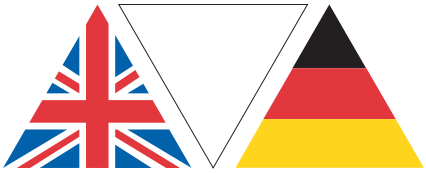

Anglo-German Foundation for the Study of Industrial Society/
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Our gratitude is also extended to those several hundred firms which have allowed us to contact and question them in detail both in 1997 and 2003. We are further indebted to those firms which also allowed us to complete a series of brief updates on their present circumstances in 2005.

Finally, we would like to acknowledge the contribution of Dr. Oliver Bürgel whose original doctoral dissertation in 1999 resulted in this long-term study.

As is usual, any omissions or errors should be seen as the sole responsibility of the authors.

Executive summary

This report documents over a twelve year period (1991–2003) the continued fortunes of 600 independent New Technology-based Firms (NTBFs) which were founded in Germany or the UK between 1987 and 1996. Our findings on these firms, often known as 'high-tech start-ups', have significant implications for policy makers in the complementary areas of Entrepreneurship and Innovation.

Significant criteria for success and failure have been identified as follows:

Survival chances of NTBFs

- Once an NTBF has survived to its 5th year, there is an approximately 80% chance that the firm will still be trading in its 12th year.
- High-tech young firms, once started, are less vulnerable to failure in dynamic and competitive technology markets than is popularly assumed.
- Despite the severe downturn in high-tech markets starting in the year 2000, a majority of sampled firms *continued* to grow sales revenues and to create new jobs.

Factors of success and failure

- A large founding team was associated with a higher probability of survival in the UK.
- Business angel finance at start-up in Germany and later-stage formal venture capital finance in the UK were both linked to lower survival probabilities.
- Firms which used 'tried and tested' technologies, a conservative strategy more prevalent in the UK, demonstrated lower long-term survival rates.
- The creation and maintenance of managerial skills in small high-tech firms continue to be of profound importance for both survival and growth. For example, persistent and unresolved weaknesses in management (Germany) and in effective financial controls (UK) both increase the long-run risk of firm failure.

Comparative performance of UK and German NTBFs

In the first five years of growth to 1997, UK start-ups generally outperformed their German peers. This situation was to reverse between 1997 and 2002.

- Overall, the typical German firm performed better than its UK equivalent. In the first 10 years since formation, the German median firm had grown 11-fold compared to an 8-fold growth in the UK.
- Employment by 2003 (the 12th year) in the median firm was 12 persons in Germany and 10 in the UK.
- Sampled German NTBFs created *more* jobs in *more* technology sectors than UK firms for each of the two consecutive five-year periods under observation.

The improbability of 'spotting winners'

- It is *not* possible to determine accurately which firms will demonstrate long-term, high-growth trajectories by reference to their early growth patterns. Firms growing rapidly in the initial five-year period were found unlikely to sustain their exceptional economic performance. In essence, it is not feasible to pick future winners early in their life cycle. This has important policy implications for small firm support and advisory services.
- Europe's dilemma, as identified in the European Commission's Lisbon Strategy (European Commission, 2000) remains the absence of significant numbers of 'gazelles' (i.e. young firms that continue to grow rapidly over several years into large and globally dominant firms) being generated within the members' economies.
- While the top five firms in our second survey had aggregate sales of €203m per annum and employed a total of 1,830 workers, the real value of our respondent firms lies in their total *aggregate* impact on their host economies. In Germany and the UK, the greatest economic value has been created by the cumulative impact of several thousand more modestly growing firms. Policy prescriptions need to recognise this somewhat pedestrian reality.

The importance of internationalisation as a 'cause and effect'

- Despite Germany's reputation for export excellence, UK firms continue to be more global than their German peers. By 2003, 72% of all sampled UK firms were international compared to 60% of German firms.
- Exporting UK firms on average serviced 16 foreign markets compared to 11 for German exporters.
- Export sales represent nearly half of total sales for UK's internationalising firms compared to just under one-third for German firms. German firms also remained strongly Euro-centric in their export focus when compared to those in the UK. For example, the USA was the most important foreign market for UK exporters compared to Switzerland for Germany.
- Firms with international business activities had, on average, higher sales, more investments and a greater number of (R&D and non-R&D) employees.

- Internationalising firms were also more productive when measured by both sales and employment growth rates.
- While internationalisation contributed to more rapid growth in the first five years of the sampled firms' existence, it was *not* the driving force supporting continuing growth. Econometric analysis showed that firms with more superior human capital and technical knowledge grew faster. These firms also internationalised more extensively. However, over time, foreign sales were an *outcome* of superior firms and not the cause of their faster growth.

Where are Europe's new world-class firms?

- It is a matter of regret how few exceptional growth companies (gazelles) were identified in a relatively large sample of UK and German high-tech young firms. While our research had a more precise focus on the long-run growth of European firms, the question still remains: 'Why does the USA appear so much better than Europe in creating successive generations of global businesses from new technology opportunities?'.
- We now have a template describing the environments, actions and consequences of new technology-based firms' behaviour in two major European economies. This can and should be appraised against their US equivalents' actions and performance. It is hoped that our research can materially contribute to a better understanding of an issue central to Europe's future economic well-being as a dynamic and entrepreneurial region.

1 Introduction

The present study, financed by the Anglo-German Foundation for the Study of Industrial Society (AGF) is now the fourth published report specifically focused on new technology-based firms (NTBFs) in Germany and the UK. This specific research focus was first supported by AGF in 1977 with the publication of a study undertaken by the technology-focused consultancy firm Arthur D. Little. Their report, *New Technology-Based Firms in the United Kingdom and the Federal Republic of Germany*, was an early and influential contribution. It was the first published document to use the term 'new technology-based firm' and to provide a definition which, despite its operational limitations, became widely deployed in the contemporary literature. More importantly, this study represented one of the first serious attempts to survey methodically the existing stock of this type of small- and medium-sized firm at a time when large firms were considered the predominant focus of industrial and innovation policies. Arthur D. Little's researchers emphasised that, in comparison with the USA, Germany and the UK were each lagging behind if judged by the rate of formation of NTBFs and in their total contribution to the overall economic activity of either country. In terms of a policy contribution, this study was instrumental in highlighting the lack of support infrastructures for the genesis and growth of high-tech start-ups in Europe's two largest economies. Given national and European policy makers' contemporary concerns with international competitiveness in knowledge-based industries, which are exemplified by the ambitious goals proposed at the European Commission's Lisbon Summit in 2000, the 1977 AGF report was prescient in its focus and concerns.

The picture in Europe painted 10 years later was a more optimistic one. A joint project, again co-funded by the AGF, involved the Institut für Systemtechnik und Innovations-forschung (ISI) of the Fraunhofer Gesellschaft and the UK consultancy Segal, Quince and Wickstead. While more limited in scope and relying mainly on secondary data sources, this 1988 study, *New Technology Based Firms in Britain and Germany*, set another milestone. It reported a significant growth in the number of high-tech start-ups being formed in both countries – albeit with a more developed NTBF sector in the UK relative to the size of its economy. Less encouragingly, the 1988 AGF report continued to corroborate the key finding of the earlier Arthur D. Little study in terms of Europe's smaller pro rata population of NTBFs compared to the US exemplar and benchmark.

The third report, commissioned by the AGF in 1997 and published in 2001, *The Rapid Internationalisation of High-Tech Young Firms in Germany and the United Kingdom*, can be seen as a continuation of the same research interest, albeit employing a more rigorous academic tradition of theory and empirical methodologies across the related disciplines of Economics, Econometrics and Management (i.e. Strategy and Entrepreneurship). While its subject continued to be an examination of NTBFs in Germany and the UK, its attention turned to an increasingly important behaviour trait of young knowledge-based firms – namely, their rapid internationalisation. Given the possible positive linkages between internationalisation and commercial success, the new study was timely. It was started at a time in the mid-1990s when advanced technology sectors were seeing an unprecedented growth in investor interest worldwide. The study sought to document the incidence and

degree of internationalisation behaviour across a significant and representative sample of young and independent high-tech firms in the UK and Germany.

This third AGF study was more quantitative than either of its predecessors in both design and execution. Some 600 firms agreed to be surveyed in a process whereby the target firms were identified from a random, stratified sample of precisely defined NTBFs.[1] Specifically, the researchers employed a 'matched sample' methodology in order to isolate those firm outcomes, and document their ensuing consequences, which were directly attributable to international activity. Internationalisation was shown not to be the exception among NTBFs but, statistically, the norm for recently formed UK and German firms. (At one stage, researchers in 1997 were concerned that they might not find enough sample firms *without* international experience.). While young and small firms were generally characterised from both theory and observation as being less likely than older or larger firms to undertake overseas sales activity, technology-based young firms demonstrated a major and important exception to this rule. Indeed, these young European firms, when matched by age and sector, are likely to be more international, or even on occasions more global, than their counterparts in the USA. Given the growing recognition of the importance of young knowledge-based firms in accelerating technological innovation in critical industrial sectors including ICT and bio-technology, the timing of this report was (like that of its predecessors) highly fortuitous. In Europe, as elsewhere in the developed world, national policy makers had become increasingly active in encouraging, within their domestic economies, the genesis and growth of firms of high potential future value.

In the third AGF study, undertaken by the present research group from 1997 to 2000, the average respondent firm had been in existence for approximately five years. A majority of the 600 firms were growing rapidly in both sales and employment but from a very small economic base. Several firms had already internationalised extensively, thereby supporting empirically the commonly used term 'born global'. The study, one of the largest of its kind, sought to understand in detail the processes of internationalisation and, critically, their contribution to sales and employment growth in the respondent firms. The nature of the internationalisation process, including the adopted mode of foreign sales and the order of host countries chosen, were specific elements of the study. The authors also explored what firm factors both accelerated and impeded the internationalisation process including, for example, managerial and other resource endowments, the innovative nature of the product or service, the end-users of the product, the mode of internationalisation chosen and the role of alternative sources of finance including public grants. From the findings, a number of theoretical and practitioner prescriptions were promulgated.

The third study was able to chart the growth of UK and German NTBFs at their earliest and most vulnerable stages after firm formation. Consequently, the researchers could offer empirically substantiated advice on what factors appeared to correlate with short-run firm growth and survival. Yet, governments' considerable policy interest in NTBFs concerns their potential over time to become (or support the rapid growth of) large, international and technology-leading firms sired from the domestic economy. In the latter

[1] See Bürgel et al. (2004) for a detailed description of the sampling procedures employed in both Germany and the UK, which resulted in 3,562 and 5,045 firms being identified in the UK and Germany, respectively. A stratified sample of 2,000 firms was drawn from each country.

half of the 20th century, the global technology marketplaces have become increasingly dominated by predominantly US-originated companies plus a few Japanese and other South Asian contenders. (It remains to be seen what influence China's rapid economic and political growth will have on this relatively ordered structure.) Many of these companies became within one or two decades among the largest and most successful economic players across a series of key technology-enabled product markets including software, micro-processors, computer hardware, telecommunications, life sciences, etc. New enterprises formed in the 1980s, such as Microsoft, Apple, Oracle, Dell, Cisco, AOL, Genentech and Amgen, have rapidly become globally known. More recent start-up companies, such as Amazon, Google, eBay and Skype, have continued this pattern as technological advances have opened up new markets, new products and new consumer opportunities. With the notable exceptions of SAP, Vodafone, and (at its genesis) Skype, very few of these technology-leading firms created in the last quarter of the 20th century were European in origin. This absence of a major representation in the next generation of corporate technology leaders has been a concern of considerable gravity for both individual European countries and the European Union.

Thus, the purpose of the fourth and present study, *The Survival and Growth of 'Adolescent' High-Tech Firms in Germany and the UK, 1997–2003*, is to ascertain the performance outcomes for the cohort of sampled firms started between 1987 and 1996. The research was undertaken simultaneously in Germany and the UK over the period 2002–05. The research objectives were based on an understanding that, in order for firms to become economically powerful, the initial surge of rapid growth within the nascent firm has to be replaced by several continuous years of sustained and substantial growth. Such firms recording growth rates of 20% per annum compound have been termed 'gazelles' in the Management literature (Birch, 1979). The AGF cohort of firms was approximately 12 years old at the time of the second survey interviews in 2003. Firm statistics had already been obtained on several of these firms via secondary data sources including FAME (UK) and Creditreform (Germany) in 2002. Thus, the researchers could chart the fortunes of what were now better described as 'adolescent' rather than 'young' firms. First, the survival rate of the firms was estimated, and the key factors influencing survival were identified.[2] Second, the performance of surviving firms was able to be assessed over two distinct periods: (i) start-up to 1997, and (ii) 1997 to 2003. Through both survey and case study methods, the researchers could look at how the firms had managed to deal by 2003 with resource constraints and other factors cited as important in 1997. Similarly, the evolution of internationalisation behaviour and its scale could also be documented and cross-referenced against the type of firm and its country of origin. The wider scope of the study allowed findings from both theoretical and policy perspectives to be given with the greater authority of a larger number of data points over an extended period of time. The AGF research programme on NTBFs has evolved purposively into a longitudinal panel study on a unique sample of European firms.

It is this latest 2003 study which will be described in this report. However, in order to understand the import of the findings presented, they will be analysed where appropriate in the context of the firms' changes over the two contiguous periods of the study. Thus, the report will repeatedly refer to the data and findings of the earlier AGF study published in 2001.

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[2] It should be noted that this is survival from 1997 to 2003, not from the firms' start up dates to 2003. The study contains a survival bias by starting in 1997 with firms that had already remained alive for their first five years on average.

2 A brief summary of theories of internationalisation

Previous publications stemming from this research programme were published by Bürgel (1999), Bürgel and Murray (2000) and Bürgel et al. (2001), and by the present authors in an extended report for *ZEW Economic Studies* published by the Centre for European Economic Research (ZEW) and Physica-Verlag (Bürgel et al., 2004). These writings have documented in detail the evolution of theory that has allowed a melding of Internationalisation and Entrepreneurship studies in order to chronicle and explain the growth trajectories of NTBFs as firms at the earliest stage of their lifecycles. Therefore, this section will only introduce these established theories to the reader.

Conceptual frameworks

Theoretical frameworks for the analysis of international business are well developed in the Management as well as the Economics literature. Most prominent among the theoretical alternatives are process models including stage models (Johanson and Vahlne, 1977, 1990; Cavusgil, 1980); the international new ventures perspective of Oviatt and McDougall (1994); monopolistic advantage theory (Hymer, 1976); internalisation and transaction cost theory (Buckley and Casson, 1976); as well as oligopolistic behaviour theories (Knickerbocker, 1973). In addition, there are frameworks addressing a broader scope of issues (for example,. Dunning, 1980), which incorporate elements of monopolistic advantage, internalisation and international trade theories. More recently, the export management and the new trade theories also address the question of international business (see Leonidou and Katsikeas, 1996; Bernard and Jensen, 1999).

The internationalisation process theory (IPT) concentrates on the managerial aspects of internationalisation. Timing of market entry, the structural forms of foreign operations and their evolution over time are seen as functions of the increasing experience and subsequently greater commitment of managers to foreign markets. The internationalisation process is ordered and sequential in a series of stages. Conversely, monopolistic advantage and internalisation theories originally tried to explain why multinational corporations exist as institutional forms for organising international production. These theories look at different aspects of internationalisation and try to answer different questions. Thus, it is perhaps better to view these theoretical models as focused on related but separate aspects of international entrepreneurship. On occasions, they are complementary rather than competitive explanations of firm actions.

As McDougall and Oviatt (2000) note, the effective study of NTBFs requires the recognition and integration of two separate but allied streams of research interest coming from Internationalisation and Entrepreneurship studies. These two authors' contribution to our theoretical understanding, in a stream of papers on international new ventures (INV) spanning the 1990s, is most frequently compared and contrasted to the

earlier process theory (see Autio, 2005, for a highly informative review that discusses Oviatt and McDougall's contributions to our theoretical understanding).

IPT was developed initially by Swedish academics as an attempt to understand the pattern of actions over several years of large and established Swedish exporters firms (Johanson and Vahlne, 1977, 1990). Internationalisation was viewed as an activity most likely to be associated with established businesses. When foreign sales were embarked upon, they were orderly and incremental and usually involved, at least initially, sales to countries that were similar to the culture and attributes of the exporting country. The seminal contribution of Oviatt and McDougall was to recognise and re-interpret theoretically the actions of new ventures that clearly had international and widely diverse sales *very early* in their commercial lives. If there was a staged process of internationalisation, it clearly did not apply to these young firms. They had managed to jump over several key development stages as fledgling companies. Extant theory had little to say regarding the existence of nascent firms that had achieved international and even global sales within months of their formation. As Autio (2005) points out, one reason for the discrepant interpretations of the two theories was that the prevailing commercial environment faced by new ventures had changed profoundly in the two decades between the birth dates of the two theories. The greater flow of information from foreign markets, the lowered costs associated with international travel and communication, the greater availability of internationally experienced managers and the enhanced ability of entrepreneurs rapidly to adapt and exploit their unique resources via international collaboration made the world of the mid-1990s a very different place from that of the mid-1970s.

