# Innovation and Export Performance

## Adjustment and remaining differences in East and West German manufacturing

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**ABSTRACT:**

Considering the economic situation in Germany, the adjustment process has come to a standstill leaving persistent differences between West and East. This paper refers to this context analyzing the export behavior comparing firms in West and East Germany. Our estimates confirm a strong relationship between innovations and export performance as well as structural differences between East and West German firms. East German firms are less likely to export than firms in the West. Besides, West German medium technology firms are comparable in their export behavior to high tech firms while East German firms are more similar to the low technology sector. Labor productivity is more important in East Germany. We interpret these findings as a specialization of West German firms towards technologically driven high quality markets, whereas East German companies seem to operate more often in less dynamic, price sensitive markets.

**Keywords:** Export, Innovation, Manufacturing firms, Microeconometrics
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# 1 INTRODUCTION

Given the current economic situation in Germany, a central question presently discussed by politicians and economists is how to enhance economic growth. In this context, international competitiveness is mentioned as a crucial aspect, since Germany gets important impulses from international trade. The question is how to boost export performance. Theories about the potential factors which export performance depends on can be distinguished into two main approaches: The first argument stresses the role of comparative advantages resulting from factor endowment. The second approach focuses on innovation activity as a key factor for success on international markets.

To understand economic differences between East and West Germany, the special situation and the development of the last fifteen years have to be considered. After unification in 1990, the convergence process seemed to be a great success. Though starting from a rather low level, the East German economy developed dynamically. In the mid nineties the catching-up process has come to a standstill, leaving a least favorable economic situation: Unemployment is higher, productivity is lower than in West Germany, and East German firms' weak export performance suggest a shortcoming of international competitiveness compared to the West German economy. Therefore the stimulation of growth and development in general as well as specifically the promotion of export activities is even more important in East than in West Germany.

Our paper refers to this context. We analyze how firms' export behavior depends on their innovative attitude, or to put it differently, whether more innovative firms are more likely to export or exhibit higher export shares. We capture innovation activities in different ways: On the one hand innovativeness means participation in the technological progress via research activities and the development of new products and production processes; on the other hand differences exist between more innovative and progressive sectors and more traditional or stagnant ones. The aim of our analysis is to identify how these aspects of firms' innovation behavior influence their export activities.

In particular the differences between East and West Germany are considered in order to examine the reasons for the continuing gap between East and West German companies' export performance. For the empirical study, we use data of German manufacturing in the time from 1993 to 2001 from the Mannheim Innovation Panel (MIP) which are provided by the Center for European Economic Research (ZEW).

The paper is structured as follows: Section 2 illustrates the theoretical framework of the determinants of export activity and briefly overviews the existing literature on innovation and exports. Section 3 develops the economic model and its econometric implementation and presents descriptive statistics of export behavior in East and West Germany. Section 4 presents the results of Probit and Tobit estimations. Section 5 summarizes and concludes.

# 2 CONCEPTUAL FRAMEWORK

Analyzing the impact of innovation activities on export performance at the micro level, a differentiated concept of innovation is essential. A rough distinction can be made between product and process innovations: Process innovations are a way to raise productivity and reduce production costs, while product innovations give the innovator a competitive edge and allow a differentiation strategy. Hence, the company will realize monopoly profits until its competitors catch up by bringing up new products themselves. But, typically product and process innovations are linked to each other, since a newly developed product often requires new production technologies, which in turn may or may not change productivity. A second distinction is made regarding the reference group to which a product innovation is new, i.e. between proper innovation and imitation. Competitive advantages result only from innovations in a strict sense, but developing new products at least enables a firm to keep up with its competitors. Thus, innovations which are new for the market as a whole are expected to have a stronger impact on competitiveness than imitative development activities.

A drawback of the named innovation measures is its lack of information on the technological quality and the economic value of new products or processes. A method to get more detailed information is to include not only variables measuring the innovation output, but also input indicators such as R&D expenditure or R&D employment. Firms investing in research and development are assumed to produce high quality innovation output, although R&D productivity may vary between firms as well as between sectors.

In context of export activities, attention is paid particularly to product innovations: Starting with Posner's (1961) technological gap theories and product lifecycle models by Vernon (1966), the neo-technology-approach points out innovations as the main reason for international trade. As innovations diffuse more rapidly within the economy than internationally firms are able to hold their competitive advantage rather in foreign trade than on national markets. Therefore, innovators tend to be engaged internationally in order to exploit the innovation profits. The lifecycle concept cannot only be applied to products, but also to product groups and especially to industrial sectors. From this results the industry lifecycle illustrates the development of sectors over stages of rise, maturity and decline that industries pass through. Product innovations combined with strong efforts in R&D are of major importance in young and rising industries (see Cassiman and Martinez-Ros 2004), whereas process innovations and productivity gain weight in later stages with dominant price competition. Industrialized countries with high wages and a skilled labor force have competitive advantages rather in emerging industries than in mature sectors' price competition. This means, in turn, that product innovations and R&D are more important in developed countries, or to put it more generally, in regions which are specialized in high technology sectors, whereas productivity and process innovations prevail in less developed regions.

Innovation activities can affect firms' export performance both in a positive and negative way since innovation efforts produce financial constrains that may lead to a trade-off between innovation and export activities (see Roper and Love, 2001). Which effect prevails depends on the level of R&D conducted and the company's financial resources. Furthermore, it is assumed that innovations have a long-term impact on export performance because of learning-by-innovating effects. Innovating companies generate and accumulate knowledge and increase their capabilities, both regarding their innovative assets and their human capital. Wakelin (1997) states: "Innovation is considered as a characteristic which fundamentally changes the firm and its performance, including the firm's export performance."

