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Enter at own risk: Technological discontinuities, endogenous entry timing and firm performance

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Abstract

We study how entry timing and different types of pre-entry experience are interrelated and thus jointly affect post-entry exit hazards along the industry life cycle. Using the historical case of the German farm tractor industry we show that the entry timing of entrants reflects the fit between their capabilities and the prevailing industry requirements. Applying a propensity score matching approach in discrete-time hazard models, we demonstrate that statistical associations of entry timing and firm performance are sensitive to (not) controlling for the endogeneity of entry timing. We moreover find that the competitive relevance of specific types of pre-entry experience changed over time.

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Keywords: Industry evolution, firm capabilities, submarket dynamics, endogenous entry, technological discontinuities

Introduction

The literature on industry evolution has established two major empirical findings that help explain the success of individual firms. First, in many industries differences in firm survival are systematically related to the time of entry into the industry. More specifically, early entrants into an industry frequently face higher survival prospects than later entrants (Suarez and Utterback, 1995; Agarwal, 1997; Klepper, 2002; Peltoniemi, 2011 for a review), even though these first-mover advantages may be muted depending on the speed of market evolution as well as technology development (Robinson, Fornell, and Sullivan, 1992; Suarez and Lanzolla, 2007). Second, pre-entry experience, especially in related industries, increases the survival chances of diversifying entrants as compared to *de novo* entrants (Mitchell, 1991; Agarwal and Gort, 1996; Klepper and Simons, 2000). Apparently, diversifying firms can transfer at least part of their previously developed capabilities to the new industry setting (Chatterjee and Wernerfelt, 1991; Farjoun, 1994; Tanriverdi and Venkataraman, 2005).

The relationship between both these empirical regularities is not well understood. However, particularly for diversifying entrants, the timing of entry into a new industry is not exogenous but should rather be seen as a strategic decision variable. This has relevant implications for the interpretation of empirical patterns in industry evolution. On the one hand, observing advantages of early entry may reflect that superior firms entered first. On the other hand, potential diversifiers may deliberately postpone entry until competence requirements in the new industry change such that they better match their own resource and capability endowments. If these considerations are empirically relevant, cohort differences in firm survival (Klepper, 2002) may simply reflect the changing composition of the population of entrants in terms of capabilities and how well these match the competence requirements prevailing in the industry at any given time.

The present paper aims to help provide a better understanding of how entry timing and different types of pre-entry experience are interrelated and thereby jointly influence post-entry performance in industry evolution. We build on the seminal theoretical work of Helfat and Liebermann (2002) and argue that over the course of industry evolution different capabilities are required to enter the market successfully. Consequently, the decision to enter an industry at a specific point in time relies on the *matching* of the entrant's set of capabilities and the prevailing market requirements, and so does their subsequent performance. This relation becomes apparent especially in times of disruptive technological change (Tushman and Anderson, 1986; Sosa, 2013), or during the emergence of new submarkets when we observe new (types of) entrants joining the market while incumbents are leaving.

Even though prior contributions have emphasized the endogeneity of entry timing (Helfat and Lieberman, 2002; Boulding and Christen, 2003; Lee, 2008), it is frequently neglected in the empirical work on industry evolution. In addition, the available evidence is inconclusive. Bayus and Agarwal (2007) find that entrants with specific types of backgrounds had survival advantages in the US personal computer industry, which however diminished for later entrants. Even though this is not in the main focus of the paper, their empirical findings (ibid, Table 6) indicate that more capable firms indeed tended to enter earlier. Franco *et al.* (2009) investigate the relationship between technological capabilities, market pioneering and firm survival in the context of the disk drive industry. They find that technological capabilities enhanced the odds of survival of market pioneers, but reject the possibility that differences in entry timing were driven by differences in capabilities on the basis of Granger causality tests.

To explore the relation between entry timing, pre-entry experience and firm performance further, in this paper we analyze a unique dataset tracing the long-term evolution of the German farm tractor industry (1896–2006). We first show that the emergence of a new tractor submarket after 1927 induced a new wave of entry, which was predominately composed of diversifying firms with suitable backgrounds to succeed in the newly emerging submarket. Using a propensity score matching approach in discrete-time hazard models, we then show that statistical associations for entry timing and firm performance are sensitive to (not) controlling for the endogeneity of entry timing. We moreover find that the competitive relevance of specific types of pre-entry experience changed over time. This allowed the post-1927 entrants to take over industry leadership from the early entrants.

The remainder of the paper is organized as follows. Section 2 provides the theoretical background and develops testable hypotheses for the empirical analysis. In Section 3 we provide an overview of our empirical setting, the German farm tractor industry. Data and empirical methods are introduced in Section 4. Section 5 presents the results of the empirical analysis, and Section 6 concludes.

Theoretical considerations

First-mover advantage, product heterogeneity and industry evolution

Early entrants into an industry have frequently been suggested to benefit from advantages over their later entering competitors (cf., e.g., Agarwal and Gort, 1996; Agarwal, 1997, for empirical evidence). In general terms, first-mover advantages of early entrants may derive from their head start on the learning curve. More precisely, being able to start the accumulation of industry- and product-relevant knowledge early on may help entrants reduce their costs, increase their higher market shares and thus attain higher performance and longevity (Liebermann and Montgomery, 1988; Jovanovic and MacDonald, 1994; Klepper, 1996). However, industry leadership is often evasive. Given a highly mobile workforce, research publications and reverse engineering, accumulated knowledge can often not be retained proprietary (Mansfield, 1985; Liebermann and Montgomery, 1988). Later entrants may then be able to free-ride on the initial investment by market pioneers (Mansfield, Schwartz, and Wagner, 1981). In line with these considerations, the managerial relevance of first- mover advantages has been challenged by studies investigating the conditions under which this allegedly universal pattern is not observed (Suarez and Lanzolla, 2007). Olleros (1986; see also Lambkin and Day 1989; Christensen, 1993) was among the first scholars to highlight that latecomers outperformed early entrants in industries such as typewriters, transistors, semiconductors or disk drives.

According to Wernerfelt and Karnani (1987) as well as Min, Kalwani, and Robinson (2006), whether or not early entrants will end up dominating a market strongly depends on product characteristics and market uncertainty. Tushman and Anderson (1986) argue that technologies undergo phases of incremental change but may also experience technological discontinuities. Incremental change leads to cumulative efficiency gains and performance increases, e.g. around a dominant design. In contrast, technological discontinuities are non-cumulative in nature. They mark breakthrough advancements over the prevailing technology that cannot be realized by gradual step-by-step improvements.

