# 5 Productivity, Growth, and Exports

Today, the overwhelming majority of economists and politicians are convinced that an outward-looking export-oriented policy positively affects a country's welfare – for example by increasing GDP growth rate or improving productivity. Aggregate cross-country data sets have been used in the past to explore the relationship between trade and macroeconomic indicators.[119] More recently, however, a growing literature investigates at the microeconomic (read: firm) level how international trade is related to various measures of firm performance. If there are positive effects of trade on macroeconomic indicators, they should be reflected by microeconomic data such as improved firm performance.

International engagement may be especially important for small technology-oriented firms, since export activities are often regarded as one way to amortise these firms' high product research and development costs. Examining the cross-sectional data set of the first survey this study is based on, Bürgel et al. (2004) found out that internationalisation did indeed improve the firms' labour productivity and increased their annualised sales growth rates between the firms' start-up and 1997, but did not affect employment growth. These results, however, contradict many other studies examining the causal relationship between exports and firm performance. All of these studies confirmed the stylised facts that exporters are larger, more productive, and exhibit higher growth rates; but most, including those by Clerides et al. (1998), Bernard and Wagner (1997), and Bernard and Jensen (1999), found a reverse causality, i.e., the superior performance of internationally active firms is a result of self-selection of "good" firms into the international market. Conversely, there is little evidence that internationalisation has a causal effect on firm performance.

One can quite reasonably assume that young high-tech firms behave differently from the firms studied in the papers cited above. Firstly, most other studies examined mature firms, in contrast to our sample of newly founded firms that were observed in 1997. Secondly, there may be structural differences in firms operating in high-technology sectors compared with firms in low-tech sectors. For example, technology-oriented firms might improve their labour productivity because they can better profit from learning effects by exporting (see the "learning by exporting" hypothesis in the next section) than low-tech firms.

119 See Baldwin (2000) for a discussion of theoretical and empirical studies analysing the relationship between trade and macroeconomic growth. Baldwin emphasised that there is still considerable controversy among economists as to how trade and economic growth interact. Particularly, there is disagreement on the precise effects of various trade policies (e.g., trade taxes, subsidies, quotas) on growth.

In order to find out whether the observed causal effects remain valid as high-tech firms age because the causalities are a result of structural differences particular to them, or whether the positive effects are restricted to the start-up period, this chapter re-examines the relationship between export behaviour and firm performance using data from the second survey conducted in 2003. In accordance with Bürgel et al. (2004), two different indicators of firm performance will be investigated: labour productivity (measured as sales per employee) and firm growth in the period from 1997 to 2002 (employment as well as sales growth). The relationship between these two indicators of firm performance and the firms' export behaviour will be elaborated using two different econometric methods. In a first step, I will estimate simultaneous equation models (section 5.4). This allows a simultaneous estimation of probability of exporting and of the determinants of firm performance. The individual equations the econometric model is based on (labour productivity, growth, and internationalisation equations) will be derived in section 5.2. In the second step, I will apply matching techniques which estimate the causal effect of exporting by comparing the mean outcome (productivity or growth) of internationally active firms with that of a control group of domestic firms (section 5.5). By using two different econometric approaches, I will check the robustness of my results. At first, however, I will review theoretical arguments and empirical studies that deal with the relationship between performance and internationalisation.

## 5.1 Performance and Internationalisation

Depending on which performance indicator is regarded, different theoretical arguments have been derived on how firm performance and international business activities might be related. The direction of causality, however, is not clear a priori. On the one hand, exporting might improve firm performance. On the other, firms with superior performance might become exporters. In the following, I will summarise arguments that relate internationalisation and the two performance indicators analysed in this chapter, productivity and growth. In related literature, the relationship between survival and internationalisation is also discussed (see, e.g., Sapienza et al. [2003] for theoretical arguments and Yli-Renko et al. [2004] or Bernard and Jensen [1999] for empirical results). Since this study's econometric analysis is based on survey data and only the representatives of still-living firms have been contacted, the influence of being an exporter on the probability of survival cannot be examined empirically. I will neglect the latter relationship hereafter. It should be emphasised that productivity, growth, and survival are neither exclusive nor independent from one another. At least in the long run, these three performance indicators can be expected to be positively correlated. For example, growing firms might profit from economies of scale so that a given number of employees can produce more output, which, taking the product price as given, results in higher sales per employee – our measure of labour productivity. Similarly, economic theory predicts that in any industry, the least productive firms exit from the market first, thus showing a smaller survival probability.[120]

One of the most frequently heard arguments on how productivity and internationalisation might be related is the "learning by exporting" hypothesis. Exporting firms are supposed to learn from internationally leading customers, suppliers, or competitors with respect to best practice technology or even product designs (see, e.g., Evenson and Westphal 1995). Thus, exporters may profit from technological or knowledge spillovers. In other words, the productivity-increasing effect of international sales results from knowledge and expertise on the foreign market that non-exporters do not have (Aw et al. 2000).

Another argument is mainly associated with McKinsey (1993b). Firms that have international sales are assumed to be exposed to greater competition than firms with domestic sales only. They are forced to exploit their resources more efficiently, reduce costs and increase their productivity in order to remain exporters. However, one might object that in open economies like Germany or the UK, domestic firms also face competition from foreign companies because of imports to the domestic market ("imported" competition; see Bernard and Wagner 1997).[121]

Labour productivity, however, is not necessarily the main interest of policy makers, employees, investors, or owners. The two former groups are primarily concerned with the employment-generating effect of internationalisation, whereas investors and owners focus on sales or a firm's market value. Since the foreign market could be regarded as an expansion of the domestic market, firms can realise economies of scale and an ensuing increase in sales and employment by carrying out international business activities. This mechanism is known in related literature as export-led growth (see Feder 1982). Moreover, international sales can compensate for variations in domestic demand (Bernard and Wagner 1997), lowering the dependence of a firm's growth processes on the domestic market.

The argument of export-led growth seems to be especially important for young technology-oriented firms. These firms often produce highly specialised products or services (niche strategy) in limited domestic markets, making international business activities the only way to ensure long-term company growth. Moreover, young high-tech firms are often faced with high costs of re-

120 In some cases, however, the correlation between different performance indicators might be negative. Reid (1995), for example, found a trade-off between profitability and growth for young, small firms in Scotland.

121 In fact, the latter argument is often stated by the literature concerning development economics. In developing countries, firms are often confronted with barriers to entry into the domestic market, implying less fierce competition (see Aw and Hwang [1995] for further details).

search and development. If exports lead to higher growth rates, this can facilitate the amortisation of high product R&D costs (Bürgel et al. 2004).

International engagement is associated with significant entry costs, such as marketing campaign expenses or the costs of setting up foreign sales channels, which may be regarded as sunk costs. Small and less productive firms might not be able to bear these costs. Therefore, we should observe that only firms that have achieved a certain size or a certain level of labour productivity enter the foreign market. This leads us to anticipate a self-selection of firms with superior performance into the international market. This argument describes the reverse causation: Firms with "good" performance become exporters (cf., e.g., Bernard and Wagner 1997 or Bernard and Jensen 1999).

Based on the Ricardian theory of comparative advantage, Bernard et al. (2000) derived a theoretical trade model that traces back the self-selection of firms with higher productivity into the export market to firm-specific differences in efficiency.[122] International business activities constitute a higher "efficiency hurdle" (Bernard et al. 2000, p. 15) than domestic sales.[123] Thus, firms with higher efficiency are more likely both to export and to have higher measured productivity, which corresponds to the usually observed stylised fact that exporting firms are more productive on average. The model is also able to explain the stylised fact that firms with international business activities tend to be larger. More efficient firms are not only more likely to export, they are also more likely to charge lower prices, which, in the case of an elastic demand, will lead to higher sales (see Bernard et al. 2000, p. 16, for more details). Similarly to Bernard et al., Melitz (2003) developed a monopolistically competitive model of trade with firm heterogeneity. According to his model, only more productive firms export while simultaneously firms with low productivity may not survive, or survive but only serve their domestic market.

The amount of empirical literature examining the relationship between firm performance and internationalisation has grown considerably in recent years (see Wagner [2005] for an extensive review of 45 microeconometric studies with data from 33 countries). Clerides et al. (1998) tested empirically a theoretical model of export participation and learning effects using a data set of

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122 Firm efficiency is defined as the inverse number of input bundles necessary to produce one unit of output. Thus, a firm is more efficient when it needs fewer input bundles to produce one unit of output. In contrast, productivity is defined as the value of output (i.e., sales) per bundle of input, or per an input factor like number of employees. Under perfect competition, measured productivity is equal to the price of the input bundle regardless of a firm's relative efficiency. Under imperfect competition, productivity is the price of the input bundle times a firm-specific markup. Bernard et al. (2000) proved that, in their model, more efficient firms charge, on average, a higher markup. Therefore, differences in productivity reflect differences both in efficiency and in a firm's monopoly power.

123 In the model, among all potential producers of any good only the most efficient ones serve the (domestic) market.

manufacturing plants in Colombia, Mexico, and Morocco observed in the 1980s. Descriptive analyses confirmed that exporting plants were more productive than their non-exporting rivals. The question of causality, however, remains. Based on their model, Clerides et al. derived two conflicting hypotheses. If learning effects are prevalent, the trajectories of average costs must reveal a cost reduction after the plant has entered the foreign market. If, however, plants with superior productivity become exporters, cost reductions must be present before the plants start exporting. Applying simulation techniques and simultaneously estimating an autoregressive cost function and a dynamic export market participation equation, Clerides et al. found evidence for the latter scenario, i.e., the positive relationship between status of internationalisation and labour productivity is a result of the self-selection of more productive plants into foreign markets.

Bernard and Jensen (1999) and Bernard and Wagner (1997) produced similar results when analysing panel data of US and German manufacturing firms respectively. Most importantly, both studies confirmed that firms with superior performance self-select into the international market. Bernard and Jensen found that exporting firms benefit from their international engagement, enjoying higher employment growth rates after foreign market entry and a higher probability of survival compared with non-exporting firms. However, the study of Bernard and Wagner revealed that the higher survival rates of exporting German firms can be explained by their superior performance characteristics before foreign market entry.

Using the same data set as Bernard and Wagner (1997), Wagner (2002) introduced the application of matching techniques in order to re-examine the export-performance relationship. In contrast to the earlier results, he then obtained evidence of the significantly positive effects that starting to export has on employment growth and wages, but no statistically significant causal effect on labour productivity. Also using a matching approach, De Loecker (2004) proved that exports generate higher total factor productivity in the case of Slovenian manufacturing firms. Analysing a panel data set of UK firms, Girma et al. (2002) applied matching techniques and found a feedback relationship between the firms' export activities and productivity (labour productivity as well as total factor productivity): Highly productive firms become exporters, but exporting also increases productivity. Apparently, using matching techniques leads to results that are more in favour of a causal effect of international business activities on firm performance. However, the results are still mixed. Arnold and Hussinger (2005) examined German manufacturing firms from the Mannheim Innovation Panel. The results of their matching analysis are in line with most of the studies cited above: Causality runs from productivity to exporting and not vice versa. Therefore, it remains questionable to what extent the conflicting findings are a consequence of varying empirical methodologies or structural differences of the analysed firms.

Using data from the first survey this study is based on, Bürgel et al. (2004) investigated the relationship between firm performance and internationalisation behaviour for the period from the firms' start-up until 1997. They found that an international engagement improves labour productivity and increases the sales growth rate, but does not affect the employment growth rate. The foreign market may be particularly important for young, small, technology-oriented firms, especially for those operating in a narrow market niche. Similarly, productivity-increasing learning effects might be more relevant for newly founded firms than for mature firms investigated in the papers quoted above (compare the theoretical models of "active" and "passive" learning developed by Ericson and Pakes [1995] and Jovanovic [1982], respectively). Moreover, young high-tech firms can be expected to be able to absorb the information gained on the international market and transform this information into increased productivity. Hence, there are arguments as to why the firms in our sample might have structural peculiarities that lead to causal effects of exporting on firm performance contradictory to most of the other studies cited above, especially with respect to labour productivity. The subsequent analysis addresses the question of whether the causal relationships pointed out by Bürgel et al. remain valid as firms age and reach a more "mature" stage of their life cycles or whether the positive role of exports is restricted to the firms' start-up periods.

## 5.2 The Model

### Labour Productivity Equation

It is assumed that firm $i$ produces according to a Cobb-Douglas production technology. Output $Y_i$ is a function of the production factors physical capital ($K_i$), R&D employees ($R_i$), and non-R&D employees ($L_i$):[124]

$$(5.1) \qquad Y_i = A \cdot K_i^{\alpha} \cdot R_i^{\beta} \cdot L_i^{\gamma} \cdot e^{u_i} .$$

The scalar $A$ is a parameter of production efficiency that shifts the isoquants of the Cobb-Douglas production function in parallel to the origin. The exponents $\alpha$, $\beta$, and $\gamma$ denote the partial production elasticities of output with respect to capital, R&D, and labour, respectively, and $u$ is a normally distributed error term. Taking logarithms and subtracting labour from both sides results in an equation for labour productivity, i.e., output per non-R&D employee:

124 Research and development often enters the production function as R&D capital (cf. Hall and Mairesse 1995). However, due to data restrictions R&D capital is sometimes approximated by R&D employees. In order to avoid double-counting, labour input is then measured by number of non-R&D employees. I decided to include R&D employees directly as an input factor, not least because, for the service firms in our sample, the knowledge-based production process can better be described by labour input than by R&D capital.

$$(5.2) \qquad \ln\left(\frac{Y_i}{L_i}\right) = \ln A + \alpha \cdot \ln\left(\frac{K_i}{L_i}\right) + \beta \cdot \ln\left(\frac{R_i}{L_i}\right) + (\mu - 1) \cdot \ln L_i + u_i \,.$$

The sum of production elasticities $\mu = \alpha + \beta + \gamma$ will be unity if the production function has constant returns to scale. Thus, the coefficient of the logarithm of labour ($\mu$ – 1) measures departure from constant returns so that equation (5.2) already includes a test for constant returns. This implies that the input factors capital and R&D employees enter the labour productivity equation as intensities with respect to non-R&D employees.[125]

To implement the labour productivity equation econometrically, output is measured as sales per 1,000 euro in 2002. Thus, labour productivity is measured as sales per non-R&D employee. In order to determine R&D employment, firms were asked how many of their employees spent at least 50 % of their time on research and development of new and existing products or services. Taking this number, I apply the most conservative estimate of R&D employment by assuming that all R&D employees only devote 50 % of their time to R&D. The number of R&D employees given by the firms is therefore halved to produce an estimate of R&D employment that will be used in the econometric model.[126]

The most severe specification problem lies in finding an approximation of firm-specific stocks of physical capital. It is generally not possible to collect information on capital stock by survey, especially not when carrying out telephone interviews. A panel data set containing information on investment in physical capital over a longer time period – a decade for instance – would allow calculation of capital stock using the perpetual inventory method.[127] Unfortunately, we only have information on investment in physical capital for the year preceding the second survey, i.e., 2002.[128] Therefore, I decided to use this value of gross investment in physical capital in 2002 to approximate physical capital.[129]

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125 This transformation of the Cobb-Douglas production function was also used by Hall and Mairesse (1995).

126 My results are not sensitive to this assumption. Using alternative approximations of the number of R&D employees, the estimated coefficients are almost identical to the results shown in section 5.4.

127 This method is described, among others., by Griliches (1979).

128 Information on investment was not collected by the first survey in 1997.

129 This approximation of capital stock was already applied by Bertschek and Kaiser (2004) and Bertschek et al. (2004). As an alternative, Bürgel et al. (2004) used data from the Mannheim Innovation Panel (MIP) to calculate an industry-specific approximation of capital stock when analysing the labour productivity of the firms that answered the first survey in 1997. The main advantage of the latter approach is that the absolute value that enters the labour productivity equation is likely to be a good approximation of unobserved capital stock. On the other hand, firm-specific variation is neglected when using industry-specific estimates. The main problem with the approach used in this chapter is that gross investment in physical capital often varies significantly from one year to the next. Hence, the results might have been different had we merely used the value of gross investment in 2001

Finally, two industry dummy variables and a dummy variable indicating whether a firm is located in Eastern Germany are added to the productivity equation. The first industry dummy variable characterises firms that belong to an engineering industry, the second indicates firms from other manufacturing sectors including ICT-hardware and health/life sciences. Thus, service firms are used as the base category. The dummy variable for Eastern German firms is intended to cover the well-known fact that firms in the eastern part of Germany exhibit a lower productivity compared with their competitors from the established Western European market economies.[130]

**Growth Equations**

From a policy point of view, technology-oriented firms are expected to create new jobs. Politicians and employees are thus primarily interested in (long-term) employment growth. Similarly, sales growth could be regarded as the main goal of owners and investors. Therefore, firm growth is examined as the second performance indicator for the surveyed firms. Although the relationships between internationalisation and employment and sales growth are estimated separately, the two growth equations are broadly identical, allowing the following combined discussion of both the employment growth equation and the sales growth equation.

Firm growth is observed over the period between the two surveys, i.e., between 1997 and 2002. The logarithm of the annualised growth rate *G* is given by (see, for example, Evans 1987a, 1987b)

$$(5.3) \qquad \ln G_i = \frac{\ln E_{i,t_2} - \ln E_{i,t_1}}{t_2 - t_1},$$

where *E* is either number of employees or the respective firm's (discounted) sales, $t_1$ is 1997 and $t_2$ is 2002. The growth equation is specified as a simple heuristic equation

$$(5.4) \qquad \ln G_i = X_i \delta + u_i,$$

where $u_i$ is a normally distributed error term. In keeping with related literature on firm growth, a vector of exogenous variables $X_i$ is identified that is intended to affect the firms' growth rates.

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instead of that of 2002. However, the econometric results of this chapter, as well as the results of Bertschek and Kaiser (2004) and Bertschek et al. (2004), give plausible estimations of the partial production elasticity of capital, i.e., the parameter we are interested in.

