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# The World Is Your Oyster: The Effects of Knowledge, Human Capital, Technology and Entry Timing on International Growth

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**Abstract.** We draw on elements of several established theories of internationalization to provide a framework for exploring international market entry and scale of entry measured by number of foreign markets entered for a sample of young, high-tech, firms from the UK and Germany. We find that founding team human capital is associated with more extensive internationalization, as is intensity of R&D, early internationalization and early stage venture capital. We also find that internationalizing firms who choose the US as their first international market entry are also those most likely to develop more extensive international market presence. Degree of asset specificity, in contrast, is associated with less extensive internationalization.

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## 1. Introduction

The development of theoretical frameworks seeking to formalize thinking about why young, entrepreneurial firms internationalize (Brush, 1992; McDougall, Shane, & Oviatt, 1994; Oviatt & McDougall, 1997) led to an emerging empirical literature seeking to test these theories using real world data (Autio, Sapienza, & Almeida, 2000; Coeurderoy & Murray, 2008; Mudambi & Zahra, 2007;

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Fernhaber, Gilbert, & McDougall, 2008). This, in turn, and sometimes in parallel, led to further advances by researchers seeking to refine and develop established theories (Cuervo-Cazurra, Maloney, & Manrakhan, 2007; Sapienza, Autio, George, & Zahra, 2006) to advance future investigation of this phenomenon. What is particularly interesting about this new body of literature is that it often (a) challenges the fundamental predictions of more established, often process, theories of internationalization (Johanson & Vahlne, 1997), and (b) empirically offers little support for established theories. Our view is that there is a gap in the knowledge base concerning two important aspects of young, entrepreneurial firms and internationalization. Firstly, there has been little cross-country comparative work. Secondly, there has been little work tracking samples of young, high-tech firms over significant periods of time. It is the purpose of our work here to address these two issues by considering the nature and scale of international market entry amongst a longitudinal sample of young, high-tech, firms from Germany and the UK.

Process, or stage, theories of internationalization tend to assume that firms are generally passive actors operating quite happily in their domestic markets until an unanticipated, exogenous, shock occurs. The nature of such shocks can be positive (an unanticipated foreign order) or negative (a large contraction of demand in the home market). Underpinning this assumed passivity is that firms are content to operate within the bounds of existing knowledge and would not, in the normal course of business, seek to operate outside of these parameters. This concept has parallels in the governance literature where 'outsiders' are only admitted if they conform to the existing status quo. From this initial internationalization, firms are assumed to proceed incrementally and slowly as they accumulate and develop international knowledge and expertise.

What is evident is that such theories, developed, as they were, to explain the behaviour of larger, more conventional, firms have little to say about entrepreneurs and entrepreneurial founding teams and the firms they create. Nor do they have much to say about innovation and technological advancement. From a theoretical, and empirical, perspective both of these characteristics help explain why some young, entrepreneurial firms internationalize at the point of inception (born globals) or soon thereafter. As neoclassical economics and the development of the production function excluded the entrepreneur by definition (Cowling, 2003), process theories of internationalization excluded a role for the entrepreneur as a creative thinker, capable of organizing resources in new and novel configurations, as an identifier of new opportunities (Blanchflower & Oswald, 1998), and exploiter of market gaps. In this context, internationalization, particularly at an early stage may be an explicit choice by an entrepreneur to maximize growth and subsequent profit streams which research has found tend to move in parallel (Cowling, 2004). Indeed, entrepreneurs may set up and configure firms specifically to facilitate international market expansion with these objectives in mind.

Given the centrality of the entrepreneur, or entrepreneurial team, to strategic decision-making in young firms, it is an empirical question as to what the most advantageous time is to begin the internationalization process. Previous research tells us that many young firms are resource constrained in terms of human capital, financial capital or a combination of the two (Westhead et al, 2001). This would support delaying the timing of international market entry. Yet often entrepreneurs who have identified opportunities or market gaps need to move quickly to exploit them. Failure to do so would result in losing the opportunity to other, often incumbent firms, or indeed to other entrepreneurs. In this paper, we broadly adopt the framework of Autio et al (2000) who used a knowledge-and-learning based conceptual approach to examine international sales growth amongst a Finnish sample of electronics firms. However, the empirical focus of our work is much broader as we have rich data on founding team and worker human capital, technological sophistication, knowledge intensity, financial capital, and firm demographics as well as imitability of the firms' core product or service. The conceptual approach is well suited to examining the effects of these factors on internationalization given the centrality of knowledge in this framework.

In order to examine these effects, we use data collected as part of a longitudinal tracking study of young, high-tech firms in Germany and the UK over the (average) period 1991 – 2004. The key internationalization variable is count data on the number of foreign markets entered conditional on the fact that a firm internationalized at all. In our sample 66.84 per cent of firms internationalized. The contrast between Germany and the UK is particularly interesting given their geographic proximity, but different economic evolution, innovation and governance models. In the context of internationalization specifically, language may also be an important area of distinction. Further, both countries are large, internationalized economies. The use of a sample of high-tech firms is also significant given that knowledge creation and its application are central to business operations in high-tech sectors, as indeed is the propensity to internationalize.