Discontinuities may take the form of newly introduced alternatives to the existing product or consist of major process-related advancements. They can either be *competence-destroying* or *competence-enhancing* for the existing producers. If the new product, submarket or process requires knowledge and capabilities which are different from those previously developed, then discontinuities are competence-destroying. In this case, former industry leaders with dedicated technology-specific expertise are likely to lose their market dominance to new innovative market entrants. At a minimum, industry experience does not provide competitive advantages to incumbents vis-à-vis new entrants, as knowledge accumulated before the competence-destroying discontinuity can no longer be leveraged. In contrast, competence-enhancing discontinuities build on incumbents' existing expertise. They are therefore not likely to result in a significant shift of power away from established firms, but will instead reinforce their advantages, in line with the first-generation models of industry evolution (Jovanovic and MacDonald, 1994; Klepper, 1996).

Heterogeneous entrants, endogenous timing of entry and firm performance

The above discussion indicates that first mover advantages are not a universal phenomenon, as pioneering firms may be outperformed by later entering competitors in the case of competence-destroying discontinuities introducing new heterogeneity into product designs. While changes in the degree of product heterogeneity were highlighted, we have so far abstracted from the heterogeneity of entrants. However, a sizable prior literature suggests that entrants differ in terms of their pre-entry experience and thus the resources and capabilities they bring to the newly entered market. Having access to a larger or better resource and capability base allows for the generation of a competitive advantage and is thus related to higher performance (Barney, 1991), with substantial repercussions on industry evolution.

It has moreover been suggested that pre-entry experience influences when firms enter into a new industry (Helfat and Lieberman, 2002; Lee, 2008). Before entering a new industry, firms form expectations about the future development of the targeted market, and about how far their resources and capabilities are useful with respect to the predicted development path. Thus, the decision to enter an industry or a newly emerging submarket at a specific point in time relates both to individual capability constellations and market conditions and how well they match at that particular point in time. As a consequence, when new product segments change the market conditions prevailing in an existing industry, this may trigger entry of experienced firms that re-evaluated the match of their own resource and capability base with industry requirements and thus decide to enter.

In this view, entry decisions are not one-time decisions but rather represent a continuous evaluation process by the potential entrant. They are thus endogenous to the eventually entering firm and its resources, as well as to the development of the respective market. At the same time, firms that once entered the market under the original conditions may no longer be best equipped to meet the challenges of the changed competitive environment e.g. after a competence-destroying disruption. They may therefore be forced to exit despite their previous first-mover advantage.

In this context, Helfat and Lieberman (2002) argue that the success of entry mainly depends on the type of pre-entry resources and capabilities the entrant possesses, and whether or not these capabilities match the requirements of the industry at the time of entry. The crucial element in their reasoning is that markets undergo various evolutionary stages attracting different types of firms, such as diversifiers or spin-offs, which enter the industry at different points in time. In particular the emergence of new customer segments or product niches gives rise to new waves of entry, which may be successful even vis-à-vis the competition of earlier entrants.

Diversifying entrants from related industries have often been found to be more successful and long-lived than start-up companies (e.g., Mitchell, 1991; Klepper and Simons, 2000; Klepper, 2002; Buenstorf, 2007). Helfat and Liebermann (2002) explain this pattern in terms of a larger resource and capability base possessed by diversifying entrants. This is not limited to financial resources, but particularly concerns technological knowledge and experience related to customer needs (Helfat and Raubitschek, 2000). As Teece (1980, 1982) has pointed out, firms tend to acquire resources and capabilities that are context specific and therefore can only be usefully deployed in a very limited set of environments, such as comparable industry conditions or regional specificities (Helfat and Lieberman, 2002). However, a large share of firms' capabilities is transferable to other markets. Some capabilities such as organizational resources and managerial knowledge are general in nature; their usefulness is largely independent of the specific market the firm is active in. Others such as marketing, sales and distribution experience, can often be leveraged when entering related markets.

In addition to diversifiers, *de novo* firms organized as spin-offs by employees leaving industry incumbents have also been identified as highly successful entrants in a variety of industry contexts. In the disk drive and other industries, spin-offs on average outperformed other de novo entrants, with spin-off performance directly related to parent firm performance (Agarwal *et al.*, 2004; Franco and Filson, 2006; see also Klepper, 2009, for a survey). While diversifiers are often prominent among the early entrants into a new industry, in various industries successful late entry primarily reflects spin-off activities. This is not surprising since spin-off founders draw on their intimate industry-related knowledge, most importantly knowledge related to markets and customer needs (cf., e.g., Chatterji, 2009, for the medical devices industry). Accumulating this knowledge obviously requires that prospective spin-off founders have time to work in the respective industry.

Following Helfat and Liebermann (2002; see also Silverman, 1999; Miller, 2004), we expect firms' entry decisions to be endogenous, being driven by entrants' expectations at any given time of how well their resources and capabilities match the requirements of the industry. In more detail, we refer to the concept of time-varying capability relevance developed by Lee (2008). In this approach, the classical resource-based view is refined. A firm's resource bundle hence reflects its ability to produce and sell a product successfully in a market at a certain point in time. As a consequence, firms which sense higher capability relevance are more likely to enter into a market.

Based on the above considerations, we expect that changes over time in the composition of entrants reflect changing prospects faced by individual types of entrants. Potential entrants will try to actually enter when conditions are best suited for them. In particular, strategic timing of entry will be a relevant issue for *de alio* entrants pondering diversification from related industries. Newly emerging submarkets may then induce a new wave of entry by firms possessing the required capabilities to serve these submarkets. This leads us to predict:

H1: Pre-existing (de alio) entrants into an industry (e.g., diversifiers from related industries) tend to enter when their resources and capabilities best match the requirements in the industry.

Endogeneity of entry timing as suggested by Hypothesis 1 can have profound but rarely explored implications for analyses of firm performance (Boulding and Christen, 2003; Peltoniemi, 2011). In general, performance differences between groups of firms that entered an industry at different points in time tend to be interpreted as being causally related to the timing of entry. As emerged from the above discussion, first-mover advantages have attracted most interest in the prior literature. They have mostly been attributed to learning effects. However, if decisions when to enter an industry are endogenous, then first-mover advantages, or more generally cohort effects on performance, need not be *caused* by the timing of entry. They may also reflect inherent differences in resources / capabilities of the various cohorts of entrants (and how well they match the requirements in the industry at that time). Empirically controlling for the endogeneity of entry timing should then reduce the observable cohort effects on performance. These considerations inform our second hypothesis:

H2a: Observable performance differences between cohorts of entrants reflect endogenous timing of entry.

