows a particularly high relative cost-advantage, due to high levels of productivity combined with relatively low wages. It is followed by Lithuania, with very low wages compensating for low productivity and the Czech Republic with a relatively high productivity but higher wages than for instance Slovakia. Slovenia ranked 6th because of its high wages and Poland ranked 7th, showing a relatively lower productivity and relatively higher wages than the other NMS. (In the appendix in Table 71, ULCs based on total labour costs are given as well, however, the picture does not change much).

Given the existing very large cost-advantage of most NMS in the automotive industry, even substantial wage increases in these countries will not threaten their competitive advantage compared to the OMS in the foreseeable future. However, different wage developments in the individual NMS may – among other things – influence foreign investors' location decisions within the region.[68]

4.2 Human Resources in Science and Technology

Qualified people are vital for growth, innovation and international competitive strength. Well-trained workers and scientists are at the heart of the knowledge-driven economy and contribute to the generation, rapid dissemination and utilisa-

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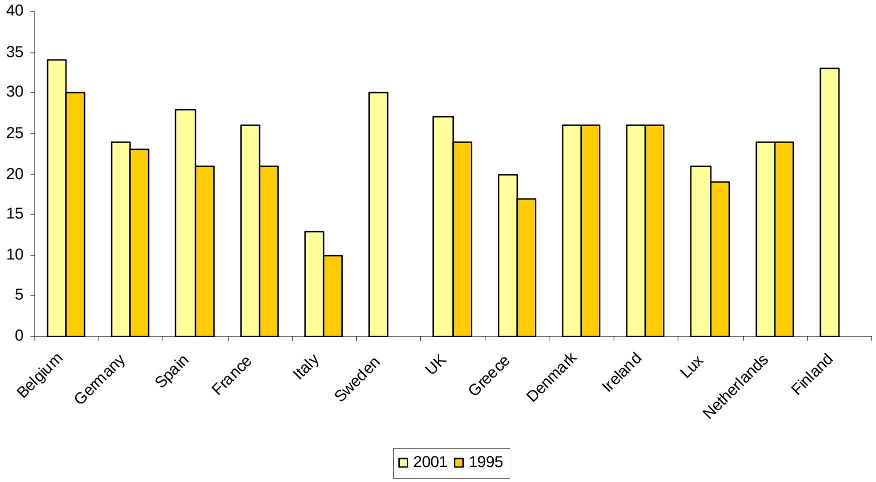
[67] Unit labour costs are defined as labour costs (LC) per unit of output (OUT). ULC = LC/OUT. Labour costs were calculated as gross wages (W) multiplied by the number of employees (EMP; W: gross wages). As labour productivity (LP) is defined as output per employed person (LP =OUT/EMP), ULC may be rewritten as wages divided by productivity (W / LP): ULC = (W*EMP)/OUT = W/(OUT/EMP) = W/LP.

[68] As ULCs are expressed in Euros for international comparison, exchange rate developments play a certain role as well.

tion of know-how. For this reason, qualified work and a high level of scientific research constitute the best conditions that highly developed economies have to offer in international competition.

In most European member states employees classified as Human Resource in Science and Technology (HRST)[69] count for about 25% of all employees, measured as the average share in services and manufacturing. And, it should be stressed that in almost every country the shares increase.[70]

Fig. 63. Human resources in science and technology (HRST) by country, 1995 and 2001 (in % of all employees)



Source: EU labour force survey, Eurostat.

In the EU-15 medium high technology manufacturing sector – including the automotive industry – almost one quarter of all people employed (25-64 years old) have enjoyed tertiary education.[71] More precisely, in Germany, France, Spain,

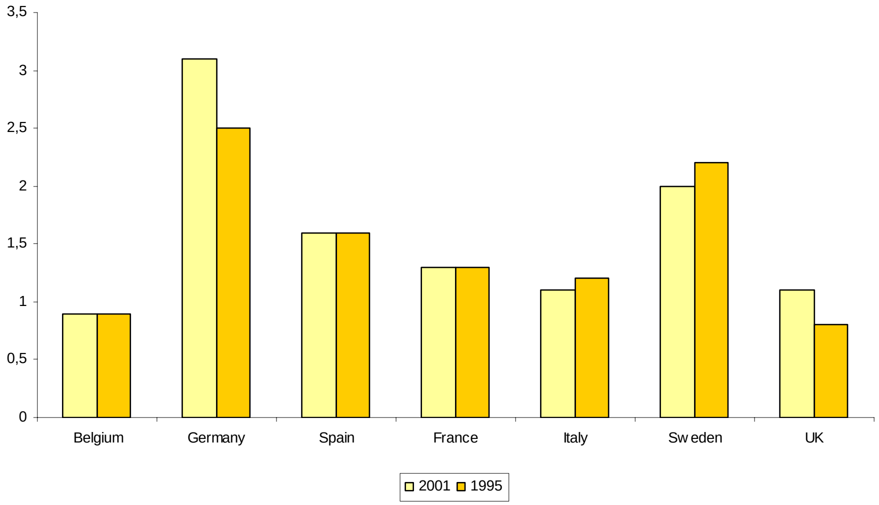
69 HRST is defined as a person fulfilling one of the following conditions: successfully completed education at the third level in an S&T field of study; HRST comprise also persons which are not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required.

70 In EU-15 almost 1 million researchers were employed. Since 1996 the number has increased with an average annual growth rate of 3.9%. This is slightly under the growth rate in the US (4.3%) but distinctively higher than it is in Japan (1.8%). The absolute number of researchers is 1.3 million in the US and roughly 675,000 in Japan.

71 In 2001, about 2.2 million persons graduated from universities, nearly 600,000 in science and technology fields of study. In relation to the US and Japan EU-15 produces a higher share of graduates in science and technology: 14% earned their degree in engineering, 12% in science. The comparable figures for the US are 8% and 9%. In

Sweden, and the UK the share of HRST in the motor industry is at some 30%.[72] But, focusing on the motor industry it is obvious that in the motor vehicle industry HRST contribute to the overall figure of HRST in a country only to a minor extent. For example, roughly 3% of all HRST employees in Germany are from the motor vehicle industry, and this is the highest share of HRST compared with other European countries.

Fig. 64. Human resources in science and technology (HRST) in motor industry by country, 1995 and 2001 (in % of all HRST)



Source: EU labour force survey, Eurostat.

How does a relatively modest share of HRST employees fit in with the "technology leadership" claim of the motor industry that is supposed to be R&D-

Japan engineering played an important role with 19%, whereas science is on a very low level with 3%.

72 Compare HRST definition: HRST is defined as a person fulfilling one of the following conditions:
successfully completed education at the third level in an S&T field of study; not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required.
It should not be confused with the previous definition for Germany: Skill structure in the German automotive industry:
- 6% is only the intensity of scientists: "Share of engineers/natural scientists of all employees in %"
- the "skill-intensity in production – share of skilled (blue-collar) workers of blue-collar workers in %." or the "intensity of academics in services – share of academics (graduates) of white-collar workers in % " are more appropriate figures.

oriented and innovation-driven?[73] To answer this question a brief review of the developments and changes in the automotive industry during the early 1990s is quite helpful. Among other things the automotive industry was confronted with radical reorganisation processes of the value chain, the rise and diffusion of information and communication technologies, and international competition that became extremely fierce. These challenges caused enormous turbulence and adjustments at the company level both inside enterprises and between companies along the supply chain. New architectures of joint ventures, international networks with interlinked, cross-border supply chains were established. And, due to reduced vertical integration, new management and operation concepts such as lean production, just-in-time and total quality management were introduced.

Unsurprisingly, the structural and organisational changes had immense implications for human resource management and led to a split of the labour force. Trying to achieve an optimum price-performance ratio, companies developed concepts of human resource management that were economically feasible. The share of low skilled occupations was cut to the lowest possible minimum which resulted in a considerable decline in the number of jobs. Large numbers of employees were made redundant, low skilled labour in car factories was replaced, substituted by processes based on CAM, or outsourced to other companies. High skilled labour became more valuable and an asset for the enterprises. That is especially the case for R&D, engineering, industrial design and other knowledge-intensive tasks. A similar development took place on the supply side. Suppliers of high quality products and services – implying high skilled workers – stabilised their market position, and studies predict that their importance will increase by the year 2010.[74] Suppliers providing ubiquitous products and services lost their market position and were substituted using global-sourcing.

Driven by globalisation automotive companies seek opportunities to optimise performance along the value chain. European suppliers of standardised products, components and parts whose production could easily be moved to low cost countries are threatened most by this development. Simultaneously, an opportunity arises for those companies which provide "key technologies" or can compete with knowledge-intensive products and sophisticated services strengthening the market position.

The European automotive industry was able to recover from the slump at the beginning of the 1990s, and the number of people employed in the automotive industry has remained more or less constant recently. In the supply sector the workforce even expanded as a result of the sector taking on additional tasks in the value chain. But, the split of the workforce increased even more. The general labour qualification level is relatively low ("low skilled") in the EU motor vehicle industry, although a dynamic use of highly qualified people in R&D and knowledge-intensive occupations and of information technologies (IT) can be observed along with a high and growing IT-labour intensity (a greater intensity of use of IT

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73 For the discussion of R&D and innovation see the part of the report "technological performance factors".

74 See Dudenhöffer (2003).

personnel) that is responsible for a relatively high percentage of high skilled labour.[75] Hence, a classification of the automotive sector as a “low skilled” sector (see e.g. Robinson et al.) is misleading because of the increasing split in qualifications.