Perhaps the greatest difference between the two theories is that, as Autio (2005) also observes, McDougall and Oviatt seek to explain how the internationalisation of new ventures is possible. In contrast, the process model of Johanson and Vahlne concentrates on defining and predicting the actual nature of internationalisation activity over time. Yet, as Bürgel (1999) notes, it is important to go beyond a cursory and wholesale application of one 'sufficient' theory. Elements of both INV and IPT, as well as other established theories, may well be useful to understand specific situations and behaviours of firms regardless of size or history. It was for this very reason that the third AGF study employed a 'matched sample' approach comparing the characteristics and behaviour of internationalisers and non-internationalisers in order to uncover which of the available theoretical perspectives contributed most to an understanding of the internationalisation decision.

Empirical studies in international entrepreneurship

At the time of the 2001 AGF report, the authors could note that 'Despite the established status of internationalisation as a field of study, surprisingly little research has been conducted into the detailed processes by which young and high-technology companies have internationalised.' The statement is no longer credible as several authors have now addressed the actions of internationalising new ventures in research studies of increasing sophistication and rigour. The academic works of, among others, Autio, Hitt, Sapienza, Westhead, Yli-Renko, and Zahra have each and in combination added to our understanding of internationalisation by a fusion of approaches that have exploited

strategy and entrepreneurship perspectives in an exploration of internationalisation. Rialp et al. (2005) examined 38 studies of 'early internationalising firms' published in academic journals over the period 1993–2003. By pointing out the scarcity of hypothesis-testing empirical papers in their sample, they suggest that internationalisation theory still remains underdeveloped They also propose that multi-theoretic approaches including case studies allied to more quantitative studies may prove fruitful.[3] Rialp et al. also sensibly point out that international new ventures theories should also be applied to new ventures other than those predominantly in high-tech sectors. At the present time, research on international new ventures has almost exclusively concerned itself with NTBFs. Yet, no author has suggested that rapid and early internationalisation is an exclusively technology-based firm phenomenon.

Thanks to the efforts of researchers including McDougall et al. (1994), Autio et al. (2000), Zahra et al. (2000), Bürgel et al. (2001), Yli-Renko et al. (2002), Zahra and George (2002) and Sapienza et al. (2006), a set of more challenging questions are now being asked given that the phenomenon of rapidly internationalising new ventures is now fully recognised. When it is appreciated that work specifically on INV was not published prior to the mid-1990s, we have in effect had a single decade of research interest. Thus, it is hardly surprising that the overwhelming majority of studies are cross-sectional in perspective. Recognising this limitation, Sapienza et al. (2006) called for both longitudinal studies as well as more 'matched sample' methodologies that will allow us to explore the effect of internationalisation on (among other things) firm survival. They also note the absence of information on the effect of internationalisation on growth and profitability. Zahra and George (2002) similarly argue the need to match the process of internationalisation to recognised performance outcomes. They also rightly suggest that we need to explore further how new ventures learn, and not assume that such processes of knowledge accumulation are necessarily identical to more established firms. This is an important point as surviving international new ventures are clearly highly skilled at learning rapidly in order to compensate for scarce resources and any incurred 'liabilities of newness or foreignness'. Autio (2005) calls for work on a 'fuller theory of internationalisation' that can address both the initiation of internationalisation (ex INV) and the process of internationalisation (ex IPT). He also makes the point that we have tended to treat technology as an undifferentiated entity. More finely grained studies would almost invariably find differences in the incidence and intensity of internationalisation by type of firm that would allow us great clarity in both theory and practice. Most certainly, it is highly improbable that the internationalisation trajectories of life science and ICT firms are likely to be similar and parallel.

As befits researchers on the threshold of a new and exciting subject area, we are more informed of our ignorance than our knowledge. The suggestions noted earlier are needed but will consume considerable resources before we have consistent results. In the interim, we have the fourth AGF study of NTBFs. It is perhaps a measure of the growing consensus of future research directions that several of the objectives that have been stipulated for this fourth study accord closely with the 'wish list' of future research developments expressed by leading academics in this synthesised set of research areas combining entrepreneurship, internationalisation and strategic management.

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[3] It is perhaps reasonable to point out that both the two AGF studies undertaken by the present authors had combined multiple methodologies including case studies and sophisticated econometric analysis.

The 2006 report, *Survival and Growth: UK and German New Technology-Based Firms Tracking Exercise 1997–2003*, addresses a number of areas where we are as yet still poorly informed. Given three data points and two time periods for each firm record (i.e. start-up date, 1997 survey and 2003 survey) we are able to look at questions of survival and, at least medium-term performance. We are able to discriminate given the size of our sample allowing us to make observations by firm age, technology sector, product innovation and country of origin. We also have data on sales and profitability for a majority of our sample. This will allow us to look at performance beyond basic survival and growth measures.

Finally, and perhaps most importantly of all, we have established a resource of comprehensive data on nearly 600 German and UK technology-based firms that goes back in some cases to 1987. It is a data set that has also been supplemented by a number of additional case studies covering major categories of growth trajectory across the two periods (i.e. fast-fast, fast-slow, slow-slow and slow-fast). It is the intention of the researchers and the AGF that this resource will eventually be made available to other academic researchers on a collaborative basis.

3 Description of the data set

While the term 'high tech' is in common usage, the actual determination of what we mean is not a trivial exercise. In this study, we continue to use the definitions employed in our first AGF report in 2001. Technology-oriented firms are identified using the definition of high-technology manufacturing sectors in the UK established by Butchart (1987). He provided a definition based on the 'ratio of R&D expenditures to sales' and the 'share of employees working in R&D'. Using this definition, Butchart identified 19 UK 1987 SIC codes, which were translated into the NACE Rev. 1 code. These are listed in Table 1, which defines four aggregated manufacturing sectors and further augments Butchart's list with a number of selected service sectors added by the present research team (Bürgel et al., 2004).

Table 1
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).

This study is based on two surveys that were carried out simultaneously in Germany and the UK, originally in 1997 and again in 2003. The source data set originates from Dun & Bradstreet in the UK and Creditreform in Germany.[4] Using these databases, all firms with

[4] 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. Dun & Bradstreet is the UK equivalent.

at least three employees in 1997, which were operating in one or more high-tech sectors as defined by Butchart (1987), and had been founded as legally independent companies between 1987 and 1996, were selected. Subsidiaries, de-mergers or firms that had been founded as a management buy-out (MBO) or buy-in (MBI) were excluded from the analysis. This resulted in a population of 3,562 firms from the UK and 5,045 from Germany. 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 (Western and Eastern Germany).The firms were first contacted in winter 1997/98 via a written questionnaire after an initial series of pilot interviews. Three hundred and sixty-two completed questionnaires were returned from the UK and 232 from Germany, resulting in a combined net sample of nearly 600 NTBFs from the two countries. This first survey is described in detail in Bürgel et al. (2004).

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. At this date, the average respondent firm was approximately 12 years old. To determine the target sample of the second survey, all formerly responding firms that turned out to be mismatches (for example, non-high-tech firms, non-independent or subsidiary companies) were first excluded. We then eliminated each German firm labelled in the database of Creditreform as 'dead' (because of bankruptcy as well as voluntary firm closure) at the beginning of 2003. In the UK, firms that could be identified as dead by the researchers themselves using multiple database sources were also excluded from the target sample. As a result, we produced and subsequently contacted a final target sample of 188 German and 250 UK-based formerly responding firms.

Since the present research team also tries to answer additional questions, in particular with respect to high-tech firms' financial strategies, a 'new' target sample was drawn from the original 1997 cohort of identified NTBFs. More precisely, from each country's population (i.e. the sample of NTBFs that was still alive in 2003) a 'new' random sample of 712 German and 561 UK-based firms was drawn, stratified by the same criteria as in 1997.

The second survey was conducted in 2003 via computer-aided telephone interviews (i.e. CATI software). The research team decided on a telephone survey for contacting the 'old' (i.e. 1997) target sample because of the assurance of a relatively high response rate by direct personal contact. This was critical given that a sufficiently high number of repeat observations was necessary to obtain reliable econometric results. In the case of the UK, the 'new' target sample was contacted using a postal survey instrument. In Germany, these additional firms were also interviewed by telephone.

In both the UK and Germany, the response rate of each country's 'old' target sample exceeded 50%. After performing several consistency checks, 217 companies were retained in the longitudinal data set. The 2003 cross-sectional data set further contains 193 'new' companies from both Germany and the UK that participated in the second survey.

4 Descriptive analysis

Employment and sales

In 2003, the average surviving firm in our sample had 25 employees (see Table 2). Firms in Germany are on average larger than their UK counterparts. Both the mean and the median number of employees are larger in the German sub-sample. Moreover, the variance of the number of employees is larger for German firms because the joint sample's largest companies are located in Germany. From 2001 to 2003, employment patterns had stabilised in both Germany and the UK.

Table 2
Number of employees 2001–03

	Germany						UK					
			Percentiles						Percentiles			
Year	Mean	Std. Dev	10th	50th	90th	*n*	Mean	Std. Dev	10th	50th	90th	*n*
2003	27.23	64.39	4	12	45	236	22.29	34.90	4	10	48	173
2002	27.31	65.83	4	12	48	236	22.44	32.80	3	10	50	173
2001	25.60	52.82	4	12	50	234	22.75	32.62	3	10	55	172

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.

For those firms that were observed in 1997 as well as in 2003, the findings reveal that on average German and UK high-tech firms increased their numbers of employees not only from the time of their start-up to 1997 but also over the period 1997–2003 (see Table 3). *Despite the severe downturn in high-tech markets starting in 2000, most sampled firms continued growing and creating new jobs.* The employment growth trajectories in Germany and the UK are, however, different. UK firms expand more rapidly initially but then growth declines to a slower rate on average. In Germany, firms grow continually at a similar rate on average over the whole period of observation.

The pattern of the volume of sales generated by each country's firms is similar to that of the number of employees. As shown by Table 4, the average turnover of German firms in 2002 was larger than the corresponding volume of sales of UK firms (€3,626K in Germany compared to €3,275K in the UK). In both Germany and the UK, the largest individual firm belongs to the software and service sector. The most outstanding differences between Germany and the UK is seen in the engineering sector. German engineering firms have on average sales of more than twice those of their UK rivals (€6,080K in Germany compared with €2,438K in the UK). In particular, the 90th percentile of the volume of sales of German engineering firms exceeds that of UK engineering firms nearly four-fold (€20,000K in Germany compared with €5,730K in the UK).

Table 3
Number of employees in Germany and the UK, longitudinal study

	Germany						UK					
			Percentiles						Percentiles			
Year	Mean	Std. Dev	10th	50th	90th	*n*	Mean	Std. Dev	10th	50th	90th	*n*
2002	26.48	53.85	4	13	44	95	23.09	33.32	4	10	56	121
1997	14.79	15.23	3	10	35	95	17.59	25.33	3	8	38	121
Start-up	4.16	6.37	1	3	7	94	4.18	7.02	1	2	6	121

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.

Table 4
Sales 2002 by industries

					Percentiles					
Industry	Mean	Std. Dev.	Min.	Max.	10th	25th	50th	75th	90th	*n*
Germany (€1,000s)										
Software/services	3,160.84	7,638.98	200	61,000	500	800	1,200	3,000	5,000	79
ICT hardware	3,548.35	5,762.69	60	28,300	1,000	1,000	1,000	3,780	10,700	16
Engineering	6,079.86	10,246.80	350	45,000	700	1,500	2,200	4,000	20,000	46
Health	2,294.93	1,854.74	220	7,200	300	800	2,000	3,300	4,500	26
Others	3,701.49	3,486.48	200	17,000	580	1,300	2,000	6,000	8,000	47
Total	3,625.95	7,235.92	60	61,000	500	900	1,700	3,500	8,000	214
UK (€1,000s)										
Software/services	3,667.44	8,654.31	78	37,245	135	239	716	1,990	9,550	37
ICT hardware	3,070.50	3,053.82	248	11,142	286	637	1,592	6,367	6,367	18
Engineering	2,437.69	2,760.27	382	13,529	573	796	1,194	3,183	5,730	34
Health	2,129.42	2,238.13	398	9,550	557	1,162	1,273	2,387	6,367	15
Others	3,609.96	5,008.24	208	24,000	398	637	1,353	4,775	8,913	53
Total	3,291.65	6,589.95	78	37,440	240	560	1,120	3,200	7,358	164

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results. UK values converted to Euros.

Sales trajectories in Germany and the UK are also different (see Table 5). In the UK, the mean volume of sales in 1997 is about five times larger than that in the firms' first financial year. In Germany, the equivalent level of growth is four times. However, in the period from 1997 to 2002, the mean volume of sales increased by 163% in Germany, whereas in the UK this growth rate dropped below Germany to 151%. The detailed analysis of the individual firms' growth patterns in Chapter 6 will indeed show that, in the period between the two surveys, the annualised growth rates of German high-tech firms exceeded those of their UK rivals.

Table 5
Sales in Germany and the UK, longitudinal study

	Germany (€1,000s)						UK (€1,000s)					
			Percentiles						Percentiles			
Year	Mean	Std. Dev	10th	50th	90th	*n*	Mean	Std. Dev	10th	50th	90th	*n*
2002	3,723.98	6,754.13	500	2,000	7,500	90	3,378.30	6,606.12	239	1,114	7,958	111
1997	1,414.27	1,870.10	228	793	3,513	90	1,346.58	2,000.61	127	553	3,375	117
Start-up	380.84	463.48	53	182	884	83	271.33	347.48	28	124	627	105

Source: ZEW, University of Exeter, own calculation.
NB: All sales at 2002 prices. Weighted results. UK values converted to Euros.

Internationalisation activities

There is substantial variation in the extent of international activity both within countries and across countries (see Table 6). For example, in Germany, international activity is very high in ICT-hardware and engineering but low in the software and service sector. In the UK, international activity is very high in ICT-hardware, engineering and particularly health. Broadly speaking, the UK has at least as many internationally active firms in any industry as Germany, and in many industries substantially more. The more parochial nature of software is likely to be explained by the greater predominance of small and local companies in this sector. Such firms may well have established domestic, niche market positions without needing to venture into international markets.

Table 6
Status of international sales 2003 (in %)

	Germany		UK	
Industry	No	Yes	No	Yes
Software/services	60.7	39.3	41.1	58.9
ICT hardware	10.5	89.5	11.7	88.3
Engineering	16.5	83.5	16.0	84.0
Health	35.9	64.1	9.5	90.5
Others	41.7	58.3	35.8	64.2
Total	44.4	55.6	31.4	68.6

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.

Table 7 displays the share of exporters among those firms that participated in both surveys. There was a slight increase in the firms' international engagement between 1997 and 2003 in most sectors. Only in both countries' sector of 'other' high-tech manufacturing and in the UK software and service sector do we observe a decreasing share of internationally active firms.

Table 7
Status of international sales 1997 and 2003 (in %), longitudinal study

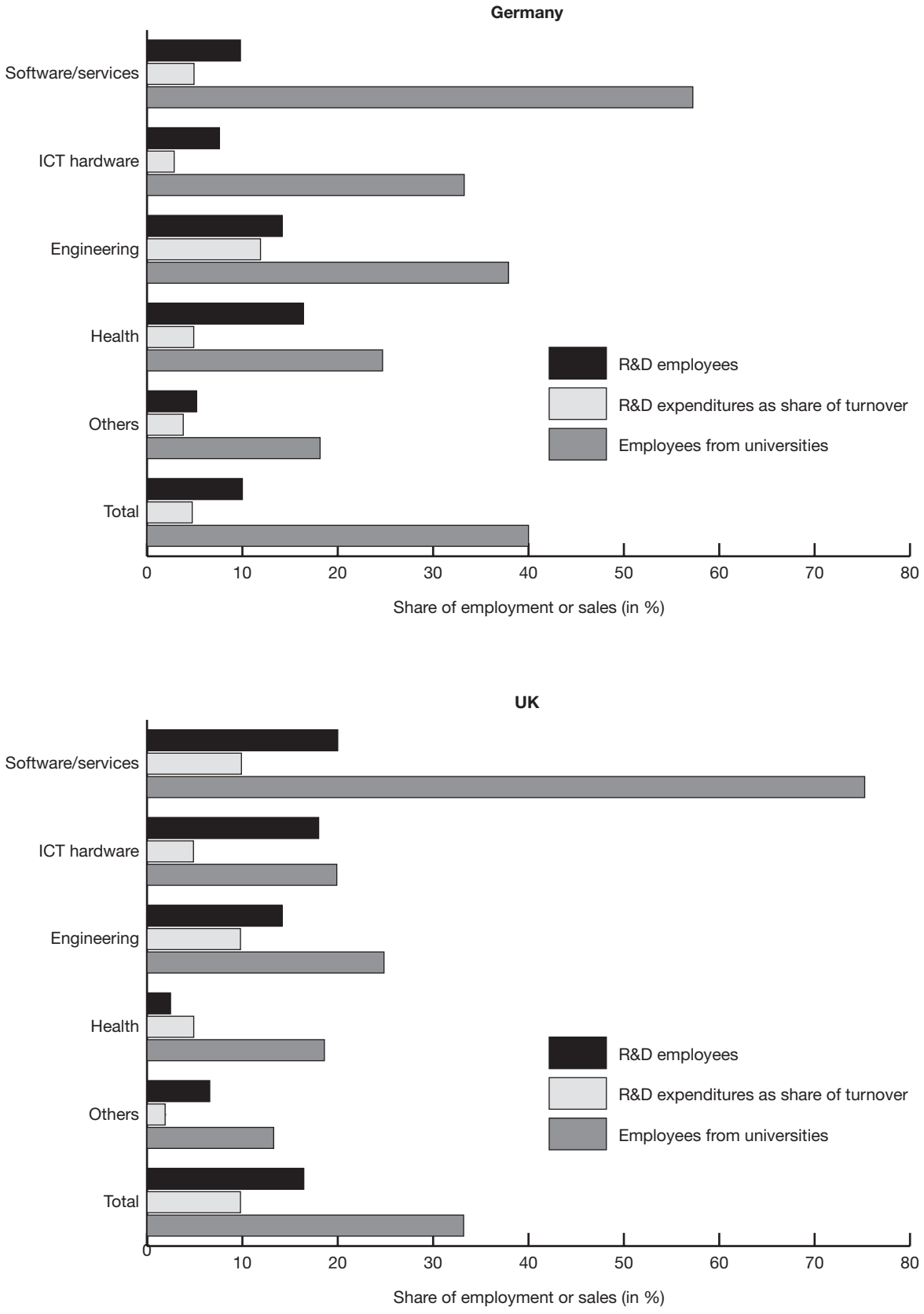
	Germany				UK			
	1997		2003		1997		2003	
Industry	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
Software/services	56.8	43.2	54.8	45.2	39.8	60.2	40.6	59.4
ICT hardware	21.4	78.6	21.4	78.6	0.0	100	0.0	100
Engineering	26.4	73.6	9.3	90.7	21.8	78.2	15.9	84.1
Health	19.5	80.5	16.0	84.0	0.0	100	0.0	100
Others	23.0	77.0	39.6	60.4	28.4	71.6	29.9	70.1
Total	42.0	58.0	40.3	59.7	31.3	68.7	28.3	71.7

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.