130 DIW et al. (2003) stated that in Eastern Germany in 2002, GDP per employee only amounted to 71 % of the corresponding Western German value. Descriptive analyses of the firms in our sample also show that the labour productivity of Western German firms is significantly higher than that of UK-based firms. However, the dummy variable for Western German firms is not significant in the productivity equation. An obvious explanation for this is that Western German firms are either better equipped with firm-specific resources than UK-based firms or that they exploit their resources more efficiently than their UK counterparts. Therefore, a dummy variable for West Germany will not be added in the final econometric specification.

Based on Gibrat's Law (Gibrat 1931), there are numerous theoretical and empirical studies that examine the relationship between firm size and growth. Whereas Gibrat's Law postulates that growth is independent of firm size (Simon and Bonini 1958, Lucas 1978), empirical studies have proved that at least for young and small firms like those in our sample, (employment) growth decreases with firm size (see Sutton 1997 for a survey). The main theoretical argument as to why growth and size are negatively correlated is as follows[131]: Firms are often founded with a sub-optimal size, i.e., smaller than the minimum efficient scale (MES). By collecting information on its own productivity and competitors, a young firm approaches the MES in the early years after firm formation (see Ericson and Pakes 1995 or Jovanovic 1982). This theoretical concept assumes a neo-classical *U*-shaped average cost curve and implies that a firm will not grow larger than its MES in order to avoid increasing average costs. This concept is, however, inconsistent with long-term growth, this study's actual intended focus. To explain long-term growth beyond the MES, we must assume imperfect competition, making the cost curve *L*-shaped. In this case, firm growth will only be restricted by the demand for the respective firm's product (see Hart 2000).

In the empirical model firm size will be measured by the logarithm of number of employees (sales) at the beginning of the growth period, i.e., 1997. Empirical studies (for example, by Evans 1987a or Almus et al. 1999) have shown a non-linear relationship between size and growth, whereby the negative effect of size on firm growth decreases as firms approach their MES. Therefore, I will also include the square of the logarithm of employees (sales) in the growth equation.

Similarly to the arguments that relate size and growth, a negative correlation between firm age and growth is hypothesised. Young firms can realise high efficiency gains due to learning processes, which lead to higher growth rates (Ericson and Pakes 1995, Jovanovic 1982). These efficiency gains decrease as firms become older. To test this hypothesis, I will include the logarithm of firm age in 1997 (measured in years).

Investment in R&D is of major concern to technology-oriented firms. The growth-enhancing effect of R&D activities was already proven for the start-up periods of the firms in our sample by Bürgel et al. (2004). R&D activities can be regarded as constituting an intangible asset that fosters firms' growth processes as argued by the resource-based view of the firm (e.g., Penrose [1959], Wernerfelt [1984], or, in the context of firm growth Geroski [2000]). However, R&D activities are not necessarily exogenous if a firm decides on the amount of R&D based on its growth prospects (see,

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131 An evolutionary theory that explains the negative correlation between size and growth was formulated by Cabral (1995). Nelson and Winter (1982), on the other hand, described a positive relationship between size and growth: Firms develop successful routines, allowing firms that have grown faster in the past to continue growing ("persistence of chance", Wagner 1992).

e.g., Felder et al. 1996). Furthermore, using R&D intensity as the exogenous variable is problematic, since we only know the firms' R&D intensity in 1997 and 2002. However, the firms' growth rates between 1997 and 2002 are certain to have been affected by their interim R&D activities as well. Therefore, instead of R&D intensity I consider two dummy variables that indicate whether a firm is carrying out R&D on a permanent basis or occasionally. Firms with no R&D activities are used as the base category. These two dummy variables better describe the firms' long-term R&D activities. Moreover, the problem of endogeneity is likely to be less severe for the two dummies than for R&D intensity. Since the dummy variable for occasional R&D activities turned out to be insignificant in the sales growth equation, it was excluded from the sales growth regression.[132]

From a theoretical as well as an empirical point of view, human capital of firm managers is regarded as one of the most important factors influencing firm growth. It can be expected that higher levels of firm managers' human capital imply increased knowledge and capabilities with respect to organisation or financial and general management (see, e.g., Bates 1990, Brüderl et al. 1998). Since it is difficult to measure the abstract concept of human capital directly, the econometric model will include two dummy variables that take the value 1 if the respective firm's managers experienced a "serious" or a "very serious" shortage of skills in marketing or R&D. These two dummy variables are hypothesised to reduce firm growth.

The role of imperfect competition was already stressed while discussing the relationship between firm size and growth. The argument was made that imperfect competition enables firms to realise long-term growth. In interviewing the firms in our sample, we asked firm representatives to estimate the time a competitor would need to launch either a similar product with superior performance or a product with similar performance at a lower price. This competition-free time period in which firms can realise temporary monopolistic rents is called the "window of opportunity". In section 4.4, this variable already proved to have an impact on a firm's decision on the appropriate sales mode. It might be intuitive that a longer competition-free period leads to a higher growth rate. However, as Porter (1979) and Caves and Porter (1979) argued, firms that successfully occupy a narrow strategic segment do not need to exploit their competitive advantage and grow rapidly in order to survive in their chosen market segment. Slow growth is then compatible with a niche product strategy. According to the econometric modelling in section 4.4, I will include a dummy variable in the econometric growth equation that takes the value 1 if the estimated window of opportunity is one year or shorter.

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132 In analysing the growth models, I also estimated a specification that includes R&D intensity. However, R&D intensity was insignificant in both the employment growth and sales growth equations.

Firms that face a short window of opportunity are forced to improve their products or to market new products or services. Thus, the age of the product may also be important for firms' growth (see Bürgel et al. 2004). Firms with relatively old products are hypothesised to grow more slowly since their products are likely to be out-of-date. Especially in high-tech industries with short product life cycles, products rapidly change or become obsolete.[133] In the questionnaire, the firms' representatives were asked in which year the then currently best-selling product was first sold by the company. Using this information, I will include the logarithm of the product's age in 2003 in the sales growth regression. I also tested this variable in the employment growth regression, but it turned out to be insignificant and will therefore be neglected in the final specification.

The growth equation will be completed by two industry dummy variables (for the engineering industry and other manufacturing industries including ICT-hardware and health/life sciences) and by a regional dummy variable taking the value 1 if the firm is located in Germany. In contrast to the productivity equation, I will not use a dummy variable for Eastern Germany because descriptive analyses reveal that there are only minor differences in firm growth between Western and Eastern Germany, but significant differences between Germany and the UK.

**Internationalisation Equation**

A profit-maximising firm will decide to internationalise if the benefits of exporting exceed the costs associated with international business activities. Potential benefits can be a result of an increased growth rate or improved labour productivity. Since the costs of international business activities cannot be observed directly, I will formulate different hypotheses concerning the factors likely to influence a firm's decision regarding exporting. In order to identify the internationalisation equation, exogenous variables are needed that increase or reduce firms' (potential) costs of international business activities, but that are independent of growth and labour productivity (see also the explanation of the econometric model in section 5.4). For example, R&D activities play an important role in the decision to internationalise. They generate assets by which a firm distinguishes itself from its competitors. These assets not only facilitate foreign market entry – they also support a long-term engagement in the international market (see chapter 4). However, as shown in the previous subsections, R&D may also be decisive for long-term growth and above-average labour productivity. In fact, the number of R&D employees is directly included in the labour productivity equation (5.1) as a production factor and (permanent) R&D activities are postulated to

133 Of course, firms may innovate and improve their products gradually so that even if the product is fairly "old", it might incorporate the latest technology.

increase the respective firm's growth rate in equation (5.4). Therefore, R&D activities are not suitable to identify the internationalisation equation.

Based on the results of chapter 4, the following explanatory variables are supposed to be independent of overall firm performance but can be expected to identify the internationalisation decision. According to the internationalisation process model developed by Johanson and Vahlne (1977, 1990), international business activities are associated with uncertainty. A firm increases its international activities gradually, starting with no international activities and entering its first foreign market at a later stage of its life cycle. However, as an exception to the process model, Johanson and Vahlne (1990) mentioned the possibility that knowledge necessary to reduce uncertainty about a foreign market can be acquired by employing an internationally experienced manager, enabling firms to take larger and faster internationalisation steps. The international experience of firm managers can also be regarded as an intangible asset that facilitates firms' export activities from a resource-based view of the firm (see, e.g., Wernerfelt 1984 and the explanations in the previous subsection). Thus, the two well-known dummy variables indicating whether a member of the firms' management team had work experience abroad or whether a manager was educated abroad before joining the company will be included in the internationalisation equation.

Product characteristics may influence firm's internationalisation behaviour. High customisation requirements may act as a constraint to entering the foreign market since they involve close contact with end-users, inducing high transaction costs prior to selling the product (cf. Williamson 1985). For the econometric estimations, a dummy variable will be used that takes the value 1 if the firm has classified the requirement of customisation as "important" or "very important". This variable has already proved to represent a decisive transaction-specific asset that significantly affects the firms' international business activities (see chapter 4).

## 5.3 Descriptive Analysis

On average, in 2002 the firms in our sample had sales of 3.6 million euro, employed 26 individuals and invested 213,000 euro. Table 5-1 compares the means of exporters and non-exporters. The results are in line with many other studies analysing the relationship between internationalisation and firm performance[134]: Firms with international business activities have, on average, higher sales, more investments, and a greater number of employees. The latter is true for non-R&D employees as well as for number of employees working in R&D. Whereas firms with international sales have an average of about three employees working on research and development of new and

[134] See section 5.1 and the literature quoted therein.

existing products, firms that do not export employ only one full-time worker for R&D activities on average.[135] Moreover, within the group of non-exporters more than half of the firms do not conduct any R&D activities. Consequently, the median of number of R&D employees in this group is zero. In contrast, only 12 % of the firms with international sales do not carry out R&D activities. This result corresponds to the values of R&D intensity in the lower part of Table 5-1: Firms with international sales spend just under 16 % of their total sales on R&D, while firms without exports allocate only just over 4 % on average for this purpose.

Interestingly, this significant difference between exporters and non-exporters with respect to R&D activities can only be observed based on the data of the second survey (see also the descriptive analysis in section 4.2.2). Comparing R&D activities in 1997, i.e., at the time of the first survey, no significant difference in mean R&D intensity could be found. Both exporters and non-exporters spent about 15 % of their total sales on R&D.[136] Obviously, during the period between the two surveys, R&D activities became a distinctive characteristic by which an internationally oriented firm distinguishes itself from its domestically focused competitors.

**Table 5-1: Comparison of Firms with and without International Sales in 2002**

| | **with international sales** | | | | **without international sales** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | mean value | median | standard deviation | *N* | mean value | median | standard deviation | *N* | *t*-test [f] |
| Sales [a] | 4,196.6 | 2,623 | 5,582.26 | 148 | 2,197.1 | 1,097 | 2,449.30 | 54 | *** |
| R&D employees | 2.9 | 2 | 4.27 | 138 | 0.9 | 0 | 1.75 | 45 | *** |
| Non-R&D employees | 28.5 | 18 | 38.87 | 137 | 14.5 | 8 | 16.07 | 45 | *** |
| Investments [a] | 249.9 | 80 | 440.22 | 135 | 111.3 | 32 | 237.16 | 47 | *** |
| Labour productivity [b] | 179.6 | 150.0 | 109.63 | 129 | 165.1 | 126.2 | 114.04 | 44 | |
| Annualised employment growth rate [c] | 7.7 | 5.9 | 12.66 | 157 | 2.2 | 3.1 | 11.29 | 55 | *** |
| Annualised sales growth rate [c d] | 14.6 | 13.0 | 14.93 | 141 | 8.3 | 7.4 | 12.20 | 51 | *** |
| R&D intensity (in %) [e] | 15.8 | 10 | 23.72 | 148 | 4.4 | 0 | 7.73 | 53 | *** |
| Age (in years) | 11.7 | 11 | 2.57 | 159 | 11.3 | 11 | 2.86 | 55 | |

[a] in € 1,000s; [b] Sales per non-R&D employee in € 1,000s; [c] Period 1997 – 2002; [d] Growth rates were computed using discounted sales; [e] Expenditures on R&D as percentage of sales; [f] *t*-test on the equality of means.
* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.
Source: ZEW, University of Exeter, own calculations.

135 Recall that the number of R&D employees given in Table 5-1 is an estimate based on the assumption that all R&D employees indicated by the firms' representatives only work on R&D for 50 % of their time.

136 Nevertheless, econometric analyses showed that R&D intensity had a positive impact on probability of internationalising in 1997 (Bürgel et al. 2004).

Descriptive statistics of the three chosen performance indicators that will be analysed econometrically (labour productivity, employment growth, sales growth) are also included in Table 5-1. Similarly to the other variables discussed above, mean labour productivity is higher for firms with international sales than for firms without exports. However, based on a t-test the difference is not significant. Regardless of whether or not a firm has international sales, it must ensure a certain level of productivity if it wants to survive. A firm without international business activities cannot afford to fall behind its internationally active competitors who (typically) also supply the domestic market. Therefore, there are only relatively small differences between exporters and non-exporters with respect to labour productivity. Figure 5-1 shows kernel density estimations of the log-labour productivity for German and UK-based firms. Both density functions are quite similar, indicating a similar distribution of log-labour productivity among German and UK firms. The density function for German firms lies slightly to the right of the UK function, showing that German firms have, on average, a slightly higher log-labour productivity than UK firms. It should be noted, however, that the labour productivity of Western German firms is significantly higher compared with UK-based firms, but the labour productivity of Eastern German firms is smaller – although not significantly according to a t-test.

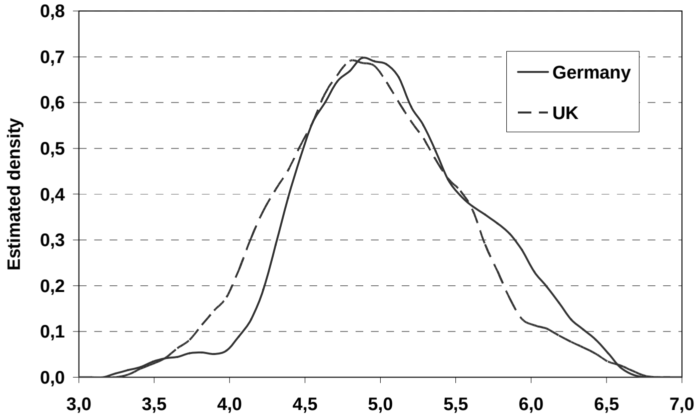
The average number of employees of firms with international sales grew significantly faster in the period from 1997 to 2002 compared with firms without international business activities. Exporters could, on average, realise an annualised employment growth rate of 7.7 %, whereas firms with only domestic sales grew by 2.2 % per year. Figure 5-1 depicts the estimated kernel densities of the logarithmic annualised employment growth rate. As in the case of log-labour productivity, the density functions for Germany and the UK are similar, but the estimated density of German firms' employment growth rates lies slightly to the right of the UK function. The estimated kernel densities in Figure 5-1 also emphasise that a relatively high proportion of firms has a negative employment growth rate, i.e., the firms shrank since 1997. The share of firms with a negative growth rate is higher for the UK (25 %) than for Germany (18 %).

Similarly, the annualised sales growth rate between 1997 and 2002 is significantly higher for exporters (14.6 % per year) than for non-exporting firms (8.3 %).[137] The estimated kernel density functions of the logarithmic annualised sales growth rate in Figure 5-1 show, on average, higher growth rates for German firms than for UK firms, but also a higher variance in the German sales growth rates. The share of firms with a negative sales growth rate is again higher for UK (18 %)

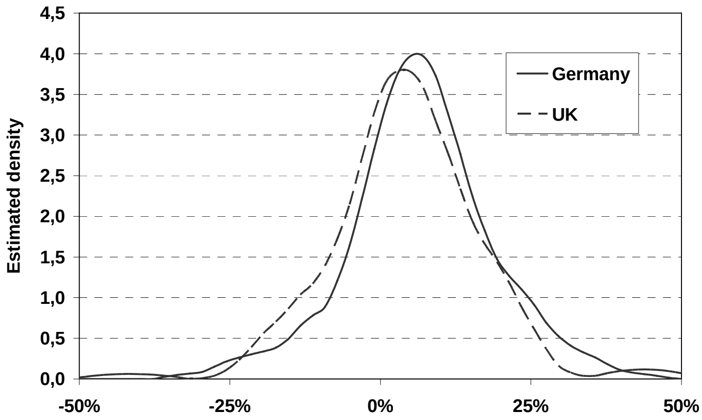
137 In order to compute the annualised sales growth rate, discounted sales were used, discounted by producer price indices (PPI). See appendix A.1 for details on the data sources used.

## Figure 5-1: Estimated Kernel Densities of Each Country's Labour Productivity and Growth Rates

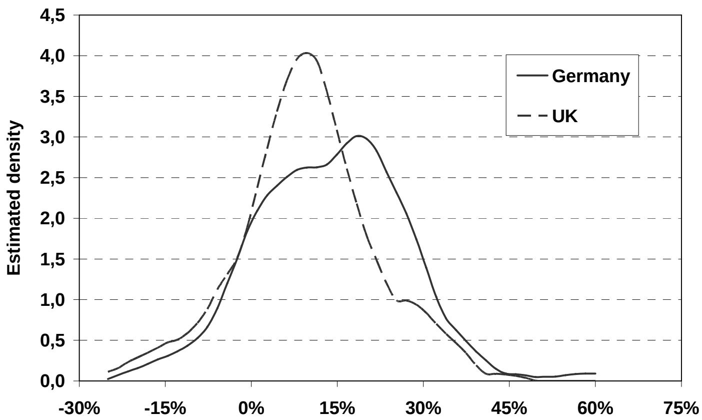
### Log-labour productivity 2002




### Annualised employment growth rate (log) 1997 – 2002




### Annualised sales growth rate (log) 1997 – 2002




Note: Only firms that participated in both surveys were considered.
Sales growth rates were computed using discounted sales.
Labour productivity: sales in € 1,000s per non-R&D employee.
Source: ZEW, University of Exeter, own estimation.

than for German firms (12 %). To summarise, internationally active firms exhibit superior performance, measured by labour productivity, employment or sales growth, than firms with only domestic sales. Further, the performance of UK-based firms lags behind that of their German counterparts.

