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Non-technical Summary

For small high-tech firms international orientation is regarded as crucial, since it is often argued that sales potential in European domestic markets is insufficient for the amortisation of high product research and development costs. If exporting increases the performance of small and young high-tech firms, this will help firms fulfil the hopes often placed upon them with respect to structural change, innovation, and job creation. In fact, examining a data set of 600 newly founded technology-based firms in Germany and the UK that were surveyed in 1997/1998, a joint research team of the London Business School and the Centre for European Economic Research (ZEW) 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.

However, these results contradict many other studies that 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. In order to reveal whether the previously 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 paper re-examines the relationship between export behaviour and firm performance. For this, data from a second survey conducted in 2003 by the ZEW and the University of Exeter were used, where all surviving firms from the original sample were contacted again. This second survey resulted in a cleaned sample of 217 companies.

The data confirm the usually observed stylised facts that exporters are larger, more productive, and exhibit higher growth rates. However, estimating a labour productivity model and a growth model (for employment and sales growth) that both consider a possible simultaneity between the decision on internationalisation and the respective measure of firm performance, my results are quite clear-cut: Good firms are or will become exporters. Both the productivity-enhancing effect of internationalisation and the (sales) growth-increasing effect are restricted to early stages high-tech firms' development in Germany and the UK and do not appear when the firms are analysed during later stages of their life cycles.

Furthermore, the results emphasize the crucial role of the firms' R&D activities: Number of R&D employees constitutes a production factor in the Cobb-Douglas production function. For firms with international sales, number of R&D employees has a productivity-increasing effect. On the other hand, for 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. Moreover, R&D activities boost the firms' growth rates of both exporting and non-exporting companies. 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.

Productivity, Growth, and Internationalisation: The Case of German and British High Techs *

by

Helmut Fryges **

November 2004

Abstract: International engagement is often expected to improve firm performance. Especially for small technology-oriented firms, export activities may be important, being regarded as one way to amortise these firms' high product research and development costs. This paper examines the relationship between international business activities and firm performance using a sample of about 200 young high-tech firms in Germany and the UK that were contacted by two surveys in 1997 and 2003. I find out that the performance enhancing effects of internationalisation that were still observed in 1997 are in fact restricted to an early stage of the firms' life cycles and disappear when technology-oriented firms become mature. The results are in line with many other studies: Firms exhibiting superior performance are or will become exporters.

Keywords: *High technology industries, internationalisation, firm growth, productivity, switching regression.*

JEL Classification: *F23, L25, L60, L86*

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1 Introduction

Today, the overwhelming majority of economists and politicians is 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.[1] 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.[2] If international business activities really increase the performance of young high-tech firms, internationalisation will help firms fulfil the hopes often placed upon them with respect to structural change, innovation, and job creation. In order to investigate the relationship between export behaviour and firm performance, a joint research team of the London Business School and the Centre for European Economic Research (ZEW) contacted a stratified random sample of German and UK technology-based firms founded between 1987 and 1996 via a written questionnaire (see Bürgel et al. 2004). It turned out that about two-thirds of the 600 responding firms had international business activities at the time of the survey 1997/1998, which is already an impressive number. Furthermore, the researchers 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.

However, these results 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

1 See Baldwin (2000) for a discussion of theoretical and empirical studies analysing the relationship between trade and macroeconomic growth. Baldwin emphasizes 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.

2 In this paper, only firms that export their products or services are regarded as internationally active. This means that only internationalisation on the sales market is considered. Of course, firms may import investment goods or components, i.e., internationalise on the procurement market. Although the latter way of internationalisation may also be important for small high-tech firms, it is neglected in this paper.

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 by the papers cited above. Firstly, most other studies examine mature firms, in contrast to the sample of newly founded firms that were observed by Bürgel et al. (2004). Secondly, there may be structural differences in firms operating in high-technology sectors, as analysed by Bürgel et al., compared with firms in low-tech sectors. For example, technology-oriented firms might improve their labour productivity because they can better profit form learning effects by exporting (see the “learning by exporting” hypothesis in the next section) than low-tech firms.

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 paper re-examines the relationship between export behaviour and firm performance. For this, data from a second survey conducted in summer 2003 by the ZEW and the University of Exeter are used. All surviving firms from the original sample, which are now 12 years old on average, were contacted again. In order to ascertain a high response rate, a computer-assisted telephone interview (CATI) was used. A response rate of 55 % was obtained, and, after performing several consistency checks, 217 companies were retained for the analyses.

Estimating a labour productivity model and a growth model (for employment and sales growth) that both consider a possible simultaneity between the status of internationalisation and the respective measure of firm performance, the results are quite clear-cut: Good firms are or will become exporters. Both the productivity-enhancing effect of internationalisation and the (sales) growth-increasing effect are restricted to early stages of high-tech firms’ development in Germany and the UK and do not appear when the firms are analysed during later stages of their life cycles. As in most other studies, firms exhibiting superior performance are or will become exporters.

