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Survival of Firms over the Product Life Cycle*

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I. Introduction

While entry and exit of firms have for long been recognized as two of the major determinants of market structure, empirical work on the subject has lagged behind for lack of adequate data. Of late, access to new data bases and the increasing use of Census of Manufactures data have enabled researchers to investigate the entry and exit of firms as well as their performance subsequent to entry. Dunne, Roberts and Samuelson use Census data for U.S. manufacturing industries [11; 12], while Baldwin and Gorecki do the same for Canadian manufacturing industries [7]. Some studies have used Small Business Administration data to track survival of firms over a ten year period [4; 5; 23; 25]. Survival of firms has also been studied as a side issue to growth of firms [16; 13]. While more is known now than ever before on survival of firms subsequent to their entry, most of the studies are cross sectional in nature and also consider entire industries rather than product markets where the actual entry and exit of firms occur. This study focuses on firm survival in product markets over the span of life of the product and considers the impact of firm attributes and the effect of evolution of markets on firm survival.

A review of the relevant literature is presented in section II. Section III highlights the stylized facts that arise from the theoretical models emphasizing firm heterogeneity and evolution of product markets. Section IV is a brief description of the data used for the empirical analysis. Sections V and VI test the hypotheses regarding the effect of various evolutionary and firm attributes on survival of firms. Conclusions, a summary of the results and the limitations of the study are presented in section VII.

II. A Brief Review

Jovanovic modeled firm growth and survival as a function of the efficiency level of the firms [18]. Firms differ in efficiency levels, which implies that they incur different costs for producing the same levels of output. A firm, characterized by unknown type \( \theta \), cannot generally observe its true cost but can only learn about it gradually through production. A higher \( \theta \) implies higher costs, and hence inefficiency. Since output \( (q) \) is a decreasing function of \( \theta \), firms exit the market if they fall below a certain level of output. Also, the longer a firm has operated in the market, the more

*I would like to acknowledge Michael Gort, Stephen Shmanske, and an anonymous referee for their helpful comments. All remaining errors are mine.
information it has gathered about $\theta$, and hence, the less likely it is to fail. The model thus predicts that firm survival will increase with age and with size (level of output produced) of firm.

Supporting evidence to this hypothesis has been found by various researchers. Dunne, Roberts and Samuelson use *Census of Manufactures* data for the 1972–1987 period and find a positive relation between firm age and survival throughout the observed age range [12]. Baldwin and Gorecki consider entry in Canadian manufacturing industries within the 1970–81 period, and find high infant mortality among entrants, but a significant percentage of the entrants are still alive after a decade [7]. Hazard rates—the probability of failure conditional on age—decline with age. Phillips and Kirchhoff use Small Business Administration data and find that six-year survival rates differ across major sectors, varying from a high of 46.9 percent in manufacturing to a low of 35.3 percent in construction [25]. They find survival rates more than double for firms that grow, and increase with age. Audretsch studies 11,000 firms from manufacturing over a ten year period using Small Business Administration data. His results too confirm the hypothesis that survival of firms increase with age [4]. Audretsch and Mahmood also test hypotheses regarding growth that are generated from the Jovanovic model and find a positive relation between growth of firms and survival [5].

Jovanovic’s model of noisy selection, however, assumes no technological progress. Hence, there is no scope in the model for changes in market conditions. Dosi, Marsili, Orsenigo and Salvatore have criticized the Jovanovic approach for “maintaining stationary fundamentals” while recognizing the evolutionary pattern of learning and market selection among heterogeneous firms [10]. The model is unrealistic over an extended span of time because it does not allow for a mutation of the environment in which firms operate and compete. The changing market structure—attributed by many as chiefly due to technological activity—is more the norm rather than the exception of modern product markets. Jovanovic and MacDonald model the life cycle of a competitive industry where firms are classified as low-tech if they employ the initial innovation, and high-tech if they adopt the final refinement. The industry evolves as more firms become high tech. Product quantity increases and price declines. The model predicts catastrophic exit of firms if price declines rapidly, and gradual exit if slowly [20].