As is apparent, sales grew faster than the number of employees. As a consequence, labour productivity was significantly higher in 2002 in comparison with 1997. This might be a result of the turbulent macroeconomic situation in high technology markets in the period from 1997 to 2002. In order to survive, firms had to improve their productivity, firstly, by employing a given number of workers more efficiently. Secondly, as shown by the descriptive analysis above, many firms dismissed workers and reduced their total number of employees. If they dismissed the least productive employees first, labour productivity would increase. Thirdly, firms may have substituted employees by other production factors, e.g., capital or (imported) intermediate products. Thus, each unit of output can then be produced by a smaller number of employees.[138]

Comparing the annualised growth rates in the period from 1997 to 2002 with the corresponding growth rates from start-up to 1997, both the employment and sales growth rates have fallen significantly on average. This observation is in accordance with the theoretical considerations that older firms are expected to grow slower (see section 5.2). As Table 5-1 shows, in 2002 the firms in our sample are an average of about 11 years old. Whether firm age is also suitable to explain varying growth rates during the period from 1997 to 2002 is questionable and will be tested in the next section, when the firms in our sample are all examined at a later stage of their development.

## 5.4 Simultaneous Equation Models

The relationship between performance and internationalisation will be analysed in a two-step approach. At first, simultaneous equation models will be applied. This allows us to estimate the structural parameters of the labour productivity and the growth model as well as to determine the causal relationship between the respective indicator of firm performance and the firms' international engagement. Thereafter, I will follow more recent literature (see, e.g., Wagner 2002, Girma et al. 2002, Arnold and Hussinger 2005, De Loecker 2004) and examine the relationship between internationalisation and firm performance using matching techniques. The latter were extensively applied in the literature in evaluating labour market policies (see Lechner and Pfeiffer 2001 for an

[138] In computing labour productivity in 1997, I have only considered firms that participated in both surveys, i.e., firms that have survived the following six years. Therefore, the increasing labour productivity cannot be a result of the market exit of less productive firms.

overview). The matching approach estimates the causal effect by comparing the mean outcome (productivity or growth) of internationally active firms with that of a control group of domestic firms. This guarantees that non-exporting firms share similar characteristics with firms that are engaged in the international market (see section 5.5).

### 5.4.1 Econometric Implementation

The labour productivity model is implemented econometrically as a switching regression model with endogenous switching as described by Maddala (1983). This model allows a simultaneous estimation of the probability of internationalisation and of the determinants of labour productivity. The model is given by three equations: two level (regime) equations for productivity, dependent on the respective firm's internationalisation status (*INTS*), and a binary selection equation that determines the internationalisation status of the firm in question:

$$\ln\left(\frac{Y_i}{L_i}\right)_{INTS=1} = \ln A_{INTS=1} + \alpha_{INTS=1}\ln\left(\frac{K_i}{L_i}\right) + \beta_{INTS=1}\ln\left(\frac{R_i}{L_i}\right) + \left(\mu_{INTS=1}-1\right)\ln L_i + u_{i,INTS=1}$$

(5.5)
$$\ln\left(\frac{Y_i}{L_i}\right)_{INTS=0} = \ln A_{INTS=0} + \alpha_{INTS=0}\ln\left(\frac{K_i}{L_i}\right) + \beta_{INTS=0}\ln\left(\frac{R_i}{L_i}\right) + \left(\mu_{INTS=0}-1\right)\ln L_i + u_{i,INTS=0}\,.$$

$$INTS_i = \begin{cases} 1 & if\ I_i^* = d\cdot\left(\ln\left(\frac{Y_i}{L_i}\right)_{INTS=1} - \ln\left(\frac{Y_i}{L_i}\right)_{INTS=0}\right) - C_i + v_i = Z_i\xi + \varepsilon_i > 0 \\ 0 & otherwise \end{cases}$$

The latent variable $I_i^*$ determines a firm's internationalisation decision, where $C_i$ are the costs of international business activities per (non-R&D) employee and $v_i$ is a normally distributed error term. The coefficient *d* measures the impact the gain in productivity due to international business activities has on the decision to internationalise. If *d* is equal to zero, the firm's export behaviour is independent of the productivity differential. The selection (read: internationalisation) equation is estimated as a reduced form. The parameter vector $Z_i$ includes both the production factors that explain labour productivity and the variables that both influence the costs $C_i$ of an international engagement and identify the selection equation. The error term $\varepsilon_i = d\cdot(u_{i,INTS=1} - u_{i,INTS=0}) + v_i$ is assumed to be normally distributed and the three error terms of equation system (5.5) follow a trivariate normal distribution, i.e.,

(5.6)
$$u \equiv \left[u_{i,\,INTS=0}, u_{i,\,INTS=1}, \varepsilon_i\right]' \sim N\left(0,\Omega\right), \quad \text{with}$$

(5.7) $$\Omega = \begin{bmatrix} \sigma_{00} & \sigma_{01} & \sigma_{0\varepsilon} \\ \sigma_{01} & \sigma_{11} & \sigma_{1\varepsilon} \\ \sigma_{0\varepsilon} & \sigma_{1\varepsilon} & 1 \end{bmatrix}.$$

$\sigma_{\varepsilon\varepsilon}$ is set to 1 due to identification. The covariance $\sigma_{01}$ cannot be estimated since one single firm is only observed either in the regime with international sales (*INTS* = 1) or in the regime without international sales (*INTS* = 0) – never simultaneously in both regimes. If $\sigma_{0\varepsilon} = \sigma_{1\varepsilon} = 0$, we have a switching regression model with exogenous switching. Otherwise, we have endogenous switching (Maddala 1983, p. 284). In the former case, labour productivity is independent of status of internationalisation. A possibly observed higher productivity for firms with international sales, then, is only a result of a superior endowment with firm-specific resources.[139]

In principle, it is possible to formulate the growth equation in dependence of the internationalisation status, analogous to equation system (5.5). However, while evaluating the labour productivity equation only requires estimates of four parameters (three partial production elasticities and the integer measuring the parameter of production efficiency), the estimation of the heuristic growth equation is more demanding in that the parameter vector $\delta$ in equation (5.4) contains more than ten parameters that have to be estimated. This constitutes a problem in the regime without international sales, where we have less than 40 observations. In fact, econometric analysis proves that almost all estimated coefficients in the regime without international sales are statistically insignificant, even if the point estimations are close to the (significant) point estimates of the respective coefficients in the regime with international sales. Thus, I decided to use a unique growth equation for both regimes (with and without international sales).

Estimating the relationship between firm growth and internationalisation, the three-equation model (5.5) then reduces to a two-equation model:

(5.8) $$\begin{aligned} &\ln G_i = X_i\delta + \theta \cdot INTS_i + u_i \\ &INTS_i = \begin{cases} 1 & if\ I_i^* = d \cdot (X_i\delta) - C_i + v_i = Z_i\xi + \varepsilon_i > 0 \\ 0 & otherwise \end{cases} \end{aligned}.$$

The two error terms $u_i$ and $\varepsilon_i = d \cdot u_i + v_i$ are bivariate normal with mean zero and covariance matrix

139 For more information see Maddala (1983) or Bertschek and Kaiser (2004). The model was estimated using the software package GAUSS, 6.0. The GAUSS code for the maximum likelihood function was written by Ulrich Kaiser and can be downloaded at http://www.ulrichkaiser.com/software.

$$(5.9) \qquad \Omega = \begin{bmatrix} \sigma_{uu} & \sigma_{u\varepsilon} \\ \sigma_{u\varepsilon} & 1 \end{bmatrix},$$

where $\sigma_{\varepsilon\varepsilon}$ is again set to 1 due to identification. As before, the selection equation is estimated as a reduced form. The parameter $\theta$ measures the effect of international sales on firm growth. Since the growth equation and the internationalisation equation are estimated simultaneously, possible self-selection of firms with higher growth into the international market is considered.[140]

Both models are estimated by Full Information Maximum Likelihood (FIML).

### 5.4.2 Empirical Results

#### Labour Productivity and Exports

The estimation results for the productivity equations with and without international sales are given in Table 5-2. In the regime with exports, the coefficients of both capital intensity and intensity of R&D employees are significant. The coefficient of the number of non-R&D employees does not differ significantly from zero, indicating that constant returns to scale cannot be rejected. The implied point estimate of the partial production elasticity of labour is 0.732. The shape of the production function in the regime without international sales differs from that in the regime with exports. The null hypothesis of constant returns to scale can also not be rejected (the coefficient of the number of non-R&D employees is insignificant). However, the partial production elasticity of R&D employees is no longer significant. In the regime of non-exporting firms more than half of the firms did not carry out any R&D activities, that is, the median number of R&D employees in this group is zero (see the discussion in section 5.3). Thus, the productivity-increasing effect of R&D employees in this regime is almost negligible. Instead, the point estimates of the partial production elasticities of capital and non-R&D employees are both higher for firms without international sales than in the regime of exporting firms (point estimate of the partial production elasticity of labour in the regime without exports: 0.870). However, due to relatively large standard errors in the productivity equation for the regime without international sales these differences are not significant.

In the regime with international sales, the dummy variable for "other manufacturing industries" is positive and significant. Compared to engineering firms and the base category, software and

140 Model (5.8) is also known as the treatment effects model (see Maddala 1983 or Greene 2000). The model was estimated using the software package STATA, version 8 SE.

**Table 5-2: Switching Regression Estimation Results: Level Equations**

| | | Coeff. | | Std. error |
|---|---|---|---|---|
| **Productivity equation for regime with international sales** | | | | |
| Log (capital intensity) | | 0.054 | * | 0.033 |
| Log (intensity of R&D employees) | | 0.242 | ** | 0.096 |
| Log (number of non-R&D employees) | | 0.028 | | 0.097 |
| Engineering | | 0.252 | | 0.165 |
| Other manufacturing industries | | 0.559 | *** | 0.161 |
| East Germany | | -0.724 | *** | 0.147 |
| Constant | | 5.344 | *** | 0.246 |
| $\rho_{1\varepsilon}$ | | -0.260 | | 0.513 |
| $\sigma_{11}$ | | 0.475 | *** | 0.041 |
| **Productivity equation for regime without international sales** | | | | |
| Log (capital intensity) | | 0.098 | ** | 0.042 |
| Log (intensity of R&D employees) | | 0.042 | | 0.247 |
| Log (number of non-R&D employees) | | 0.009 | | 0.335 |
| Engineering | | -0.020 | | 0.448 |
| Other manufacturing industries | | 0.199 | | 0.165 |
| East Germany | | -0.157 | | 0.200 |
| Constant | | 4.933 | *** | 0.417 |
| $\rho_{0\varepsilon}$ | | -0.230 | | 0.653 |
| $\sigma_{00}$ | | 0.391 | *** | 0.079 |
| **Wald tests for joint significance** | | | | |
| | | $\chi^2$ | | Prob > $\chi^2$ |
| Sector dummies | with internat. sales | 14.029 | | 0.001 |
| | without internat. sales | 1.510 | | 0.470 |
| Correlation coefficients | | 0.519 | | 0.771 |
| **Wald tests for identity of coefficients** | | | | |
| Log (capital intensity) | | 0.722 | | 0.396 |
| Log (intensity of R&D employees) | | 0.586 | | 0.444 |
| Log (number of non-R&D employees) | | 0.003 | | 0.957 |
| Production elasticity of non-R&D empl. ($\gamma$) | | 0.843 | | 0.359 |
| Sector dummies | | 2.472 | | 0.291 |
| East Germany | | 5.224 | | 0.022 |
| Constants | | 0.724 | | 0.395 |
| Number of observations | | | 143 | |
| Log-likelihood | | | -135.330 | |

* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.
Base category: a software/service firm.
Source: own estimation.

services, other manufacturing exporters exhibit higher labour productivity. In accordance with descriptive results, East German firms manifest significantly lower levels of labour productivity than their West German and UK rivals. Although this finding is in line with macroeconomic data, it might nevertheless be surprising, considering that we are examining firms that export and operate in a high-tech industry. East German firms with these characteristics should be able to realise world market prices and rents, allowing them to keep up with West German and UK firms. Note, however, that labour productivity is defined as sales per non-R&D employee. Because wages are lower in Eastern Germany (at least for non-R&D employees), firms might have substituted, for example, the production factor capital by non-R&D labour, leading statistically to a lower value for productivity.

The three dummy variables controlling for sectoral and regional differences are not significant in the regime without international sales. As already mentioned in the previous subsection, the number of observations is relatively small in this regime (only 35 for the final specification reported here). Whereas the estimations of the production function's parameters lead to plausible results, it appears to be impossible to empirically determine differences between industries and locations since there are only 5 engineering firms and 8 firms sited in Eastern Germany that belong to the regime of non-exporting firms.

The integer in the productivity equation measures the parameter of efficiency $A$ of the Cobb-Douglas production function. The point estimate of the efficiency parameter is smaller in the regime without international sales, indicating, ceteris paribus, that the isoquants of the production function of non-exporting firms lie closer to the origin. The difference is, however, not significant.

Decisive for the causal relationship between productivity and internationalisation are the estimations of the two correlation coefficients $\rho$ between the residuals of the regime equations and the internationalisation equation. As can be seen in Table 5-2, the two correlation coefficients are neither individually nor jointly significantly different from zero. Thus, the labour productivity equations are independent of the internationalisation equation. In other words, differences in labour productivity cannot be explained by export market participation, but are a result of a varying endowment with production factors, especially R&D, and of the distinct shape of the production function. This finding contradicts the results of Bürgel et al. (2004), who examined the same firm sample at an early stage of the firms' life cycles and found that internationalisation improves labour productivity. Hence, internationalisation may increase productivity during early stages of firm development. After firms have become established in the market and have reached a "mature" stage of their life cycles, the positive effect of internationalisation disappears.

**Table 5-3: Switching Regression Estimation Results: Selection Equation**

| | Coeff. | | Std. error |
|---|---|---|---|
| Work experience abroad | 0.760 | * | 0.399 |
| Education abroad | 1.089 | * | 0.630 |
| Intense product customisation | -1.144 | * | 0.620 |
| Log (capital intensity) | -0.091 | | 0.097 |
| Log (intensity of R&D employees) | 0.951 | *** | 0.312 |
| Log (number of non-R&D employees) | 1.306 | *** | 0.330 |
| Engineering | 1.185 | ** | 0.567 |
| Other manufacturing industries | 0.541 | | 0.392 |
| East Germany | 0.152 | | 0.534 |
| Constant | -0.893 | * | 0.536 |
| **Wald tests for joint significance** | | | |
| | $\chi^2$ | | Prob > $\chi^2$ |
| Entire set of identifiers | 7.050 | | 0.070 |
| Factor inputs | 16.498 | | 0.001 |
| Sector dummies | 5.309 | | 0.070 |
| Entire productivity equation | 27.212 | | 0.000 |
| Number of observations | | 143 | |
| Log-likelihood | | -135.330 | |

* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.
Base category: a software/service firm.
Source: own estimation.

Table 5-3 depicts the estimation results of the switching regression model for the selection, i.e., the internationalisation equation. In order to identify the selection equation, three variables were included that are assumed to be independent of labour productivity, but that determine the firms' internationalisation decisions.[141] The international experience that the firms' managers acquired before entering their respective firms facilitates international business activities. If one member of the management team has previous work experience abroad or was educated abroad, his firm will be more likely to have international sales. This result supports Johanson and Vahlne (1990), who stated that an internationally experienced management team can overcome the uncertainty present in foreign markets, and the resource-based view of the firm that regards international experience as an intangible asset that differentiates firms from their competitors. Further, intense product cus-

141 I also estimated the labour productivity equation separately for the two regimes by OLS, including the three identifying variables from the selection equation. The OLS model is, in fact, appropriate, because we found that the productivity equations and the internationalisation equation are independent from one another. In the productivity equation without international sales all three identifying variables are neither individually nor jointly significant. In the regime with international business activities, only the dummy variable that indicates whether one member of the firm's management team has work experience abroad is individually significant at the five-percent level, but the three variables are nevertheless jointly insignificant on the same level of significance. Thus, the three chosen variables can be regarded as appropriate for identifying the selection equation.

tomisation is a barrier to international business activities. If a firm has to consider the special needs of each customer, this increases the costs of international engagement. These findings are completely in accordance with the previous results obtained in chapter 4. The entire set of identifying variables is jointly significant, although only on the 10 % level.

Apart from capital intensity, the production factors enter the selection equation significantly. The intensity of R&D employees and the number of non-R&D employees are positively correlated with foreign market participation. Thus, the strategic role of R&D for the export behaviour of (small) technology-oriented firms that was already highlighted in chapter 4 is confirmed by this section's model. Firm size, measured by number of non-R&D employees, also increases the probability of being an exporter. As stated in the previous chapter, larger firms possess more resources that facilitate international business activities. Finally, engineering firms are significantly more likely to have international sales compared with the other manufacturing and service sectors, and the dummy variable indicating firms that are located in Eastern Germany does not influence the probability of foreign market participation.[142]

The variables determining labour productivity are obviously also relevant for the decision to export. Since the selection equation is estimated as a reduced form, the parameter *d* in the selection equation of equation system (5.5) that indicates whether the productivity differential between the regimes with and without international sales has an effect on the internationalisation decision is not estimated directly. However, because the coefficients of the variables of the productivity equations are individually and jointly significant, it can be concluded that the decision on export market participation is influenced by labour productivity in the sense that more productive firms are (or will become) exporters. Thus, this study confirms the findings of many other studies (see section 5.1): The higher labour productivity of firms with international sales is a result of self-selection into the foreign market.

This is a rather sobering result, considering that the productivity-increasing role of internationalisation is often stressed by policy makers and consultants. However, firm managers themselves are not motivated by potential productivity-enhancing effects when deciding on internationalisation.

