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Pioneer burnout: Radical product innovation and firm capabilities

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Abstract

The question of whether and when to enter a newly emerging product market has been the focus of practitioners as well as researchers. This paper contributes to the literature by investigating the order of entry as well as pre-entry experiences with a population-based approach for the radically new product market of multifunctional machine tools for the case of Germany between 1949 and 2002. Estimation results show, that later entrants outperform pioneers. Moreover, it turns out that industry and technology specific capabilities do not increase survival chances. But when decomposing the known positive age effect on survival, we see that particularly dynamic capabilities, i.e. the competence to integrate additional business activities into the current product portfolio, significantly lower the risk of failure in the new product market.

I. Introduction

Technological progress often confronts market participants with the question, of whether, and even more importantly, when to enter newly emerging product markets. A substantial body of empirical literature comes to the conclusion that pioneering entrants are able to achieve a so called first mover advantage, and therefore early entry into a new market should be preferred over delayed entry (Agarwal, 1997; Klepper, 1997; Lieberman and Montgomery, 1988; Shepherd, 1999). But examples as being witnessed in the semiconductor industry highly challenge this maxim of "be[ing] the first to develop tomorrow's technology and you'll dominate tomorrow's markets" (Olleros, 1986, p.7). Whereas firms such as General Electric, RCA and Hughes led and accomplished the technology's commercialization, later entrants like Texas Instruments, Fairchild Semiconductor, and Intel grew into leadership positions next to the sizable incumbents AT&T and IBM. Moreover, it is frequently argued that industry dynamics lead to a shakeout of smaller firms when technologies become more and more standardized and large-scale, process focused production procedures favor firms above a certain minimum size within the price competition of maturing sectors. But again, this explanation does neither apply for the presented case nor does it account for other instances of pioneer burnouts such as in sewing machines, typewriters, and transistors (ibid). A common feature of all these examples though is that each of these markets represents the consequence of radically new technologies as opposed to incremental innovations. Thus, within the context of entering a newly emerging market the characteristics of the product relative to existing technologies are equally decisive for the entrants' success. Whereas these product and market related considerations constitute a solid ground for entry decision making, the other side of the coin, namely business internal competencies, play an equally important role for the success within a new market. Therefore, theoretical as well as empirical studies have addressed the issue of pre-entry experience of competitors in new markets (Helfat and Lieberman, 2002; Klepper, 2002; Buenstorf, 2007). It is argued that firms already possessing similar resources, in terms of capabilities, with respect to the new market will be more successful than their less experienced competitors. In particular, diversifying firms as well as spin-offs outperform de novo entrants (see also Mitchell, 1991; Klepper and Simons, 2000) as they could mainly rely on technological experience from related industries. But in addition to these technological capabilities it is argued that generally older firms tend to have a lower risk of failure as they accumulated general capabilities which are mainly related to organizational and management tasks.

Based on these findings on entry timing and pre-entry experience the present paper investigates the question how both factors, entry timing and different types of initial capabilities, affect survival rates in a radically new emerging market, i.e. the market for multifunctional machine tools. Moreover, we ask the question whether entry into this state of the art market guaranteed long-term survival in the industry. The empirical event history analysis is based on a dataset encompassing the entire firm population of machine tool producers between 1949 and 2002. The main result of the paper confirms previous theoretical and empirical studies by finding that within this radically new market, general capabilities lower the risk of failure whereas specific technological pre-experience does not affect the likelihood of long-term success within the new product segment. It turns out that when decomposing the set of general capabilities it is no longer the pure fact of being older and larger that lowers a firm's risk of failure, but it is particularly the experience of having already managed to integrate a new business activity into the product portfolio that increases survival chances in the market under investigation. Moreover, we find that later entrants benefit from technological discontinuities within the new market as well as a delayed replacement cycle within the industry and are thus able to outperform pioneering entrants.

The remainder of the paper is organized as follows: In the next section we discuss the theoretical background of the paper. Subsequently, section III introduces the empirical setting, before we present our empirical estimation strategy and data in section IV. Estimation results are given in section V and section VI concludes.

II. Theoretical background

The relation between order of market entry and the success of a firm is crucial for understanding industry dynamics, but empirical results on the existence of a pioneer's advantage in new markets are highly controversial. Therefore, this section summarizes the theoretical and empirical considerations with respect to first mover advantages and the conditions under which later entrants are expected to outperform pioneers. Within this context we refer to market pioneers as firms entering a new market first in line with Robinson and Fornell (2985, p.305).

II.1. First-mover advantages

The central argument within the discussion on first mover advantages is based on the concept of entry barriers (Bain, 1956). Shaw and Shaw (1984) argue in this respect that early entrants derive an advantage from the "learning" or "experience" curve as costs fall with cumulative output. Therefore, pioneers are able to generate a sustainable cost advantage, but only if this accumulated knowledge can be kept proprietary (Spence, 1981) e.g. via patenting (Gilbert and Newbery, 1982; Reinganum, 1983), and pioneers can thus continue establishing high market shares (Robinson and Fornell, 1985). But given the high workforce mobility, research publications, informal communications and especially reverse engineering, technological leadership is rather short-lived nowadays (Lieberman and Montgomery, 1988; Mansfield, 1985; Lieberman, 1982). Moreover, Lieberman and Montgomery (1988) argue that next to technological leadership, first mover advantages may arise from preemption of scarce assets such as buying natural resource deposits before market prices are driven up or from entering the market at the most attractive location including e.g. securing exclusive (local) supply channels. The strategic positioning either based on product or geographic space leads to the unprofitability of the remaining space for later entrants (cf. Prescott and Visscher, 1977; Schmalensee, 1978).