Strong empirical evidence on the evolutionary phenomena is presented by Agarwal who studies 33 product markets and shows the evolution of product markets through regularities in the time paths of key industry variables like product price, quantity, patenting activity and number of firms [1]. Gort and Klepper distinguish among five stages in the development of a product market based on net entry [15]. This work is further extended by Agarwal and Gort, who decompose the stages by gross entry and exit. The technological conditions as well as demand differ across these stages [2]. The stages also relate to the concept of technological—entrepreneurial and routinized—regimes of Nelson and Winter, and Winter [24; 29].

There is also some evidence regarding the impact of technological activity on firm survival. Audretsch finds an increase in small firm survival within an entrepreneurial regime, defined by a high small firm innovation rate relative to total innovation rate [4]. Mahmood investigates the difference of hazard rates across low and high-tech industries, and finds them to be different [23]. No test is conducted though, to see if inter-group variation exceeds within group-variation, so one cannot surmise the extent and the sign of the difference. Investigating the impact of variables that include startup size, scale economies and market growth, Mahmood finds that start-up size reduces hazard rate in both types of industries, while presence of scale economies have a positive effect on survival in high tech industries. Market growth is not seen to significantly affect survival in either group in his study.
Related literature on organizational ecology/evolution [3; 8; 14; 17] consider chiefly the effect of the number of firms on firm survival. As an industry evolves and the number of firms increases, political and social legitimacy increase the probability of survival of firms, but competition due to an increasing number of firms cause survival rates to decline. The literature, however, is lacking in precise definitions of political and social legitimacy, and does not rigorously establish the ways in which these variables affect the probability of survival. While the mortality rates of the firms are explicitly “age-dependent” and high for young firms, Carroll and Hannon find survival of entry cohorts affected by their time of entry. They hypothesize that the number of firms at the time of entry of a firm has a positive effect on its hazard rate. Their empirical results—based on five case studies of “organizational populations”—seem to confirm the hypothesis [8].

III. Stylized Facts

This section formulates some stylized facts that emerge from the literature on firm heterogeneity and product evolution. The theoretical models coupled with evidence of empirical regularities suggest the following.

The market is introduced after a major invention which spawns future avenues for technological activity. Technology increases demand both due to increases in scope of application and increases in the quality of product, and increases supply of the product due to increase in the number of firms and process innovations. Technology advances due to the innovative effort of firms. Major applications and avenues are adopted first, and later innovations render earlier innovations obsolete. The technology frontier is increasing (though possibly at a decreasing rate), as is the lower bound of technologies used in production. Informational barriers to technology imply that firms cannot switch technologies costlessly. As a result, only a fraction of the firms (new entrants and incumbents) adopt the frontier technology. These fractions may increase with time as imitation becomes easier and as increasing competitive pressures force firms to either exit the market or stay near the technology frontier. The race of technological activity ends/slow down after the development of a dominant product design.

Profit maximizing firms choose to stay in operation in a period if their profit is above their opportunity cost. The price in the period \( t \) reflects the evolutionary stage in the product cycle. It is a function of a change in demand and supply caused by the introduction of the frontier technology at time \( t \), and the existing number of firms. The growth in demand affects price positively, but an increase in the number of firms and the effect of innovative activity on supply cause a downward pressure on price. The sequence of prices could hence either increase or decrease. Agarwal presents strong empirical evidence that product price declines over the product life cycle [1].

A firm's costs are a function of its initial endowments, the technology it currently uses, and the success with which it manages to adapt them to the changing circumstances of the market. A firm has either the choice of maintaining the current technology level, or innovating/imitating to stay close to the frontier level of technology. If the firm maintains its current technology level, it increases the risk of failure as the lower bound of existing technologies is increasing over time. While there are advantages to adapting constantly to the new technological environment, a firm is restricted in its ability to do so by its initial endowments or its idiosyncratic characteristics. Some firms are better able to adapt than their cohorts in terms of time of entry and technology used. The adaptability of the firm to changing market conditions is assumed first to increase and then decrease with age [2]. This is because continued production in the market will cause the firms to
perform better; additional experience cannot adversely affect firm performance. However, beyond a certain level senility sets in, which implies a growing inability to adapt initial endowments to vastly different sets of circumstances.

