Firm Survival and the Evolution of Market Structure: The Case of the Japanese Motorcycle Industry*

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This paper explores firm survival and the evolution of market structure in the Japanese motorcycle industry during 1946–1965. In the post-war era, the number of firms grew rapidly and peaked in 1953 at 200, and then declined sharply for the first 20 years. As a consequence, only four firms survived, and the industry evolved to be an oligopoly. To address what caused the shakeout of firms, we examine the determinants of firm survival. It is found that firms which made early entry and had previous experience in motor vehicle manufacturing tend to survive longer. It is also found that offering high-quality products, broadening product-line, and avoiding product-line overlap from rivals played significant roles in the survival of firms.

Key words: Firm survival; industry evolution; market structure; motorcycle.

1. Introduction

This paper explores firm survival and the evolution of market structure in the Japanese motorcycle industry over the period 1946–1965. An important feature of the industry is that the number of firms grew and then declined sharply in the first 20 years during the post-war era, and consequently the industry evolved to be an oligopoly. To address what factors cause a shakeout of producers and consequently shape the structure of the industry, this study examines the determinants of firm survival.

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In the fields of evolutionary economics and organizational ecology, a number of studies have addressed firm survival and the evolution of industries over a long period of time to address the determinants of market structure. For example, Gort and Klepper (1982) investigated the diffusion of product innovations in the evolution of market structure, by examining the spread in the number of producers engaged in manufacturing a new product. Klepper and Simons (2000) also explored the determinants of firm survival in the evolution of the US tire industry, and emphasized the importance of technological change in shaping the structure of the industry. These studies provided important evidence on the evolution of industries in several countries, including UK and US. However, research on the evolution of Japanese industries has been quite limited until now. As is well known, Japanese industries developed remarkably after the World War II, and consequently some of them achieved highly competitive positions in the global market (e.g., Porter, 1990). Especially, the Japanese motorcycle industry appears to have special characteristics in terms of industry evolution. In the post-war era, the industry had experienced a lot of new entry, rapid technological change, considerable growth in market demand, and a shakeout of producers. As a consequence, while the Japanese motorcycle industry evolved to be an oligopoly, Japanese successful companies, Honda, Kawasaki, Yamaha, and Suzuki, became market leaders in the global motorcycle market in the early 1960s. In addition, Porter (1990) argued that the motorcycle industry is the most successful in Japanese industries in terms of world export share.[1] Therefore, findings derived from such an industry may be of some interest to the discussion on the evolution of market structure. Then, this paper will provide some implications as to how an industry evolved over time and what factors shaped the structure of the industry.[2]

The remainder of this paper is organized as follows. Section 2 describes the data set employed for this study, including the overview of the Japanese motorcycle industry during 1946–1965. In Section 3, we develop our hypotheses for the determinants of firm survival. In Section 4, we explain the methods employed in the analyses. The empirical results are

[1] Porter et al. (2000) also emphasized that the competitive success of Japanese motorcycle companies was resulted from their huge cost advantages over Harley-Davidson, BMW, and other western manufacturers.

[2] Yamamura et al. (2005) addressed the evolution of the Japanese motorcycle industry over 1948–1964 and examined the determinants of firm growth and product quality. However, they did not necessarily focus on the determinants of firm survival (or exit). Also, some studies, including Demizu (2002), examined historically the Japanese motorcycle industry, with a focus on technological development.

presented in Section 5. The final section includes some concluding remarks.

2. Data

To describe the evolution of the Japanese motorcycle industry, we made every efforts to collect the detailed data on the Japanese motorcycle industry over the period from 1946 to 1965. The data set employed for this study comes from many sources. First, we obtained data on motorcycle products mainly from *Japanese Motorcycle History* (hereafter, JMH), which is compiled and published in 2007 by Yaesu Shuppan, a Japanese publishing company. The data source collects data on motorcycles produced during the post-war era, and includes not only data on the product name, horsepower, engine displacement, and production year for each motorcycle but also data on the name and headquarter of producers.

However, the JMH does not necessarily cover data on all motorcycles produced during the observation period, especially for the early years. Therefore, we employ additional data sources to obtain data on motorcycles unavailable in the *JMH*; that is, the *History of Japanese Small Vehicles (Nihon Kogata Jidosha Hensenshi)*, the *History of the Small Vehicle Industry (Kogata Jidosha Gyokai no Ayumi)*, and *Information on Small Vehicles (Kogata Jyoho)* (hereafter, ISV) by Kotsu Taimusu Inc., Kogata Jidosha Shimbum Inc., and the Japan Small Vehicle Manufacturers Association, respectively. The variables for firm-specific characteristics are constructed based on information from these data sources.

Based on these collected data, we attempt to identify the years of entry into and exit from the motorcycle industry for each firm, but it was cumbersome to identify the timing of entry and exit for some small-sized producers, because of the limited availability of data. By collecting complementary information from some historical studies, such as Nakaoki (1984), Demizu (1991, 2002), and Ozeki (2002, 2007), we identified the years of entry and exit for those firms. Further, we used other data sources, such as the company's web or *Google*, to check the years of entry into and exit from the motorcycle industry. Nevertheless, there is the possibility that these data sources do not necessarily cover data on all motorcycles produced during the observation period. However, compared to previous studies, including Yamamura et al. (2005), we can cover a greater number of producers mainly because of the use of additional data sources. As a result, we obtained a data set for 251 motorcycle producers that entered the motorcycle industry during the period 1946–1965. Using the newly constructed data set, we examine firm survival and the evolution of market structure in the Japanese motorcycle industry.

