Firm Age and the Evolution of Borrowing Costs: Evidence from Japanese Small Firms

Koji Sakai* Iichiro Uesugi† Tsutomu Watanabe‡

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Abstract

This paper investigates how a firm's borrowing cost evolves as it ages. Using a new data set of more than 200,000 bank-dependent small firms in 1997-2002, we find the following. First, the distribution of borrowing cost tends to become less skewed to the right over time. Second, this shift of the distribution can be partially attributable to "selection" (i.e., firms with lower quality and higher borrowing costs exit from markets), but mainly explained by "adaptation" (i.e., surviving firms' borrowing costs decline as they age). Third, we find an age dependence of a firm's borrowing costs even if we control for firm size, but fails to find an age dependence of its profits volatility once we control for firm size. Empirical results suggest that age dependence of borrowing costs comes not from the Diamond's (1989) reputation-acquisition mechanism, but from bank's learning about borrower's true quality over the duration of bank-borrower relationship.

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*Graduate School of Economics, Hitotsubashi University, `ed042002@srv.cc.hit-u.ac.jp`
†Research Institute of Economy, Trade and Industry (RIETI), `uesugi-iichiro@rieti.go.jp`
‡Institute of Economic Research, Hitotsubashi University, `tsutomu.w@srv.cc.hit-u.ac.jp`

1 Introduction

What happens to a firm as it ages? This question has been addressed by a number of studies that empirically investigate the relationship between firm age and the firm's real activity variables, including growth, volatility of growth, and employment: Evans (1987b) shows that the growth rate of U.S. small firms and the volatility of growth are both negatively associated with firm age; Cabral and Mata (2003) shows that the firm size distribution for Portuguese manufacturing firms moves towards the right hand side as firms age; Davis et al. (1996) reports that the rates of job creation and destruction in U.S. manufacturing firms are decreasing in firm age.[1] The purpose of this paper is to search for such an "age dependence" in firms' *financial* activities rather than in their *real* activities. Specifically, we look for it in one of the most important financial variables for the firm: the borrowing cost. Based on a unique panel data set of more than 200,000 small Japanese firms in 1997 to 2002, we provide a careful analysis of the relationship between firm age and borrowing cost.

Our study is most closely related to Diamond (1989), which yields an important prediction about a channel through which the borrowing cost distribution evolves with age. Specifically, Diamond (1989) investigates entrepreneur's dynamic decision making under the environment in which borrowing cost crucially depends on a borrower's repayment record: borrowing cost for a firm declines over time as long as it keeps a good track record, while a single default leads to a large increase in the interest rate charged. In this circumstance, borrowers with a long period of good track record choose a safe project as they do not want to lose a valuable asset, which is called "reputation". In this sense, reputation acquisition can be seen as a channel through which the borrowing cost evolves with age. One of the objectives of this paper is to see whether the data is consistent with this reputation story.

On the other hand, the Diamond model is almost silent about the "selection" channel, which has been emphasized by the theoretical studies on firm dynamics as a determinant of industry evolu-

[1] Other examples include Dunne, Roberts, and Samuelson (1989) which reports that manufacturing plants that have been in business longer are less likely to close, and Brown and Medoff (2003) which finds a U-shaped relationship between firm age and wages.

tion. This is simply because borrowers are assumed to be observationally equivalent in the Diamond's model: imperfect information does not allow lenders to distinguish among different types of borrowers, so that all borrowers are lumped together and charged the same interest rate. Given the absence of any difference between prospective defaulters and survivors in terms of borrowing costs, it is almost impossible to say something about the role of "selection" in the evolution of borrowing cost distribution. In this respect, we deviate from the Diamond's setting by assuming that there are two different channels through which the borrowing cost distribution evolves with age: "selection" and "adaptation". Selection affects the evolution of the borrowing cost distribution just because prospective defaulters and survivors are different in terms of the interest rate charged. If it is true that nonviable firms are forced to exit from markets through selection, and that those firms pay higher interest rates than those who successfully survive, we should observe that the average borrowing cost declines over time. On the other hand, adaptation affects the evolution of the borrowing cost distribution because a surviving firm (or its surrounding agents) changes its behavior as it ages. The reputation story can be seen as one of the hypotheses that could explain why survivors change their behavior as they age.[2]