[142] The higher probability of engineering firms having international sales contradicts the results obtained in section 4.2. The probability of foreign market entry of engineering firms is lower than that of other manufacturing firms and does not differ significantly from that of software and service firms. These contradictory results may be due to the fact that in this chapter, the status of internationalisation at the time of the second survey is examined, whereas in section 4.2 foreign market entry in the two periods from start-up to 1997 and from 1997 to 2003 is analysed. Moreover, the probability of engineering firms exiting from the international market is lower when compared with firms from other high-tech sectors. This finding is consistent with the greater probability of engineering firms being internationally engaged in 2003.

**Table 5-4: Motives for Entering the International Market 1997**

| | most important motive (in %) | least important motive (in %) |
|---|---|---|
| Potential of foreign market | 74.19 | 7.10 |
| Limited potential of domestic market | 22.58 | 22.58 |
| Amortisation of R&D costs | 7.10 | 38.71 |
| Learning effects | 3.87 | 32.90 |
| Reputation benefits | 14.84 | 18.71 |

Note: Firms with international sales in 1997. Only firms that participated in both surveys were considered. Some firms indicated more than one motive as most or least important.
Source: ZEW, London Business School.

When the firms in our sample were contacted for the first time, the firms' representatives were asked about the motives behind their international business activities. Firm managers had to rank five motives given by the questionnaire in order of importance. The ranking is illustrated by Table 5-4. Only 4 % of the firm managers indicated learning as their most important motive. On the other hand, for one-third of the respondents learning was least important. Instead, sales-oriented motivations proved to be far more essential. The limited potential of the domestic market and the expected potential of the foreign market, actually only two aspects of the same object, were cited by about 97 %[143] of the firm managers as their key reason for internationalisation. The amortisation of high research and development costs was regarded by 7 % of the firms as the most important motive. Since the amortisation of R&D costs is often only possible through fast company growth, this can also be regarded as a sales-oriented motive. Hence, sales and growth-related motivations are far more important than productivity or cost-related aspects.[144] Considering our estimation results, firm representatives do well not to expect too much from potential learning effects – at least in the long run. Whether their expectations with respect to growth effects of internationalisation are justified in the long run will be examined in the next subsection.

### Growth and Exports

The estimation results of the employment growth and the sales growth models are displayed in Tables 5-5 and 5-6, respectively. The upper part contains the results of the heuristic growth equations, the lower shows the estimations for the internationalisation equations.

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143 Some firms indicated two or three of the five given motives as most or least important. Therefore, the percentages do not add up to 100 %.

144 Even reputation effects of being an internationally active firm are more important than expected learning effects. 15 % of the firms indicated their hope of an improved reputation as their most important motive.

## Table 5-5: Employment Growth Model Estimation Results

| | Coeff. | | Std. error |
|---|---|---|---|
| **Employment growth equation** | | | |
| Log (number of employees $t$ - 1) | -0.138 | *** | 0.040 |
| Log (number of employees $t$ - 1) $^2$ | 0.019 | *** | 0.007 |
| Log (age in $t$ - 1) | -0.010 | | 0.017 |
| Permanent R&D activities | 0.118 | *** | 0.043 |
| Occasional R&D activities | 0.061 | * | 0.033 |
| Shortage of competencies: Marketing | -0.043 | ** | 0.020 |
| Shortage of competencies: R&D | -0.010 | | 0.024 |
| Window of opportunity ≤ 12 months | -0.015 | | 0.017 |
| Engineering | 0.035 | | 0.026 |
| Other manufacturing industries | 0.022 | | 0.022 |
| Dummy Germany | 0.024 | | 0.017 |
| Constant | 0.183 | *** | 0.060 |
| *International sales* | *0.001* | | *0.077* |
| $\rho$ | 0.157 | | 0.474 |
| $\sigma_{uu}$ | 0.010 | *** | 0.006 |
| **Internationalisation equation** | | | |
| Work experience abroad | 0.629 | ** | 0.294 |
| Education abroad | 0.446 | | 0.421 |
| Intense product customisation | -0.936 | *** | 0.336 |
| Log (number of employees $t$ - 1) | 0.367 | | 0.668 |
| Log (number of employees $t$ - 1) $^2$ | -0.034 | | 0.123 |
| Log (age in $t$ - 1) | -0.059 | | 0.315 |
| Permanent R&D activities | 1.911 | *** | 0.372 |
| Occasional R&D activities | 0.926 | ** | 0.385 |
| Shortage of competencies: Marketing | -0.040 | | 0.337 |
| Shortage of competencies: R&D | -0.085 | | 0.401 |
| Window of opportunity ≤ 12 months | 0.571 | * | 0.302 |
| Engineering | 1.193 | *** | 0.410 |
| Other manufacturing industries | 0.676 | ** | 0.300 |
| Dummy Germany | -0.175 | | 0.288 |
| Constant | -1.503 | | 1.022 |
| **Specification tests** | | | |
| | $\chi^2$ | | Prob > $\chi^2$ |
| *LR*-test of independence of equations ($\rho = 0$) | 0.13 | | 0.7223 |
| Wald test for joint significance in internat. eq.: | | | |
| Entire set of identifiers | 12.78 | | 0.0051 |
| Entire employment growth equation | 34.89 | | 0.0003 |
| Number of observations | | 175 | |
| Log-likelihood | | 94.5165 | |

* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.

Base category: UK software/service firm without R&D activities.

Source: own estimation.

In contrast to Gibrat's law, employment growth rate decreases with number of employees, measured at the beginning of the growth period 1997. As was the case in other empirical studies, for example, by Evans (1987a) or Almus et al. (1999), I find a non-linear, convex relationship between firm size and employment growth, indicated by the positive sign of the squared number of employees. It is, however, questionable whether the observed negative relationship between firm size and growth can be explained by firms approaching their minimum efficient scale (MES). On the one hand, there is indeed a number of firms that were founded only a few years before the onset of the growth period examined.[145] It is plausible to assume that these firms underwent growth processes in order to reach their MES. On the other hand, our sample includes firms that were ten years old in 1997. It can be expected that the latter firms had already arrived at their MES by 1997, making the negative relationship between number of employees in 1997 and employment growth unattributable to the firms' growth processes before reaching their MES. Further, we observe many firms that shrank during the growth period. For those firms the negative sign of the coefficient of number of employees means that the smaller the firm is, the slower it shrinks. Small firms that survive can only reduce their number of employees by a limited amount. Large firms can, and often have had to, reduce their number of employees significantly, probably because of decreasing demand following the high-tech market downturn in 2000.

In the sales growth equation, the coefficient of the amount of sales at the beginning of the growth period has the expected negative sign. Similarly, the coefficient of the squared sales in 1997 is positive as predicted by theory. However, neither previous sales nor squared previous sales are significant in the sales growth equation. It is not possible to determine whether there are systematic differences between employment growth and sales growth, or whether the insignificant results are due to the relatively small sample size in the sales growth equation, where we have 22 observations less than in the employment growth equation. Nevertheless, Gibrat's law cannot be rejected statistically by the results of the sales growth model. Sales growth is then determined by other variables or random effects.

The logarithm of firm age does not affect employment growth but has a negative impact on sales growth. On the basis of these mixed results, it is not clear whether the younger firms in our sample can still realise efficiency gains due to learning processes, or whether this effect has become irrelevant because most of the firms in our sample have, after all, reached a "mature" stage of their life cycles.

145 Remember that our sample contains firms that were founded between 1987 and 1996, inclusive. The growth period observed starts in the year of the first survey (i.e., 1997).

### Table 5-6: Sales Growth Model Estimation Results

| | Coeff. | | Std. error |
|---|---|---|---|
| **Sales growth equation** | | | |
| Log (sales $t$ - 1) | -0.105 | | 0.094 |
| Log (sales $t$ - 1) $^2$ | 0.006 | | 0.007 |
| Log (age in $t$ - 1) | -0.044 | ** | 0.020 |
| Permanent R&D activities | 0.049 | * | 0.029 |
| Shortage of competencies: Marketing | -0.049 | ** | 0.023 |
| Shortage of competencies: R&D | 0.013 | | 0.027 |
| Window of opportunity ≤ 12 months | -0.003 | | 0.018 |
| Log (age of product) | -0.026 | * | 0.015 |
| Engineering | -0.044 | | 0.028 |
| Other manufacturing industries | -0.031 | | 0.026 |
| Dummy Germany | 0.027 | | 0.020 |
| Constant | 0.629 | ** | 0.317 |
| *International sales* | *0.056* | | *0.057* |
| $\rho$ | -0.266 | | 0.313 |
| $\sigma_{uu}$ | 0.106 | *** | 0.006 |
| **Internationalisation equation** | | | |
| Work experience abroad | 0.638 | ** | 0.304 |
| Education abroad | 0.464 | | 0.498 |
| Intense product customisation | -0.832 | ** | 0.357 |
| Log (sales $t$ - 1) | 1.498 | | 1.536 |
| Log (sales $t$ - 1) $^2$ | -0.096 | | 0.110 |
| Log (age in $t$ - 1) | -0.190 | | 0.353 |
| Permanent R&D activities | 1.568 | *** | 0.343 |
| Shortage of competencies: Marketing | 0.095 | | 0.378 |
| Shortage of competencies: R&D | -0.111 | | 0.438 |
| Window of opportunity ≤ 12 months | 0.434 | | 0.318 |
| Log (age of product) | 0.183 | | 0.279 |
| Engineering | 1.016 | ** | 0.448 |
| Other manufacturing industries | 0.832 | ** | 0.367 |
| Dummy Germany | -0.277 | | 0.312 |
| Constant | -6.237 | | 5.203 |
| **Specification tests** | | | |
| | $\chi^2$ | | Prob > $\chi^2$ |
| *LR*-test of independence of equations ($\rho = 0$) | 0.13 | | 0.7169 |
| Wald test for joint significance in internat. eq.: | | | |
| Entire set of identifiers | 9.95 | | 0.0190 |
| Entire sales growth equation | 29.79 | | 0.0017 |
| Number of observations | | 153 | |
| Log-likelihood | | 71.9526 | |

* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.

Base category: UK software/service firm.

Source: own estimation.

As hypothesised, R&D activities increase both a firm's employment and sales growth rates. The dummy variable for permanent R&D activities characterises firms that carried out R&D continuously during the examined growth period. Thus, the firms created intangible assets that increased their growth rates, argued in accordance with the resource-based view of the firm. Firms may even build up inimitable assets that boost their growth through occasional R&D activities, but this dummy variable is only relevant in the employment growth equation and insignificant in the sales growth equation. It was thus neglected in the final specification of the sales growth model.

The dummy variable indicating an experienced shortage of skills in marketing significantly reduces employment and sales growth. On the other hand, shortages of skills in R&D do not significantly affect growth of sales or employment. Looking at the experienced shortages of skills over time indicated by firm managers, the percentage of firms with an affirmed shortage of competencies in R&D decreased between start-up and the first survey and again between 1997 and 2003, thus reflecting learning effects with respect to technical fields like production and R&D. Therefore, growth is evidently not restricted in this way. The shortages of skills in a more sales-oriented field such as marketing also reduced between the start-up period and 1997, but between 1997 and 2003 the percentage of firms whose management teams experienced a crucial shortage rebounded. In times of growing markets and a favourable macroeconomic situation, selling one's product might be relatively easy. After the high-tech market downturn in 2000, however, the intensified competition on the high-tech market forced firms to increase their efforts to promote sales in order to ensure growth or even survival. During a period of macroeconomic stagnation, firms' products and services are no longer sold "automatically". Sales-related capabilities become more important and shortages of competencies in marketing reduce growth.

Firms with a window of opportunity that lasts 12 months or shorter do not distinguish themselves significantly from firms with longer periods of this sort. Interestingly, when analysing the firms in our sample during the growth period between start-up and 1997, dummy variables indicating a large window of opportunity significantly reduced (employment) growth rates (see Bürgel et al. 2004). Probably, in the 1990s firms could afford to grow more slowly, under today's difficult market conditions, however, firms must fully exploit competitive advantages in order to maintain market position, even if they are potentially able to profit from a relatively long competition-free period. As hypothesised, the age of a firm's best selling product negatively affects its sales growth rate, although the coefficient is only significant on the 10 % level and insignificant in the employment growth equation (and therefore not included in the final specification of the employment growth model). Firms with older and possibly out-of-date products exhibit smaller sales growth rates than firms that generate a higher share of sales with more recently developed products.

Industry-specific differences are of minor importance after controlling for the factors discussed above. Similarly, in accordance with the descriptive results depicted in Figure 5-1, the dummy variable for German firms is positive but insignificant. Thus, there are no systematic differences between German and UK firms additional to those covered by the growth models.

International sales do not affect employment or sales growth significantly. Furthermore, the estimated correlation coefficients $\rho$ between the residuals of the growth equation and the internationalisation equation are also not significantly different from zero, making the employment growth and sales growth equations each statistically independent of the respective internationalisation equation. As in the case of labour productivity and in contrast to the expectations of the firms' managers, internationalisation does not improve firm performance (measured by employment or sales growth).

The set of identifying variables in the internationalisation equation is jointly significant. Further, the estimation results for the individual variables are similar to the labour productivity model: Firm managers having work experience abroad increase the probability of their companies being exporters, whereas high product customisation is a barrier to entry into the foreign market.[146] [147]

The variables of the growth equation are jointly significant in the corresponding internationalisation equation, thus showing that the variables determining growth also affect the internationalisation decision. Somewhat surprisingly, neither number of employees nor amount of sales is significant in the estimated reduced form of the selection equation. In most other studies, in which a measure of firm size is regressed on the probability of having international sales, the coefficient of firm size is positive and significant. My findings may be due to the fact that the number of employees and the volume of sales at the beginning of the growth period were included in the selection equation, while the endogenous variable is a firm's participation in the foreign market in 2003. Current firm size is intended to approximate the firms' current resources and thereby expected to be positively correlated with their current export activities. Over a six-year period,

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146 In contrast to the estimation results for the labour productivity model, the dummy variable indicating whether a firm manager was educated abroad is not significant in the growth models. It is difficult to interpret why this single variable is significant in the selection equation of the labour productivity model but insignificant in that of the growth models. However, since there are two variables measuring specific human capital that facilitates international business activities and at least one dummy variable is significant, the two dummy variables should be interpreted together as reflecting one dimension of specific human capital.

147 As with the productivity model, I estimated the two growth equations by OLS, including the three identifying variables from the selection equation. The OLS model is again appropriate, since the growth equation and the respective selection equation are independent of one another. In both OLS regressions, the three identifying variables are individually and jointly insignificant. Thus, employment and sales growth are independent of these variables.

however, firms vary in size. Firms' dimensions at the beginning of the growth period might be very different from their size at its end. Hence, there may not be a positive correlation between lagged firm size and current export activities. It is also surprising that the dummy variable indicating a short window of opportunity becomes significant in the selection equation of the employment growth model. I cannot currently offer a convincing interpretation of this effect. The higher probability of manufacturing firms being exporters, however, is plausible and in line with the descriptive results (see section 4.2).

The estimation results of the internationalisation equation particularly emphasise the crucial role of R&D activities. On the one hand, R&D activities increase the probability of exporting; on the other, they enhance employment and sales growth. This means that good firms – or, to be more precise, more innovative firms – become exporters. After considering the self-selection of the more innovative firms into the foreign market, the status of internationalisation has no marginal effect on firm growth.

## 5.5 Matching Approach

As an alternative to the simultaneous equation models estimated in the previous section, I will now re-examine the relationship between internationalisation and firm performance using matching techniques, which have often been applied when evaluating labour market policies (see Lechner and Pfeiffer 2001). The basic idea of a matching approach based on the model of potential outcomes by Roy (1951) and Rubin (1974) is to estimate the causal effect of a labour market programme or, as in our case, of export market participation by comparing the mean of outcomes (e.g., wage level, unemployment duration, labour productivity, or firm growth) of those individuals or firms that participated in the labour market programme or in the foreign market with the mean of outcomes of a control group of non-participants. The matching approach guarantees that the non-participating individuals or firms in the control group share similar (ideally identical) characteristics (e.g., gender, level of education, endowment with firm-specific assets) with the individuals or firms in the group of participants. If the mean outcome of the participants is still lower or higher than that of the non-participants, this effect cannot then be attributed to varying characteristics of individuals or firms but can be interpreted as a causal effect of the labour market programme or firms' export activities.

### 5.5.1 Econometric Implementation

Let $\theta^1$ denote the causal effect that results from firms' international engagement:

(5.10) $$\theta^1 := E\left[Y^1 - Y^0 \middle| INTS = 1\right] = E\left[Y^1 \middle| INTS = 1\right] - E\left[Y^0 \middle| INTS = 1\right],$$

where $E\left[Y^1 \middle| INTS = 1\right]$ is the expected outcome of exporting firms and $E\left[Y^0 \middle| INTS = 1\right]$ is the average counterfactual outcome the same firms would have experienced had they not exported. Since an exporting firm (*INTS* = 1) cannot be observed in the regime without international sales (*INTS* = 0), $E\left[Y^0 \middle| INTS = 1\right]$ cannot be calculated using non-experimental survey data and must therefore be estimated. Moreover, since exporting and non-exporting firms in our sample differ in various important characteristics (see Table 5-1), it is not appropriate to estimate the counterfactual outcome by the simple mean outcome of non-exporting firms. This would be possible only in the case of an experiment where the internationalisation status is randomly assigned to the firms in the sample. Otherwise, the mean outcome of non-exporting firms is a biased estimator:

(5.11) $$E\left[Y^0 \middle| INTS = 1\right] \neq E\left[Y^0 \middle| INTS = 0\right].$$

In order to identify a causal effect in a non-experimental setting, Rubin (1977) introduced the conditional independence assumption (CIA):

(5.12) $$Y^0 \perp INTS \middle| X = x,$$

i.e., internationalisation status and outcome are independent for firms with the same realisations *x* of a set of exogenous variables *X*. The CIA is, however, only valid if all relevant variables that simultaneously influence the outcome and the internationalisation process are known and observed in the data set. In the previous section, three simultaneous equation models of the relationship between the firms' internationalisation behaviour and the respective indicator of firm performance (labour productivity, employment growth, sales growth) were estimated. For all three models, it was possible to determine which variables explain both the level of firm performance and the probability of having international business activities. Thus, our previous results provide information that ensures the validity of CIA. However, as Lechner (1998) pointed out, it is not possible to check the validity of CIA with a formal statistical test.