For the analysis of East and West Germany the effect of geographical factors on export success should hold for an explanation as well. Firstly, a firm's location determines its transportation costs, so that companies located near to the main foreign markets or in regions with developed railway and road network are more likely to export (see Ebling and Janz 1999). Secondly, location counts for regional spillovers which foster knowledge and technology diffusion as well as export activities. Knowledge spilling over from neighboring companies increases a firm's capabilities to innovate so that firms which are part of regional innovation clusters are expected to be more competitive. Exports of clustered firms might be enhanced by greater innovation efforts due to technology spillovers, but on the other hand by network and branding effects. Acting in an export oriented geographical area allows a firm to get in touch with foreign trade partners easily, for example through regional cooperation partners or local trade fairs. Consequently, East German firms seem to have disadvantages in entering international markets.

In addition, East German companies tend to be smaller, younger, less productive, and specialized in different branches than West German firms, which might explain their weak export performance as well. Firm size is regarded as one of the main factors regarding export activities (see Lefebvre and Lefebvre 2001), since larger companies have easier access both to internal and external financial resources as well as adequate organizational capacities required for international success. Economies of scale influencing export costs in favor of larger companies play an important role as well.

Several studies take into account firm age as a determinant of export performance assuming a gradual expansion of a company's activities (see Johanson and Vahlne 1990). A related argument refers to the existence of sunk costs which constrain the entry in foreign markets, and therefore explain why firms that were engaged in international markets in the past exhibit a higher export probability (see Bernard and Jensen 2001). Summing up the probabilities to enter international markets, the over all probability increases with firm age.

Regarding firms' competitiveness, productivity seems to be crucial for export success. As exporting implicates additional costs such as sunk costs for the market entry, extra transport and transaction costs etc, a firm will be the more likely to

come up with these costs, the higher its productivity and thus the lower its production costs are. The relationship between productivity and exports has been shown by a range of empirical studies. (For an overview see Arnold and Hussinger (2004).)

Substantial studies to the relationship between export and innovation have been published in recent years. One of the first contributions stems from Hirsch and Bijaoui (1985) who observed that the intensity of research and development positively influences changes in export performance, using data of 111 R&D conducting companies in Israel. Following studies mainly supported their findings of a positive relationship between export and innovation, for example Brouwer and Kleinknecht (1993) for the Netherlands, Zhao and Li (1997) for China, and Gourlay and Seaton (2004) for Great Britain. In addition, Brouwer and Kleinknecht (1993) emphasizes that product innovation, in contrast to process innovation is relevant for trade performance. Schlegelmilch and Crook (1988), and Landesmann and Pfaffermayr (1997) do not report positive results regarding the relationship of R&D and export performance. Wakelin (1998), and Verspagen and Wakelin (1997) even find negative effects of research and development activities on export behavior in certain sectors, such as small enterprizes and some high technology sectors.

Considering these seemingly contradictory results it is argued that indicators such as R&D expenditure, which was used as measure in most studies, do not capture innovation efforts properly. Thus, several authors started using more sophisticated innovation variables. Lefebvre and Bourgault (1998) do not report positive effects of R&D intensity on export activities while some other indicators like the share of scientific employees or external R&D cooperation proved to be significant. Bernard and Jensen (2004) analyzed 13,550 US-American firms and found that larger and more productive companies exhibit a higher probability of exporting and that the introduction of a new product increases export performance. Furthermore, Castellani and Zanfei (2004) state differences between exporters and non-exporters regarding productivity as well as R&D intensity and innovation performance.

Export and innovation in Germany have been discussed in several studies. Arnold and Hussinger (2004) focus on the influence of productivity, but R&D expenditure and the market share of new products as well. They find a positive relationship between exports and innovation activity. Roper and Love (2001), comparing German and British firms, report a strong positive impact of product innovations both on the probability to export and export shares, but a negative relationship between R&D intensity and the probability to export for the sample of German firms. Lachenmaier and Wößmann (2004) analyze the effects of promoting or impeding export activities using data of 981 companies in 2002. Their results support the hypothesis that larger and more innovative firms tend to export more.

However, although these studies took into account the structural differences between East and West Germany, mostly via dummy variables, none of them focused on the question why East German firms perform worse regarding their export activities than West German companies.

# 3 DATA AND EMPIRICAL SPECIFICATION

## 3.1 Empirical model and variables

Testing the effect of innovation activities on export success we use a common empirical model that defines the export behavior of a firm $i$ as a function of its innovation activity $Inno$, a vector of firm characteristics $Char$, and its location in Germany $East$:

$$Export_i = f(Inno_i, Char_i, East_i)$$

Several measures of export activity have been tested in empirical studies. Our investigation uses two different variables: First we implement a dummy variable that equals one if a firm exported in the observed period, to get an idea about what determines the probability of exporting. Second, we use export intensity, which is measured as the ratio of exports to the total revenue, in order to test the robustness of our results and getting differentiated insights to the firms' export behavior. We used Probit and Tobit estimations respectively.

As we are focusing on the role of innovation efforts we include indicators measuring both input and output of the innovation process that are assumed to perform differently. According to the OSLO-Manual (see OECD and Eurostat 1997) a firm is defined as innovating if it is implementing technologically new products and processes and significant technological improvements in products and processes. Products do not have to be novelties on the market, which means imitative development activities are included in this classification of innovation, too. We use the dummy variables $InProd$ and $InProc$ to indicate if a firm implemented new or improved products or processes respectively during the last three years. Product innovations are expected to have a stronger influence on export than process innovations.