## 2. Knowledge, Learning, and International Growth

How rapidly young firms grow has been the subject of intense scrutiny since the seminal job generation study of Birch (1979). The factors that are associated with the growth of entrepreneurial firms have been the subject of an expanding volume of literature and on some core strategic competencies a consensus has been established. For example, Chandler & Hanks (1993), Lerner & Haber (2000) and McGee, Dowling, & Megginson (1995) all found that greater competence at the managerial level is positively associated with business growth. The Scottish work of Reid & Smith (2000) also found that organisational capability enhances growth, and the case study work on e-commerce based SMEs of Feindt, Jeffcoat,

& Chappell (2002) linked having defined processes and product presentation to better performance. The German work conducted by Dencker, Gruber, & Shah (2009) used a novel set of human capital variables, including proxies for 'breadth of knowledge' and 'leadership experience' and found contrasting results. On the former there was a negative association with job growth and on the latter a positive one. These findings suggest that not all types of human capital are 'good' if growth is the performance measure.

Empirically, there appears to be a reasonable body of evidence that suggests that reactive, or follower, strategies are associated with lower growth (Bruderl & Preisendorfer, 1998; Van Gelderen, Frese, & Thurik, 2000). Reid & Smith (2000) found that the extent of the strategic horizon (the time period over which strategic decisions are intended to cover) is critical to growth, and Feindt et al. (2002) show a positive association between managing customer relationships and success in E-commerce. Thus it does appear that the outward market-facing role of entrepreneurs and entrepreneurial decision-making is a vital element in the determination of early stage performance.

A fundamental underpinning of our study is that international knowledge, including country and market-based knowledge, as well as knowledge of operating in international markets per se, and how quickly new knowledge is absorbed and learning occurs, is an important determinant of international market expansion for young, entrepreneurial, high-tech firms. Research has suggested that knowledge and learning based theories have empirical validity. For example, Autio et al. (2000) found that greater knowledge intensity was associated with more rapid growth in international sales over a five year period using Finnish data.

Before we set out our knowledge and learning framework in more detail, we reiterate that our hypotheses are derived explicitly to reflect the high-tech nature of our sample of firms. As the more wide ranging growth literature cited previously had shown, the basic principle that knowledge and learning are associated with growth amongst more conventional firms is supported. It is our contention, however, that these attributes are likely to be more important in fast-moving, highly innovative industry sectors where technological change is rapid. This contention is discussed in more detail after we present our core findings from the analysis.

## 2.1. A Knowledge and Learning Framework

Learning and knowledge are the central components underlying the causes, processes, and outcomes of early internationalization (De Clercq et al., 2012). When a firm intends to pursue an internationalization strategy, it usually suffers from lack of knowledge about the foreign market (Carlson, 1966). Therefore a

critical barrier to overcome during the process of internationalization is how to obtain the knowledge needed for overseas operation.

Organizational learning is the process through which a firm acquires the collective information and techniques to accept, make sense of, and respond to internal and external changes (Argyris & Schon, 1996; Fiol & Lyles, 1985), i.e. organizational knowledge (Autio et al., 2000). Generally speaking, organizational learning facilitates strategy renewal and opportunity recognition (Lumpkin & Lichtenstein, 2005), and helps the firm maintain a long-term competitive advantage through learning from its own experience (Slater & Narver, 1995) or acquiring new knowledge (Zahra et al., 2000). Libaers & Meyer (2011) refer to the acquisition and management of this firm-specific knowledge and capabilities as the 'inventive prowess' of a firm, which is "a distinctive trait that sets some small technology-based firms apart from others (p. 1427)". Therefore, although theories or models underpinning organizational learning vary, it is well accepted that learning will improve future performance (Fiol & Lyles, 1985; Zahra et al., 2000). In order to enhance the essential ability, or know-how, to improve task performance, firms can either learn to exploit their existing knowledge or acquire new ones from collaboration partners and public sources (Cohen & Levinthal, 1990; Grant, 1996). The former is referred to as experimental learning (EL) and the latter acquisitive learning (AL) (Dess et al., 2003).

Both EL and AL can have significant impact on the decision, pattern and outcome of internationalization. EL occurs when a firm generates new knowledge that is distinctive to the organization by exploiting its existing knowledge (Zhao et al., 2009). Since learning is most efficient in domains close to an existing knowledge base, EL is likely to have larger potential in creating or reinforcing the firm's competitive advantage (Zahra et al., 1999). By entering into the international market, the operational environment of the firm is likely to become more volatile and unstable. EL enables the firm to manage market turbulence more effectively through exploiting existing knowledge (Grant, 1995) and undertaking various responses in different situations (Zahra & Garvis, 2000). In turn, knowledge gained from internationalization will create additional value for the firm (Zahra et al., 2000). More importantly, as argued in Autio et al. (2000), organizational knowledge is gained not only by learning new knowledge, but also the 'unlearning' of existing knowledge. This is particularly relevant in the process of internationalization as it often involves overcoming the rigidities within the firm's present operation, especially when the old knowledge was obtained with substantial effort (Cohen and Levinthal, 1990).

Acquisitive learning on the other hand, is concerned with learning new competencies and knowledge externally beyond the firm's current boundaries (Morgan & Berthon, 2008). As AL involves shifting the way in which strategies and consequences are framed, it is also called breakthrough learning (Slater & Narver, 1995) or double-loop learning (Argyris & Schon, 1996). By "modifying

an organization's underlying norms, policies and objectives" (Argyris & Schön, 1978: pp. 2-3), value is created through knowledge exploration (March, 1991) or knowledge generation (Spender, 1996). Since knowledge generated externally may not be applicable to a specific enterprise, the uniqueness of the knowledge is likely to be lower than that obtained from EL activities. In this sense, AL is both riskier and harder for the organization to control. From a resource-based perspective, when a young, entrepreneurial firm uses its limited resource to pursue knowledge that has no uniqueness and can be easily imitated by competitors, the outcome of AL could be both uncertain and less positive (Hughes et al., 2007). However, since AL is necessary if practitioners and organizations are to make informed decisions in rapidly changing and often uncertain contexts (Argyris, 1990), as in the case of internationalization, firms must improve their abilities for AL if they are to succeed.