The firm's profitability is captured by the change in the environment due to the technological activity and its own technology level, initial endowments and the ability to adapt to changing circumstances. In any period, a firm using a particular technology level will exit if it falls below the lowest technology level for which the opportunity cost of staying in the market is equal to profits earned. The survival of a firm is then a function of evolutionary variables such as changes in demand and supply, number of firms and range of technologies currently being used, as well as firm specific attributes.

IV. Data Description

Data on the entire inventory of firms that entered, survived and exited within 33 product markets are compiled from the time of birth of the product to 1991 from the Thomas Register of American Manufacturers [28]. Lavin in extensively describing various sources of business information, states that the Thomas Register is the best example of a directory which provides information on manufacturers by focusing on products. According to Lavin, "The Thomas Register is a comprehensive, detailed guide to the full range of products manufactured in the United States. Covering only manufacturing companies, it strives for a complete representation within that scope" [21].

A total of 3,435 firms are pooled across products for the survival analysis. Firms are subjected to checks to ensure actual entry rather than a renaming/relocation of existing firms. A change in the name of the firm is tracked by checking its address, and vice versa for a change in address. A change in both name and address, however, is treated as a new entry, since no other checks are possible for verifying prior existence. The margin of error is assumed to be small for such cases. Mergers between two firms are treated as an exit of the smaller and continuance of the larger firm.

The Thomas Register also lists the asset size of the firm. Firms are categorized as small, medium or large size, and the boundaries of the classes are adjusted over time to account for inflation. Growth of the firm over its lifetime is measured as the difference between the categorical initial size of firm and the size of firm prior to its exit. Firms that have the same size at time of entry and prior to exit have a growth index of 0. Small sized firms at time of entry who exited as medium sized firms, and medium sized firms that exited as large sized firms have a growth index of 1. An index of 2 captures the growth of small sized firms to large firms before their

1. For the product list, see Agarwal [1]. The products are chosen to be representative sample including consumer, industrial and military products. The earliest product market is Phonograph Records (1908), while the most recent market is Video Cassette Recorders (1974).

2. The importance of imports in manufacturing has increased over the last few decades. The Thomas Register includes foreign manufacturers of the product if the firm maintains an office or distribution channel for its product in the United States.

3. For instance, a firm (AMETEK) dropped out of a market in the same year that another firm appeared in the same city and state with a slightly different street address. An inspection of the name KETEMA confirmed the idea that it was one and the same firm (Ketema is an anagram (spelled backwards) of Ametek).

4. Some of the acquisitions represent failing firms, while others may be highly successful. Data limitations do not allow us to make a distinction between the two types of firms. To the extent that the newly created firm represents the capitalized value of both firms that merged, the survival rates would reflect the attributes of both firms.
exit. The Alphabetical listing of the Thomas Register is used to obtain information regarding the diversification code for the firm. The diversification index of a firm is 1 if the firm is listed in the Alphabetical Index in the year prior to its entry into the relevant product. If the firm did not operate in any other product market in the prior year, it has a diversification index of 0.