In practical applications, the vector *X* has a relatively high dimension in order to ensure the validity of CIA. For example, the internationalisation equation of both the employment and the sales growth models derived in the previous subsection contain 14 exogenous variables (not including the integer). However, Rosenbaum and Rubin (1983) showed that the problem posed by a high dimension of $X$ can be avoided by using so-called balancing scores. If a function $b(x_i)$ is a balancing score, equation (5.12) becomes:

$$(5.13) \quad Y^0 \perp INTS \,|\, X = x \quad \Rightarrow \quad Y^0 \perp INTS \,|\, b(X) = b(x).$$

The function $b(x_i)$ must further meet condition (5.14):

$$(5.14) \quad E\left[ INTS \,|\, b(X) = b(x) \right] = E\left[ INTS \,|\, X = x \right] = \Pr(x).$$

The conditional probability of export market participation $\Pr(x)$ is also labelled as the propensity score. Finally, the vector $X$ must not contain firm-specific characteristics for which the probability of exporting takes the values zero or one, i.e., $0 < \Pr(x) < 1$. Examples of balancing scores that are compatible with the CIA cover a wide range of measures including $b(x) = x$ and $b(x) = \Pr(x)$.

In order to interpret the results of the matching approach as causal effects, the validity of another condition is essential: Individual firms' outcomes must not be influenced by the potential foreign market participation of other firms. This condition is called SUTVA (stable unit treatment value assumption; see Angrist et al. 1996). This assumption may be problematic if regional spillover effects exist, allowing non-exporting firms to profit from other firms' exporting activities such that the latter's international business activities have a productivity or growth-increasing effect on both exporting and non-exporting companies (cf. Aitken et al. 1997).[148] In this case, it will be difficult to interpret differences in firms' performance as a result of their international engagement. However, regional spillover effects are more likely to be caused by large multinational companies than by young and small high-tech firms like those in our sample. Furthermore, the number of firms that is actually observed in our data set is relatively small and distributed throughout Germany and the UK. It is thus unlikely that the international engagement of our sample's exporters has an indirect effect on the performance of our sample's non-exporters. Nevertheless, we have to consider that our results may be biased if regional spillover effects are prevalent. However, as Lechner (1998) argued, a microeconometric analysis seems to be reasonable even if the SUTVA condition is not fulfilled, since such an analysis can at least illustrate the boundaries of the real effects.

Assuming that the CIA and SUTVA conditions are both valid, the average counterfactual outcome of the sample's exporters can be estimated in an unbiased way by the outcome of non-exporters – provided that exporters and non-exporters (i.e., the control group) have similar (ideally identical) realisations of $X$:

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148 In the related literature, SUTVA is sometimes labelled as the absence of general equilibrium effects (cf. Lechner 1998) or the absence of macroeconomic effects (cf. Garfunkel et al. 1992).

(5.15) $E\left[Y^0 \middle| INTS = 1, X = x\right] = E\left[Y^0 \middle| INTS = 0, X = x\right]$.

Equation (5.10) then becomes:

(5.16) $\theta^1 := E\left[Y^1 \middle| INTS = 1, X = x\right] - E\left[Y^0 \middle| INTS = 0, X = x\right]$.

As already mentioned above, the relatively high dimension the vector *X* has in practical applications prohibits conditioning on *X*. Instead, as Rosenbaum and Rubin (1983) showed and I discussed above, it is possible to reduce the problem of multidimensionality by choosing another balancing score. The most simple matching algorithm then involves selecting for each exporting firm *i* a partner *j* from the pool of non-exporters for which the chosen balancing score is as close as possible to the related score of the exporting firm *i*. The balancing scores are usually obtained by initially estimating a probit model which directly calculates the propensity score (i.e., the most simple form of the balancing score) for each firm in the sample:

(5.17) $E\left[INTS_i \middle| x_i\right] = \Pr\left[INTS_i = 1 \middle| x_i\right] = \Phi\left(x_i'\hat{\beta}\right)$,

where $\Phi\left(x_i'\hat{\beta}\right)$ is the cumulated density function of the standard normal.

In the previous section, three simultaneous equation models were estimated. Each model contained an internationalisation equation through which the probability of an engagement in the foreign market was determined. Since our results showed that the internationalisation equation and the related level equation (for labour productivity or firm growth) are independent from one another, the former equation can be estimated by a simple probit model. Thus, as the first step of the matching analysis in this section, I applied a probit model to re-estimate the three internationalisation equations. Not surprisingly, the results are very similar to those in section 5.4.2 and are given in Table 5-7. It should be emphasised that in the following, I will use three different specifications of the internationalisation equation – one for each indicator of firm performance. For the CIA to be valid, the vector *X* must include all variables that simultaneously influence both the status of internationalisation and the measure of firm performance that constitutes the outcome variable of the related matching estimator. By design, the internationalisation equations contain all variables that determine the related level equation. Additionally, in order to identify the export decision, three dummy variables were included indicating whether a firm manager had work experience abroad before joining the company, whether he was educated abroad, and whether the firm's best-selling product required intense product customisation. The internationalisation equations are interpreted in detail in the previous subsection and will therefore not be re-examined here.

## Table 5-7: Probit Estimations Results for Export Market Participation

| | | | |
|---|---|---|---|
| **Labour productivity model** | | | |
| Number of observations | 143 | | |
| Log-likelihood | -48.282 | | |
| McFadden's $R^2$ | 0.393 | | |
| | Coeff. | | Std. error |
| Work experience abroad | 0.760 | ** | 0.321 |
| Education abroad | 1.089 | ** | 0.523 |
| Intense product customisation | -1.144 | *** | 0.390 |
| Log (capital intensity) | -0.091 | | 0.078 |
| Log (intensity of R&D employees) | 0.951 | *** | 0.271 |
| Log (number of non-R&D employees) | 1.306 | *** | 0.300 |
| Engineering | 1.185 | *** | 0.441 |
| Other manufacturing industries | 0.541 | | 0.332 |
| East Germany | 0.152 | | 0.425 |
| Constant | -0.893 | * | 0.481 |
| **Employment growth model** | | | |
| Number of observations | 175 | | |
| Log-likelihood | -61.552 | | |
| McFadden's $R^2$ | 0.328 | | |
| Work experience abroad | 0.648 | ** | 0.280 |
| Education abroad | 0.464 | | 0.411 |
| Intense product customisation | -0.907 | *** | 0.327 |
| Log (number of employees $t$ - 1) | 0.352 | | 0.668 |
| Log (number of employees $t$ - 1) $^2$ | -0.030 | | 0.123 |
| Log (age in $t$ - 1) | -0.071 | | 0.316 |
| Permanent R&D activities | 1.893 | *** | 0.369 |
| Occasional R&D activities | 0.941 | ** | 0.385 |
| Shortage of competencies: Marketing | -0.061 | | 0.329 |
| Shortage of competencies: R&D | -0.056 | | 0.395 |
| Window of opportunity ≤ 12 months | 0.583 | * | 0.298 |
| Engineering | 1.214 | *** | 0.405 |
| Other manufacturing industries | 0.695 | ** | 0.293 |
| Dummy Germany | -0.185 | | 0.290 |
| Constant | -1.518 | | 1.006 |

*Continued next page.*

*Continued from Table 5-7.*

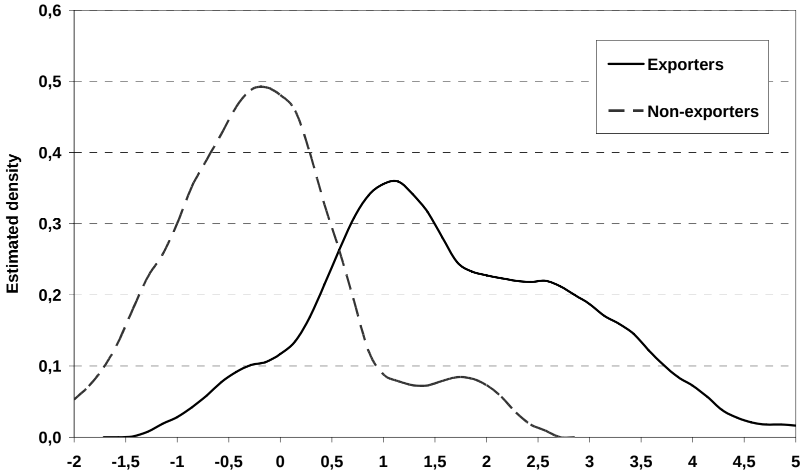
| **Sales growth model** | | | |
|---|---|---|---|
| Number of observations | | 153 | |
| Log-likelihood | | -54.986 | |
| McFadden's $R^2$ | | 0.332 | |
| Work experience abroad | 0.609 | ** | 0.297 |
| Education abroad | 0.497 | | 0.498 |
| Intense product customisation | -0.828 | ** | 0.358 |
| Log (sales $t$ - 1) | 1.583 | | 1.523 |
| Log (sales $t$ - 1) $^2$ | -0.102 | | 0.109 |
| Log (age in $t$ - 1) | -0.170 | | 0.347 |
| Permanent R&D activities | 1.589 | *** | 0.338 |
| Shortage of competencies: Marketing | 0.114 | | 0.374 |
| Shortage of competencies: R&D | -0.129 | | 0.434 |
| Window of opportunity ≤ 12 months | 0.442 | | 0.317 |
| Log (age of product) | 0.194 | | 0.277 |
| Engineering | 0.990 | ** | 0.441 |
| Other manufacturing industries | 0.837 | ** | 0.368 |
| Dummy Germany | -0.277 | | 0.312 |
| Constant | -6.601 | | 5.126 |

* 10 % level of significance; ** 5 % level of significance; *** 1 % level of significance.
Base category: a software/service firm.
Source: own estimation.

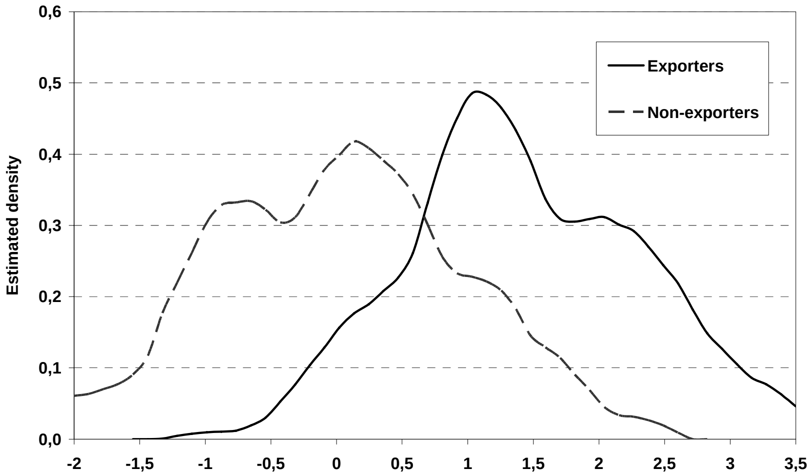
Following Lechner (1999), I use the unbounded propensity score $x_i'\hat{\beta}$ that results from the probit estimations instead of the bounded propensity score $\Phi\left(x_i'\hat{\beta}\right)$ as the main matching variable. As Lechner (1999) argued, matching on the bounded propensity score leads to undesirable asymmetry if $\Phi\left(x_i'\hat{\beta}\right)$, i.e. the predicted probability of internationalisation, is close to 0 or 1. In our data set there are a large number of exporters whose bounded propensity score is, in fact, close to 1, supporting the decision to use the unbounded score for the matching approach in this study. Figure 5-2 depicts the estimated kernel densities of the unbounded propensity scores taken from the labour productivity model and the two growth models. It is evident that the estimated densities that relate to exporting firms always lie to the right of the densities describing the unbounded scores of firms without international sales. The latter density curves reach their global maximum at a lower unbounded propensity score than the curves of exporting firms. Most importantly, the curves do not overlap over the entire range of the unbounded propensity score. However, the matching approach is only meaningful if it is possible to find a comparable non-exporting firm for each firm with international sales. Of course, it is always possible to carry out a nearest-neighbour matching, selecting mechanically for each exporter *i* the non-exporting firm *j* for which the (unbounded)

**Figure 5-2: Estimated Kernel Densities of Unbounded Propensity Scores**

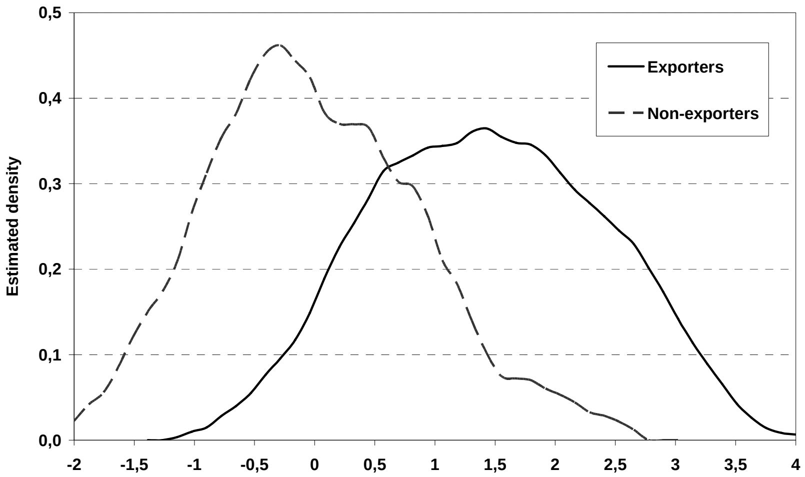
**Labour productivity model**




**Employment growth model**




**Sales growth model**




Explanations: see text.

Source: own estimation.

propensity score is closest to that of exporter *i*. However, as Heckman et al. (1997) pointed out, matches are likely to be poor if the (unbounded) propensity scores are very different for the paired firms, i.e., if the firms deviate considerably from each other with respect to their specific characteristics. Unfortunately, in non-experimental studies it is not uncommon to find that participating individuals or firms are very different from those in the non-participating subsample. As a consequence, matching analyses are generally conditioned on the support *S* shared by both the participant and control groups:

$$(5.18)\quad S = \text{Supp}\left(X \,|INTS = 1\right) \cap \text{Supp}\left(\text{X}|\text{INTS=0}\right).$$

The region of common support *S* has to be estimated if the balancing score on which the matching is conditioned is not the vector *X* but, e.g., the estimated propensity score $\hat{P}$. In this case, we have:

$$(5.19)\quad \hat{S} = \left\{\hat{P} \in \hat{S}^1 \cap \hat{S}^0 : \quad \hat{f}\left(\hat{P}|INTS = 1\right) > 0 \quad \wedge \quad \hat{f}\left(\hat{P}|INTS = 0\right) > 0\right\},$$

where $\hat{S}^1$ is the estimated support of participants (exporting firms) and $\hat{S}^0$ the support of non-participants; $\hat{f}$ is an estimated density at all the sample $\hat{P}$ values (Heckman et al. 1997).

Restricting the analysis to the region of common support assures the similarity of exporting firms to those from the control group. The disadvantage is, however, that the estimated causal effects are only valid for those firms in our sample of which the balancing scores belong to the region of overlapping support. As depicted in Figure 5-2, there is a relatively large number of exporting firms for which the unbounded propensity score exceeds the maximum score of the firms without international sales. For example, in the labour productivity model, 41 of 108 exporters have an unbounded propensity score that is higher than the maximum score from the group of non-exporting companies. Evaluating a job training programme, Heckman et al. (1997) compared its estimated impact using experimental data (i.e., where the common support condition is met by design) with the estimated outcome using a non-experimental data set which required a restriction on persons in the overlapping support region. Heckman et al. proved empirically that such a restriction led to a severe bias in the estimated impact of the programme. Since experiential data are, of course, not available for our study, a potential bias of the estimated causal effects cannot be avoided and has to be considered when interpreting the results.

Strictly speaking, the common support condition demands that all firms for which the balancing score does not belong to region of common support have to be excluded from the matching analyses. Since the number of observations in our data set would be relatively small even if we were able to use all responding firms for the matching analyses, I decided to retain those exporting firms in the data set for which the estimated balancing score exceeds, but is "close" to the maximum score of firms without international sales.[149] For these internationally active firms, the non-exporting firm responsible for this maximum score should be a sufficiently appropriate match – at the least, it should not be worse than matching the non-exporting firm with the maximum score with exporters that have a slightly smaller balancing score.

Before explaining in detail the matching techniques used in this study, it has to be stressed that this study distinguishes itself from most other analyses that have also applied matching techniques (in particular, those from the field of labour economics) in an important way. Normally, there are far more non-participants in the investigated data sets than participating individuals or firms. In our data set, however, there are about three times as many firms evincing international business activities as firms with only domestic sales.[150] This will probably impede finding a similar non-exporting counterpart for each internationally active firm in our data set even if we restrict the analysis to the region of common support. Technically, it may be necessary to match a non-exporter to more than one firm with international sales (matching with replacement).

### 5.5.2 Results of Kernel Matching

In this study, I decided to use two different matching techniques: kernel matching and a combination of Mahalanobis distance matching and caliper matching. I will begin by discussing the results of the kernel matching approach (see Heckman et al. 1997, Heckman et al. 1998).

In contrast to nearest neighbour matching, where exactly *one* firm from the pool of non-exporters is assigned to each firm with international sales, kernel matching pairs to each exporter *i* a *group* $D_i$ of similar non-exporting firms. The realised outcome of exporter *i*, $y_i^1$, is then associated with a weighted average outcome $\tilde{y}_i^0$ of all members of group $D_i$:

$$(5.20) \qquad \tilde{y}_i^0 = \sum_{j \in D_i} w_{ij} y_j^0 \qquad \text{with} \qquad \sum_{j \in D_i} w_{ij} = 1,$$

where $w_{ij}$ is the weight on the outcome of non-exporting firm *j*, $y_j^0$, in calculating a comparison outcome for exporter *i*. Kernel-based matching weights the outcome of non-exporting firms by a kernel function $K(\cdot)$ such that

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149 What is meant by a "close" distance with respect to the balancing score is explained in detail below.