H2b: Controlling for endogenous timing of entry reduces the statistical association between entry time and firm performance.

While Hypotheses 1 and 2 focus on the timing of entry and its association with firm performance, our final hypothesis addresses pre-entry experience as a foundation of entrants' resources and capabilities and therefore as a driver of firm performance. We generally expect that entrants' resources and capabilities predict their performance in the industry. In industries faced with the emergence of new submarkets and competence-destroying discontinuities, the competitive relevance of individual resources and capabilities is likely to vary over time. Again following Helfat and Liebermann (2002), we moreover predict that more general capabilities such as organizational procedures, which develop as firms mature and whose usefulness is not limited to a specific industry, have a systematic effect on firm performance. In addition, experience accumulated in related markets is expected to be important for entrants' ability to make correct inferences about the industry's future development and their own odds of survival. These conjectures are in line with Buenstorf's (2008) earlier findings for the U.S. farm tractor industry where diversifiers, especially those with a background in agricultural implements, outperformed *de novo* entrants. Notably, this included diversifiers such as John Deere, a plow maker, whose prior products were technologically much less sophisticated than tractors. Based on this prior evidence, we expect technological expertise to be of lesser relevance as compared to organizational and market-related capabilities. We therefore hypothesize:

H3a: Entrants whose resources and capabilities best match the requirements of the market at any given time tend to outperform other entrants.

H3b: Organizational and market-related capabilities are more relevant than technological capabilities as a determinant of firm performance.

Empirical context: technological discontinuities in the German farm tractor industry[1]

Farm tractors – defined here as agricultural traction machines powered by an internal combustion engine – were first invented in the U.S. (in 1889). They triggered an extraordinary growth in agricultural productivity in the 20th century (Olmstead and Rhode 2000). The German farm tractor industry was launched 1896 by Adolf Altman with his prototypic 'Trakteur'. In the first decades, the industry was dominated by single-purpose motor plows.[2] Their usefulness was limited to large croplands, which were concentrated in northern and eastern Germany. In contrast, early farm tractors were not profitable for small scale farmers in southern Germany.

Demand for the German tractor industry noticeably increased after the end of World War I in 1918. Because of the war, there was a serious shortage of food, as well as a pronounced shortage of labor and draft horses leading to an increased demand for mechanical power in agriculture. This promoted entry into the market, giving rise to a first peak in firm population size in 1920 with 48 active producers (Figure 1). Subsequently, firm numbers fell again to reach a low of 16 in 1932.

[1] This section heavily draws on the historical accounts by Bach (1999), Bauer (1987, 1995), Gebhard (1988, 2006) and Rödiger (1990).

[2] A motor plow is a plow carried by two or three wheels and powered by an internal combustion engine.

Insert Figure 1 about here

The motor plow farm tractor design became extinct around 1928 when the multipurpose farm design had been established through a series of innovations. One of them was the use of Diesel engines for farm tractors pioneered by Benz-Sendling in 1922. In addition, several technological achievements from the U.S. were adopted by German producers at this time, for instance block construction (in 1923) and assembly line production (in 1924). However, the decisive innovations contributing to the emergence of a new submarket through the multipurpose farm tractor design in the late 1920s were the standardized power takeoff and the balloon tire, both of which were also taken over from U.S. producers. The standardized power takeoff was first used by German producers around 1927 and was well-established by the mid-1930s. It allowed tractors to be used as a versatile source of mechanical energy in a variety of farm applications, which was decisive to make farm tractors attractive to the small-scale farmers of Southern Germany. Balloon tires were introduced in the late 1920s in the U.S. farm tractor market. In Germany, the first serial production of farm tractor balloon tires was started by Continental in 1934.

As the standardized power takeoff had been developed in the U.S., no particular technological expertise was required to introduce it in Germany. The other key components of the emerging multipurpose tractor design were likewise borrowed from other industries (as the Diesel engine) and/or from the U.S. market (assembly line production, block construction, balloon tire). The multipurpose tractor design can thus be interpreted as a competence-destroying discontinuity reducing the competitive relevance of technological competences as well as market knowledge accumulated in the northern market. It was in-depth knowledge about agricultural procedures and customer needs in the South that was needed to perceive and exploit market opportunities there. This knowledge was mostly possessed by producers located in the South, in particular diversifiers with intimate experience in other agricultural markets.

Following this series of innovations, a boom in the German farm tractor market occurred around 1935, which was fueled by strongly increased demand from small farmers, especially in southern Germany. This new demand was primarily served by local producers designing and marketing small multipurpose farm tractors. Many of them were newly entering the industry at this time. Hence, a surge of entry into the industry took place from 1935 that strongly raised the number of producers in the market up to 37 in 1939.

The Nazi regime and the ensuing World War II brought drastic changes for German farm tractor producers. In 1939 the ‘Schell Plan’ enacted by the Nazi government orchestrated a consolidation of the German farm tractor industry. To free resources for weapons production, the number of tractor types was cut by two thirds, forcing many producers to exit between 1939 and 1945 (Bauer, 1987; 1995). After the war, the large croplands of eastern Germany were no longer available to feed the western population, and large areas of pasture land in southern and western Germany were now transformed into cropland. At the same time, large parts of the German infrastructure were destroyed and the allied forces imposed severe restrictions on manufacturing. In this market context of high demand for agricultural machinery and limitations in other product markets, many producers newly entered the (West) German farm tractor market. Another surge of entry from 1946 to 1950 ensued, leading to a third peak in firm numbers with a total of 67 active producers in 1951.

At the beginning of the 1960s, many German producers withdrew from the farm tractor market. Exit was triggered by various developments. First, markets were saturated, as even smaller German farms were usually equipped with farm tractors at this time. Second, foreign producers entered into the German market and increased the competition. Third, the farm tractor had become a highly homogeneous product and shakeout dynamics set in, consistent with the model of Bhaskarabhatla and Klepper (2009). In particular, the standardized three point suspension helped establish a stable farm tractor design at this time. Overall, the number of registered farm tractors rose from 140,000 in 1949 to 1 million in 1963. From the beginning of the 1970s to present, the number of active German producers has remained relatively stable between 15 and 25.