Spotlight – Qualification Split in the German Motor Industry, 1999

A car is a highly complex product with a variety of features and components, and a number of tasks and processes have to be co-ordinated during the various stages of manufacturing. Inter and intra-industry linkages are the results of the disassembly of production and the division of labour. These factors are responsible for a heterogeneous pattern of employment in the German automotive industry with two extreme positions: In motor vehicles and engines (NACE 34.1) we find a relatively large number of academics or equally qualified employees in the field of

Table 27. Skill structure in the German automotive industry

	Manufacturing of				
	Motor vehicles NACE 34	Motor vehicles and engines NACE 34.1	Vehicle bodies, trailers, caravans NACE 34.2	Parts and accessories NACE 34.3	For comparison: Manufacturing
Production-intensity[1]	72.7	72.0	74.3	73.7	63.3
Skill-intensity in production[2]	43.7	46.6	63.0	32.5	46.1
Service-intensity[3]	27.3	28.0	25.7	26.3	36.7
Intensity of academics in services[4]	32.7	35.8	17.0	28.7	20.9
Intensity of academics[5]	8.9	10.0	4.4	7.5	7.7
Intensity of scientist[6]	6.0	6.9	2.2	4.8	4.4

1) Share of blue-collar workers of all employees in %.
2) Share of skilled (blue-collar) workers of blue-collar workers in %.
3) Share of white-collar workers of all employees in %.
4) Share of academics (graduates) of white-collar workers in %.
5) Share of academics (graduates) of all employees in %
6) Share of engineers/natural scientists of all employees in %.
Source: German Statistical Office.

business-oriented services – measured as the share of academics (graduates) in percent of white-collar workers, or as intensity of academics and scientists – as

75 See European Communities (2003).

well as a distinctive high number of low skilled jobs at the assembly line – measured as production-intensity. A split of the workforce is also visible in manufacturing of parts and accessories (NACE 34.3): a high share of employees with education and training as engineers for R&D or related work and at the same time a large number of jobs in production that do not require specific skills.[76]

4.3 R&D, Innovation, and Patents

4.3.1 Expenditures on R&D

Research and development is an investment in technological know-how which can be translated into new products, processes and services in subsequent years. In this regard, R&D activities also reflect a company's assessment of its future prospects, and its willingness to pursue market opportunities. Particularly in the industrial sector, technological R&D is crucial for innovation activity and an important factor in determining technological performance and competitive advantages.

In Japan, the US and the EU-15 high-tech industries account for 40% to 45% of manufacturing business enterprise R&D (BERD), medium-high-tech industries for about 45%, and medium-low-tech and low-tech industries for 10% to 15%. Japan (14.1%) dedicates a somewhat larger share of its business sector R&D to medium-low-tech and low-tech industries than either the EU-15 (11.0%) or the US (9.4%). On the other hand, the US (45.8%) spend a somewhat larger proportion of their business sector R&D in high-tech industries than either the EU-15 (41.4%) or Japan (39.3%). The differences are greater between EU member states than between Japan, the US and the EU-15.

Looking at R&D expenditures of the three major car producing regions – U.S., Japan and EU – there is a shift in R&D spending worth mentioning. Between 1995 and 2000 the EU enlarged its share with regard to overall R&D expenditures in the three regions from 34% to 38%. (see Figure 65).

Broken down by country we shed light on the R&D distribution within the EU as well as on the relative importance of automotive R&D for the R&D performance of the country as a whole. R&D expenditures by German car manufacturers account for more than 30% or roughly EUR 11 bn of total R&D expenditures in Germany in 2000. In Sweden the share is 18%, in France 16% and in Italy 16%. In these countries R&D activities undertaken by manufacturers of cars and other transport equipment have a significant impact on the national R&D investments. It is also obvious that automotive R&D is increasingly important in Germany. In addition, the expansion of the EU's worldwide R&D share is mainly due to the increased R&D intensity of the German automotive industry.

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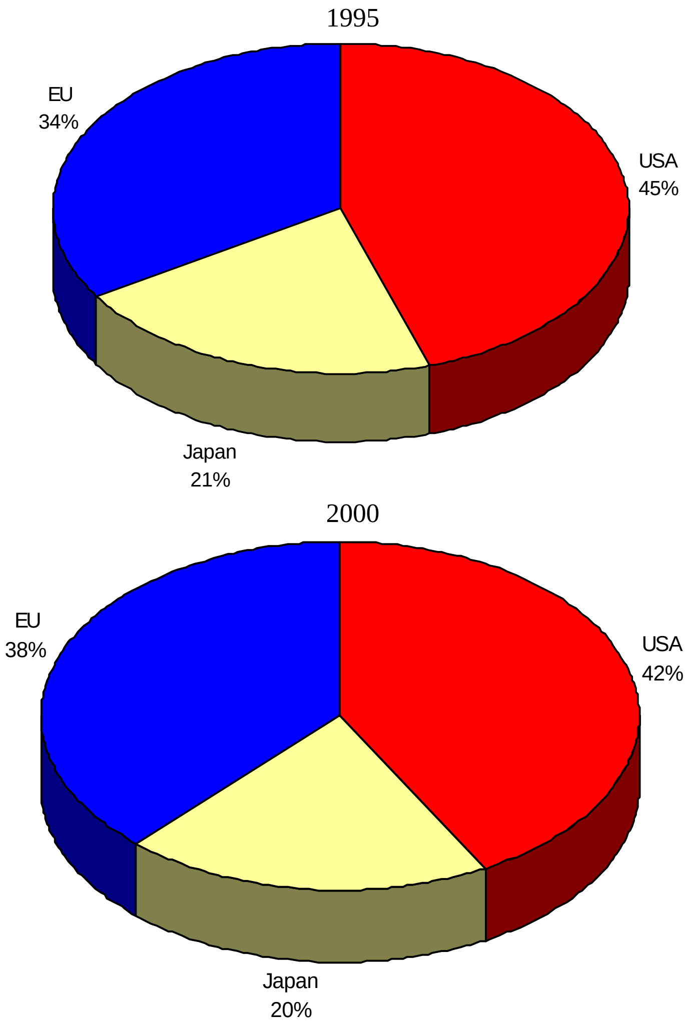
[76] The above figure on skill structure in the German automotive industry rests on different definitions when compared to the HRST. HRST not only comprise academics and scientists but also third level education like the German vocational training "Masters" degree and technicians.

At the company level, relating the annual growth rate of R&D expenditure of the top 300 international companies to the absolute R&D expenditure levels, leads to interesting insights concerning the competitiveness of the automotive industry. This exercise shows that "IT hardware", "automobiles & parts" and "pharma & biotech" constitute the top three sectors in terms of absolute R&D expenditure levels in 2002. While "IT hardware" has grown hardly at all in recent years the two other sectors, especially "automobiles & parts" have experienced rapid growth.

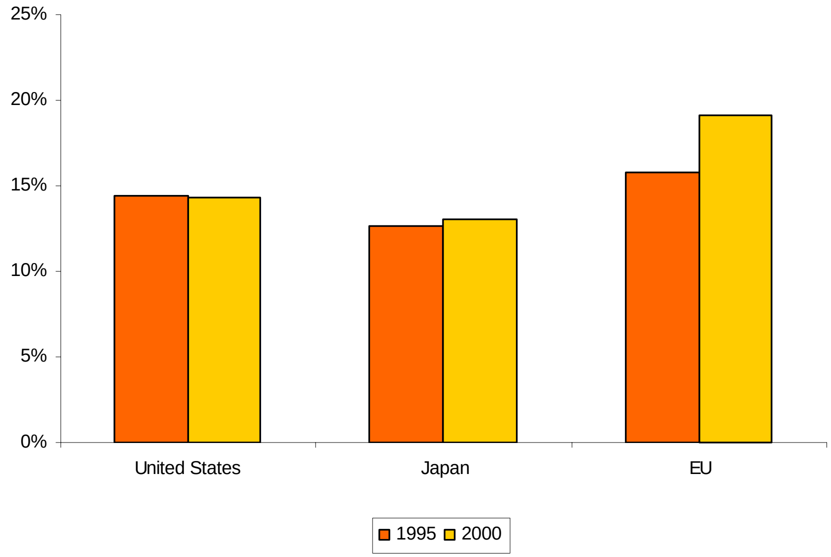
Fig. 65. R&D expenditures in the motor industry, 1995 and 2000 (in % of total expenditures in EU, Japan, U.S.)

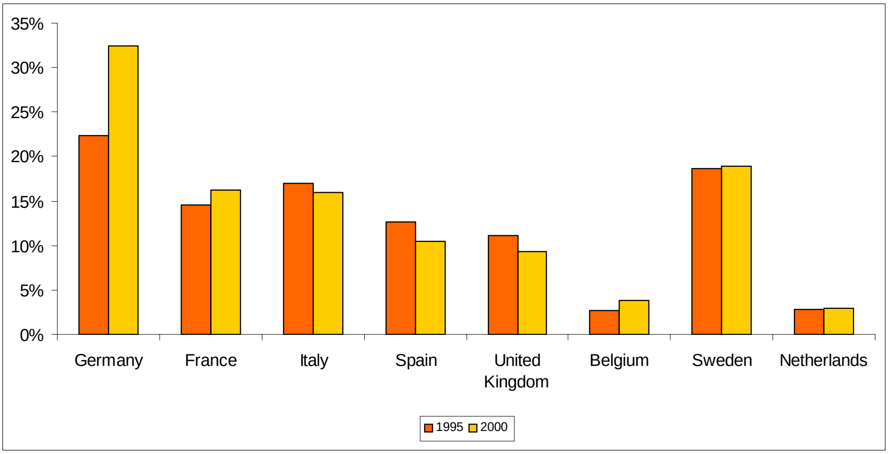


Source: OECD Research and Development Expenditure in Industry database, 1987-2001.

The increasing importance attached to R&D by European car manufacturers is also expressed by the share of the motor industry's R&D expenditures in R&D expenditures in total manufacturing. In the year 2000 the share of the European motor industry's R&D expenditures in the total manufacturing industry was close to 20%. That was a distinct increase between 1995 and the year 2000. The level exceeded comparable figures of the US (~15%) and Japan (~13%).

Fig. 66. Share of R&D expenditures in the motor industry 1995 and 2000 (in % of total manufacturing)

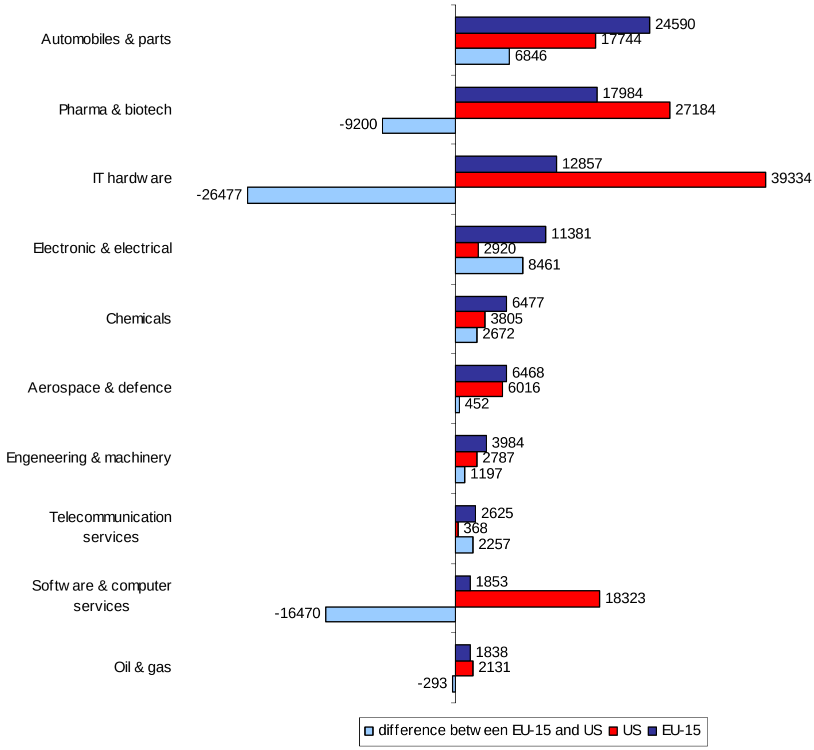




Source: OECD Research and Development Expenditure in Industry database, 1987-2001.