This paper proceeds as follows: Section 2 reviews theoretical arguments and empirical studies that deal with the relationship between performance and internationalisation. Section 3 describes the data set, and section 4 derives the models the econometric analysis is based on. The econometric methodology is explained in section 5. Section 6 contains the descriptive analyses. The econometric results are discussed in section 7, and section 8 concludes.

2 Performance and Internationalisation

Depending on the performance indicator 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, and on the other, firms with superior performance might become exporters. In the following, I will summarize arguments that relate internationalisation and the two performance indicators analysed in this paper: 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 the econometric analysis of this paper 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 emphasized 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.[3]

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 (1993). Firms that have international sales are assumed to be exposed to greater competition than firms with only domestic sales. 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

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

UK, domestic firms also face the competition from foreign companies because of imports to the domestic market ("imported" competition; see Bernard and Wagner 1997).[4]

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) so that firm's growth processes are less dependent 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 research 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 of foreign market entry. Therefore, we should observe that only firms that have achieved a certain size or a certain level of labour productivity enter the international 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.[5] International business activities constitute a

4 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).

5 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

higher "efficiency hurdle" (Bernard et al. 2000, p. 15) than domestic sales.[6] 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).

The amount of empirical literature examining the relationship between firm performance and internationalisation has grown considerably in recent years. Clerides et al. (1998) tested empirically a theoretical model of export participation and learning effects using a data set of manufacturing plants of 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 a 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.

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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) prove 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.

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

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 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 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 (2004) 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.

This paper examines a data set of German and UK technology-oriented firms founded between 1987 and 1996. The firms in the sample were contacted by two surveys, one in 1997 and the other in 2003 (see the following section for more details). Bürgel et al. (2004) investigated the relationship between firm performance and internationalisation behaviour for the period from the firms' start-up until 1997, using data from the first survey. They found that an international engagement improves labour productivity and increases sales growth rate, but does not affect 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 by 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 there might be structural peculiarities of the firms in our sample 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. This paper addresses the question of whether these causal relationships 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 high-tech firms' start-up periods.

3 The Data

This paper examines the relationship between internationalisation and performance of technology-oriented firms in Germany and the UK. Technology-oriented firms are identified using the definition of high-technology manufacturing sectors in the UK established by Butchart (1987). He provides a definition based on, firstly, the ratio of R&D expenditures to sales and, secondly, the share of employees working in R&D. A sector is defined as “high-tech” if it is characterised by a “substantially above-average” value in at least one of the two criteria and an “above-average” value in the other. Using this definition, Butchart identified nineteen UK 1987 SIC codes, which were translated into the NACE Rev. 1 code and are listed in detail in Table 7 of this paper’s appendix. Table 7 defines four aggregated manufacturing sectors and augments Butchart’s list with a number of selected service sectors (cf. Bürgel et al. 2004).

The data for this paper’s empirical analysis result from two surveys simultaneously carried out in Germany and the UK. The source data set originates from Dun & Bradstreet in the UK and Creditreform[7] in Germany. Using these databases, all firms with at least three employees in 1997 that were operating in one or more high-tech sectors as defined by Butchart (1987) and having been founded as legally independent companies[8] between 1987 and 1996 were selected. This resulted in a population of 3,562 firms from the UK and 5,045 from Germany. The sample composition of the 1997 population is given in Table 8 in the appendix. A random sample of 2,000 firms was drawn from each country’s population, stratified by size, sector (manufacturing versus services), and, for Germany, by region (West and East Germany).

The firms were first contacted in winter 1997/1998 via a written questionnaire. The first survey was carried out by the London Business School in the UK and the Centre for European Economic Research (ZEW) in Germany. The written questionnaire contained questions regarding the profile of the firms’ founder(s), product characteristics, international business activities, entry modes into foreign markets, and perceived opportunities and risks of international activities. 362 completed questionnaires returned from the UK, 232 questionnaires from Germany, resulting in a combined net sample of nearly 600 NTBFs from the two countries. The net sample showed no bias with

[7] As Germany’s largest credit rating agency, Creditreform has the most comprehensive database of German firms at its disposal. Creditreform provides data on German firms to the Centre for European Economic Research (ZEW) for research purposes.

[8] Subsidiaries, de-mergers or firms that were founded as a management buy-out (MBO) or buy-in (MBI) were excluded from the analysis.

respect to age, size, or sector when compared with the random sample. A bias with respect to internationalisation behaviour could, however, not be ruled out.[9]

In order to determine the development and status of internationalisation of this sample of 600 NTBFs, a joint research team from the University of Exeter and the ZEW prepared a new survey in which all previously responding firms were to be contacted a second time. In 2003, the companies from the original sample were on average of 12 years old. Thus, some of them were no longer definable as new technology-based firms.[10] Considering this notion, we shifted our interest from analysing newly founded firms to a more longitudinal perspective of firm development.