Innovation activities and characteristics of products and services

The median share of R&D employees within the UK sub-sample amounts to 17%, thereby exceeding the respective value for the median German firm (10%). Similar to the median share of R&D employees, the median firm's R&D intensity is also larger in the UK sub-sample. Whereas the median UK high-tech firm spent 10% of its total turnover on R&D, the respective German firm's R&D intensity amounts to merely 5%. Only with respect to the third indicator, the share of employees from universities, does the median German firm outperform its UK counterpart (40% in Germany compared with 33% in the UK). However, the mean share of employees with a university degree is almost equal in both countries (circa 45%).

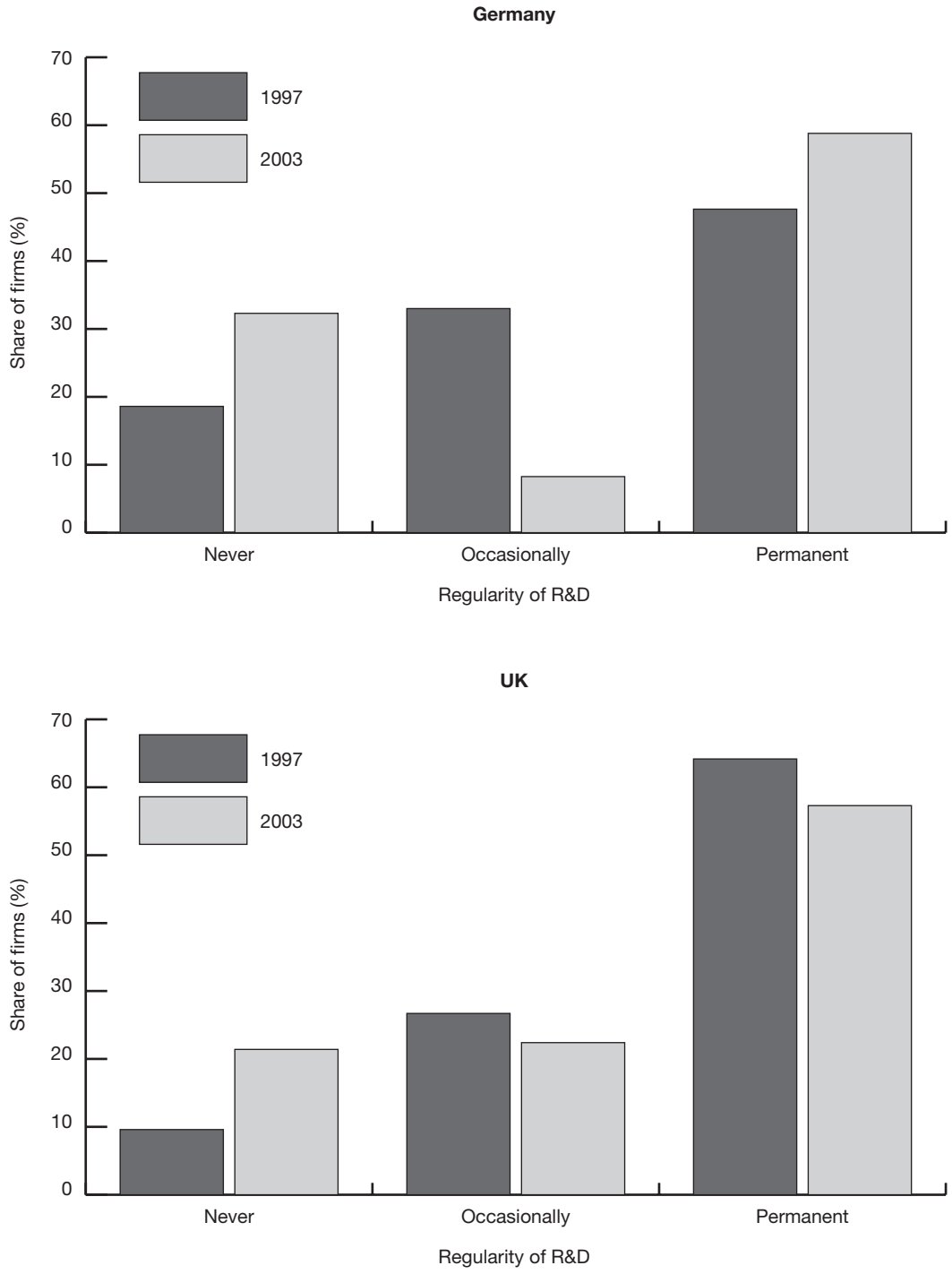
Figure 1 displays the medians of three indicators of the firm's knowledge base: (i) the share of employees that work for at least 50% of their time on R&D for existing and new products and services; (ii) a firm's expenditure on R&D as share of total turnover (R&D intensity); (iii) the share of employees with a university degree. We have used the medians in preference to the means because, as expected, the distribution of the firms' R&D intensities is highly skewed. In these circumstances, the medians give more reliable figures for the 'typical' firm.



NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 1
Medians of R&D intensity and human capital intensity 2003

Over the duration of the study, firms in Germany either tended to do more R&D on a permanent basis or abandon the activity (see Figure 2). In contrast, the UK firms actually did less permanent R&D in 2003 than in 1997. As a consequence, in 2003 the share of firms carrying out permanent R&D activities in the UK was lower than in Germany. However, the share of firms that do not carry out any R&D activities in 2003 is still higher in Germany than in the UK.

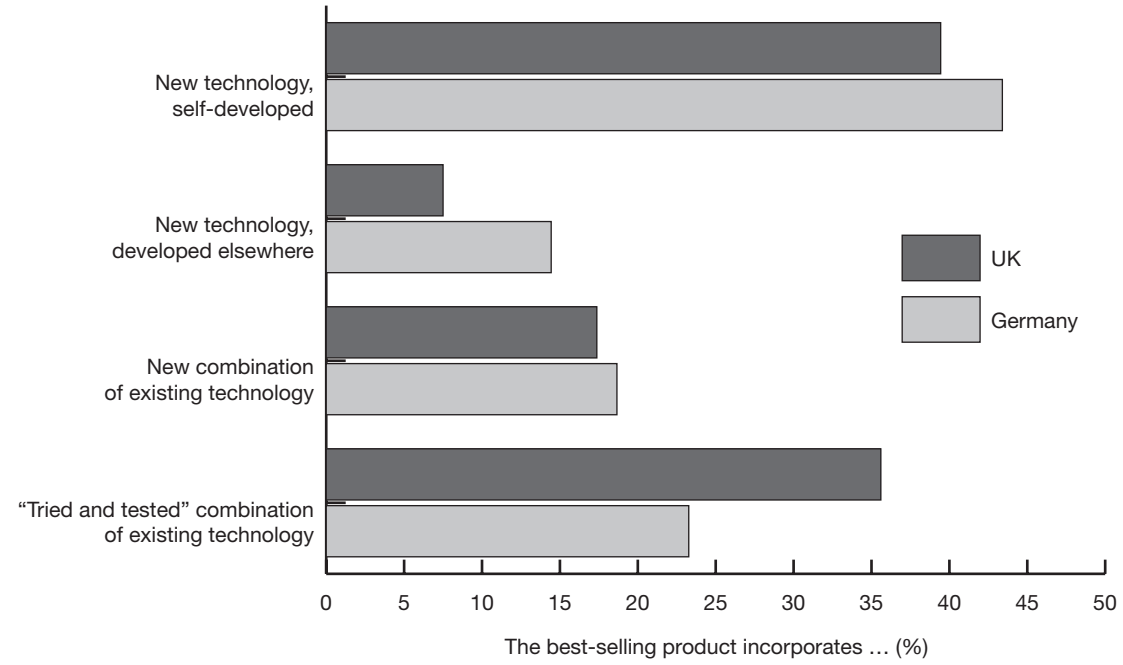


NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 2
Participation in R&D activities, longitudinal study

Even firms that do not carry out their own R&D activities may still produce high-tech products. These firms may buy novel technology that was developed by other companies and subsequently incorporate it into their own products and services. Figure 3 shows four different categories describing the provenance of technology incorporated into the firms' best-selling product or service in 2003. UK firms were more likely to use 'tried and tested' technologies, whereas German firms were much more likely to introduce novel technologies, both self-developed and purchased, into their best-selling product or service – that is, although there were only 21% of the UK-based firms that did not carry out in-house R&D activities, 36% of UK firms produced their best-selling product using a tried and tested technology.[5] Conversely, 20% of those German firms that did not conduct their own R&D activities were able to provide a high degree of innovativeness in their best-selling product by buying novel technology from other companies. In the UK, only 8% of the firms without their own in-house R&D activity used novel technology that was developed elsewhere.

In order to estimate the duration when firms possess a competitive advantage over their rivals, respondents were asked to estimate the time period (in months) necessary for a competitor to launch a substitute product with superior performance or to bring to market a cheaper product with similar functionality to their own offerings. The longer

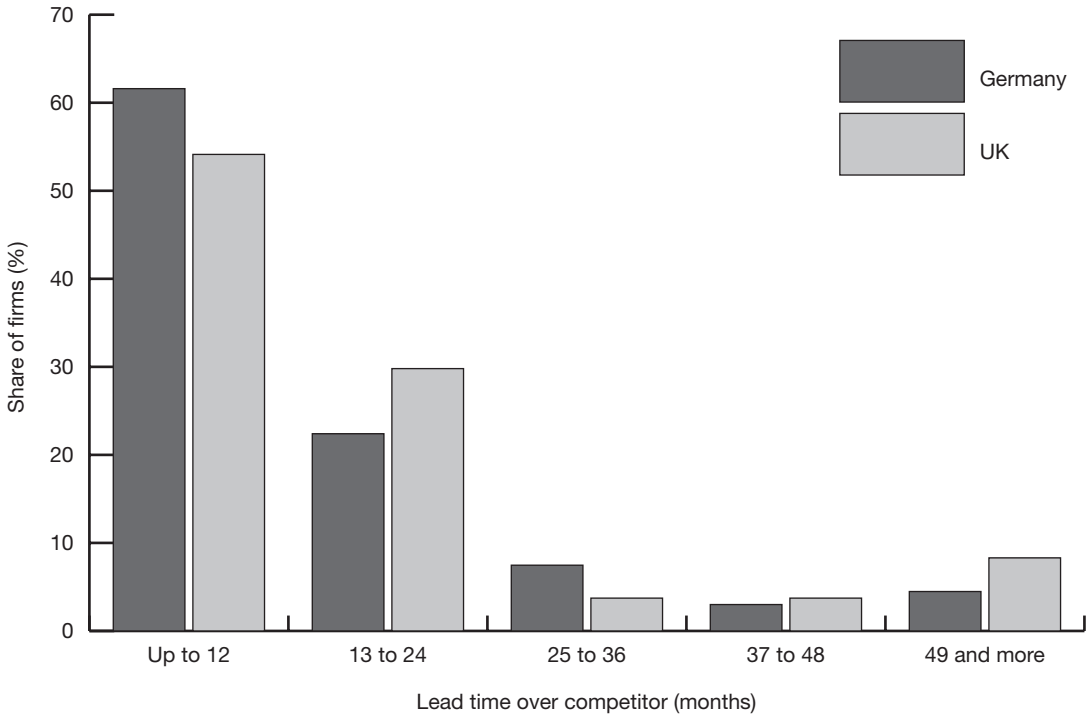


NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 3
Technological novelty incorporated into the best-selling product 2003

[5] The knowledge and technology generated by a firm's own R&D activities may be incorporated into other than the firm's best-selling product or service. In particular, this can be the case if the firm intends to change its core line of business. The firm may still generate the highest share of total turnover with a technologically less advanced product. At the same time, however, the firm may already be developing new products that are intended to replace the older one and enhance the firm's competitive advantage in the future.

this period, the less contestable is the market for the firm's best-selling product, thereby allowing the firm to exploit some degree of monopolistic advantage. We call this period the firm's 'window of opportunity.' As Figure 4 shows, a larger share of German firms than their UK counterparts have 12 months or fewer in which to exploit their new products without direct competitors. This implies that continual innovation is more necessary in Germany if firms seek to generate high and continuing returns on their sales efforts. However, the inter-country differences with respect to the firms' window of opportunity are less pronounced than differences because of other firm characteristics – for example, sector.



NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 4
Lead time over competitors 2003

The relationship between the firms' R&D activities and their window of opportunity is highlighted in Table 8. We observe that extremely high R&D activities do not provide German firms with more time to exploit a monopoly position regardless of the specialisation pattern of German manufacturing firms often observed in international trade studies.

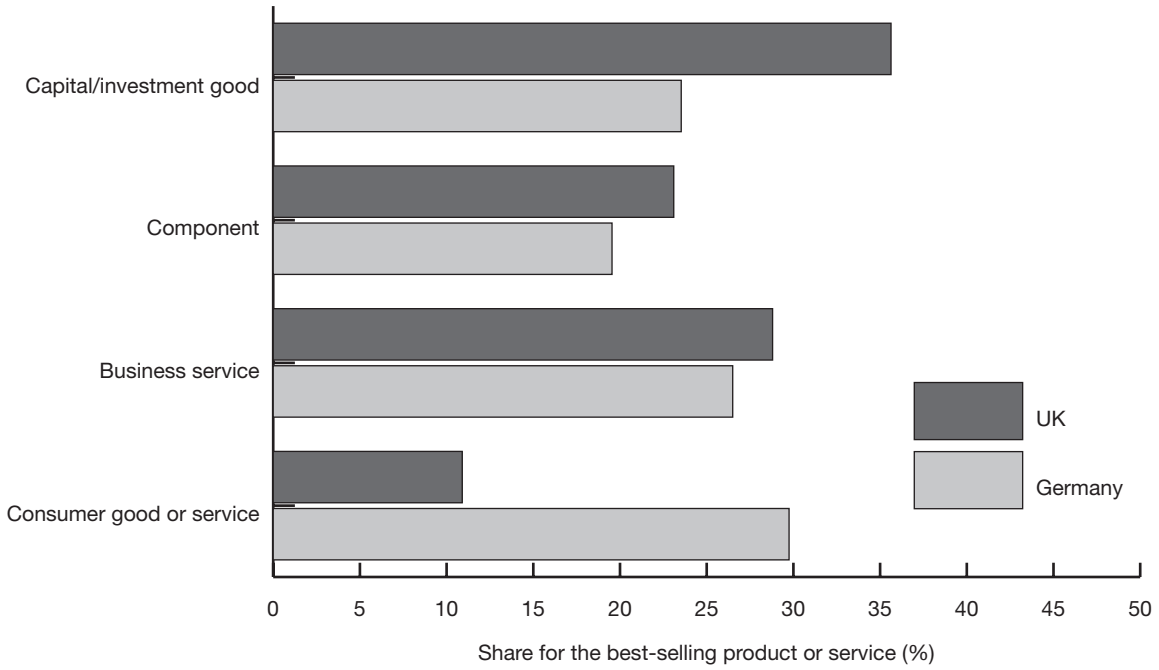
UK sampled firms are substantially more likely to be making capital goods, whereas German firms' products and services are more consumer orientated (see Figure 5). This suggests that UK and German NTBFs are focused at different ends of the value chain. This result was seen as unexpected to all the researchers involved, particularly given Germany's international reputation for advanced engineering. The study also shows a general and

marked shift away from consumer goods towards business services or capital goods in the UK. Germany reflects a similar trend although the decline in consumer goods or services is less marked.

