Resource productivity, environmental tax reform and sustainable growth in Europe

Resource Productivity and Economic Performance – An Analysis for Germany

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Work package 1a:

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1 INTRODUCTION

The objective of work package 1A of the petrE project is to investigate if there is any relationship between trends in environmental/resource inputs, resource productivity, environmental quality, economic growth and competitiveness. This paper aims to identify the relationship between resource productivity and economic performance in Germany.

The idea of an existing relation between resource productivity and economic performance is based on the famous Porter hypothesis. In his paper "America's Green Strategy" (1991) M.E. Porter suggested that stricter environmental regulations might have a positive effect on the competitiveness of firms. He claims that regulations are an incentive to innovate and innovation results in more efficient production patterns. For an analysis this can be broken down into two parts: first, regulation leads to innovation, which itself implies higher resource productivity. Second, higher resource productivity fosters competitiveness and hence economic performance. There are many papers trying to support this hypothesis, but there are as many papers trying to contradict this hypothesis. This opposed statement is known as the theory of pollution haven. A rather recent survey on literature concerning the Porter hypothesis can be found in Wagner (2003). He points out that it is rather important to distinguish between firm, industry and country levels when analyzing the Porter hypothesis, since one might find completely different results. He further introduces different regulation instruments that might themselves lead to different outcomes of policy regulations. The result of his analysis is that market-oriented instruments that have high incentive effects (with regard to technology development) may not necessarily lead to lower emissions in the short term, but can achieve higher emission reductions in the long run since they have "more potential to achieve a move towards a more efficient production function". He stresses that the probably most important assumption when analyzing the Porter hypothesis is the one of efficient regulations.

In his literature review Wagner distinguishes between formal models and empirical analyses. Examples for empirical analyses are *Albrecht (1998)*[1], Jaffe et al. (1995), *Mulatu et al. (2001)*, *Murty and Kumar (2003)*, *Porter and van der Linde (1995 b)* and *Romstad (1998)*. Formal models are presented in *Alpay (2001)*, *Lankoski (2000)*, *Mohr (2002)*, *Simpson and Bradford III (1996)*, *Sinclair-Desgagné and Gabel (1993, 1999, 2001)* and *Xepapadeas and de Zeeuw (1999)*. Constantini and Crespi (2007) apply the old gravity model of trade flows in the context of environmental-friendly technologies. Lanoie et al. (2001), Silveira (2000) and Türpitz (2004) on the other hand have conducted empirical analyses as well. The results of the BMBF-project (project of the Federal Ministry of Education and Research) "Improvement of resource productivity as a mean for sustainable development" are presented by Acosta-Fernández and Bringezu (2007).

Jaffe et al. (1995) were among the first economists trying to conduct an empirical analysis of the Porter hypothesis and hence finding evidence against the conventional view that environmental regulation leads to a loss of competitiveness noticeable through declining exports, increasing imports and a long-term movement of domestic

[1] The papers of the authors whose names are printed in *italic* are summarized by Wagner (2003) only and the reader is referred to the paper of Wagner for a detailed analysis.

manufacturing capacity to other countries. The positive effect of environmental regulations is hard to capture quantitatively due to a variety of possibilities of measuring competitiveness. They therefore try to qualitatively answer the question whether net exports in the U.S. have been systematically lower due to relatively stringent regulations. They conclude that some firms will benefit from stringent environmental regulations, on the expense of other firms. This might be due to early mover advantages and closing of inefficient plants. An important implicit assumption in this discussion is that firms do not operate on the production frontier.

The central question of Türpitz (2004) is when and for what reasons environmental product innovations have been successfully diffused in the market and have contributed to cleaner production. To answer this question she conducted six case studies based on expert interviews and company-specific documents on companies operating in the German manufacturing sector. The results show that main drivers for ecological innovation are regulation and newly available technologies. She further mentions that environmental policy has a powerful influence on the speed and direction of technological progress with respect to eco-innovations. In context of the Porter hypothesis, she only investigated the first part, i.e. whether regulations lead to innovations. She did not address the question whether these innovation lead to an overall improvement of competitiveness.

A recent formal approach to the Porter hypothesis is the gravity model applied by Constantini and Crespi (2007). They restrict their attention to a specific type of environmental-friendly technologies rather then testing the effects of regulation on the generic trade flow. The gravity model is a theoretical model for trade between two countries. The volume of trade should be positively related to the product of the countries' GDP and negatively to the trade barriers between the countries. Constantini and Crespi not only discover that national innovative capacity of exporters play a crucial role in affecting their ability to penetrate the international market for energy technologies, but also that the intensity of research activities of countries has a positive and significant effect on their export performance, while regulatory activities and technological capacities of importing countries are not significant.

Rogério Silveira (2000) shortly summarizes the existing literature on the Porter hypothesis as well; but instead of giving a detailed analysis of the different papers he emphasises the different findings. He claims that the analysis of the Porter hypothesis is inconclusive overall. Some authors point to positive relationships between stringent regulations and competitiveness, while others find evidence for negative relations. Some detect strong effects; others only identify low statistical significance of the identified relationships. He suggests that the inconclusiveness is due to several reasons, e.g. the high diversity of tested relationships, the fact that costs incurred by complying with environmental regulations are only a very small fraction of overall production costs, differences in regulations between countries are small, environmental regulations have different impacts on different sectors, products and manufacturing processes, environmental investments tend to follow the state-of-the-art in technological terms even if this is not required, regulation has little influence on location decisions and last but not least, international competitiveness of sectors and countries depends on countless factors so that the effects based on environmental regulations are hard to isolate.

The project of the BMBF (Acosta-Fernández, Bringezu, 2007) investigates whether improvement of resource productivity can be used as a mean for sustainable development. The first part of the project deals with potential improvement capacities of

the German economy and its effects on greenhouse gas emissions (GHG), gross value added (GVA) and employment. They focus their analysis on the twelve sectors, which together directly and indirectly use 75% of total material requirement (TMR) in Germany between 1991 and 2000. These sectors are at the same time the twelve most resource intensive sectors, which generate 29% of GVA, 28% of employment and 62% of production-related GHG emissions. They investigate the effect of a 10% reduction of all inputs in these sectors. This reduction leads to 20% lower TMR of the German economy, has a small positive effect on German GVA and leads to a 15% reduction of GHG emissions. They conclude that it is useful to start reducing inputs in those sectors with highest material requirements and use their interdependencies with other sectors to achieve an even higher decrease of raw material inputs.