Therefore, internationalization performance is to a large extent dependent on the effort, and effectiveness of this organizational learning process. From the above review of previous literature, we postulate that organizational learning will not only affect the outcome, but also the decision and the scale of international market entry. However, traditional models on the relationship between knowledge and learning, and internationalization process (e.g. Johanson & Vahlne, 1977) suffer from reducing validity because of the subsequent changes in company behavior since the inception of the original models (Johanson & Vahlne, 2009; Forsgren, 2002). First, whilst dealing almost exclusively with experiential learning (Forsgren, 2002), previous theoretical studies assert that internationalization is an incremental learning process through the firm's own operations (Johanson & Vahlne, 1977) and yet later studies show that such process can sometimes be radical or non-linear (Eriksson et al., 1997; Levitt & March, 1988; Molero, 1998) through imitating (Fligstein, 1985; Lewitt & March, 1988), acquisition of organizations or people with the knowledge, or other 'short-cuts' (Huber, 1991; Nadolska & Barkema, 2007). Thus when examining the determinants of internationalization, the time of entry, the relevance and intensity of knowledge, and the effectiveness of learning should all be considered. Second, internationalization is increasingly recognized as the consequence of proactive rather than reactive learning especially in the context of entrepreneurial firms (Blanchflower & Oswald, 1998). Modelling internationalization as a reactive process excludes a role for the entrepreneur as a creative thinker, capable of organizing resources in new and novel configurations, as an identifier of new opportunities, and exploiter of market gaps (Blanchflower & Oswald, 1998). In this sense, young, high-tech firms, entrepreneurs and entrepreneurial founding teams, along with their idiosyncratic knowledge that shapes their competitive advantages, could all play a significant part in the firm's internationalization process.

## 2.2. Learning Effects of Firm Age at International Entry

According to the Uppsala Theory of Internationalization, firms have to undergo a lengthy and evolutionary learning process to overcome the liability of foreignness or outsidership (Johanson & Vahlne, 1977, 2009), so older firms at international entry are more likely than younger firms to possess such tacit knowledge for international operation. However, it is found that some firms internationalize in the start-up stage (McDougall et al., 1994; Oviatt & McDougall, 1994, 1997, 2005) or are even born global (Knight & Cavusgil, 1996), and this process tends to be more rapid than predicted (Madsen & Servais, 1997). These findings are consistent with studies on the general growth performance of small businesses, where a firm's performance is usually found to be diminishing as the firm ages (Chandler and Hanks, 1993 and 1994; Durand and Coeurderoy, 2001; Nunes et al., 2013) because older firms may suffer from the owners' lower commitment and involvement compared to young firms (Churchill and Lewis, 1983).

In the context of internationalization, there are two streams of related theories arguing that entry age is more of a liability than an asset. The first theory by Hannan & Freeman (1984) states that organizations are subject to inertia forces that prevent them from "making radical changes in strategy and structure in the face of environmental threat" (p. 149), and that the degree of inertia increases as the firm ages. The second theory concerns the learning advantages of younger firms over older firms in the sense that the older the firm, the lower the flexibility in the learning process due to the increasing organizational rigidities within the firm (Autio et al., 2000; Carr et al., 2010; Sapienza et al., 2006).

Both theories are consistent with the 'age being a liability' argument. On the one hand, compared to young organizations, older organizations at the time of international entry have a cost advantage in continuing existing routines, which involve extensive investments at the early age of the firm (Hannan & Freeman, 1984). This coincides with the declining nature of the learning curve. Further, this organization-specific knowledge gained from the development stages of a firm (after the firm has passed the 'survival mode') is likely to have an 'imprinting' effect (Hannan, 1998) so that it generates a self-reinforcing path of value creation and the firm is able to take advantage of the knowledge for a relatively long time. Therefore, once a firm has acquired substantial domestic, organization-specific skills, it will be reluctant to switch to the overseas market both due to the rising cost of switching and the benefit of maintaining existing domestic competitive advantages.

On the other hand, younger firms at the time of international entry have an advantage over older firms in both learning new knowledge, and 'unlearning' old routines. Once a firm is confronted with the decision to undergo a fundamental change, old routines such as technology, procedure, or even beliefs or culture must be unlearned before any new routines can be learnt (Hedberg, 1981;

Barkema & Vermeulen, 1998). Fundamental as it is, internationalization could imply the disruption of domestic systems and practices even if such systems and practices are crucial in shaping the existing competitive advantages of the firm (Carr et al., 2010). If a firm has a profound organizational-specific advantage in the domestic market, it may be difficult or impossible to bring these advantages into the new overseas market because of organizational inertia. In this sense, the profound resource and knowledge stock generated from years of domestic business activities are likely to become a liability to older firms. On the contrary, if a firm internationalize at a younger age, it is likely to be more flexible in adapting new approaches to operations or market exploration since they are less constrained by the existing routines than older firms (Sapienza et al., 2006). This flexibility not only concerns technology or procedures, but also exists in terms of "political and relational barrier" which older firms devote considerable effort in developing and thus are more reluctant to give up for the opportunities in the foreign market (Autio et al., 2000). As Bettis and Prahalad (1995: p. 10) suggested, young firms "do not have the problem of having to run down an unlearning curve in order to be able to run up a learning curve".