Data and methods

Data

Our empirical analysis is based on a unique dataset encompassing the full population of German farm tractor producers, which was constructed from historical trade publications (Flücht and Blum 1942; Neubauer 1950, 1952, 1954, 1956, 1958, 1961, 1966) as well as more recent accounts of the industry’s history (Herrmann 1987; Bauer 1987, 1995;

Gebhardt 1988, 2006; Bach 1999). Altogether, we identified 293 entrants into the German farm tractor industry from 1896 to 2006. Out of this population, we were able to classify 246 firm or founder backgrounds. The majority of these entrants are experienced (226). In total, 187 entrants diversified out of other industries, 30 re-entered[3] into the German farm tractor market and 9 could be identified as spin-offs. We furthermore classified the pre-entry experience of the diversifying entrants, allowing for multiple experience backgrounds. A total of 88 diversifiers possessed experience in agricultural implements, 59 had produced non-agricultural vehicles such as trucks or automobiles, 26 were engine producers, and 117 had other types of pre-entry experience.

Dependent variables

We follow a two step empirical approach. We start with a simple logit regression to test whether, consistent with Hypothesis 1, the new submarket for small multi-purpose tractors emerging after 1927 indeed induced a specific type of entrants (diversifiers with market-related experience and from the South) to join the industry. We then adopt longevity as a general measure of firm performance and apply survival analysis to probe how the hazard of exit from the tractor industry was related to pre- and post-entry experience as predicted by Hypotheses 3a and 3b. Since the underlying data on firm survival are based on annual observations, we employ discrete-time complementary log-log hazard rate regressions (Allison, 1982). Accordingly, the hazard rate is defined as

[3] Re-entrants are firms that exit the German farm tractor market for more than five years and then reenter. Correspondingly, firms that re-entered after less than six years are not treated as a new re-entrant. Rather we retain the original entrant type and deduct the period of market abstinence from the whole market spell.

$$h_i(t) = 1 - \exp\left[-\exp\left(a_t + \beta_t x_i\right)\right], \tag{1}$$

where $h_i(t)$ is the probability that firm *i* exits the German farm tractor industry in year *t*, given it survived up to *t*, a_t is a baseline hazard function that may be duration dependent, and β_t is a vector of coefficients estimating the relevance of firm characteristics x_i. (time-varying covariates should be allowed for in equation 1) for the hazard.

As we are interested in the hazard of exit due to poor firm performance, exits related to World War I or II are treated as censored observations. In line with earlier work on industry evolution (e.g., Klepper, 2002), exits due to mergers or acquisitions are coded as follows. Firms that were acquired by foreign farm tractor producers that have not been active in the German market before are coded as continuing firms. If a German farm tractor producer acquired another one, the acquiring firm is coded as continuing, while the acquired firm is censored. We only have a single domestic acquisition in our sample, namely that of Daimler and Benz, which is handled intuitively. As Benz was the smaller firm, Daimler is the continuing firm, while Benz is censored.

Hypothesis 1 posits that firms with regional and market-related knowledge are more likely to enter the German farm tractor market after 1927. If true, this gives rise to the empirical problem of sample selection bias or confounding when testing Hypotheses 3a and 3b (Deheija and Whaba, 2002; Imbens, 2004). In other words, if firms with promising local and market related experience are more likely entering into the German farm tractor market after 1927, firms operating from 1928 on are generally more capable, and the hazard rate estimator for firms entering after 1927 will be downward biased. One possibility to overcome this problem would be the inclusion of interactions of all relevant firm-background constellations with firm entry after 1927. However, for reasons of model parsimony and to economize on degrees of freedom, we prefer to use a propensity score weighting approach to handle the problem of market-entry selection bias.

Propensity score weighting is an efficient methodology to remove almost all sample selection bias (Lunceford and Davivian, 2004; Ukoumunne *et al.*, 2010; Busso, DiNardo, and McCrary, 2011). It is based on first estimating a firms' probability (propensity score) $\hat{e}_i(v)$ of entering into the German farm tractor market after 1927, where v represents a vector of covariates. Second, a weighting estimator for the average causal effect of entering after 1927 $\Delta h(t)$, based on $h_i(t)$ and $\hat{e}_i(v)$, is generated. It is important not to employ the *true* entry probability $e_i(v)$ for the weights, which can be assured either by estimating it non-parametrically (Hirano, Imbens, and Ridder, 2003; Imbens, 2004) or parametrically by using a logit estimation (Lunceford and Davidian, 2004). In the latter case, it is important that enough treated and untreated observations face not too many covariates v so that perfect prediction is unlikely (Kline, 2011), which is valid in our case. $\Delta h(t)$ has the following shape (see Hirano *et al.*, 2003; Lunceford and Davidian, 2004; Imbens 2004):

$$\Delta h(t)=\frac{\sum_{i=1}^{n}\frac{h_i(t)Z_i}{\hat{e}_i(v)}}{\sum_{i=1}^{n}\frac{Z_i}{\hat{e}_i(v)}}-\frac{\sum_{i=1}^{n}\frac{h_i(t)(1-Z_i)}{(1-\hat{e}_i(v))}}{\sum_{i=1}^{n}\frac{(1-Z_i)}{(1-\hat{e}_i(v))}} \tag{2}$$

In (2) Z_i indicates whether entry into the German farm tractor market was after $(Z_i = 1)$ of before 1927 $(Z_i = 0)$. Thus, interpreting (2), every firm that entered until 1927 is assigned with a weight of $1/(1-\hat{e}_i(v))$, while firms that entered after 1927 are weighted by a factor of $1/\hat{e}_i(v)$. This procedure assures that observations with relatively a high $\hat{e}_i(v)$ are weighted more heavily in case they entered until 1927 and vice versa for firms that entered after 1927. Put differently, a pseudo population is generated which has the property of equally distributed pre-entry experiences across both examined entry cohorts, thus removing sample selection bias regarding local and market related knowledge (see Imbens, 2004; Hernan and Robins, 2006). The weights in (2) are normalized with the respective entry cohort sum of weights such that they always sum up to 1, which helps ensure higher efficiency (Lunceford and Davidian, 2004; Imbens, 2004).