Considering also a consumer based line of reasoning, being first to the market certainly allows a firm to confront customers with their version of the new product. Thereby, pioneers gain recognition and reputation in the new market place, and profit from the fact that consumers tend to prefer buying pioneering brand products once they have proven their functionality (Lane and Wiggins, 1981; Schmalensee, 1982; Urban et al, 1986). On top of this brand loyalty pioneering products may emerge as the standard (Wernerfelt and Karnani, 1987), thus shaping consumer's perception of competing products and their features (Carpenter and Nakamoto (1989). Therefore, later entrants will have to attract customers away from the pioneering product, which is likely to entail high switching costs (Wernerfelt, 1985).

Besides the prominent empirical support by Agarwal (1997), and Agarwal and Gort (1996) for the existence of first mover advantages, studies by Biggadike (1976), Dillon et al (1979) and Shaw and Shaw (1984) confirm this phenomenon for 40 respectively 174 industrial goods as well as the Western Europe synthetic fiber industry. In all cases pioneering in the market was the main source of long-term success within a new market. The same live-prolonging effect of early entry holds for consumer goods industries as investigated for the prescription drug industry (Bond and Lean, 1977) and the cigarette market (Whitten, 1979). Moreover, Robinson and Fornell (1985) found that pioneers in consumer goods industries tend to have higher quality products, broader product lines and stronger distribution supports.

II.2. Pioneer burnout

But on the other hand there is also empirical evidence for exactly the opposite scenario, i.e. under specific circumstances delayed entry proofs to be more beneficial than pioneering initiatives (e.g. Lambkin and Day, 1989; Golder and Tellis, 1993). Especially Olleros (1986) draw the attention to the phenomenon of "pioneers' burnout" in emerging industries such as typewriters, transistors or the semiconductor industry. The two most striking reasons for pioneering disadvantages are in this context, first, the high development costs for a new product and the market, and second, the accompanied risk of not being rewarded for this high initial investment as later entrants imitate the product at lower costs and thus free ride on the pioneers efforts (Mansfield, Schwartz, and Wagner, 1981). Within this debate Wernerfelt and Karnani (1987) as well as Min et al (2006) argue that the nature of the product, its characteristics and the implied market uncertainty are the decisive factor of whether pioneers are superior to later entrants. In the case of incrementally new products, pioneers face a situation of established customer needs and technologies and are therefore confronted with a situation of comparably low risk and uncertainty. Combined with the possibility to benefit from continuously accumulating experience, pioneers should outperform later entrants. In case of radically new products in contrast, Lieberman and Montgomery (1988) point out that there are immense market uncertainties in terms of a proper technological solution as well as unknown or changing customer preferences. In particular, products that "shift market structures, represent new technologies, require consumer learning, and induce behavior changes" (Urban et al, 1996, p. 47) are confronted with slow adaption by consumers as they have to learn and accept the new technology, probably wait for a standard to emerge, and often rely on complementary hardware or software (Min et al, 2006). Given these uncertainties, pioneers are less likely to make sizable investments to achieve scale effects that ultimately lead to the presented size benefits (Kerin et al, 1992). Furthermore, later entrants can profit from the later on resolved technological uncertainties and thus build their success exactly on these early day technological discontinuities (Scherer, 1980). A last argument in favor of first mover disadvantages in radically new product markets stems from the population ecology literature, which argues that firms suffer from inertia, i.e. firms cannot change after the blueprint of the organization including the technological core competence has been established (Lieberman and Montgomery, 1988). But it could also be argued that first mover advantages should be extremely strong in the case of radically new products, as pioneers benefit from a temporary monopoly, the risk of imitation is lower, and the potential benefit from "branding" the new product with your brand name is high (Min et al, 2006). Empirical evidence on radically new products is scarce but later entrants outperformed early entrants in the case of the diagnostic imaging market (Mitchell, 1991) as well as for rigid disk drives (Christensen et al, 1998).

II.3. The role of pre-entry experience

Next to the mediating factor of the product's degree of newness Capon (1978), Schnaars (1986) and Biggadike (1976) develop the argument that the long-term success within a market is not only a question of the order of entry, but moreover also depends on firm-specific capabilities. According to their line of reasoning, entry at any point in time may lead to success, but entry at different stages of the product life cycle requires different capabilities. One famous example in this context is Du Pont which could enter as a late entrant into the Western Europe synthetic fiber industry as analyzed by Shaw and Shaw (1984). While all other later entrants withdrew from the market Du Pont could use its experience form the US market to establish a significant market share.