150 Almus and Czarnitzki (2003) used matching techniques in order to evaluate the effects of public R&D subsidies on firms' innovation activities in Eastern Germany. Due to the special situation in Eastern Germany after reunification, their data set contains about twice as many firms that received subsidies as non-recipients.

(5.21) $$w_{ij} = \frac{K\left(\frac{(x_i'\hat{\beta}) - (x_j'\hat{\beta})}{h}\right)}{\sum_{j \in D_j} K\left(\frac{(x_i'\hat{\beta}) - (x_j'\hat{\beta})}{h}\right)}.$$

The kernel function depends on the chosen balancing score, i.e., in our case, the estimated unbounded propensity score; $h$ is a predetermined bandwidth (see below). Various kernel functions could be used (e.g., Gaussian, biweight, uniform, Epanechnikov). Most of them place higher weights on non-exporters that are close to the internationally active firm $i$ (in terms of the unbounded propensity score) and lower weights on more distant observations.[151] In this study, I used the Epanechnikov kernel function, which is defined as

(5.22) $$K_{Epan}(z) = \begin{cases} 1 - z^2 & if \quad |z| < 1 \\ 0 & otherwise \end{cases}.$$

This functional form implies that only the non-exporting firms within the predetermined bandwidth $h$ from $x_i'\hat{\beta}$ constitute the comparison group $D_i$:

(5.23) $$D_i = \left\{ j \in \{INTS = 0\} \middle| \left| x_i'\hat{\beta} - x_j'\hat{\beta} \right| < h \right\},$$

where $\{INTS = 0\}$ is the set of all non-exporting firms in the data set. The bandwidth was set to $h = 0.6$.[152] If the absolute distance in terms of the unbounded propensity score between an exporter $i$ and the closest non-exporting firm $j$ is greater than the predetermined bandwidth $h$, there will not be any observations in the comparison group $D_i$ and exporter $i$ will be excluded from the causal analysis. In this way, most exporters whose unbounded propensity scores do not belong to the region of common support (i.e., the score of exporter $i$ exceeds the maximum score of the firms without international sales) are no longer considered. Similarly, some non-exporting firms with the smallest unbounded propensity scores do not enter into any comparison group $D_i$ and are thus also left out of the analysis of causal effects.[153] It should further be noted that for some exporters $i$, their

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151 An exception is the uniform kernel function, which places an equal weight an all non-exporting firms that belong to the comparison group $D_i$.

152 I chose the bandwidth arbitrarily. My results presented below are, however, sensitive neither to the size of the bandwidth nor to the kernel function applied.

153 If a Gaussian kernel function were used, all non-exporting firms would belong to the comparison group of each internationally active firm – even though the weight of some non-exporters may be very small. Since, in contrast to the Epanechnikov function, the range of the normal density function is infinite, no firms would be excluded from the causal analysis. Thus, the Gaussian kernel function seems to be inappropriate for examining our data set.

comparison group $D_i$ only contains one or two non-exporting firms since there are no additional firms without international sales within a bandwidth of $h$. This is particularly relevant for exporters with a relatively large unbounded propensity score since, as is evident in Figure 5-2, there are only a few non-exporting firms evincing high scores.

The causal effect $\theta^1$ of international business activities on the related indicator of firm performance is consistently estimated as the difference of the mean outcome of exporters (provided that they are not excluded from the analysis) and the weighted mean outcome of matched non-exporters (the so-called "average treatment effect on the treated"):

$$(5.24) \qquad \hat{\theta}^1 = \frac{1}{N^1}\left(\sum_{i=1}^{N^1} y_i^1 - \sum_{i=1}^{N^1} \tilde{y}_i^0\right),$$

where $N^1$ is the number of exporting firms that are retained for the causal analysis. The results are given in Table 5-8.[154] $N^0$ is the unweighted number of non-exporters that enter the analysis (the weighted number is, of course, equal to $N^1$). The standard errors and confidence intervals of the estimated differences $\hat{\theta}^1$, i.e. the causal effects, were obtained via bootstrapping using 500 replications. The 90 % confidence intervals were estimated in two distinct ways: The upper row shows

**Table 5-8: Results of Kernel Matching**

| Mean outcome of exporters | ($N^1$) | Mean outcome of non-exporters (weighted) | ($N^0$) | Difference | Std. error | 90 % confidence interval | | |
|---|---|---|---|---|---|---|---|---|
| **Log-labour productivity 2002** | | | | | | | | |
| 5.034 | (80) | 5.037 | (32) | -0.003 | 0.164 | -0.299 | 0.243 | (P) |
| | | | | | | -0.272 | 0.267 | (N) |
| **Annualised employment growth rate (log) 1997–2002** | | | | | | | | |
| 0.072 | (127) | 0.041 | (36) | 0.031 | 0.025 | -0.002 | 0.078 | (P) |
| | | | | | | -0.010 | 0.071 | (N) |
| **Annualised sales growth rate (log) 1997–2002** | | | | | | | | |
| 0.128 | (107) | 0.150 | (33) | -0.022 | 0.042 | -0.064 | 0.071 | (P) |
| | | | | | | -0.091 | 0.047 | (N) |

N: Confidence interval assuming an approximately normally distributed statistic; P: Percentiles of the bootstrap distribution.

Note: Only firms that participated in both surveys were considered.

Source: own estimation.

154 The results were obtained using the `psmatch2` command programmed by Edwin Leuven and Barbara Sianesi for the software package STATA, version 8.2 SE (see Sianesi 2001). The command is available online at http://ideas.repec.org/s/boc/bocode/html.

the percentiles of the bootstrap distributions, while the lower row contains confidence intervals based on the assumption of approximate normality of the bootstrap distributions. Our results are, however, the same, regardless of the method used for calculating the confidence intervals.

The main finding is quite straightforward: International business activities do not have any significant influence on the three examined indicators of firm performance. The differences between exporters' mean outcomes and the average outcomes of matched firms without international sales do not diverge significantly from zero at any conventional level. The point estimates of the differences between the labour productivity and the sales growth model are even negative, although not significantly so. Thus, the results obtained from estimating the simultaneous equation models in the previous section are confirmed when matching techniques are applied: The superior performance of exporters is a result of the self-selection of "good" firms into the international market.

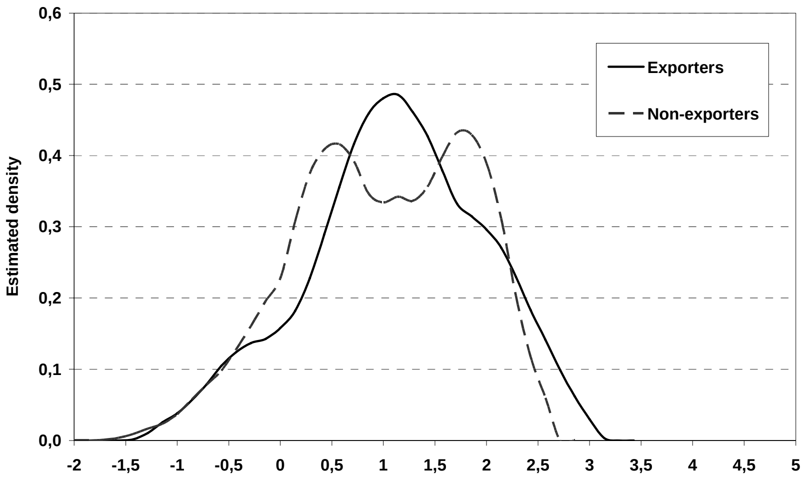
Figure 5-3 displays the estimated kernel densities of the unbounded propensity scores after matching. The curves representing exporting firms differ from those depicted in Figure 5-2 by the firms which are excluded from the causal analysis since there are no non-exporting firms within the bandwidth $h$. The graphs indicating firms without international sales are weighted by $\sum_i w_{ij}$ , with $w_{ij}$ defined in equation (5.20). Since matching with replacement was carried out, these weights may add up to a value greater than one.

Obviously, after matching, the range of the two curves overlaps almost completely. There are still some observations in the group of exporting firms whose unbounded propensity scores are higher than the maximum score of firms without international sales. This is a result of the fact that exporting firms for which the propensity score is close to the maximum score of the control group are allowed into the causal analysis. The three curves representing the respective control group of non-exporting firms each have two local maxima. This is most apparent for the labour productivity model but also applies to the other two models. As is evident from Figure 5-2, most firms without international sales have a relatively low unbounded propensity score, centred around the left local maximum. On the other hand, there are only a few non-exporting firms that have a large unbounded propensity score. Thus, the right local maximum represents a small number of firms with high weights, since these firms are (repeatedly) matched to a relatively large number of internationally active firms.[155] Our results therefore depend to a great extent on a few observations in the control group.

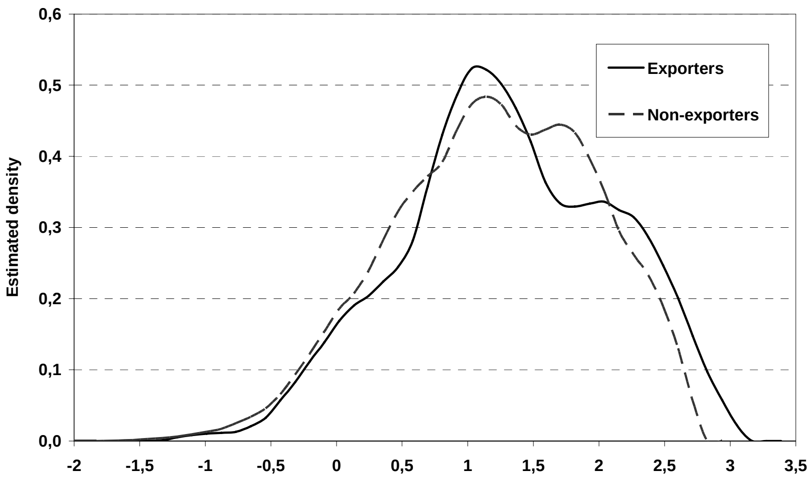
155 In fact, in the labour productivity model only three (!) non-exporting firms are responsible for the right local maximum.

## Figure 5-3: Estimated Kernel Densities of Matched Unbounded Propensity Scores: Kernel Matching

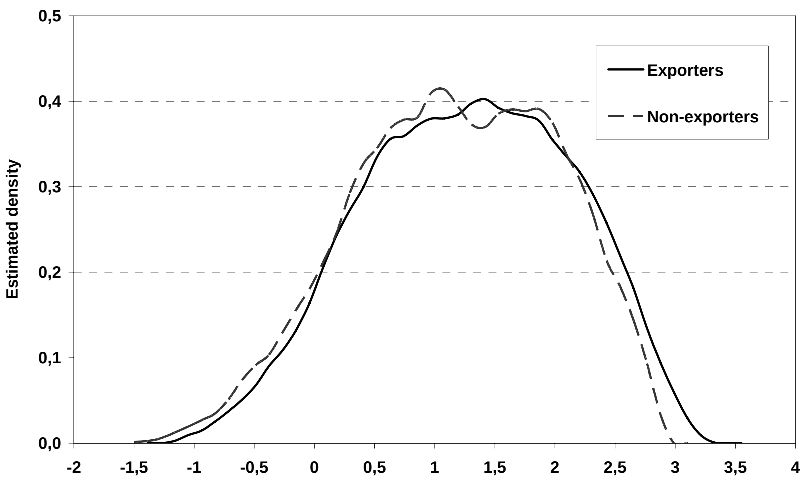
### Labour productivity model




### Employment growth model




### Sales growth model




Estimated kernel densities of non-exporters weighted. Further explanations: see text.

Source: own estimation.

### 5.5.3 Results of Mahalanobis Distance Matching Within Caliper

In order to test whether my results are sensitive to different matching techniques, I applied, as an alternative to kernel matching, a combination of Mahalanobis matching (see Rubin 1980) and caliper matching (see Cochran and Rubin 1973).

The balancing score used for Mahalanobis matching is a mixture of the unbounded propensity score and a subset of *X* that significantly influences the probability of having international sales. The Mahalanobis distance $MD_{ij}$ between exporter *i* and the non-exporting firm *j* is defined as

$$(5.25) \quad MD_{ij} = \left[ \left( x_i'\hat{\beta}, m_i \right)' - \left( x_j'\hat{\beta}, m_j \right) \right]' COV^{-1} \left[ \left( x_i'\hat{\beta}, m_i \right)' - \left( x_j'\hat{\beta}, m_j \right) \right], \qquad \text{with}$$

$$(5.26) \quad COV = \left[ \left( N^1 - 1 \right) COV^1 + \left( N^0 - 1 \right) COV^0 \right] \Big/ \left( N^1 + N^0 - 2 \right),$$

where $N^{1,0}$ is the number of exporting (non-exporting) firms and $COV^{1,0}$ is the sample covariance matrix of $\left( x'\hat{\beta}, m \right)$ in the exporting (non-exporting) subsample (cf. Rubin 1980, p. 294). *m* is a subset of *x* and contains all variables that are significant at the 1 % level according to the results of the probit estimations shown in Table 5-7. Mahalanobis matching seeks to increase the similarity of matched firms by conditioning not only on the (unbounded) propensity score but also on those variables which discriminate between exporters and non-exporters. However, regarding the labour productivity and the employment growth model, a relatively large subset of exogenous variables is significant, at least at the 10 % level. Therefore, I decided to include in the vector *m* only those variables that are significant at the 1 % level. On the other hand, proceeding this way means that in the sales growth model, the vector *m* only consists of one single variable, namely the dummy variable indicating permanent R&D activities.[156]

After calculating the Mahalanobis distance between exporter *i* and each firm *j* that did not have international sales, the firm *j* with the smallest Mahalanobis distance (i.e., the nearest neighbour in terms of $MD_{ij}$) serves as the matched control observation. In order to avoid a substantial gap between exporter *i* and its potential non-exporting partner *j*, I further combined Mahalanobis matching with caliper matching: Only those matched pairs for which the Mahalanobis distance $MD_{ij}$ is smaller than a pre-specified tolerance *d* are accepted for the causal analysis. Any exporter *i* will be excluded from the causal analysis if the Mahalanobis distance to its nearest neighbour is

[156] I also applied Mahalanobis matching to the sales growth model in which all variables that are significant at the 5 % level were included in the vector *m*. The key results concerning potential causal effects, however, are not sensitive to the specification of the vector *m*.

larger than *d*. This results in a similar effect to that of choosing a predetermined bandwidth *h* for kernel matching as used in the previous subsection. Only exporting firms for which it is possible to find a similar non-exporting company in terms of the balancing score used are retained for the causal analysis. The tolerance *d* is arbitrarily set to the 75th percentile value of the minimum Mahalanobis distances found for the sample's exporters. In this way, a quarter of exporting firms is excluded from the causal analysis. I also used the 90th and the 95th percentile values for specifying the tolerance *d*. The results of the causal analysis, however, do not depend on the chosen percentile value.

The estimated causal effect $\hat{\theta}^1$ is equivalent to equation (5.24). The only difference is that the outcome of exporter *i*, $y_i^1$, is no longer associated with a weighted average outcome but with the outcome of a single non-exporting firm $y_i^0$ (i.e., the outcome of the firm's nearest neighbour in terms of the Mahalanobis distance). The results are given in Table 5-9. They confirm the results of the estimated simultaneous equation models as well as the findings of the kernel matching analysis: There is no causal effect of international business activities on any of the three investigated indicators of firm performance. Apparently, this finding is not sensitive to the applied econometric method.

By design, only three-quarters of those exporting firms that were used to estimate the probit models for export market participation were retained for the causal analysis (see above). Interestingly, the number of non-exporting firms that were selected as the nearest available neighbour for at least

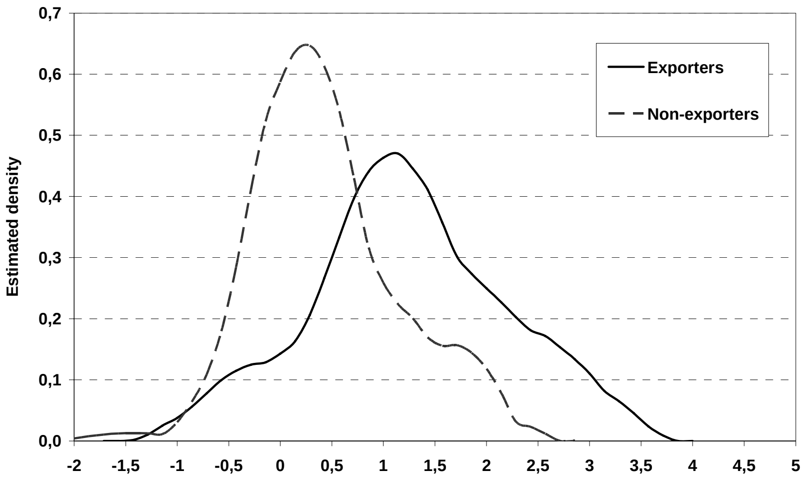
**Table 5-9: Results of Mahalanobis Distance Matching Within Caliper**

| Mean outcome of exporters | ($N^1$) | Mean outcome of non-exporters | ($N^0$) | Difference | Std. error | 90 % confidence interval | | |
|---|---|---|---|---|---|---|---|---|
| **Log-labour productivity 2002** | | | | | | | | |
| 5.067 | (81) | 4.880 | (20) | 0.187 | 0.140 | -0.069 | 0.397 | (P) |
| | | | | | | -0.044 | 0.418 | (N) |
| **Annualised employment growth rate (log) 1997–2002** | | | | | | | | |
| 0.066 | (102) | 0.053 | (22) | 0.012 | 0.028 | -0.022 | 0.073 | (P) |
| | | | | | | -0.034 | 0.058 | (N) |
| **Annualised sales growth rate (log) 1997–2002** | | | | | | | | |
| 0.124 | (88) | 0.121 | (19) | 0.004 | 0.036 | -0.037 | 0.081 | (P) |
| | | | | | | -0.056 | 0.063 | (N) |

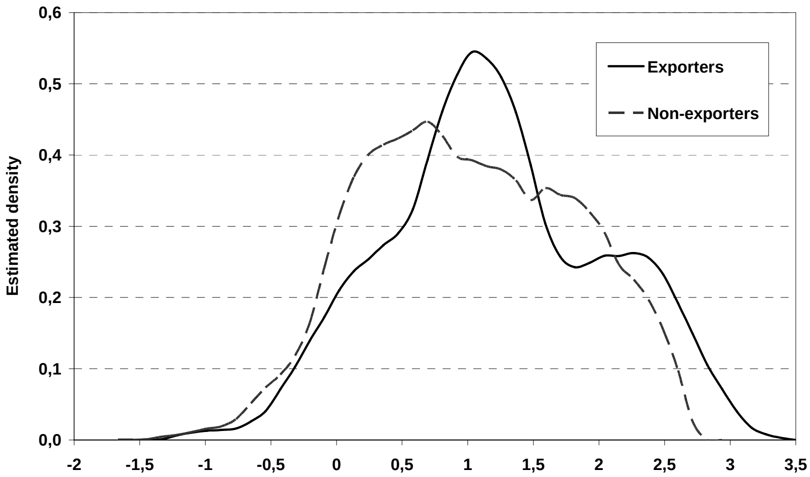
N: Confidence interval assuming an approximately normally distributed statistic; P: Percentiles of the bootstrap distribution.
Note: Only firms that participated in both surveys were considered.
Source: own estimation.