The problem at hand whether resource productive sectors perform better than other sectors is similar but not the exact same problem as the one underlying the Porter hypothesis. One could say that it is the second step in the Porter argumentation, since for being resource productive the innovations following (environmental) regulations must already have started to become effective. We therefore do not need to consider time lags in our analysis. Resource productivity as well as economic performance can be quantitatively measured. In contrast to the analyses of the Porter hypothesis, which are often purely qualitative, this problem can be statistically analysed. Acosta-Fernández and Bringezu (2007) discovered that a reduction of inputs in the resource intensive sectors has a small positive effect on Germany's gross value added. The paper at hand aims to quantify this effect of higher resource productivity. After a description of the available data, it starts with a correlation analysis, which quickly shows whether a linear relationship between resource productivity and economic performance exist, before continuing with an econometric time series analysis to establish dependency relations. These analyses are conducted on two different data sets. In the next section physical data on direct material requirement is used and economic performance is measured by exports and profit-turnover ratio. Since this data is available on a rather aggregated level, the analysis in section three is conducted using more disaggregated data. Economic performance is measured by profit rates of the different economic activities and productivity of the inputs from industrial sectors, calculated from monetary input-output tables, is used as a proxy for resource productivity. Section 4 concludes and gives an outlook on future research possibilities.

2 RESOURCE PRODUCTIVITY AND ECONOMIC PERFORMANCE

2.1 DATA

The data needed to do an analysis of resource productivity is data on use of abiotic primary material, gross value added, exports, profits and output value for all sectors. Since there was no data available in the detailed 59 classification, the classification used here is the ISIC Rev. 3 top-level classification (A,B,…,P). Only the manufacturing sector (D) is more disaggregated. In Table 1 the classification of 59 sectors and the corresponding ISIC Rev. 3 top-level classification are displayed. Those sectors for which only part of the data are available are grey (sectors 6, 7, 17 and 59). They were not considered in this analysis. In the remainder of this section the time series data (1994 – 2004) of resource productivity, exports and profit-turnover ratio of the 15

different top-level economic activities and 13 manufacturing sub-sectors will be presented.

Table 1: Classification of ISIC Rev. 3 in 59 sectors corresponding to INFORGE

ISIC Rev. 3	INFORGE 59	
A		**Agriculture, hunting and forestry**
	1	Agriculture, hunting and related service activities
	2	Forestry, logging and related service activities
B	**3**	**Fishing**
C		**Mining and quarrying**
	4	Mining of coal and lignite; extraction of peat
	5	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying
	6	Mining of uranium and thorium ores
	7	Mining of metal ores
	8	Other mining and quarring
D		**Manufacturing**
DA		**Manufacture of food products, beverages and tabacco**
	9	Manufacture of food products and beverages
	10	Manufacture of tobacco products
DB		**Manufacture of textiles and wearing apparel**
	11	Manufacture of textiles
	12	Manufacture of wearing apparel; dressing and dyeing of fur
DC	**13**	**Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footware**
DD	**14**	**Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials**
DE		**Manufacture of paper and paper products; publishing, printing and reproduction of recorded media**
	15	Manufacture of paper and paper products
	16	Publishing, printing and reproduction of recorded media
DF	**17**	**Manufacture of coke, refined petroleum products and nuclear fuel**
DG	**18**	**Manufacture of chemicals and chemical products**
DH	**19**	**Manufacture of rubber and plastics products**
DI	**20**	**Manufacture of other non-metalic mineral products**
DJ		**Manufacture of basic metals and fabricated metal products, except machinery and equipment**
	21	Manufacture of basic metals
	22	Manufacture of fabricated metal products, except machinery and equipment
DK	**23**	**Manufacture of machinery and equipment**
DL		**Manufacture of office, accounting and computing machinery; electrical machinery and apparatus; medical, precision and optical instruments**
	24	Manufacture of office, accounting and computing machinery
	25	Manufacture of electrical machinery and apparatus
	26	Manufacture of radio, television and communication equipment and apparatus
	27	Manufacture of medical, precision and optical instruments, watches and clocks
DM		**Manufacture of transport equipment**
	28	Manufacture of motor vehicles, trailers and semi-trailers
	29	Manufacture of other transport equipment
DN		**Manufacture of furniture; manufacturing n.e.c.; recycling**
	30	Manufacture of furniture; manufacturing n.e.c.
	31	Recycling
E		**Electricity, gas and water supply**
	32	Electricity, gas, steam and hot water supply
	33	Collection, purification and disribution of water
F	**34**	**Construction**
G		**Wholesale and retail trade; repair of motor vehicels, motorcycles and personal and household goods**
	35	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
	36	Wholesale trade and commission trade, except of motor vehicles and motorcycles
	37	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
H	**38**	**Hotels and restaurants**
I		**Transport, storage and communication**
	39	Land transport; transport via pipelines
	40	Water transport
	41	Air transport
	42	Supporting and auxiliary transport activities; activities of travel agencies
	43	Post and telecommunications
J		**Financial intermediation**
	44	Financial intermediation, except insurance and pension funding
	45	Insurance and pension funding, except compulsory social security
	46	Activities auxiliary to financial intermediation
K		**Real estate, renting and business activities**
	47	Real estate activities
	48	Renting of machinery and equipment without operator and of personal and household goods
	49	Computer and related activities
	50	Research and development
	51	Other business activities
L	**52**	**Public administration and defense; compulsory social security**
M	**53**	**Education**
N	**54**	**Health and social work**
O		**Other community, social and personal service activities**
	55	Sewage and refuse disposal, sanitation and similar activities
	56	Activities of membership organizations
	57	Recreational, cultural and sporting activities
	58	Other service activities
P	**59**	**Private households with employed persons**

2.1.1 Resource productivity

Resource productivity (RP) is calculated from data of the German System of integrated Environmental and Economic Accounting (SEEA, UGR in German), which is a satellite system to the SNA. Use of abiotic primary material differentiated according to 69 different economic activities is displayed in Table 4.4 of the German SEEA. Gross value added can be found in Table 2.3 of the SEEA in real terms. The units in which the numbers are displayed are 1000t and billion Euros respectively. Resource productivity is calculated as the ratio of gross value added and direct use of abiotic primary material:

$$\textit{Resource productivity} = \frac{\textit{Gross value added}}{\textit{Use of abiotic primary material}}$$

Hence, resource productivity is measured in billion Euro/1000 t or equivalently million Euros per ton. Table 2 shows the average resource productivity and average resource productivity growth in the 1994- 2004 and 1995- 2004 periods, respectively. The five sectors with highest average resource productivity are those sectors with relatively low total abiotic primary material use. Sector K (Real estate, renting and business activities) uses by far the least with 105000 tons per year on average, while sub-sector DI (Manufacture of non-metallic mineral products), the sector with the lowest resource productivity, uses 358419000 tons per year, which is more than half of what the complete manufacturing sector (D) is using. The highest annual average resource productivity growth is in sector B (Fishing) with 4,63%, closely followed by sectors A (Agriculture, hunting and forestry) and O (Other community, social and personal service activities) with 4.54% and 4.52% respectively. Those sectors ranked last not only have low or no productivity growth, they have on average negative resource productivity growth, so that they are less resource productive in 2004 than they were 10 years before.