To determine the target sample of the second survey, at first all formerly responding firms that turned out to be mismatches (e.g., non-high-tech firms, non-independent foundations) were excluded. We then eliminated each German firm labelled in the database of Creditreform as "dead" (due to bankruptcy as well as voluntary firm closure) at the beginning of 2003.[11] In the UK, firms that could be identified as dead by the researchers themselves were also excluded from the target sample.[12] As a result, we produced and subsequently contacted a final target sample of 188 German and 250 UK-based formerly responding firms.

The second survey was conducted in 2003 via computer-aided telephone interviews (CATI). The research team decided on a telephone survey because, due to the limited number of formerly responding firms in the target sample, the assurance of a relatively high response rate and thereby a sufficiently high number of observations was necessary to obtaining reliable econometric results. Fortunately, in both the UK and Germany, the response rate exceeded 50 %, giving us a pool of 244 completed interviews. After performing several consistency checks, 217 companies were retained in the data set for econometric analyses.

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9 The first survey is described in detail in Bürgel et al. (2004). This report also includes numerous descriptive and econometric analyses of this unique data set.

10 In his influential study, Little (1977) used a definition of NTBFs which includes firms as old as 25 years. In contrast, the first survey this paper is based on considered only firms that were ten years of age or younger at the time it was taken, which is in line with more recent studies of NTBFs (see, e.g., Storey and Tether 1996).

11 According to the analysis of Prantl (2001), those firms indicated as "dead" by Creditreform have almost certainly left the market. The reverse, however, is not true: Voluntary firm closures are often recorded by Creditreform after a considerable delay, causing the number of closed firms to be underestimated.

12 Table 8 in the appendix also shows the number of still-living firms in 2003. Since the number of mismatches in the population is indeterminable, possible mismatches are not considered in Table 8.

4 The Model

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):[13]

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

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 α, β, and γ 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:

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

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 (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.[14]

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

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[13] 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.

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

given by the firms is therefore halved to produce an estimate of R&D employment that will be used in the econometric model.[15]

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.[16] Unfortunately, we only have information on investment in physical capital for the year preceding the second survey, i.e., 2002.[17] Therefore, I decided to use this value of gross investment in physical capital in 2002 to approximate physical capital.[18]

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 characterizes firms that belong to an engineering industry, the second indicates firms from other manufacturing sectors including ICT-hardware and health and life sciences. Thus, service firms are used as the base category. More disaggregated industry dummies might be desirable, but the number of firms from the sectors ICT-hardware and health and life sciences is very small (cf. section 6), prompting my decision to consider only two industry dummy variables. 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.[19]

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15 My results are not sensitive to this assumption. Using alternative approximations of number of R&D employees, the estimated coefficients are almost identical to the results shown in section 7.

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

17 Information on investment was not collected by the first survey in 1997/1998.

18 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 paper is that gross investment in physical capital often varies significantly from one year to the next. Hence, the results might be different had we merely used the value of gross investment in 2001 instead of that of 2002. However, the econometric results of this paper, 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.

19 DIW et al. (2003) state that in Eastern Germany in 2002, GDP per employee only amounts 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

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 by owners and investors. Therefore, firm growth is examined as the surveyed firms' second performance indicator. 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 described in section 3, i.e., between 1997 and 2002. The logarithm of the annualised growth rate G is given by (see, for example, Evans 1987a, 1987b)

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

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

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

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

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[20]: Firms are often founded with a sub-

for Western German firms is not significant in the productivity equation. An obvious explanation for this is that Western German firms are better equipped with firm-specific resources than UK-based firms. Therefore, a dummy variable for West Germany was not added in the final econometric specification.

20 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, describe 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).

optimal size, i.e., smaller then 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 paper'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 is 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: The negative effect of size on firm growth decreases as firms approach their MES. Therefore, I also include the square of the logarithm of employees (sales) in the growth equation.

Similar 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 leads to higher growth rates (Ericson and Pakes 1995, Jovanovic 1982). These efficiency gains decrease as firms become older. To test this hypothesis, I 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. The latter theory (e.g., Penrose [1959], Wernerfelt [1984], or, in the context of firm growth Geroski [2000]) regards a firm as an idiosyncratic bundle of assets (physical resources as well as intangible resources like know-how or experience). Since physical assets are relatively easily obtained or imitated, a firm differentiates from its rivals by the intangible resources it possesses or may create via R&D activities. However, R&D activities are not necessarily exogenous if a firm decides on the amount of R&D based on its growth prospects (see, e.g., Felder et al. 1994). Furthermore, using R&D intensity (expenditures on R&D as percentage of total sales) 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 also have been affected by their interim R&D activities. 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 variables were gathered by the two surveys in addition to R&D intensity. They better describe the firms' long-term R&D activities. Moreover, the problem of endogeneity is likely to be less severe for the two dummy variables 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.[21]

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, firm managers were asked to indicate on a five point Likert scale whether they experienced a shortage of skills in different areas, among them marketing, logistics, and R&D. The econometric model will include two dummy variables that take the value 1 if the respective firm's managers experienced a "serious" (4) or a "very serious shortage" (5) in marketing or R&D. These two dummy variables are hypothesised to reduce firm growth.