Additional empirical evidence for the influence of pre-entry experience on firm success was delivered by Klepper (2002) and Buenstorf (2007) for the US respectively German laser industry. In their population based investigation they showed that in both countries experienced entrants outperform less experienced competitors. In particular, they observed that diversifying firms as well as spin-offs proof to be longer-lived than de novo entrants without any prior experience. Dunne et al (1988) supports these findings and shows that de novo entrants are more frequent than diversifying entrants into the US manufacturing industry, but experienced firms outperformed their inexperienced competitors. Klepper and Simons (2000) as well as Thompson (2002) deliver additional empirical support for the relevance of pre-entry experience for the US television receiver industry and the early US shipbuilding market respectively. Within this discussion Helfat and Lieberman (2002) do not only differentiate between these different types of entrants but provide a comprehensive framework on the interrelation of different types of pre-entry experience/capabilities of each of these entrant types, the market they ultimately choose to enter, as well as the mode of entry, the timing and subsequent success. Within their framework of capabilities they argue that firms can accumulate various types of experience and thus establish different types of capabilities, i.e. specialized and generalized capabilities similar to Teece (1980). Specialized capabilities are highly bound to a particular setting and are thus of limited use in a different context such as another industry. Specific R&D activities, industry-specific or region-specific knowledge, customer relations, patents, and brand names clearly fall into this category. In contrast generalized capabilities are useful in a broader set of environments and are represented by general organizational capabilities such as managerial or financial skills, the ability to coordinate multiple business units within a firm, or the ability to enter a new market and refocus the business activities respectively to integrate products into the existing product portfolio. Especially the last aspect is of crucial importance as it represents the interaction of the firm and a changing market environment, e.g. in terms of technological discontinuities, and is therefore referred to as dynamic capabilities (Teece and Pisano, 1994). It represents a firm’s ability of timely responsiveness in terms of flexible product innovation as well as managerial competencies to appropriately adapt, integrate, and re-configure internal and organizational competences and resources.

Given all these theoretical and empirical considerations, the paper at hand conducts a population-based survival analysis for the German machine tool market between 1949 and 2002 and investigates the influence of order of entry and firm-specific pre-entry capabilities in the radically new product market for the industrial goods case of multifunctional machine tools.

III. Empirical setting

Today's machine tool industry is one of the smallest sectors within manufacturing contributing only about 2% of the national industrial production (Arnold, 2003), it's production equipment builds the technological foundation for the entire metalworking industry, and is thus of strategic importance in the industrialized world (Carlsson, 1989). Especially highly sophisticated industries such as automobiles, aircraft, military, and computers heavily rely on the machine tool industry (Ashburn, 1988). According to this diverse set of customers, the industry is marked by a high degree of product heterogeneity with respect to size, type, complexity and functionality (Sciberras and Payne, 1985). Furthermore, the industry is characterized by its high capital intensity, long reinvestment cycles (Arnold, 2003), and importance of international trade (Carlsson, 1989). Lastly, the industry consists first and foremost of small and medium-sized firms, which are not heavily engaged in formal R&D activities (Sciberras and Payne, 1985), but instead rely on a strong manufacturer-user relationship as the main source of innovation (Lee, 1996; Hirsch- Kreinsen, 2000).

Even though, the machine tool industry's roots date back until the end of the 18th century it continuous to be subject to endogenous technological change. Especially throughout the second half of the 20th century demand conditions changed all over the place. In particular, the industry experienced a clear trend towards a buyer's market with increasingly sophisticated customers asking for machines with stricter tolerance, higher precision and a high degree of automation (CEC Report, 1990). Among them the automobile industry as one of the major customers continuously enlarged its product portfolio and demanded increasingly flexible and versatile machine tools to produce a variety of models (Fleischer, 1997; Roy and McEvily, 2004). Additionally, small job shops were asking for increasingly adjustable machinery as their own development cycles shortened and the pressure to minimize time to market, massively reduce costs, and to increase flexibility of production processes came to the fore (Hirsch-Kreinsen, 2000). This request for advanced flexible manufacturing became an overarching issue in the general international customer base and thus called for innovations dealing with these changing requirements. The development of numerical controls and their computerized successors[1] served exactly this purpose and allowed, amongst other things, for the construction of multifunctional machinery and products such as machining centers, flexible manufacturing cells or even entire manufacturing systems[2]. These state of the art machining concepts integrate several single function-specific machines, e.g. for drilling, milling, and boring, thus rendering conventional standalone one function machines almost obsolete, technically speaking (Arnold, 2003). Despite the fact that the new machining concepts opened up a new product segment of metal processing tools within the machine tool industry, this innovation can be described as rather radical as the required capabilities to produce these integrated multifunctional machines strongly differ from the mechanical engineering tradition within the industry. In particular, whereas previously mechanical functions were designed around hardware constructions including fixtures, jigs and wires the new machining concepts were now built around electronic control equivalents (Wieandt, 1994). Thus, old accumulated technological capabilities, which guided the design and construction process of the predominately mechanical machine tools, were not necessarily useful in the new market segment. Furthermore, the accumulated knowledge with respect to the competitive landscape and industry setting remained only partly applicable after the technological change. The fusion of formerly independent submarkets of conventional single function standalone machines led to a new set of previously irrelevant competitors. On the other hand, new competencies, i.e. in electronics, were needed. To be more precise, the understanding of the electronic

[1] (Computerized) numerical controls operate the tools automatically with the help of computerized control tapes which contain pre-programmed sets of commands. All process relevant actions, such as machine feed and speed, selection of a particular tool, distance and direction are carried out automatically as opposed to a skilled worker continuously supervising the production processes. By changing the set of commands and thus the processing instructions an entirely different operation can be initiated (Arnold, 1997).