A sector-to-sector comparison of business R&D expenditure between EU-15 and US companies out of the top 300 international firms shows that EU-15 companies spend substantially less than their US counterparts in “pharma & biotech”, “IT hardware” and “software & computer services”, but maintain substantial leads in “automobiles & parts“ and “electronics” (see Figure 67). In 2002 the top business R&D spenders in EU-15 invested more than EUR 24 bn, considering that Germany alone stands for about EUR 15 bn. That was nearly EUR 7 bn more than U.S. companies spent for R&D in the field of “automobiles and parts”. The figure also suggests that the automotive sector is one of the few sectors where EU based multinationals have a competitive edge compared to the other triad regions.

Fig. 67. R&D expenditure by top EU-15 and top US business R&D spenders in selected sectors, 2002



Source: European Commission (2004b). Key Figures 2003-2004.

4.3.2 Automotive Innovation as Mirrored in Patent Statistics

Looking at patent data will provide us with a more detailed picture. For international comparisons based on data from regional patent offices we have to bear in mind that the pure figures might be severely influenced by “home country advantages”. The traditional approach to eliminate home market advantages is to look only at those inventions which are represented by patents at all relevant regional patent offices. Hence, this approach would suggest that for comparisons between US, Japan and EU one should focus on patents applied for at the USPTO, EPO and JPO. However, this approach involves severe time lags and is also burdensome to calculate at the level of sectors mainly due the availability of JPO data. Therefore, we look at EPO data only but account for differences between all patent classes and those patent classes which are most relevant for automotive innovation in the interpretation of the importance of the automotive sector. In addition, we are interested in Europe as the region where the R&D activity for which the patent is awarded has been performed. Hence, we look at the inventor’s address (address where the inventor resides) to extract country information.[77]

The results confirm the conclusion drawn above. Europe (EU-25) is the leading region in automotive R&D. The EU’s share in all EPO patent applications in automotive is around 60% and has increased since the mid-1990s. Japan, too, has increased its inventive capabilities in the light of patent statistics whereas the US and the “rest of the world” have lost “market share” in the patent domain. Comparing automotive patents with all patents we can further conclude that with regard to the ranking of regions the EU is clearly ahead of Japan which is ahead of the US. Inventive activity in the automotive sector is dominated by these three regions more than any other sphere of technological inventions.

Comparisons within the EU can also be performed using patent data. Here, the dominant position of Germany as leading country for automotive R&D is even more obvious. Germany accounts for nearly 60% of EPO applications in the automotive sector. This share has dramatically increased, especially in the 1990s. This corresponds nicely to the increasing share of automotive R&D performed in Germany as already shown. Other EU countries could hardly follow the momentum of the number of patent applications from Germany. Only Belgium, Austria and surprisingly the new member states could stand the momentum of patenting of the German automotive industry in the last ten years. However, the share of patent applications of the new member states is still very small. Compared to the significance of the new member states as production location, their share in automotive patenting is extremely small.

The increasing intensity of automotive patenting is predominantly driven by large companies. Not surprisingly, the leading vehicle manufacturers are among the leading patent applicants. However, patent data also reveal the importance of suppliers for automotive related inventions. For example the leading German company Bosch is among the leading patent applicants.

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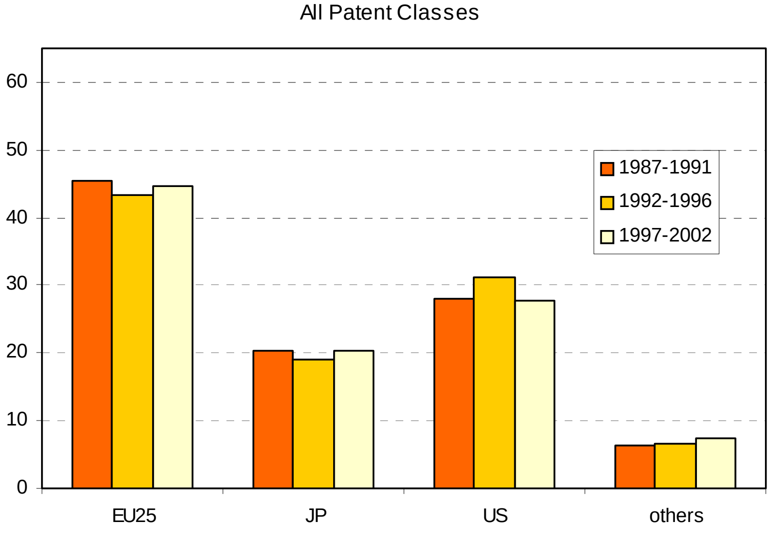
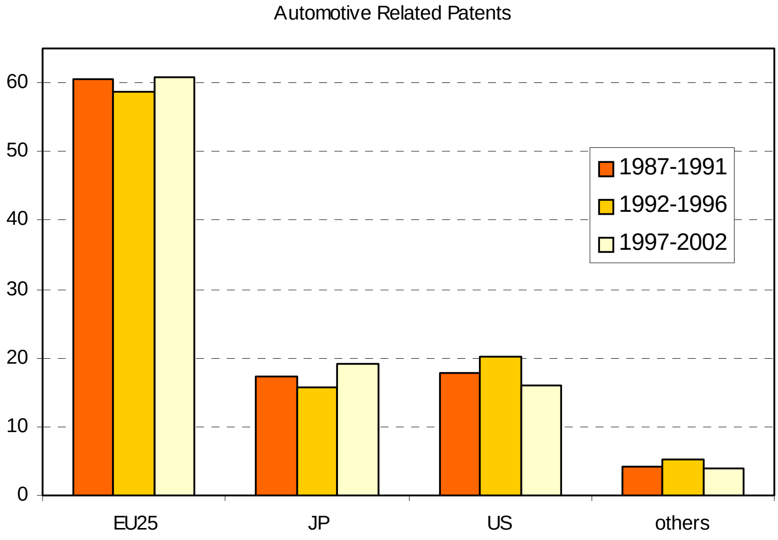
77 In those few cases were inventors from different countries are involved in the same patent application we randomly select (based on normal distribution) one inventor and assign the patent to the country where this inventor resides.

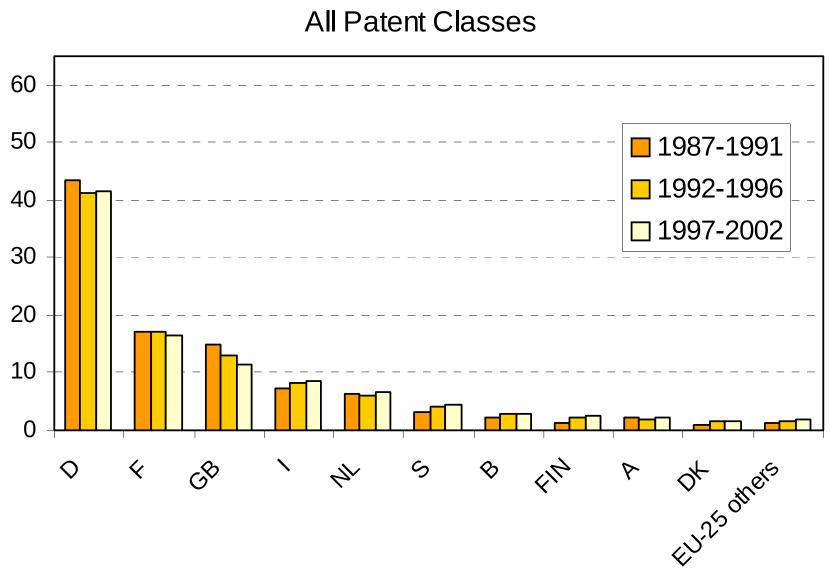
Fig. 68. Share of EPO application in all patent classes and automotive related IPC classes

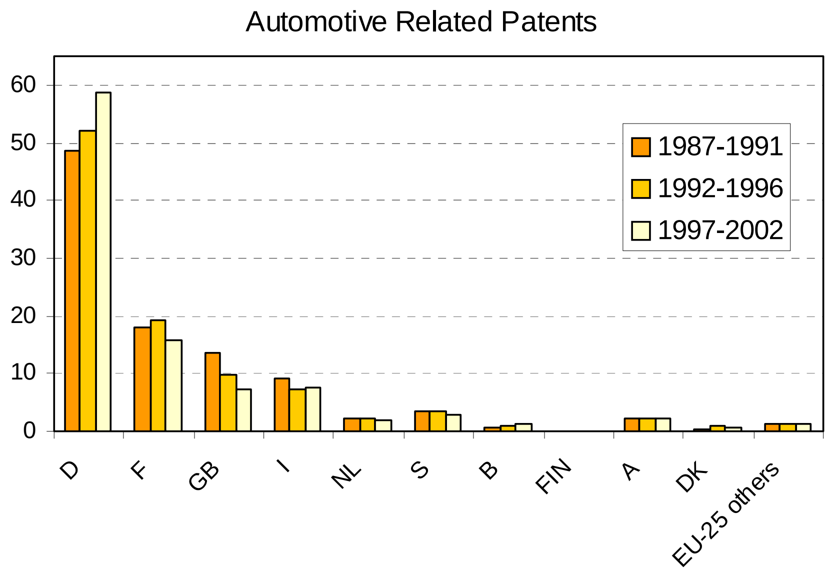




Automotive related patent classes are defined by the following IPC class numbers: B62D, B62J, B62K11, B62M7, B60B, B60C, B60D, B60F, B60G, B60H, B60J, B60K, B60L, B60N, B60P, B60Q, B60R, B60S, B60T, F01M, F02B, F02C, F02D, F02F, F02M, F02N, F02P, F16B, F16D, F16H, F16J, F16K, F16N, F21L, C08C, C10K.
Source: EPO-Espace, EPO-EPOline.

Fig. 69. Distribution of Patent Application by country within the EU





Source: EPA-Espace, EPO-EPOline.