Table 8
Lead time over competitors and R&D intensity 2003

	R&D intensity*					
	Germany			UK		
Lead time (in months)	**Mean**	**Std. dev.**	***n***	**Mean**	**Std. dev.**	***n***
Up to 12	10.75	16.26	113	8.96	14.16	86
13 to 24	12.85	17.76	47	15.02	31.03	39
25 to 36	20.03	23.41	17	22.22	10.99	7
37 to 48	10.93	9.85	5	19.18	6.02	5
49 and more	12.66	23.85	12	38.43	31.21	8
Total	11.97	17.42	194	14.23	22.91	145

Source: ZEW, University of Exeter, own calculation.
*Expenditures on R&D per total sales.
NB: Weighted results.



NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 5
Classification of best-selling product or service 2003

Financial characteristics

Public grants are much more prevalent in Germany than the UK although UK firms appear more effective in accessing European funds (see Table 9). This may be a reflection of the greater scarcity of domestic grants in the UK obliging financially constrained firms to be more proactive in tapping European sources of funding. When grants are available in the UK, they appear to be provided on a more regional basis than in Germany. This finding is consistent with UK contemporary policy of supporting enterprise via devolved regional or national agencies.

Table 9
Receipt of public grants

	Germany	UK
Receipt of public grants or awards (in %)	20.81	13.59
Among them (conditional percentage)*		
Regional agencies	56.67	79.36
National agencies	55.13	31.53
European agencies	14.15	20.52
Public banks	14.30	0.00

Source: ZEW, University of Exeter, own calculation.
NB: Only grants or awards, received since January 1998 and individually greater than €30,000 or £20,000 respectively, are recorded. Weighted results.
*Example: 55% of German firms that received public grants or awards had received at least one grant greater than €30,000 from a national agency.

As depicted in Table 10, the structure of financing of German and UK firms is very different. For example, all types of external finance sources – with the notable exception of short-term bank loans – are more widely used in the UK. UK managers are more likely to have to convince the capital markets as to the attractiveness of their enterprises. This is particularly noticeable for venture capital finance. UK NTBFs are over six times more likely to use external providers of risk capital (see Martin et al., 2003).

Table 10
Sources of finance 2001–03

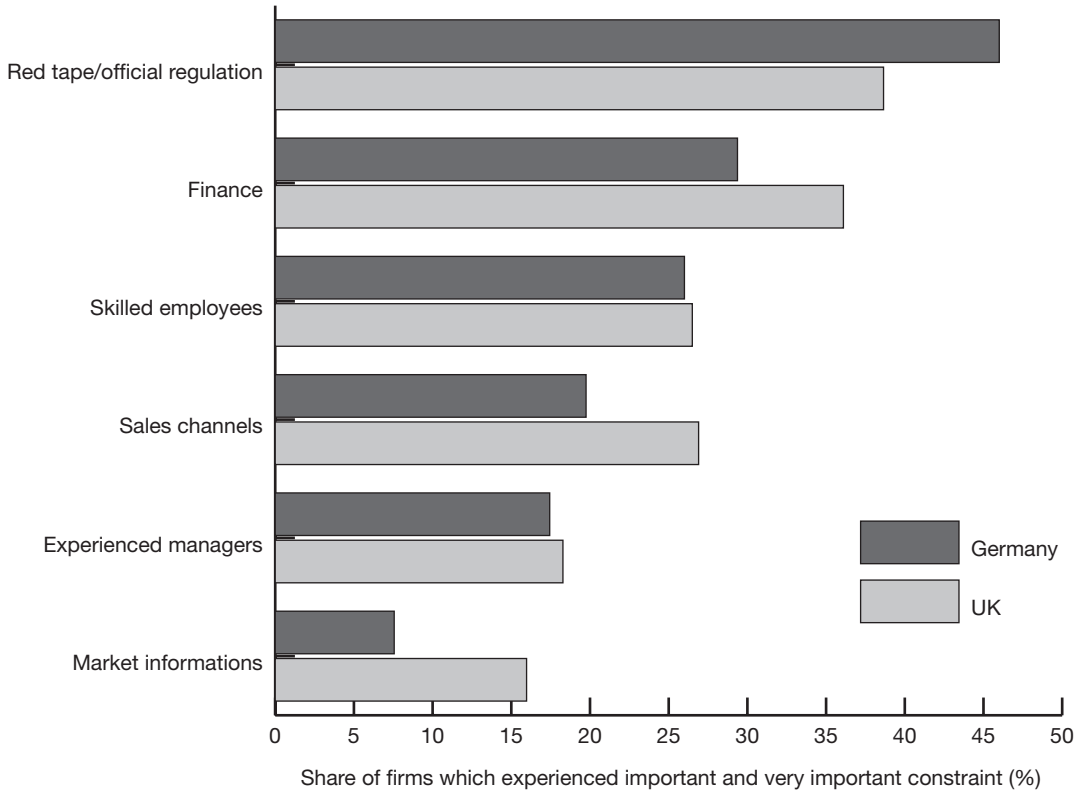
Share of firms that received additional finance from...	Germany (%)	UK (%)
Owners and employees	29.54	18.10
Business angels and private individuals	0.92	1.30
Venture capitalists	0.98	6.26
Short term loans from banks[a]	31.75	22.64
Long term loans from banks[b]	17.72	22.23
Finance from other sources	3.90	5.61

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.
[a] Loans with a maturity of less than 3 years.
[b] Loans with a maturity of 3 years or longer.

By comparison, German firms are more likely to use internally generated finance from owners and employees. There are cultural and legal components to these patterns which relate to the status of ownership of company assets in both countries.

Constraints on firm development

Firm representatives were asked to determine what they believed were important or very important external constraints on the contemporary development (i.e. last two years) of their businesses. Figure 6 shows the respondents' own views as to the most material factors inhibiting their growth. That regulation or 'red tape' was seen as a constraint is not unexpected. Also, given the considerable governmental efforts in the UK to remove barriers to small firm formation and growth, again it is not surprising that the UK is perceived as a more enterprise-friendly environment when compared to Germany. Despite the apparently more flexible UK environment, it was the UK respondents who believed that they experienced greater constraints than their German counterparts. This also includes finance with more than a third of UK respondents citing this constraint to be important or very important. (In the absence of some objective measure of the quality of the firm seeking external finance, it is difficult to determine how important such financial constraints are in practice.)



NB: Weighted results
Source: ZEW, University of Exeter, own calculation

Figure 6
Constraints on the development of business 2003

5 The continued process of internationalisation

One of the prime objectives of this study is to examine high-tech firms' longer term export behaviours. In this chapter, we will investigate in more detail the firms' processes of internationalisation. In doing so, we will concentrate on four dimensions of internationalisation: (i) the *decision* to internationalise; (ii) the *degree* of internationalisation; (iii) selection of target countries; and (iv) sales modes or channels used in the foreign markets.

The decision to internationalise

In the previous chapter we have already shown that there was a slight increase in the total share of internationally active firms between 1997 and 2003 in most technology sectors in Germany and the UK. These numbers, however, do not allow us to see how many firms have entered the foreign market for the first time since 1997 and how many firms have also abandoned all international markets. Roberts and Tybout (1997) have already shown that, although some firms continue to sell internationally due to sunk costs, large numbers of firms do change their internationalisation status. This leads to considerable entry and exit traffic over time. The development of the internationalisation status of those firms that participated in both surveys is listed in Table 11. This table also includes a separate column for its international status at the time of start-up. A firm is deemed to have international sales during its start-up period if it entered its first foreign

Table 11
Development of internationalisation status

International sales			Germany		UK	
Start-up	**1997**	**2003**	**%**	***n***	**%**	***n***
Yes	Yes	Yes	21.8	26	19.2	29
Yes	Yes	No	6.4	3	0.4	1
Yes	No	Yes	0.0	0	0.6	1
No	Yes	Yes	24.5	29	44.9	53
Yes	No	No	0.0	0	0.0	0
No	Yes	No	7.5	8	7.1	8
No	No	Yes	14.5	13	8.3	8
No	No	No	25.3	15	19.5	16
Total			100	94	100	116

Source: ZEW, University of Exeter, own calculations.
NB: Percentages weighted.

market no later than one year after firm formation – the so called 'infant multinationals' (Lindqvist, 1991) or 'born globals' (Oviatt and McDougall, 1994).

About a quarter of all firms had international sales shortly after their formation. (It was this high incidence of such activity by start-ups that was largely unrecognised until the pioneering work of McDougall, Oviatt and other European scholars in the mid-1990s.) Furthermore, just under 25% of the German firms and less than 50% of the firms in the UK did not export during their start-up period, but were internationally active when the first of the two surveys was conducted in 1997. On the other hand, 25% of German and almost 20% of UK respondent firms have never had any international sales. Of more interest are the firms that have changed their internationalisation status over time. Ignoring for the moment the firms' behaviour at time of start-up, nearly 14% of German and 7.5% of UK-based firms left the international market between 1997 and 2003. During the same period, 14.5% of German firms and just under 9% of UK entered an international market for the first time. Thus, German high-tech firms change their internationalisation status more frequently than UK-based firms.

We estimate the probabilities of a non-exporter becoming an exporter, or an existing exporter remaining an exporter.[6] The means of three key explanatory variables in the group of exporting firms versus the respective means in the group of non-exporting firms are compared in Table 12. As before, the table only describes those firms that participated in both surveys. The 1997 and 2003 surveys both show that exporting firms employ more workers and grow their employee numbers more quickly. Average firm age remains slightly higher for exporting firms.

Table 12
Comparison of means between exporters and non-exporters

	Germany		UK	
	International sales		International sales	
	No	Yes	No	Yes
1997				
Number of employees	10.26	18.07	11.04	20.49
Firm age (in years)	5.16	5.80	6.72	7.56
R&D intensity (in %)[a]	20.83	19.15	16.80	18.33
2003				
Number of employees	11.04	36.80	11.50	28.00
Firm age (in years)	11.26	11.74	12.60	13.49
R&D intensity (in %)[a]	2.66	19.84	6.65	18.73

Source: ZEW, University of Exeter, own calculations.
[a] Expenditures on R&D as percentage of sales.
NB: Weighted results. Only firms that participated in both surveys were considered.

[6] Detailed methodology and estimation results are presented in Fryges (2004a) based on the 2000 and 2003 research data of our study.

In 1997, German and UK-based technology-oriented firms spent an average of 19% of their total sales on R&D. Neither in Germany nor in the UK is the mean R&D intensity of exporting firms significantly different from the respective value of non-exporting firms. In 2003, R&D intensity decreased by five percentage points to an average of 14%. This is not necessarily a result of falling expenditures on R&D. It may also be attributed to rising sales. It is, however, remarkable that the drop in R&D intensity has occurred primarily in non-exporting firms, whereas the average R&D intensity of exporters has changed only slightly. As a consequence in 2003, the mean R&D intensity of exporting firms is significantly higher than that of non-exporting firms. In fact, among those firms that have never had international sales just under 80% did not carry out any own R&D activities in 2003. Thus, the level of a firm's R&D activities is likely to allow us to be able to discriminate between exporters and non-exporters.

We now return to the multivariate analysis of foreign market entry and exit. Previous empirical studies of firms' export activities have focused on sunk costs as the main reason for the observed persistence in export behaviour (for example, Roberts and Tybout 1997 and Bernard and Jensen 2004). Sunk costs present a barrier to entering the international market. The ability of a firm to overcome this barrier is influenced by the firm's intangible assets including its stock of technical and operational knowledge. Although our data set is not suitable to prove empirically the existence of sunk costs, our results are consistent with the sunk costs hypothesis. In particular, the econometric results highlight the strategic role of investment in R&D. R&D activities can generate inimical assets by which a firm distinguishes and protects itself from its rivals. These assets not only facilitate foreign market entry, but also support a long-term engagement in the international market. Firms that had never had international sales before 2003, and firms that had exited from the foreign market, spent a significantly smaller share of total sales on R&D in 2003. Since all the firms in our sample operate in high-tech sectors, the firms' R&D activities constitute an essential asset that discriminates between firms and correlates with their international business activities.

Finally, the success of a firm's international engagement also depends on the characteristics of its product. High and client-specific product customisation is a barrier to entry into a foreign market. If a firm has to consider the unique needs of each customer, it will be more difficult to realise economies of scale and fully profit from the foreign market's sales potential. Firms that entered a foreign market with a product requiring intensive product customisation have often stopped exporting. Their decision may be because they have recognised that exporting was not profitable for them given the cumulative demands of foreign customers.

The degree of internationalisation

In the academic literature, the share of non-domestic revenues (also called export-sales ratio or export intensity) is the most widely adopted measure of the degree of internationalisation (see Sullivan, 1994, for a review), and is therefore also used in this section. Table 13 compares the mean degree of internationalisation for various groups in our sample. In 1997, the firms generated an average of just under 20% of total sales from foreign markets. In the period between the two surveys, the average export intensity rose by five percentage points to a value of 25% in 2003. As discussed in Chapter 4, the

Table 13
Comparison of mean degree of Internationalisation

	Germany	UK	West Germany	East Germany
Exporters and non-exporters				
Pooled sample	15.95	30.74	19.28	10.10
1997	14.04	27.31	13.32	6.88
2003	17.93	34.26	20.63	18.00
Exporters only				
Pooled sample	27.29	43.97	29.33	22.13
1997	24.23	39.81	27.58	15.37
2003	30.42	48.06	31.16	28.62

Source: ZEW, University of Exeter, own calculations.
NB: Weighted results. Only firms that participated in both surveys were considered.

percentage of internationally active firms in our sample increased only slightly from 1997 to 2003. Hence, the higher average export intensity is not explained by additional firms entering the international market. The rise in the sample's export-sales ratio is primarily caused by the continued international growth of exporting firms: the average share of total turnover generated through foreign sales for the exporting companies in our sample went up from 31% in 1997 to just under 39% in 2003.

On average, the degree of internationalisation of UK-based firms exceeds that of German firms. This statement is valid for the pooled sample as well as for the two sub-samples of 1997 and 2003. Restricting ourselves solely to the group of exporting firms, Table 13 shows that the average export intensity of UK-based (German) exporters rose from 40% (24%) in 1997 to 48% (30%) in 2003. Thus, although both UK and German firms had, on average, intensified their international engagement, the 2003 export-sales ratio of UK exporters was still higher than that of their German peers. As Bürgel et al. (2004) have argued, this might be because British exporters exploit the sales potential of foreign markets more proactively and/or because German firms are less dependent on the international market due to the larger size of their domestic market.

Fryges (2006) analysed the sample firms' degree of internationalisation. He shows that the decision to enter a foreign market and the degree of international commitment are both influenced by virtually the same variables. Essentially, firms that generate intangible assets through (permanent) R&D activities generate a higher share of their total sales abroad. Similarly, if a firm employs internationally experienced managers, it will be able to increase its export-sales ratio. On the other hand, the optimal volume of exports is negatively influenced by the requirement of intense product customisation. These results strongly support the findings from the first study presented in the initial AGF report in 2001.

The key result of Fryges (2006) is that neither youth nor smallness is necessarily an obstacle to high export intensity. Firms that internationalise at or shortly after their

inception ('born globals') proactively exploit foreign markets and reach a relatively high degree of internationalisation at an early stage of their international engagement. Even firms that have fewer than 10 employees are able to attain a high export-sales ratio. However, this requires that the firms possess firm-specific assets in order to overcome barriers to entry into the foreign market. As our analysis shows, these assets may be acquired by the firm conducting its own R&D activities, buying novel technology from other companies or by employing internationally experienced managers. If young and small technology-oriented firms in Germany and the UK acquire the necessary firm-specific resources, they will have the best qualifications for becoming successful exporters or, as Simon (1996) called them, 'hidden champions'.

The pattern of target countries entered

In this and the following section, we examine the geographical pattern of market entries and the determinants of the decision to change the dominant sales mode used in a particular foreign target market. The questionnaires of both the 1997 and the 2003 surveys asked firm representatives to indicate the total number of foreign countries in which they currently sold their products and services. At the time of the first survey, UK-based exporters had sales in an average of 10 foreign countries, whereas German firms supplied just under 7 foreign countries. These numbers rose by the second survey in 2003 to just under 16 foreign destinations for UK firms and just under 11 foreign countries for German firms.[7] Thus, consistent with the firms' growing average export intensity, both UK-based and German exporters were able to expand their international business activities.

In addition to the number of foreign markets entered, the two surveys asked the sample's exporters to indicate the three most important countries (in terms of their contribution to total sales). Aggregating these countries shows that countries from the European Union (15 member states, plus Switzerland, Norway, and Iceland [EU 15]) presented the main regional group for both German and UK firms (see Table 14).[8] Countries from the EU 15 were markedly more important for German than for UK firms. Conversely, more geographically distant markets were of greater importance for UK firms. This is in part due to the more prominent role of English-speaking countries from the British Commonwealth (for example, Australia, South Africa and Canada). Coeurderoy and Murray (2005), using the 1997 data set, have shown that the compatibility of the host and target countries' legal domains also influences the choice and ordering of expert activity by both UK and German firms. Even when internationalising, remaining in compatible institutional environments remains important for the exporting firms.

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[7] These numbers are based on the complete cross-sectional data set of the respective survey. However, if we restricted ourselves to those firms that participated in both surveys, the numbers would be quite similar.

[8] Note that the unit of analysis for these figures is not the individual firm but the single country entered by the firm. Exporters that have international sales in only one country enter the figures in Table 14 once; exporters that indicated their three most important foreign markets contribute three observations to these figures. Furthermore, in order to avoid a possible survival bias, the statistics in Table 14 are restricted to those firms that participated in both surveys.