Some previous studies suggest that, when industries are new, there is a lot of entry, firms offer many different versions of the industry's product, and the rate of product innovation is high (e.g., Klepper, 1996). Klepper (1996) also suggests that despite continued market growth, subsequently entry slows, exit overtakes entry and there is a shakeout in the number of producers.[3] In this subsection, we examine data on the evolution of market structure in the Japanese motorcycle industry over the period 1946–1965.

First, Figure 1 shows the volume of production in the Japanese motorcycle industry during 1946–1965. In the post-war Japan, only 200 or more motorcycles were produced in the early years. But, the volume of production had continued to grow rapidly from 1952, and it reached 2 millions of motorcycles in the early 1960s. Figure 2 also describes entry, exit, and total number of firms during the observation period. This figure indicates that the number of entry increased considerably from 1952, and total number of firms peaked in 1953 at 200. These figures indicate that despite continued market growth, subsequently entry slows, exit overtakes entry and there is a shakeout in the number of firms. This evolutionary pattern is quite similar to that from some previous studies, including Klepper (1996) and Klepper and Simons (2000).

3. Hypotheses

To address what factors caused a shakeout of producers in the Japanese motorcycle industry, we explore the determinants of firm survival and test whether firms with different characteristics exhibit different performance in terms of the duration of survival. In this section, we develop our hypotheses for the determinants of firm survival.

First, we discuss the role of order-of-entry in explaining firm survival. As already described in Figure 1, the motorcycle industry started with the production of about 200 motorcycles in 1946. Dowell and Swaminathan (2006) argued that in the early period of an industry, firms face both tremendous opportunities and tremendous uncertainties. In practice, in the

[3] For discussions on these patterns, see also Utterback and Abernacy (1975) and Utterback (1994).

early period of the motorcycle industry, technologies for producing motorcycles are primitive, and they tended to be rapidly improved over time. In such dynamic environments, as suggested by Christensen and Bower (1996), even if firms are ragarded as capably managed at one point, they may subsequently lose the positions when faced with technological changes. In this respect, early entrants may not necessarily have advantages than late entrants.

On the other hand, a number of studies have found that early entrants are more likely to survive longer than late entrants in industries, because of their first-mover advantages (e.g., Klepper and Simons, 2000). Lieberman and Montgomery (1988, p.41) pointed out that first-mover advantages arise from three primary sources, technological leadership, preemption of assets, and buyer switching costs. First, technological advantages tend to be derived from the learning (experience) curve that costs fall with cumulative output, and they are related to the success in R&D (or patent) races that technological advances are a function of R&D expenditures.[4] The second is that first-movers can obtain advantages by preempting their rivals in terms of scarce assets. For example, Lieberman and Montgomery (1988) argued that the first-mover gains advantage by controlling assets that already exist, rather than those created by the firm through development of new technology. While such assets may be physical resources or other process inputs, the assets may relate to positioning in space, including geographic and product spaces. The third is related to buyer switching costs, which have been often argued in the strategic management literature. In the context of imperfect information regarding the quality of products, there is the possibility that buyers stick with the first brand because of uncertainty (e.g., Schmalensee, 1982). When a buyer chooses a brand-specific product, the buyer may find it costly to shift to another brand.[5]

In the case of the Japanese motorcycle industry, early entrants appeared to enjoy technological advantages related to the learning curve or R&D races. In addition, early entrants may tend to establish more efficient production system and wide distribution networks earlier, and this may be a reason that they could enjoy first-mover advantages. We thus predict that early entrants are more likely to survive longer than late entrants.

[4] For a theoretical model associated with preemptive patenting, see, for example, Gilbert and Newbery (1982).

[5] Alternatively, Lieberman and Montgomery (1988, 1998) argued that there may be also cases that first-mover disadvantages arise, including free-rider problems. For additional discussions on first-mover (dis)advantages, see, for example, Lieberman and Montgomery (1988, 1998), Robinson et al. (1994), and Tellis and Golder (1996).

Why some firms are strong persistently over time has attracted large attention from scholars in the fields of strategic management and evolutionary economics. Some studies argued that firms' capabilities and resources at the time of entry play important roles in differences of the post-entry performance of firms, and found that they tend to persist over time. For example, Helfat and Lieberman (2002, p.725) emphasized the importance of pre-entry history in firm survival and concluded that the greater the similarity between pre-entry firm resources and the required resources in an industry, the greater the likelihood that a firm will enter that particular industry, and the greater the likelihood that the firm will survive and prosper. Carroll et al. (1996) also examined the effects of pre-entry experience on the survival of firms in the US automobile industry, and found that automobile producers with prior experience in engine manufacturing have lower death rates than other *de alio* producers.