To summarize, in the presence of internationalization opportunities, younger firms are supposed to be more likely to pursue international strategies than older firms because they possess some extent of learning advantages in obtaining and adopting foreign knowledge, or simply because 'they have nothing to lose'. Recent empirical studies have found support for this proposition in different countries, that the growth performance in international markets tends to decline as firm ages (cf. Autio et al., 2000; Carr et al., 2010; Lu & Beamish, 2001; Zahra et al.,2000).

*Hypothesis 1: Firm age at international entry is negatively related to the degree of internationalization.*

## 2.3. Knowledge as a Competitive Advantage

Consistent with both traditional and more recent theories, knowledge that helps to tackle the uncertainty of foreign markets will improve the speed and performance of internationalization. Traditional firms, under an Uppsala setup (Johanson & Vahlne, 1977), usually internationalize incrementally by adapting and exploiting existing knowledge and apply it to the new overseas market. Knowledge-intensive firms, on the other hand, take a more proactive stand in product design, and process and service improvement, then use this as a competitive advantage in both domestic and foreign markets, which enable them to internationalize faster than other firms (Oviatt & McDougall, 2005; Patel & Vega, 1999). Oviatt and McDougall (1994 and 2005) also propose a third kind of firm, the 'knowledge-based firms'. This type of firms usually possesses a unique sustainable knowledge

advantage (such as a novel patent) that can be applied to multiple countries, thus are likely to have the highest speed in internationalization.

In this sense, the intensity of knowledge (whether the knowledge is unique or not) is a key source of competitive advantage crafting an entrepreneurial firm's learning capacity, which is critical for foreign expansion. Both conceptual (Oviatt & McDougall, 2005; Prashantham, 2005) and empirical studies (Autio et al., 2000; Jones, 1999; Patel & Vega, 1999) have found support for this view. Autio et al. (2000: p. 913) define knowledge intensity as "the extent to which a firm depends on the knowledge inherent in its activities and outputs as a source of competitive advantage". They argue that in a dynamic environment, higher knowledge intensity can help firms to develop market-specific skills, and provide firms with higher effectiveness and flexibility because knowledge as a resource can be combined with fixed assets in foreign markets at a lower cost than the combination of domestic and foreign fixed assets alone (Eriksson et al., 1997).

R&D is usually used as a proxy for knowledge intensity. However, objective measures of R&D, such as R&D expenditure and number of patents, can be problematic especially for entrepreneurial firms (Autio et al., 2000). First, the information necessary to assess the degree of R&D may be limited for smaller firms. Second, R&D is not an independent measure of knowledge in the sense that it is usually a strategic concern when a firm starts its production (Ramani, 2002). Thus more subjective measures of R&D, such as managers' perceptions, are the more preferred method to assess knowledge intensity (Autio et al., 2000). Moreover, there could also be costs related to R&D especially in the process of internationalization (Asakawa, 2001), in the form of coordination cost and communication cost between domestic headquarters and foreign subsidiaries. Therefore, the relationship between R&D and international performance may not necessarily be linear (Chen et al., 2012).

Other proxies for knowledge intensity relate to the founder or entrepreneurial team because knowledge can be highly individualized for entrepreneurial firms (Oviatt & McDougall, 2005). Higher human capital is associated with greater learning capability, which facilitates the accumulation of necessary foreign knowledge and makes speedier international entry more possible. Recent empirical studies have found that prior overseas experience or international exposure increases the likelihood and extent of subsequent internationalization (Chandra et al., 2009; Kocak & Abimbola, 2009; Kuemmerle, 2002; Loane et al., 2007; Prashantham & Dhanaraj, 2010; Sapienza et al., 2005; Schwens & Kabst 2009).

*Hypothesis 2: Higher human capital and knowledge endowments are positively related to the degree of internationalization.*

### 2.4. Imitability and Window of Opportunity Effects

Firms do not always follow a learning curve from scratch. As opposed to incremental learning, firms can acquire knowledge about foreign markets through the imitation of organizational routines and practices of other firms (Fligstein, 1985; Levitt & March, 1988; Aldrich, 1999). In turn, firms pursuing an internationalization strategy are likely to face greater competition from both domestic and targeting countries due to higher publicity and larger exposures to expropriation and imitation (Autio et al., 2000). Therefore, although geographical or cultural proximity may facilitate bilateral collaboration and help firms to overcome liabilities of foreignness (Johanson & Vahlne, 1977; Picci, 2010), threats from imitation (e.g. diluted customer base, loss of idiosyncratic competitive advantage) must be carefully assessed before any decision on internationalization is made.

From a resource-based view, products difficult to imitate provide the firm with a monopolistic position over potential competitors, which facilitates resource accumulation and opportunity realization. This monopolistic rent also prevents rival firms from quickly improving their competitiveness through vicarious learning (Fernhaber & Li, 2010). Moreover, the effect of imitability is closely related to how the practice of imitation may influence international entry and performance. Imitation is a 'short-cut' through which imitating organizations become similar to those being imitated, usually more established and successful firms, and overcome the liability of newness or foreignness (Scott & Meyer, 1983). This is especially true in the context of internationalization, as Fernhaber et al. (2007) find that established, internationalizing firms are more subject to imitation by firms located geographically close to them. Using a sample of US start-up firms, Fernhaber and Li (2010) show that international entry by new ventures is, in part, an imitative response to the internationalization of other firms in the venture's home country. Therefore, high imitability is likely to limit the economic benefit from internationalization. This is particularly important for high-tech firms, which rely heavily on the materialization of their idiosyncratic knowledge as a competitive advantage during internationalization.

