German Institute
for Economic Research

No. 11/2010
Volume 6
March 26, 2010

DIW BERLIN

www.diw.de

Weekly Report

Germany is well positioned for international trade with research-intensive goods

Germany is the world's biggest gross and net exporter of research-intensive goods, even ahead of the US and Japan. Per capita Germany also has the largest export surplus for research-intensive goods with around USD 3,900. Furthermore, Germany increasingly benefits as an importer—and thus as a user of technologies—from the international division of work. However, Germany's comparative advantages for research-intensive goods have declined in comparison to the middle of the 1990s. This is not due to a change in export specializations but rather to the tremendous increase in imports; this is reflected above all in the medium and low price segments where emerging markets have been catching up in research-intensive goods.

After the financial market crisis had its impact on the real economy, it is now even more important to strengthen the innovative capabilities of German companies. The most important prerequisite of ensuring this is being equipped with R&D and human capital.

Marius Clemens
mclem@uni-potsdam.de

Dieter Schumacher
dschumacher@diw.de

According to the findings of the international trade theory, every country benefits from the international division of work because it can achieve higher productivity and thus a higher real income through the exploitation of comparative advantages with a better exploitation of resources. The goal of exports is to cover demand more cost efficiently through imports than directly through domestic production. Technological efficiency is crucial for income levels in international comparison.[1] A country that—as a consequence of better technology—uses its production factors more efficiently and produces innovative products will also achieve a higher income level. Such a country has comparative advantages with goods whose production requires the use of demanding technologies, and accordingly presupposes a good provision of human capital as well as high expenditures for research and development.

JEL Classification:
F10, F14, O14

Keywords:
International trade, Country and industry studies of trade, Industrialization, Manufacturing and service industries, Choice of technology

1 Cf. Belitz, H., Clemens, M., Gornig, M., Schiersch, A., Schumacher, D.: Wirtschaftsstrukturen, Produktivität und Außenhandel im internationalen Vergleich. Studien zum deutschen Innovationssystem [Economic Structures, Productivity and International Trade in International Comparison. Studies on the German Innovation System] No. 5/2010, Expert Commission for Research and Innovation (Publ.), Berlin, www.e-fi.de.

Table 1

International trade indicators of selected countries and regions for research-intensive goods in 2007

	Germany	USA	Japan	EU-14	EU-10[1]
Exports in USD billions					
Research-intensive goods	791.1	712.5	498.8	1 645.0	218.0
Cutting edge technology	204.2	316.3	119.3	550.4	63.5
High end technology	586.9	396.1	379.4	1 094.6	154.5
Imports in USD billions					
Research-intensive goods	469.5	892.5	197.8	1 660.2	215.4
Cutting edge technology	180.7	369.0	96.7	579.1	72.3
High end technology	288.8	523.4	101.1	1 081.1	143.1
Balance of trade - balance per capita in USD					
Research-intensive goods	3 904	–600	2 356	–49	40
Cutting edge technology	286	–176	177	–93	–139
High end technology	3 619	–425	2 179	44	179
Contribution to exports (CTX)[2]					
Research-intensive goods	54	53	120	–10	1
Cutting edge technology	–23	41	–16	–12	–21
High end technology	77	12	136	2	22
Contribution to imports (CTM)[2]					
Research-intensive goods	5	–6	–32	–15	3
Cutting edge technology	6	15	12	–10	–8
High end technology	–2	–21	–44	–5	10
Contribution to balance of trade (CTX—CTM)[2]					
Research-intensive goods	49	59	152	4	–1
Cutting edge technology	–29	27	–28	–2	–14
High end technology	79	33	180	7	12
Relative share of exports in world trade (RXA)[3]					
Research-intensive goods	15	21	29	–4	0
Cutting edge technology	–20	41	–13	–12	–22
High end technology	30	8	47	1	11
Relative share of imports in world trade (RMA)[3]					
Research-intensive goods	2	–2	–16	–5	–1
Cutting edge technology	7	11	14	–10	–7
High end technology	–1	–10	–37	–3	5
Comparison of the export and import share (RCA)[4]					
Research-intensive goods	13	23	45	1	–1
Cutting edge technology	–27	30	–27	–3	–15
High end technology	31	18	85	4	6

1 Countries that acceded in May of 2004.
2 A positive value indicates that research-intensive goods contribute an above average amount to the exports, the imports or a balance
3 A positive value indicates that the share of research-intensive goods in the exports, or imports,respectively, is greater than the share
4 A positive value indicates that the share of research-intensive goods in the exports is greater than in the imports..