Table 14
Geographical focus of three most important target countries, longitudinal study

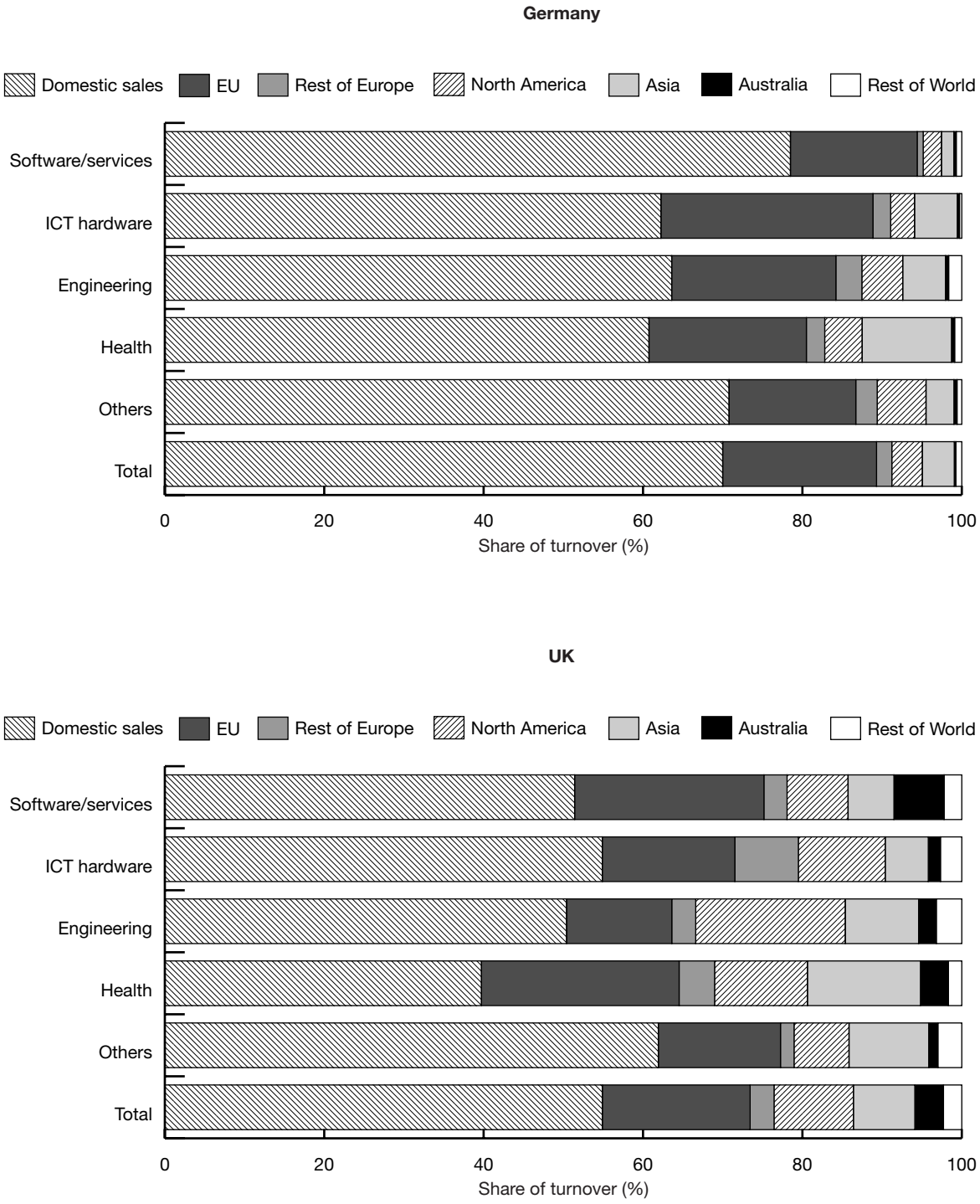
	Germany		UK	
	1997	**2003**	**1997**	**2003**
EU 15 (incl. Norway, Switzerland, and Iceland)	70.74	70.55	56.06	50.12
Rest of Europe	8.75	6.01	3.26	3.21
NAFTA (USA, Canada, Mexico)	9.82	9.68	15.55	20.16
Latin America (without Mexico)	1.52	0.32	0.61	0.97
Asia	8.12	12.84	11.55	17.07
Australia	0.60	0.30	9.09	6.52
Africa	0.45	0.30	3.89	1.94
Total	100	100	100	100

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results. Only firms that participated in both surveys were considered.

Comparing the regional distribution of each nation's three most important foreign destinations in 1997 and 2003, a similar pattern emerges between the two points in time. However, while the importance of countries from the EU 15 remained unchanged for German firms, the share of EU 15 member countries had fallen for UK firms. Moreover, for German firms, Asian markets became more prominent and the role of Eastern European markets decreased in return. For UK firms, the share of both North American and Asian markets increased. The USA presented the single most important destination for UK NTBFs in 2003. On the contrary, for German firms this place was occupied by Switzerland followed by Austria and France.

Figure 7 shows the share of turnover German and UK exporters generated in different regions of the world including domestic sales. With the exception of the health/life sciences sector in the UK, domestic sales contribute on average more than 50% to the firms' total sales.[9] In accordance with the geographical distribution of exporters' three most important countries, the most consistent pattern is that UK firms have a much greater presence in North American markets than German firms. The same can be said of Asia, Australia and the rest of the non-EU world. This is consistent with the UK having much deeper historical connections with several parts of the world through both empire and commonwealth connections (Coeurderoy and Murray, 2005). Surprisingly, UK exporters even generated on average a higher share of total sales in Eastern European markets than German exporters. Thus, although Eastern European countries more often belong to the three most important foreign destinations of German exporters, the share of total sales they generate in these markets is smaller than the respective share of UK-based exporters.

[9] Note that the shares presented in Figure 7 reflect the weighted average of the individual exporters' shares generated in the respective geographical region. The average shares are *not* corrected by firm size. Thus, Figure 7 does not show the share of *aggregated sales* generated by the firms in the respective geographical region.



NB: Weighted results. Only firms with international sales in 2003
Source: ZEW, University of Exeter, own calculation

Figure 7
Geographical distribution of international sales

Foreign sales modes

Both before and after first entering a foreign country, the choice of the appropriate sales mode becomes a major strategic decision. First, it determines the amount of resources a firm has to invest in establishing business relationships with its foreign partners and customers. Second, the way of organising and optimising the firm's distribution and logistics depends crucially on the chosen sales mode. For example, if a firm decides to export directly by using the internet to generate foreign sales, it will have to build an electronic trade platform and organise its logistics and workplace appropriately. Alternatively, a firm that sells its product via a foreign distributor or agent needs to provide, for instance, technical training for the foreign intermediary's sales personnel.[10] Finally, the sales mode used also determines the level of control the exporting firm possesses over its international transactions.

Direct exporting (i.e. selling to foreign customers directly without use of third parties) was the most important foreign sales mode used by German and British high-tech firms in 2003, followed by the use of regular distributors and foreign agents who sell ad hoc on a commission basis (see Table 15). Although the firms in our sample were an average of 12 years old in 2003, more resource-intensive modes like sales joint ventures and wholly owned sales subsidiaries were rarely chosen. Even in 2003, most of our sample's exporters did not possess the necessary resources to supply the foreign market via the creation of a dedicated sales subsidiary.

Table 15
Sales modes in most important foreign markets of 2003

Entry mode	Germany (%)	UK (%)
Direct exporting	57.1	56.6
Agents	9.0	15.5
Distributors	21.5	25.6
Sales joint venture	1.7	0.3
Wholly owned subsidiary	5.6	1.4
Licensing	5.1	0.5
Total	100	100

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.
Example: UK firms with international sales in 2003 use a foreign distributor as the dominant sales mode in just under 26% of their most important foreign markets.

Considering the far-reaching consequences of a sales mode choice, it is important that the selected channel is as compatible as possible with a firm's available resources and

[10] Distributors, in contrast to agents, are defined as sales channels with which the exporting firm has a continuing relationship.

capabilities. However, this statement implies that the young firms have unimpeded freedom to choose between alternative channels. In reality, this is often not the case. Entrenched and powerful distributors (value-added resellers) often have the authority whether or not to accept new clients. The resources, capabilities and demands of NTBFs change over time. Firms grow and decline, accumulate financial and physical capital, develop new products and introduce them into their domestic and foreign markets. Accordingly, it will be necessary for a firm to adjust its foreign sales mode over time to accommodate these changing conditions.

Referring to the three most important target countries, the first survey asked the firms' representatives to indicate the sales modes at the time of market entry and at the time of the study in 1997. The second survey in 2003 also focused on the three most important markets that the companies had identified in 1997. Firms were first asked whether or not they still had foreign sales in each of the originally named countries. If this was the case, firms were asked to indicate the dominant sales channel they were currently using in each of these three foreign markets. Thus, we arrived at a sequence of three foreign sales modes – at start-up, in 1997 and in 2003 – in each of the firms' most important foreign markets of 1997. Of course, the investigated markets may no longer represent the firms' most important markets of 2003. In fact, a good one-third of the firms' three most important countries in 1997 no longer belonged to this group of most important countries in 2003.

German firms most frequently used direct exporting to end-users as their entry mode in foreign markets (see Table 16). In contrast, foreign distributors were the preferred entry mode for UK exporters. The more prominent role of direct exporting among German firms might reflect that they more often started exporting due to an unsolicited order from abroad before they had made any contractual agreement with a foreign distributor. UK-based exporters that tended to exploit the foreign market proactively more often began their international business activities based on a contractual agreement with a foreign partner. UK firms' relative preference of using a foreign distributor probably also reflects that the UK firms' three most important foreign markets were frequently more distant, non-European countries. Given the logistics of serving remote foreign customers, co-operation with a foreign partner can be particularly advantageous. Furthermore,

Table 16
Sales modes used in most important foreign markets of 1997 (in %)

	Germany			UK		
Sales mode	**Entry mode**	**1997**	**2003**	**Entry mode**	**1997**	**2003**
Direct exporting	44.33	37.02	43.03	39.51	32.96	38.09
Agents	15.40	16.07	4.48	10.02	11.00	14.58
Distributors	36.24	40.67	35.27	41.84	40.11	44.03
Sales joint venture	0.53	0.55	0.80	2.10	7.89	0.90
Wholly owned subsidiary	0.49	3.01	6.81	0.85	2.19	2.41
Licensing	3.01	2.66	9.62	5.68	5.85	0.00
Total	100	100	100	100	100	100

NB: Weighted results. Only firms that participated in both surveys were considered.
Source: ZEW, University of Exeter, own calculation.

German (UK) exporters used foreign agents in a good 15% (10%) of the most important foreign markets as their entry mode. In the following analysis, we regard the two export intermediaries (distributors and agents) as one sales mode called 'exporting via an intermediary', because both are assumed to possess local-market knowledge and crucial contacts with foreign customers. Until 1997, the share of foreign countries that were served via direct exporting decreased for both German and UK firms – that is, some firms that had first entered a foreign market with direct exports changed their sales mode to exports via an intermediary before 1997. In the period between the two surveys, changes of the dominant sales mode in the reverse direction were observed: German firms in particular increased the share of foreign markets where they used direct exports so that in 2003 this sales mode was more important than exporting via an intermediary. The share of foreign markets where UK firms sold their products via direct exporting also rose between the two surveys, although intermediaries remained their most frequently used sales mode.

In order to detect the determinants of the decision to change foreign sales modes, we estimate two 'logit models'. The first model explains the probability of switching from direct exporting to exporting via an intermediary. Such a transition primarily occurred in the period between foreign market entry and 1997. The second model estimates the probability of a transition in the opposite direction – i.e. from exporting via an intermediary to direct exports, which was observed primarily in the period between the two surveys. The econometric results are discussed in Fryges (2005). In short, our empirical analyses confirm that a firm's physical and intangible resources as well as transaction-specific assets are both relevant for explaining the probability of switching from one sales mode to another. However, especially during an early stage of a high-tech firm's international engagement, there are strategic and structural influences that might dominate the impact of the exporter's (intangible) resources or its transaction-specific assets. Owing to the so-called 'liability of alienness' (Bürgel et al., 2004), an exporter might be forced to use an intermediary for selling its products abroad because foreign customers might not trust a young and small firm that is not yet established in its own domestic market. In this case, the reputation of an established foreign distributor or agent might be one vicarious way for the internationalising firm to gain legitimacy. After becoming more established in the foreign market, the high-tech firm might be able to exercise more choice.

6 The relationship between export behaviour and firm performance

Internationalisation is often expected to improve firm performance. It may be especially important for small technology-oriented firms, because export activities are often regarded as one way to amortise these firms' high product R&D costs via increased sales (Bell, 1995; Petit and Sanna-Randaccio, 1998). If international business activities really do increase the performance of young high-tech firms, internationalisation will also help firms fulfil the hopes placed upon NTBFs and other knowledge-based companies with respect to wider structural change, innovation and job creation. The relationship between internationalisation and firm performance was initially examined in the first survey in 1997. The researchers found out that internationalisation did indeed improve the firms' labour productivity and increased annualised sales growth rates for the period between the firms' start-up and 1997. Yet, importantly, foreign sales did not appear similarly to affect employment growth. However, these results contradict many other studies examining the causal relationship between exports and firm performance. Wagner (2005) provided an extensive review of 45 micro-econometric studies using data from 33 countries published between 1995 and 2004. He concluded that exporters are found to be more productive than non-exporters, and the more productive firms self-select into the export market.

Thus, this chapter re-examines the relationship between export behaviour and firm performance in order to find out whether the causal effects found by the first AGF study remain valid as the high-tech firms in our sample grow older. We wished to ascertain whether these causalities were a result of long-term structural differences particular to our firm sample or, conversely, whether the positive effects were restricted to the start-up period concluding in 1997. First, however, we will discuss some descriptive statistics of two different measures of firm performance: firm growth and labour productivity. The latter is measured as 'sales per employee'.

Table 17 shows the annualised employment growth rate by industry sector. The table has some salutary lessons for the UK: German NTBFs appear to create *more* jobs in *more* technology sectors for both periods under observation. In Germany and the UK, the growth of firms declines over time as would be expected from a theoretical point of view. Young firms can realise high efficiency gains due to learning processes, which leads to higher growth rates (Jovanovic, 1982; Ericson and Pakes, 1995). These efficiency gains decrease as firms become older. With the exception of firms in the sector of 'other high-tech manufacturing' where there is a reversal of UK's earlier advantage, the other four technology sectors show Germany having a higher average growth rate over both periods. Note, however, that the growth figures related to the firms' start-up period in Table 17 are biased upward because in this table we only consider firms that participated in both surveys – i.e. only firms that survived at least until 2003. It is very likely that firms that exhibited the lowest employment growth rates from start-up until 1997 left the market in the period from 1997 to 2003.