The interest of this paper is threefold. First, we are interested in the relative importance of selection and adaptation in the evolution of borrowing cost. In this respect, Cabral and Mata (2003) reports an interesting finding that selection plays a less important role in the evolution of firm size distribution than it is assumed in the theoretical literature. This is echoed with Okazaki's (2004) empirical finding that the role of selection did not play a dominant role in the evolution of the Japanese main bank relationship. Second, we are interested in whether selection is natural or unnatural one. As a diagnosis to the Japanese economy which has been in stagnation for more than ten years, some argue that inefficient "zombie" firms are allowed to stay in markets because of perverse incentives of troubled banks, and they crowd out new entrants with profitable investment opportunities, which

[2]Needless to say, the words of "selection" and "adaptation" are borrowed from evolutionary biology. We think this analogy is very useful to make clearer to readers what our exercise is all about, but we do not wish to go more than that, as we recognize that there are non-trivial differences between industry evolution and biological evolution.

leads to a deterioration in the efficiency of the economy (Cabarello et al. (2004); Peek and Rosengren (2004, 2005); Nishimura et al. (2003)).[3] We would like to see if this unnatural selection story is supported by the data. The third interest is about the mechanism of adaptation. As shown by Evans (1987a) and Hall (1987) among others, firm size plays an important role in firm dynamics. Given a positive association between firm size and age, this implies that firm age could be correlated with borrowing cost by way of firm size. We would like to distinguish this indirect relationship from a direct one implied by some hypotheses including the reputation story.

The rest of the paper is organized as follows. Section 2 explains our empirical approach, including our methodology to identify age effects. Section 3 addresses three empirical questions: selection versus adaptation in section 3.1, natural versus unnatural selection in section 3.2, and track record versus firm size in section 3.3. Section 4 concludes the paper.

2 Empirical Approach

2.1 Data

The data in this study are obtained from the Credit Risk Database (hereafter CRD),[4] which covers about 60 percent of small businesses in Japan.[5] One advantage of the CRD is that it contains reliable information about default events, which consists of four types of events: delinquent payment for three months or more; de facto failure; failure; repayment of debts by a loan guarantee corporation. Default information allows us to identifying defaulters and non-defaulters in each year.

Using more than 5 million firm-years contained in the CRD, we construct a panel data set as follows. First, we choose 1997-2002 as the sample period, so that we have enough observations in each year. Second, we limit the sample to those firms satisfying either of the following two conditions:

[3]In a related context, Cabinet Office of Japan (2003) claims that six percent of Japan's large, publicly traded firms need to be closed in order to revitalize the economy.

[4]The CRD was established in 2001 at the initiative of the Small and Medium Enterprises Agency of Japan in order to provide financial institutions with detailed and reliable P/L and B/S information about small businesses, thereby enabling financial institutions to obtain accurate estimates of default probabilities.

[5]There were about 1.6 million small and medium- size businesses in Japan as of 2001, of which the CRD covers 0.9 million.

(1) firms that survived from 1997 to 2002, and that reported information to the CRD Association in each year; (2) firms that defaulted between 1997 and 2002, and that reported information to the CRD Association until the year of default. Put differently, a firm is not included in our panel data set if it does not report to the CRD Association in 1997, or if it disappears without a record of default between 1997 and 2002. It should be noted that firms born in and after 1998 are *not* included in our data set. Third, we remove outliers for each variable based on the following rule. As for interest rates, we first remove outliers in the lower tail by omitting observations with exactly zero interest rates (0.91 percent of the total observations), and then remove observations in the upper tail by the same percentage. As for other variables (operating profits and net worth), we remove the top and bottom 1 percent of the entire observations. After making the above adjustments, we finally obtain a panel data set whose structure is described in Table 1. The number of firms starts with about 240 thousand in 1997, and declines by about 8 thousand per year,[6] finally reaching about 200 thousand in 2002.

Below we explain the major variables employed in our analysis.

Borrowing Cost: The CRD does not provide borrowing cost for each individual loan contract. To calculate the borrowing cost, we divide interest payments for a year by the average of total borrowing outstanding (including discounted notes receivable) at the end of current and previous years.

Birth Year and Firm Age: We define the year when a firm is registered at the Legal Affairs Bureau as its birth (cohort) year. The difference between the current year and the cohort year is the age of the firm. The number of firms that are very old or very young is quite limited, and thus we mainly focus on the samples with cohort years between 1950 and 1995.