The role of imperfect competition was already stressed in discussing the relationship between firm size and growth. The argument was made that imperfect competition enables firms to realize 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. Bürgel et al. (2004) called this competition-free time period in which firms can realize temporary monopolistic rents the "window of opportunity". 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. Following Bürgel et al. (2004), I 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.

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

[21] 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.

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.[22] 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 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 is therefore neglected in the final specification.

The growth equation is completed by two industry dummy variables (for the engineering industry and other manufacturing industries including ICT-hardware and health and 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 do 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-maximizing 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 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 export activities, but that are independent of growth and labour productivity (see also the explanation of the econometric model in section 5). 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 rivals. These assets not only facilitate foreign market entry – they also support a long-term engagement in the international market (cf. Fryges 2004). However, as shown in the previous subsections, R&D may also be decisive for long-term growth and above-average labour productivity. In fact, number of R&D employees is directly included in the labour productivity equation (1) as a production factor and (permanent) R&D activities are postulated to increase the respective firm's growth rate in equation (4). Therefore, R&D is not suitable to identify the internationalisation equation.

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[22] 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.

Using the same data set this paper is based on, I evaluated the impact of different variables proposed by theories of economics and international management on entry into and exit from the international market (see Fryges 2004). Based on these results, 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) and the so-called stage models of internationalisation (e.g., Bilkey and Tesar 1977, Bilkey 1978), international business activities are associated with uncertainty. Accordingly, 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 exclusion of the internationalisation 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 steps in their internationalisation processes. Therefore, the firms in our sample were asked whether a member of their respective management team had work experience abroad or whether a manager was educated abroad before joining the company. The international experience of firm managers can also be regarded as an intangible asset that facilitates firms' international activities from a resource-based view of the firm (see, e.g., Wernerfelt 1984 and the explanations in the previous subsection).

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 contacts to end-users, inducing high transaction costs prior to selling the product (cf. Williamson 1985 for a presentation of transaction cost economics). The questionnaire measures the degree of customisation on a five point Likert scale ranging from 1 "unimportant" to 5 "very important". For the econometric estimations, a dummy variable is used that takes the value 1 if the firm has classified the requirement of customisation as "important" (4) or "very important" (5).

5 Econometric Implementation

The relationship between labour productivity and internationalisation is implemented econometrically as a switching regression model with endogenous switching as described by Maddala (1983). This model allows a simultaneous estimation of 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 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) $$\ln\left(\frac{Y_i}{L_i}\right)_{INTS=0} = \ln A_{INTS=0} + \alpha_{INTS=0} \ln\left(\frac{K_i}{L_i}\right) + \beta_{INTS=0} \ln\left(\frac{R_i}{L_i}\right) + \left(\mu_{INTS=0} - 1\right)\ln L_i + u_{i,INTS=0}$$

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

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 a measures the impact the gain in productivity due to international business activities has on the decision to internationalise. If a is equal to zero, the firm's export behaviour is independent of the productivity differential. The selection 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 $\varepsilon_i = a \cdot (u_{i,INTS=1} - u_{i,INTS=0}) + v_i$ is assumed to be normally distributed and the three error terms of equation system (5) follow a trivariate normal distribution, i.e.,

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

(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 σ_{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.[23]

[23] 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.

In principle, it is possible to formulate the growth equation in dependence of the internationalisation status, analogous to equation system (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 δ in equation (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) then reduces to a two-equation model:

(8)
$$\ln G_i = X_i\delta + \theta \cdot INTS_i + u_i$$
$$INTS_i = \begin{cases} 1 & if\ I_i^* = a\cdot\left(X_i\delta\right) - C_i + v_i = Z_i\Pi + \varepsilon_i > 0 \\ 0 & otherwise \end{cases}.$$

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

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

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 θ measures the effect of international sales on firm growth. Since the growth equation and the internationalisation equation are estimated simultaneously, a possible self-selection of firms with higher growth into the international market is considered.[24]

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

[24] Model (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.