**Figure 5-4: Estimated Kernel Densities of Matched Unbounded Propensity Scores: Mahalanobis Matching**

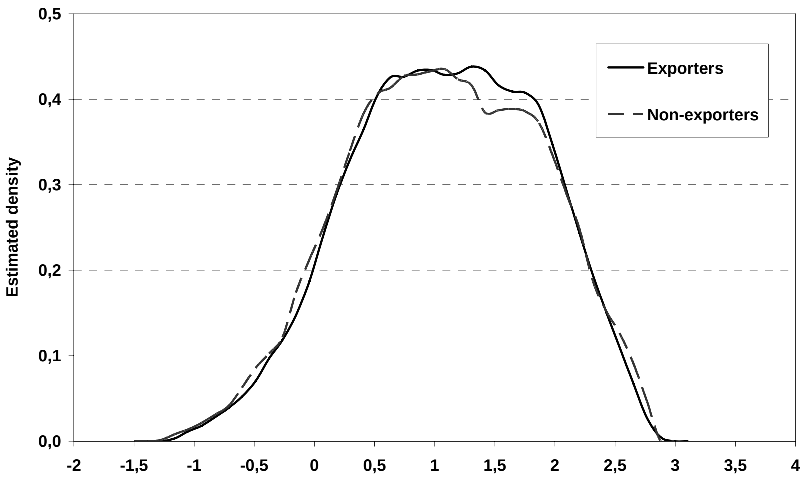
## Labour productivity model




## Employment growth model




## Sales growth model




Estimated kernel densities of non-exporters weighted. Further explanations: see text.
Source: own estimation.

one internationally active firm is also significantly smaller than the complete pool of potential control observations. For example, in the labour productivity model the pool of non-exporting firms contains 35 observations, but only 20 were selected for the causal analysis. The Mahalanobis distance of the remaining non-exporting firms to each of our sample's exporters is relatively large, indicating that the former firms differ considerably in terms of their firm-specific characteristics from internationally active firms and are therefore not appropriate for estimating the counterfactual outcome needed for the causal analysis.

The labour productivity model also best demonstrates in which way the selection of the "most similar" non-exporting firm is influenced by explicitly considering the vector *m*, i.e., the variables which discriminate between exporters and non-exporters. Some exporting firms with relatively high unbounded propensity scores are matched to non-exporting companies with relatively small propensity scores. This is obvious from Figure 5-4, which depicts the estimated kernel densities of matched firms' propensity scores.[157] Since the unbounded propensity score is only one dimension of the balancing score used when Mahalanobis matching is applied, a larger gap in propensity score is possible, provided that the firms are similar in terms of the firm-specific characteristics included in the vector *m* (e.g., the firms' R&D activities). As is also evident in Figure 5-4, the two density curves of the sales growth model are almost identical, probably due to the fact that in the sales growth model the vector *m* contains only one variable (i.e., the dummy variable indicating permanent R&D activities). Thus, the unbounded propensity score is more important in the sales growth model for determining the nearest neighbour of each exporting firm than in the labour productivity model, where four firm-specific variables are included in the vector *m*.

## 5.6 Conclusion

This chapter examines the relationship between three indicators of firm performance (labour productivity, employment growth, and sales growth) and the export behaviour of our sample of young, small, technology-oriented firms in Germany and the UK. Examining the firms during an early stage of their life cycles (from start-up to 1997), Bürgel et al. (2004) showed that international business activities improved the firms' labour productivity and increased sales growth rates, but did not affect employment growth. The positive effect of internationalisation on firm performance contradicts many other empirical studies which concluded that causality runs from firm performance to internationalisation and not vice versa. Thus, the question arises whether the

[157] The kernel density curves of non-exporting firms in Figure 5-4 are weighted by the number of internationally active firms to which the related non-exporter is matched (recall that matching with replacement has been carried out).

results of Bürgel et al. will hold true if the firms are analysed at a later, more “mature” stage of their life cycles, or if the performance-improving effect of internationalisation is only a phenomenon prevalent during early stages of the firms’ development.

My results are quite straightforward: Good firms are or will become exporters. The better performance of firms with international sales is therefore a result of self-selection of firms with superior performance into the international market. Technology-oriented firms in Germany and the UK behave exactly like the firms in most other samples studied so far. Only during the early stages of the firms’ life cycles does the relationship between internationalisation and performance seem to be different. It is possible that learning effects which may increase the firms’ productivity are more relevant during early stages of firm development. However, when considering a later stage of the firms’ life cycles, the productivity-increasing effect disappears.

This finding is not sensitive to the econometric method applied. The estimation results of the simultaneous equation models as well as the matching approach do not find any causality that runs from the firms’ internationalisation status to firm performance. However, as far as the matching approach is concerned, this conclusion is only valid for those internationally active firms for which it was possible to find a non-exporting firm with similar firm-specific characteristics, i.e. a firm without international sales, the chosen balancing score (either the unbounded propensity score or the Mahalanobis distance) of which is close to the related score of the exporting firm. Unfortunately, a relatively large number of exporters had to be excluded from the causal analysis since there is no firm without international sales in our data set which possesses similar firm-specific characteristics. Thus, our matching analysis does not provide any information of whether exporting improves the performance of those firms that had to be excluded from the analysis. Of course, the results of the simultaneous equation models are valid for all firms in our sample. Since in the latter models the partial effect of the status of internationalisation is insignificant, our analyses reject the hypothesis of a performance-improving effect of exporting for both the full sample and the reduced sample of matched firms.

This chapter’s analyses further point out the crucial role R&D activities play in both the productivity and growth models as well as for the firms’ (long-term) internationalisation behaviour. Firstly, the mean R&D intensity of firms in the regime without international sales decreased significantly between the two surveys, whereas firms with international sales maintained a high level of R&D activities. Secondly, R&D activities improve labour productivity as well as employment and sales growth. The number of R&D employees constitutes a production factor in the Cobb-Douglas production function. For firms with international sales, the number of R&D employees has a productivity-increasing effect. On the other hand, in the regime of non-exporting firms, where more than half of the firms do not carry out any R&D activities, the effect of R&D employees as a production factor can almost be neglected. In this regime, the estimated partial production elasticity is not significantly different from zero. Moreover, (permanent) R&D activities boost the firms' growth rates when estimating a joint growth equation for both exporting and non-exporting firms. Finally, the more intensive a firm's R&D activities, the higher its probability of internationalisation. After controlling for R&D, there is no partial effect of internationalisation on firm performance. Hence, we can reformulate the above statement in the sense that more innovative firms self-select into the foreign market. By investing in R&D, firms create intangible assets that improve their growth prospects, increase labour productivity, and facilitate export activities with respect to both foreign market entry and long-term engagements in the international market (cf. chapter 4).

## 6 Summary and Conclusion

International business activities are widespread among our sample of about 200 technology-oriented firms in Germany and the UK. In 2003, 74 % of the sampled firms had international sales. At the same time, exporters generated an average of 43 % of their total sales abroad. In this study, three dimensions of firms' international engagements are examined econometrically: foreign market entry and exit, degree of internationalisation, and the change of sales modes in international markets. Moreover, the causal relationship between a firm's status of internationalisation and its performance (measured by the firm's labour productivity as well as its employment and sales growth rates) is analysed. Our results have several managerial and policy implications. Furthermore, they deliver new insights into the validity of different internationalisation theories. I will thus begin my final conclusions in this chapter with a discussion of the applicability of the theories of internationalisation presented in section 4.1 to explain the long-term export behaviour of young high-tech firms.

### Validity of Internationalisation Theories

The primary objective of the dynamic model of foreign market entry and exit developed by Roberts and Tybout (1997) is to investigate the role of sunk costs and to empirically quantify their impact on firms' decisions to enter and exit the foreign market. If sunk costs are prevalent, we should observe a relatively high persistence in the firms' export participation trajectories. Since the firms in our sample have been contacted only twice, our data set is not suitable for estimating the dynamic model derived by Roberts and Tybout. Nevertheless, the descriptive analysis revealed a high persistence in the sampled firms' export activities. This finding is in line with the sunk cost hypothesis, although it is not empirical proof. Roberts and Tybout's model further predicts that a firm will leave the foreign market if expected current and discounted future profits from its international engagement are no longer positive. Hence, foreign market entry is not irreversible. Firms decide on their export activities based on factors exogenous to the firm, firm-specific characteristics, and the level of sunk (re-)entry costs. A foreign market exit as observed in our data set is thus a result of a firm maximising its current and future profits. In this study, it was possible to determine firm-specific characteristics that are decisive for foreign market entry and exit according to Roberts and Tybout's model (see the discussion below). However, our estimation results did not reveal any effect of the industry real exchange rate, the only factor exogenous to the firm that was included in the vector of explanatory variables. This finding is probably due to the small variance of the real exchange rate and should not be interpreted as a disproof of its importance for high-tech firms' export decisions. In summary, Roberts and Tybout's model provides an appropriate framework for explaining the foreign market entry and exit of the firms in our sample. Moreover, according to Roberts and Tybout's model, a firm decides simultaneously on foreign market participation *and* its profit-maximising level of exports. Thus, Roberts and Tybout implicitly modelled a firm's decision on its optimal degree of internationalisation. The notion of this model is also helpful when examining exporters' changes of sales modes used abroad. Similarly to the firms' participation in the foreign market, there is a high persistence in chosen sales modes – probably because of sunk costs that may arise in building up a new sales channel in a foreign target market. Besides the importance of possible sunk costs, the choice of the optimal sales mode is determined by firm-specific characteristics, which are also included in Roberts and Tybout's model.

An alternative model that attempts to explain firms' long-term internationalisation behaviour is the two-period model derived by Lautanen (2000). In his model's first stage, an epidemic learning process determines which firms become interested in exporting. Since our data set does not contain information on the stimuli that lead to exporting, this part of the model could not be tested empirically. Provided that a firm has become interested in exporting in the first stage, the firm decides to commit to exporting on three conditions: that expected profits are non-negative, that it is not profitable to postpone foreign market entry, and that the firm possesses sufficient resources for its planned export activities. This study's empirical results are able to determine which firm-specific resources facilitate entry into the foreign market in the second stage of Lautanen's model.

In order to identify firm-specific variables that are likely to influence the firms' export behaviour, I used different theories of internationalisation from the field of international management. One of the most prominent theories is the internationalisation process model developed by Johanson and Vahlne (1977, 1990). Internationalisation is regarded as a gradual process in which firms incrementally increase their commitment in the foreign market. However, this model is not appropriate for explaining the international engagement of small technology-oriented firms. The very occurrence of foreign market exit contradicts the notion of the process model. Similarly, the descriptive result that firms change from direct exports to exporting via an intermediary during an early stage of their international engagement and that a transition in the other direction is observed during a later stage does not correspond to the process model. In particular, the stage models which are rooted in Johanson and Vahlne's process model predict a gradually increasing commitment in a foreign market which follows a pre-specified, deterministic path. Young high-tech firms, however, decide on their internationalisation process contingent on market conditions and the firm-specific resources they possess. With respect to the choice of the appropriate foreign sales mode, the latter conclusion is valid at least during later stages of the firms' international engagements. At that point, firms have become established in the target market and are less dependent on the foreign partners they required during the early stages of their export activities in order to overcome the liability of alienness. This study's econometric results further show that foreign market entry and switching from an intermediary to direct exports are facilitated by firm size and the international experience of firm managers. Similarly, the probability of an exit from the foreign market is reduced by these two influencing factors. These results confirm two exceptions Johanson and Vahlne (1990) pointed out to explain in which cases firms might deviate from the gradually expanding commitment predicted by their model. For our sample's firms, the exceptions are the rule. These findings are in line with other empirical studies which emphasise that the process model is not suitable for high-tech or service firms like those included in our sample (see, e.g., O'Farrell et al. 1995, Bürgel and Murray 2000).

The importance of firm size, which approximates the amount of physical and financial resources available to the firm, is also pointed out by the resource-based view of the firm and Madhok's organisational capability (OC) perspective (cf. Madhok 1997). More essential from these theories' points of view are, however, a firm's intangible assets. Throughout this study the crucial role of a firm's R&D activities, by which a firm generates just such intangible assets, is emphasised. Intangible assets may also be incorporated into the firm's product if the firm has bought novel technologies that were developed by other companies. However, the respective dummy variable indicating the use of such a technology only positively affects the firms' degrees of internationalisation; it cannot explain foreign market entry and exit. Further, the international experience of a firm's managers constitutes an intangible asset since it represents the managers' knowledge of operating in a foreign environment, which allows the firm's product to be sold to foreign customers without a loss in value. Thus, international experience facilitates exporting and switching from exporting via an intermediary to direct exports as hypothesised by the OC perspective. Finally, it corresponds to the OC perspective that a firm will prefer an integrated sales mode if the time period for exploiting a technological advantage in a foreign market is limited (i.e., in the case of a short window of opportunity). Hence, this study verifies the hypotheses derived from the resource-based view of the firm and the OC perspective to a large extent. However, during an early stage of a high-tech firm's international engagement there are strategic and structural influences that might dominate the impact of the exporter's intangible assets. Thus, there is only weak evidence of an effect of a firm's intangible resources on the probability of changing from direct exports to exports via an intermediary.

More recently, theories of international entrepreneurship have combined models of international business and entrepreneurship. Their main focus is the acting entrepreneur who triggers the internationalisation process. Andersson (2000) distinguished between a technical entrepreneur, who is mainly interested in technology, and a marketing entrepreneur, who pro-actively creates his firm's internationalisation process. According to our empirical results, however, a distinction between different types of entrepreneurs influences neither the probability of an international engagement nor the degree of internationalisation. Admittedly, the variables that are intended to discriminate between marketing and technical entrepreneurs (i.e., the two dummy variables indicating whether firm managers experienced shortages of competencies in sales/distribution and production/R&D, respectively) are only a deficient measure. Unfortunately, there are no other variables in our data set which can operationalise different types of entrepreneurs. Thus, carrying out more profound analyses on the entrepreneurial perspective of firms' internationalisation process is left to future research.

The requirement of intense product customisation is a barrier to a firm's export activities since it induces high transaction costs prior to selling the product. Customisation complicates foreign market entry and increases the probability of an exit from the international market. Similarly, it reduces the firm's degree of internationalisation and leads to a lower probability of changing to exporting via an intermediary during an early stage of the firm's international engagement. The latter effect validates the transaction cost theory derived by Anderson and Gatignon (1986) in order to explain firms' foreign sales modes. The remaining hypotheses proposed by Anderson and Gatignon's transaction cost approach are also confirmed by our estimation results. As already shown above when discussing the validity of the resource-based view of the firm, a company's intangible assets, which are supposed to increase the necessity of an integrated sales mode, are of particular importance in explaining a change from exporting via an intermediary to direct exports. Furthermore, if the firm employs internationally experienced managers, it will be able to reduce internal uncertainty, which allows the firm to export directly to foreign customers. External uncertainty (i.e., the rank of country risk) has no individual effect on the probability of a sales mode change. Only in combination with a firm's intangible assets did we find a significantly negative, although only slight, effect on the transition probability of switching from direct exports to exports via an intermediary.

Since Dunning's OLI-framework combines elements of the other theories discussed in this chapter, the validity of these theories also proves that the OLI-framework is appropriate for explaining the international engagement of high-tech firms in Germany and the UK. Thus, ownership advantages (e.g., a firm's physical, financial, and intangible assets) and internalisation advantages (e.g., transaction-specific assets) are decisive for a firm's export market participation, degree of internationalisation, and choice of optimal foreign sales mode. However, there is no evidence supporting the hypothesis that locational advantages (e.g., foreign market potential) influence the sales mode selection of our sample's firms. The insignificance of target country-specific factors might be due either to the fact that most of the target countries of our sample's exporters are located in Western Europe or North America, or that the proxies used are too vague to measure target country-specific differences with respect to market potential or the target country's importance for the exporter's total sales.

Hence, it can be concluded that the resource-based view of the firm (and Madhok's organisational capability perspective, which is rooted in the resource-based view of the firm) and the transaction cost analysis theory are most suitable to derive firm-specific variables that can discriminate between exporters and non-exporters. These variables should be included in the dynamic model developed by Roberts and Tybout (1997) in order to explain the long-term internationalisation behaviour of young high-tech firms in Germany and the UK. Alternatively, relevant firm-specific variables may also be motivated by Dunning's eclectic framework. On the other hand, the internationalisation process model and entrepreneurial perspective of a firm's international engagement cannot be confirmed by our empirical results.