Table 2: Average RP 1994-2004 and RP growth 1995-2004

	Resource productivity in million Euro per ton	Absolute Average			Resource productivity growth in %	Average Growth %
1	**K Real estate, renting and business activities**	**4309.510**		1	**B Fishing**	**4.631**
2	**J Financial intermediation**	**133.620**		2	**A Agriculture, hunting and forestry**	**4.544**
3	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**54.053**		3	**O Other community, social and personal service activities**	**4.516**
4	**N Health and social work**	**44.884**		4	**L Public administration and defense; compulsory social security**	**3.923**
5	**M Education**	**39.872**		5	**D Manufacturing**	**3.709**
6	DD Manufacture of wood and of products of wood and cork, except	11.198		6	**H Hotels and restaurants**	**3.199**
7	**H Hotels and restaurants**	**11.186**		7	DD Manufacture of wood and of products of wood and cork, except	2.987
8	DL Manufacture of office, accounting and computing machinery; ele	11.168		8	DI Manufacture of non-metalic mineral products	2.575
9	**I Transport, storage and communication**	**8.937**		9	DN Manufacture of furniture; manufacturing n.e.c.; recycling	2.329
10	DN Manufacture of furniture; manufacturing n.e.c.; recycling	8.604		10	**I Transport, storage and communication**	**2.209**
11	DK Manufacture of machinery and equipment n.e.c.	7.125		11	**E Electricity, gas and water supply**	**1.279**
12	DE Manufacture of paper and paper products; publishing, printing a	5.874		12	DG Manufacture of chemicals and chemical products	0.797
13	DC Manufacture of leather and leather products	5.793		13	DJ Manufacture of basic metals and fabricated metal products, exc	0.593
14	**O Other community, social and personal service activities**	**5.611**		14	**N Health and social work**	**0.276**
15	DM Manufacture of transport equipment	4.148		15	DK Manufacture of machinery and equipment n.e.c.	0.215
16	DB Manufacture of textiles and wearing apparel	3.817		16	DL Manufacture of office, accounting and computing machinery; ele	0.148
17	**L Public administration and defense; compulsory social security**	**3.201**		17	**C Mining and quarrying**	**0.072**
18	DH Manufacture of rubber and plastic products	2.856		18	**M Education**	**-0.071**
19	**A Agriculture, hunting and forestry**	**2.059**		19	**J Financial intermediation**	**-0.096**
20	DA Manufacture of food products, beverages and tabacco	1.858		20	DH Manufacture of rubber and plastic products	-0.136
21	**B Fishing**	**1.114**		21	DM Manufacture of transport equipment	-0.439
22	DG Manufacture of chemicals and chemical products	0.946		22	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**-0.517**
23	**D Manufacturing**	**0.641**		23	DC Manufacture of leather and leather products	-0.991
24	DJ Manufacture of basic metals and fabricated metal products, exc	0.596		24	**F Construction**	**-2.383**
25	**F Construction**	**0.353**		25	**K Real estate, renting and business activities**	**-2.485**
26	**C Mining and quarrying**	**0.283**		26	DB Manufacture of textiles and wearing apparel	-3.555
27	**E Electricity, gas and water supply**	**0.136**		27	DA Manufacture of food products, beverages and tabacco	-4.011
28	DI Manufacture of non-metalic mineral products	0.042		28	DE Manufacture of paper and paper products; publishing, printing a	-6.309

Table 3: Average export ratio 1994-2004 and export ratio growth 1995-2004

	Export ratio	Absolute Average			Export ratio growth in %	Average Growth %
1	**B Fishing**	**76.343%**		1	**E Electricity, gas and water supply**	**26.621**
2	DC Manufacture of leather and leather products	75.286%		2	**J Financial intermediation**	**13.513**
3	DB Manufacture of textiles and wearing apparel	69.825%		3	**O Other community, social and personal service activities**	**9.859**
4	DL Manufacture of office, accounting and computing machinery; ele	60.324%		4	DD Manufacture of wood and of products of wood and cork, except	9.508
5	DG Manufacture of chemicals and chemical products	60.196%		5	DB Manufacture of textiles and wearing apparel	7.549
6	DM Manufacture of transport equipment	58.163%		6	**K Real estate, renting and business activities**	**7.268**
7	DK Manufacture of machinery and equipment n.e.c.	54.859%		7	**C Mining and quarrying**	**7.209**
8	**D Manufacturing**	**45.520%**		8	DC Manufacture of leather and leather products	7.000
9	DH Manufacture of rubber and plastic products	37.991%		9	DL Manufacture of office, accounting and computing machinery; ele	6.788
10	DJ Manufacture of basic metals and fabricated metal products, exc	36.007%		10	DE Manufacture of paper and paper products; publishing, printing	6.620
11	DN Manufacture of furniture; manufacturing n.e.c.; recycling	32.630%		11	DH Manufacture of rubber and plastic products	6.617
12	DE Manufacture of paper and paper products; publishing, printing	26.468%		12	DI Manufacture of non-metalic mineral products	6.181
13	DI Manufacture of non-metalic mineral products	20.713%		13	**L Public administration and defense; compulsory social security**	**6.161**
14	DA Manufacture of food products, beverages and tabacco	18.762%		14	**H Hotels and restaurants**	**5.257**
15	DD Manufacture of wood and of products of wood and cork, except	15.928%		15	DN Manufacture of furniture; manufacturing n.e.c.; recycling	4.802
16	**C Mining and quarrying**	**14.347%**		16	DJ Manufacture of basic metals and fabricated metal products, exc	4.649
17	**I Transport, storage and communication**	**11.545%**		17	**D Manufacturing**	**4.417**
18	**A Agriculture, hunting and forestry**	**10.211%**		18	DA Manufacture of food products, beverages and tabacco	4.140
19	**H Hotels and restaurants**	**5.241%**		19	**I Transport, storage and communication**	**3.770**
20	**J Financial intermediation**	**3.723%**		20	DG Manufacture of chemicals and chemical products	3.616
21	**K Real estate, renting and business activities**	**3.460%**		21	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**3.315**
22	**E Electricity, gas and water supply**	**2.423%**		22	DK Manufacture of machinery and equipment n.e.c.	1.966
23	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**1.664%**		23	**A Agriculture, hunting and forestry**	**1.805**
24	**O Other community, social and personal service activities**	**0.625%**		24	DM Manufacture of transport equipment	0.963
25	**L Public administration and defense; compulsory social security**	**0.318%**		25	**B Fishing**	**-4.671**
26	**F Construction**	**0.053%**		26	**F Construction**	**-6.796**
27	**M Education**	**0.000%**		27	**M Education**	**#DIV/0!**
28	**N Health and social work**	**0.000%**		28	**N Health and social work**	**#DIV/0!**

2.1.2 Exports

The export data used here are nominal exports in billion Euro (current prices) divided by nominal output values (data source: DESTATIS). Time series data for German exports is available from 1991 on, but since the German SEEA only starts in 1994, only data from 1994 onwards will be considered.