*Hypothesis 3: The more uniqueness endowed in the product or service, and hence lower imitability, the greater the degree of internationalization.*

## 3. Methods

We tested the hypotheses derived from knowledge and learning theories using data from a longitudinal tracking study of young, high-tech UK and German firms.

While the term 'high tech' is in common usage, the actual specification of what is meant by this term is not without difficulties. In this study, we continue to use the definitions employed in the first Anglo-German Foundation report in 2001 (Burgel et al., 2004). Technology-oriented firms are identified using the definition of high-technology manufacturing sectors in the UK established by Butchart (1987) and subsequently adopted as the official European Union definition.

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 33 industries with above average expenditures for R&D which were classified into nineteen 1987 SIC codes in the UK (see Table 1). One further category, which was not included by Butchart, was added to the nineteen sectors to reflect contemporary patterns of enterprise, i.e. high tech activities in

*Table 1*: Definition of High-Tech Industries (ex Butchart, 1987)

| Aggregated industries | 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 Telephony and 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 |
| Misc. 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 |

The present study is based on two identical surveys that were carried out simultaneously in Germany and the UK. The first survey was undertaken in 1997. The respondents from both countries were re-interviewed in 2003. The source data set originates from Dun & Bradstreet in the UK and Creditreform in Germany. Using these large national databases, all firms with 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 1990 and 1996, were selected. This resulted in a target population of 3,562 firms from the UK and 5,045 from Germany. A random sample of 2,000 firms was drawn from both country's populations and were stratified by size, sector (manufacturing versus services) and for Germany alone by region (West and East Germany). The firms were first contacted in the autumn of 1997 and invited to complete a four page written questionnaire. This survey instrument was constructed after an initial series of six detailed, pilot interviews

were undertaken in each country during which several questions were tested. (Subsequently, a further twenty case studies in each country were made in order to be able to interpret more fully the survey material.).

Three hundred and sixty two completed and usable questionnaires were returned from the UK and 232 from Germany resulting in a combined net sample of nearly 600 new technology-based firms (NTBFs) from the two countries. This represented a response rate of 14% and 24% in the UK and Germany, respectively, despite using identical measures. Robustness checks found no systematic bias between respondent and non-respondent firms in either country across a range of selection criteria.[2]

In order to determine the changes over time occurring to this sample of nearly 600 NTBFs, a joint research team from the University of Exeter and the Centre for European Economic Research (ZEW, Mannheim) prepared a new follow-on survey in which all previously responding firms were to be contacted a second time in 2003. At this date, the average respondent firm from the 1997 survey was approximately 12 years old. To determine the target sample of the second survey, all formerly responding firms that had 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 labeled in the database of Creditreform as 'dead' (because of bankruptcy as well as voluntary firm closure) at the beginning of 2003.[3] 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 identified and subsequently contacted a final target sample of 188 German and 250 UK-based formerly responding firms (70.78% response rate).

**Dependent Variable**

Number of international markets entered. We studied international market entry over the (average) period 1992-2003, using the number of international markets entered as the dependent variable. The number of international markets entered was defined by the survey respondents by naming the countries they derived sales in. This data was then simply counted up to provide a new variable for analysis.

**Independent Variables**

International entry timing post start-up. The variable was measured as the time, in years, between a firm's founding and its first international market entry. The mean age of entry was 3 years as was the median age of entry. Just over 28 percent of the sample firms went international in their first year of operation. The slowest time to international market entry was 13 years.

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2. This construction and sampling procedures of this first survey is described in detail in Burgel et al. (2004).
3. According to the analysis of Almus and Prantl (2002), those firms indicated as "dead" by Creditreform have almost certainly left the market. The converse, however, is not true.

*Knowledge intensity.* We use multiple measures of knowledge intensity including human capital measures, and intensity of R&D. Regarding human capital, we have a dummy variable indicating whether or not the firm was a de novo start-up. If this variable is zero (i.e., not a de novo start-up), then this is a proxy for embodied human capital as spin-outs and other forms of ownership transfer from existing firms have existing knowledge which may transfer into the new firm. We also allow for the size of the founding entrepreneurial team to play a role via a human capital accumulation process and via a complementary knowledge process. Here we express the variable in logarithmic form to correct for skewness. Concerning the founding entrepreneurial team per se, we include dummy variables which indicate whether or not members of the team (a) have international work experience, (b) were educated abroad, (c) have multinational work experience, and (d) previously worked together. We also include a broader human capital measure which is simply the number of employees who have a graduate degree.

On R&D, we use three proxy variables. Firstly, we have an R&D intensity variable which is defined by three, mutually exclusive, categories including; regular R&D, occasional R&D, and no R&D. Secondly, we have a variable indicating the share of employees within the firm who work at least 50 percent of their time on the development of existing and new products. Thirdly, we have a variable indicating the number of employees who have a technical or scientific education at degree level.

*Imitability.* We were looking for variables which captured how easy or difficult it would be for outsiders (other firms) to copy a firm's technology, products or services. With the former in mind, we constructed a complexity variable. With the latter in mind we had an explicit survey question relating to the entrepreneur's perception of how long (in elapsed time) it would take a rival to 'launch a similar product with superior performance or a product with similar performance at a lower price?'. This is expressed in logarithmic form to correct for skewness. The variable is labeled 'window of opportunity'.