Source: Calculations of the DIW Berlin. **DIW** Berlin 2010

In both absolute figures as well as per capita, Germany is the world's biggest exporter of research-intensive goods; the biggest import market by far is the US.

Exports and imports: Germany is one of the biggest technology providers

In the 1990s, the US led the world market when it came to research-intensive goods, with a clear margin compared to Japan and Germany. In 2007, Germany was the largest exporter of research-intensive goods with USD 791 billion (Table 1). The US and Japan follow in second and third place with USD 713 and 499 billion respectively. The EU members who acceded to the EU in 2004 (EU-10) still have a relatively low level with USD 218 billion.

When it comes to research-intensive imports, Germany is behind the US and ahead of similarly large countries such as the United Kingdom and France. Japan still has the fewest research-intensive imports (despite the high increase in the 1990s) of all the countries and regions. Among the three countries, the US continues to play the biggest role by

far as an import market when it comes to research-intensive goods (with USD 893 billion in 2007).

When considering research-intensive goods, a distinction is made between cutting edge technology and high end technology. Included in cutting edge technology are goods that display a share of R&D expenditures in the overall turnover of seven percent or more. For high end technology this share lies between 2.5 and seven percent. This differentiation depends solely on the research intensity and is not a valuation in the sense that high tech is more modern or more valuable.

The export of research-intensive goods means that research-based knowledge is sold to other countries. Accordingly, research-intensive imports are an indicator for the degree to which technology is purchased via goods trade and can be used to supplement domestic knowledge holdings. Whether a country is more of a technology provider (exports greater than imports) or a technology user (exports less than imports) can be seen through goods trade on balance by means of the difference between research-intensive exports and imports. Accordingly, Japan and Germany have long been the biggest net exporters of research-intensive goods. The EU-10 have also had a slight net export surplus since 2006. The largest net importer by far is the US. In Germany, the export surplus has grown tremendously since the end of the 1990s, and in the US the same is true for the import surplus.

With around USD 3,900 per capita, Germany is the country with the biggest export surplus for research-intensive goods, followed at a distance by Japan with USD 2,356 per capita. This means that Germany is one of the biggest technology providers not only in absolute terms, but also in relation to its population.

Specialization pattern in international trade with research-intensive goods

The level of export-import balances depends on the economic situation and on exchange rate ratios, but it also reflects the size of the sectors. In order to be able to make statements independent of these influencing variables, the balances below will be adjusted initially by the total international trade balance, and then by the size of the sectors (box).[2]

If one adjusts by the influence of economic fluctuations and changes in exchange rates, then research-intensive goods make the greatest above-average contribution to exports (CTX) in Japan, followed by Germany and the US. Cutting edge technology is a major contributor to exports in the US. For high end technology this is particularly true in Japan, Germany and the EU-10, but also in the US. Overall, research-intensive goods make an above-average *contribution to imports* (CTM) in Germany. In contrast to imports, there appears to be a trend in exports towards a stronger focus on the areas where specialization advantages are found in the individual countries. In the imports, the deviations from world trade are considerably less and the greatest deviations are restricted to far fewer categories of goods.

The difference between CTX and CTM makes evident the *comparative advantages and disadvantages of a country*. Accordingly, research-intensive goods in Japan make the greatest contribution to the international trade balance by far, and in the US and Germany this contribution is also above average. Therefore, these countries have comparative advantages with research-intensive goods. For the US, this applies for cutting edge technology and high end technology; for Japan, Germany and the EU as a whole, only in high end technology.

If one goes a step further and adjusts not only by overall international trade but also by the size of the sectors, one can use traditional indicators that do not put differences but rather ratios in relation to one another. If one places the goods structure of a country's exports vis-à-vis the goods structure of world trade, indicators for the evaluation of export specialization become evident.[3] If one considers the position of the individual countries when it comes to research-intensive goods—on the one hand with exports (RXA) and on the other with imports (RMA)—then one comes to the following classification of countries for 2007: In cutting edge technology, only the US is above average in its involvement in both exports and imports in international trade, while this is only true for imports for Germany and Japan. The other regions are below average in international trade in both imports and exports with high-tech goods. In high end technology, only the EU-10 are involved above average in both imports and exports in international trade; this is only true on the export side for Japan, Germany, the EU-14 (EU members up to 2004 without Germany) and the US.