In the post-war era in Japan, a number of *de alio* entrants entered the motorcycle industry from other industries, including the war industry. While there were some *de alio* entrants from technologically related industries, there were other *de alio* entrants, who have no technological experiences. For example, a number of engine and aircraft manufacturers entered the motorcycle industry, and they tended to have technological experiences closely related to motorcycles. On the other hand, there were some *de alio* entrants without technological experiences, such as those from automobile dealers. In addition, there were *de novo* entrants that have no previous experiences in other industries before entering the motorcycle industry. For example, parent-company spin-offs founded by established firms, entrepreneurial spin-offs, or start-ups entered the motorcycle industry in the early periods.

To examine whether the post-entry performance of firms varies according to their pre-entry experiences in the motorcycle industry, we distinguish motorcycle producers into experienced firms and inexperienced firms in terms of technological relatedness. Most historical studies on the Japanese motorcycle industry argued the importance of engine development in technological competition, and in practice successful motorcycle producers came from engine and aircraft manufacturing. In this study, therefore, firms with previous experiences in engine and aircraft manufacturing are regarded as experienced firms, whereas others are classified into inexperienced firms. Note that there are some firms with unknown pre-entry experiences, and they are classified as firms with unknown background in the analyses. It is predicted that experienced firms tend to have technological advantages at the time of entry than inexperienced firms, and that experienced firms are more likely to survive longer than inexperienced ones.

Also, we examine the role of product quality in explaining the survival of firms. As some studies argued, when dominant design may be not yet emerged, firms may have more opportunities for improvements in the early and formative phases of an industry (e.g., Klepper, 1996). Christensen et al. (1998) also emphasized the importance of technology strategies as predictors of survival in fast-changing industries, using data on the rigid disk drive industry. Banbury and Mitchell (1995) also found that incremental innovations significantly affect the likelihood of business survival. In these respects, it is considered that competition for product quality between firms played an important role in their survival.

To examine whether firms with high quality products performed better than those with low quality ones, we test the effect of product quality on the survival of firms. In the motorcycle industry, competition for engine development has been fairly severe, and firms that was successful in engine development appeared to grow faster than others. Therefore, we predict that firms that can offer high-quality products are more likely to survive longer than firms that do not. In this study, we attempt to measure firm's engine quality as a proxy of product quality. We adopt a similar measure of Yamamura et al. (2005) and measure the engine quality of motorcycles as the horsepower divided by the displacement volume at each year. If a firm offers multiple products in a year, the maximum value of engine quality is regarded as the firm's engine quality in the year. In addition, a firm's engine quality in a year is divided by industry average in the year.

In addition to product quality, we examine the effect of product line length as a product strategy on the survival of firms. In the field of organizational ecology, the niche width of an organization means its variance in resource ulitization (e.g., Hannan and Freeman, 1977). Dobrev et al. (2002, p.236) discussed that organizations pursuing strategies based on operations across a wide range of environmental resources possess a wide or broad niche and would be classified as generalists. Specialists organizations pursue strategies based on operations across a tight band of resources. According to this viewpoint, when environments change in uncertain ways, generalists organizations typically display lower mortality rates than specialists (Freeman and Hannan, 1983).

Also, as discussed by Sorensen (2000, p.577), in uncertain environments, rational managers can use multiple product offerings to gather information about the distribution of consumer preferences. Then, Sorensen also argued that selection amongst these offerings can provide an effective means of aligning the firm's product line with demand. In addition, Forfuri and Giarratana (2007) pointed out that especially in highly dynamic industries, firms might signal an aggressive behavior by entering a large number of product niches. In these respects, firm's decision on product portfolio may be fairly important for survival in the early periods of an industry.

In practice, in the motorcycle industry, while some firms offer motorcycle products in multiple sub-segments in terms of displacement volume, others offer them only in a single sub-segment. In the motorcycle industry during the observation period, motorcycle producers faced demand and technological uncertainty. Therefore, it is predicted that firms with long product-line can avoid more uncertainty and they are more likely to survive longer rather than firms that do not. In this study, the variable for product line length is measured as the counts of sub-segments at each year, by dividing the motorcycle industry into six sub-segments in terms of displacement volume (DV); that is, $\text{DV}\leq\text{50cc}$, $\text{50cc}<\text{DV}\leq\text{90cc}$, $\text{90cc}<\text{DV}\leq\text{125cc}$, $\text{125cc}<\text{DV}\leq\text{250cc}$, $\text{250cc}<\text{DV}\leq\text{400cc}$, $\text{DV}\geq\text{400cc}$. If a firm offers motorcycle products in two sub-segments in a year, the firm's product line length is calculated as two in the year. In addition, a firm's product line length in a year is divided by industry average in the year.

As an additional variable for product strategies, we consider the effect of product-line overlap on the survival of firms. Until now, a number of studies argued that firms' product-line overlap with their rivals is crucial in explaining firm survival. For example, as Dowell (2006, p.964) argued, a new entrant to an industry faces a choice of whether to place itself in a position where its product line faces little overlap from rivals, or where overlap is relatively high. Some firms may choose a position with low overlap to avoid fierce competition between rivals. Alternatively, other firms may prefer a position with high overlap to that with low overlap, because a position with low overlap may indicate less opportunities for growth.