[2] A flexible manufacturing system (FMS) is defined as " a grouping of CNC machines (often including machining centers) which is fed by an automatic materials handling and transfer system meeting the needs to manufacture small and medium batches of a variety of products" (CEC Report, 1990, p. 53). Flexible manufacturing cells (FMC) and machining centers are also based on CNC technology, but contain fewer machines/tools than FMS.

components and their interrelation with the performance of the machine tool replaced the accrued competencies in almost pure mechanical engineering (Mazzoleni, 1997; Stöckmann, 1969). This competence–destroying effect turned the international machine tool industry upside down and reopened the market (Arnold, 2003; Guenther, 2009).

On the consumer side learning was required nearly to the same degree, as the previously manually guided work process was now replaced by software applications. In particular, instead of retooling a work process by physically changing the machine configuration and parameters, adjustments needed to be made via software reprogramming. Given these learning requirements on both sides, the technology underwent an evolutionary process itself with a major discontinuity at the beginning of the 1980s when the transition from numerically controlled machines towards computer integrated numerically controlled machines was implemented, and the full potential of the new technology could be realized. Moreover, as Europe's manufacturing landscape was reconstructed altogether after WW2, the rather long replacement cycles of 15 years (Arnold, 2003) did not allow smaller job shops for replacing their machines right away at the timing of the invention of multifunctional machine tools in the late 1960s (Fornahl und Guenther, 2008). Therefore, according to the definition of Urban et al. (1996) this market can be described as a radically new product market, even though demand for these products existed from the beginning.

Figure 1 represents the lifecycle of this new market segment between 1969 and 2002. Whereas during the first 15 years the number of producer increases only slowly but steadily, the pace of growth accelerates from 1985 onwards leading to a peak number of producers of 62 in 1991. In 2002 the number has dropped to 45.

Based on the theoretical framing of section II we investigate the order of entry as well as pre-entry experience in this radically new product segment. We expect first that industry-specific pre-knowledge in terms of technological expertise does not enhance survival chances within the new product segment of multifunctional machine tools. Second, within this radically new product type pioneers are expected to be outperformed by later entrants, who are, given their delayed entry timing, less confronted with market uncertainties. On top of that, the delayed replacement cycle is expected to foster this tendency. Moreover, we hypothesize that firms possessing a higher degree of general capabilities are more successful than less experienced firms as they, independent of the specific technological challenges, have already overcome their liability of newness. More specifically, we argue that firms which exhibit diversification and thus dynamic capabilities, have a higher likelihood of long-term survival within the new market as they already managed to reorganize their business activities and successfully integrated the production of additional products in their production processes and product portfolio.

IV. Empirical estimation strategy and Data

IV.1. Estimation strategy

This just portrayed scenery builds the basis for the upcoming analysis. We will use data on the entire firm population of machine tool companies between 1936 and 2002 in order to estimate the effect of different types of pre-entry experience respectively capabilities on the hazard of exit within the new state of the art product market as well as the overall industry. The analysis will be carried out in three steps. First, we estimate the influence of the timing of entry, age as well as being an industry internal and external entrant on the probability to exit the newly entered product market. In a second set of estimations we additionally decompose the age effect into four types of capabilities, namely general, organizational, industry-specific and dynamic capabilities, and again test for their individual effects on the survival rates. Moreover, we investigate the intensity of this new business activity with respect to the overall product portfolio and test for its effect on the risk of failure. In a last set of estimations we take a broader perspective and change the level of analysis from this one specific new product market to the entire machine tool industry. We pose the question whether long term survival within the machine tool industry is systematically influenced by entering the new product market, i.e. whether it is necessary to keep track with the technological progress and refocus business activities towards these newly emerging products in order to ensure a company’s long term success.

To analyze these three sets of estimations we apply the following simple proportional Cox hazard model (Cox, 1972):

$$h_i(t) = h_0(t)\, exp(\alpha_e + \alpha_r + \alpha_t + \beta_1 x_{i1} + \beta_2 x_{ik} + \cdot \cdot \cdot + \beta_k x_{ik}) \qquad (1)$$

with $h_i(t)$ being the hazard rate, i.e. the risk of failure, at time t of firm i conditional on a set of k firm-specific (time-varying) covariates $x_{i1}, \ldots, x_{ik}$. $h_0(t)$ represents an unspecified baseline hazard function and α_e , and α_r each represent a set of dummies specifying the entry cohort and the location of firm i further specified below. When estimating equation (1) we account for the fact that not all firms are closed down within the observation period, i.e. they do not experience a failure event and are thus right censored.

α_e is a set of dummies differentiating the group of entrants into the new product market according to their timing of entry as being either pioneers, early-followers or late entrants. These dummies allow for entry-cohort specific variation within the baseline hazard. Accordingly, we define α_r and α_t as region-specific and year specific fixed effects in order to account for varying baseline hazards within regions and individual years thus capturing all observed and unobserved location and year related effects i.e. due to agglomeration externalities or industry-specific time trends such as industry lifecycle and business cycles respectively.

The set of (time-varying) covariates includes firm-specific measures such as age, firm-size, industry-experience, and diversification-experience as well as the number of new products, and relative business intensity within the new product market.

Finally, from Model 10 onwards we additionally control for the specific type of new product a firm offers within the new market as well as the technology field a firm is active in apart from the new business activities, i.e. metal cutting, metal forming, or special purpose machinery. Thereby, we capture the remaining production-specific unobserved within-industry heterogeneity which results from the diverse set of customers being served, including the high degree of product heterogeneity with respect to size, type, complexity, and functionality of the various machine tools (Sciberras and Payne, 1985).