2 Starting point for this analysis is world trade, calculated as imports of OECD countries from all countries plus the exports of OECD countries into the non-OECD countries. Lacking are the deliveries between the non-OECD countries, which make up around one-fifth of world trade.

3 Dividing the structures by one another results in a measure already introduced by Balassa in 1965 for quantifying the specialization pattern of a country in international trade. Cf. Balassa, B.: Trade Liberalization and „Revealed" Comparative Advantage. In: The Manchester School of Economics and Social Studies, Vol. 33, 99-123.

Indicators for measuring specialization in international trade

The specialization patterns of a country are measured by whether a country has an especially large or small market share in world trade in the individual categories of goods for exports or imports, each in comparison to its share for all manufacturing goods. The comparative advantages of a country are determined from a comparison of exports and imports. If the export-import balance adjusted by the entire balance of trade in a category of goods is positive, the country has a comparative advantage there. If it is negative, the country has a comparative disadvantage[1] in the category of goods concerned. The indicators can be formed from ratios, which are then independent of the size of the various categories of goods. Alternatively, they can be calculated from differences; they are then additive and also take into account the size of the individual categories of goods. The calculations in detail are the following:[2]

The export specialization (CTX) (import specialization CTM) is calculated from the *additive indicators* by multiplying the difference between the sector-specific share and the entire share of a country in world exports (world imports) with the share of this category of goods in world exports (world imports):

The indicator arises by thinking of the contribution by a category of goods to exports (imports) as the difference between the actual exports (imports) and a hypothetical export (import) value that would result based on the average global market share of the country in question.

If one applies the same concept to the balance of exports and imports, then the difference of CTX and CTM can be calculated as the indicator for the comparative advantage and disadvantage that quantifies the contribution of the individual categories of goods to the international trade balance.

The *non-additive* specialization indices RXA (RMA) adjusted by the size of the category of goods point to a specialization of a country for exports (imports) if its share in world exports (world imports) in the category of goods concerned is greater than for all manufactured goods. When doing logarithms, the indicator value is then greater than zero.

A positive value thus means that the national economy is specialized in the (export) production of goods of the respective category, and a negative value that it is merely participating in world exports at a below average level.

The goods structure of exports is put in relation to the goods structure of its own imports with an even more frequently used ratios. These so-called RCA values result from the difference of RXA and RMA and characterize the pattern of the comparative advantages and disadvantages of a country in international trade, taking into account the import competition in one's own domestic market. Accordingly, the extent to which the import structure of a country deviates from that of world trade also plays a role for the RCA pattern.

1 Rising (dropping) comparative advantages in individual categories of goods thus imply ever-rising (ever-dropping) comparative disadvantages in other categories of goods.

2 The analysis of comparative advantages and disadvantages using international trade data (revealed comparative advantage) was developed by Balassa in 1965 and was also frequently used in his mathematical formulations. Cf. Kriegsmann, K.-P., Neu, A.: Global, regional and sectoral competitiveness of the German economy—concepts and results. Frankfurt, Berne 1982. For a discussion of various specialization measures cf. also Vollrath, T. L.: A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage. In: Weltwirtschaftliches Archiv, Vol. 127, 1991, 265–280. The logarithmic formulation used here has the advantage that the measure is simultaneously continuous, non-committed and symmetrical. Cf. Wolter, F.: Factor Proportions, Technology and West-German Industry's International Trade Patterns. In: Weltwirtschaftliches Archiv, Vol. 113, 1977, 250–267.

Automotive engineering is the most important category of goods for Germany

A closer look at the values classified by categories of goods and adjusted by economic and exchange rate influences in Table 2 shows that Germany's exports are oriented to motor vehicles to an above-average extent. Motor vehicle parts, engines, machinery for food, beverage and tobacco processing, machine-tools, other general purpose machinery and electricity distribution and control apparatus are other high end technology sectors with a high export specialization. The cutting edge technology area includes pharmaceuticals and instruments for measuring and checking. Pharmaceuticals make the largest contribution to the import of research-intensive goods. Overall, Germany displays high comparative advantages in automotive engineering and in special machinery for certain industries, and comparative disadvantages for data processing devices. Since 1995, only automotive engineering has gained comparative advantages in Germany, while these advantages declined in electronics and

Table 2

Germany's international trade specialization with research-intensive goods by categories of goods in 2007