Regarding differences between East and West Germany, process innovation should have stronger impact in East Germany, where productivity is rather low. Our assumption is that firms in West Germany operate mainly in high-technology-sectors and provide technologically developed products, while East German firms more often serve low quality markets with fierce price competition. Thus, higher coefficients of product innovations are predicted for the West than for the East German sample and vice versa for process innovations.

In addition, we include the variable $R\&D$ measuring intensity of research and development activities, given as the ratio of R&D expenditures on total sales, and a squared term $R\&D^2$ to allow for a nonlinear relationship between export and R&D. We expect innovativeness measured by these indicators being positively correlated with both export probability and export intensity. As competition on international markets increases and product life cycles become shorter, the impact of innovations on exports should rise over the observed period.

According to theories on firm performance and international trade, several variables controlling the companies' main characteristics are included. Controlling for firm

size, we classified small *(size-s)*, medium *(size-m)* and large *(size-l)* companies, which have less than 50, from 50 to 249, and 250 and more employees respectively. Firm size is expected to have a positive impact on export success, especially in East Germany, where small firms might face even larger difficulties entering foreign markets, being less linked to international networks and having less trade experience.

Controlling for differences in productivity, we include a variable of labor productivity ($LP$) in relation to the average in industry and year. We expect a positive effect of productivity on exports, especially in the East German sample, as low productivity and high unit labor costs are said to be one of East Germany's main weaknesses regarding international competitiveness.

As both innovation and export behavior varies between sectors, dummy variables controlling for the sector are included. In order to test the hypothesis that German industry has comparative advantages in high-technology industries, we use a technology-based classification which refers to the OECD industry ranking according to sector average R&D expenditures between 1991 and 1999 (see OECD 2003, and Hatzichronoglou 1997). Higher ranked industries exhibit higher R&D expenditures per value added and R&D expenditures per production. We divided industries into three technology classes: The high technology sector *(high tech)* contains branches like chemical and pharmaceutical industry, automotive and aeronautical engineering, electronics, and communications engineering. In the medium technology class *(medium tech)* metal, plastic and glass industries are included. Finally, food, beverages, tobacco, textiles, wood and paper industries are classified as low technology branches *(low tech)*; medium technology firms were used as the reference value. For a detailed description of the technology classification see Appendix, table A.1.

We present estimations both for the whole sample and for East and West Germany separately, analyzing the period from 1993 to 2001. Within the convergence process after reunification the differences between East and West Germany are assumed to decrease, i.e. both the coefficient of the dummy variable East, indicating if a company is located in the Eastern or Western part of Germany, and the differences between the separate estimations for East and West Germany should be smaller in 2001 than in the previous years.

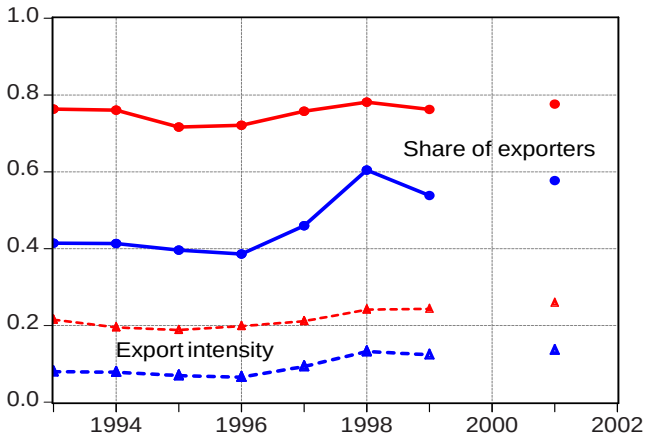
Regarding the causality between innovations and exporting, both directions have been discussed by economic theory: One might argue that experience in foreign trade enables a company to conduct more research and development and to draw greater benefits from it, as well. Moreover, firms increase their innovation efforts in order to enter foreign markets, or that only excellent companies in terms of innovativeness and technological level have the ability to succeed in international trade. Focusing on innovation output during a certain period before the observed year, our analysis implies that the latter named direction of causality is the more plausible one. The question, if the innovation or the export decision comes first, i.e. if a firm innovates with foreign markets in mind or if it decides to export after a successful innovation project, cannot be resolved nor is it substantial for our analysis.

### 3.2 Descriptive statistics

Our analysis uses micro data from a representative survey of the German manufacturing sector provided by the Mannheim Innovation Panel (MIP). The MIP is a yearly survey which focuses on firms' innovation behavior according to the OECD recommendations published in the OSLO-Manual (see Janz, Ebling, Gottschalk, and Peters 2002). The data set used in this paper covers about 7,400 firms for a period of 9 years, 1993-2001, which means that the data correspond to the years 1992-2000. For the analysis data of about 5,100 manufacturing firms in West and about 2,300 firms in East Germany are used. Firms in East and West Berlin are excluded.

As figure 1 indicates, the share of exporting firms in West Germany remains roughly constant over time. In contrast, East German companies' export behavior has changed: Over the observed period the share of exporters rose from 40 to 60 percent, leaving tough a gap to West German firms' export activities of which export amounts to nearly 80 percent. Export intensity depicts a similar picture although the difference between East and West is smaller. East German firms' average export intensity amounts to about 10 percent in 1993 and rises over the observed period, especially since 1996 while firms in West Germany export about 20 percent on average. Thus, some adjustment is visible, but the difference still persists.