4.3.3 Innovation Patterns

Technical progress, competitiveness and innovation are based on research and development. But even in R&D-intensive industries, R&D is only one aspect, but nevertheless the essential core of all innovation activities. Innovation means in this context the development and economic exploitation of new or improved products and services, and the optimisation of business processes. Innovation continuously redefines markets and opens up new sectors of economic and social activity. It concerns every industrial sector, especially the automotive industry.[78]

Table 28. Share of enterprises with innovation activity 1996 (in %) in NACE DM

Country	Innovation active enterprises	Process innovators	Product innovators	Innovators with products new to the market	Share of innovation active firms performing R&D
Belgium	41	30	30	12	65
Denmark	85	28	85	18	68
Germany	74	47	72	30	80
Spain	46	40	41	20	66
France	58	37	47	28	86
Ireland	88	71	76	21	88
Italy	49	43	38	29	62
Luxembourg	17	-	-	-	-
Netherlands	67	41	57	36	81
Austria	78	53	77	37	80
Portugal	26	18	12	3	24
Finland	45	26	35	21	92
Sweden	60	33	51	19	81
United Kingdom	65	47	57	19	54
EU-15	60	42	52	24	69
Benchmark: EU-15 manufacturing	54	39	44	21	68

NACE DM: Manufacture of transport equipment.
Source: Results of the second community innovation survey (CIS2) Eurostat.

78 The innovation activity conducted by individual firms is embedded in an extensive meshwork of incentives, rules, institutions and regulatory structures. Depending on their effect these factors have a significant influence on the intensity and direction of corporate innovation efforts. This includes technological means and human capital, mechanisms to protect revenue generated by innovation activities, know-how and its transfer. See for example Audretsch and Fritsch (2002); Porter (2000); Breschi (2000); Breschi and Malerba (1997); Tidd, Bessant and Pavitt (2001); Stoneman (1995); Dodgson and Rothwell (1994); Freeman (1994).

About 50% of the companies which belong to the EU-15 manufacturing sector introduced new or significantly improved products or processes, and are categorised as innovating enterprises. In the manufacturing of transport equipment[79] the share of innovators was slightly higher with nearly 60%. Germany accounted for the largest share of innovators where more than 70% of the car manufacturers introduced innovations, 72% developed product innovations, and 30% were innovators with new products also new to the market. Compared with the findings for Germany the other European car producing enterprises in France and Italy are less innovative. 52% of the EU-15 manufacturers of transport equipment are product innovators, and 24% are innovating companies with products also new to the market. In total, the weighted results for EU-15 are highly influenced by the performance of Germany – and to some extent by France, Sweden, and UK – based on the weight the countries have in the European automotive industry.

Comparing CIS II (1996) and CIS III (2000) results we find declining shares of innovative active firms in the leading car producing countries in the EU. Having the development of R&D in mind this indicates that the contribution to technological progress is more concentrated in recent years. However, the participation rate of technological innovation in the automotive industry is still above the average of the manufacturing sector. This shows that even second and – to a lesser extent – third tier suppliers have to perform innovation to stay in the market. On the other hand, the cost pressure in small supplier companies increased and some companies had to stop their innovating activities for financial reasons.

When it comes to R&D activities in innovating enterprises, the trends are even more pronounced than with innovation activity. R&D requires additional resources and organisational dimensions going beyond some sporadic or operative work related to innovation. Research activities are based on a strategic business decision with long-term perspectives. A company that established an R&D facility is determined to continuously reap benefits from this infrastructure. About 70% of the innovative firms in the manufacturing sector of transport equipment reported that they engaged continuously and/or occasionally in R&D, the same percentage was found for the entire manufacturing sector. R&D activities seem to be a necessary input factor for innovating enterprises in the automotive industry. Especially in Germany, France, and Sweden the propensity to R&D is very high. More than 80% of innovative enterprises engage in R&D. These countries are obviously more R&D-oriented than the other major European car competitors situated in Italy, Spain or U.K.

About 70% of the innovative firms in the manufacturing of transport equipment reported having engaged continuously and/or occasionally in R&D, the same

[79] Data are only available at the level of transport equipment (NACE 34-35). Given the relative size of the automotive sector in terms of the number of enterprises (NACE 34) results presented mainly reflect the data of the automotive sector. In addition, data from CIS III referring to the year 2000 are not available at the two digit level. For selected countries we obtained some information of trends between 1996 and 2000 calculated in the IEEF project funded by the Commission. We will mention trends between 1996 and 2000 in the text where appropriate.

percentage reveals for the total manufacturing. R&D activities seem to be a necessary input factor for innovating enterprises in the automotive industry. Especially in Germany, France, and Sweden the propensity to R&D is very high. Over 80% of innovative enterprises engage in R&D. These countries are obviously stronger R&D-oriented than the other major European car competitors situated in Italy, Spain or U.K. Overall, only 30% of the innovating enterprises among EU-15 manufacturers of transport equipment are not R&D-related.

Table 29. Composition of total innovation expenditures (in % of total innovation expenditures) 1996, by NACE DM

Country	Industrial design (manufacturing sector) or preparations to introduce new services or methods (service sector)	Machinery and equipment acquisition	Market introduction of innovation	External technology acquisition	Extramural R&D	Intramural R&D	Training directly linked to technological innovation
Belgium	8	33	5	1	4	47	2
Denmark	3	11	1	11	2	72	-
Germany	6	11	3	1	24	53	1
Spain	10	19	2	2	7	60	1
France	4	12	17	-	11	53	3
Ireland	4	28	6	5	3	52	2
Italy	16	41	5	3	4	29	2
Netherlands	3	18	2	1	13	60	3
Austria	6	20	6	1	7	55	5
Portugal	10	32	1	28	1	28	-
Finland	2	14	3	6	15	58	2
Sweden	13	15	7	5	9	49	3
United Kingdom	2	33	5	4	-	53	3
EU-15	7	17	5	2	16	51	2
EU-15 manufacturing	6	22	4	4	9	53	2

NACE DM= Manufacture of transport equipment.
Source: Results of the second community innovation survey (CIS2) Eurostat.

In order to benefit from challenges due to innovation, companies have their own strategies and go different ways. One strategic concept places its focus on in-house R&D and combines in-house activities with additional R&D undertaken by external partners. The other strategic option tends more towards technology transfer by purchasing new equipment and machinery. For companies with less internal and/or external R&D the purchase of equipment, imitation and learning by doing seem to be valuable innovation strategies. Therefore, these firms invest in trial production, training and tooling-up in combination with industrial design and product design.

In general, EU-15 innovators spend most of their innovation expenditures for R&D, and invest the money in intramural and extramural research projects. Especially German companies are following this path of innovation. Here, 53% of the innovation budget goes into in-house R&D and 24% is dedicated towards joint projects with external R&D partners. The behaviour of companies in France and Sweden is comparable to companies in Germany. Italy and the U.K. prefer the other innovation process by using various channels of technology transfer and by innovating via R&D that is embodied in new equipment. Here, the companies purchase new machinery and equipment and integrate these installations into the in-house production and innovation processes. In Italy, for a change, industrial design is of some importance in the innovation process and an Italian strength.

The structure of innovation expenditure underlines the importance of suppliers and their specific contribution even during the R&D stage. The share of external R&D in the automotive sector is considerably larger than in manufacturing as a whole. And this is especially the case in those countries where automotive R&D is particularly strong (Finland seems to be an exception).

4.3.4 Innovation Networks

Empirical studies lead to the conclusion that countries and regions have different ways to disseminate knowledge and to carry out innovations in specific sectoral contexts. These specific features include in particular the type of market competition, the opportunities available for collaboration with other companies, the transfer of knowledge and know-how from universities and research institutes to businesses, and the criteria for the development of technological norms and standards. In many cases, it is not technologies or products that are transferred within the innovation networks, but knowledge, which enables companies to develop market-driven innovations in-house on their own, thus expanding their own innovative potential.

Some available sources of information for innovation are closer to the market, e.g. suppliers, customers or competitors. Other sources are more related to the scientific sector such as universities or private or government R&D labs. Market-related external information sources such as customers, suppliers or competitors are just as important as in-house sources. But suppliers of material and equipment or competitors are only valuable for a relatively small number of European vehicle manufacturers. Given that most firms are (1^{st}, 2^{nd}, or 3^{rd} tier) suppliers the widespread use of customers as information source also underlines the vertical information flows in the sector.

Table 30. Share of innovation active enterprises maintaining collaboration with innovation project by type of partner chosen, 1996, by NACE DM (in %)

Country	Other enter-prises(s) within the group	Competitor(s)	Clients or cus-tomers	Consultancy enterprises	Suppliers [1)]	Universities or other higher education insti-tutes	Government or private non-profit research institutes
Belgium	100	29	87	9	25	21	31
Denmark	81	12	43	6	43	37	37
Germany	60	41	34	29	68	44	41
Spain	65	8	40	19	50	35	27
France	69	19	48	17	72	28	20
Ireland	89	3	76	33	53	59	40
Italy	60	25	36	13	43	52	11
Luxembourg	-	-	-	-	-	-	-
Netherlands	58	33	53	31	70	31	46
Austria	88	38	75	12	57	43	19
Portugal	26	16	52	66	50	100	48
Finland	49	33	88	42	69	71	63
Sweden	46	25	84	28	39	54	9
United King-dom	54	14	34	31	51	53	18
EU-15	62	23	47	24	56	44	27
EU-15 manu-facturing	58	18	48	22	49	37	32

[1)] Suppliers of equipment, materials and components of software.
Source: Results of the second community innovation survey (CIS2) Eurostat.

Cooperation in innovation projects and joint projects in innovating activities are increasingly important sources to achieve a competitive edge. But cooperative research projects are usually conditional on ongoing R&D activities in the companies involved. The cooperation partner can always contribute only complementary knowledge. In the car industry the average ratio of companies with R&D cooperation amounts to 34% and is higher than in total manufacturing (26%).

If companies decide to cooperate they consider every potential partner. Besides cooperation within the group manufacturers of transport equipment have strong ties with their suppliers. Around 50% of transport equipment manufacturers carry out collaborative innovation projects with suppliers and/or clients. Compared to the rest of manufacturing it is striking that competitors are often used as collaboration partners. This again reflects the intense links needed for the development of complex products. Thus, automotive innovation is not only characterised by vertical links but also by intense networking both between vehicle manufacturers and suppliers.

As we pointed out, any information provided by universities or institutions of higher education is not very important for the innovation activities of a firm. On the other hand, knowledge from the science sectors influences ongoing research in companies and is sometimes even the first step to an innovation.[80] We found that universities are an important cooperation partner for companies with cooperative relations in innovation. On average, 44% of innovating and cooperating enterprises cooperate closely with an university, and are searching for a technology push. In the manufacturing sector the share of science-business links, measures by cooperation between companies and universities, is somewhat lower with 37%.