IV.2. Data

The dataset for the upcoming analysis was constructed on the basis of the buyer's guide *Wer baut Maschinen (Who makes machinery)* which has been issued annually since the 1930s by the *Verein Deutscher Maschinen- und Anlagenbau (VDMA; Association of*

German machine tool producers). This source allows us to identify the entire firm population of West German machine tool producers between 1949 and 2002, a total of 2,267 machine tool producers subject to the general definition of machine tools as being power-driven machines that are used to produce a given form of a work piece by cutting, forming, or shaping metal (Wieandt, 1994). Moreover, survival time of each individual firm can be traced as well as the composition of their annual product portfolio. Finally, extensive archival research was conducted to determine the respective year of foundation of the individual firms.

For the paper at hand, we extract the following information from these sources. First of all, we record the overall observed survival time for each firm being defined as the time span between the first and last year of observation. Given that the beginning of our observation period in 1949 is not identical to the starting point of the industry we are aware of the fact that firms might have existed before the observation period starts, and were thus already exposed to the risk of failure before we start the analysis. In order to account for this we either include the exact year of firm foundation or as of Model 10 onwards we use a dummy for "incumbency" of firms we already observed in the catalogues between 1936 and 1943 and the founding date is not known. Second, we collect the yearly product portfolio / business activities of each firm within the machine tool sector and thereby differentiate between innovators and non-innovators with respect to the new product market for multifunctional machine tools, and determine their respective years of entry and exit within this segment. Based on the entry years we define the following three entry cohorts for the new product market:

1) **Pioneers**: all firms entering the market for multifunctional machine tools within the first two years of the markets' existence, i.e. 1969 and 1970;[3]
2) **Early followers**: all firms entering the market between 1971 and 1985;
3) **Late entrants**: all firms entering the market after 1985.

[3] Within the empirical analysis we allow for multiple first entrants and extent this definition to the group of early entrants. This rather practical definition refrains from taking into consideration if the pioneering entrant actually *invented* the technology or product category and patented it; we are only interested in the firm(s) *offering/selling* a product within the new product category first (cf Golder and Tellis, 1993).

This specific division was chosen as market pioneers should be defined as entrants which are confronted with an entirely new market in the sense that they could not have learnt about the market opportunity, competitive scenery, specific customers or from the failure of earlier entrants. Given the rather long development cycles within the machine tool sector of 3-5 years this situation is surely present within the first two years. Early followers on the contrary could have witnessed the entry of the pioneers into the new market and have decided to enter the market as a reaction and developed their own product within this segment. Moreover, this entry cohort can either copy the original product or modify the pioneers' product and eliminate part of the witnessed shortcomings. Late entrants are defined as entrants joining the new product market in the late growth phase when firms start offering different product versions of the emerged standard.

As a third step we additionally compile four firm-specific pre-entry variables for the group of innovators in order to measure their starting conditions, i.e. their set of capabilities, before entering the new product market segment:

General capabilities:

a) **Age**: defined by the number of years between the year of foundation and the entry year;
b) **Size** before entry: approximated by the number of submarkets a firm is active in one year before it enters the new product market (Klepper and Thompson, 2006);
c) **Dynamic capabilities**: whether or not a firm has previously diversified into another machine tool product market between 1949 and the year of entry into the new market segment under investigation.

Specific capabilities:

d) **Industry experience**: defined by the number of years a firm has been active in the machine tool industry between 1936 and the year of entry into the new product market;

V. Analysis: Survival in the new product market and on the industry level

V.1. Survival in the new product market

The initial set of models in Table 1 investigates all 130 identified entrants in the new product market with respect to the different hazards to exit (only within this new field of business activities) based on the timing of entry and three additional firm-specific background variables. Starting with the question whether the timing of entry influences survival patterns within this market we differentiate between three entry-cohorts, namely pioneers (1969-1970), early followers (1971- 985), and late entrants (after 1985). Thus, as a first step Model 1 shows the estimation results examining only the influence of entry timing on the hazard to exit with late entrants serving as the reference group.

INSERT TABLE 1 HERE

Within **Model 1** and all following models we control for region specific fixed effects in order to capture the unobserved initial heterogeneity with respect to the entrants' location. On top of that, year specific fixed effects account for industry specific time trends such as the industry lifecycle or business cycles. The coefficient estimates in Model 1 show that pioneers have a significantly higher hazard to exit as compared to late entrants whereas early followers are not statistically distinguishable form the reference group with respect to their survival chances. Given the empirical setting, this result can be explained by the fact that first of all, the new market segment represents a radical innovation. Secondly, early entrants might have been unable to establish high market shares as demand was rather low in the beginning as machinery equipment has just been renewed during the 1950s and 1960s and therefore replacement cycles were rather unfavorable during the early 1970s. Thus, even though pioneers have identified the technological window of opportunity this was not accompanied by a prosperous market opportunity. Third, given the technological discontinuities within the new product segment itself, producers entering the market in the early 1980s could benefit from the transition of numerically controlled to computer numerically controlled multifunctional machine tools.