Category of goods	Contribution[1] to			Relative share in world trade[2]		Share of exports vs. imports[3]
	Exports	Imports	Balance of trade	Exports	Imports	
R&D intensive goods	**54**	**5**	**49**	**15**	**2**	**13**
Cutting edge technology	**–23**	**6**	**–29**	**–20**	**7**	**–27**
Processing of nuclear fuel	0	0	0	–26	19	–45
Pesticides and other agro-chemical products	0	0	0	7	–12	19
Pharmaceuticals, medicinal chemicals and botanical products	4	6	–2	14	29	–15
Weapons and ammunition	0	0	0	–98	–164	66
Data processing devices & facilities, parts for DP devices	–12	0	–12	–72	0	–72
Electronic valves and tubes and other electronic components	–9	–1	–8	–57	–4	–53
Television and radio transmitters	–5	–2	–3	–56	–27	–29
Television and radio receivers	–8	–1	–7	–106	–7	–99
Medical and surgical equipment and orthopaedic appliances	1	0	1	14	–3	17
Instruments for measuring, checking, testing, navigating and other purposes	4	1	3	36	13	24
Aircrafts and spacecraft	1	3	–2	8	29	–21
High end technology	**77**	**–2**	**79**	**30**	**–1**	**31**
Basic chemicals, except fertilizers	–3	1	–5	–16	8	–24
Plastics in primary forms and of synthetic rubber	2	1	1	13	10	3
Paints, varnishes and similar coatings, printing ink and mastics	3	0	3	24	2	23
Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	1	0	1	18	–5	23
Rubber products	0	1	–1	3	27	–25
Engines and turbines, (except aircraft, vehicle and cycle engines), pumps, compressors, taps & valves, bearings, gears, gearing & driving elements	8	0	8	39	4	35
Other general purpose machinery	6	–1	6	48	–10	58
Agricultural and forestry machinery	2	0	2	50	–20	70
Machine-tools	5	0	4	57	3	54
Machinery for mining, quarrying and construction	0	–2	2	1	–62	63
Machinery for food, beverage and tobacco processing, textile, apparel and leather production and other special purpose machinery	7	–2	9	46	–33	79
Office machinery	–1	0	–1	–44	–5	–39
Electric motors, generators and transformers	1	1	0	11	10	1
Electricity distribution and control apparatus	5	0	5	50	5	45
Accumulators, primary cells and primary batteries	–1	0	–1	–44	2	–47
Electrical lamps and lighting equipment	0	0	0	0	–8	7
Other electrical equipment n.e.c.	–1	1	–2	–8	23	–31
Optical instruments and photographic equipment	–1	–1	0	–26	–53	27
Motor vehicles	36	–3	39	53	–8	61
Parts and accessories for motor vehicles & their engines	8	2	6	31	13	18
Railway and tramway locomotives and rolling stock	1	0	1	57	–3	60
Non-research-intensive goods	**–54**	**–5**	**–49**	**–24**	**–3**	**–21**
Manufacturing	**0**	**0**	**0**	**0**	**0**	**0**

1 A positive value indicates that the research-intensive goods contributed an above-average amount to the exports, the imports or to a positive balance of trade.
2 A positive value indicates that the share of research-intensive goods within the exports, or the imports, respectively, is greater than the share in world trade.
3 A positive value indicates that the share of research-intensive goods in the exports is greater than in the imports.
Source: Calculations of the DIW Berlin. **DIW** Berlin 2010

High end technology plays a significantly greater role than cutting edge technology in Germany. By far the most important categories of goods are motor vehicles, motor vehicle parts and accessories.

parts for electrical engineering, in chemistry and in mechanical engineering.

After adjusting by the sector size, a totally different sectoral profile is revealed because all sectors are now evaluated independently, regardless of their size. This also allows for a better international comparison for the smaller sectors, e.g. the RCA values show that Germany displays comparative advantages in several categories in the areas of mechanical engineering, chemistry and electrical engineering, which correspond to those categories that quanti-

tatively have the most favorable cost factors for motor vehicles and special machinery for certain industries. While the US posted comparative advantages for 21 of the in-total 32 research-intensive categories of goods in 2007, for Germany it is 20. Japan, the EU-14 and the EU-10 have comparative advantages in 20, 19 and 12 research-intensive categories of goods, respectively. There tend to be more categories of goods, the larger the country is and the greater the overall comparative advantages afforded by research-intensive goods are.