Figure 1: Export behavior of firms in East and West Germany



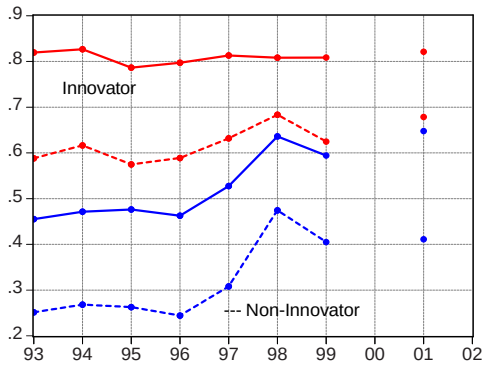

*Red line: West German firms* *Data for 2000 are not available*
*Blue line: East German firms* *Source: MIP*

For a more detailed picture export behavior of innovators and non-innovators is shown in the left panel of figure 2. Structures are similar in both parts of Germany: Innovators are more orientated towards foreign markets than non-innovators, though relative participation of the latter in exporting has been rising since 1997. Easy visible as well are the differences between East and West German firms. Firms in East Germany and non-innovating firms seem to have difficulties in entering

international markets, but they have been making up the leeway during the last decade.

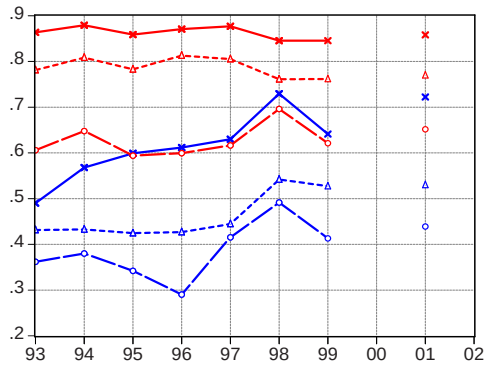
Figure 2: Innovativeness and export behavior

Innovator vs. Non-Innovator




*Red Line: West German firms*
*Blue Line: East German firms*
*Source: MIP*

Technology classes




*High, medium and low technology sectors*
*Data for 2000 are not available*

Industry structure in East and West differs as well, as West Germany is dominated by firms operating in high tech branches whereas East Germany is characterized by a more or less equal distribution of the branches regarding their technological level (see table A.2 in the Appendix). Considering the hypotheses that larger firms and firms operating in high tech sectors are more likely to export, the described differences of East and West German industry structure should explain at least partly eastern companies' backlog regarding their export activities. As the right panel of figure 2 shows, firms in high technology sectors are more often engaged in foreign markets than medium or low technology industries. Visible is the strong international orientation of high and medium technology sectors of western firms as well as the increasing export behavior of high technology firms in the East: In 1993 just 50 percent of these firms exported, whereas in 2001 more than 70 percent did so. This supports our hypothesis regarding export advantages of the German high tech industry.

Finally, table A.2 summarizes some further characteristics of firms in East and West Germany. Labor productivity is higher in West than in East German firms. Obviously, there is an upward motion in both parts of Germany, as well as an adjustment between East and West. But as the convergence process faded out in the mid nineties, the productivity gap persists. Besides, firms in the West are larger: More than 25 percent of the western firms employ 250 and more people, whereas in East Germany large firms amounts only to 9 percent.

# 4 EMPIRICAL RESULTS

This section presents econometric evidence on export behavior in German manufacturing with special regard to the development of East and West German firms. Our approach proceeds in three steps. At first, we use a Probit model of the decision to export analyzing the determinants of export behavior in Germany. Second, for a deeper insight of differences within exporting firms we use a Tobit model for export intensity. In a third step, we separate our sample into two sub samples, East and West. So we focus on the question why East German firms perform worse. We test our results on the differences between East and West Germany using the Wald-Test.

Having a first look on the coefficients of the Probit estimation at table 1, coefficients indicating product or process innovations show an interesting picture. As expected, innovation measured as product innovation has a significant impact on the probability to export which indicates that firms with new or improved products are more able to succeed in the international competition. The impact of process innovations is negative but not significant. R&D expenditures have a significantly positive effect on export probability which points out the comparative advantage of technologically developed firms. $R\&D^2$ has the expected negative sign and is strongly significant as well. The variable of firm size confirms the hypothesis that a minimum size is required to enter foreign markets. Also, labor productivity increases the export probability. Firms operating in the low tech sector exhibit a lower probability to export than medium tech firms while firms in the high-tech sector are more likely to export. For a detailed picture of the development see table A.3 in the Appendix.

Noticeable are the strong negative but decreasing coefficients for East Germany over the observation period, indicating that firms in East Germany are less likely to export than firms in the West. These structural differences were expected as well as the decreasing effect of being located in East Germany. But, in the year 2001 firms in the East still seem to have problems keeping up with western firms. From 1997 on marginal effects indicate a very slight decline of the East Dummy's coefficients, which we interpret as a sign of slowdown in the adjustment process.

To check the robustness of our estimations we run Tobit estimations in order to analyze the impact of innovation on export intensity (see table 1, right column). All in all, the results confirm our findings. There is a strong positive influence of R&D and product innovation, firm size and productivity. Industries seem to differ even more regarding their export intensity than in terms of the probability to export. The export gap which we observed in the Probit estimations is visible also regarding export intensity, but differences are slightly smaller. This implies that once the export decision is made, East and West German companies behave rather similar.