Table 3 displays average export ratios and average export ratio growth of the 15 sectors and 13 sub-sectors considered here. Sector B (Fishing) has the highest average export ratio with more than 75%, closely followed by sub-sector DC (M. of leather and leather products). The complete manufacturing sector D has an average export ratio of 45% over the time period 1994-2004. All manufacturing sub-sectors are ranked in the top half according to their export ratios, whereas the service sectors have export ratios less than 10%. Sectors M (Education) and N (Health and social work) do not have any exports at all. This result is not surprising since most services are provided locally. Construction sector F has the lowest average export ratio with 0.05%. Export growth does not seem to depend on average exports during the time period though. Sector DC is 9th in the growth ranking, while construction sector F, which has the lowest average ratio, and fishing sector B, which has the second largest average ratio, have negative average growth rates.

2.1.3 Profit-turnover ratio

Profit-turnover ratio (PTR) is the ratio of profits to output value in real terms, disaggregated at the 59 classification level (data source: DESTATIS). Sector K (Real estate, renting and business activities) has the highest average PTR (35%) with considerable distance to sector O (Other community, social and personal service activities), which is second with 21%. Sector D and most of its sub-sectors have rather low PTR's (only the education sector (M) and the public sector (L) are lower), while they have highest profit-turnover ratio growth (6 out of the 8 highest). Seven (sub-)sectors have negative average profit-turnover ratio growth, with the education sector M being the most negative with more than -20%.

When looking at these tables one cannot observe any pattern or relationship between absolute resource productivity and economic performance. Some of the sectors that have high resource productivity have high exports or profit-turnover ratio, some have medium and some have low export or profit-turnover ratios. The same holds when comparing growth rates of resource productivity with growth rates of export or profit-turnover ratios. Even when comparing resource productivity growth rates with absolute economic performance or economic performance growth rates with absolute resource productivity one cannot identify any possible relation. The pattern suggested in the literature that sectors, which are more exposed to international competition, are more competitive, cannot be found here either.

Table 4: Average PTR 1994-2004 and PTR growth 1995-2004

	Profit-turnover ratio in %	Absolute Average			Profit-turnover ratio growth in %	Average Growth %
1	**K Real estate, renting and business activities**	**35.295%**		1	DK Manufacture of machinery and equipment n.e.c.	19.516
2	**O Other community, social and personal service activities**	**21.334%**		2	DG Manufacture of chemicals and chemical products	15.138
3	**B Fishing**	**19.530%**		3	DJ Manufacture of basic metals and fabricated metal products, exc	13.820
4	**N Health and social work**	**16.731%**		4	DC Manufacture of leather and leather products	13.035
5	**A Agriculture, hunting and forestry**	**16.659%**		5	**I Transport, storage and communication**	**11.144**
6	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**13.320%**		6	**B Fishing**	**9.421**
7	**J Financial intermediation**	**12.631%**		7	DE Manufacture of paper and paper products; publishing, printing	8.352
8	**E Electricity, gas and water supply**	**12.609%**		8	DB Manufacture of textiles and wearing apparel	7.235
9	**F Construction**	**11.278%**		9	**H Hotels and restaurants**	**6.240**
10	**H Hotels and restaurants**	**8.998%**		10	**D Manufacturing**	**5.621**
11	DD Manufacture of wood and of products of wood and cork, except	7.123%		11	**A Agriculture, hunting and forestry**	**3.851**
12	DE Manufacture of paper and paper products; publishing, printing	7.084%		12	DL Manufacture of office, accounting and computing machinery; ele	3.449
13	**I Transport, storage and communication**	**6.824%**		13	**J Financial intermediation**	**1.994**
14	**C Mining and quarrying**	**6.465%**		14	**G Wholesale and retail trade; repair of motor vehicels, motorcyc**	**1.967**
15	DH Manufacture of rubber and plastic products	6.331%		15	DM Manufacture of transport equipment	1.908
16	DA Manufacture of food products, beverages and tabacco	5.077%		16	DH Manufacture of rubber and plastic products	1.635
17	DI Manufacture of non-metalic mineral products	5.015%		17	DD Manufacture of wood and of products of wood and cork, except	1.154
18	DG Manufacture of chemicals and chemical products	4.848%		18	**N Health and social work**	**0.800**
19	DK Manufacture of machinery and equipment n.e.c.	3.724%		19	**F Construction**	**0.483**
20	DJ Manufacture of basic metals and fabricated metal products, exc	3.708%		20	DA Manufacture of food products, beverages and tabacco	-0.474
21	**D Manufacturing**	**3.622%**		21	**O Other community, social and personal service activities**	**-0.935**
22	DN Manufacture of furniture; manufacturing n.e.c.; recycling	2.543%		22	**E Electricity, gas and water supply**	**-1.341**
23	DL Manufacture of office, accounting and computing machinery; ele	2.529%		23	**K Real estate, renting and business activities**	**-1.693**
24	DC Manufacture of leather and leather products	2.413%		24	**C Mining and quarrying**	**-2.856**
25	DB Manufacture of textiles and wearing apparel	1.953%		25	DI Manufacture of non-metalic mineral products	-4.339
26	DM Manufacture of transport equipment	0.594%		26	**M Education**	**-21.870**
27	**M Education**	**0.454%**		27	DN Manufacture of furniture; manufacturing n.e.c.; recycling	#ZAHL!
28	**L Public administration and defense; compulsory social security**	**0.001%**		28	**L Public administration and defense; compulsory social security**	**#DIV/0!**

2.2 RESULTS

In the following we use correlation and regression analysis to find out about a possible connexion between resource productivity and economic performance.

Table 5 shows the unconditional correlation of resource productivity (rp) and profit-turnover ratio (ptr, middle column) and of resource productivity and export ratio (er, right column), respectively. The bold numbers represent “high” or “strong” correlation, i.e. a correlation coefficient of absolute value greater than or equal to 0.5. At first, the correlation coefficients were calculated for each sector separately. Six sectors (H, D, A, I, J, K) and two subsectors (DM and DN) show strong positive correlation between resource productivity and profit turn-over ratio, while sector O and F and subsectors DB, DC and DI exhibit strong negative correlation. For sectors G, M and N and subsectors DA and DL the correlation coefficient is not significant. From this sectoral analysis we can not conclude that there is any specific relation between resource productivity and profit-turnover ratio.

Calculating the correlation coefficient using all sectors leaves us with a strong and significant positive correlation, which is mainly induced by the subsectors of the manufacturing sector D, for which the correlation coefficient is 0.698 (using only the subsectors for the calculation). The aggregated sector D shows a significant positive

correlation of 0.789. When calculating the correlation coefficient only considering the top-level sectors, i.e. discarding the subsectors of D, we get a correlation coefficient that is negative and significant, but very small (-0.044).