Operating Profit and Net Worth: These performance variables are used as a measure of firm's observable quality. We define operating profit as profits divided by the value of total assets outstand-

[6] The default rates are two to four percent per year.

ing, and net worth as total capital divided by total assets outstanding.

Table 2 presents summary statistics for these variables. The mean borrowing cost of firms is 2.83 percent in the overall sample, and there is a substantial difference in performance between the surviving and defaulting firms. The performance of defaulting firms in terms of default probability, net worth, and operating profit is markedly worse than that of surviving firms.

2.2 Identification of Age Effects

Let us denote the borrowing cost of firm i, which belong to a birth cohort group τ, in year t by $R_i(t,\tau)$, and assume that $R_i(t,\tau)$ is modelled as a confluence of three effects: a year effect $\alpha(t)$, a cohort effect $\beta(\tau)$, and an age effect $\gamma(t-\tau)$. That is,

$$R_i(t,\tau) = \alpha(t) + \beta(\tau) + \gamma(t-\tau) + \epsilon_i(t,\tau)$$

where $\epsilon_i(t,\tau)$ represents an individual error term. Since there is an exact linear relationship between these three effects, a serious identification problem emerges when we try to extract an age effect. To be more specific, the cross-sectional study inherently contains the confound of age and cohort effects, while the longitudinal study contains that of age and year effects. For example, Petersen and Rajan (1995) uses a cross-sectional data to depict the age profile of borrowing cost under the assumption of "stationarity of the survival process" (p.419); however, if it is not stationary, we are not allowed to ignore a cohort effect, thereby failing to identify an age effect.[7]

It is easy to see that cross-sectional data is not enough, and that dynamic data is indispensable to overcome the identification problem. Also, as is argued by Cabral and Mata (2003), it is natural to think that researchers need to have dynamic data set at their hands if they seriously want to investigate the evolution of variables that are related to firm age, independently of whether they are real or financial ones. However, having dynamic data at hands is not enough to overcome the

[7] Recent researches in the area of consumers behavior, birth cohort effects are not negligible in the evolution of various variables related to consumers decision making. Given that our sample consists of small firms with about twenty employees on average, birth cohort effects could play a non-negligible role in the evolution of borrowing cost as it does in consumers decision making.

identification problem. One way to cope with this problem is to make a normalization assumption. For example, Deaton (1997) proposes a normalization that makes the year effects orthogonal to a time trend, so that the entire effect is attributed to age and cohort effects. However, it is often noted that estimated results are extremely unstable, particularly in the case of limited time-series horizon.

As an alternative way to cope with the identification problem, we remove year effects by subtracting a weighted average of short and long prime lending rates, whose weights are given by the share of short- and long-term borrowings outstanding at the end of each year, from $R_i(t, \tau)$.[8] The weighted prime rate can be seen as a risk-free rate, which is basically determined by monetary policy. In this sense, subtracting it from $R_i(t, \tau)$ amounts to removing the year effect $\alpha(t)$ in the borrowing cost, so that

$$R_i(t, \tau) = \beta(\tau) + \gamma(t - \tau) + \epsilon_i(t, \tau).$$

Then, it is easy to see that

$$R_i(t + 1, \tau) - R_i(t, \tau) = [\gamma(t - \tau + 1) - \gamma(t - \tau)] + \epsilon_i(t + 1, \tau) - \epsilon_i(t, \tau),$$

which indicates that we successfully identify the first difference of the age effect, although we are still not able to identify the age effect itself. Since we are mainly interested in the slope of age profile of borrowing cost, the first difference provides enough information to us,[9] and we will basically adopt this method in the subsequent sections.

[8] The procedure is as follows. First, we calculate the stock-based long and short prime rates. The stock-based long prime rate is defined as the average of long prime rates over the past sixty months, while the stock-based short prime rate is defined as the average of short prime rates over the past twelve months. Second, we calculate a weighted stock-based prime rate for individual firms, with weights being given by the share of long- and short-term borrowings outstanding at the end of each year. Third, we regress $R_i(t, \tau)$ on this weighted stock-based prime rate and a firm-specific term. We use the estimated coefficient on the weighted stock-based prime rate, 0.5488 (std. err. 0.0016), to calculate an adjusted borrowing cost.