Table 1: Panel estimations for Germany

| | Probit | | Tobit | |
|---|---|---|---|---|
| Variable | Coefficient | s.d. | Coefficient | s.d. |
| constant | .500 *** | *(0.059)* | .059 *** | *(0.011)* |
| InProd | .328 *** | *(0.045)* | .061 *** | *(0.009)* |
| InProc | -.006 | *(0.042)* | -.017 ** | *(0.008)* |
| R&D | 23.495 *** | *(1.802)* | 3.502 *** | *(0.279)* |
| $R\&D^2$ | -134.553 *** | *(12.775)* | -17.798 *** | *(2.011)* |
| size-s | -.694 *** | *(0.039)* | -.147 *** | *(0.008)* |
| size-l | .390 *** | *(0.053)* | .079 *** | *(0.008)* |
| low tech | -.218 *** | *(0.045)* | -.032 *** | *(0.009)* |
| high tech | .110 *** | *(0.042)* | .063 *** | *(0.008)* |
| LP | .179 *** | *(0.031)* | .059 *** | *(0.005)* |
| East 1993 | -.942 *** | *(0.063)* | -.180 *** | *(0.013)* |
| East 1995 | -.707 *** | *(0.076)* | -.142 *** | *(0.015)* |
| East 1997 | -.639 *** | *(0.065)* | -.116 *** | *(0.013)* |
| East 1999 | -.622 *** | *(0.065)* | -.106 *** | *(0.013)* |
| East 2001 | -.470 *** | *(0.072)* | -.079 *** | *(0.015)* |
| Mean dep var | 0.736 | | 0.207 | |
| Observations | 7,948 | | 7,948 | |
| Log likelihood | -3,451.24 | | -1,850.32 | |

*(***) 1% level of significance; (**) 5% level of significance; (*) 10% level of significance*
*s.d. in parantheses*

More details are shown in table 2 and 3, where we report results for East and West sub samples.[1] As corporate with the results for the whole sample, the constant is lower for East Germany. The basic probability to export (expressed by the constant) is significantly and strong positive for firms situated in West Germany, while the coefficient for the East is significant negative. In other words, the probability of being an exporter is significantly lower for East than for West German companies.

Product innovation has a clear positive impact on the probability to export in East and West. Remarkable are the different effects and their development in both parts of Germany: The influence of product innovation on West German firms' probability to export declines, whereas the influence on firms in East Germany increases over

[1] In order to test the disparity between East and West Germany to regard the considered factors' impact on export performance. We ran Wald-Tests (see Tabel A.4 and A.5 in the Appendix) showing that although coefficients converge equality is not reached yet.

the observed period. In contrast, process innovations are found insignificant, but coefficients develop from negative to positive, gaining importance especially for East German firms. Considered with our finding of a stronger impact of productivity on East German companies, we interpret this as a first indicator of different specialization in East and West: East German firms tend to operate in the more price sensitive markets than western firms.

The strong and positive influence of R&D expenditure on export activities is significantly higher in East than in West Germany. The higher impact of R&D on exports in East Germany may indicate large differences between technologically advanced firms with high R&D expenditures, which are likely to export, and firms on a lower technological level which are not. In contrast, West German business strategies and main characteristics of R&D intense and non-R&D conducting firms seem to be more similar.

Firm size reflecting economies of scale and scope has a strong and significant influence as well. Small firms tend to export less than medium size firms whereas large firms have a significantly higher probability to export. The difference is persistent for the whole observed time. Remarkable is the contrary development in East and West Germany. Regarding marginal effects, in East Germany small firms' disadvantages decrease from 28 percent in 1993 to 19 percent in 2001. In contrast, small West German companies have a significant 12 percent lower probability to export in 1993 which rises up to about 17 percent in 2001. The large companies variable in the West has a significant positive influence on the probability to export. For East Germany differences between medium and large companies are insignificant, but this could be due to the small number of large firms in the sample. The results indicate that a minimum size is probably required to export but scale economies beyond this threshold might be small.

Notable are the differences regarding technology classes in East and West Germany: Beyond the expected advantages and disadvantages of high and low technology firms respectively, the differences between East and West Germany indicate that West German medium tech firms are more comparable in their export behavior to high tech firms while in the East they are more similar to the low technology sector. In fact, in the East German sample the coefficient for the difference between low and medium technology class, but for West Germany the difference of medium and high technology sectors are insignificant. All in all, the advantages of operating in high technology sectors are smaller for East German companies. This implies that East Germany's comparative advantages in technologically advanced industries are less distinct. We interpret this technology class effect as specialization towards the more price competitive sectors for firms in East Germany.

Labor productivity is insignificant and negative for the first years of West German firms, but positive and significant for the following years. That means higher productivity leads to a higher probability to export, while in the early nineties West German firms were engaged more in quality than in price competition where pro-