In the motorcycle industry, while there were a great number of firms in some sub-segments, such as 50cc or 125cc, there were few firms in others, such as 400cc or more.

In practice, some firms with low overlap with rivals appeared to survive in the motorcycle industry. The impact of avoiding fierce competition between firms may be larger than that of pursuing growth opportunities. We thus predict that firms whose product lines overlap with their competitors have higher hazard than firms that do not. In this study, the mean count of firms whose sub-segments in terms of displacement volume overlap with the sub-segments of the focal firm, which can change over time. In addition, a firm's product line overlap in a year is divided by industry average in the year. The definitions and summary statistics of these variables are presented in Table 1.

Furthermore, industry-level variables are included in the regressions to control for industry conditions over time. The organizational ecology literature emphasized that founding conditions, especially density measured as the number of firms, are fairly important in explaining the post-entry performance of firms (e.g., Carroll and Hannan, 1989, 2000; Hannan and Freeman, 1984, 1989). On the other hand, in the field of industrial organization, industry's number of firms or concentration is one of major measures regarding the degree of competition, and some studies have examined the effect of concentration on firm survival (e.g., Audretsch and Mahmood, 1994). Therefore, the variable for density at the year of entry is used to control for initial conditions, and density at each year is also included as an independent variable to control for industry conditions over time. In addition, we use the variable for industry growth at each year, which can change over time, to control for changes in market size.

4. Methods

In this section, we explain the methods employed in the analyses for the determinants of firm survival. To test whether firms with different characteristics exhibit different performance in the Japanese motorcycle industry, we adopt the methodology of survival analysis. Following some previous studies, we define the duration of survival t as the period from the year of entry into the motorcycle industry to the year of exit from the industry (e.g., Mata et al., 1995; Buenstorf, 2007).[6] In this study, the duration of survival is only related to the firm's

[6] Honjo (2000a) investigated the determinants of business failure of new firms by estimating a multiplicative hazards model based not only on age but also on calendar time, and argued that calendar time is more suitable than age as the time dimension. Following Honjo (2000a), we also estimated the model based on calendar

activities in the motorcycle industry, and exit does not always mean that the firm has ceased to exist. In the analyses, we use a nonparametric and a semiparametric methods.

4.1. Nonparametric method

By using a nonparametric method proposed by Kaplan and Meier (1958), we estimate the duration of survival.[7] If all the times at which the event occurs in the sample are ordered, and labeled $t_j (j = 1, 2, \ldots, m)$, such that $t_1 \leq t_2, \ldots, \leq t_m$, then the Kaplan-Meier estimator, $\hat{S}(t)$, which is a standard method to estimate the survival function is given by

$$\hat{S}(t) = \prod_{j|t_j \leq t} \left(1 - \frac{d_j}{n_j}\right), \tag{1}$$

where d_j is the number of individuals who experience the event at time t_j, and n_j is the number of individuals who have not yet experienced the event at that time and therefore still "at risk" of experiencing it (including those censored at t_j). Here, let d_j denote the number of firms that exit the motorcycle industry at time t_j. Also, let n_j denote the number of firms that do not yet exit the motorcycle industry at t_j and therefore still 'at risk' of experiencing it.

To show differences in the duration of survival between firms, we divide the full sample into subsamples and examine whether the survival functions differ according to firm-specific characteristics. In addition, we test the equality of survival functions between subsamples by using a log-rank test and a Wilcoxon test.

4.2. Semiparametric method

Using a proportional hazards model proposed by Cox (1972), we attempt to identify whether the covariates affect the hazard of firms.[8] The proportional hazards model is well-known as a semiparametric approach for survival data, and particularly it is useful to show the effects of covariates on the hazard of individuals. In the proportional hazards model, the hazard

time, but the result was generally similar to that based on age.

[7] For more discussion on nonparametric methods, see, for example, Klein and Moeschberger (2003) and Rabe-Hesketh and Everitt (2007).

[8] We also estimated discrete-time duration models to examine the effects of covariates on the hazard rates. Estimation results were almost consistent with those with continuous-time duration models.

function that represents the instantaneous failure rate, $h(t; \boldsymbol{x}_i)$, is assumed to be

$$h(t; \boldsymbol{x}_i) = h_0(t)\exp(\boldsymbol{\beta}^T \boldsymbol{x}_i), \tag{2}$$

where $h_0(t)$ is the baseline hazard function, $\boldsymbol{\beta}$ is a vector of parameters to be estimated, and $\boldsymbol{x}_i$ is a vector of covariates for individual i. With respect to our analysis, it should be noted that part of covariates can change over time. Let $t_1 < t_2 < \cdots < t_k$ denote the ordered event times during the observation period, and R_i is a set of individuals who have not yet experienced the event before just prior to time t_i.[9] That is, R_i indicates firms that continue to survive until firm i exits. To estimate the parameters, the partial likelihood, $L(\boldsymbol{\beta})$, is given by

$$L(\boldsymbol{\beta}) = \prod_{i=1}^{k} \frac{h(t; \boldsymbol{x}_i)}{\sum_{j \in R_i} h(t; \boldsymbol{x}_j)} = \prod_{i=1}^{k} \frac{\exp(\boldsymbol{\beta}^T \boldsymbol{x}_i)}{\sum_{j \in R_i} \exp(\boldsymbol{\beta}^T \mathbf{x}_j)}. \tag{3}$$