Inter-firm specific relationships, our proxy for technological imitability, can be measured through the degree of specificity of assets between the companies and their customers. We introduce a construct variable based on six survey items indicating the key characteristics of the product or service sold by the sample firms. This list includes: (1) technical consultation prior to sales; (2) individual client customization; (3) specific configuration/system requirements; (4) complex or time consuming installation; (5) regular maintenance and/or upgrades; and (6) specialized training required for sales personnel. The respondents provided an assessment for each item from low to substantial on a 5 point Likert scale[4]. A Cronbach's alpha of 0.71 for the construct variable is acceptable. The variable is labeled 'complexity'.

A final variable which may capture aspects of imitability is a dummy variable indicating whether or not the internationalizing firm entered the US as its first international market. Our basis for including this variable is firstly to test whether 'if I can make it there, I'll make it anywhere' holds true as far as if a firm successfully enters the competitive US market, then subsequent entry into other countries might be relatively easier. It is also intended to capture other aspects of imitability in the sense that in such a competitive technology market if a rival can replicate your product they will, thus negating the advantage of internationalizing in the first place. Thirdly, it may capture market scale effects in the sense that successful entry into the large US market can provide a solid base upon which to build a presence in other international markets.

**Control Variables**

Aside from our core independent variables capturing elements of our theoretical hypotheses, we also have a rich set of control variables which we, a priori, might expect to influence (the degree of) internationalisation. The first is industry sector. As our sample was predetermined to only include high-tech sectors, we use a simple categorisation including Software/IT services, IT Communications hardware, Engineering, Bio/Medical/Life Sciences, and Other high-tech industry sectors. In line with Oviatt & McDougall (1997) and Autio et al. (2000) we include firm age, expressed in logarithmic form, to control for accessibility factors in relation to international market entry. We also include a set of financing mode variables indicating whether or not a firm has venture capital, business angel investment, and/or government investment. Given the high fixed, and sunk, cost of international market entry, the ability to raise external funds, particularly equity capital might be an important factor in developing sales in foreign countries. As our sample covers firms in Germany and the UK, we also include a dummy variable indicating country of origin. Finally, we have data on first year employment, an indicator of initial scale of operations which might affect credibility and legitimacy aspects of internationalization.

## 4. Results

Table 2 presents summary statistics for the variables included in the analysis[5]. The first point of note is that internationalizing firms, on average, entered eight international markets. The median was four international markets. The average lag between start-up and entering the first international market was three years. More than 24 percent of internationalizing firms entered the US as their first international country of entry. 83 per cent of firms were de novo start-ups. The

4. The precise formulation of the question was: "Please describe key characteristics of the product / service, particularly, the extent to which it requires:", then followed the six mentioned items.
5. A correlation coefficient table is available on request from the authors.

average 'window of opportunity' was thirteen months. The average size of founding entrepreneurial team was two, and total employment eight employees of which nearly 36 per cent were graduates and 15 per cent held technical or scientific degrees. Three quarters of employees were engaged in R&D. Amongst the founding team, nearly 53 per cent had worked together prior to starting this firm, 14 per cent had been educated abroad, 45 per cent had multinational work experience, and 44 per cent had worked internationally. Regarding financing, 10 per cent had venture capital investments, 18 per cent business angel investments, and 21 per cent had accessed government backed finance. On R&D, 57 per cent conducted R&D on a regular basis, 27 per cent on an occasional basis, and the remaining16 per cent did not engage in R&D.

*Table 2*: Descriptive Statistics

| Variable | Mean | s.d | Minimum | Maximum |
|---|---|---|---|---|
| 1. Number of international markets entered | 8.09 | 11.05 | 1.00 | 90.00 |
| 2. Industry: IT/Communications Hardware | 0.20 | 0.40 | 0.00 | 1.00 |
| 3. Industry: Engineering | 0.16 | 0.37 | 0.00 | 1.00 |
| 4. Industry: Bio/Medical/Life Sciences | 0.09 | 0.29 | 0.00 | 1.00 |
| 5. Industry: Other high-tech | 0.27 | 0.44 | 0.00 | 1.00 |
| 6. UK | 0.61 | 0.49 | 0.00 | 1.00 |
| 7. De novo start-up | 0.83 | 0.38 | 0.00 | 1.00 |
| 8. ln Number of Founders | 0.65 | 0.54 | 0.00 | 2.48 |
| 9. USA First International Market | 0.24 | 0.43 | 0.00 | 1.00 |
| 10. Complexity | 2.89 | 1.08 | 0.00 | 5.00 |
| 11. ln Window of Opportunity (months) | 2.55 | 0.86 | 0.00 | 4.28 |
| 12. ln Age | 2.22 | 0.30 | 1.39 | 3.43 |
| 13. Early stage venture capital | 0.10 | 0.30 | 0.00 | 1.00 |
| 14. Early stage business angel investment | 0.18 | 0.38 | 0.00 | 1.00 |
| 15. Early stage government investment | 0.21 | 0.41 | 0.00 | 1.00 |
| 16. Occasional R&D | 0.27 | 0.45 | 0.00 | 1.00 |
| 17. Permanent R&D | 0.57 | 0.50 | 0.00 | 1.00 |
| 18. Founder work experience abroad | 0.44 | 0.50 | 0.00 | 1.00 |
| 19. Founder multinational experience | 0.45 | 0.50 | 0.00 | 1.00 |
| 20. Founder educated abroad | 0.14 | 0.35 | 0.00 | 1.00 |
| 21. Founding team prior joint experience | 0.53 | 0.50 | 0.00 | 1.00 |
| 22. Share of technical/science graduates | 0.15 | 0.36 | 0.00 | 1.00 |
| 23. Share of graduates | 0.36 | 0.31 | 0.00 | 1.00 |
| 24. Share of R&D employees | 0.74 | 0.44 | 0.00 | 1.00 |
| 25. Start-up employment size | 7.94 | 39.25 | 1.00 | 900.00 |
| 26. International entry timing post start-up | 3.02 | 2.05 | 1.00 | 13.00 |