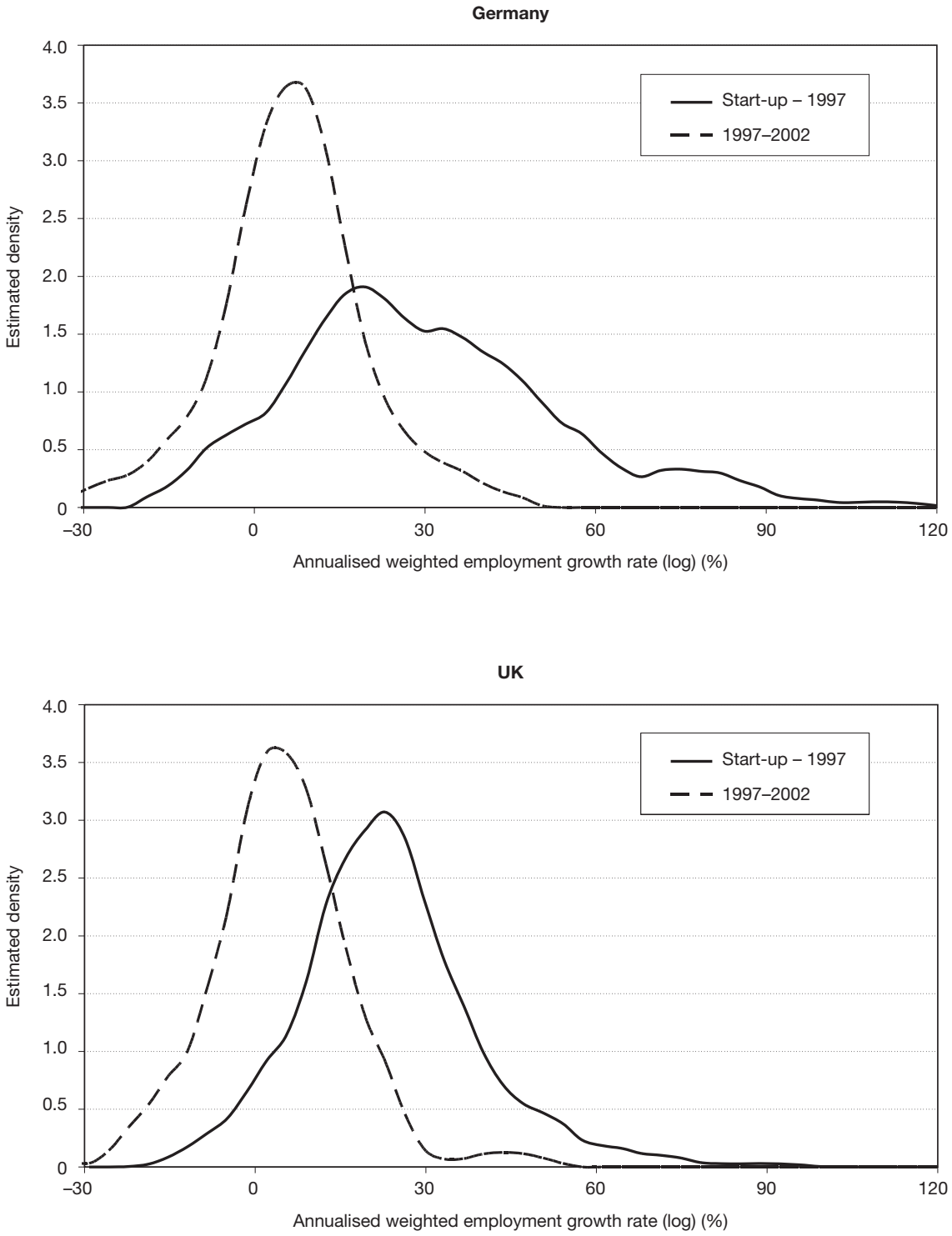
Table 17
Annualised employment growth rate by industries

	Germany					UK				
			Percentiles					Percentiles		
	Mean	Std. Dev.	10th	50th	90th	Mean	Std. Dev.	10th	50th	90th
Start-up – 1997										
Software/services	32.0	38.2	0.0	29.1	71.0	18.5	12.7	4.4	18.5	29.7
ICT hardware	46.5	20.6	26.0	39.9	73.2	23.9	13.5	8.5	20.9	38.4
Engineering	24.4	16.6	10.4	17.0	53.3	23.5	15.6	10.4	20.8	41.4
Health	29.8	27.7	0.0	27.6	71.0	17.8	5.9	11.5	14.7	25.1
Others	26.9	16.3	10.1	21.8	53.3	33.1	23.7	7.0	25.7	58.7
Total	30.4	31.1	0.0	26.6	58.5	22.9	16.3	5.2	20.1	41.4
1997–2002										
Software/services	6.2	13.2	–9.7	5.9	18.8	2.3	15.2	–15.6	3.7	17.8
ICT hardware	13.4	12.1	0.8	10.8	32.0	3.4	9.7	–7.8	3.5	13.8
Engineering	10.8	15.5	–6.5	9.9	33.9	9.5	14.4	–0.6	5.9	21.7
Health	9.9	10.9	–5.6	9.2	21.1	7.2	11.1	0	5.2	27.7
Others	6.7	11.2	–7.8	7.2	23.4	4.9	10.9	–12.9	4.6	19.3
Total	7.6	13.0	–7.8	6.8	22.9	4.5	13.6	–11.4	4.6	19.4

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results. Only firms that participated in both surveys have been considered.

Figure 8 indicates that the German advantage is narrowing over time with the pattern and distribution of growth converging to become more like the UK. The estimated densities in Figure 8 also emphasise that a relatively high proportion of firms have a negative employment growth rate – i.e. a number of firms became smaller between the start and the end of each of the two periods. In the period from the firms' start-up to 1997, 8% of NTBFs in Germany and 4% in the UK exhibited a negative growth rate (cross-sectional data from the first survey). In contrast, from 1997 to 2002, the share of firms with a negative growth rate is higher for the UK (26%) than for Germany (18%).

Consistent with the employment growth figures, the sales figures over time for the German and UK samples raise some difficult questions for the UK (see Table 18). Sampled firms across all sectors in the UK grew more slowly, post 1997, than their German peers. UK firms appear to start off with higher rates of growth when measured by the 90th percentile, whereas the mean rates are generally similar. However, over time, the German mean figures and 90th percentiles in the period from 1997 to 2002 seem almost universally better than the UK figures. An important exception is the sector of health/life sciences where the German mean and 90th percentile sales figures remain superior through both periods. Overall, UK firm sales performance appears to level off faster than



NB: Weighted results. Only firms that participated in both surveys have been considered
Source: ZEW, University of Exeter, own estimation

Figure 8
Estimated distribution of employment growth

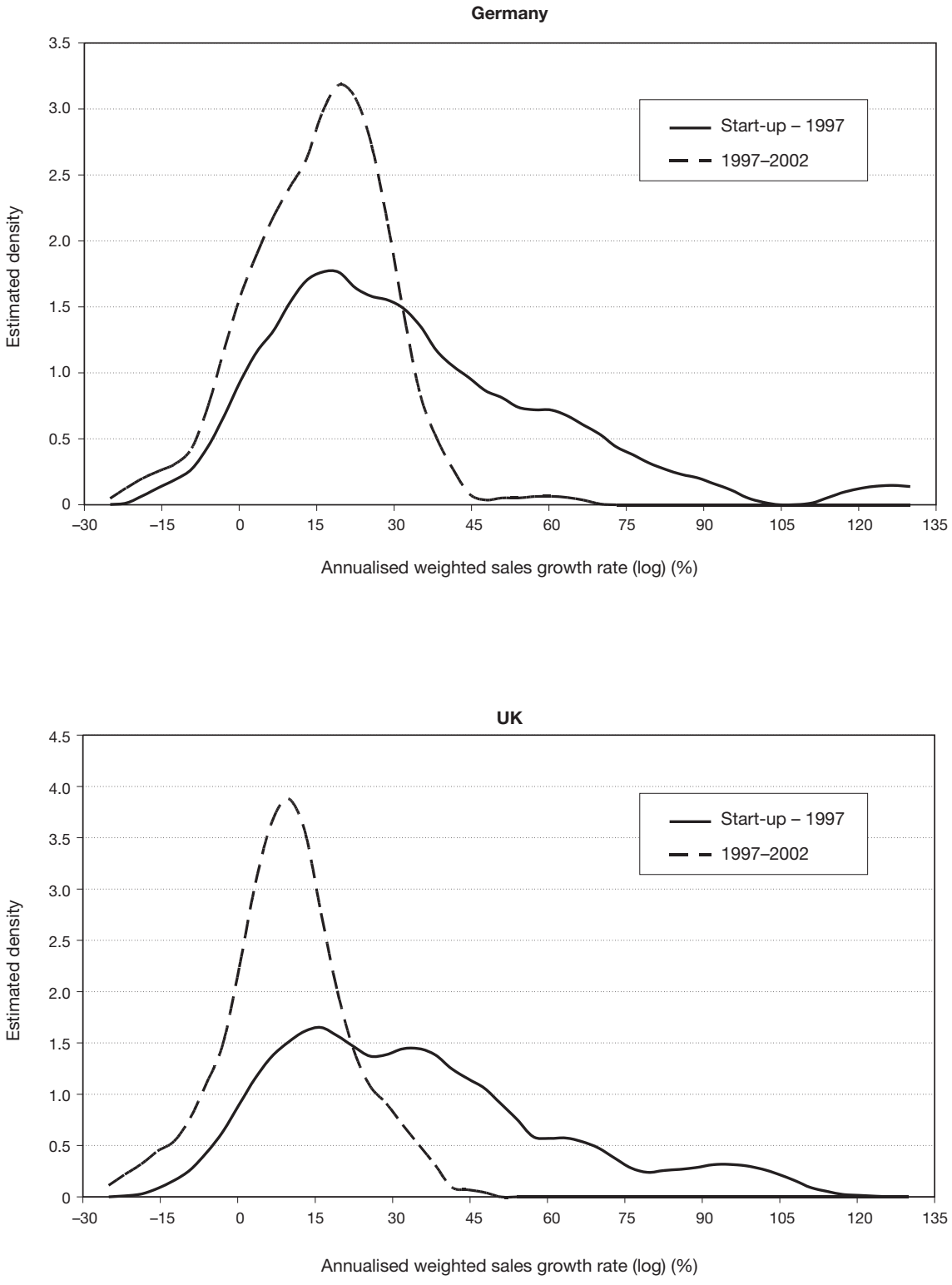
Table 18
Annualised sales growth rate by industries

	Germany					UK				
			Percentiles					Percentiles		
	Mean	Std. Dev.	10th	50th	90th	Mean	Std. Dev.	10th	50th	90th
Start-up – 1997										
Software/services	51.5	61.3	5.7	31.2	101.2	44.8	49.3	4.7	29.6	157.2
ICT hardware	62.7	31.1	37.6	50.6	94.0	62.8	51.5	10.4	51.5	102.9
Engineering	38.0	26.5	14.2	25.0	84.0	39.4	36.3	9.2	31.4	84.5
Health	47.8	48.8	–1.1	38.8	143.5	37.3	20.0	8.2	43.1	57.2
Others	37.3	30.6	7.8	34.8	96.3	55.9	45.0	9.4	44.6	128.1
Total	47.0	50.8	5.7	31.2	101.2	46.9	44.2	5.5	34.4	107.6
1997–2002										
Software/services	19.1	14.9	1.1	19.9	31.4	10.0	18.6	–14.6	12.2	37.8
ICT hardware	22.5	8.4	13.2	20.6	33.8	16.2	11.7	3.6	14.0	32.5
Engineering	17.1	13.6	1.2	23.5	32.6	10.4	10.7	0.0	7.3	29.1
Health	15.5	14.1	–5.1	15.2	40.1	11.1	11.5	0.9	9.8	20.9
Others	14.2	17.2	–0.7	7.8	41.7	10.1	11.2	–2.9	10.8	19.7
Total	17.7	14.7	1.1	17.8	35.3	10.6	15.1	–8.7	11.3	29.1

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results. Growth rates are computed using discounted sales. Only firms that participated in both surveys have been considered.

for the equivalent German firms. The performance differences are also captured in Figure 9. The depicted density functions show, on average, higher growth rates for German firms compared with UK firms. In the period from 1997 to 2002, the share of firms with a negative sales growth rate is again higher for UK (21%) than for German firms (8%). During the firms' start-up period, only 2% of both German and UK high-tech enterprises exhibited a negative growth rate. It appears that the greater promise of rapid growth exhibited by the UK cohort of firms in the initial five-year period of their existence up until 1997 has not been sustained. The relative advantage of the UK firms to their German counterparts has been *reversed* in the succeeding six years to 2003.

Transition tables indicate how many firms stay or move out of each growth regime across the observed time periods. Growth regimes are defined arbitrarily but in accordance with the related literature on firm growth (see, for example, Brüderl and Preisendörfer, 2000; Almus, 2002). The fast (slow) growth regime comprises all firms that showed an average annualised growth rate larger (smaller) than the 90th (10th) percentile value of the growth rate distribution. Thus, the tables indicate the probability of a firm staying in the same growth regime over time or moving, for example, from a high growth to a low growth regime or vice versa. Table 19 shows employment growth regimes, Table 20 displays the related figures of the firms' sales growth distributions. Given the importance that both countries have conferred on supporting young knowledge-based firms, the sustainability of growth over a protracted period of time is essential if the new firms are to make any material and permanent impact on the future economy.



NB: Weighted results. Growth rates are computed using discounted sales. Only firms that participated in both surveys have been considered.
Source: ZEW, University of Exeter, own estimation.

Figure 9
Estimated distribution of sales growth

Table 19
Transition between employment growth regimes – 10% percentiles

		Growth regime 1997–2002			
	n **%**	Slow growing[a]	Moderate growth	Fast growing[b]	**Total**
Growth regime Start-up – 1997	Slow growing firms[a]	0 0.0	20 90.9	2 9.1	22 100
	Moderate growth	21 12.7	130 78.3	15 9.0	166 100
	Fast growing firms[b]	3 13.6	15 68.2	4 18.2	22 100
	Total	24 11.4	165 78.6	21 10.0	210 100

Source: ZEW, University of Exeter, own calculation.
[a] Slow growing firms comprise all firms that show an annualised employment growth rate less than the 10% percentile value of the employment growth rate distribution in the respective period.
[b] Fast growing firms comprise all firms that show an annualised employment growth rate larger than the 90% percentile value of the employment growth rate distribution in the respective period.
The 10% and the 90% percentile values differ between the two regarded periods.

Table 20
Transition between sales growth regimes – 10% percentiles

		Growth regime 1997–2002			
	n **%**	Slow growing[a]	Moderate growth	Fast growing[b]	**Total**
Growth regime Start-up – 1997	Slow growing firms[a]	2 12.5	13 81.3	1 6.3	16 100
	Moderate growth	13 10.2	104 81.9	10 7.9	127 100
	Fast growing firms[b]	3 18.8	12 75.0	1 6.3	16 100
	Total	18 11.3	136 85.5	12 7.5	159 100

Source: ZEW, University of Exeter, own calculation.
[a] Slow growing firms comprise all firms that show an annualised sales growth rate less than the 10% percentile value of the sales growth rate distribution in the respective period.
[b] Fast growing firms comprise all firms that show an annualised sales growth rate larger than the 90% percentile value of the sales growth rate distribution in the respective period.
NB: Growth rates are computed using discounted sales. The 10% and the 90% percentile values differ between the two regarded periods.

We see that less than one in five (18.2%) of the original fastest growing firms within the highest performing decile manage to remain in the top 10% of the employment growth distribution during the second observed period. Conversely, over two-thirds (68.2%) of these fast growing firms in the first period slow down to moderate employment growth by the second period. On the other hand, and more encouragingly, over 90% of slow

growing firms in the first period (start-up to 1997) migrate to moderate employment growth over time. Two formerly slow growing firms even leapfrogged to become fast growing firms in the period from 1997 to 2003. This result, however, could be expected: Firms with the worst performance in the first period (i.e. shrinking firms) had either to improve their (relative) performance or to leave the market. Those firms that survived until 2003 had overcome their initial slow growth period. Conversely, slow growing firms that did not successfully develop strategies to improve their performance relative to their competitors left the market. It is very unlikely that a firm will survive if it belongs to the regime of slow growing firms over more than a decade. Technology markets have no room for the 'living dead' as venture capitalists label such firms. The transition table reflecting changes between different sales growth regimes confirms what is found in the employment table. Essentially, it is difficult for an initially fast growth firm to sustain this performance over an extended period of time. *Only one single firm* managed to retain its status within the top 10% of the sales growth distribution over the two periods (compared to four firms in the employment growth tables).

Labour productivity is measured as sales per employee. Table 21 indicates that there are profound differences in the productivity between German and UK firms in 2002. Labour productivity in the ICT-hardware sector is very high in Germany compared to all other German sectors. The difference between ICT and health/life sciences is approximately €100,000 sales per worker. In contrast, the productivity in the UK health/life sciences sector is greater than for the ICT-hardware sector. In fact, UK labour productivity is highest in the health/life sciences sector where the average difference is €90,000 sales per worker when compared to the UK's software and service sector.

Both in 1997 and 2002, mean labour productivity of German firms exceeded that of UK-based firms (1997: €97,900 in Germany compared with €78,300 in the UK; 2002: €165,700 in Germany compared with €127,500 in the UK; see Table 22). This is true for most industry sectors with the exception of health/life sciences. In both countries and for all industry sectors, labour productivity increased from 1997 to 2002.

Table 21
Labour productivity* by industry in 2002 (in €000s)

	Germany					UK				
			Percentiles					Percentiles		
	Mean	Std. Dev.	10th	50th	90th	Mean	Std. Dev.	10th	50th	90th
Software/services	135.3	93.9	62.5	102.2	225.0	97.8	56.2	39.8	79.6	199.0
ICT hardware	223.9	143.6	125.0	150.0	357.1	164.0	98.1	62.8	135.9	244.9
Engineering	141.6	78.9	71.4	120.0	250.0	123.0	53.5	63.7	106.1	206.3
Health	124.2	56.8	60.0	120.0	192.3	188.0	148.3	70.2	139.3	265.3
Others	158.7	107.8	65.0	110.0	350.0	151.7	86.9	51.9	129.1	287.5
Total	146.3	99.6	62.5	116.7	266.7	122.7	79.0	45.2	95.5	212.8

Source: ZEW, University of Exeter, own calculation.
*Sales per employee, all sales in €000s at 2002 prices; weighted results.
NB: Only firms that participated in both surveys have been considered.