The log-likelihood function is written as

$$\log L(\boldsymbol{\beta}) = \sum_{i=1}^{k} \left[\boldsymbol{\beta}^T \boldsymbol{x}_i - \log \sum_{j \in R_i} \exp(\boldsymbol{\beta}^T \mathbf{x}_j) \right]. \tag{4}$$

Maximizing $\log L(\boldsymbol{\beta})$ gives the estimated parameters without specifying a function form of $h_0(t)$.

5. Empirical results

In this section, we present the estimation results using the nonparametric and semiparametric methods. First, we estimated the survival functions for the survival of motorcycle producers using the Kaplan-Meier method. To show how the duration of survival varies according to firm-specific varibles, we compare the Kaplan-Meier survival estimates, dividing the full sample into three subsamples.

The Kaplan-Meier survival estimates for the full sample are shown in Figure 3 (a). We show the survival estimates by firm-specific variable in Figure 3 (b)–(f). In Table 2, we show the survival estiamtes at selective years both for the full sample and for subsamples by firm-specific variable. In Table 2, we also estimated the mean duration of survival of motorcycle

[9] Here, simultaneous events are ignored, but the approximated formulations to calculate the likelihood function are established by some previous studies. In this study, the Breslow's (1974) approximation method is used.

producers. In addition, Table 2 shows the log-rank and the Wilcoxon tests for equality in the survival estimates between subsamples. In Table 3, we show the estimation results using the proportional hazards model. Because of the correlations between product line length and product line overlap, we show additional estimation results without parts of those variables in Table 3 (ii)–(iv). Also, the estimation result without industry-level covariates is shown in Table 3 (v).

To examine whether order-of-entry affects firm survival, the full sample is grouped into three subsamples according to the order of entry; that is, firms that entered the motorcycle industry until 1951, firms that entered the industry from 1952 to 1954, and firms that entered the industry after 1954. Figure 3 (b) describes the survival functions by the order of entry. As shown, earliest entrants have the highest survival rates, and this suggests that earlier entrants are more likely to survive for longer periods. In Table 2, the equality tests also indicates that the survival estimates vary significantly across the subsamples. In Table 3, we examine the effect of order-of-entry measured as entry year minus 1946, which corresponds to the inception of the industry, on the hazard rates. The coefficients of this variable are significantly positive in any models of Table 3. This indicates that order-of-entry is still important in firm survival while controlling for other factors. This result is generally consistent with some previous studies, including Klepper and Simons (2000).

With respect to pre-entry experience, Figure 3 (c) suggest that experienced firms tend to survive longer than inexperienced firms. As shown in Table 2, this finding is statistically significant and consistent with some previous studies, including Carroll et al. (1996). The finding of Table 3 is also consistent with that of the nonparametric method. Therefore, this result suggests that firms with previous experience in engine and aircraft manufacturing had technological advantages at the time of entry, compared to firms without technological experiences.

As for the variable for product quality, Figure 3 (d) indicates the Kaplan-Meier survival functions by product quality. In Figure 3 (d) and Table 2, the full sample is roughly equally divided into three subsamples according to product quality at the year of entry; that is, high, moderate and low quality. As shown in Figure 3 (d) and Table 2, firms with high quality tend to survive longer than those with moderate and low quality. In Table 2, the equality tests also indicate that the survival estimates are significantly different between the three subsamples. Table 3 indicates that product quality has negative effects on the hazard rates, suggesting that offering high quality products over time increases the likelihood of survival. The finding suggests that firms with low product quality were forced to exit the industry, and that competition for engine quality played an important role in firm survival.[10] This result is also generally consistent with that of Yamamura et al. (2005).

In addition to product quality, Figure 3 (e)–(f) indicates the survival estimates by product line length and product line overlap in terms of displacement volume, respectively. In Figure 3 (d)–(f) and Table 2, the full samples are roughly equally divided into three subsamples according to product line length and product line overlap at the year of entry, respectively; that is, long, moderate and short product-line for product line length, and large, moderate and small overlap for product line overlap. Figure 3 (e) and Table 2 indicate that the survival estimates are significantly different between the three subsamples, and firms with long product-line tend to survive longer. At the same time, Figure 3 (f) and Table 2 indicates that firms with small overlap tend to survive longer than those with large overlap with rivals. The results of Table 3 generally support those of the nonparametric method, although the coefficients of the variable for product line overlap are not significant in models with the variable for product line length. These results suggest that broadening product-line and avoiding product-line overlap with rivals over time have significantly positive influence on firm survival.

With respect to the effects of industry-level covariates, Table 3 indicates that both density at the time of entry and density at each year have significantly positive effects on the hazard rates. The finding is consistent with the argument of organizational ecology literature. Table 3 also indicates that industry growth has a significantly positive effect on the hazard rates. The finding suggests that firms are likely to face higher hazard rates in the growing phase of the industry.