Table 2: Wave-specific estimates of Probit for West and East Germany

dependent variable: Export (0/1)

| | **West** | | | **East** | | |
|---|---|---|---|---|---|---|
| | 1993 | 1997 | 2001 | 1993 | 1997 | 2001 |
| constant | .568*** | .746*** | .376** | -.151 | -.607*** | -.434** |
| | *(0.204)* | *(0.156)* | *(0.157)* | *(0.237)* | *(0.182)* | *(0.197)* |
| InProd | .493*** | .424*** | .251** | .296* | .184 | .451*** |
| | *(0.147)* | *(0.142)* | *(0.127)* | *(0.178)* | *(0.171)* | *(0.164)* |
| InProc | -.040 | -.065 | .024 | -.104 | .177 | .143 |
| | *(0.114)* | *(0.138)* | *(0.125)* | *(0.135)* | *(0.155)* | *(0.157)* |
| R&D | 26.908*** | 27.834*** | 20.722*** | 22.014*** | 25.826*** | 26.399*** |
| | *(5.202)* | *(6.712)* | *(6.849)* | *(4.765)* | *(5.627)* | *(7.245)* |
| $R\&D^2$ | -181.671*** | -152.053*** | -127.774*** | -130.201*** | -135.366*** | -135.962*** |
| | *(36.604)* | *(50.998)* | *(49.994)* | *(33.026)* | *(39.703)* | *(50.694)* |
| size-s | -.591*** | -.775*** | -.665*** | -.737*** | -.506*** | -.707*** |
| | *(0.117)* | *(0.111)* | *(0.114)* | *(0.121)* | *(0.126)* | *(0.152)* |
| size-l | .398*** | .242* | .685*** | .601*** | .327 | -.002 |
| | *(0.129)* | *(0.143)* | *(0.183)* | *(0.179)* | *(0.237)* | *(0.273)* |
| low tech | -.093 | -.237* | -.359*** | -.161 | .024 | -.123 |
| | *(0.141)* | *(0.123)* | *(0.130)* | *(0.152)* | *(0.151)* | *(0.178)* |
| high tech | .106 | -.024 | .163 | -.083 | .251* | .232 |
| | *(0.117)* | *(0.118)* | *(0.127)* | *(0.136)* | *(0.145)* | *(0.167)* |
| LP | -.071 | .106 | .381*** | .010 | .449*** | .515*** |
| | *(0.063)* | *(0.086)* | *(0.093)* | *(0.111)* | *(0.123)* | *(0.135)* |
| Mean dep var | .859 | .813 | .772 | .489 | .531 | .571 |
| Observations | 1,244 | 1,164 | 914 | 591 | 518 | 422 |
| Log likelihood | -419.02 | -443.28 | -386.06 | -340.86 | -297.63 | -219.98 |

*(***) 1% level of significance; (**) 5% level of significance; (*) 10% level of significance*

*s.d. in parantheses*

ductivity is of minor importance. The impact of labor productivity on export probability is stronger for East than for West Germany, which means that especially East German firms might be able to export only if they reach a high level of labor productivity. One explanation might be that for firms located in the East low production costs are essential to be competitive, as they do not have western competitors' advantages in branding and quality competition. Due to the lower integration into the western markets and therefore higher transaction costs, for East German firms productivity is more important in order to bear these additional costs of exporting. Furthermore, firms in East Germany tend to operate in the low technology sector which is more price sensitive. Looking at the West German sample, productivity seems to have played a secondary role in the beginning of the observed period. This could be due to branding effects, which allowed West German firms to charge high prices. In addition, a certain domestic orientation after reunification West German firms found growing markets in East Germany without strong price competition. When market growth faded out in the mid nineties, West German companies had to step into foreign markets. Therefore, since 1997/1998 West German companies are influenced by stronger price competition in the international trade as well, and consequently labor productivity plays an increasing role.

The results of our Tobit estimations confirm our findings drawn from the Probit estimations (see table 3). The low significance of product innovations in the East attracts attention. Innovating firms in East Germany are more likely to export, but they do not export a higher share of their total turnover than companies without innovations. In contrast, R&D expenditure is more important for export intensity in East than in West Germany. This finding leads to the conclusion that innovations in East and West Germany are not of the same quality, as East German firms might be more often engaged in imitating product innovations while West German firms rather develop new products.

Besides, technology classes are even more important for export intensity and shows remarkable differences between firms in West and East Germany. Operating in low technology sectors reduces a firm's expected export intensity in West Germany by about 6.8 percent in 2001, while for East Germany the respective figure is insignificant. The positive impact of being in high technology sectors seems to be stronger in East Germany from 1997 on, despite its low significance. This implies that although for a firm's decision to export its technology class is of minor importance, the export success, expressed by export intensity, depends strongly on the sector. The fact that differences between sectors are increasing over time indicates that German manufacturing firms gain competitiveness in high technology industries and loose it in the low tech sector. Firms in the East tend to specialize in low and medium technology sectors characterized by a stronger price competition.