Cooperation partners were mostly chosen at the national level. In addition, enterprises cooperate with other European companies. Innovation projects with U.S. partners rank third. The ranking is comparable with the manufacturing sector.

4.3.5 Summary

Against the background of the economic potential of mass production, combined with the complexity of specific goods such as cars and other transport equipment the risks of failure related to radical innovations are very high. Therefore, processes and products are developed incrementally on the basis of earlier experience coming from improvement of machinery as well as from the assembly line and operations management. In-house R&D activities and product engineering are the main strength for technical progress. Additionally, the work of specialised suppliers – sometimes research facilities – is integrated into the value chain. The important tasks of innovating companies consist in taking incremental steps forward, and to diffuse knowledge throughout the company or group. Therefore, information technologies now offer opportunities to save time and money.

Technological progress in the automotive industry is to a certain degree “path dependent.” In other words, learning, experience curve effects and long-term factors lay the foundation for the respective innovation system and its development and have to be linked to opportunities arising due to information and communication technologies and human resources. As a result, the innovative strengths of the European automotive industry gradually improve, thus leading to standardised high-quality products that fulfil customers’ needs and expectation. This development is based on production regimes that require sophisticated skills in handling

80 Particularly in the case of cooperative projects with public-sector research institutions, companies cannot outsource the competency to design market-driven product/process innovations. Universities and public-sector institutions, remote as they are from the marketplace, are only to a limited degree suited for developing finished products for the actual market. Cooperative projects both between the science sector and the industry and inter-company collaborations, are the most effective form of knowledge and technology transfer.

complex processes, maintenance service and close customer relations – namely, diversified high-quality production.

EU-15 firms have increased their investments in new products, new processes and new technologies considerably in the 1990s. Compared to the USA and Japan, EU has gained market share both in terms of investment in innovation (R&D) and with regard to results of R&D (as measured by patents). The technological competitiveness of the EU-15 rests not only on the presence of leading car makers but also on innovation activities wide-spread within the supplier part of the industry. Intense networking of the suppliers and assembly firms is present in Europe and also has contributed to a high technological competitiveness of EU automotive industry.

4.4 Innovation and Restructuring of the Value Chain

In recent years the demand for cars has increased only slowly in many developed countries, and the sale of new automobiles only covered the replacement demand. Apart from the US, a significant increase in sales is only observed in emerging markets. The maturity of the European market is characterised by the intensive use of marketing instruments such as price and product policy. The customers expect additional enhancements from vehicle manufacturers, but are not willing to pay higher prices. Therefore, product innovations have to be financed with an increased efficiency along the value chain which includes component suppliers as well as after-sales services.

In addition, future innovations in vehicle manufacturing will be closely intertwined with electronics and software control systems. These innovations have to be linked with the traditional mechanical automobile components. The traditional component supplier or other companies, which are new in the sector, will take over these new value added activities. Also, new entrants (specialised suppliers) are expected to appear on the scene. The result will be that the R&D and the value added activities will shift to the component suppliers. The vehicle manufacturers will try to ensure their added value share with cost pressure on the component supplier and cost optimisation on the side of their retail business. Changes in the legal framework like Block Exemption as well as new channels of distribution like internet sales will also influence the value chain of vehicle manufacturers in the future. The organisational and market strategic changes, which will arise from the physical innovations, will be described below.

4.4.1 Innovation in the Value Chain

It is no secret, that firms in modern management terms are rather regarded as network elements than as isolated entities. Therefore the organisation and optimisation of inter-organisational structures is a prerequisite for successful business. Only if the configuration of inter-company interfaces from the original supplier through end user succeeds in creating products, services, and information that add value for customers and stakeholders, can be offered (Lambert et al., 1997).

The vehicle manufacturers succeeded like no other industry in managing the organisation and strategic control of the whole value chain. Intermediate inputs from the chemical, steel, electric and textile industry are integrated in the value chain as well as downstream sectors like automobile retail, body shops, petrol station and other services.

Innovation in vehicle manufacturing will also in future affect the value chain. Suppliers own specific and unique knowledge concerning the functioning and integration of electronic parts in vehicle components. Those will play a larger role in the innovation and value added process in the future.

4.4.2 The Relation Between Supplier and Vehicle Manufacturer

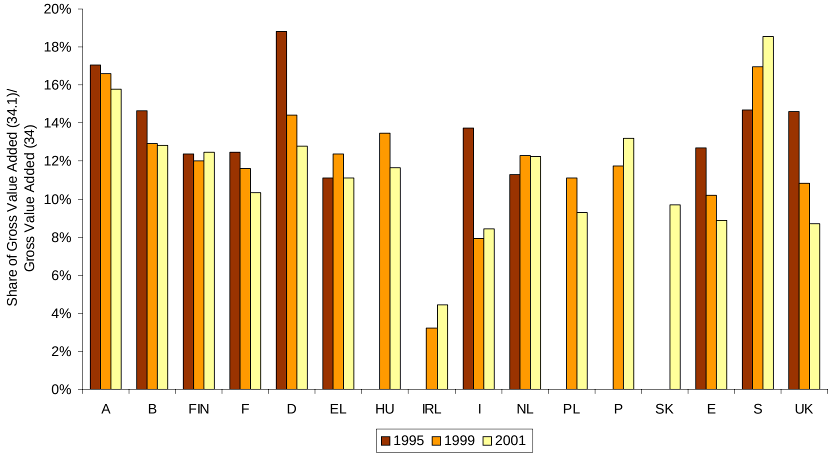
In the 1980s the modern passenger car consisted of up to 10,000 different parts. The special knowledge of vehicle manufacturers concerns the management of the complexity of the production process, which required co-ordinating up to 2,500 suppliers, of course, depending on manufacturer and model (Womack and Jones, 1991). Contract periods for standard products in general were disposed with short notice and suppliers were regarded rather as specific suppliers than strategic partners in innovation (see Fieten, 1995).

In the scope of vehicle manufacturers' make-or-buy decisions, a very high integration of the production was an advantage in competition. Above all American manufacturers like General Motors purchase 70% of their parts from own production which in the end requires innovations and capital lockup respectively (Terporten, 1999).

At the beginning of the 1990s, new developments could barely be accomplished by manufacturers because of the high pressure to innovate. In addition cost pressures led to a reduction of the manufacturing task to the so-called "core manufacture" (Terporten, 1999). Hence, the development of the vertical range of manufacture in the sector "Manufacture and assembly of motor vehicles and engines" (which is the quotient of gross value added and the gross value added of the whole automotive industry, see NACE 34.1-34.3) shows a decreasing drift. The share of the value added of vehicle manufacturers in total automotive value added declined from 18% in 1995 to 12.8% in 2001 in the German case. Another decline can be registered likewise for the UK (about -5.9 percentage points), Italy (about -5.3 percentage points), Spain (-3.8 percentage points) and France (-2.1 percentage points). Only in Sweden the vehicle manufacturers' proportion of the value added increased compared to the other sectors of the automobile industry. Simultaneously the absolute number of employees declined, but the number of people employed in and the gross value added of the supplier industry increased in the respective period (NACE 34.3).[81]

[81] That relation is also influenced by reconfigurations in the cross-border changes in the value added chain.

Fig. 70. Share of gross value added of "manufacture and assembly of motor vehicles and engines" (NACE 34.1) and automotive industry (NACE 34.1-34.3)



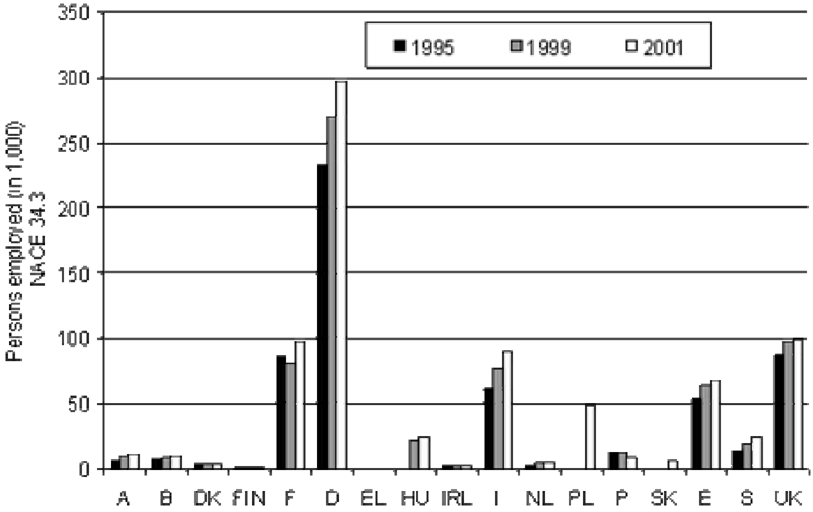
Source: Eurostat and German Association of the Automotive Industry VDA: International Auto Statistics Edition 2003, Frankfurt.

Because of the fact, that the decrease of the vertical range of manufacture does not reduce the complexity of the whole process of vehicle manufacturing, but rather relocates tasks on the value chain, several suppliers take responsibility for greater systems of vehicles (components/modules), for example the petrol injection. This responsibility of the first tier suppliers not only comprehends the construction of systems, the just-in-time delivery to vehicle manufacturers and the co-ordination of second and third tier suppliers but the corresponding R&D of the system, too. Thus half of the total R&D activity of the automobile industry has been allocated to the suppliers in the last few years. Merely in the areas engine and car body the vehicle manufacturers still retain the highest control (Larsson, 2002 and McKinsey&Company, 2003).

Due to this trend a pyramid of manufacturers emerged, with first tier supplier becoming a close partner in the innovation and production process of the vehicle manufacturers at the forefront leaving second and third tier suppliers with no direct contact to vehicle manufacturers (Terporten, 1999).

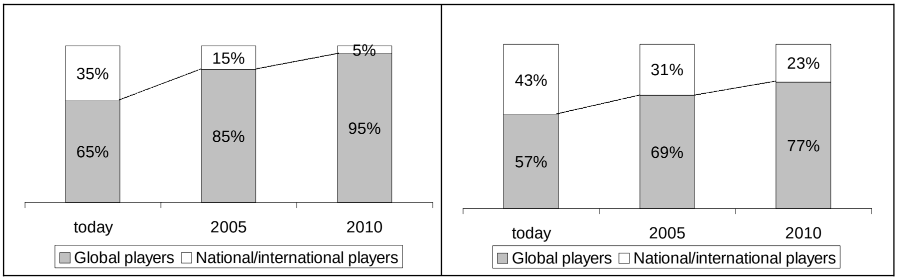
Therefore only suppliers with large knowledge with respect to the integration of their own products into the final automotive output, which have adequate capabilities to finance R&D and which can follow vehicle manufacturers in their ambition to become global players will be considered as first tier supplier in the future. Concerning globalisation not only following to the manufacturers' particular international locations is required, but also the realisation of cost reduction potential through using advantages of low-cost locations. With a view to increasing globalisation, the expectances of manufacturers and the resulting pressure for suppliers are accordingly high albeit there seems to be a larger demand for international players on the side of the vehicle manufacturers than on the suppliers' side (see Larsson, 2002 and Doran and Roome, 2003).