V. Survival of Firms and Stage of Evolution

Gort and Klepper, and Agarwal and Gort develop the following stylized facts about the relation of stage of development and underlying demand, supply and technological variables [15, 2]. Stage 1 is the period immediately after the introduction of a new product, characterized by few producers. Stage 2 is a period where the number of firms in the product is increasing, and it represents the period of rapid growth in both supply and demand of the product. According to Gort and Klepper, this stage is characterized by innovations of a fundamental nature. Agarwal and Gort show that gross entry reaches its peak early in stage 2, and the number of firms is increasing with time. Exit of firms is initially slow, but towards the end of the stage, there is a substantial increase in the exit rate, partly because of the population increase, and partly because of increase in competitiveness among firms. Stage 3 is the intermediate phase that reflects a temporary equality between a decreasing entry rate and an increasing exit rate. Stage 4 is the shake-out period characterized by a decreasing number of firms in the product market. A decrease in the growth of demand, and market saturation may be a plausible reason for firms that may have earlier been sheltered by a high price cost margin to exit. Gort and Klepper offer evidence that innovations are minor in this stage, mostly of the product enhancement type. Stage 5 is the mature phase in the market. No consistent trends in net entry are observable as gross entry and exit are erratic, having already passed their peaks in stages 2 and 4 respectively. To summarize the findings of Gort and Klepper and Agarwal and Gort, price cost margins are expected to be high in stages 1 and 2, partly because the competition in the newly developed product market is low, and partly because of a rapid growth in demand. Stages 3 and 4, on the other hand, experience the opposite set of circumstances. Firms in these stages find their profit margins squeezed by increasing competition and a decline in growth rate of demand as the market approaches saturation [2, 15]. The time trends of the industry variables also lend support the above stylized fact, since one observes declines in the rate of decay of price and the growth of quantity over time. Patenting activity declines in the later years of the life cycle, and the number of firms also follow a time trend consistent with the stylized fact [1].

The analysis of the effect of evolutionary variables such as changes in demand and supply and technological advance on survival of firms is simplified by using the stages in the product life cycle as proxies for the changes in the evolutionary variables.5 The above stylized fact implies that survival of firms is negatively related to the stage of product market at time of entry, at least until stage 4.

In order to test this hypothesis, the study considers both the survival rate of entrants in each stage as well as their hazard rate. A $\tau - 1$ year survival rate for a stage is defined as the fraction of the total number of entrants in the stage that survived at least $\tau$ years. The hazard rate gives the number of firms that die conditional on their age, i.e., it represents the probability of failure given

5. For a description of the decomposition of the years within the product life cycle into stages of evolution with the use of discriminant analysis, see Gort and Klepper [15] and Agarwal and Gort [2].
that the firm has survived $\tau$ years. The survival rate will, hence, give the instantaneous impact of stage on survival, while the impact of a stage on entrants in earlier stages can be surmised by the pattern followed by the hazard rate.

Table I shows the 4 and 12 year survival rate of firms by stage of entry and the results of three tests of homogeneity of survival rates (for all $\tau$) across stages. It confirms the hypothesis that stage of entry has a negative impact on survival. Survival rates of entrants in later stages are significantly lower than those of earlier entrants, and the tests strongly reject the hypothesis of homogeneity of survival rates across stages. Stage 5 shows an increase in survival rates relative to stage 4, which is also consistent with the hypothesis since the stylized facts in the evolutionary literature show competitive intensity to be highest in stage 4. The higher survival rates of stage 2 entrants lend support to the hypothesis that survival is higher when industries are growing more rapidly, and is consistent with the results of Audretsch and Mahmood [5].

It is also interesting to note that a significant percentage of entrants—across all stages—exist even 12 years after entry. Phillips and Kirchhoff discuss the common assumption that starting a new business involves high risk. They refer to the quote: "Four out of five new firms fail in the first five years," a statement of unknown source with little empirical evidence to support it [25]. As can be seen in Table I, even in stage 4—where entrants have the lowest survival rate—at least 70 percent of the entrants live for four years. Earlier entrants enjoy still higher probabilities. The results lend support to Phillips and Kirchhoff's claim that entrants indeed do not suffer from a high risk of failure. The results are also consistent with those of Baldwin and Gorecki [7]. Although they did find high infant mortality, Baldwin and Gorecki show that a significant percentage of entrants were still alive after a decade.

Hazard rates are used to test the hypothesis of age of firm and mortality, and the effects of product evolution. Table II gives the moving average of hazard rates (in percentage terms) at 4 year intervals. A three period moving average is used to eliminate erratic behavior and focus on
the trend of the hazard rates. According to the stylized facts, hazard rates of entrants in the early stages (i.e., stage 1 or 2) should reflect the increase in competitive intensity faced by firms that survive to the later stages (stage 4 or 5). Product or stage attributes should dominate over the effect of firm attributes/initial endowments. A firm that entered in stage 1 would chronologically experience the impact of stage 4 product characteristics only if it survived to that stage.