Independent Variables

To test the hypotheses developed in Section 2, we focus on a set of explanatory variables accounting for entrants' pre-entry experience and regional background (location in or outside southern Germany). Experienced firms are divided into diversifiers, spin-offs, and firms re-entering the tractor industry after having exited before. For diversifiers, we further distinguish between different types of backgrounds. We take prior experience in vehicle or engine production as an indication of technological capabilities, whereas experience in agricultural implements is interpreted as a source of market-related knowledge. Multiple backgrounds of individual firms are reflected by positive values for more than one of the respective indicator variables. Another indicator variable denotes the cohort of post-1927 entrants to allow the emergence of the multi-purpose farm tractor submarket to modify the influences on entry and performance.

The empirical analysis moreover controls for several other factors that may affect hazard rates of German farm tractor producers. We control whether a firm was designated as a farm tractor producer in the Schell Plan (cf. above Section 3) and thus authorized to make farm tractors between 1939 and 1945. We also control for market density, or, in other words, the number of competitors in the market. Carroll and Hannan (1989) propose that the hazard rate has an inverted-U relationship with market density. We therefore control for the logarithm of market density as well as the squared logarithm of market density in t. To allow for agglomeration externalities to affect the hazard rate of industry exit, the share of all active producers in t that were located in the same region, or in an adjacent region, as the target firm is used as another control. As there might be regional spillover effects from related industries (Eriksson, 2011), we also control for the number of regional automobile firms. Data on the location and activity of German automobile firms was taken from Dressler (2006). Finally, several prior studies suggest that the hazard rate of market exit is duration dependent (Klepper, 2002; Buenstorf and

Guenther, 2011). Taking these findings into account, we allow for linear and squared effects of duration dependence.

All independent variables are listed and described in more detail in Table 1.

Insert Table 1 about here

Empirical results

Summary statistics of our data may be found in Table 2 and correlation coefficients may be taken from Table 3.[4]

The German farm tractor industry provides a highly suitable empirical context to assess the relevance of endogeneous entry timing and the performance implications of differences in pre-entry experience. The decisive development in the industry's early decades was the emergence of the submarket for small multi-purpose tractors. Its timing can be pin-pointed to 1927 when the standardized power takeoff was introduced in Germany (cf. the above discussion in Section 3).

Insert Table 2 about here

Insert Table 3 about here

Hypothesis 1 predicted that *de alio* entrants enter when their resources and capabilities best match industry requirements. In the empirical context of the German tractor industry, this endogeneity of entry timing should lead to a higher likelihood of

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[4] The summary statistics and correlation table does not include the time-varying variables as those change every year in which the firms are operating. Thus, such one-dimensional measures as correlation coefficients have no explanatory power.

companies with a location in southern Germany and/or diversifying from an agricultural background to enter after 1927, when their market-based knowledge was of strategic value to exploit the opportunities opening up in the new submarket for multi-purpose tractors. Results of the logit regressions to test Hypothesis 1 are presented in Table 4. Model 1 confirms our conjecture with respect to the regional dimension. Model 2 further corroborates our prediction that both a location in southern Germany as well as pre-entry experience in agricultural implements is directly related to entering the industry after 1927. We also observe that a background in engine production, which represented technological rather than market-related experience, significantly lowered the likelihood to enter after 1927. In addition, standardized mean differences (cf. Austin, 2009) of the backgrounds of firms entering until and after 1927, respectively, are reported in Table 5. All values exceed the threshold of |0.1|, which has been proposed as a benchmark for covariate imbalance (Normand *et al.*, 2001).Thus, our initial empirical findings provide support for Hypothesis 1.

Insert Table 4 about here

Insert Table 5 about here

These findings imply that 'market-entry selection bias' is a relevant concern in our sample. In order to account for 'market-entry selection bias', we estimate firms' $\hat{e}_i(v)$ with the help of Model 2 from Table 4 and create propensity score weights. Standardized differences of all observations in our sample after weighting are shown in Table 5. All values are far below |0.1|, which indicates that after weighting our sample is almost entirely balanced with regard to pre-entry backgrounds.

In a next step, weighted complementary log-log hazard rate regressions with normalized weights, as well as analogous non-weighted models, are estimated to test Hypotheses 2a –3b (Tables 6 and 7). As described above, output volumes in the farm tractor market reached a considerable size, and the struggle for market dominance via scale advantages set in, only after the emergence of the new southern submarket in 1927. Before this time, much of the accumulated experience with earlier tractor versions in the North was of little relevance with respect to both technology and customer demand in the larger southern market. Relevant post-entry accumulation of industry-specific knowledge only started after 1927. New entrants were still able to compete with incumbents on equal terms at this time. If they could draw on relevant pre-entry experience, they could even be in an advantageous position. On this basis, no systematic advantages to early entry are expected to be found. We moreover expect that for the post-1927 entrants, a background in related markets was more important in reducing exit hazards than experience in technologically related industries. Given their familiarity with regional markets, we also expect to find that post-1927 entrants located in southern Germany have a lower exit hazard than entrants from northern Germany.

Without controlling for the endogeneity of entry times, we find that post-1927 entrants and firms with pre-entry experience were systematically more long-lived than earlier and inexperienced peers (Models 3 and 4). In Model 5 and 8 we find that experience has a stronger effect for later entrants. Controlling for endogeneous timing of entry in the weighted regressions, the effect of entering after 1927 on performance is reduced and is no longer statistically significant (Models 6 and 7). These findings are consistent with Hypothesis 2a –b.

Models 9 –12 (Table 7) provide a more detailed analysis of the associations between specific pre-entry backgrounds and exit hazards. In line with the predictions of Hypothesis 3a, we find that entrants whose resources and capabilities best matched the requirements of the market on average were more long-lived. Specifically, being located in the South or diversifying from agricultural implements is associated with a lower hazard, but only for post-1927 entrants when market-related capabilities were of utmost importance (Model 12). None of the other types of industry experience provided late entrants with specific competitive advantages. If anything, Model 12 is suggestive of technological capabilities enhancing the performance of early diversifiers from the vehicle industry. These patterns are consistent with the predictions of Hypothesis 3a. In all models (with or without correcting for endogenous timing of entry, with or without interaction terms for late entrants) we find robust evidence of performance effects for only three types of backgrounds: intra-industry experience accumulated by re-entrants and spin-offs, as well as experience in agricultural implement markets brought by the respective group of diversifiers. This finding corroborates Hypothesis 3b.[5]

Insert Table 6 about here

[5] As a robustness check, we also estimated hazard rate regressions with a time-varying dummy measuring whether firms participated in the German farm tractor industry when the submarket of the multipurpose farm tractor started to boom in 1935 (Bauer 1987, 1995), instead of a dummy representing entry after 1927. Results, which are very similar to those reported above, may be obtained from the authors upon request.