Fig. 71. Turnover, gross value added and persons employed in "manufacture of parts and accessories for motor vehicles" (NACE 34.3)



Source: Eurostat and German Association of the Automotive Industry VDA: International Auto Statistics Edition 2003, Frankfurt.

Fig. 72. Supplier market shares by degree of internationality



Source: Roland Berger & Partners (2000).

In the late 1990s only a small part of first tier suppliers succeeded in realising these tasks on their own. The worldwide number of first tier suppliers will continue to decrease as a result of M&A, joint ventures and "down-grading" to the second tier supplier level, even though this process has slowed down since 2001. This consolidation continues for a short time on the level of second tier suppliers. A PricewaterhouseCoopers study on M&A in 2002 comes to the conclusion, that the cost pressure forwarded by vehicle manufacturers to first tier suppliers is passed on to second tier suppliers. Increasing requirements regarding global sourcing and innovation thus demand from second tier suppliers an international business orientation, too. These rather small and medium-sized companies are often only capable of accomplishing these challenges by joint ventures or joint foundations (Burwell and Wylie, 2002).

Comparing developments in Europe, North America, and Japan, one realises, that European vehicle manufacturers led the trend of modular production and downstream integration. The European industry has a large specialised firm structure for shared product development and production tasks at its disposal. “If the future lies in the increased specialisation of actors in the value chain, the European automotive industry seems to be particularly well positioned in terms of structures and capabilities” (Jürgens, 2003).

The American companies – but also PSA and Fiat in Europe – reduce in-house production via spin-off activities (Jürgens, 2003). However, the proportion of the value added of the American vehicle manufacturers in the total American added value of the automobile industry still lies around 55% and hence way above the European production structure. Also Japanese companies follow this trend rather reserved. 15.4% of the value added of the automotive sector is allotted by vehicle manufacturers in Japan. This value is above the values of most car producing EU countries. A modularisation of the production took place in-house. Toyota and Honda see a strategic advantage rather in the total control of the value chain and avoid the hand-over of responsibilities to the supplying industry. Specific know-how in the electronic/IT area is to be built strategically (Jürgens, 2003).

There are different opinions with regard to the future development of the interface between suppliers and vehicle manufacturers:

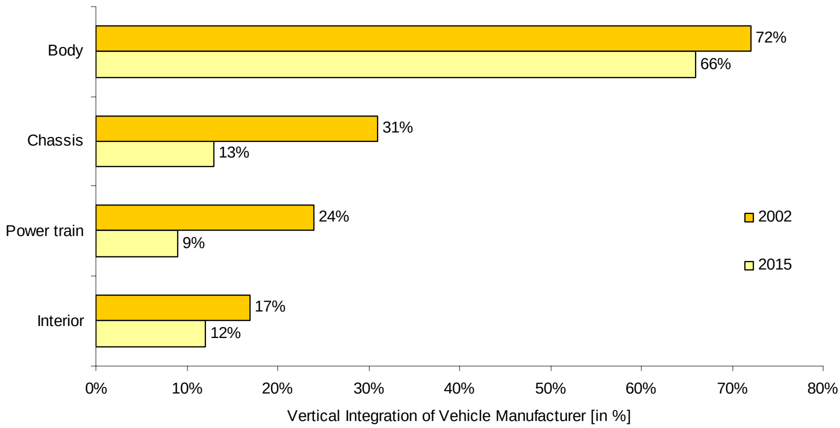
- The management consultants Roland Berger & Partners expect a worldwide fall of the number of suppliers from 5,600 at present to 3,500 by the end of the decade. In this period the number of first tier suppliers per module/system is said to fall from today’s 7-8 to 5-3, with a simultaneous decrease of the number of modules/systems per vehicle from 20-18 today to about 10 in the year 2010 (Berger & Partners, 2000).
- PricewaterhouseCoopers – using obviously another definition of tier 1 and tier 2 supplier – expect a decrease in the number of first tier suppliers from 800 to 35 and a reduction of second tier suppliers from 10,000 to 800 in the same time period.
- The associations of the automotive industry are questioning this degree of consolidation: If a continually decreasing number of first tier suppliers meets a continually increasing demand on behalf of the vehicle manufacturers, the result will be an adjournment in the power of negotiation to the disadvantage of the automobile manufacturers. The manufacturers try to abide a credible threat of an upstream integration and to apply a dual sourcing strategy for the different vehicle components.[82]

[82] See German Association of the Automotive Industrie VDA (2003) and Neuner (1993).

In any case, the upcoming innovations in the field of automobile manufacturing will bring about yet further changes at the interface of suppliers and vehicle manufacturers. The increase of the production costs of a motor vehicle mainly induced by product improvements[83] will probably lead to an additional transfer of R&D and other value generating activities, which are beyond the core competencies of the vehicle manufacturers, to the suppliers. The arising expenses for R&D will not be pre-financed by the vehicle producer anymore, but will be added to the price per unit of the delivered component. The vehicle manufacturer will not provide for a complete amortisation anymore (KPMG, 2003). Overall, the vehicle manufacturer will pass on the cost-pressure to the suppliers, who will need to consolidate further through strategic alliances (PricewaterhouseCoopers, 2003).

Figure 73 describes the expected development of vehicle manufacturers' vertical integration until 2015: There will be an estimated decrease of 10 percentage points of the value added proportion of the vehicle manufacturers. This decline will be explained mainly through the spin-off of tasks from the area of chassis technology (-18 percentage points) and the area of engine technology (-15 percentage points) to the suppliers. Even in the core competencies of the body the value added shares of the vehicle manufacturers are decreasing by 6 percentage points from 72% to 66%. A reduction of costs can be achieved through strategic alliances in the form of cross-border platform developments and by sharing of parts and design. Moreover, new laser-welding technologies and a reinforced use of plastic parts, enabled through the application of the colour matching technology, from different suppliers are hidden cost reduction potentials.

Fig. 73. Development of vehicle manufacturers' vertical integration



Source: McKinsey&Company, 2003

Since the innovations will exceed the classical limits of supplier segmentation some analyst hypothesise that the traditional supplier pyramid composed of tier 1,

[83] Recent studies expect this cost increase to amount to nearly 30%.

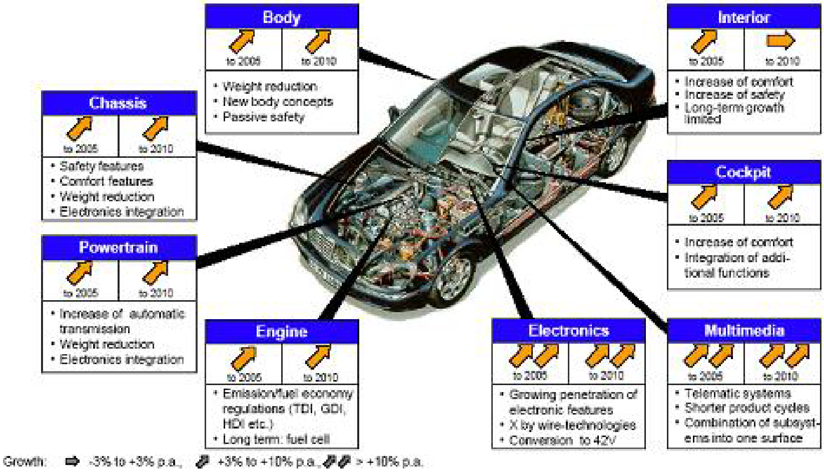
tier 2, and tier 3 suppliers will be replaced by a segment structure of the suppliers. Manufacturers of brake and steering systems for example would network with manufacturers of the chassis technology (Doran and Roome, 2003). Partially, this networking is supposed to reach the consumer via spare parts. Whether the supplier industry will be able to cope with the increased requirements of the cooperation management, will depend mainly on the solution of the financing problem. This financing problem results from a low equity basis of the medium-sized supplier industry. Only with sufficient financial resources it is possible to deal with the financial risks of R&D and product liability, for example through call-backs. Furthermore, it is very doubtful that the vehicle manufacturers will support a technical network of suppliers in terms of corporate and brand-independent standards, which is not controlled by them.

4.5 Trends in Innovation Activities

Many studies deal with "the car and the future". After euphoric forecasts with regard to the introduction of technologies for "automated guided driving" or alternative propulsion technology like the fuel cell more recent studies offer a more sceptical look at the time horizon for the implementation of such technologies. This change can be explained by a multiplicity of reasons like the degree of maturity of these technologies, legal problems of product liability or high opportunity costs in comparison with other technologies. Hence, one should expect the basic features of vehicles to be the same in future: Automated guided vehicle technologies for example will not be avaiable in the near future, innovations will be rather incremental than radical and be hidden to the end customer or be revealed on the second sight.

A study accomplished by Roland Berger & Partners (2000) yields an illustration of upcoming trends in value added for different components of a vehicle induced by innovations (Figure 74). This illustration highlights especially the importance of incorporating IT into automotive innovation. It is expected that 90% of all future innovation in the automobile will be driven by IT (electronics, 2002). This affects both electronics dominated spheres of multimedia and traditional mechanical components as chassis, body or engine. In succession of X-by-wire-systems the fraction of electronics in the construction of chassis will increase from 12 to 40%. Similar developments are expected for safety features e.g. pedestrians' protection, traction control, backward driving cameras, night-view display in windshield, sensor controlled brakes or fuel economy regulation. Even product differentiation will take place more and more through electronics: Engines constructed in the same way could be adjusted to different performances. "Traditional mechanical parts will be either electronically supported or fully replaced by electronics. Components will communicate with one another and change their behaviour based on the information received from other components" (McKinsey & Company, 2003). The value of electronic components in vehicle will rise from 20% today to 40% in 2015. This development won't be without effects on vehicle manufacturers and their component suppliers. Vehicle manufacturers are trying to establish themselves in particular in electronic engine controls, but with minor success so far. In fact it appears that component suppliers specialised on electronic interfaces could occupy this growth segment (McKinsey&Company, 2003).