Agarwal and Gort show that a firm entering in stage 1 will experience stage 4 on an average between the age of 24 to 35 [2]. As Table II and Figure 1 show, the hazard rates for stages 1 through 3 show the impact of stage attributes on survival of firms through an increasing hazard rate. The hazard rate in stage 1 reaches a peak at age 26 while the hazard rate for stage 2 reaches a peak at age 18. Firms that enter in the later stages experience their peak hazard rate at the onset itself. The results seem to show that there is indeed an advantage to early entry, in terms of lower initial hazard rates. Further, the peak level attained by the hazard rate is also seen to increase over the stages, which implies that in general, the probability of failure is lower across all ages for earlier entrants. This lends support to Jovanovic and Lach’s hypothesis that early entrants enjoy the advantage of higher per unit revenue, at least in the initial period of the product cycle [19].

Consistent with other studies [5; 12; 23; 25], once the industry effects are accounted for, the hazard rate declines with age. The data also allows for the exploration of the pattern of hazard rate for a longer period than the above mentioned studies. Hence, one can observe the point where the effect of senility sets in. The shape of the hazard rate is also consistent with the hypothesis that initial endowments of the firm affect the probability of survival. The declining and then increasing hazard rate reflects the initial success of firms in adapting endowments to changing market conditions, followed by the onset of senility. The analysis also shows the robustness of the results of Agarwal and Gort to an increase in number of products and hence number of firms in the study [2].

Table II. Moving Averages of Hazard Rates by Stage of Product Cycle*

<table>
<thead>
<tr>
<th>Age Midpoint</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4.34</td>
<td>5.99</td>
<td>7.90</td>
<td>8.10</td>
<td>6.55</td>
</tr>
<tr>
<td>10</td>
<td>3.81</td>
<td>6.73</td>
<td>9.35</td>
<td>7.80</td>
<td>6.37</td>
</tr>
<tr>
<td>14</td>
<td>3.58</td>
<td>6.68</td>
<td>8.23</td>
<td>6.72</td>
<td>6.45</td>
</tr>
<tr>
<td>18</td>
<td>3.82</td>
<td>6.73</td>
<td>6.39</td>
<td>5.65</td>
<td>6.11</td>
</tr>
<tr>
<td>22</td>
<td>3.69</td>
<td>6.35</td>
<td>3.48</td>
<td>4.79</td>
<td>6.75</td>
</tr>
<tr>
<td>26</td>
<td>5.01</td>
<td>5.55</td>
<td>4.84</td>
<td>3.36</td>
<td>n.a.</td>
</tr>
<tr>
<td>30</td>
<td>3.81</td>
<td>6.10</td>
<td>3.80</td>
<td>1.59</td>
<td>n.a.</td>
</tr>
<tr>
<td>34</td>
<td>3.19</td>
<td>6.04</td>
<td>n.a.</td>
<td>1.59</td>
<td>n.a.</td>
</tr>
<tr>
<td>38</td>
<td>2.70</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.38</td>
<td>n.a.</td>
</tr>
<tr>
<td>42</td>
<td>4.52</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>46</td>
<td>3.84</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>50</td>
<td>3.13</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Source: Based on data compiled from the Thomas Register of American Manufacturers.

*Hazard rates are defined as percent of firms that die conditional on age over four-year intervals. The moving averages are calculated using the hazard rates from three consecutive intervals.

n.a.: not available. When an age interval contains more censored observations than actual exit of firms, the hazard rate reported by life table analysis is not an accurate indicator of the actual risk of death.
VI. Survival, Stage and Firm Attributes