Insert Table 7 about here

6. Discussion and conclusions

In this paper we study the relationship between entry timing, pre-entry experience and post-entry performance in industry evolution. Analyzing entry and firm survival in the historical German farm tractor industry, we found empirical support for the conjecture that entry timing is endogenous and reflects entrants' attempts to find the best match between capability endowments and market requirements. The emergence of a new submarket for small multi-purpose tractors induced a new wave of entry after 1927, which was predominately composed of southern firms diversifying from agricultural backgrounds. With their market-related knowledge, these new entrants were well-positioned to succeed in the newly emerging submarket. They subsequently outperformed the earlier entrants into the industry.

Our finding that late diversifiers with market-related knowledge were more likely to survive the shakeout in the German farm tractor industry resonates with recent work by Ulaga and Reinartz (2011) who identify a firm's sales force and distribution network as critical resources. Among the specific capabilities highlighted by these authors is personal selling. In our context, personal selling presumably provided a distinct advantage for regional producers in the dominant southern submarket. Hybrid sales offerings and deployment capabilities are also suggested as important by Ulaga and Reinartz (2011). Again, this seems to have been relevant in the historical tractor industry, as diversifying producers of agricultural implements could leverage their ability to offer complementary equipment for the multipurpose farm tractor. The competitive relevance of sales capabilities and presence in horizontally related sales market is also consistent with the account provided by Buenstorf (2008) to explain the large number and competitive success of diversifiers from agricultural implements in the U.S. farm tractor industry.

How much can we generalize from the above analysis of a single historical industry? One limit of generalization relates to the role of technological discontinuities. In some industries a single submarket dominates over the entire evolution of the industry, and hence no technological discontinuities are observed. Penicillin and TV receivers have been suggested as cases in point (Bhaskarabhatla and Klepper, 2009). Yet of course a large number of industries other than the German farm tractor industry experienced technological discontinuities. Future research should focus on these industries to provide a more complete account of the interplay of endogenous entry timing and firm success. In a similar vein, our data do not provide direct evidence to what extent and in which way entry or incumbency shaped the technological discontinuity in the German farm tractor market. Recent research by Sood and Tellis (2011) shows that technological disruptions are mainly introduced by incumbents. However, at least in individual industries incumbents have possessed the required capabilities to introduce a technological discontinuity as well as the ability to deploy it (Buenstorf and Klepper, 2010). Yet another limitation, which pertains to many studies of industry evolution studies, relates to the role of demand-side factors (Adner, 2002). Again owing to insufficient data, we could not study in detail how the new submarket for small multi-purpose tractors gained dominance among the small scale farmers in southern Germany. A fuller account of the demand-side dynamics remains a desideratum for further research.

The limitations notwithstanding, in light of the increasing product heterogeneity in many contemporary markets, we would generally suspect that early entry is no longer a guarantee for success (if it ever was). In this respect, from the example of the historical tractor industry lessons can be drawn both for practitioners and for researchers. For practitioners, our study suggests the importance of entry timing as an object of strategic management. Changing markets may provide opportunities to new entrants well after the first wave of entry into this market. Strategic decision making should then try to balance the costs and benefits of waiting, as postponed entry may not just come at a cost of foregone experiential learning but may also prevent the firm from the problems of entering a hostile environment. For researchers, our study holds the message to devote more effort to identifying the emergence and evolution of submarket structures within industries, e.g. when investigating entry barriers and entry decisions. In particular, further empirical investigations should pay increased attention to the *interplay* of entry timing decisions and pre-entry capabilities of market entrants along the life cycle, instead of treating them separately. It is the joint examination of changing market conditions and the endogenous entry timing decision that serves to capture the main determinants of individual firm survival and industry evolution.

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Table 1: Description of variables

Experienced	Dummy that indicates whether the entrant is *experienced,* 1=YES, 0=NO.
Diversifier	Dummy that indicates whether the entrant is a *diversifier,* 1=YES, 0=NO.
Re-entrant	Dummy that shows whether the entrant is classified as a *re-entrant*, 1=YES, 0=NO.
Spin-Off	Dummy variable that shows whether the entrant is a *spin-off* or not, 1=YES, 0=NO.
Agr. Impl.	Dummy that indicates whether the diversifier has experience in the production of *agricultural implements*, 1=YES, 0=NO.
Div Vehicles	This variable shows whether the diversifier has pre-entry experience in the production of *vehicles*, 1=YES, 0=NO.
Div Engines	A Dummy that shows whether the diversifier has pre-entry experience in the production of *engines*, 1=YES, 0=NO.
Div Others	Dummy variable that indicates whether the diversifier possess *other* pre-entry experience than in agricultural implements, vehicles or engines*,* 1=YES, 0=NO.
ENTRY1927	*Entry-cohort from 1928 – 2007,* 1=YES, 0=NO.
South	Dummy variable that indicates whether the entering firm is located in South Germany (Southern German Federal States Bavaria or Baden-Wuerttemberg)*,* 1=YES, 0=NO.
2WW	Dummy that indicates whether the entrant was *active during the World War II, 1939–1945,* 1=YES, 0=NO.
LogMDEN	Time varying; renders the *logarithm of number of firms in the market.*
LogMDEN^2	Time varying; renders the *squared logarithm of number of firms in the market.*
RegDEN	Time varying; shows *the regional fraction of the whole number of firms in the market*. The region is mainly based on German counties, Raumordnungsregionen. In case the entrant was located in former German areas, we used Polish counties, Województwos, or French counties, Régions.
NRegDEN	Time varying; shows the *neighbour regional fraction of the whole number of firms in the market*. The region is mainly based on German counties, Raumordnungsregionen. In case the entrant was located in former German areas, we used Polish counties, Województwos, or French counties, Régions.
ARegN	Time varying; *shows the regional number of automobile firms in the market.* The region is mainly based on German counties, Raumordnungsregionen. In case the entrant was located in former German areas, we used Polish counties, Województwos, or French counties, Régions.
T	Time varying; indicates the *number of years of market experience from the time of entry.*
T^2	Time varying; indicates the *squared number of years of market experience from the time of entry.*