Table 5: Unconditional correlations[2] of resource productivity and export ratio/profit turnover ratio

Sector	CORR(rp,ptr)	CORR(rp,er)
A Agriculture, hunting and forestry	**0.658** ***	0.479 ***
B Fishing	0.404 ***	**-0.621** ***
C Mining and quarrying	0.289 ***	0.073
D Manufacturing	**0.789** ***	**0.956** ***
DA Manufacture of food products, beverages and tabacco	-0.095	**-0.934** ***
DB Manufacture of textiles and wearing apparel	**-0.725** ***	**-0.875** ***
DC Manufacture of leather and leather products	**-0.640** ***	**-0.594** ***
DD Manufacture of wood and of products of wood and cork, except furniture	0.245 ***	0.384 ***
DE Manufacture of paper and paper products; publishing, printing and reproduction	-0.421 ***	**-0.843** ***
DG Manufacture of chemicals and chemical products	0.338 ***	-0.133
DH Manufacture of rubber and plastic products	-0.161 *	-0.077
DI Manufacture of non-metalic mineral products	**-0.536** ***	**0.796** ***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	0.449 ***	**0.628** ***
DK Manufacture of machinery and equipment n.e.c.	0.393 ***	**0.518** ***
DL Manufacture of office, accounting and computing machinery; electrical machinei	-0.009	-0.091
DM Manufacture of transport equipment	**0.753** ***	0.173 *
DN Manufacture of furniture; manufacturing n.e.c.; recycling	**0.787** ***	**0.574** ***
E Electricity, gas and water supply	0.303 ***	**-0.671** ***
F Construction	**-0.569** ***	0.066
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	-0.127	0.267 ***
H Hotels and restaurants	**0.831** ***	**0.886** ***
I Transport, storage and communication	**0.647** ***	**0.640** ***
J Financial intermediation	**0.641** ***	-0.138
K Real estate, renting and business activities	**0.503** ***	-0.457 ***
L Public administration and defense; compulsory social security		0.389 ***
M Education	-0.048	
N Health and social work	0.141	
O Other community, social and personal service activities	**-0.728** ***	**0.805** ***
All	**0.655** ***	-0.198 ***
Top-Level	-0.044 ***	0.039 ***
Subsectors of D	**0.698** ***	-0.138 ***

*Significance: * 10%, ** 5%, *** 1%*

The correlation coefficients between resource productivity and the second measure of economic performance, the export ratio, are considerably different from those above. While sectors D, H and I and subsector DN again have high positive correlation coefficients, sector O and subsector DI, both having strongly negative correlated resource productivity and profit-turnover ratios, have high positive correlations between the resource productivity and export ratio, as do subsectors DJ and DK. A strong negative correlation can be found in sectors E and B and subsectors DA, DB, DE and DC. The correlation coefficient is not significant for sectors C, J and F, as well as for subsectors DG, DH, and DL. Though the group measures for all, only the top-level sectors, and only the subsectors of D, are significant, they are rather low with -0.198, 0.039 and -0.138, respectively. Again, total correlation seems to be driven by the manufacturing subsectors, though this time, the aggregate sector D shows a strong positive correlation, while the correlation coefficient calculated using its subsectors is negative.

Calculating correlation coefficients directly from the data as is done for Table 5 disregards that the correlation could be influenced by third variables, e.g. the size of the sector. It can be influenced in both ways, either inducing correlation where there is none or not showing the correlation if there is some. We therefore also calculated conditional correlations, where the size of the sector, measured by its real output value, and sector

[2] The correlations calculated here are sample correlations only and might not be the true correlations. Since the available data series are very short, the true correlation values might deviate from the sample correlation values to some extend.

specific fixed effects are used as control variables. For that we regressed the logarithm of resource productivity, profit-turnover ratio and export ratio on the logarithm of output values using fixed effects regression analysis for this panel of sectors (including both, the toplevel, as well as the subsectors). The correlation coefficients were then calculated using the residual from the regressions. These residuals can be interpreted as resource productivity, profit-turnover ratio and export ratio corrected for the sector size (total output) and sector fixed effects. The conditional correlation coefficients are displayed in Table 6. The correlation coefficients for sectors H, D, I, J, A and E and subsector DM are strongly positive; those for sector O and subsectors DI and DC are strongly negative; and those of sectors N and M, as well as those of subsectors DL and DD are insignificant. These results are similar to those of the unconditional correlation analysis. The group measures though show lower correlations for all sectors and for the subsectors of D, while the top-level sectors in total show a significant positive conditional correlation (0.247) between profit-turnover ratio and resource productivity.

Table 6: **Conditional correlations of resource productivity and export ratio/profit turnover ratio based on residuals from fixed effects regression regarding all sectors and subsectors**

Sector	CORR(rp,ptr)	CORR(rp,er)
A Agriculture, hunting and forestry	**0.609** ***	0.400 ***
B Fishing	0.476 ***	-0.320 ***
C Mining and quarrying	0.300 ***	0.246 ***
D Manufacturing	**0.769** ***	**0.936** ***
DA Manufacture of food products, beverages and tabacco	-0.321 ***	**-0.939** ***
DB Manufacture of textiles and wearing apparel	-0.475 ***	**-0.838** ***
DC Manufacture of leather and leather products	**-0.652** ***	**-0.615** ***
DD Manufacture of wood and of products of wood and cork, except furniture	0.111	0.422 ***
DE Manufacture of paper and paper products; publishing, printing and reproduction	-0.472 ***	**-0.870** ***
DG Manufacture of chemicals and chemical products	0.344 ***	-0.206 ***
DH Manufacture of rubber and plastic products	-0.180 *	-0.010
DI Manufacture of non-metalic mineral products	**-0.558** ***	**0.754** ***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	0.393 ***	**-0.559** ***
DK Manufacture of machinery and equipment n.e.c.	0.380 ***	0.480 ***
DL Manufacture of office, accounting and computing machinery; electrical machinei	-0.097	-0.056
DM Manufacture of transport equipment	**0.568** ***	0.249 ***
DN Manufacture of furniture; manufacturing n.e.c.; recycling	0.481 ***	**0.561** ***
E Electricity, gas and water supply	**0.608** ***	-0.365 ***
F Construction	-0.382 ***	0.064
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	-0.186 **	0.157 *
H Hotels and restaurants	**0.780** ***	**0.912** ***
I Transport, storage and communication	**0.732** ***	**0.573** ***
J Financial intermediation	**0.627** ***	-0.194 **
K Real estate, renting and business activities	**0.501** ***	-0.457 ***
L Public administration and defense; compulsory social security		0.305 ***
M Education	0.006	
N Health and social work	0.116	
O Other community, social and personal service activities	**-0.794** ***	**0.832** ***
All	0.017 ***	0.022 ***
Top-Level	0.247 ***	0.133 ***
Subsectors of D	-0.162 ***	-0.240 ***

*Significance: * 10%, ** 5%, *** 1%*

The conditional correlation coefficients between resource productivity and export ratio at the sectoral level are again similar to the unconditional correlation coefficients. While the correlation coefficient for all sectors is again lower than before, the correlation coefficients for the top-sectors only (0.133), and the subsectors of D (-0.240) only are stronger, but still not “strong”.