Germany consistently specialized in research-intensive exports

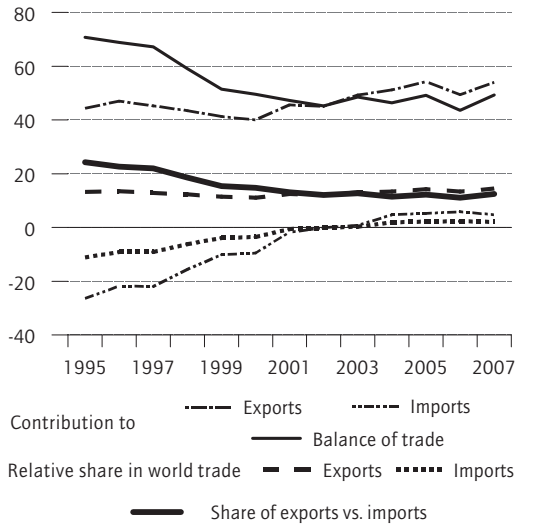
Germany's comparative advantage for research-intensive goods has declined compared to the first half of the 1990s (see figure). This is not due to changes in export specializations but rather to the tremendous increase in imports; this is reflected above all in the medium and low price segments where emerging markets have been catching up in research-intensive goods. The R&D intensity of German exports did not change during the observation period, nor did they when compared to overall world trade or when compared to the exports of the OECD countries. Increases vis-à-vis Japan, but also the US were counterbalanced by decreases vis-à-vis the EU-14 and EU-10.

Since the end of the 1990s, a decline in the R&D intensity of German exports in comparison to other euro countries is countered by an increase in comparison to other OECD countries. In the former case, the sale of more price-sensitive non-research- intensive goods may well have been spurred on by the negligible cost and price increase in Germany, in the latter case however it may have been dampened by the upvaluation of the euro.

The most important prerequisite for comparative advantages with research-intensive goods is being well equipped with R&D and human capital. In addition, however, the economic size and the geographic location of a country play a decisive role. Thus, large countries that produce research-intensive goods have advantages because the average cost—due to high fixed costs for research and development and manufacturing plants—drops the higher the quantity of pieces produced is. This shows even more favorably in the books for high end technology than for cutting edge technology. The reason for this may well be overall higher fixed production costs for cutting edge technology due to the use of high end technologies.

Figure

International trade specialization for research-intensive goods in Germany



Source: Calculations of the DIW Berlin. **DIW** Berlin 2010

By all indications, Germany's export specialization with research-intensive goods has declined since the mid 1990s, the reason not being a weakness in the economy, but rather the increase in imports..

Furthermore, countries experiencing the same conditions, such as the European OECD countries—which are located in close proximity to the most important export markets—the share of high end technology—which has higher transportation costs—turns out to be comparably large. In contrast, the share of cutting edge technology—which has lower transportation costs—tends to be less for countries such as OECD countries overseas, which are considerably further removed from the export markets.

So with the same factor conditions, large countries or those located closer to the export markets have advantages with high end technology compared to cutting edge technology. Therefore, more emphasis should be placed on a country's position with regard to research-intensive versus non-research-intensive goods and less on the differentiation between cutting edge technology and high end technology when evaluating a country's export position. Accordingly, the relatively weak specialization of German exports on cutting edge technology is the backside of high specialization in high end technology in view of the size of the German economy—in comparison for instance with Switzerland or Finland—and due to the nearby location of the sales markets—in comparison for instance with the US or Japan.

Outlook: Crisis forces export economy to produce innovations

After the financial market crisis had its impact on the real economy, German exports collapsed dramatically in 2009. Especially impacted were automotive engineering and mechanical engineering, two core areas of the German export economy. In order to revitalize exports with a weakening of global demand, it becomes more important to strengthen the innovative capabilities of German companies. This includes giving a higher priority to research and development as well as to higher expenditures for education. The data available on 2007 international trade indicates that the specialization of German exports on research-intensive goods is becoming stronger in comparison to OECD countries outside of the euro zone. In contrast, compared to other providers from the euro zone, the pricing competitiveness of German companies in recent years has continued to increase, such that deliveries that are less research-intensive are also continuing to get a boost.

(First published as "Deutschland im Außenhandel mit forschungsintensiven Waren gut aufgestellt", in: Wochenbericht des DIW Berlin Nr. 9/2010.)

DIW Berlin
Mohrenstraße 58
10117 Berlin

Tel. +49-30-897 89-0
Fax +49-30-897 89-200

ISSN 1860-3343
Translated from the German.