In **Model 2** we additionally control for a first firm-specific background variable dubbed "traditionals", indicating whether the entrant has been traditionally active within the machine tool industry in general before entering the new product market under investigation. This dummy gives a first impression of whether industry or technology specific knowledge affects the survival chances of firms within the new market. The results show that the group of 103 traditional machine tool producers does not outperform entrants without any prior machine tool experience. As in Model 1 only the timing of entry influences the hazard to exit and favors the group of early followers as well as late entrants. These first results support the conjecture that in radically new product markets pioneers do not necessarily benefit from their head start. Moreover, the technological pre-knowledge of traditional machine tool builders does not lead to a significant competitive advantage.

Model 3 introduces the age of the entrant as a second firm-specific background measure, with age being defined as years that a company existed before entering the new market. Estimation results show that the older the entrant before entering the new market, the lower the hazard to exit. Moreover, now as we control for age, the group of early followers has a statistically significant higher risk of failure than late entrants, while pioneers remain having the lowest survival chances in the new market.

In **Model 4** we additionally control for the number of products each of the entrants offers within the new market over time. The estimated coefficient turns out to be negative, thus lowering the hazard of exit the more products a firm offers within the new market, but this effect is statistically insignificant. In an unreported model we also tested whether it makes a difference which of the new products is offered, but similar to the number of products we did not find any significant difference between the individual products.

V.2. Survival in the new product market of traditional machine tool builders

The second set of models in Table 2 gets involved into a more detailed analysis of the different types of capabilities which influence the survival rate of companies entering the new product market. Within Model 5 to Model 11 only the group of 103 traditional machine tool builders is investigated as data limitations do not allow for analyzing any type of pre-experience of the 27 external entrants except for age. Again we control for region and year specific fixed effects and take the group of late entrants as our reference group in the estimation.

INSERT TABLE 2 HERE

Model 5 replicates Model 1 for the subset of entrants consisting of only traditional machine tool builders, and confirms that pioneers exhibit the highest failure rate as compared to both types of later entrants. Within **Model 6** we start testing for the effect of the various types of capabilities which entrants posses one year before offering a machine tool within the new product market. Similar to Model 3 the influence of age is estimated as it is used in previous studies to capture the effect of any type of experience a company gained throughout its lifetime. Also for the subset of entering traditional machine tool builders a risk decreasing effect of an additional year of existence can be confirmed as well as a lower hazard rate attributed to the early follower and late entry cohort.

The subsequent models 7-9 are devoted to decomposing the "one catches all" experience measure age and to differentiate further between various qualities of experience a company makes throughout its lifetime, i.e. to isolate the influence of general, organization and coordination related capabilities from industry-specific capabilities as explained in section II.

In **Model 7** we therefore add a measure for firm size in order to tell apart the influence of general capabilities captured by age and the effect assigned to organizational and management related capabilities on the risk of failure.[4] The estimation coefficients reveal that the firm size at the time of entry does not significantly lower the hazard to exit while leaving the effects of timing of entry as well as for age unchanged. Thus, a company's capability to coordinate more business activities within the machine tool sector than a specialized competitor does not increase its survival chance when entering the new product market in question.

[4] Similar to Klepper and Thompson (2006) we only observe firm activities within the industry under investigation, in this case machine tools. If a firm is active in other (probably related) industries, we do not account for this part of the product portfolio. But as this industry is marked by small and medium-sized specialized companies we assume that our measure includes their main business activities.

The influence of technological expertise, industry-relevant knowledge as well as existing customer relationships within the machine tool industry is now examined in **Model 8**. This set of specific capabilities is approximated by the years of experience within the machine tool sector before entering the new product market. Similar to the results of Model 2 where we did not find any advantage for traditional machine tool producers over external entrants, there is no significant influence to be observed for companies that have additional years of experience within the machine tool industry before entering the new product segment as it was expected in this radically new product market.

Finally, **Model 9** investigates the question whether entrants that have already managed to diversify into a new product market within the machine tool industry before entering the submarket under investigation, systematically outperform competitors which do not have successfully diversified into a new submarket previously. This diversification experience is accounted for by a dummy variable separating experienced from non-experienced entrants. This type of experience is used as a proxy for dynamic capabilities, as the introduction of a new product requires a firm to be able to recognize and analyze the market beyond its own current business activities, develop a new technological solution and to introduce it to the market. Thus, the firm adapts to the competitive environment and redirects and broadens current business activities including changes within the production and organization of the new product portfolio. The estimation reveals that having already managed to diversify into another product market within the machine tool industry at least once significantly lowers the hazard to exit within the present new market segment. In addition we estimated an unreported model including the rate of failure of these diversification endeavors, i.e. in how many of these previously entered new product segments the respective firm is still active in, but this variable turned out to be insignificant.

Model 10 and 11 dwell a little deeper into the actual business activities within the new market and its relation to the rest of the companies' product portfolio. More specifically, Model 10 includes the number of products a company offers within the new market over time, and controls for the different versions of the new product. In **Model 11** we additionally test whether companies that strongly refocus their business activities towards the new product market over time have a disadvantage as compared to companies with a more diversified product portfolio. This business intensity within the new segment is simply measured by the share of products within the new product market within the entire product portfolio over time. Whereas the actual number of products does not lead to significant differences in survival chances of entrants, the stronger the focus / specialization on this new market the higher the risk of failure.

Consistent with our prior models survival chances increase the later a company enters the market. Moreover, the decomposition of the one catches all capability variable age reveals that the risk of failure in the radically new product market under investigation is only significantly influenced by a firm's dynamic capability to coordinate the integration of additional business activities into the current product portfolio. Industry-specific capabilities as well as general abilities in terms of age and size do not lead to a lower hazard of exit. Moreover, in line with the simple risk-spreading argument, we find that a narrow focus on the new business activities substantially increases the probability to exit the new market.