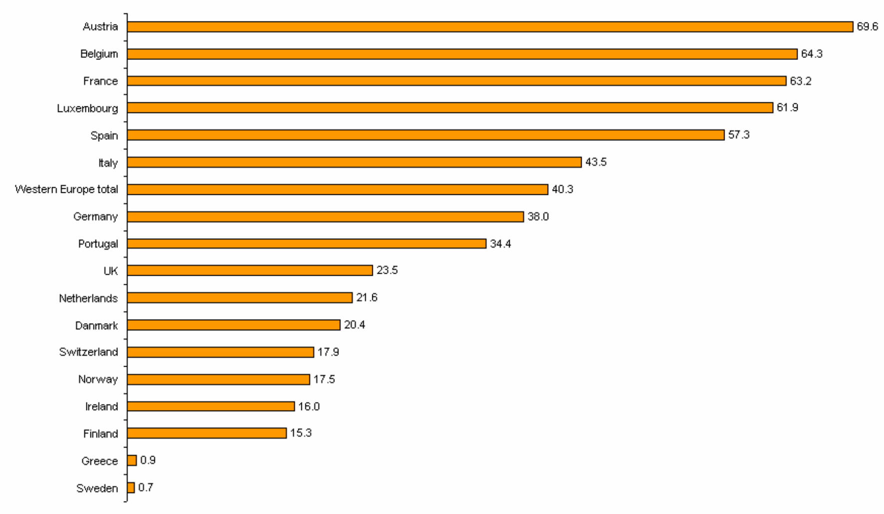
Fig. 74. Technological innovations



Source: Roland Berger & Partners, 2000.

When and where technologies will be accepted depends first of all on the character of final markets. In order to understand the international diffusion of innovations, it has to be explained beforehand why countries initially prefer different innovation designs. It is commonly expected that the same products are being consumed and similar processes are being applied worldwide due to globalisation. However, national differences can be observed in the applied technologies and product designs. In the USA for example other automobile designs are preferred than in Europe or Japan. The international diffusion of a specific innovation design is complicated through different conditions in each country. This may by rooted in international difference with regard to the fit of local frameworks and technical specifications which then leads to county-specific innovation designs. The riding conditions, the infrastructure, the fuel prices and the customer preferences differ by country. The European consumers e.g. prefer innovation reducing the variable costs of the ownership. As consumers are increasingly more affected by the variable costs of a motor vehicle (e.g. fuel prices), a very high increase in the first registration rate of diesel fuelled passenger cars can be observed.

Fig. 75. Share of diesel cars in first registrations of passenger cars in Western Europe, 2002 in %



Source: Eurostat and German Association of the Automotive Industry VDA: International Auto Statistics Edition 2003, Frankfurt.

In contrast, diesel cars are not present in the US-American market where the incentive to buy diesel vehicles is so far not profitable due to the low fuel prices. Accordingly, the European and Japanese manufacturers are leading in the production of diesel technologies and due to the high market share in the first registrations of diesel-fuelled passenger cars in Europe they push innovations in the field. When and to what extent the diesel technology will be used in other countries will crucially depend on fuel price development (including taxes) in these countries. In that case, the European automotive market would be a lead market in the field of power train technology.

The Lead Market concept (Beise, 2001) suggests that for many innovations lead markets exist that initiate the international diffusion of a specific design of an innovation. Once a specific innovation design has been adopted by users in the lead market subsequent adoption by users in other countries are more likely. Therefore we define lead markets as regional markets with specific attributes that increase the probability that a locally preferred innovation design becomes internationally successful as well (Beise and Cleff, 2003). In addition, based on first mover advantages producers supplying these markets early will have permanent advantages when the technology spills over to other countries. It indicates that several European countries show the characteristics of a lead market concerning the automobile branch. Porter (1990) describes the demand conditions in Germany as one of the factors explaining the German firms' immense success in export. In addition, French companies seem to have an advantage in designing cars due to the responsiveness of their local customers.

The lead market for automobiles in Germany is characterised through a combination of several lead market factors:

- The propensity to consume with respect to automobiles leads to a comparatively high valuation of this good. The latter also determines the willingness to search, examine and select new products. This fosters the perception of product innovations by the consumer.
- High fuel prices stimulate the early diffusion of new engines with high fuel efficiency. This may result in a price advantage due to the manufacturing experience of large lot sizes for corresponding product innovations.
- The German automotive industry also benefits from a transfer advantage[84], which is maintained through the strong presence of the firms abroad and the established image of the German automotive industry as high-quality suppliers. The transfer advantage reduces the concerns of foreign consumers in terms of adopting new innovation, hence leading to an export advantage.
- The German automobile market is open and overall intensively competitive especially between local manufacturers. In addition, the size of the German automotive industry leads to industry-structure advantages through a dense network of highly specialised and technologically competent component supplier firms from all industrial sectors. Those are – opposed to the industry-structures in the USA and Japan – not bound to certain manufacturers but deliver mostly to several manufacturers. Therefore, innovations in the area of parts and components diffuse especially rapidly between the companies and foster competition further.
- Finally, the lead market role of the automobile manufacture is also strengthened by infrastructure and legal framework (dense motorway network, no speed limits, taxation). This fosters the customers' high pretensions towards driving qualities at high speed as well as safety criteria.

Because lead market consideration seems to be at the heart of competitiveness in complex products we will illustrate the importance of the factors mentioned by the example of ABS.[85] After the Second World War, ABS systems were at first developed by American and British companies, particularly for aeroplanes and racing cars. The German companies, which developed an anti-lock braking system (ABS) ready for start of production in the 1960s did not have any technical advantage at this time. Quite the contrary: The first development steps of German companies as Daimler-Benz and Teldix consisted of testing the existing (foreign) ABS systems (Bingmann, 1993). Due to insufficient technological maturity, it took until the late 1970s that a now electronic system as special equipment for luxury class vehicles was introduced at the market. Figure 76 shows the estimated process of the diffusion of ABS in passenger cars in Germany, Western Europe, USA and Japan.

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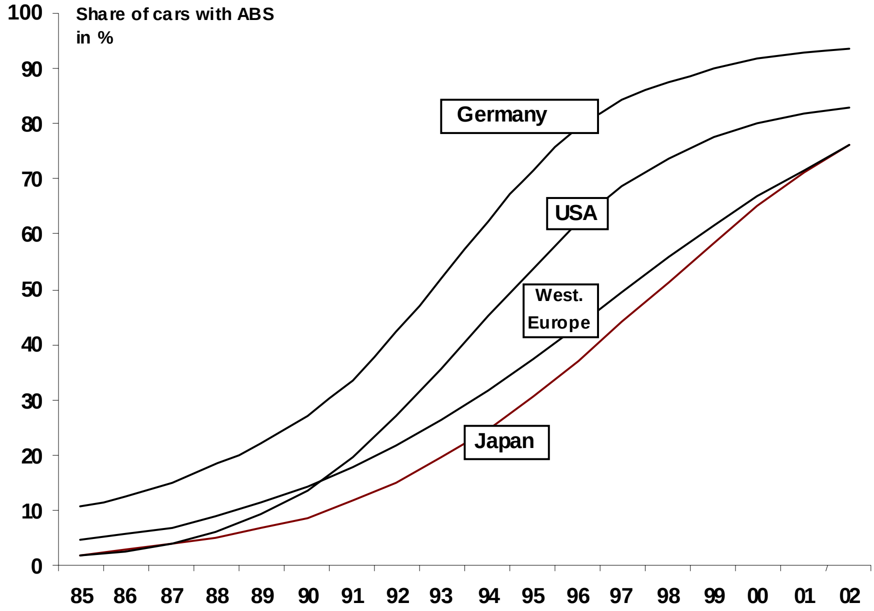
84 A country has a transfer advantage if innovations first introduced and accepted in a country give hints to the innovators that this innovation is also accepted by customers in other countries.

85 For details see Beise et al. (2002).

Fig. 76. International diffusion of ABS



Source: Beise (2001).

The diffusion process in Germany is characterised by marketing and pricing behaviours of the pioneering companies (Daimler-Benz, BMW) as well as by strong competition. First, the additional costs for the ABS equipment were kept below the sales-price in order to establish the ABS at the market. The prices could be cut even further through the use of economies of scale in combination with the expansion of automated production facilities by the suppliers Bosch and Teves. In the meantime other companies also developed anti-block braking systems which boosted competition. Bosch was not a monopolist at the market; since the ABS could not be patented, the know-how of the technique spread out quickly. In the USA the market for ABS developed with a delay of approximately two years. Because the use of ABS was at first lower than in Europe due to the general speed limit and the drier climate so that the penetration of the market succeeded only when cost advantages of mass production allowed for lower prices for ABS. In addition the US market generally suffers from a strict manufacturer's liability. The US automotive manufacturers are retentive concerning the introduction of security innovations because each additive electronics in the vehicle could lead to additional accidents by malfunction and faulty operation in extremely rare cases. The airbag is another example: There was much fear that engine misfires could lead to injuries of the driver. Already few accidents could lead to extremely high compensation payments and losses resulting from the introduction of an innovation. For this reason, US automotive manufacturers normally wait until they observe the experiences from Europe before offering innovations in vehicles on their own. The reason for the sluggish diffusion in Japan was the additional price for ABS in proportion to the basic price of the vehicle (Bingman, 1993).

Due to the first mover effect German companies, particularly Bosch, have a significant world market share on passenger car anti-lock braking systems up to now. This national advantage has been maintained up to the present with regard to further development on electronic brake control systems (e.g. ESP, Sensotronic, ASR). Although the technical know-how was already well-known and the ability of components suppliers in many industrial countries approved the development of anti-lock braking systems in passenger cars, German companies have acquired a lead function, which is due to the early adoption of this technology in Germany (Beise et al., 2002).