Table 7 shows the conditional correlation results based on regression analysis on subsets of the total panel. For the upper part, the panel regression only considered the top-level sectors, while for the lower part only the subsectors were included in the regression. This segregation for the regression does not change the qualitative results for the correlation coefficients between resource productivity and profit-turnover ratio to a great extent. The only sector where there is a substantial difference is sector G and

subsector DJ. The same holds for the correlation coefficients between resource productivity and export ratio, where again subsector DJ is the only sector with a different result. The total correlation coefficients in Table 7 including all toplevel sectors or all subsectors do not differ from those in Table 6, either. From this we can conclude that the correlation coefficients are robust, though eventually we can not conclude that there is a distinct relation between resource productivity and either of profit-turnover ratio or export ratio at the sectoral level.

Table 7: **Conditional correlations of resource productivity and export ratio/profit turnover ratio based on residuals from fixed effects regression regarding only top-level sectors or subsectors, respectively**

Top-level sector	CORR(rp,ptr)		CORR(rp,er)	
A Agriculture, hunting and forestry	**0.673**	***	0.427	***
B Fishing	-0.018		-0.465	***
C Mining and quarrying	0.195	**	0.026	
D Manufacturing	**0.806**	***	**0.939**	***
E Electricity, gas and water supply	**0.646**	***	-0.335	***
F Construction	**-0.840**	***	0.017	
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	**0.519**	***	0.242	***
H Hotels and restaurants	**0.816**	***	**0.924**	***
I Transport, storage and communication	**0.785**	***	**0.652**	***
J Financial intermediation	**0.591**	***	-0.021	
K Real estate, renting and business activities	**0.539**	***	**-0.517**	***
L Public administration and defense; compulsory social security		***	0.312	***
M Education	-0.031			
N Health and social work	0.125			
O Other community, social and personal service activities	-0.337	***	**0.558**	***
Top-Level - total	0.218	***	0.120	***
Subsector of D	**CORR(rp,ptr)**		**CORR(rp,er)**	
DA Manufacture of food products, beverages and tabacco	-0.466	***	**-0.923**	***
DB Manufacture of textiles and wearing apparel	-0.483	***	**-0.825**	***
DC Manufacture of leather and leather products	**-0.673**	***	**-0.642**	***
DD Manufacture of wood and of products of wood and cork, except furniture	0.005		0.384	***
DE Manufacture of paper and paper products; publishing, printing and reproduction	-0.457	***	**-0.880**	***
DG Manufacture of chemicals and chemical products	0.248	***	-0.306	***
DH Manufacture of rubber and plastic products	-0.149		-0.041	
DI Manufacture of non-metalic mineral products	**-0.540**	***	**0.714**	***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	**-0.699**	***	0.402	***
DK Manufacture of machinery and equipment n.e.c.	0.290	***	0.366	***
DL Manufacture of office, accounting and computing machinery; electrical machinei	-0.002		-0.319	***
DM Manufacture of transport equipment	**0.590**	***	0.218	**
DN Manufacture of furniture; manufacturing n.e.c.; recycling	0.437	***	**0.531**	***
Subsectors of D - total	-0.184	***	-0.256	***

*Significance: * 10%, ** 5%, *** 1%*

The main question addressed in this paper is whether resource productivity influences economic performance. Additional to the correlation analysis above, we use panel regression, where resource productivity is the independent variable and export or profit-turnover ratio are the dependent variables. The regression equations used here are a simple pooled regression:

$$y_{it} = \alpha + \beta x_{it} + \varepsilon_{it},$$

and a fixed effect regression:

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it},$$

where y_i is either export or profit-turnover ratio of sector i and x_i is resource productivity of sector i. The regression results are displayed in Table 8. We again did three different analyses, the first including all sectors and subsectors in the panel, the second only including the top-level sectors and the third only including subsectors of the manufacturing sector D. The regression results are very different. First of all, including fixed effects improves the fit of the regression substantially. Further, Akaike and Schwarz information criteria also suggest that fixed effect regressions are better. The results of the fixed effects regressions for all sectors and subsectors show that

resource productivity is neither a significant determinant of the profit-turnover ratio nor of the export ratio. The coefficient of resource productivity in the fixed effects regression for profit-turnover ratio for the top-level sectors though is positive and significant at the one percent level. Further, the coefficients of resource productivity in both profit-turnover ratio and export ratio estimations considering the manufacturing subsectors only are negative and significant at the one percent level.

Table 8: Regressions of profit-turnover ratio and export ratio on resource productivity

Dependent variable	Profit-turnover ratio	Profit-turnover ratio	Export ratio	Export ratio
Years	1994 - 2004	1994 - 2004	1994 - 2004	1994 - 2004
Regression type	simple pooled	fixed effects	simple pooled	fixed effects
Sectors considered	all	all	all	all
Constant	-7.625***	-7.606***	-2.097***	-2.225***
Resource productivity	0.075**	0.062	-0.06	0.037
Adjusted R^2	0.016	0.784	0.002	0.978
Akaike IC	3.233	1.806	4.123	0.400
Schwary IC	3.258	2.168	4.148	0.746
Sectors considered	top-level	top-level	top-level	top-level
Constant	-7.175***	-8.413***	-3.388***	-3.768***
Resource productivity	0.065*	0.698***	-0.006	0.228
Adjusted R^2	0.013	0.887	0.007	0.969
Akaike IC	3.330	1.244	4.232	0.386
Schwary IC	3.370	1.560	4.274	1.127
Sectors considered	subsectors of D	subsectors of D	subsectors of D	subsectors of D
Constant	-7.938***	-7.316***	-1.052***	-0.733***
Resource productivity	-0.098**	-0.738*	0.088***	-0.231**
Adjusted R^2	0.019	0.455	0.052	0.882
Akaike IC	2.658	2.152	1.590	-0.416
Schwary IC	2.700	2.449	1.631	-0.126

*Significance: * 10%, ** 5%, *** 1%*

The results from the different conditional correlation analysis and the regression analysis point to a negative relation between resource productivity and economic performance for the manufacturing subsectors (DA through DN). Though, all correlations, conditional and unconditional, of the aggregated manufacturing sector D are significant and strongly positive. The results using the complete set of sectors and subsectors are too weak for any conclusion. The top-level sector results on the other hand are somewhat stronger and suggest a positive connexion between resource productivity and economic performance.

Combing the descriptive analysis from section 2.1 with the correlation and regression analysis, we cannot conclude that sectors, which are more composed to international competition, i.e. those sectors that have high export ratios, have high resource productivity as well. On the contrary, for the manufacturing sectors, those sectors with the highest export ratios, the relation with resource productivity seems to be negative. This outcome might be due to the fact that only data on direct and not on indirect material use is available for the calculation of resource productivity. The resource (biotic and abiotic material) intensive sectors are sectors A through D. A, B and C only extract the material, but do not process it. It is therefore not easily possible to have productivity gains in these sectors. The manufacturing sector D does not extract the material itself, it uses the material that is extracted by A, B and C. Hence, the direct material use of sector D is rather low, while it has high indirect material use.