[10] Kato (2008) also provided evidence that the market share of Honda increased considerably from the middle of 1950s, and it was caused by the introduction of epoch-making new product, 'Honda Super Cab,' which had the highest quality of engine at that time. In practice, Kato (2008) found that Honda's relative product quality tended to increase clearly from the late 1950s, which corresponds to the period of the emergence of Super Cab. In addition, as Demizu (2002) argued, the engine quality was extraordinarily high compared to other motorcycles, and then became a fairly popular motorcycle in Japan at that period.

6. Conclusion

This paper explore firm survival and the evolution of market structure in the Japanese motorcycle industry over the period 1946–1965. To examine the causes of a shakeout of producers, we conduct a survival analysis for the determinants of firm survival. We provide evidence that not only "at entry" conditions but also firms'product strategies have significant effects on firm survival. The findings indicate that order-of-entry and pre-entry experience significantly affect the duration of survival, and that early and experienced entrants tend to survive longer. As for product strategies, we found that offering high-quality products, broadening product-line, and avoiding product overlap with rivals have significantly positive influence on firm survival.

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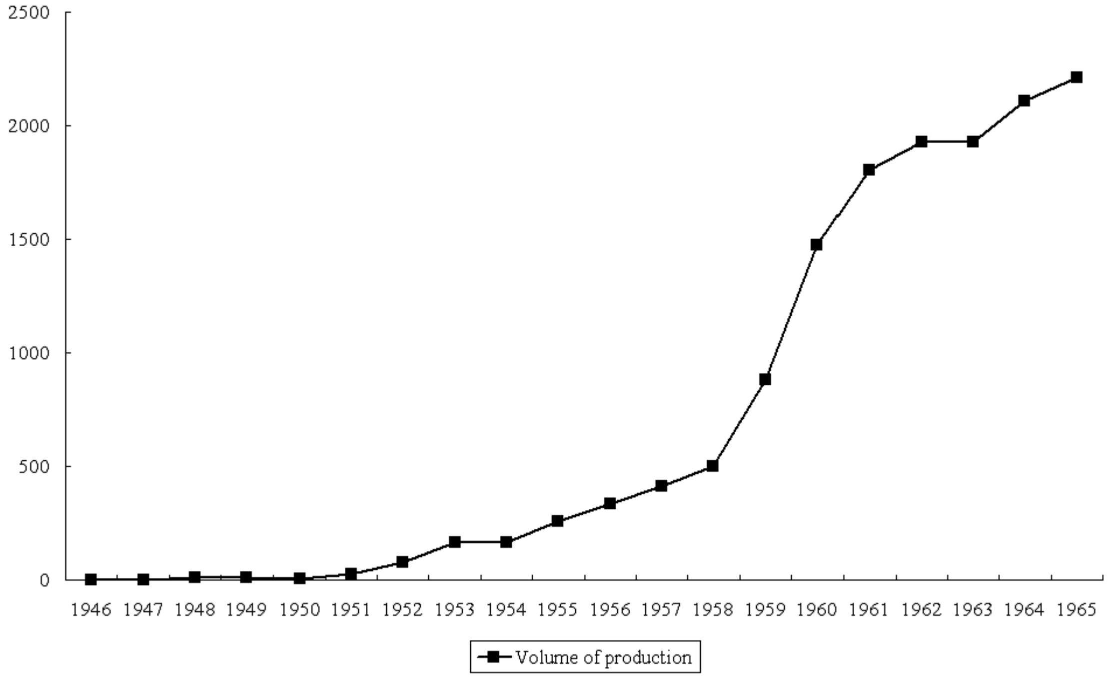

Figure 1: Volume of production in the Japanese motorcycle industry, 1946–1965 (thousand motorcycles)