International market entry was correlated positively with bio/medical/life sciences, UK firms, firms that entered the US market first, older firms, and firms conducting permanent R&D. On the human capital side, founding entrepreneurial

teams with work experience abroad, multinational experience, and those with high shares of employees engaged in R&D were all positively associated with international market entry. It was also the case that international market entries were negatively associated with the time lag between founding and entering the first international market. In short, firms that internationalized quickly also, ultimately, entered more international country markets.

All three models are statistically significant and explain a reasonable proportion of the variance. The general findings show support for hypothesis 1 in that our lagtime variable is negatively related to the number of international markets entered (IRR significantly smaller than one). Thus firms that internationalized earlier in their life-cycle were able to expand, and extend, their international operations across more countries. Interestingly, the coefficients on this variable were nearly identical for Germany and the UK (IRR = 0.814 and 0.819) in the separate country models, implying that the benefits of early internationalization are equally apparent across the two countries. The results suggest that the penalty for a firm that waits five years until it internationalized compared to a born global comes at the cost of 2/3 of the international markets the firm could have entered. The negative impact of age at international market entry was confirmed by an additional (unreported) tobit model with left and right censoring in which the lagtime variable was found to be negative and significant (coefficient=-2.37, t-stat=6.03). Results from the formal hypothesis testing are shown in Table 3. The econometric method adopted across all three models is a Poisson maximum-likelihood regression where the dependent variable is a non-negative count variable, here the number of international markets entered. Each model is then subjected to a goodness of fit test with the Pearson statistic dictating whether or not this specification is appropriate. The default option was a negative binomial model. Prior to that we conducted preliminary tests using a Heckman two-stage selection model with a binary outcome model (international market or not), then a second conditional model for those with an international market presence. The results showed that there was no systematic relationship between entering an international market and the number of markets entered. Thus we defaulted to our Poisson models for the core analysis. For reasons of clarity, we report the estimated coefficients transformed into incidence rate ratios (IRRs) which is the rate at which events occur, here entry into international markets. Specifically, IRRs are obtained by taking the exponential of the Poisson regression coefficient, and hence for an IRR greater than one, it suggests that a unit change in the independent variable will change the outcome variable (number of international markets entered) by a factor of more than one unit, and vice versa.

*Table 3*: Results of Regression Analysis

| Hypothesis | Variable | Number of International Markets Entered | | |
|---|---|---|---|---|
| | | **Full Model** | **UK** | **Germany** |
| 1 | International entry timing post start-up | 0.82*** | 0.82*** | 0.81*** |
| 2 | Knowledge intensity | | | |
| | Occasional R&D[a] | 1.18 | 1.12 | 1.53 |
| | Permanent R&D[a] | 1.55*** | 1.50*** | 2.79*** |
| | Founding team human capital | | | |
| | ln Number of Founders | 1.23*** | 1.37*** | 1.15 |
| | Founder work experience abroad | 0.98 | 1.01 | 1.07 |
| | Founder multinational experience | 1.01 | 0.99 | 1.04 |
| | Founder educated abroad | 1.25*** | 1.13* | 0.86 |
| | Founding team prior joint experience | 0.88** | 0.89 | 0.85 |
| | Employee human capital | | | |
| | Share of technical/science graduates | 1.01* | 1.01** | 1.00 |
| | Share of graduates | 1.01** | 1.00*** | 1.00 |
| | Share of R&D employees | 0.94 | 0.94 | 0.53*** |
| | De novo start-up | 1.04 | 1.64*** | 0.63*** |
| 3 | Imitability | | | |
| | ln Window of Opportunity (months) | 1.02 | 1.02 | 1.02 |
| | Complexity | 0.90*** | 0.94** | 0.82*** |
| | USA First International Market | 1.34*** | 1.30*** | 1.69*** |
| 4 | Control variables | | | |
| | UK Dummy | 1.18*** | n.a | n.a |
| | ln Age | 13.37*** | 25.16*** | 50.70*** |
| | Start-up employment size | 1.00 | 1.01* | 1.00 |
| | | | | |
| | Early stage venture capital | 1.19*** | 1.21*** | 0.98 |
| | Early stage business angel capital | 1.01 | 1.05 | 0.85 |
| | Early stage government grant | 0.76*** | 0.66*** | 1.37*** |
| | Industry[b] | | | |
| | IT/Communications Hardware | 1.17** | 1.26*** | 0.73 |
| | Engineering | 1.08 | 0.9 | 1.52** |
| | Bio/Medical/Life Sciences | 1.70*** | 1.76*** | 1.61** |
| | Other high-tech | 1.03 | 1.07 | 1.27 |
| | | | | |
| | N | 438 | 250 | 188 |
| | Pseudo R2 | 0.24 | 0.27 | 0.40 |
| | Log likelihood | -1330.85 | -1006.89 | -224.65 |

Notes: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Reference categories are (a) never conduct R&D, (b) software industry sector.