This section turns to firm attributes as explanatory variables of firm survival. Observed firm characteristics are used as proxies for their endowments. Initial firm size and degree of diversification represent initial endowments. The superiority of a firm can further be deduced from its ability to grow and its continued existence. The size of the firm prior to its exit from the product market serves not only as the instantaneous explanatory variable for survival, coupled with size at time of entry, it also gives the measure of growth. These measures of initial endowments and firm heterogeneity are well established in the literature. When discussing the results, the findings of this study are compared with those of other researchers and interpreted for similarities and differences. The Cox proportional hazards method [22] is used to estimate the parameters of the model. The model allows for censored observations, i.e., firms that have not exited the product market by 1991. The hazard function of a firm $h_f(t)$ is expressed as:

$$h_f(t) = h(t; x_f) = h_0(t) \exp(x_f \beta)$$
where \( h_0(t) \) is an arbitrary and unspecified baseline hazard function, \( x_f \) is a vector of measured explanatory variables for the \( f \)th firm, and \( \beta \) is the vector of unknown regression parameters to be estimated.

The Cox regression method is invalid if firms do not have the same baseline hazard function \( h_0(t) \). It is clear from Figure 1 that the hazard rates in each stage are significantly different. Separate regressions are hence conducted for each of the stages in the product lifecycle. Further, there are two separate expositions of the effect of firm attributes on survival for each stage. Since growth is a linear combination of entry and exit size, regression A for each stage looks at the effect of entry and exit size, and diversification on hazard rates, while regression B considers the combination of entry size, diversification and growth. This allows for the isolation of the effects on survival of growth from the scale of production. Table III reports the maximum likelihood estimates of the parameters and the risk ratios of the Cox regression model for each stage. A positive sign of the parameter implies that the variable would increase the hazard rate (decrease survival rate). A risk ratio less than 1 implies that an increment in the value of the explanatory variable will cause the hazard rate to decrease, while a risk ratio greater than 1 implies an increase in the hazard rate for a unit increase of a variable.

Clearly, the stage of evolution systematically affects the parametric relationship between firm attributes and survival. The global hypothesis that the explanatory variables do not matter is strongly rejected (\( p \)-value of 0.0001) for each of the stage regressions. Diversifying firms can, a priori, have a positive or negative relation with hazard. This is particularly true if one recognizes that entry decisions and diversification are often determined together. When diversifying firms bring knowledge to the product from outside sources, their probability of survival should be

<table>
<thead>
<tr>
<th>Variables</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Diversified</td>
<td>0.29</td>
<td>0.29</td>
<td>-0.05</td>
<td>-0.05</td>
<td>-0.44</td>
</tr>
<tr>
<td></td>
<td>0.06</td>
<td>0.06</td>
<td>0.45</td>
<td>0.45</td>
<td>0.03</td>
</tr>
<tr>
<td>Entry Size</td>
<td>0.11</td>
<td>-0.43</td>
<td>0.31</td>
<td>-0.24</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>0.259</td>
<td>0.653</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0004</td>
</tr>
<tr>
<td>Exit Size</td>
<td>-0.54</td>
<td>-0.55</td>
<td>-0.77</td>
<td>-0.59</td>
<td>-0.51</td>
</tr>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Growth</td>
<td>-0.56</td>
<td>-0.54</td>
<td>-0.75</td>
<td>-0.58</td>
<td>-0.59</td>
</tr>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>158.65</td>
<td>1185.16</td>
<td>162.40</td>
<td>344.12</td>
<td>405.5</td>
</tr>
<tr>
<td>Risk Ratio</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Source: Based on data compiled from the Thomas Register of American Manufacturers.

Table III. Maximum Likelihood Parameters and Risk Ratios of Firm Attributes by Stage of Product Cycle
higher. The negative effect of diversification on entrants in stage 1 may be on account of the phenomenon that the introduction of a new product market is often by individual innovators starting a new firm. Consistent with Gort and Klepper and with the stylized fact that innovations in stage 2 favor entrants with outside information, the parameter estimates as well as risk ratios for stages 2 and 3 reflect the lower hazard rate of diversifying firms. On the other hand, when such information is relatively less important to incumbent information—as in stages 4 and 5—one sees the reversal of the relation between diversification and hazard rates. This is consistent with the hypothesis that absent any other advantage, diversifying firms have higher opportunity costs of not exiting relative to non diversified firms, and hence are more likely to exit. Caves and Porter argue that this would be true if the top management of a diversified firm could effectively reallocate resources and internally place personnel displaced from exit from a particular product market [9].