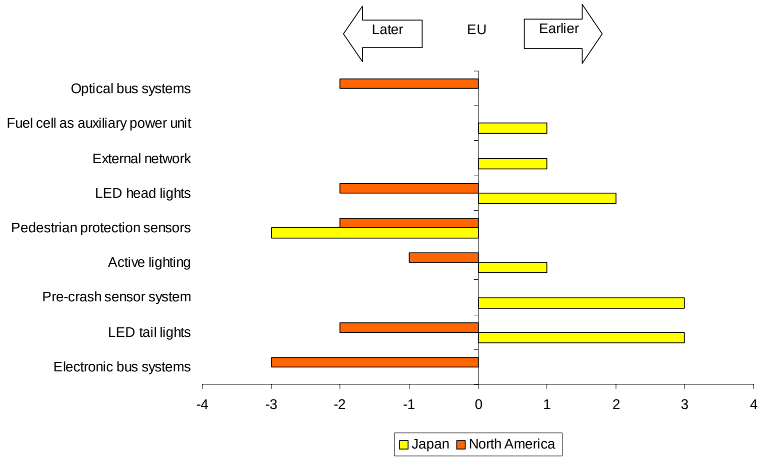
It is important to mention that lead markets do have an impact on the value chain. Companies of a lead market take up the specific demand and convert it to a demand of components and preliminary products. This way, lead market impulses are passed upstream along the value chain. Idiosyncratic product innovations, which quickly adopt an innovation design that is never adopted by other countries, limit the competitiveness of firms acting within this country. A firm responding to idiosyncratic markets can achieve a temporary local innovation success but is later pushed to switch to the globally dominant design. A consideration of the lead market aspect in the national innovation policies generally means the following:

1. To support the competition between innovation designs. The different power train technologies (petrol-operated engine, diesel engine, liquid gas engines, electric motor, fuel cell) represent for example different innovation designs. The high competition between the European automotive manufacturers and between the suppliers is particularly characteristic for the European market.
2. To be amenable to the diffusion of new technologies from other countries/regions and the support of technologies on future international trends in the field of the application of these technologies, tends to result in early adoption or adaptation of new technical trends. This could be illustrated by the example of ABS brakes. This move is facilitated when manufacturers and suppliers are global players, which is particularly right for the European suppliers and automotive industry.
3. To advocate open markets between industrial countries, also particularly by supporting the diffusion of regulations and internationally uniform standards.

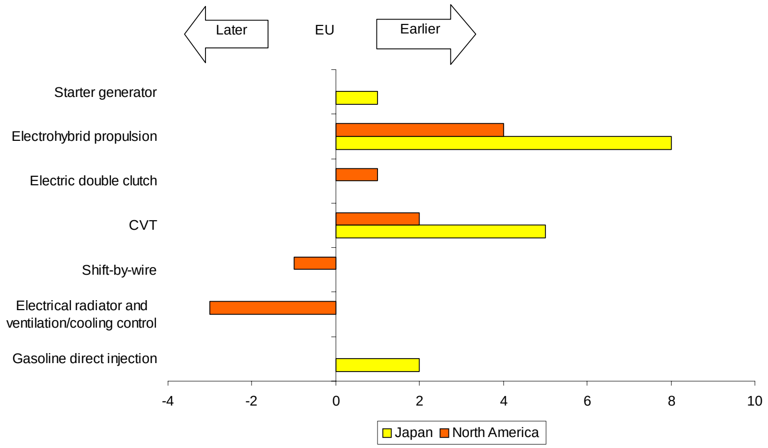
In Figure 77 innovations in the field of vehicle manufacturing that are expected for different dates of introduction in different regions of the triad are listed. Europe and Japan may be called a lead market for innovations in the field of driving security (chassis and body). The customer have a high interest in those aspects, whether they are willing to pay for particular features remains to be seen. Due to high costs of fuel the driving forces of innovations on the Japanese market will be those in the field of power train technologies. Innovations in driving assistant systems are also expected in Japan and Europe. In North America many innovations are expected to be introduced with a lag of three to five years, due to the legislation of product liability and the extensive cost pressure. And it is expected that the organisation of the value chain and the limited role of suppliers in innovation will also hinder early introduction by US based firms.

Fig. 77. Innovation road map for different functional themes of the triad

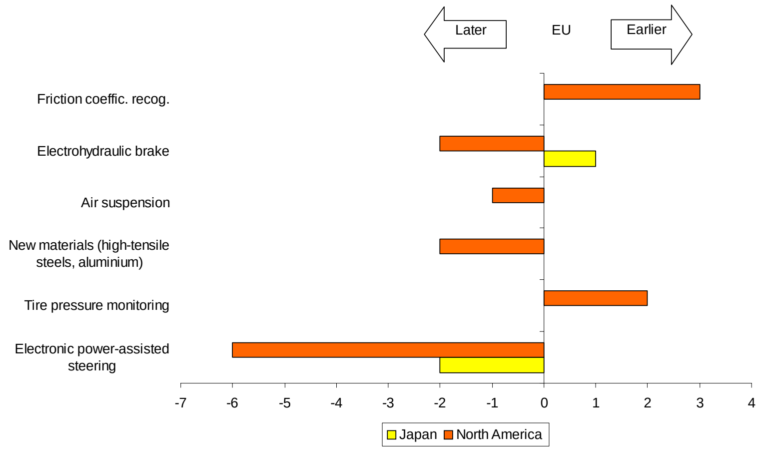
Interior



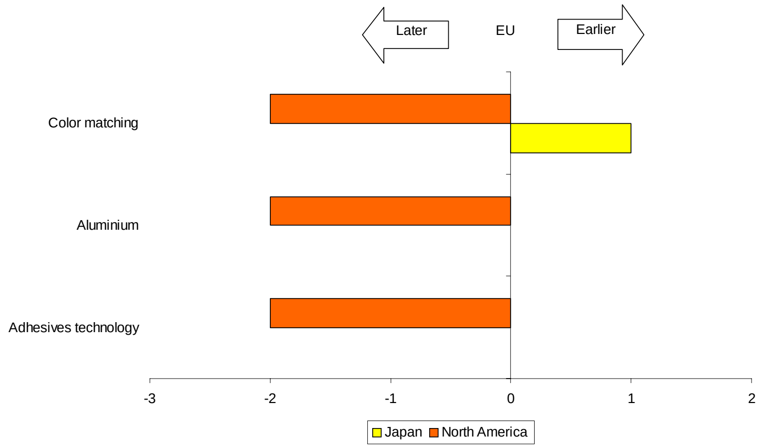
Power Train



Chassis



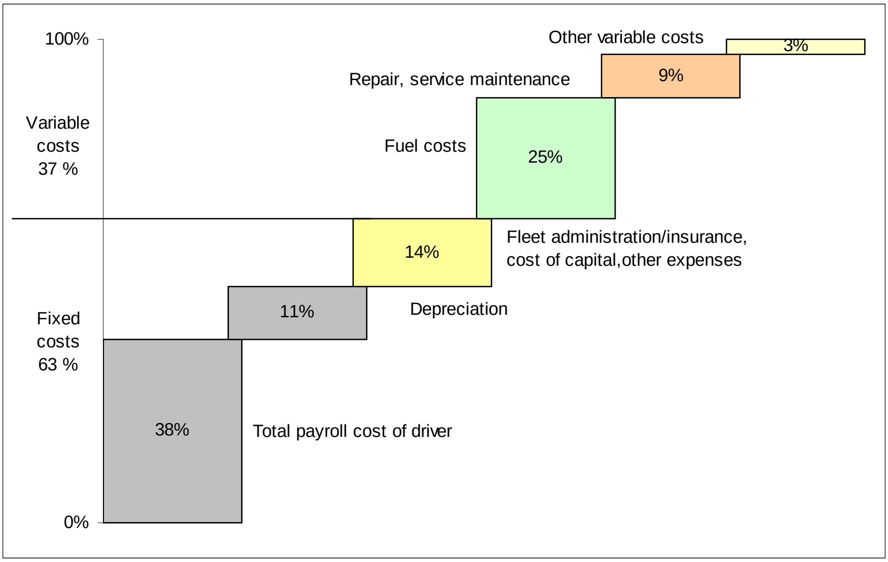
Body



Source: McKinsey&Company, 2003.

Comparing the customer requirement of commercial vehicles with those of passenger cars, there seem to be differences in buyers' profiles, that one may assume differences in innovations' performances, too. For a customer of a passenger car the cost of purchase is most important, while a buyer of commercial vehicles tries to minimise the "total cost of ownership". Constructing lighter car body materials can reduce costs of usage, which in fact results in dynamic innovations in the area of commercial vehicles. This tendency is boosted by regulations governing emissions (EPA04/EPA07 in the USA and EURO 4 in the EU). This will in the medium term lead to innovations in fuel-injection technology and emissions after-treatment systems (particle filters, exhaust gas recirculation, etc.) and will also affect the passenger car sector.

Fig. 78. Total cost of ownership (TCO) for commercial vehicle 2002



Source: McKinsey&Company, 2003.

Innovations for minimising repair time through self and remote diagnostics and lowering insurance rates through higher driving safety (e.g. electronic driving assistance like night-view display) do not vary from the needs of a passenger car customer (McKinsey&Company, 2003). Recapitulating, electronic engineering dominated paths of innovations can be identified, which are similar for the range of passenger and commercial vehicles. The basic trigger for product innovation in vehicle manufacturing lies particularly in an improvement of the whole passenger car or separate components and for this reason in an improvement of the customers' utility. This excess of innovation is not always related to consumers' willingness to pay an increased price. These innovations will increase the production costs of passenger cars up to 27% in 2015, and this increase has to be compensated, at least partly, through process innovations along the value chain.

4.6 Price and Technological Competitiveness – A Short Summary

The automotive industry is characterised by an increasing competition on a worldwide scale. All leading manufacturers produce and sell in all major regions of the world. Customers are able to chose from a wide variety of automotive products. This is especially the case in the car sector. In order to stay in the market manufacturers need to keep competitive with regard to the price dimension but also with regard to the technological dimension of competitiveness.

EU-15 automotive industry is gradually catching-up in terms of labour productivity which induces an improvement in terms of price competitiveness. However, the catching-up in the area of labour costs has been steep. Taken together EU-15 automotive industry is now under severe pressure with regard to price competitiveness. This is especially true with regard to the US which gains price advantages due to decreasing labour costs connected with some advance in the productivity area. The process of enlargement adds regions with extremely low labour costs to the EU. This will help the automotive industry to regain price competitiveness. Hence, we see increased outsourcing in the assembly as well as in the supplier industries to these new locations. However, the other side of the coin is that traditional locations of car or car-parts production in the EU-15 will face a double pressure resulting from the need of increasing price competitiveness in world markets and low cost production possibilities in the new member states. Hence, although enlargement will help the EU automotive industry to stay competitive enlargement will increase the need and the possibilities for restructuring the value chain.

Given the problems in the area of price competitiveness EU-15 automotive industry invests heavily in product and process innovation, namely R&D. There are several indications that these investments have already improved the technological competitiveness of EU automotive industry. Especially the increasing share of EU automotive industry in patenting in the 1990s nurture the hope that the catching-up of EU automotive industry will regain momentum in the future. A detailed look at the innovation possibilities in the car sectors show that the EU is well equipped for future technological challenges especially in the area of construction of car bodies and chassis. In some other areas of technological innovation the EU lags behind Japan. Especially pronounced is the technological lead of Japan in the areas of active safety features and engine technology.