Unfortunately, the German SEEA records data on direct material use only. The resource extensive sectors on the other hand use only little (direct or indirect) abiotic material, so its use only represents a very small fraction of total costs. An improvement of resource productivity can only be seen from changes in the indirect material use. Data for indirect material use exists (Acosta-Fernández and Bringezu, 2007), but is not publicly available yet.

3 INPUT COEFFICIENTS AND PROFIT RATE

Since the relationship analysis of the indicators above does not lead to a conclusive outcome, we use other – proxy – data to investigate a possible relation between resource productivity and economic performance, now represented by monetary inputs of industrial sectors and profit rates. Here again, data from INFORGE, originating from data of Germany's national accounts, is used. The advantage of using this data is that to our knowledge the indirect material use is better reflected.

3.1 DATA

The time series data starts in 1991 and lasts until 2004. Data is available for the 59-classification. For comparability reasons, we use the same classification of the 15 sectors and 13 sub-sectors.

3.1.1 Profit rate

Economic performance is now measured by the profit rate. It is calculated from net earnings divided by output value for each of the 28 economic sectors:

$$\textit{Profit rate} = \frac{\textit{Net earnings}}{\textit{Output value}}$$

Net earnings as well as output value are given in billion Euros (in prices of 2000), so that the profit rate is a ratio. The ranking of the sectors according to their average profit rate is similar to the ranking of the profit-turnover ratio, but not exactly the same. Sector K (Real estate, renting and business activities) has the highest profit rate (36%) with considerable distance to sector O (Other community, social and personal service activities), which is ranked second with 21.8%. They are followed by sectors B (Fishing), N (Health and social work) and A (Agriculture, hunting and forestry), which have 18%, 16% and 15.7% respectively. Sector M (0.8%) and sub-sectors DM (Manufacture of transport equipment, 0.9%) and DB (Manufacture of textiles and wearing apparel, 2.2%) have the lowest profit rates. There is no data available for sector L (Public administration and defence; compulsory social security). Some of the manufacturing sub-sectors even have a negative profit rate for one or two years (DL, DM, DN).

3.1.2 Input productivity

Resource productivity is represented by the ratio of gross value added to monetary input coefficients. A more adequate analysis would be possible if physical input-output

tables were used. The input coefficients are calculated from the monetary input-output tables of the Federal Statistical Office. Since we would like to represent resource productivity, we take the input coefficients of the industrial sectors[3] only (first 32 sectors in the 59-classification) and add them up to one coefficient for each of the economic activities. This gives a ratio as well, namely gross value added per Euro input from industrial sectors.

$$\textit{Input productivity} = \frac{\textit{Gross value added}}{\sum(\textit{Input of industrial sectors})}$$

Ranking the sectors from those with highest average input productivity to lowest input productivity does not result in the exact same, but still a similar ranking as the one for resource productivity in section 2. The service sectors, having rather low absolute material inputs, are those with highest input productivity while the manufacturing sectors as well as agriculture (A), fishing (B) and mining and quarrying (C) are mainly found in the lower part of the ranking.

3.2 RESULTS

Again, results of correlation and regression analysis will be presented. The data for profit rate and input productivity are available for a longer time period than the data used in section 2, i.e. from 1991 to 2004. Since statistical results are generally more meaningful we will use this complete time period for the subsequent analysis. For comparability reasons we will also present the results for the time period 1994 to 2004. The conditional correlation results in turn could only be calculated on the 1994 to 2004 basis, since output data (which is needed for the control variable) was not available for the years prior to 1994.

As can be seen from Table 9, the unconditional correlation coefficients are quite robust to time period variations. The only sectors where the sign changed and the coefficients remained significant are DB, F and M. For the remaining sectors the correlation coefficients for the two periods are more or less the same. For sectors I, A, D, N and O input productivity and profit rate are strongly positive correlated, while they are negatively correlated for sectors C, H, and K. The total correlation coefficients are positive and significant when considering all sectors and subsectors as well as when considering only the top-level sectors. They are insignificant for the manufacturing subsectors. The results drastically change when considering the corresponding conditional correlations (Table 10). For the former two the coefficients are negative and very low (-0.057 and -0.076), though still significant, while the coefficient for the manufacturing subsectors is positive (0.179) and significant. This is also true when using the residuals from the regressions only considering the respective subsets (top-level: -0.080, subsectors: 0.299), see Table 11. When looking at the aggregated manufacturing sector D, all calculated correlation coefficients are strongly positive and significant, similar to the results for sector D in section 2.

[3] Resources are mostly used to produce physical capital. Since the service sectors do not produce physical capital as inputs for other sectors, their inputs are not considered in the sum. This sum therefore represents the indirect material use of each sector.

Table 9: Unconditional correlations of profit rate and input productivity

Sector	1994 - 2004 CORR(ip,pr)	1991 - 2004 CORR(ip,pr)
A Agriculture, hunting and forestry	**0.707** ***	**0.718** ***
B Fishing	0.290 ***	0.487 ***
C Mining and quarrying	-0.393 ***	-0.414 ***
D Manufacturing	**0.832** ***	**0.733** ***
DA Manufacture of food products, beverages and tabacco	**0.553** ***	**0.745** ***
DB Manufacture of textiles and wearing apparel	**-0.510** ***	0.196 **
DC Manufacture of leather and leather products	-0.145	0.033
DD Manufacture of wood and of products of wood and cork, except furniture	0.291 ***	0.216 **
DE Manufacture of paper and paper products; publishing, printing and reproduction	0.068	-0.017
DG Manufacture of chemicals and chemical products	**0.892** ***	**0.825** ***
DH Manufacture of rubber and plastic products	0.039	-0.264 ***
DI Manufacture of non-metalic mineral products	**0.773** ***	0.416 ***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	**0.824** ***	**0.819** ***
DK Manufacture of machinery and equipment n.e.c.	**0.514** ***	0.172 *
DL Manufacture of office, accounting and computing machinery; electrical machine	**0.549** ***	0.329 ***
DM Manufacture of transport equipment	0.450 ***	**0.661** ***
DN Manufacture of furniture; manufacturing n.e.c.; recycling	**0.785** ***	**0.785** ***
E Electricity, gas and water supply	0.243 ***	0.109
F Construction	-0.269 ***	0.187 **
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	0.111	0.445 ***
H Hotels and restaurants	-0.382 ***	**-0.519** ***
I Transport, storage and communication	**0.828** ***	**0.872** ***
J Financial intermediation	0.298 ***	0.193 **
K Real estate, renting and business activities	**-0.817** ***	**-0.867** ***
L Public administration and defense; compulsory social security		
M Education	0.168 **	**-0.694** ***
N Health and social work	**0.724** ***	**0.846** ***
O Other community, social and personal service activities	0.419 ***	**0.617** ***
All	0.449 ***	0.454 ***
Top-Level	0.258 ***	0.274 ***
Subsectors of D	0.034	0.010