Table 2: Summary statistics

	Mean	SD	Max	Min
1. Experienced	0.924	0.265	1	0
2. Diversifiers	0.708	0.455	1	0
3. Reentrants	0.113	0.317	1	0
4. Spin-offs	0.215	0.412	1	0
5. Div Agr. Impl	0.488	0.5	1	0
6. Div Vehicles	0.325	0.469	1	0
7. Div Engines	0.162	0.369	1	0
8. Div Others	0.522	0.5	1	0
9. De Novo	0.075	0.265	1	0
10. ENTRY 1927	0.56	0.497	1	0
11. South	0.405	0.491	1	0
12. 2WW	0.162	0.369	1	0

Table 3: Correlation coefficients

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Experienced	1.00											
2. Diversifiers	0.45***	1.00										
3. Reentrants	0.10*	-0.56***	1.00									
4. Spin-offs	0.15***	-0.82***	0.68***	1.00								
5. Div Agr. Impl	0.28***	-0.06	0.20***	0.24***	1.00							
6. Div Vehicles	0.20***	-0.03	0.01	0.17***	-0.10	1.00						
7. Div Engines	0.13**	-0.12**	0.10*	0.22***	-0.10*	0.15***	1.00					
8. Div Others	0.30***	0.32***	-0.16***	-0.16***	-0.07	-0.02	-0.05	1.00				
9. De Novo	-1.00***	-0.45***	-0.10*	-0.15***	-0.28***	-0.20***	-0.13**	-0.30***	1.00			
10. ENTRY 1927	0.21***	-0.05	0.20***	0.19***	0.27***	0.01	-0.15***	-0.08	-0.21***	1.00		
11. South	0.12**	-0.01	0.07	0.09	0.23***	0.07	0.05	-0.14**	-0.12**	0.33***	1.00	
12. 2WW	0.09	0.08	-0.03	-0.03	0.16***	0.11*	-0.00	-0.01	-0.09	0.23***	0.07	1.00

Table 4: Models 1 –2.

Dep. Var.: Entry1927	1.	2.
South	0.845***	0.780***
	(0.265)	(0.291)
Spin-Offs		0.586
		(0.786)
Reentrants		1.754***
		(0.571)
Diversifier*Agricultural Implements		0.878***
		(0.309)
Diversifier*Vehicle Producers		0.0291
		(0.345)
Diversifier*Engine Producers		-1.376***
		(0.502)
Diversifiers*Others		-0.0625
		(0.302)
Const	-0.152	-0.485
	(0.175)	(0.300)
N	246	246
Events	137	137
AIC	331.4	313.3
BIC	338.4	341.3
Log-likilhood	-163.678	-148.638
p>chi2	0.0014	0.0000

Standard errors in parentheses
* p<.1, ** p<.05, *** p<.01

Table 5: Standardized mean differences before and after propensity score weighting

	before weighting			after weighting		
	mean entry<=1927	mean entry>1927	standardized differences	mean entry<=1927	Mean entry>1927	standardized differences
South	0.55	0.23	-0.637	0.42	0.41	-0.008
Spin-Offs	0.04	0.03	-0.79	0.04	0.04	0.016
Reentrants	0.18	0.05	-0.352	0.12	0.11	-0.024
Diversifier*Agricultural Implements	0.42	0.28	-0.299	0.36	0.36	0.011
Diversifier*Vehicle Producers	0.22	0.27	0.113	0.23	0.24	0.011
Diversifier*Engine Producers	0.04	0.17	0.635	0.09	0.10	0.056
Diversifiers*Others	0.43	0.53	0.204	0.50	0.49	-0.024

Table 6: Models 3–8.

	non weighted			weighted		
Dep.Var.: Hazard Rate	3.	4.	5.	6.	7.	8.
Entry 1927	-0.501***	-0.438**	1.013*	-0.293	-0.228	0.978*
	(0.172)	(0.175)	(0.570)	(0.192)	(0.193)	(0.551)
Experienced		-1.036***	-0.798***		-1.115***	-0.842***
		(0.279)	(0.291)		(0.262)	(0.278)
Experienced*Entry 1927			-1.505***			-1.268**
			(0.581)			(0.569)
2WW	-1.242***	-1.225***	-1.224***	-1.422***	-1.394***	-1.398***
	(0.217)	(0.215)	(0.219)	(0.241)	(0.237)	(0.243)
log(MDEN)	-0.933**	-0.754	-0.767	-0.945**	-0.706	-0.729
	(0.452)	(0.476)	(0.468)	(0.480)	(0.517)	(0.507)
log(MDEN)^2	0.192**	0.167**	0.166**	0.175*	0.139	0.139
	(0.0821)	(0.0849)	(0.0837)	(0.0908)	(0.0947)	(0.0932)
Log(RegDEN)	-0.0963	-0.146	-0.127	-0.135	-0.205	-0.181
	(0.112)	(0.114)	(0.114)	(0.130)	(0.129)	(0.131)
NRegDEN	1.198	1.111	1.395	1.480	1.551	1.820
	(1.546)	(1.612)	(1.561)	(1.699)	(1.754)	(1.688)
ARegN	0.0157	0.00576	0.00857	0.0151	0.00885	0.0112
	(0.0132)	(0.0150)	(0.0143)	(0.0127)	(0.0138)	(0.0131)
T	-0.0549***	-0.0508***	-0.0497***	-0.0652***	-0.0601***	-0.0591***
	(0.0140)	(0.0141)	(0.0140)	(0.0138)	(0.0139)	(0.0138)
T^2	0.000535**	0.000488**	0.000469**	0.000589***	0.000535**	0.000516**
	(0.000222)	(0.000226)	(0.000227)	(0.000206)	(0.000211)	(0.000211)
Const	-0.865	-0.382	-0.496	-0.648	-0.247	-0.353
	(0.643)	(0.674)	(0.654)	(0.625)	(0.711)	(0.683)
N	246	246	246	246	246	246
Fails	217	217	217	217	217	217
AIC	1376.7	1366.9	1364.4	2648.3	2620.7	2614.1
BIC	1435.7	1431.8	1435.2	2707.2	2685.6	2684.8
log-liklihood	-678.370	-672.442	-670.196	-1314.129	-1299.372	-1295.167
p>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Standard errors in parentheses
* p<.1, ** p<.05, *** p<.01

Table 7: Models 9–12.