6 Descriptive Analysis

Table 1 shows the share of firms with and without international sales in 2003. In both countries, more than two-thirds of the responding firms had international sales. Even the majority of firms from the service sector (mainly software firms) turned out to have international business activities, although the percentage of these firms with foreign sales is smaller than in any high-tech manufacturing sector. In the manufacturing industry, firms that belong to the sectors ICT-hardware, engineering, and health/life sciences export more often than other manufacturing firms. In the UK sample, all firms in the sectors ICT-hardware and health/life sciences are internationally active. However, it should be mentioned that the number of observations in these two sectors is rather small. In Germany only 5 ICT-hardware firms (15 firms in health/life sciences) answered both surveys; in the UK there were 12 responding firms in the ICT-hardware sector (10 respondents in health/life sciences).[25]

Table 1: Firms with International Sales in 2003 (in %)

	Germany		UK	
Sector	No	Yes	No	Yes
Software/services	45.5	54.5	35.5	64.5
ICT-hardware	20.0	80.0	0.0	100
Engineering	10.5	89.5	13.8	86.2
Health/life sciences	20.0	80.0	0.0	100
Other high-tech manuf.	27.3	72.7	31.4	68.6
Total	28.7	71.3	22.2	77.8

Source: ZEW, University of Exeter, own calculations.

There is a slight increase in international engagement between 1997 and 2003. The overall share of exporting firms increases from 72 % in 1997 to 74 % in 2003. With the exception of other manufacturing firms in the UK, in all sectors the share of firms with exports in 2003 is at least as high as in 1997. Although there is a high persistence in the individual status of internationalisation[26], a

25 In fact, in contrast to the first survey in which a bias with respect to sector was not found, the ICT-hardware sector is underrepresented in the German as well as in the UK sample. On the other hand, the sector health/life sciences (engineering) is overrepresented in the German (UK) sample.

26 Roberts and Tybout (1997) presented a dynamic model with sunk costs that can explain the observed high persistence in firms' export behaviour. The authors can also prove empirically the existence of sunk costs for a sample of Colombian plants in the manufacturing sector observed between 1981 and 1989, inclusive. For the sample used in this paper, I analysed entry into and exit from the foreign market. Although the data set is not suitable to prove empirically the existence of sunk costs, my results are consistent with the sunk costs hypothesis (cf. Fryges 2004).

rather high number of firms changes the internationalisation status, leading to entry and exit over time. Nearly 12 % of German and 8 % of UK firms left the international market between 1997 and 2003. During the same time period, 14 % of German firms and 8 % of firms sited in the UK entered the international market. Thus, German high-tech firms more frequently change their status of internationalisation, whereas UK firms show a higher persistence in their internationalisation behaviour.

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 2 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[27]: 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 on R&D. Whereas firms with international sales have an average of about three employees working on research and development of new and existing products, firms that do not export employ only one full-time worker for R&D activities.[28] Moreover, within the group of non-exporters more than half of the firms do not have 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 are not carrying out R&D activities. This result corresponds to the values of R&D intensity in the lower part of Table 2: 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. 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.[29] Obviously, during the period between the two surveys, R&D activities became a distinctive characteristic by which an internationally oriented firm discriminates itself from its domestically focused competitors.

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[27] See section 2 and the literature quoted therein.

[28] Remember that the number of R&D employees given in Table 2 is an estimate based on the assumption that all R&D employees indicated by the firms' representatives only work on R&D 50 % of their time.

[29] Nevertheless, econometric analyses show that R&D intensity had a positive impact on probability to internationalise in 1997 (Bürgel et al. 2004).

Table 2: 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 € 1,000; [b] Sales per non-R&D employee in € 1,000; [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.

Descriptive statistics of the three chosen performance indicators that will be analysed econometrically (labour productivity, employment growth, sales growth) are also included in Table 2. Similar 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 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 labour productivity of Western German firms is significantly higher compared with UK-based firms, but 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 annual employment growth rate of 7.7 %, whereas firms with only domestic sales grew by 2.2 % per year. Figure 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 lies slightly to the right or the UK function. The estimated kernel densities in Figure 1 also emphasize 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 %).[30] The estimated kernel density functions of the logarithmic annualised sales growth rate in Figure 1 show, on average, higher growth rates for German firms compared with 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 %) than for German firms (12 %). To summarize, 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 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

[30] In order to compute the annualised sales growth rate, discounted sales were used, discounted by producer price indices (PPI) for the 3-digit NACE code of the respective manufacturing sector in Germany or 4-digit NACE code of the corresponding manufacturing sector in the UK, as they are available online from the time series services of the Federal Statistical Office of Germany (https://www-genesis.destatis.de) and the Office for National Statistics in the UK (http://www.statistics.gov.uk). Since the PPI of the 4-digit NACE code 30.02 (manufacturing of computers) was the only time series where hedonic pricing methods were applied by the UK Office for National Statistics, I also used the PPI of the corresponding German sector for the UK firms in order to avoid varying methods of PPI determination. Sales of software and service firms were discounted using the implied deflator of gross value added of the 2-digit NACE code as available from the German Federal Statistical Office. Since comparable data were not available for the UK, I also used the German deflators for the UK-based software and service firms.

by other production factors, e.g., capital or (imported) intermediate products. Thus, one unit of output can then be produced by a smaller number of employees.[31]

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 growth slower (see section 4). As Table 2 shows, in 2002 the firms of 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 of our sample are all examined at a later stage of their development.