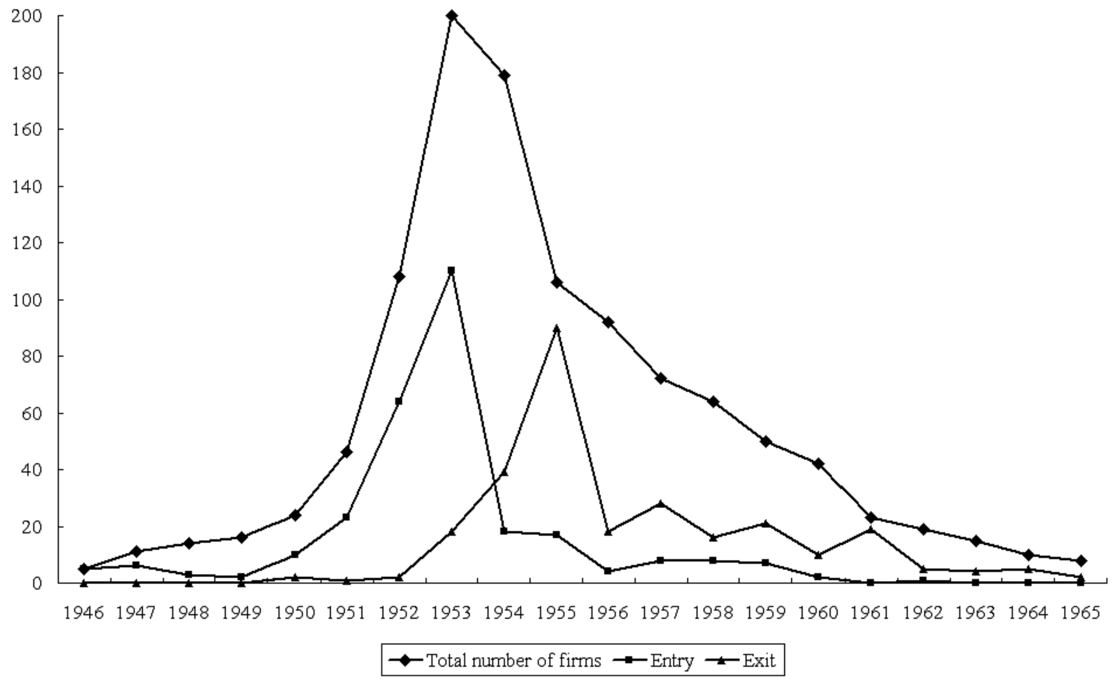

Figure 2: Entry, exit, and total number of firms in the Japanese motorcycle industry, 1946–1965

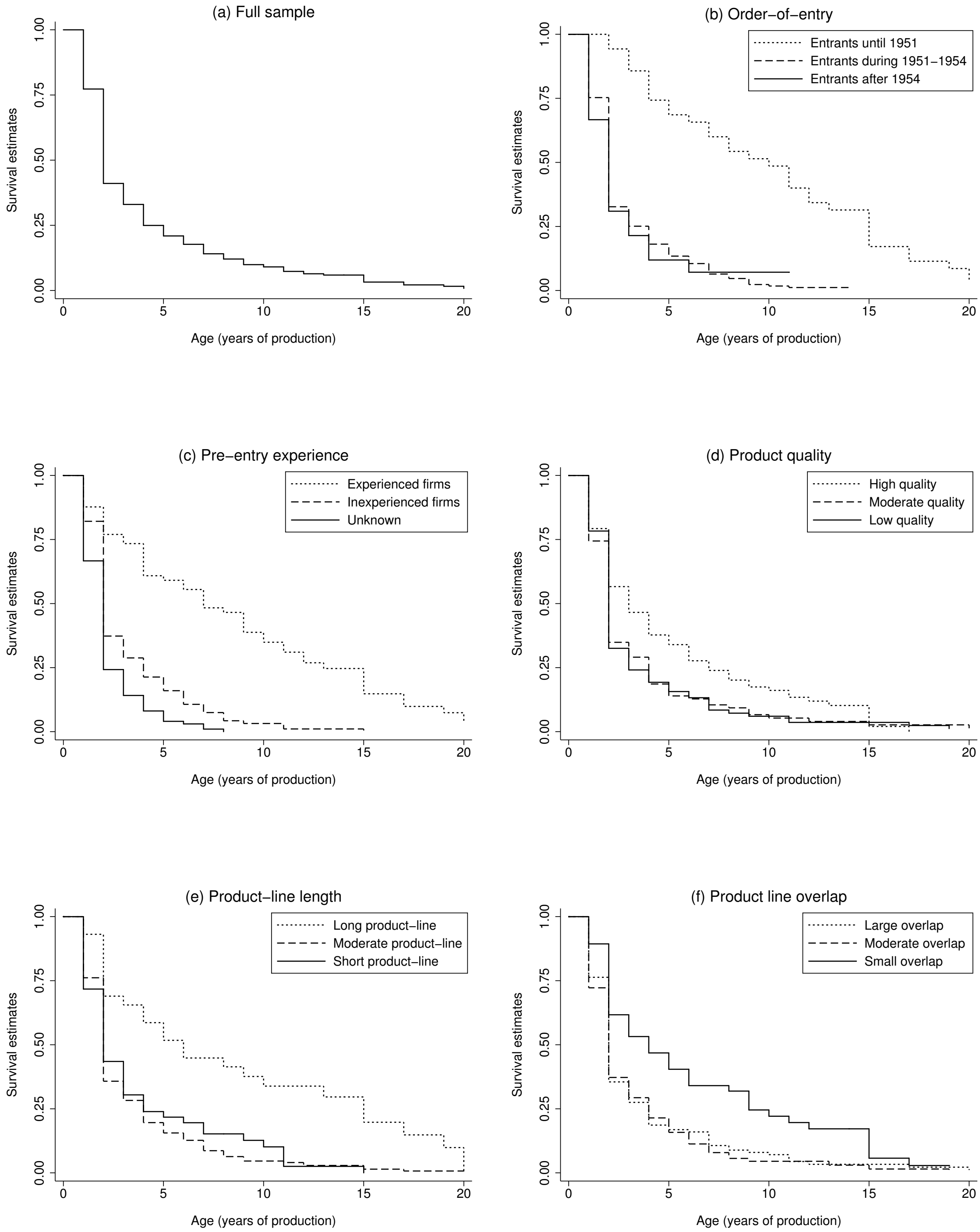

Figure 3: Kaplan-Meier survival estimates

Table 1: Definition and descriptive statistics for covariates.