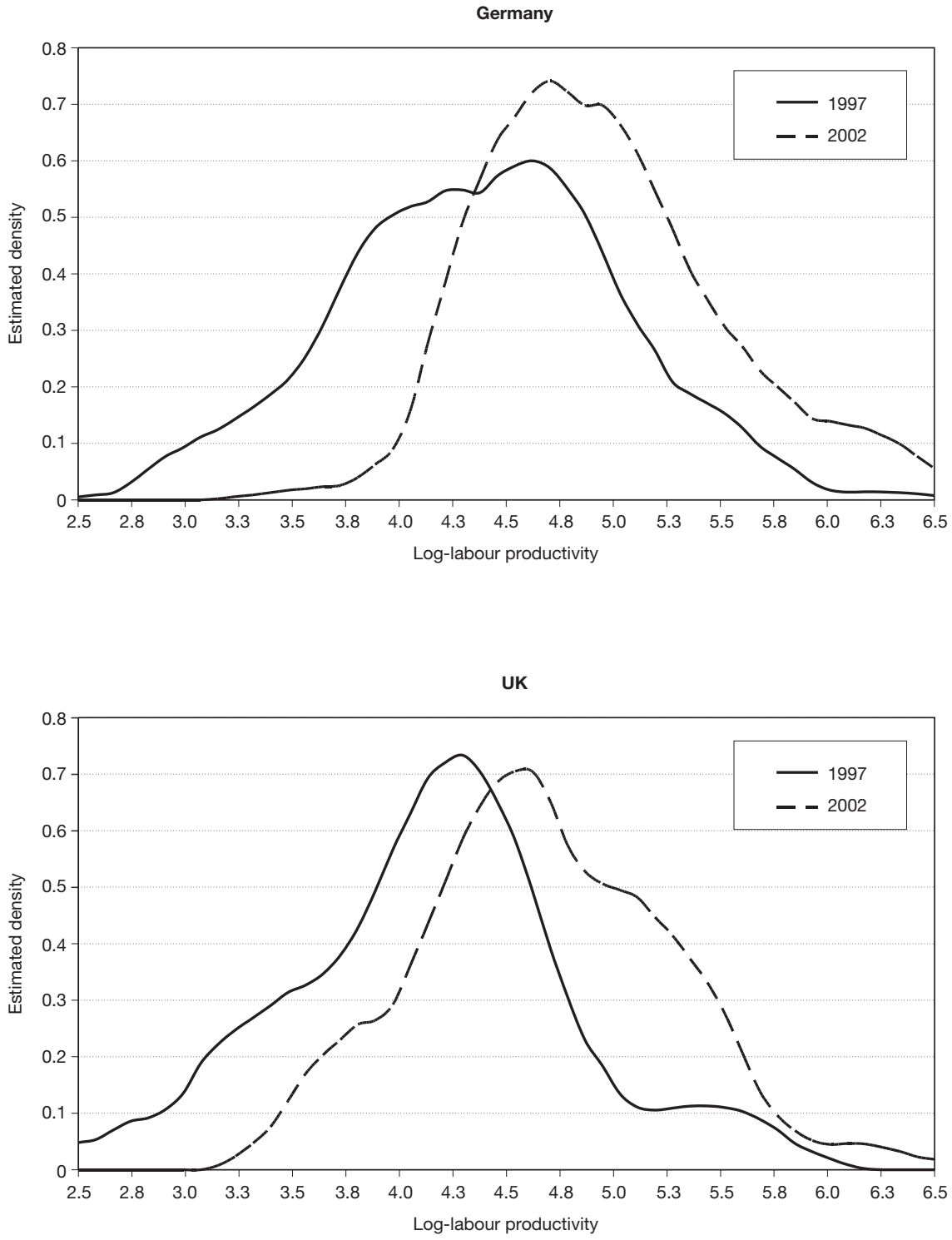
Table 22
Labour productivity* by industry in 1997 and 2002 (in €000s), longitudinal study

	Germany					UK				
			Percentiles					Percentiles		
	Mean	Std. Dev.	10th	50th	90th	Mean	Std. Dev.	10th	50th	90th
1997										
Software/services	86.8	61.7	25.3	62.4	187.3	56.9	38.0	20.7	54.9	85.4
ICT hardware	120.9	76.2	45.6	90.3	247.0	73.8	30.7	35.4	69.4	108.9
Engineering	89.0	39.9	39.4	75.1	122.2	99.4	61.1	38.6	87.6	189.0
Health	116.1	66.4	45.1	115.9	211.7	127.6	78.5	46.3	130.7	223.7
Others	126.8	100.2	52.5	98.8	196.4	94.9	75.0	26.8	73.7	118.9
Total	97.9	68.7	37.9	84.4	187.3	78.3	58.4	26.5	65.6	130.7
2002										
Software/services	163.3	125.1	80.0	125.0	285.7	98.3	53.8	39.8	79.6	199.0
ICT hardware	196.2	94.7	134.6	150.0	357.1	190.3	114.9	95.5	135.9	397.9
Engineering	149.5	80.3	83.3	121.6	300.0	124.4	51.3	63.7	115.8	184.8
Health	155.9	55.4	94.3	142.9	233.3	207.4	183.8	70.2	119.4	596.8
Others	186.6	114.5	81.3	166.7	421.1	152.3	87.8	51.9	136.4	254.7
Total	165.7	110.8	80.0	133.3	300.0	127.5	87.3	47.8	100.8	212.8

Source: ZEW, University of Exeter, own calculation.
*Sales per employee; all sales in €000s at 2002 prices; weighted results.
NB: Only firms that participated in both surveys have been considered.

The rising labour productivity is also apparent from Figure 10: The estimated distribution of the logarithm of labour productivity in 2002 lies to the right of the distribution of 1997. This development is a result of the fact that from 1997 to 2002 sales grew faster than number of employees. The increasing labour productivity might be a result of the turbulent macro-economic situation in high-technology markets in the period from 1997 to 2002. In order to survive, firms had to improve their productivity, first by employing a given number of workers more efficiently. Second, as shown by the earlier descriptive analysis, many firms dismissed workers and reduced their total number of employees. If they dismissed the least productive employees first, labour productivity would increase. Third, firms may have substituted employees by other production factors – for example, capital or (imported) intermediate products. Thus, one unit of output can then be produced by a smaller number of employees. Note, however, that in computing labour productivity in Table 22 and Figure 10, we only considered firms that participated in both surveys – i.e. firms that had survived until 2003. Therefore, the increasing labour productivity cannot be a result of the market exit of less productive firms.

The main objective of this chapter is to analyse the nature of the causal relationship between internationalisation and firm performance. Table 23 shows descriptive statistics of firms with and without international sales. The results are in line with other micro-econometric studies. Firms with international business activities have, on average, higher sales, more investments and a greater number of employees (this applies to both R&D and non-R&D staff).



NB: Weighted results.
Remark: *Sales (in €) per employee. Labour productivity is computed using discounted sales. Only firms that participated in both surveys have been considered.
Source: ZEW, University of Exeter, own estimation.

Figure 10
Estimated distribution of labour productivity*

Table 23
Comparison of firms with and without international sales in 2002, longitudinal study

	With international sales				Without international sales			
	Mean value	Median	Standard deviation	*n*	Mean value	Median	Standard deviation	*n*
Sales[a]	4,637.5	2,387.5	8,058.20	148	1,735.9	800	2,149.91	54
R&D employees	3.39	2	4.93	138	0.53	0	1.24	45
Non-R&D employees	31.7	14	56.31	137	10.0	6	11.08	45
Investments[a]	217.7	50	405.77	135	85.8	40	171.96	47
Labour productivity[b]	146.2	127.4	84.48	147	158.0	103.4	130.95	52
Annualised employment growth rate[c]	9.4	7.0	13.51	157	0.9	3.1	11.35	55
Annualised sales growth rate[c,d]	17.1	16.2	15.29	141	10.4	12.2	13.80	51

Source: ZEW, University of Exeter, own calculations.
[a] in €1,000; [b] Sales per employee in €1,000; [c] Period 1997–2002; [d] Discounted sales were used.

The annualised average growth rates for employment and (price indexed) sales are significantly higher in the group of exporting firms when compared with non-exporting firms. Surprisingly, labour productivity of firms without international sales exceeds that of exporting firms. However, we must be cautious when interpreting these figures. Recall that the statistics in Table 23 are *weighted* statistics. Calculating the corresponding non-weighted statistics leads to the conventional result that exporting firms exhibit higher labour productivity than firms without international business activities (non-weighted, mean labour productivity of exporting firms is €152,300, and for non-exporting firms is €139,500). Moreover, analysing the complete cross-sectional data set of the second survey also reveals a higher labour productivity for exporting firms. This is true regardless of using weighted or non-weighted statistics. Nevertheless, we may conclude that the difference in labour productivity between firms with and without international sales in much smaller (and in most cases statistically insignificant) than the respective differences in the firms' employment and sales growth rates. 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 their domestic market.

In order to examine the relationship between firm performance and internationalisation, three simultaneous equation models were estimated, one for each measure of firm performance (i.e. labour productivity, employment growth and sales growth). These models enable us to test whether causality runs from a firm's international business activities to firm performance (i.e. whether exporting improves firm performance) or vice versa (i.e. firms with superior performance self-select into foreign markets). In this report, we will only present the main results of our analysis.[11]

[11] The econometric implementation of these models as well as a detailed discussion of the estimation results can be found in Fryges (2004b).

The econometric results are unambiguous for our sample firms which were 11 years old in 2002. Good firms are or will become exporters. Internationalisation does not lead to better performance. This finding reflects theoretical orthodoxy. Only during early stages of our sampled firms' lifecycles 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, at subsequent stages of the firms' development, the performance-enhancing effects of internationalisation disappear.

R&D activities play a crucial role in both the productivity and growth models as well as for the firms' (long-term) internationalisation behaviour. R&D improves labour productivity as well as employment and sales growth. Moreover, the more intensive the R&D activities, the higher is the firm's probability of internationalisation. After controlling for R&D, there is no partial effect of internationalisation on firm performance. By investing in R&D, firms create intangible assets that improve their growth prospects, increase labour productivity, and facilitate (long-term) international business activities.

The changing relationship between firm performance and internationalisation is a rather sobering result, considering that the performance-enhancing role of internationalisation is often stressed by policy makers and consultants. However, the question remains: What are the benefits of international engagement? Arguing that good or more innovative firms become exporters is merely to state that firm quality is 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.

Finally, the econometric models only estimate the impact of internationalisation status on firm performance. However, we found significant differences among our sample's exporters with respect to the extent of their international engagements (see Chapter 5). In 2003, 26% of exporting firms generated more than 50% of their total revenues in the foreign markets (cross-sectional data from the second survey). On the other hand, there are some firms that occasionally receive unsolicited orders from abroad. It is unlikely that such serendipitous exports induce any performance-enhancing effects of internationalisation. Nevertheless, the latter group of firms was classified as exporters in our econometric models. Thus, there might be some threshold value of the degree of internationalisation an exporter has to exceed in order to profit from its international engagement. Accordingly, we must be cautious when interpreting econometric studies that examine the export-performance relationship.

7 Modelling business survival

It is important to first point out that the survival statistics relate to the two periods over which our sample firms were tracked. On average, the firms were five years of age when they were first identified by the study. Thus, the earliest stages of a firm, when survival is likely to be most problematic (Audretsch and Mahmood, 1995; Cressy, 2006), are not captured in this analysis. Rather, the statistics broadly relate to the sample firms' longer term survival beyond start-up – i.e. the period from Year 5 to Year 11. The term 'survival' describes firms that are still alive, trading and independent. Firms that have been taken over have been removed from the data along with dead and insolvent firms. Table 24 shows survival rates by sector. It is the uniformity of the figures across industry and country that is most evident. Essentially, four out of five firms have continued to trade up to the time of the second research contact. This spans a period of considerable market disruption for technology-based companies. German firms in our sample appeared to have better survival rates across all sectors. However, this is only true for the sample of 1997 respondents. Based on the population, the survival rates are comparable (about 80% for both German and UK firms).

Table 24
Survival status 2003 of firms participating in the 1997 survey (in %)

	Germany		UK	
Industry	**Non-survivors**	**Survivors**	**Non-survivors**	**Survivors**
Software/services	11.75	88.25	20.81	79.19
ICT hardware	15.58	84.42	20.98	79.02
Engineering	9.22	90.78	21.18	78.82
Health	11.28	88.72	23.24	76.76
Others	4.64	95.36	19.24	80.76
Total	10.68	89.32	20.75	79.25

Source: ZEW, University of Exeter, own calculation.
Weighted results.

The survival statistics were also classified by the key characteristics of German and British firms in Table 25.

Here considerably more heterogeneity was evident between the factors that characterised survivors and non-survivors for the two countries. Interestingly, surviving firms had smaller total numbers of employees than failed firms. This negative influence of firm size runs counter to other empirical studies (Phillips and Kirchhoff, 1989; Audretsch 1993; Audretsch and Mahmood, 1995; Thornhill and Amit, 2003). That age is positively related to survival is less contentious. Survivors do more R&D and are more likely to have permanent R&D activity. The impact of R&D intensity on survival is more

Table 25
Key characteristics of survivors and non-survivors

		Germany		UK	
Firm characteristics	**Measure**	**Non-survivors**	**Survivors**	**Non-survivors**	**Survivors**
Number of employees 1997	Mean	19.49	14.20	20.12	14.92
Annualised employment growth rate from start-up to 1997 (in %)	Median	21.64	29.10	31.14	25.99
Age in 1997 (in years)	Mean	4.85	4.89	4.85	5.57
R&D intensity 1997	Mean	17.99	19.24	10.62	14.32
Permanent R&D activities	%	48.58	45.44	49.33	58.83
New, self-developed technology	%	32.09	37.19	31.73	33.50
Window of opportunity (in months)	Mean	20.49	20.27	14.74	16.70
Venture capital 1997	%	10.44	8.51	10.94	8.54
Public grants 1997	%	29.82	20.24	17.74	12.45
International sales 1997	%	42.35	56.07	68.65	58.27

Source: ZEW, University of Exeter, own calculation.
NB: Weighted results.

marked in the UK with greater R&D reducing the speed of the competitive threat compared to Germany. As was expected, the presence of venture capital finance was associated with greater failure rates. However, the negative effect of public grants in Germany and the UK was more surprising and suggests a moral hazard problem.[12] While UK firms were more international overall than German firms, this characteristic was more likely to be associated with failure in the UK than in Germany.

Descriptive tables are useful but can lead to the adoption of false findings unless the possible interaction between variables is also accommodated. Thus, in the next section we investigate econometrically the determinants of business survival. The data on which survival is based are made over two time points – the initial survey data in 1997 and a database review of surviving businesses made in 2002. Our basic procedure is to estimate a series of probit models which take into account the binary nature of the dependent variable – i.e. coded 1 if the business has survived and 0 if it has failed. In the following analysis, we do not discriminate between the reasons for termination. To allow a more meaningful interpretation of the results, we choose to report the marginal effects of the probit models calculated around the means of the independent variables. This enables us to determine the influence and importance of each variable on firm survival in both countries.[13]

[12] A 'moral hazard' may be defined as a lack of incentive(s) to guard against risk activities where one is protected from their adverse consequences by, for example, an insurance policy. In the above case, government grant dilutes the full economic impact of firm failure on the entrepreneur.

[13] Details of the econometric model's specification are available from the authors.

Table 26
The determinants of business survival in Germany and the UK

	(1) Germany		(2) Germany		(3) UK		(4) UK	
Variables:	**dF/dx**	**z-stat**	**dF/dx**	**z-stat**	**dF/dx**	**z-stat**	**dF/dx**	**z-stat**
Employment size at start-up					–0.0019*	–1.71	–0.0018*	–1.93
Age (years)	–0.0040**	–2.43	–0.0140**	–2.55				
International sales share %					–0.0020*	–1.70		
Founding team size							0.0485**	1.96
Venture capital later stage (yes)							–0.1670*	–1.82
Angel finance at start-up			–0.1051**	–2.40				
Government finance at start-up					–0.2291*	–1.84		
Government finance at later stage	–0.0462*	–1.71			0.1430*	1.91		
Technology								
Tried and tested combination (yes)							–0.1560**	–2.36
Skills shortages (yes=1)								
Finance at later stage							–0.0799***	–3.01
General management at start-up	0.0129**	2.12						
General management at later stage	–0.0205***	–2.59	–0.0608***	–2.97				
-2LL	–34.629		–59.625		–72.975		–102.470	
Pseudo R2	0.388		0.160		0.181		0.121	

*10 % level of significance; **5 % level of significance; ***1 % level of significance
NB: Dependent variable: survival=1, non-survival=0 (marginal effects reported). Base categories are: software industry; produced for end user; technology developed internally; window of opportunity – time unspecified. Only significant coefficients (p = <10%) are reported.

In Table 26, two models are presented for each country – a fully specified model (1 and 3), in which all variables of potential importance are included, and a refined and more parsimonious model (2 and 4) where non-statistically significant variables (i.e. >10% probabilities) are removed from the subsequent computation. The table only shows significant variables identified by each method. Both fully specified and parsimonious model variants have strengths and weaknesses, and both will produce some results that are contradictory. Thus, all results need to be interpreted given that they remain estimates for a larger and unknown population.

Survival results – Germany

We observe that in Germany business survival decreases as a function of age. The older a business was, the lower the probability that it survived until 2001. This is contrary to the findings of previous studies of business survival in more conventional sectors of the economy. As already noted, empirical evidence suggests that age usually increases the chances of firm survival. By implication, this result may reflect the technological orientation of this sample of German businesses, and the highly volatile and peculiar conditions between 1997 and 2002 in domestic and international technology markets.

The means by which German technology businesses are financed also appears to play a role in the determination of survival or exit. In model 1 we note that businesses which received government finance at a later stage (i.e. in 1997, the year of the survey) had a 4.6% lower probability of surviving until 2001. In model 2, this effect ceased to be relevant. However, businesses in receipt of business angel finance at the time of start-up had a 10.5% lower chance of survival. This may suggest that German business angels find it difficult to evaluate new, technology-based businesses adequately. Alternatively, it may also indicate that follow-on financing by the formal venture capital market is hard to obtain in 2002.[14] The former finding, although weaker, suggests that government financiers may need to examine their investment appraisal techniques and existing venture capital policy when dealing with follow-on funding.

Finally, we observe that skills shortages at the general management level at a later stage also play a role in determining which businesses survive. This appears to be a robust finding in that it is significant across both models 1 and 2, although it becomes stronger in the more parsimonious second model. The magnitude of the coefficient here implies that businesses experiencing a skills shortage at the general management level have a 6.1% lower survival probability.