V.3. Survival on the industry level: entrants versus non-entrants

Model 11 already dealt with the question of how the new product market relates to the rest of the companies business activities within the machine tool industry, but has so far only been looked upon with respect to firms that actually enter the new product market. The question now arises whether a company necessarily has to enter this state of the art submarket in order to ensure overall long-term survival within the machine tool sector. Therefore, we estimated a last set of models in Table 3 comparing first of all the overall hazard of exit of firms entering the new market with machine tool producers which do not enter.

INSERT TABLE 3 HERE

Model 12 shows that firms entering the new product market ("inventor") have a significantly lower hazard of exit as compared to the reference group of not entering firms. Moreover, we find that experienced firms, i.e. incumbents, outperform newly founded firms as well as larger firms exhibiting higher survival rates than smaller competitors. In a second step, **Model 13**, we again differentiate between the three entry-cohorts as in the previous models. As not all founding dates are known, we cannot use the exact firm age within these estimations. Instead, we split the population into incumbents, i.e. companies which were observed already before 1949, and newly founded firms after 1949. Thus, we are restricted to the use of a very broad measure of capabilities for these two estimations. Size is again approximated by the number of submarkets a company is active in. Moreover, we control for the technological field of activity of each firm, distinguishing producers of metal cutting or forming machine tools as well as machine tools for special purpose machinery in order to capture effects related to the overall technology life cycles within these groups of producers. Region and year specific fixed effects are again included in the estimations.

The closer look at the different entry-cohorts in Model 13 shows that not all entrants into the state of the art product market demonstrate superior survival rates as compared to non-entrants. Only early-followers as well as late entrants display a lower risk of failure; pioneering entrants are statistically not distinguishable in their survival patterns from companies that did not enter the new product segment in their overall survival pattern. Thus, it is not per se beneficial to enter this market for state of the art products as the pioneers' disadvantage lowers the survival rate to the level of non-entering firms. But this also implies that the group of pioneers is not worse off by entering the new market as compared to their non-entering competitors. Further investigations should concentrate on comparing the characteristics of the different entry cohorts as well as non-entering firms. Thereby possible systematic differences between these individual groups can be detected which influence their survival, e.g. whether a certain type of firms tends to pioneer in the new market while another type of firms, e.g. larger and older firms are more likely to belong to the group of early followers.

VI. Conclusion

The question of which factors influence the success of firms entering a new market has been subject to extensive research within management and economics studies. In this context theoretical as well as empirical studies deliver ambiguous results in terms of finding support for either the existence of a first mover advantage or the phenomenon of pioneers' burnout where later entrants outperform early movers. Despite these results, three important factors have been identified that influence the likelihood of firm success within newly emerging markets. Besides the order of entry product characteristics, i.e. whether the new product market represents an incremental or radically new innovation, as well as firm-specific capabilities in terms of different types of pre-entry experience affect individual firms' survival chance. The paper at hand contributes to the empirical literature by conducting a population-based survival analysis for the German machine tool industry by analyzing hazard rates of different entry cohorts in the radically new market for multifunctional machine tools incorporating the effect of specific and generalized capabilities. The Cox estimations show that general capabilities lower the risk of failure whereas as specific technological pre-experience does not affect the likelihood of long-term success within the new product segment. It turns out that when decomposing the set of general capabilities it is no longer the pure fact of being older and larger that lowers a firm's risk of failure, but it is particularly the experience of having managed to integrate a new business activity into the product portfolio, and thus dynamic capabilities, that increase survival chances in the market under investigation. Moreover, we find that later entrants benefit from technological discontinuities within the new market as well as a delayed replacement cycle within the industry and are thus able to outperform pioneering entrants. Future research on this as well as other empirical settings should concentrate on overcoming current limitations of the analysis. For the case at hand, it is so far unexplored whether the group of entrants systematically differs from those machine tool companies that did not decide to enter the newly emerging market. Whereas this potential selection bias could be overcome as all potential entrants from within the machine tool industry are known, there is no way of analyzing the entire set of potential entrants outside of the machine tool industry without establishing long-term population based datasets for other industries as well. For the time being the presented study on industrial goods nonetheless delivers a valuable empirical contribution and highlights the fact that first mover advantages can be overruled by experienced late comers who enter a new market after technological discontinuities were largely solved and customers were willing and able to replace their older equipment.

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Appendix:

Figure 1: Number of machine tool producers in the new submarket for multifunctional machine tools, 1969-2002.