Covariate	Definition	Mean	S.D.
Order-of-entry	Entry year minus 1946.	5.638	3.014
Experienced firms	Dummy variable: 1 if having any technological experience in motor vehicles before entering the motorcycle industry, 0 otherwise.	0.461	0.499
Unknown background	Dummy variable: 1 if background before entering the motorcycle industry is unknown, 0 otherwise.	0.227	0.419
Product quality	Horsepower divided by displacement volume, adjusted by industry average, at each year.	1.005	0.262
Product line length	Counts of sub-segments in terms of displacement volume, adjusted by industry average, at each year.	1.001	0.451
Product line overlap	Mean number of firms whose sub-segments in terms of displacement volume overlap with the sub-segments of the focal firm, adjusted by industry average, at each year.	1.000	0.317
Density	Number of firms at each year.	84.83	61.07
Density at entry	Number of firms at entry.	94.37	55.29
Changes in market size	Difference of industry's volume of production, divided by the volume of production, at each year.	0.555	0.813

Note: S.D. indicates standard deviation.

Table 2: Summary statistics for Kaplan–Meier survival estimates by subsample.

Subsample	Survival rates after				Duration
	1 years	2 years	5 years	10 years	
(Order-of-entry)					
Entrants until 1951	1.000	0.943	0.686	0.486	10.3
Entrants during 1952-1954	0.753	0.327	0.134	0.018	3.0
Entrants after 1954	0.667	0.310	0.119	0.071	3.1
Log-rank test: $\chi^2 = 58.35^{***}$. Wilcoxon test: $\chi^2 = 51.95^{***}$					
(Pre-entry experience)					
Experienced firms	0.877	0.770	0.591	0.349	8.7
Inexperienced firms	0.821	0.373	0.160	0.032	3.2
Unknown	0.667	0.242	0.040	0.000	2.2
Log-rank test: $\chi^2 = 79.84^{***}$. Wilcoxon test: $\chi^2 = 52.47^{***}$					
(Product quality)					
High quality	0.793	0.567	0.340	0.161	5.1
Moderate quality	0.744	0.349	0.140	0.053	3.5
Low quality	0.783	0.325	0.157	0.060	3.4
Log-rank test: $\chi^2 = 7.07^{**}$. Wilcoxon test: $\chi^2 = 8.25^{**}$					
(Product line length)					
Long product line	0.931	0.690	0.517	0.339	8.5
Moderate product line	0.761	0.358	0.156	0.046	3.3
Short product line	0.717	0.435	0.217	0.101	3.7
Log-rank test: $\chi^2 = 22.34^{***}$. Wilcoxon test: $\chi^2 = 16.65^{***}$					
(Product line overlap)					
Large overlap	0.763	0.355	0.169	0.071	3.6
Moderate overlap	0.722	0.372	0.158	0.045	3.3
Small overlap	0.894	0.617	0.404	0.221	6.4
Log-rank test: $\chi^2 = 14.39^{***}$. Wilcoxon test: $\chi^2 = 13.98^{***}$					
Full sample	0.773	0.411	0.210	0.091	4.0

Notes:

1. N indicates the number of industries.
2. ‘Duration’ represents the mean duration of survival, measured by extending the survival estimates from the largest observed year to zero using an exponential survival function.
3. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Estimation results: a proportional hazards model.

Covariate	(i)	(ii)	(iii)	(iv)	(v)
Order-of-entry	0.275***	0.271***	0.318***	0.273***	0.109***
	(0.043)	(0.042)	(0.041)	(0.043)	(0.026)
Experienced firms	−0.735***	−0.735***	−0.946***	−0.760***	−0.850***
	(0.180)	(0.179)	(0.186)	(0.179)	(0.175)
Unknown background	0.346***	−0.367***	0.324***	0.351***	0.359***
	(0.095)	(0.097)	(0.092)	(0.094)	(0.105)
Product quality	−0.574**		−0.978***	−0.576**	−0.529***
	(0.248)		(0.242)	(0.245)	(0.254)
Product line length	−1.260***	−1.403***		−1.274***	−1.015***
	(0.254)	(0.251)		(0.251)	(0.226)
Product line overlap	0.220	0.224	0.335*		0.196
	(0.167)	(0.163)	(0.191)		(0.172)
Density	0.011***	0.010***	0.010***	0.011***	
	(0.002)	(0.002)	(0.002)	(0.002)	
Density at entry	0.003**	0.003***	0.002**	0.003**	
	(0.001)	(0.001)	(0.001)	(0.001)	
Changes in market size	0.696***	0.682***	0.701***	0.695***	
	(0.084)	(0.084)	(0.083)	(0.084)	
Wald χ^2	173.71***	168.79***	157.41***	175.40***	138.60**
Log pseudolikelihood	−1071.768	−1073.593	−1083.602	−1072.269	−1092.567
Number of firms	251	251	251	251	251

Note:

1. Standard errors adjusted for 251 clusters are in parentheses.
2. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.