Table 3: Wave-specific estimates of Tobit for West and East Germany

dependent variable: Export intensity

| | **West** | | | **East** | | |
|---|---|---|---|---|---|---|
| | 1993 | 1997 | 2001 | 1993 | 1997 | 2001 |
| constant | .071** | .044* | .059** | -.092 | -.167*** | -.151** |
| | *(0.034)* | *(0.026)* | *(0.028)* | *(0.059)* | *(0.043)* | *(0.047)* |
| InProd | .077*** | .074*** | .061*** | .078* | .017 | .064* |
| | *(0.027)* | *(0.024)* | *(0.022)* | *(0.046)* | *(0.039)* | *(0.039)* |
| InProc | -.008 | -.008 | -.006 | -.051 | .023 | .029 |
| | *(0.017)* | *(0.021)* | *(0.021)* | *(0.031)* | *(0.034)* | *(0.034)* |
| R&D | 3.366*** | 3.548*** | 3.411*** | 4.921*** | 5.749*** | 4.099*** |
| | *(0.607)* | *(0.788)* | *(0.942)* | *(1.055)* | *(1.149)* | *(1.410)* |
| $R\&D^2$ | -20.974*** | -17.311*** | -15.504** | -25.979*** | -27.740*** | -20.126** |
| | *(4.484)* | *(5.903)* | *(7.082)* | *(7.248)* | *(8.055)* | *(9.684)* |
| size-s | -.131*** | -.127*** | -.161*** | -.169*** | -.134*** | -.168*** |
| | *(0.019)* | *(0.019)* | *(0.021)* | *(0.029)* | *(0.029)* | *(0.034)* |
| size-l | .067*** | .076*** | .111*** | .148*** | .109** | .062 |
| | *(0.016)* | *(0.019)* | *(0.023)* | *(0.035)* | *(0.046)* | *(0.054)* |
| low tech | .003 | -.036* | -.068*** | .005 | .005 | -.027 |
| | *(0.022)* | *(0.022)* | *(0.025)* | *(0.036)* | *(0.036)* | *(0.043)* |
| high tech | .084*** | .052*** | .050** | .011 | .073** | .079** |
| | *(0.017)* | *(0.019)* | *(0.022)* | *(0.031)* | *(0.032)* | *(0.037)* |
| LP | .005 | .061*** | .107*** | .001 | .130*** | .171*** |
| | *(0.010)* | *(0.014)* | *(0.016)* | *(0.027)* | *(0.027)* | *(0.031)* |
| Observations | 1,244 | 1,164 | 914 | 591 | 518 | 422 |
| Log likelihood | -124.87 | -204.52 | -214.54 | -192.42 | -167.17 | -142.60 |

*(***) 1% level of significance; (**) 5% level of significance; (*) 10% level of significance*

*s.d. in parantheses*

# 5 CONCLUSION

Analyzing export behavior of German manufacturing in the decade after reunification, we find significant differences between innovating and non-innovating companies. Innovating firms are more likely to export and tend to realize a larger share of their revenue on international markets. The results suggest a strong impact of product innovations both on the decision to export and export intensity, while process innovations did not proof significant for firms' probability to export. Indeed, we find a strong positive, nonlinear relationship between R&D and both export probability and export share. Similarly, there is a positive correlation between the technological level of the sector which a firm is operating in and the firm's export success. Firms in high tech sectors such as chemical, automotive and optical industries exhibit higher export intensity, while in low tech industries like food, tobacco and textile production export shares are significant lower. Besides, further factors play a crucial role determining firms' export behavior. Firm size has a strong impact both on the probability of exporting and export intensity, as well as labor productivity. These influences gain importance during the observed period, which implies price competition getting fiercer and economies of scale and scope, branding and network effects becoming more essential.

Comparing East and West German firms, we find significant differences regarding firms' characteristics as well as their export behavior although disparities get smaller over time. East German companies are less likely to export and tend to realize smaller shares of their total turnover abroad. This can partly be explained through East Germany's economic structure which is dominated by small firms without a distinct focus on more competitive sectors. One of the main factors hindering East German companies from further export success seems to be the low labor productivity which lowers price competitiveness. Our results show that innovative activities are more important for East than for West German firms, which we interpret as a sign for greater differences in East Germany between competitive innovating firms on the one hand, and on the other hand firms who lack dynamics regarding both their innovative attitude and their export behavior. The role of process innovations and labor productivity increases over time, being thereby more important for East Germany. From these findings we draw the conclusion that, firstly in both parts of Germany firms have to face sharper price competition, and secondly that East German companies tend to be specialized towards low price markets where cost cutting is crucial, whereas West German firms rather operate in high price markets.

Finally, a number of questions remain unanswered, regarding both regional aspects and a more detailed specification of innovation activities. To get deeper insights in the function of innovations for export performance subject to the industry lifecycle, firm strategy and technical opportunities, more specific information on the quality of innovation output is needed. Moreover, strong regional disparities within East and West Germany can be assumed, so that further research on the influence of regional networks and spillovers might be promising.

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# APPENDIX

Table A.1: Classification of technology classes

| Technology class | Classification of manufacturing industries* | NACE-Rev.1 |
|---|---|---|
| Low tech | Food products and beverages | 15 |
| | Tobacco products | 16 |
| | Textiles, textile products, leather and footwear | 17-19 |
| Medium tech | Rubber and plastics products | 25 |
| | Non-Metallic mineral products | 26 |
| | Basic metals and fabricated metal products | 27,28 |
| High tech | Coke, refined petroleum products, chemical industry | 23,24 |
| | Machinery and equipment, n.e.c. | 29 |
| | Office, accounting and computing machinery | 30 |
| | Radio, TV and communications equipment | 32 |
| | Motor vehicles, apparatus, Aircraft and spacecraft | 34,35 |

** The data includes firms in the manufacturing sector, as defined by NACE-Rev.1 classification; Data on natural resources based activities such as agriculture, fishing, mining and utilities like the construction sector are exclude.*