	non weighted		weighted	
Dep. Var.: Hazard Rate	9.	10.	11.	12.
Entry 1927	-0.215	0.0566	-0.198	0.194
	(0.203)	(0.383)	(0.217)	(0.427)
South	-0.288	0.0602	-0.175	0.323
	(0.193)	(0.267)	(0.214)	(0.293)
Spin-Offs	-0.954***	-1.135***	-1.012***	-1.429***
	(0.211)	(0.287)	(0.213)	(0.264)
Reentrants	-1.039***	-1.293*	-1.017***	-0.944**
	(0.297)	(0.771)	(0.337)	(0.479)
Diversifier*Agricultural Implements	-0.947***	-0.404*	-0.810***	-0.118
	(0.170)	(0.235)	(0.193)	(0.265)
Diversifier*Vehicle Producers	-0.335*	-0.627***	-0.293	-0.561**
	(0.173)	(0.226)	(0.190)	(0.284)
Diversifier*Engine Producers	-0.177	-0.258	-0.158	-0.405
	(0.189)	(0.224)	(0.280)	(0.266)
Diversifiers*Others	-0.272	-0.357	-0.283	-0.537**
	(0.167)	(0.222)	(0.188)	(0.247)
South*Entry 1927		-0.620*		-1.092***
		(0.364)		(0.416)
Spin-Offs*Entry 1927		0.0318		0.510
		(0.436)		(0.463)
Reentrants*Entry 1927		0.147		-0.216
		(0.866)		(0.643)
Diversifier*Agricultural Implements*Entry 1927		-0.920***		-1.223***
		(0.331)		(0.376)
Diversifier*Vehicle Producers*Entry 1927		0.629*		0.748*
		(0.355)		(0.401)
Diversifiers*Engines*Entry 1927		0.500		0.986
		(0.551)		(0.653)
Diversifier*Others*Entry 1927		0.0146		0.290
		(0.341)		(0.381)
2WW	-1.234***	-1.363***	-1.451***	-1.751***
	(0.205)	(0.217)	(0.233)	(0.273)
log(MDEN)	-0.620	-0.649	-0.580	-0.570
	(0.470)	(0.480)	(0.479)	(0.486)
log(MDEN)^2	0.155*	0.159*	0.123	0.119
	(0.0833)	(0.0847)	(0.0888)	(0.0888)
Log(RegDEN)	-0.0621	-0.0451	-0.135	-0.0456
	(0.115)	(0.124)	(0.130)	(0.149)
NRegDEN	1.880	3.176*	1.846	4.286**
	(1.738)	(1.728)	(2.001)	(1.778)
ARegN	0.00732	0.00836	0.0104	0.0112
	(0.0159)	(0.0170)	(0.0155)	(0.0163)
T	-0.0382**	-0.0331**	-0.0521***	-0.0394***
	(0.0159)	(0.0154)	(0.0151)	(0.0149)
T^2	0.000414	0.000372	0.000521**	0.000371
	(0.000268)	(0.000255)	(0.000241)	(0.000242)
Const	-0.788	-0.769	-0.619	-0.581
	(0.693)	(0.704)	(0.682)	(0.695)
N	246	246	246	246
Fails	217	217	217	217
AIC	1350.0	1349.9	2591.2	2545.7
BIC	1450.3	1491.5	2691.4	2687.2
Log-likilhood	-657.989	-650.961	-1278.577	-1248.835
p>chi2	0.0000	0.0000	0.0000	0.0000

Standard errors in parentheses
* p<.1, ** p<.05, *** p<.01

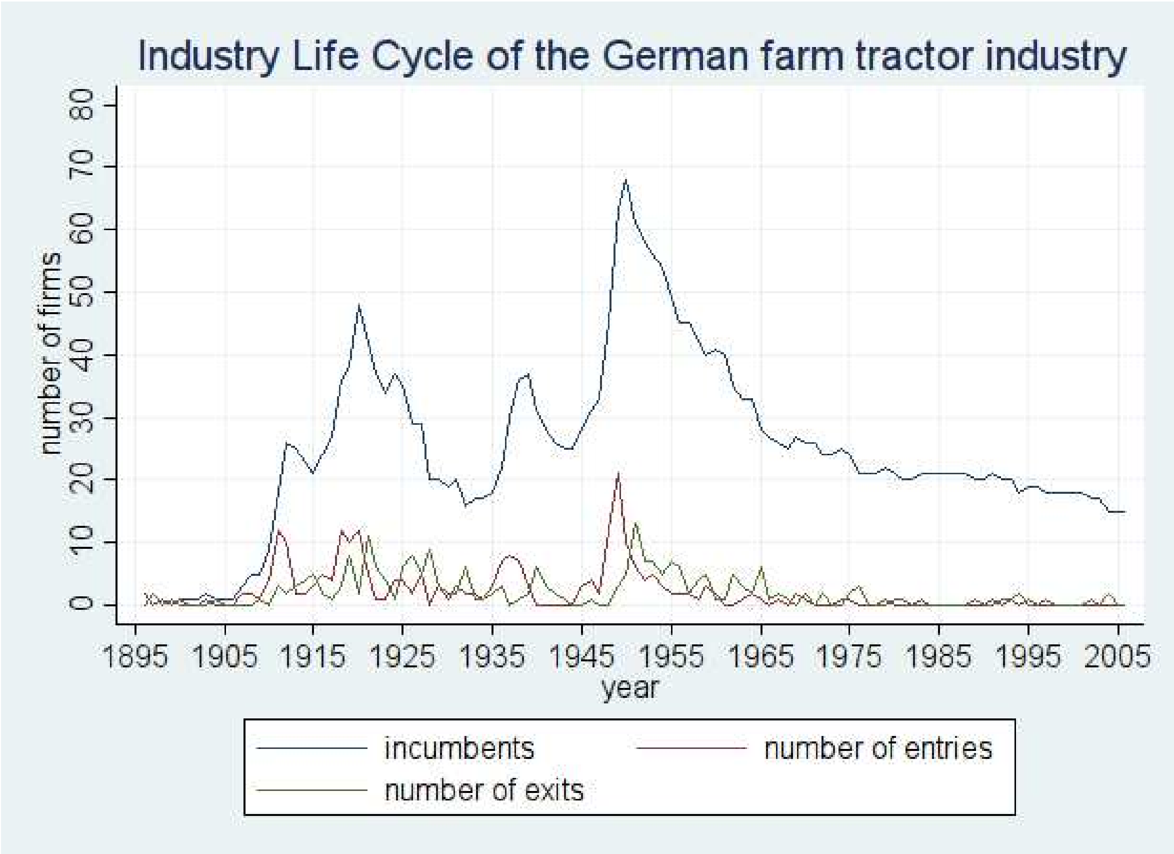

Figure 1: Lifecycle of the German farm tractor industry