7 Empirical Results

Labour Productivity and Internationalisation

The estimation results for the productivity equations with and without international sales are given in Table 3. In the regime with exports, the coefficients of both capital intensity and intensity of R&D employees are significant. The coefficient of 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 0.676.

The dummy variable for "other manufacturing industries" is positive and significant. Compared to engineering firms and the base category, software and services, other manufacturing firms exhibit higher labour productivity in the regime with international sales. 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 be nevertheless 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 of productivity.

[31] 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.

Table 3: 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
σ_{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
σ_{00}	0.391	***	0.079
Wald tests for joint significance			
	χ^2		Prob > χ^2
Sector dummies with internat. sales	14.029		0.001
Sector dummies 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
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.

The three dummy variables controlling for sectoral and regional differences are not significant in the regime without international sales. As already mentioned in section 5, 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 determine empirically 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 ρ between the residuals of the regime equations and the internationalisation equation. As can be seen in Table 3, 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 4 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 supposed to be independent of labour productivity, but that determine the firms' internationalisation decisions. 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 customisation 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 my previous results, when analysing empirically the determinants of foreign market entry and exit for the firms in our sample (cf. Fryges 2004). The entire set of identifying variables is jointly significant, although only on the 10 % level.[32]

Excluding capital intensity, the production factors enter the selection equation significantly. Intensity of R&D employees as well as number of non-R&D employees are positively correlated with foreign market participation. Thus, the strategic role of R&D for the internationalisation behaviour of (small) technology-oriented firms is highlighted by the model. R&D activities can be expected to create assets within the firm that are difficult for the firm's rivals to imitate and thus ease the internationalisation process as predicted by the resource-based view of the firm. Firm size, measured by number of non-R&D employees, also increases probability of being an exporter. As Johanson and Vahlne (1990) stated, 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 there are no region-specific factors influencing the export decisions of Eastern German firms.

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 a in the selection equation of equation system (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 paper confirms the findings of many other studies (see section 2): The higher labour productivity of firms with international sales is a result of self-selection into the foreign market.

32 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.

Table 4: 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			
	χ^2		Prob > χ^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.

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. 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 9 in the appendix. 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 %[33] 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

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

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.[34] 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 Internationalisation

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

In contrast to Gibrat's law, employment growth rate decreases with number of employees, measured at the beginning of the growth period 1997. Like 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 negative 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 regarded growth period.[35] For these firms it is plausible to assume 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' grow 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.

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[34] 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.

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

Table 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 in competencies: Marketing	-0.043	**	0.020
Shortage in 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*
ρ	0.157		0.474
σ_{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 in competencies: Marketing	-0.040		0.337
Shortage in 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			
	χ^2		Prob > χ^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 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. As hypothesised, R&D activities increase both a firm's employment and sales growth rates. The dummy variable for permanent R&D activities characterizes firms that carried out R&D continuously during the examined growth period. Thus, the firms created intangible assets that increase their growth rates, as argued by 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 in marketing significantly reduces employment and sales growth. On the other hand, experienced shortages in R&D do not significantly affect growth of sales or employment. When regarding the experienced shortages over time indicated by firm managers, the percentage of firms with an affirmed shortage 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: 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, however, firms had to intensify their sales-promoting efforts 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 in marketing reduce growth.

Table 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 in competencies: Marketing	-0.049	**	0.023
Shortage in 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*
ρ	-0.266		0.313
σ_{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 in competencies: Marketing	0.095		0.378
Shortage in 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			
	χ^2		Prob > χ^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.

Firms with a window of opportunity that lasts 12 months or shorter do not distinguish themselves significantly from firms with larger such periods. 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 were 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 1, the dummy variable for German firms is positive but insignificant. Obviously, their are no structural differences between German and UK firms additional to those covered by the variables included in the growth equations.

International sales do not affect employment or sales growth significantly. Furthermore, the estimated correlation coefficients ρ 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' work experience abroad increases the probability of their companies being exporters, whereas high product customisation is a barrier to entry into the foreign market.[36] [37]

[36] 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.

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. A bit 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 probability of having international sales, the coefficient of firm size is positive and significant. Our findings may be due to the fact that number of employees and amount of sales at the beginning of the growth period were included in the selection equation, while the endogenous variable is the firms' 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. During a six-year period, however, firms vary in size. Firms' dimensions at the beginning of the growth period might be very different form their size at its end. Hence, there may not be a positive correlation between lagged firm size and current export activities. It is also surprisingly 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 analysis in Table 1.

The estimation results of the internationalisation equation emphasize in particular 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, internationalisation has no marginal effect on firm growth.