Table A.2: Characteristics of firms in East and West Germany

| **Variable** | **West** | | | **East** | | |
|---|---|---|---|---|---|---|
| | 1993 | 1997 | 2001 | 1993 | 1997 | 2001 |
| Exporter (yes/no) | 0.76 | 0.75 | 0.77 | 0.41 | 0.45 | 0.57 |
| Export intensity (if exporter) | 0.21 | 0.21 | 0.25 | 0.07 | 0.09 | 0.13 |
| Innovator (yes/no) | 0.81 | 0.66 | 0.59 | 0.77 | 0.60 | 0.60 |
| Innovation intensity (if innovator) | 0.07 | 0.03 | 0.03 | 0.14 | 0.04 | 0.04 |
| R&D expenditure | 0.02 | 0.01 | 0.01 | 0.03 | 0.02 | 0.02 |
| Labor productivity | 0.26 | 0.28 | 0.28 | 0.12 | 0.19 | 0.20 |
| Sales in Mio. € | 399.3 | 239.8 | 253.8 | 43.1 | 33.0 | 24.9 |
| Low tech in % | 22.1 | 27.1 | 28.0 | 28.6 | 35.5 | 31.2 |
| Medium tech in % | 24.0 | 26.9 | 27.5 | 29.2 | 30.9 | 32.6 |
| High tech in % | 53.9 | 46.0 | 44.4 | 42.1 | 33.6 | 36.3 |
| Small size firms in % | 31.9 | 32.2 | 42.5 | 45.0 | 49.7 | 56.9 |
| Medium size firms in % | 27.8 | 32.3 | 32.1 | 39.4 | 38.8 | 34.2 |
| Large firms in % | 40.4 | 32.4 | 25.4 | 15.6 | 10.6 | 9.0 |

*Source: MIP 1993-2001*

Table A.3: Results of Probit estimates for Germany

dependent variable: Export (0/1)

| | 1993 | 1995 | 1997 | 1999 | 2001 |
|---|---|---|---|---|---|
| constant | .698*** | .977*** | .478*** | .309*** | .271** |
| | *(0.163)* | *(0.235)* | *(0.124)* | *(0.120)* | *(0.128)* |
| InProd | .414*** | .112 | .312*** | .331*** | .324*** |
| | *(0.114)* | *(0.145)* | *(0.108)* | *(0.112)* | *(0.099)* |
| InProc | -.078 | -.132 | .061 | .053 | .077 |
| | *(0.086)* | *(0.133)* | *(0.102)* | *(0.107)* | *(0.097)* |
| R&D | 23.863*** | 18.027*** | 24.956*** | 24.756*** | 22.968*** |
| | *(3.455)* | *(4.037)* | *(4.224)* | *(4.066)* | *(4.947)* |
| $R\&D^2$ | -151.172*** | -106.686*** | -130.958*** | -128.932*** | -124.258*** |
| | *(24.249)* | *(28.439)* | *(30.696)* | *(28.963)* | *(35.397)* |
| size-s | -.654*** | -.673*** | -.656*** | -.754*** | -.677*** |
| | *(0.084)* | *(0.102)* | *(0.082)* | *(0.081)* | *(0.091)* |
| size-l | .462*** | .472*** | .299** | .249** | .490*** |
| | *(0.103)* | *(0.126)* | *(0.120)* | *(0.114)* | *(0.149)* |
| low tech | -.131 | -.239** | -.124 | -.335*** | -.272*** |
| | *(0.103)* | *(0.118)* | *(0.094)* | *(0.094)* | *(0.104)* |
| high tech | .031 | .262** | .090 | .093 | .179* |
| | *(0.088)* | *(0.112)* | *(0.091)* | *(0.087)* | *(0.100)* |
| LP | -.052 | .039 | .231*** | .350*** | .421*** |
| | *(0.055)* | *(0.090)* | *(0.070)* | *(0.069)* | *(0.076)* |
| East | -1.006*** | -.758*** | -.750*** | -.503*** | -.496*** |
| | *(0.085)* | *(0.103)* | *(0.081)* | *(0.080)* | *(0.089)* |
| Mean dep var | .740 | .822 | .726 | .693 | .709 |
| Observations | 1,835 | 1,377 | 1,682 | 1,716 | 1,336 |
| Log likelihood | -762.97 | -495.92 | -746.74 | -793.57 | -611.70 |

*(***) 1% level of significance; (**) 5% level of significance; (*) 10% level of significance*
*s.d. in parantheses*

Table A.4: Wald-Tests on equality of export probability across East and West

| Year | $\chi^2$-Test of equality of all coefficients | Test for individual coefficient |
|---|---|---|
| 1993 | 25.0266(10): reject | reject equality of constant, product innovation, R&D, size<br>do not reject equality of process innovation,<br>technology classes, LP |
| 1995 | 16.0450(10): reject | reject equality of constant, R&D, size, technology classes<br>do not reject equality of product and<br>process innovation, LP |
| 1997 | 18.5694(10): reject | reject equality of constant, product and<br>process innovation, R&D, LP, size, technology classes |
| 1999 | 12.6159(10): reject | reject equality of constant, R&D, technology classes<br>do not reject equality of product and process innovation,<br>LP |
| 2001 | 10.7484(10): reject | reject equality of constant, size, technology classes<br>do not reject equality of product and<br>process innovation, R&D, LP |

Table A.5: Wald-Tests on equality of export intensity across East and West

| Year | $\chi^2$-Test of equality of all coefficients | Test for individual coefficient |
|---|---|---|
| 1993 | 35.0985(10): reject | reject equality of constant, size, technology classes<br>do not reject equality of product and process innovation,<br>R&D, LP |
| 1995 | 24.5057(10): reject | reject equality of product innovation, technology classes<br>do not reject equality of process innovation,<br>R&D, size, LP |
| 1997 | 19.4002(10): reject | reject equality of constant, product innovation<br>do not reject process innovation, R&D,<br>technology classes, size, LP |
| 1999 | 21.6159(10): reject | reject equality of constant, product<br>innovation, size, technology classes<br>do not reject equality of process innovation, R&D, LP |
| 2001 | 19.3839(10): reject | reject equality of constant, size, technology classes<br>do not reject equality of product and<br>process innovation, R&D, LP |