*Significance: * 10%, ** 5%, *** 1%*

Table 10: Conditional correlations of profit rate and input productivity based on residuals from fixed effects regression regarding all sectors and subsectors (1994 – 2004)

Sector	CORR(ip,pr)
A Agriculture, hunting and forestry	**0.701** ***
B Fishing	**-0.778** ***
C Mining and quarrying	-0.437 ***
D Manufacturing	**0.687** ***
DA Manufacture of food products, beverages and tabacco	**0.518** ***
DB Manufacture of textiles and wearing apparel	**-0.539** ***
DC Manufacture of leather and leather products	-0.348 ***
DD Manufacture of wood and of products of wood and cork, except furniture	0.271 ***
DE Manufacture of paper and paper products; publishing, printing and reproduction	**0.842** ***
DG Manufacture of chemicals and chemical products	**0.919** ***
DH Manufacture of rubber and plastic products	-0.244 ***
DI Manufacture of non-metalic mineral products	**-0.633** ***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	**0.906** ***
DK Manufacture of machinery and equipment n.e.c.	**0.526** ***
DL Manufacture of office, accounting and computing machinery; electrical machine	-0.207 **
DM Manufacture of transport equipment	0.426 ***
DN Manufacture of furniture; manufacturing n.e.c.; recycling	**0.702** ***
E Electricity, gas and water supply	0.222 ***
F Construction	-0.084
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	-0.355 ***
H Hotels and restaurants	**0.647** ***
I Transport, storage and communication	**0.804** ***
J Financial intermediation	0.332 ***
K Real estate, renting and business activities	**-0.814** ***
L Public administration and defense; compulsory social security	**0.776** ***
M Education	0.322 ***
N Health and social work	**0.714** ***
O Other community, social and personal service activities	0.416 ***
All	-0.057 ***
Top-Level	-0.076 ***
Subsectors of D	0.179 ***

*Significance: * 10%, ** 5%, *** 1%*

Table 11: Conditional correlations of resource productivity and export ratio/profit turnover ratio based on residuals from fixed effects regression regarding only top-level sectors or subsectors, respectively (1994 – 2004)

Top-level sector	CORR(ip,pr)	
A Agriculture, hunting and forestry	**0.701**	***
B Fishing	**-0.816**	***
C Mining and quarrying	-0.457	***
D Manufacturing	**0.707**	***
E Electricity, gas and water supply	0.230	***
F Construction	-0.126	
G Wholesale and retail trade; repair of motor vehicels, motorcycles and personal ar	-0.371	***
H Hotels and restaurants	**0.871**	***
I Transport, storage and communication	**0.807**	***
J Financial intermediation	0.271	***
K Real estate, renting and business activities	**-0.814**	***
L Public administration and defense; compulsory social security	**0.773**	***
M Education	0.213	**
N Health and social work	**0.716**	***
O Other community, social and personal service activities	0.064	
Top-Level - total	-0.080	***
Subsector of D	**CORR(ip,pr)**	
DA Manufacture of food products, beverages and tabacco	**0.539**	***
DB Manufacture of textiles and wearing apparel	**-0.506**	***
DC Manufacture of leather and leather products	0.061	
DD Manufacture of wood and of products of wood and cork, except furniture	0.338	***
DE Manufacture of paper and paper products; publishing, printing and reproduction	-0.259	***
DG Manufacture of chemicals and chemical products	**0.886**	***
DH Manufacture of rubber and plastic products	-0.006	
DI Manufacture of non-metalic mineral products	**0.878**	***
DJ Manufacture of basic metals and fabricated metal products, except machinery a	**0.706**	***
DK Manufacture of machinery and equipment n.e.c.	0.450	***
DL Manufacture of office, accounting and computing machinery; electrical machinei	0.493	***
DM Manufacture of transport equipment	0.441	***
DN Manufacture of furniture; manufacturing n.e.c.; recycling	-0.247	***
Subsectors of D - total	0.299	***

*Significance: * 10%, ** 5%, *** 1%*

Table 12: Regression of profit rates on input productivity

Dependent variable	Profit rate	Profit rate
	1994 - 2004	1991 - 2004
Regression type	fixed effects	fixed effects
Sectors considered	all	all
Constant	0.821	-0.761
Input productivity	0.220	0.585***
Adjusted R^2	0.785	0.703
Akaike IC	1.634	1.930
Schwary IC	1.987	2.227
Sectors considered	top-level	top-level
Constant	1.724	0.986
Input productivity	0.104	0.244
Adjusted R^2	0.888	0.834
Akaike IC	0.884	1.204
Schwary IC	1.181	1.456
Sectors considered	subsectors of D	subsectors of D
Constant	-0.250	-2.907**
Input productivity	0.438	1.215***
Adjusted R^2	0.483	0.353
Akaike IC	2.104	2.376
Schwary IC	2.401	2.630

*Significance: * 10%, ** 5%, *** 1%*

The regression analysis conducted here is equivalent to the one in section 2, though we only present the results of the fixed effects regression. The coefficient of input

productivity in the fixed effects regression analysis is not significant in any of the three data sets (complete, top-level only, subsectors only) if only the years between 1994 and 2004 are considered, see Table 12. Additionally including 1991 to 1993 changes the picture: the coefficient of input productivity is positive and significantly different from zero at the one percent level for the regressions including the complete data set and the subsectors. It is insignificant for the top-level sector set though. These results support the results from the conditional correlation analysis on this data set.

The results contradict those from the regression analysis in section 2. This might well be due to the fact that we only consider direct material use in section 2, while in this section we consider indirect material through the proxy input productivity.

4 CONCLUSION

Even though one cannot directly compare the problem at hand to the problem of the Porter hypothesis, similarities are obvious. The problem at hand can be seen as the second step in the Porter hypothesis. Outcomes of analyses of the Porter hypothesis depend on the level (state, industry, firm), the method used and the assumptions taken.

Both the conditional correlation analysis as well as the regression analysis using data on direct material use, profit-turnover ratio and the export ratio point to a significant negative relation between resource productivity and economic performance in the manufacturing subsectors, while the second data set, which better reflects the indirect material use, points to a significant positive relation. The opposite is true when considering the top-level sectors only. There the first data set points to a significant positive relation between economic performance and resource productivity, while the second data set does not reveal meaningful results. These different predictions by the two data sets can be explained by the importance of indirect material use for the manufacturing subsectors. While the indirect material use of these subsectors is high compared to the direct material use, this difference is not that large in the other top-level sectors. To fully capture the real effect on indirect material use physical input-output tables are necessary. Once these are available, preferably for different years, this analysis could be substantially improved.

Even though our results do only partly confirm the Porter hypothesis, they do confirm the results from the literature. As already pointed out by Silveira (2000), there are as many different findings concerning the Porter hypothesis as there are papers on it. The paper at hand is one of many that find some statistically significant relations between economic performance and resource productivity, but, since the relations are as well positive as negative, they are not clearly in favour of the Porter hypothesis.

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