To summarise, German businesses, which are likely to have the highest probability of survival, are younger (i.e. started later), did not have an equity investment from a business angel at start-up nor government financial support at a later stage, and do not suffer from general management skills shortages after they have been trading for a few years.

[14] This is a credible assumption after the major reduction in venture capital investments in Germany after the intern-tional market corrections in 2000–01.

Survival results – UK

The UK results are reported in Table 26. Here we note that business survival decreases significantly with initial (employment) size of business. Larger sized start-ups have a higher probability of exit (non-survival). This again is contrary to findings regarding business survival in more conventional sectors of the economy. However, the size of the founding team was found to exert a positive, and significant, effect on survival. This can be interpreted as a 'human capital effect' as larger groups of founders have more tacit resources to invest in the business through greater accumulated experience. It may also be the case that businesses with larger founding teams also have more financial capital available. The magnitude of this founding team size effect is very substantially larger than the (negative) employment size effect.

In model 3, the more internationally orientated a business is (when measured by the ratio of international to total sales), the lower the survival probability. However, this result did not hold true in model 4. Mode of financing was also found to be important. Here, from model 1, we observe that businesses in receipt of government-backed finance at start-up had lower survival probabilities. Yet those who received government investments at a later stage were more likely to survive. These two findings suggest that UK government finance providers are less competent at evaluating new technologies at the point of business start-up than when the businesses have been up and running for a few years. It could also suggest that there is a greater moral hazard in financing unknowable start-ups. In model 4, businesses in receipt of later stage venture capital investments had a 16.7% lower survival probability than those firms that had not received venture capital finance. This suggests that formal venture capitalists in the UK are not particularly good at picking winners from smaller, newer technology-based businesses. However, it should be noted that venture capitalists do not try to optimise portfolio survival but rather the value of the portfolio over time. Regarding the greater success of later stage government investment, this might suggest that formal venture capitalists could learn from the evaluation techniques of government-backed financiers.

We see that UK businesses using 'tried and tested' combinations of existing technology had lower survival probabilities than those using newer technologies, irrespective of whether these were developed externally or internally. The scale of this effect was large, effectively reducing survival probabilities by 15.6%. This strongly suggests that staying technologically innovative in both products and services enhances firm survival. Businesses not at or near the technology frontier are more likely to fall by the wayside as their sales and profitability are less likely to be protected by unique and defensible intellectual property resources over the longer term.

Finally, we observe that businesses with financial skills shortages at the managerial level after they have been trading for a few years have significantly lower survival probabilities. These firms have an 8% lower chance of survival. This suggests that training in financial management is critical for new technology-based businesses seeking to establish themselves. (The issue of training is also likely to be reflected in the widely differing productivity of UK and German firms in our sample.)

To summarise for the UK, the probability that a business will survive is dependent upon the size of the initial founding team, the total size of the business at start-up, mode of

financing, technological sophistication and financial management skills at the managerial level. Businesses that have larger founding teams but smaller numbers of other employees, who are using advanced technology and have adequate financial management skills, will be significantly more likely to survive. However, they should be wary of venture capitalists' involvement in their businesses, particularly at later stages, and might be better served by seeking out government sources of finance after the start-up period.

Tentative conclusions from the 2002 data

These early figures give a number of interesting insights into the respondent firms which have either survived or failed over a five-year period during their early growth stages. The findings also raise a number of important issues for further investigation. Clearly, the great majority of these firms have survived despite enduring very volatile and increasingly difficult trading conditions in the period 1997–2002. Even accepting that the firms' survival was appraised between their sixth and eleventh years on average, this subsequent survival rate of four out of five young companies remains a highly impressive statistic. This is particularly the case given that these firms generally compete as relatively new entrants in highly contestable markets where any protection provided by unique assets can be quickly eroded away by the technological and other responses of competitors.

The survival statistics pose a number of important questions from both policy and theory perspectives. Of particular interest is the high degree of difference in the key variables influencing survival between the two country cohorts. In a majority of cases, a variable shown to be important in one or both model variants for Germany does not register as significant at all for the UK (and vice versa). When the variables are seen as significant, the direction of the coefficient is on occasion reversed between countries. For example, the provision of government finance at a later stage is associated with a reduced probability of survival in Germany and an increased probability in the UK.

Overall, the results serve to challenge accepted wisdom in a number of areas. In Germany, the negative associations (with survival) of firm age, angel financing and government finance at later stage are interesting. Similarly, in the UK, the negative effects of employment size at start-up, the role of government finance at start-up and the contribution of venture capital are also somewhat counter-intuitive. These results are a powerful argument for more work in these areas.

8 Concluding comments

The economic potential of entrepreneurial young firms to reinvigorate mature Western economies is of considerable interest to both scholars and policy practitioners alike. The so-called 'new entrepreneurial economy' holds out the prospect of a virtuous circle of enhanced employment, tax revenues, self-generating innovation and future growth (Birch, 1979; Romer, 1990; Acs, 1996; Kirchoff and Phillips, 1998) in an environment where many of the roles of large and small firms become increasingly complementary. Yet, despite widespread governmental support for enhanced entrepreneurial activity, our understanding of nascent and early growth entrepreneurial firms is still wanting at the fine-grained levels that can inform policy decisions. In a recent large-scale review of entrepreneurial financing of emerging technologies in the USA, academics Auerswald and Branscomb (2003: 227) conclude that '…the process by which a technical idea of possible commercial value is converted into one or more commercially successful products – the transition from invention to innovation – is highly complex, poorly documented and little studied.' This present concern with the paucity of robust, longitudinal and comparative analyses is similarly articulated by Autio (2005) and Sapienza et al. (2006) when focusing on internationalising young firms – i.e. those firms which are most likely to embody the transformational economic power of new knowledge-based enterprises.

Given these concerns, the advent of this report is timely. It is the fourth in a series of AGF studies on high-tech young firms, and it provides a detailed comparative analysis of the growth and performance over time of a large cohort (600 firms) of new technology-based firms (NTBFs) in the UK and Germany. A time series spanning a dozen years allows us a unique dynamic perspective on the relative fortunes of these high-potential enterprises. It is comfortable to hold stereotypical opinions about the particular nature of the commercial strengths or weaknesses of commercial activity in either country. In the context of growing, and maturing, technology enterprises, we are now a little more able to replace subjective opinion with robust and empirically validated analysis.

The present study is a full-scale revisiting of the authors' original study (Bürgel et al., 2004) in which 594 independent firms started between 1987 and 1996 were first interviewed in 1997. As such, it precisely meets the needs expressed by Sapienza et al. (2006) for both comparative ('matched sample') and longitudinal (1987–2003) analyses of the performance implications of small firm internationalisation. Our research looks at the surviving members of the 1997 cohort some five to six years after the first study. We know that five years can be a very long time in a dynamic technology environment especially for the nascent or, as yet, un-established firm. Both studies confirm the small window of exclusive market opportunity that our respondent firms enjoy before having to address major competitive threats. Thus, a detailed understanding of how our original 1997 sample of firms had fared over a substantial period of time is of material interest.

Further, our investigation spans a truly exceptional period when technology markets, and particularly start-up and young firms in promising new technologies, became part of one of the most notorious market 'bubbles' of the late 20th century. After the *hubris* of the mid-1990s with sometimes hugely unrealistic valuation being given to interesting but unproven new technology-based enterprises, we saw *nemesis* arrive in the shape of a

widespread collapse of technology market valuations in the first quarter of 2000. Many young firms failed as investors withdrew support and sales opportunities dried up. For those firms that did survive, the start of the new century was to usher in a period of very severely constrained trading conditions in many technology markets. Thus, this study is timely in chronicling the aftermath of a period when considerable concern was expressed as to the legacy of the technology bubble on the future innovative capacity of advanced economies. In addition, the study is unique in the Management and Entrepreneurship literatures (as far as the authors can ascertain) in chronicling empirically, and in detail, the internationalisation and related activities of a substantial, international cohort of high-tech young firms over more than a decade of activity.

This latest AGF survey provides several reasons for optimism for policy makers with either a national or a European remit. The majority of small firms in our sample have exhibited a remarkable degree of resilience. They have managed to sustain their employment and sales activities throughout a period of extremely hostile market conditions at the start of the 21st century. That approximately four out of five of the original sample survived and, in many cases, continued to grow sales both domestically and in export markets is a tangible recognition of the quality of management and/or the attraction of the firms' innovative products and services. Since 1997, our German and UK sample firms have demonstrated double-digit, annualised sales growth rates (18% and 11%, respectively) and employment growth rates were similarly positive (at 7% and 5%, respectively). Over the same period, firms from both countries also expanded the scale of their international sales activities. These figures help reinforce the putative economic benefits of technology-based small- and medium-sized enterprises to a modern Western economy.

In our 1997 AGF study, we showed that a large proportion of both German and (particularly) UK firms are internationally oriented in their expansionist growth strategies. The present report confirms that firms from both countries have continued to increase the importance of international sales as a percentage of total sales. German firms on average now sell in 11 foreign markets with UK firms similarly selling to 16 overseas markets. These figures reiterate the reality that the small scale of many of these firms is not an implacable barrier to either export or total sales activity. For both countries, the most rapidly growing firms were invariably highly international in their focus, although, as we have also shown, it is the most competent firms that self-select internationalisation strategies. A comparison of internationalising and non-internationalising firms shows that on average the former category registered higher performance statistics on several major economic criteria – i.e. total sales, total employment, sales growth, employment growth, labour productivity and investment. Thus, our sample firms have also clearly demonstrated their aggregate economic contribution to the balance of trade in both countries.

Over time, our sample firms have had to make the strategic choice whether or not to continue permanent R&D activities – essentially the defining activity of a technology-based enterprise. It appears that these firms have two choices. They either further entrench R&D activities into their operations or, conversely, they abandon such activities. This is particularly the case in Germany. However, comparisons between Germany and the UK on the outcomes of R&D investment are not clear cut. UK firms show a higher median complement of R&D workers and a higher level of R&D expenditures when expressed as a percentage of turnover. Descriptive statistics further indicate that UK firms, which engage in higher R&D investments, are able to enjoy a longer period before major competitive challenges. The German data do not show a similar relationship. Yet, the

descriptive statistics do not include information on the quality or the effectiveness of the R&D created. An alternative explanation is that German firms are able to realize a longer window of opportunity (49 months and more) while investing a smaller share of their total turnover in R&D than UK firms. These conflicting interpretations are a cogent argument for further research. Yet, all firms with strong overseas sales regardless of nationality were also substantially more likely to engage in intense R&D activities including the employment of significant numbers of 'knowledge workers' in their labour force. These firms, despite their relative youth and small size, demonstrate an important and continuing role in the diffusion of technologies and related innovations from the laboratory to the marketplace.

The earlier AGF study specifically reviewed the importance of internationalisation to firm sales and employment growth. The figures collected in 1997 showed that internationalisation was a desirable strategic choice for the expansionist firm – that is, the act of internationalisation was shown to be one cause in the subsequent, superior, relative performance of the exporting firms. The present study sought to ascertain whether or not this important finding was still supported given the longitudinal data now available. Econometric analysis did *not* confirm this causal relationship – namely, internationalisation per se was not shown to be responsible for superior enterprise performance. Rather, an investigation of the expanded data set tells a more subtle story. Internationalisation and superior performance are still interlinked. However, the present analyses indicate that it is the superior performing firms that appear to self-select internationalisation strategies. Thus, while internationalisation activities may augment the subsequent economic growth of such firms, the act of export sales activity does not itself result in the superior performance of these firms. This alternative explanation suggests that it is the best-performing firms that have been able to identify, accrue and exploit superior assets, including the human capital of their managers and workforce as well as other tacit resources such as intellectual property. By such means, these faster growing firms have been able to execute superior strategies including, for a majority of such firms, international activities.

That both economies are characterised by a vigorous supply of new companies in genuinely high-technology areas must be seen as an advantage in a world where intangible sources of intellectual value are becoming of ever greater importance. Yet, as has frequently been noted, the developing of inimitable resources to enhance and sustain both firm and spatial (i.e. cluster) capabilities remains highly challenging (Kenney and von Burg, 1999; Winter et al., 2003; Venkataraman, 2004). Nonetheless, a number of highly successful firms were created from our sample of 1987–96 start-ups. The top five firms in our sample had aggregate sales and employment of €203m and 1,830 workers.

Yet, the European dilemma, as identified in the European Commission's Lisbon Agenda (European Commission, 2000), remains the absence of significant numbers of 'gazelles' – i.e. young firms that continue to grow rapidly into substantial and globally competitive firms – within the members' economies (Birch, 1979). That the mean and modal figures for both employment and sales after 12 years in our sampled firms are relatively modest in scale is arguably a cause for disappointment. Even the top decile of firms had employment levels hovering around 50 employees and annual sales (excepting German Engineering and ICT-Hardware) of usually under €10m. These firms barely register as 'medium-sized' under current European Commission definitions. Given that they are now entering their teenage years, the prognosis for their metamorphosis into large firms is remote (although not impossible). Despite periods of extremely rapid growth in

international technology markets, the reality is that only approximately 10% of sampled firms have grown to be capable of any material economic impact as individual firms rather than in their contribution to aggregate statistics. Storey (1998) has called this elite group of growth companies resident in the wider population 'the ten percenters'.

Europe and many other Western economies have sought to emulate the success and vigour of the US entrepreneurial model. The premise has been that, while the history of American technology and innovation excellence cannot be exactly emulated given 'path dependencies' (Kenney and von Burg, 1999), the major European requirements should be centred on infrastructural improvements enabling a more conducive environment for a greater volume of new enterprises to be created and to prosper. These policy prescriptions would include, for example, improved access to finance and particularly risk capital investment; legislation facilitating the creation of new firms and their subsequent growth, including allowing intellectual property rights to be easily and widely protected; access to other country markets for capital or corporate control without protectionist constraints; legal and financial systems more tolerant of legitimate entrepreneurial failure and renaissance; and academic/commercial linkages with a greater ability to spin-out effectively and rapidly innovative ideas from university or public research laboratories to commercial enterprises (Lambert, 2003; Lockett et al., 2005). Such commercialisation frequently requires the agency of highly experienced formal and informal investors working in collaboration with growing cadres of skilled and experienced entrepreneurial managers.

More rarely do such lists of desirable conditions acknowledge that the cultural preconditions necessary for increased entrepreneurial action may be much more intractable to change than, for example, those identified barriers amenable to a government legislative bill or more incentivised and risk-tolerant financial markets. Individual or team ambition and enterprise must also be understood within a culturally and socially determined context. It may well be that the similarity to North America that has been witnessed in the entrepreneurial metamorphosis of some European economies since the mid-1980s may not be able to be widely emulated – at least across the present European Union configuration of 25 members. Thus, we raise the caveat that high-tech enterprises may still be hostages in part to their domestic cultural traditions despite their ambitions for a global reach.

If there is a single *leitmotif* to this report, it is the imperative and desirability of change. Our findings repeatedly re-confirmed the importance of growing firms over time generating, enhancing and renewing their technical and commercial competencies in order to ensure continuing productivity and growth. Change is endemic and ceaseless for the successful firm in aggressively competitive international markets for technology-based products and services. To reiterate the well-known words of Intel co-founder, Andy Groves, 'Only the paranoid survive' (1996). Firms need to invest in both human capital and technology in order to innovate effectively and continuously in these meritocratic markets. As we have shown, permanent R&D investment can 'buy time' from competitor threats. But R&D expenditure, while necessary, is not sufficient in itself. It also needs to be complemented by the employment of trained and experienced operatives at all levels of the workforce including management. Accessing high-quality labour is a persistent and chronic problem for both young and maturing firms.

As our firms enter their teenage years, they can no longer sensibly be described as 'start-ups'. They are now developing into a cohort of 'maturing' high-tech firms. The present

research has an important role in chronicling in detail this process among our sampled firms. This change of status is reflected by numerous results. For example, the decision to exit one or more foreign markets over time is seen as a relevant option for firms in our sample. Furthermore, with greater experience, exporting firms appear less reliant on a foreign intermediary when distributing and selling their products abroad. This lessening dependence on agents may be because they are no longer restricted by a 'liability of alienness', the phenomenon noted in our original study. These changing relationships influencing both export activities and firm performance corroborate the results of many other papers that investigate the export-performance relationship in mature firms. A longitudinal perspective also allows us to review the ability of firms to address over time their original weaknesses in, for example, access to finance or to skilled labour resources. UK firms appear less able than German firms to correct long-term resource constraints, with finance and market information appearing to be particular problems.

The creation of hugely successful companies with global reach has been a rare event in Europe over the last 20 years. In their absence or scarcity, developed economies need to spawn and nurture thousands of new technology-based firms that will have a substantial and positive net effect on their host economies. Our results suggest that the true contribution of European new technology-based firms at present is best captured in their aggregate and positive impact on their host economies and regions. Expecting one or a few young firms to grow rapidly into global enterprises and bring attendant advantages to the host economy is unrealistic as an exclusive *deus ex machina* policy prescription. Furthermore, our results confirm the improbability of recognising early these exceptional growth firms given the essential randomness of the development process. Thus, the imperative of continued and substantial new firm formation in Europe will need to be recognised – for both its strengths and its weaknesses – in any robust assessment of the future role of small firms in national or European innovation policy.

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