8 Conclusion

This paper examines the relationship between three indicators of firm performance (labour productivity, employment growth, and sales growth) and the export behaviour of a sample of young, small, technology-oriented firms in Germany and the UK founded in the period 1987-1996. These firms were contacted by two surveys, which were conducted in 1997 and 2003. Examining the

[37] 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.

firms in our sample 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 to many other empirical studies which concluded that causality runs from firm performance to internationalisation and not vice versa. Thus, the question arises whether the 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 of most other samples studied so far. Only during 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.

R&D activities play a crucial role 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 first and the second survey, 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. Number of R&D employees constitutes a production factor in the Cobb-Douglas production function. For firms with international sales, 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 international business activities with respect to both foreign market entry and long-term engagements in the international market (cf. Fryges 2004).

However, the question remains: Why do firms actually enter the foreign market? What are the benefits of international engagement? Arguing that good or more innovative 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 theoretic 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 other studies this paper 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, the latter 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 seems to be no long-term benefits. The sufficient condition for international engagement is not met in the long run.

Additionally, the results contradict assumptions regarding profit-maximizing 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, exporting firms would not behave rationally because they could realise high levels of performance at a lower cost. However, our findings should not be interpreted to suggest that firms with international sales do not behave rationally. Firstly, 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 to 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 a better endowment with firm-specific assets – to higher probability of international engagement. Secondly, in this paper 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.[38] If spillover effects exist, it will be difficult to measure productivity differences as a result of international engagement. Thus, 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 international engagement, however, remains unanswered.

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

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Appendix

Table 7: Definition of High-tech Sectors

Aggregated industries used	NACE Rev. 1	Short description according to NACE Rev.1
R&D-Intensive Service Industries	64.20; 72.20; 72.30; 72.40; 72.60; 73.10	Telecommunication, Computer Programming and Software Services, Data Processing, Misc. Computer Services, R&D in Natural Sciences and Engineering
ICT-Hardware	30.01; 30.02; 32.20; 32.30	Office Equipment; Computers and other Information Processing Equipment; Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraphy; Television and Radio Receivers, Sound or Video Recording and Reproducing Apparatus
Engineering Industries	33.20; 33.30; 33.40	Electronic Instruments and Appliances for Measuring, Checking (except Industrial Process Control); Electronic Industrial Process Control Equipment; Optical Instruments; Photographic Equipment
Health and Life Sciences	24.41; 24.42; 33.10	Pharmaceutical Products and Preparations; Medical and Surgical Equipment and Orthopaedic Appliances
Other High-tech Manufacturing	24.16; 24.17; 31.10; 31.20; 32.10; 35.30	Plastics and Synthetic Rubber in Primary Form; Electric Motors, Generators and Transformers; Electricity Distribution and Control Apparatus; Electronic Valves, Tubes and other Components; Aircraft and Spacecraft Manufacturing

Source: Manufacturing sector: Butchart (1987); service sector: Bürgel et al. (2004).

Table 8: Sample Composition of the Population of High-tech Firms, 1997 and 2003

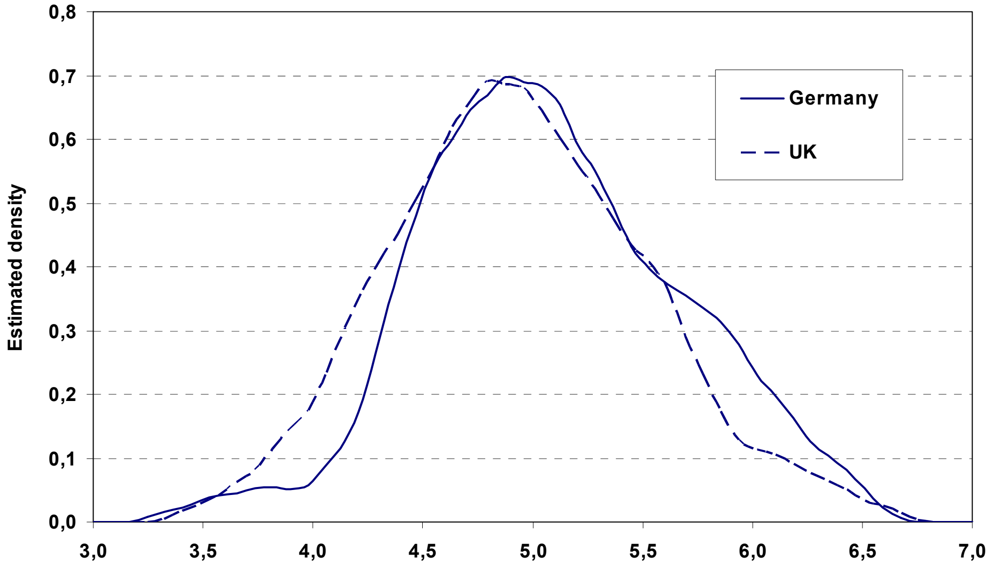
	Surviving firms 1997			Surviving firms 2003		
Employees	Manufacturing	Services	Total	Manufacturing	Services	Total
Germany						
3-5	637	1,241	1,878	508	959	1,467
6-9	401	654	1,055	338	517	855
10-19	525	596	1,121	437	463	900
20+	621	370	991	515	269	784
Total	2,184	2,861	5,045	1,798	2,208	4,006
UK						
3-5	673	742	1,415	581	643	1,224
6-9	474	370	844	405	286	691
10-19	472	292	764	411	210	621
20+	362	177	539	277	141	418
Total	1,981	1,581	3,562	1,674	1,280	2,954