The theories of Reynolds and Baden-Fuller are also consistent with the notion that multi-product firms are more likely to close subsidiary establishments than are single product firms [6; 26]. The stage dependent relationship of diversification and survival can hence offer a plausible reason for the conflicting results on multi-plant/multi-product firms in the literature. (Audretsch and Baldwin and Gorecki find positive effects of diversification on survival [4; 7] while Dunne Roberts and Samuelson and Audretsch and Mahmood find the effect to be negative [5; 11]).

The instantaneous impact of size on hazard rates i.e., the effect of size prior to exit, is consistently and significantly negative across all stages. Larger firms have a higher probability of survival, and the effect of size on hazard has an increasing trend across stages. This finding is consistent with the hypothesis that firms falling below MES level of output find it increasingly difficult to survive as competitive intensity increases. The result confirms Jovanovic’s hypothesis that survival increases with size and is consistent with the empirical results on the subject. Alternatively, one can also interpret the positive effect of exit size on survival as an effect of growth on survival. Since larger exit size is more than likely to have been achieved through growth, it may be the case that the characteristics of a firm that cause it to grow also cause it to have a higher probability of survival. This is more explicitly seen when one considers the effect of initial firm size on hazard rates.

From Regression A in each stage, larger initial entry size apparently increases the hazard rate. This is contradictory to intuition as well as the above effect of size on instantaneous survival. The negative effect of initial size on survival simply reflects the fact that higher initial size is negatively correlated with growth. That is, for a given growth rate, initial size will be smaller for the highest growth firms. Dunne, Roberts and Samuelson also obtain the same results, and offer fixity of capital and an inability to alter high fixed costs as a possible explanation. Another plausible explanation lies in differentiating smaller sized firms into those which exhibit growth and those that do not. This captures the effect of superior initial endowments of firms that start small. This explanation allows one to interpret the effect of growth of firms on hazard rates as not merely a scale effect, but a reflection of the superior endowments of a firm which cause it to grow, and also survive for a longer time. Indeed, when growth is explicitly incorporated in Regression B, one sees the expected effect of size on survival. Growth of small and medium sized firms decreases their hazard rate. Table IV further illuminates the impact of initial size and growth on the probability of survival.

When no growth firms are distinguished from growing firms for small and medium entry sizes, the median residual life at time of birth of each group clearly reveals the shorter life expectancy of small firms which do not grow when compared to the growing firms in the same class as well non-growing firms of the other classes. For example, the growth of small firms to large size
before they exit increases their mean residual life almost three times that of firms that do not grow at all. The residual life is seen to be highest for medium sized firms who grow to a large size. (For large sized firms, the index 0 is more realistically indicative of all exiting firms, since data limitations do not allow the trace of growth in large sized firms.) This is consistent with the findings of Phillips and Kirchhoff that growth among firms more than doubles the survival rate [25].

Table III also shows that the influence of growth on hazard rate is higher in stages 4 and 5 in comparison to stages 1 and 2. This seems to confirm further the hypothesis that as competitive intensity increases, adaptation of initial endowments to changing market conditions becomes increasingly important to survival. This aspect can be further explored in Table V, by looking at the actual survival rates (in percentage terms) of firms in the different growth categories. Large size firms are omitted in this analysis as their growth index classes would be zero due to the definition of size classes. Also, Table V refers only to firms that exited and does not take into account censored observations.

For both 4 and 12 year survival rates, the percentage of firms surviving in each stage is seen to increase significantly with increase in the growth index. There is a sharp distinction between small size firms that grow to become large sized firms before exiting and firms that do not grow at all. This is especially clear when one compares the 12 year survival rates for each stage category. Also, for every growth index, one sees a fall in the percentage of firms that survive 12 years as the stage of entry increases from 1 through 4, reflecting once again, the impact of evolutionary aspects of the product life cycle.