The second objective of this study's econometric analyses was to examine the relationship between the sampled firms' international business activities and firm performance. Investigating the firms that participated in the first survey this study is based on, Bürgel et al. (2004) showed that internationalisation improved the firms' labour productivity and increased their annualised sales growth rates between the firms' start-up periods and 1997, but did not affect employment growth. In contrast, this study revealed that the performance-enhancing effects of internationalisation are in fact restricted to early stages of the firms' life cycles and disappear when technology-oriented firms become mature. Our results are in line with many other studies: Firms exhibiting superior performance are or will become exporters.

However, the question remains: Why do firms actually enter the foreign market? What are the benefits of international engagement? Arguing that good firms become exporters is only a necessary condition for international business activities. Only firms that are endowed with (intangible) firm-specific assets, primarily created by their intensive R&D activities, are able to bear the additional costs of international engagement. But this argumentation does not constitute a sufficient condition. All of the theoretical models of individual firms' foreign market participation – for example, the dynamic model formulated by Roberts and Tybout (1997) – state that a firm will enter the international market if the (expected) benefits of such an engagement are positive. However, like many others, this study does not ascertain any long-term benefits. A productivity-increasing effect of exporting is apparent only during early stages of young technology-oriented firms' life cycles and disappears when firms become older. Similarly, the positive influence internationalisation has on sales growth that was found in the firms' start-up periods also vanishes when the firms mature. Admittedly, these performance-enhancing effects may be extremely important for newly founded technology-based firms as a means of establishing themselves on the market. Besides these early-stage effects, however, there seem to be no long-term benefits. The sufficient condition for international engagement is not fulfilled in the long run.

Additionally, the results contradict assumptions regarding rationally behaving firms. The econometric results suggest that high labour productivity and long-term growth might be realised by a firm with only domestic sales – provided that the firm invests intensively in R&D or other firm-specific assets. If we considered the additional costs of international engagement, firms who export would not be behaving rationally because they could realise high levels of performance at a lower cost without exporting. However, our findings should not be interpreted as suggesting that firms with international sales are not behaving rationally. Firstly, in this study firm performance was operationalised as labour productivity and growth. However, Roberts and Tybout's (1997) model assumes a profit-maximising firm: A firm will have international sales if the profits the firm receives by selling its products abroad are non-negative. Thus, a firm may benefit from its international engagement by increasing profits rather than by achieving higher labour productivity or growth rates. Unfortunately, it is almost impossible to collect information on firm profits gained abroad via a telephone survey. Therefore, we do not know whether internationalisation has a profit-increasing effect. Secondly, the observed self-selection of more innovative firms might be a result of forward-looking behaviour (see Bernard and Wagner 1997, or Bernard and Jensen 1999). If firms expect that they can realise long-term growth only through an expansion onto the foreign market, they will invest in R&D in order to generate the necessary assets before becoming internationally active. In this case, we observe intensive R&D activities in a continuously growing firm with international sales. Statistically, this observation is consistent with a causality running from superior performance – due to better endowment with firm-specific assets or a more efficient exploitation of these assets – to higher probability of international engagement. Thirdly, in this study only direct effects of international business activities on the performance of exporting firms are considered. Under circumstances involving regional spillover effects, non-exporting firms might also profit from other firms' exporting activities such that international business activities have a productivity-increasing effect on both exporting and non-exporting companies. If spillover effects exist, it will be difficult to measure productivity differences as a result of international engagement.[158] Finally, the econometric models in chapter 5 only estimate the impact of internationalisation status on firm performance. However, when examining the degree of internationalisation we find significant differences among our sample's exporters in the extent of their international engagements. At the time of the second survey, 37 % of exporting firms generated more than 50 % of their total revenues in the foreign market. On the other hand, there may be some firms in our sample which merely occasionally receive unsolicited orders from abroad. It is unlikely that such occasional exports induce any performance-enhancing effects of internationalisation. Nevertheless, the latter group of firms was classified as exporters in our econometric models. Thus, there might be some threshold value of the degree of internationalisation an exporter has to exceed in order to profit from its international engagement. As a result, we must be cautious when interpreting the econometric results of this and other studies. It is econometrically apparent that firms with superior performance self-select into the foreign market. The question of whether and how firms benefit from their export activities, however, remains unanswered.

**Differences in the Firms' Export Behaviour over Time**

The changing relationship between internationalisation and firm performance is one of the most outstanding findings of this study. When observing our sample of newly founded technology-based firms over a longer time period, the results we obtain are similar to those of most other studies examining data sets of mature firms in various countries. This conclusion is not restricted to the export-performance relationship, but can rather be generalised to other fields of this study's analyses. For example, during early stages of the firms' life cycles the cumulative share of internationally active firms was a continuously increasing function (cf. Bürgel et al. 2004). At the time of the first survey, it seemed that for young high-tech firms the question was not whether to internationalise, but when. Exits from the foreign market were negligible, and when extrapolating the expansion path of German and UK-based firms' international engagements observed in 1997, it could be expected that, sooner or later, all of the high-tech firms in our sample would have international sales. At the time of the second survey, however, a different picture emerges. The overall share of internationalised firms increased only slightly (from 72 % in 1997 to 74 % in 2003). However, foreign market exit has become a relevant option for those firms whose international engagements were not successful. International business activities are still widespread among our sampled firms. Nevertheless, about 15 % of the firms have never had any international sales. Thus,

158 For a discussion on spillover effects of export activities see Aitken et al. (1997).

the international business activities of our sampled firms are characterised by foreign market entry *and* exit, and by a group of firms for which staying a purely domestic firm is the profit-maximising decision. This finding is in accordance with the behaviour of mature firms like those examined by Roberts and Tybout (1997) or Bernard and Jensen (2004).

Regarding the firms' degrees of internationalisation over time, we find that on average our sampled firms raised their export intensity significantly. The same is true for the number of foreign target markets in which an exporter sells its products and services. Unfortunately, the observed shift in export intensity in the period between the two surveys cannot be explained by this study's econometric analysis, but it can be interpreted as reflecting a trend towards increasing globalisation on high-tech markets. With respect to the third dimension of the firms' international business activities, i.e. change of sales modes in foreign target markets, our results demonstrate one major difference between an early stage and a "mature" stage of the firms' life cycles. In the period between foreign market entry and the 1997 survey, exporters were often forced to change from direct exports to exports via an intermediary, probably in order to overcome the liability of alienness. After the firms had become established in the foreign market, they were able to change from an intermediary to direct exports, since they were no longer reliant on a foreign partner in 2003. The transaction cost theory and the resource-based view are both relevant for explaining the latter sales mode change, whereas the theories' explanatory power is relatively small with respect to sales mode changes during early stages of the firms' international engagements. This is another example of the firms' export behaviour at the time of the second survey no longer being determined by peculiarities specific to the early stages of high-tech firms' life cycles.

Analysing the firms' growth rates over a longer time period, it turned out that both the employment and the sales growth rates in the period from 1997 to 2002 are significantly smaller than those recorded between the firms' start-up and 1997. According to theory, growth rates decrease as firms get older. For example, the high efficiency gains young firms can realise due to learning processes during early stages of their life cycles decrease as firms get older, leading to declining growth rates. Moreover, it can be expected that most of the firms in our sample have already reached their minimum efficient scale (MES). Thus, the growth rates of our sampled firms are approaching those of mature technology-based firms.

**Differences Between German and UK-Based High-Tech Firms**

In addition to the temporal dimension of the analysis, a second major focus of this study is the comparative dimension between German and UK-based firms. Our descriptive analyses reveal some interesting differences between German and UK firms with respect to their export behaviour. At the time of both surveys, the share of UK firms with international sales was higher than that of German firms, although the differences were not significant according to Pearson's $\chi^2$-test. More importantly, the average number of foreign countries to which UK-based exporters sold their products and the mean export intensity of UK firms exceeded the respective values of German high-tech firms. It was argued that these differences might be due to the fact that UK firms more pro-actively exploit the sales potential of foreign markets or because German firms are less dependent on the international market because of the larger size of their domestic market. Further, UK exporters more often used exporting via an intermediary as the dominant sales mode in their three most important foreign target markets of 1997. This might either reflect that, in contrast to German firms, UK firms pro-actively seek out an appropriate foreign partner. Alternatively, it might reflect that the three most important foreign markets of UK-based exporters are relatively often non-European markets (in particular the United States and Asian markets), where cooperation with a foreign partner might be more beneficial than in the case of exports to a neighbouring European country.

At the time of the second survey, German firms exhibited superior performance when compared with their UK-based competitors. The mean labour productivity of German firms significantly exceeded that of UK firms. Similarly, in the period from 1997 to 2002 German firms realised significantly higher average employment and sales growth rates than technology-oriented firms in the UK. This is, of course, a rather worrying result for UK managers and policy makers since it indicates that UK-based high-tech firms have fallen behind their rivals in at least one other major European economy.

Unfortunately, these country-specific differences highlighted by the descriptive statistics can only partly be explained by the subsequent econometric analysis. As already pointed out in chapter 3, the relatively small number of observations in our data set inhibits a thorough econometric examination of potential differences between German and UK-based technology-oriented firms. This study's various estimation equations only contain dummy variables indicating whether each firm is located in (Western or Eastern) Germany or the UK. Such dummy variables control for systematic differences that are not covered by the empirical model. For example, in the fractional logit model in section 4.3 the two dummy variables indicating Western and Eastern German firms reveal that the export-sales ratio of German firms is significantly smaller than that or their UK-based rivals. Presumably, the higher export intensities of British firms reflect UK managers' more pro-active export behaviour. However, the effects of such "soft" factors are indeterminable based on our data set. Another example of a country-specific effect that is not covered by our model is the significantly lower labour productivity of Eastern German firms. It was argued that Eastern German firms might have substituted the production factor labour for capital because wages paid to (non-R&D) employees are lower in Eastern Germany. Thus, the relatively low labour costs in Eastern Germany potentially led to a lower level of sales per non-R&D employees (at least in the regime of firms with international sales), reflected by a significantly negative dummy variable in the labour productivity equation. Since we do not have any information on wages paid by the firms in our sample, we cannot validate this interpretation.

In most of the estimated models, however, the country-specific dummy variables are insignificant. Thus, the observed differences between German and UK-based firms are covered by the derived econometric models. On the one hand, high-tech firms in Germany and the UK may differ from each other by a varying endowment with firm-specific resources that are found to affect the firms' internationalisation behaviour. On the other hand, the effects the exogenous variables have on the firms' export activities may vary between German and UK firms, leading to a different functional form of the regression equation. An empirical proof whether or not the individual exogenous variables influence the firms' international engagement in the same way would require country-specific estimations of this study's econometric models. Due to the limited number of observations in our data set, such country-specific estimations are impossible.

Of course we can determine in which way German and UK-based firms deviate from each other with respect to their endowments with firm-specific resources. For example, the R&D intensity of UK-based firms in 2003 was larger than that of German firms, although the difference is not significant according to a t-test (cf. Table 4-1). Moreover, the share of firms in which at least one member of the management team had experience of working abroad was also larger in the UK than in Germany. Furthermore, the share of firms whose best-selling products required intense product customisation was higher in the German subsample. These are only three firm-specific variables that possibly led to the UK firms' higher probability of entering the foreign market according to the model estimated in section 4.2. However, this interpretation is only correct if these three firm-specific resources affect the probability of foreign market entry of German and UK firms in the same way. Similarly, the firms' mean gross investment in physical capital in 2002 (i.e., our rough approximation of the firms' capital stock) was significantly smaller in the UK than in Germany. Thus, a lack of investments in physical capital might have led to reduced labour productivity in the UK. Alternatively, German firms might have utilised their production factors more efficiently. In this case, the partial production elasticities of German firms would exceed those of UK companies. These two examples show that based on our analyses of a pooled data set of German and UK high-tech firms we can draw only limited conclusions on how technology-oriented firms in Germany and the UK are distinguished from each other with respect to the determinants of firm performance and export behaviour.

**Managerial and Policy Implications**

From a managerial point of view, this study contributes to answering two important questions: (i) How can a technology-oriented firm ensure a long-term international engagement? (ii) What are the prerequisites for sustaining high levels of labour productivity and growth? Our econometric results suggest that these two objectives are independent of each other. Based on this finding, we cannot advise firm managers to internationalise in order to attain a higher level of firm performance. Conversely, we are not able to determine the benefits of internationalisation for a firm. Therefore, in this concluding section it is assumed that the decision to internationalise results from firms' optimising behaviour, leaving the question of how firms actually benefit from an international engagement to future research.

This study reveals that firms' own R&D activities play a crucial role in the internationalisation process. Thus, firms that intend to enter the foreign market or are interested in establishing themselves in the international market are advised to maintain a high level of permanent in-house R&D activities. At first glance, this advice seems to be self-evident since we are examining a sample of high-tech firms. However, it was shown that in 2003, level of R&D intensity could be used to discriminate between exporters and non-exporters. This was not the case at the time of the first survey, when both internationally active firms and firms with purely domestic sales spent a comparably large amount of money on R&D activities. Reducing the level of R&D as a firm becomes older is not a consistent strategy if firm managers are interested in long-term export activities. In order to overcome the numerous obstacles that are linked with an international engagement, firms should recruit managers with high levels of international experience. Firms are advised to avoid high transaction costs, for instance, by reducing the requirement of individual client product customisation. A high level of customisation is only compatible with a long-term international engagement if a firm can sell its product to a limited number of key foreign customers that represent sufficient sales potential for the supplying firm. The choice of the appropriate sales mode may also support a long-term international engagement. Exporters of high-tech products that incorporate highly sophisticated technologies are advised to use an integrated sales mode, i.e. direct exporting.

These recommendations are admittedly not new. In particular, they are very similar to the advice given by Bürgel et al. (2004) on the basis of the first survey.[159] The variables that facilitated the firms' international business activities during early stages of their life cycles are broadly identical to those that support a long-term international engagement. There are merely some peculiarities of young firms' export activities that disappear as firms mature (e.g., young firms' need to export via an intermediary because of a prevalent liability of alienness). However, firms are well advised to adjust their internationalisation strategies regularly to changing firm-specific and macroeconomic conditions. For example, if a firm has carried out intense R&D activities and increased the degree of innovativeness in its products, it might be optimal to change its foreign sales mode from exporting via an intermediary to direct exports. It is important that the firms do not rest on their former success. If they abstain from investing in physical capital or from developing innovative, up-to-date products, this will not only make future international business activities more difficult, but will also negatively affect their performance (labour productivity and growth).[160] According to this study's results, the most promising way of ensuring a high level of firm performance in the long run is to carry out permanent in-house R&D activities. Through these, a firm creates intangible, inimitable, firm-specific assets and assures a competitive advantage over its rivals.

In the context of high-tech firms, policy makers are primarily interested in the creation of new jobs, i.e., firms' long-term employment growth. In the period from 1997 to 2002, the (surviving) firms in our sample exhibited an average annualised employment growth rate of 6.2 %. Only 22 % of the firms reduced their number of employees in this period. These are, in fact, impressive numbers, in particular if we consider the downturn on high-tech markets in 2000. Although the firms in our sample were challenged by newly founded firms entering the market – at least in the period from 1997 to 2000 – and were faced with constant or even decreasing aggregate demand in most recent years, they were nevertheless able to establish themselves in the high-tech market and hire new employees. However, in 2002 the firms in our sample employed an average of just 26 indi-

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159 It might be argued that this finding is implied by the chosen research design. In order to cover changes of firm-specific variables, the second survey replicates the questions of the first survey. Thus, the number of firm-specific variables in our data set is limited. In particular, important variables suggested by more recently developed theories (e.g., network theory) are not included in the data set. Although it is true that we do not know whether alternative theories would lead to alternative managerial implications, it should be noted that the econometric models derived in this study fit well with the data, implying that the models are appropriate for explaining the sampled firms' export behaviour.

160 A reduced investment in physical capital or R&D is not necessarily a result of the decision by firm managers to refrain from investing. It may also reflect a firm's financial restrictions, which were in particular prevalent for high-tech firms after the downturn on high-tech markets in 2000 (see Bank of England 2001). Although a firm may be interested in investing in physical capital or R&D, it may not be able to find the necessary funding sources for the planned investment.

viduals. The 90th percentile value amounted to just 60 employees, and even the largest firm employed a mere 370 individuals. Thus, the firms in our sample did not realise the exceptionally high long-term growth rates which would have allowed them to grow into large firms.[161] Hence, this study does not give any evidence of fast-growing, high-tech firms that have become world-class companies (like Microsoft, Cisco Systems, or SAP) and have created a huge number of new jobs. Nevertheless, most of the small and medium-sized firms in our sample also contributed to the creation of new jobs. Considering current high unemployment rates, particularly in Germany, this is a positive development. Of course, this argumentation is restricted to the direct job-creating effects of the firms in our sample. Furthermore, a successfully growing high-tech firm may squeeze its competitors out of the market, leading to job losses of those individuals so far employed by the dissolved firms. On the other hand, the sampled high-tech firms may induce job creation by their customers: If high-tech firms' products and services are integrated into their customers' production processes, this will possibly improve the customers' competitiveness, entailing job creation by the high-tech firms' customers. Thus, there are both positive and negative indirect effects on employment and the total (macroeconomic) effect is not necessarily positive.

According to this study, the superior performance of internationally active firms is a result of the self-selection of more innovative firms into the foreign market. Thus, our findings do not suggest that promoting firms' export activities will have a positive impact on firms' (employment) growth or labour productivity. Nevertheless, policy makers may be interested in promoting firms' exports (e.g., via export counselling, export subsidisation, export credits). There is almost no doubt among economists that international trade improves a country's welfare. Thus, Germany and the UK are both well advised to participate in the international division of labour. This is probably one reason why each country's government intends to promote either the foreign market entry of previous non-exporters or an expansion of exporters' volume of international sales.

161 According to the European Commission (2002), a "large" firm is defined as a company with 250 or more employees. Only the largest firm in our sample exceeded this threshold in 2002.

## 7 References


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