Hypothesis 2 is supported by our permanence of R&D variable which implies that firms conducting R&D on a regular basis enter more international country markets. Interestingly, comparing the two coefficients on this variable in our German and UK models implies that the 'returns' to regular R&D, as far as international market presence is concerned, are substantially greater for German firms than UK firms (IRR = 2.79 compared to 1.50). Whether or not de novo start-ups were at a disadvantage was not found to be significant in our general model. But it was found to be related negatively to international market entry in the German model (IRR = 0.63, as compared to 1.64 for UK firms). Other aspects of human capital and knowledge accumulation were also found to be important. For example, founding entrepreneurial teams with foreign educations tended to own firms with wider international market entry, as were larger founding entrepreneur teams. It was also the case that a higher share of graduate employment, particularly those with technical or scientific degrees, was associated with firms operating in more international markets, although this tended to be a particular advantage to UK firms. In contrast, the share of employees engaged in R&D conferred a particular disadvantage to German firms. Hypothesis 3, which relates to imitability has empirically contrasting results. On complexity, the model relates increasing complexity to fewer international markets entered. And this negative relationship is stronger in Germany than the UK (IRR = 0.82 compared to 0.94). On US first market entry, the results show a strongly positive and significant result. This offers support for the argument that firms that can successfully enter the competitive US technology market, find it relatively easy to subsequently enter other foreign country markets. And this effect is larger for German high-tech firms than their UK counterparts (IRR = 1.69 compared to 1.30). Our third proxy for imitability relates to the length of the 'window of opportunity'. Here the results across all three models are insignificant. This may suggest either that the window is so short in duration that it doesn't realistically prevent reactive competitors or that it is imprecisely measured by survey respondents.

Concerning our control variables, the results show industry variation as expected. In the general model, firms operating in IT/Communications Hardware and Bio/Medical/Life Sciences were associated with more extensive international market entry. German engineering firms were also found to have a presence in more international markets. Early stage venture capital investment was also found to be positively related to greater international market presence implying a mutually beneficial relationship between investor and investee whereby the firm gets valuable capital to finance international expansion and the venture capitalist has the potential to secure higher returns associated with international expansion. In contrast, government backed early stage investment was associated with smaller scale international expansion in the UK. This finding highlights the difficulties that UK public led interventions have in making returns on their investments. However, the reverse was true for German government backed early

stage investments, which were found to be positively related to international market expansion.. Finally, we note that initial scale, measured by total start-up employment did not appear to be an important determinant of international market presence.

## 5. Discussion

We undertook this empirical analysis with the objective of improving our understanding of how knowledge, technology and human capital affected the scale of internationalization across country markets of German and UK high-tech firms during the first decade of their lives. Building on earlier theoretical and empirical work we were able to test a rich longitudinal data set covering two large European countries against three core hypotheses relating to age at international market entry, knowledge intensity and human capital, and imitability in the vein of Autio et al (2000). Our core findings offer support for early international market entry in the sense that early international exposure appears to be a pre-cursor to subsequent international market development and expansion. We also find some support for knowledge and learning theories of internationalization, particularly in relation to permanence of R&D and certain types of human capital, explicitly measures relating to the founding entrepreneurial team and technical employees. On imitability, our results were inconclusive. What was apparent was that the more complex the relationship between a firm, its product and its customers the less scope there appears to be for expanding, or diversifying, into other international markets. And the 'window of opportunity' is so short that the ability to earn supra-normal profits (the return to innovation or first mover advantage) does not appear to encourage or deter further international market entry. The finding that internationalizing firms who choose the US as their first international market entry are also those most likely to develop more extensive international market presence is intriguing and offers support for the notion that if a firm can make it there, it can make it anywhere.

We are also drawn, on the basis of our empirical findings, to argue that there is indeed a substantive role for the entrepreneur (or here typically an entrepreneurial founding team) in explaining internationalization. Implicitly, conventional, established firms react slowly and adopt a cautious approach to internationalization. Just under three in ten firms in our internationalizing sample (and one in five of the whole sample) eschew this convention and begin a process of internationalization in their first year of operations. And when combined with the more formal human capital related attributes of the entrepreneurial founding team this confers a very substantial advantage for such firms, particularly when backed up by a strong commitment to R&D. For those entrepreneurial firms brave enough to target the US market straight away the returns are even greater. Finally, we do note that there are areas of difference between German and UK firms which

generate different outcomes even given the same resource endowments. Equally, there are substantial areas of commonality.

## 6. Limitations and Future Avenues

The generalizability of our findings is limited to the extent that our German and UK results differ in some areas. However, we do find substantial commonality between the two countries across key variables such as R&D permanence and timing of international entry. In comparison with earlier studies we suggest that our broad findings are more generalisable as we cover two countries over a fairly lengthy period of time and across a multitude of high-tech industry sectors. And, reassuringly, we find a degree of consistency with the findings of the Autio et al (2000) study which used a sample of high-tech, Finnish, firms in electronics. This, of course, begs the question as to whether results using high-tech samples would hold using more conventional samples of firms. This is an area which merits further empirical work using less glamorous samples of lower-tech firms. It is also worth noting that our dependent variable, number of international markets entered is also different from the Autio et al (2000) study which used growth in international sales as the dependent variable. This does add to the generalisability of common findings, at least for high-tech samples.

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