VII. Conclusions, Limitations and Future Extensions

This paper has investigated the post entry performance of firms, and the systematic impact of evolutionary phenomena and firm attributes on the probability of survival. The important results that emerge are:

1) Probability of survival significantly differs across evolutionary stages. One sees a consistent decline in survival rates with increase in the competitive intensity. Early entrants enjoy a higher probability of survival. Further, entrant survival rates are significantly higher, across all stages, than what is commonly assumed.

2) The probability of survival does not monotonically decrease with age. Evolutionary phenomena cause hazard rates of early entrants (stages 1 and 2) to increase with age corresponding

<table>
<thead>
<tr>
<th>Initial Size</th>
<th>Growth Index</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>5.81</td>
<td>13.67</td>
<td>14.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.27)</td>
<td>(0.91)</td>
<td>(1.02)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>6.88</td>
<td>15.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(1.75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>8.35</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(0.41)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Based on data compiled from the Thomas Register of American Manufacturers. Standard errors indicated in parentheses.
Table V. Survival Rates for Growth Index by Stage of Product Cycle

<table>
<thead>
<tr>
<th>Stage</th>
<th>Growth Index</th>
<th>4 Year Survival Rate</th>
<th>12 Year Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>62.50</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>(4.7)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>2</td>
<td>68.96</td>
<td>98.18</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>(1.6)</td>
<td>(0.9)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>3</td>
<td>69.49</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>(5.5)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>4</td>
<td>51.20</td>
<td>94.44</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>(3.8)</td>
<td>(0.5)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>5</td>
<td>56.28</td>
<td>75.00</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>(3.3)</td>
<td>(1.25)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

Source: Based on data compiled from the Thomas Register of American Manufacturers. Standard errors indicated in parentheses.

3) Diversifying firms have a lower hazard rate in earlier stages, consistent with the hypothesis that entrants with external information enjoy advantages. In the later stages, diversifying firms have a higher hazard rate, lending support to the hypothesis that absent innovational information, diversifying firms have a higher opportunity cost of staying in the market.

4) The size of the firm in the period prior to exit has a negative impact on hazard rate. Large sized firms have a lower failure rate across all ages than medium or small sized firms, possibly due to superior endowments which made them grow to a larger size.

5) The superior endowments of a firm, reflected in its ability to grow, increase the probability of survival. Small firms that grow before they exit on an average have almost three times higher lifetimes than firms who do not exhibit any growth.

While the data used in the analysis allow for the testing of hypotheses linking survival of firms to evolutionary stages for the first time, they suffer from certain limitations. The size and diversification measures are crude indexes. The asset size reported by Thomas Register overestimates the size of a firm in a particular product market when the firm is multi-product, since it reflects the overall size of the parent firm, and not the size of the firm in the relevant product.
market. A rationalization of the use of the parent firm asset size is that it reflects the potential assets that could be transferred to existence in the relevant product market. Further, the asset portfolio of the firm may contain capital of different vintages and assets acquired at different time periods, and the nominal value reported in any one year may not accurately represent the true economic value of the assets of the firm. Size of the firm just prior to exit is more sensitive to this problem than the size at time of entry. As a result of this limitation, the analysis of the impact of the size of the firm is restricted only to developing three broad categories of the firm sizes. The diversification measure is also only a crude index since no distinction can be made between firms producing in two, as opposed to ten product markets.

Clearly, the field of research is rich in both the theoretical and empirical avenues that are as of yet unexplored. Much theoretical modeling needs to be done in order to explain endogenous innovative activity of firms in a race for survival, evolutionary phenomena and the dynamic conditions in which firms operate, and the behavior of the technological frontier over product life cycle. Empirically, the focus needs to be on the development of data-sets at the product market level, with more powerful measures of firm attributes and product market conditions. The distinction between survival of technological and non-technological firms, and differences in the ratio of entrant to incumbent survival rates across these groups is an additional avenue of interest which may shed light on the importance of technical uncertainty.

References