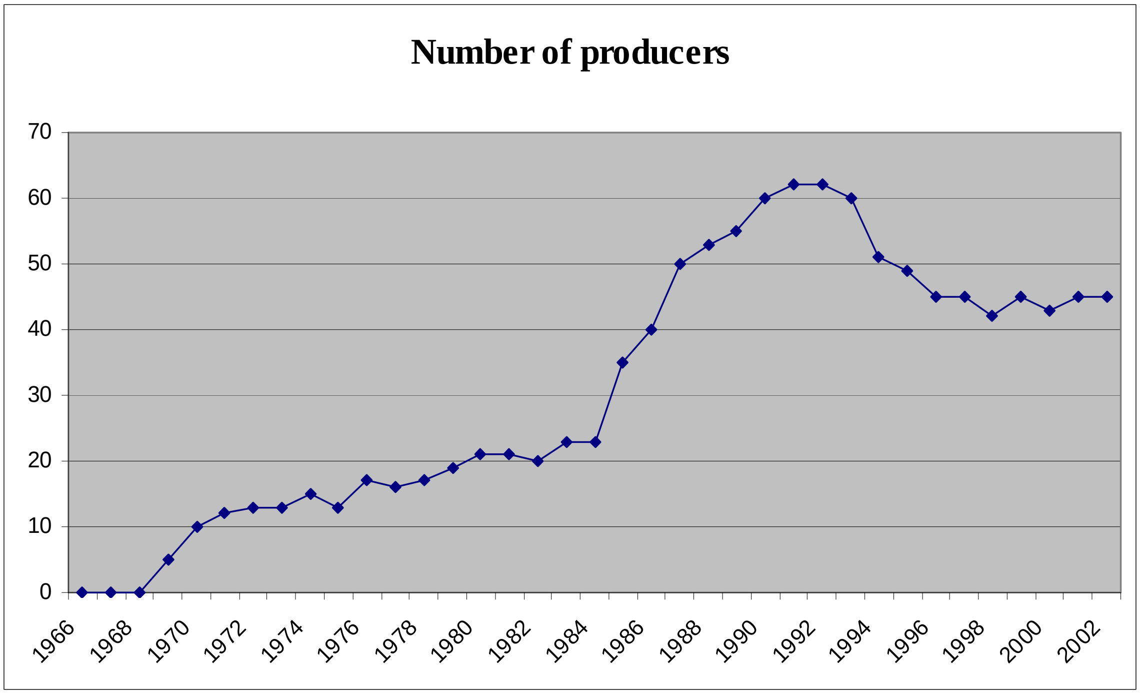

Table 1: Exit hazards for all entrants into the new product market

	Model 1	Model 2	Model 3	Model 4
Pioneers	1.916**	1.938**	2.059**	2.099**
	(.862)	(.858)	(.837)	(.835)
Early_followers	.904	.913	1.40*	1.036*
	(.581)	(.580)	(.538)	(.535)
Traditionals		-.213	.192	.220
		(.495)	(.564)	(.562)
Age			-.012**	-.011**
			(.006)	(.006)
# products				-.253
				(.243)
Region dummy	yes	yes	yes	yes
Year dummy	yes	yes	yes	yes
Observations	1270	1270	1270	1270
Subjects	130	130	130	130
Failures	83	83	83	83
Log-likelihood	-284.359	-284.244	-281.03	-280.420
Prob>chi2	.000	.000	.000	.000

Note: Robust standard errors (adjusted for clustering by firm) in parentheses;
*** p ≤ .01; ** p ≤ .05; * p ≤ .10

Table 2: Exit hazards for traditional machine tool companies in the new product market

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
Pioneers	2.291**	2.419**	2.646**	2.647**	2.800**	2.934**	3.014**
	(1.049)	(1.028)	(1.080)	(1.082)	(1.124)	(1.150)	(1.216)
Early_followers	1.076	1.289*	1.422*	1.418*	1.527**	1.417*	1.534*
	(.746)	(.701)	(.776)	(.781)	(.764)	(.848)	(.819)
Age		-.011*	-.010*	-.010	-.011*	-.009	-.009
		(.007)	(.006)	(.006)	(.006)	(.006)	(.006)
Size			-.0532	-.050	-.027	-.027	-.008
			(.065)	(.066)	(.063)	(.072)	(.067)
Industry_exp				-.006	.019	.018	.014
				(.021)	(.023)	(.022)	(.023)
Diversi_exp					-1.168*	-1.271*	-1.268*
					(.686)	(.689)	(.681)
# products						.547	.382
						(.461)	(.512)
intensity							2.659***
							(.991)
Prod dummy	no	no	no	no	no	yes	yes
Region dummy	yes	yes	yes	yes	yes	yes	yes
Year dummy	yes	yes	yes	yes	yes	yes	yes
Observations	1102	1102	1102	1102	1102	1102	1102
Subjects	103	103	103	103	103	103	103
Failures	68	68	68	68	68	68	68
Log-likelihood	-201.149	-198.811	-198.036	-197.973	-196.542	-193.502	-190.254
Prob>chi2	.000	.000	.000	.000	.000	.000	.000

Note: Robust standard errors (adjusted for clustering by firm) in parentheses;
*** $p \leq .01$; ** $p \leq .05$; * $p \leq .10$

Table 3: Exit hazards for all machine tool producers aggregated on industry level

	Model 12	Model 13
inventor	-.887***	
	(.123)	
Inv_pioneer		-.167
		(.200)
Inv_early_follower		-.560***
		(.162)
inv_late_entry		-1.219***
		(.187)
incumbent	-.564***	-.569***
	(.060)	(.060)
size	.-143***	-.145***
	(.018)	(.018)
Technolgie dummy	yes	yes
Region dummy	yes	yes
Year dummy	yes	yes
Observations	35505	35505
Subjects	2267	2267
Failures	1896	1896
Log-likelihood	-12550.975	-12546.319
Prob>chi2	.000	.000

Note: Robust standard errors (adjusted for clustering by firm) in parentheses;
*** $p \leq .01$; ** $p \leq .05$; * $p \leq .10$