Note: The 1997 assignment of a single firm to a stratification cell was used.

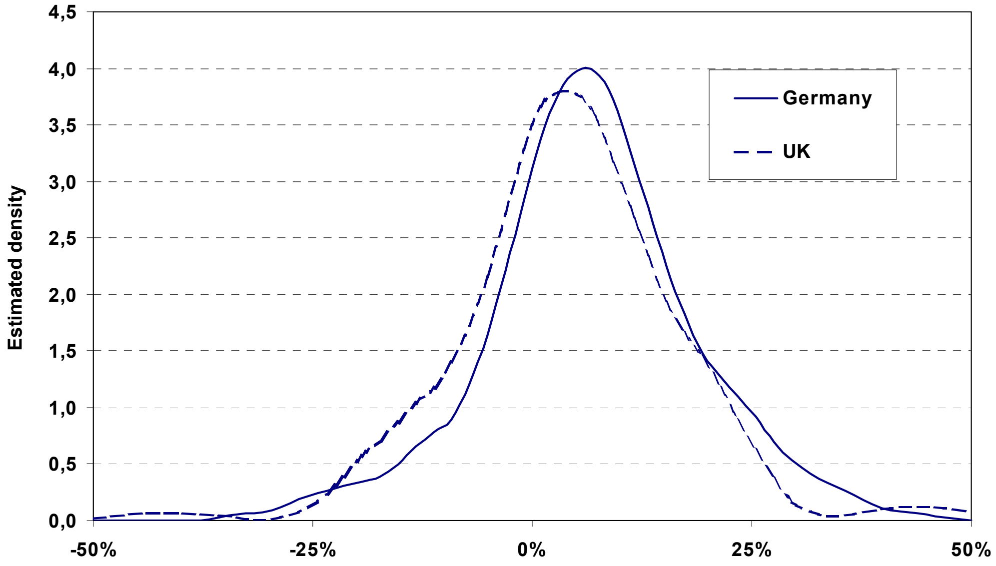
Source: ZEW, University of Exeter.

Figure 1: Estimated Kernel Densities

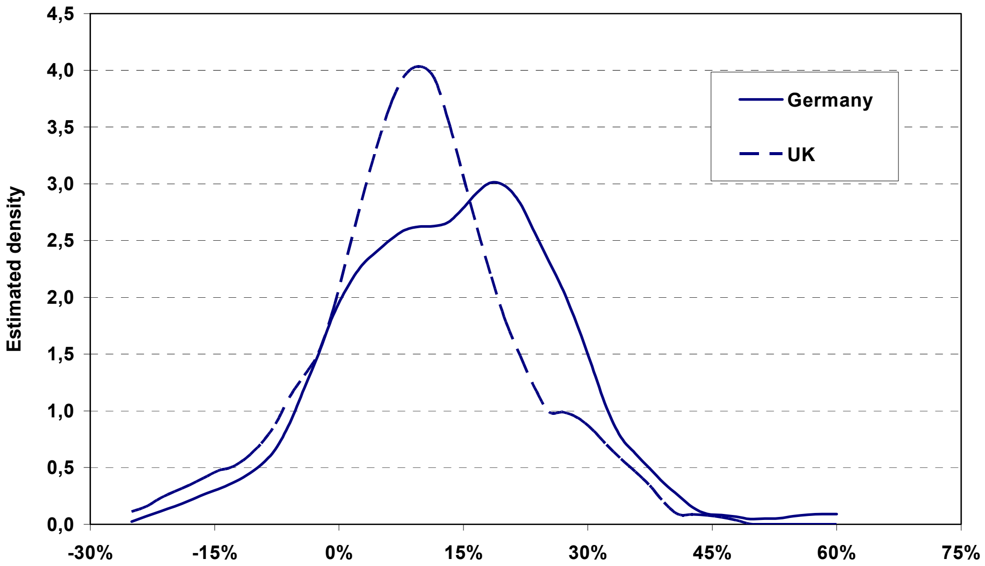
Log-labour productivity 2002



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 € 1,000 per non-R&D employee.
Source: ZEW, University of Exeter, own estimation.

Table 9: 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.