[9] As proposed by Mckenzie (2002), one can identify second differences of the age effects, $[\gamma(t - \tau + 1) - \gamma(t - \tau)] - [\gamma(t - \tau) - \gamma(t - \tau - 1)]$, even without any strong assumptions. However, since the second differences provide information only about the curvature of the age profile of borrowing cost (no information about its slope), his methodology does not suit our purpose.

3 Empirical Results

3.1 Selection versus Adaptation

We start by looking at the age profile of borrowing cost. We first take the mean of each firm's borrowing cost over i, and then take its first-order time difference. That is, we calculate

$$E_{i \in A(t+1,\tau)} R_i(t+1,\tau) - E_{i \in A(t,\tau)} R_i(t,\tau), \tag{1}$$

where $A(t,\tau)$ represents the set of all firms operating in year t and belonging to the birth year cohort τ. We then regress this expression on age dummies $D(a)$, which equals to one if $t - \tau = a$ and zero otherwise. The coefficient on the age dummy $D(a)$ represents the estimate for the slope of the age profile, $\hat{\gamma}(a+1) - \hat{\gamma}(a)$. Given $\gamma(0) = 0$ as a normalization, we add $\hat{\gamma}(1) - \hat{\gamma}(0), \hat{\gamma}(2) - \hat{\gamma}(1), \hat{\gamma}(3) - \hat{\gamma}(2), \cdots$ to obtain the age profile presented in Figure 1. Figure 1 shows important features of the age profile of borrowing cost. First, it is downward sloping: the difference between age 0 and age 50 is about 170 basis points. Second, it is convex: the slope becomes smaller with age until it reaches almost zero at age 50.

It is important to note that the age profile shown in Figure 1 contains two components: changes due to selection and those due to adaptation. To know the relative importance of these two components, Figure 2 compares three kinds of borrowing cost distribution: the solid line labeled "1997" represents the distribution of all firms in 1997; the broken line labeled "1997S" represents the distribution in 1997 of those firms that survived until the end of our sample period, 2002; the dashed line labeled "2002" represents the distribution in 2002 of those firms that survived until 2002.

If we compare the distributions "1997" and "2002", we can see that the distribution "2002" is less skewed to the right, and therefore the mean of the distribution "2002" is clearly smaller, which is consistent with the downward age profile we saw in Figure 1. Then the question we would like to address is where this shift in borrowing cost distribution comes from. If we compare the distributions "1997" and "1997S", we see that "1997S" is slightly less skewed to the right, which implies that selection plays a role in the shift of the borrowing cost distribution. On the other hand, if we compare the distributions "1997S" and "2002", we see that "2002" is again less skewed to the right, which implies that adaptation plays a role in the shift of the distribution. However, as clearly seen in Figure 2, the contribution of selection in the evolution of the distribution is much smaller than that of adaptation. Figure 3 repeats the same exercise for each cohort, and shows that (1) adaptation plays a more important role for each cohort; (2) the relative importance of selection is particularly smaller for younger cohorts.

To see the relative importance of the two sources of evolution in a more robust manner, Table 3 decomposes the total evolution of the borrowing cost from year t to $t+1$ into evolution due to selection and that due to adaptation. That is,

$$
\begin{aligned}
& E_{i \in A(t+1,\tau)} R_i(t+1,\tau) - E_{i \in A(t,\tau)} R_i(t,\tau) \\
= & \ \theta(t,\tau) \left[E_{i \in S(t,\tau)} R_i(t,\tau) - E_{i \in D(t,\tau)} R_i(t,\tau) \right] \\
& + E_{i \in A(t+1,\tau)} R_i(t+1,\tau) - E_{i \in S(t,\tau)} R_i(t,\tau)
\end{aligned} \tag{2}
$$

where $S(t,\tau)$ represents the set of firms which belong to cohort τ and survive from year t to $t+1$, $D(t,\tau)$ is the set of firms which belong to cohort τ and default in year $t+1$, and $\theta(t,\tau)$ is the default rate for cohort τ in year t.[10] Note that the first term on the right hand side of the equation represents the contribution of selection, while the second term represents the contribution of adaptation.

Table 3 presents the results of decomposition for the whole sample, as well as for six industries including construction, manufacturing, wholesale, retail, real estate, and service. The rows labeled "Total" represent the left hand side of equation (2), and the rows labeled "Selection" and "Adaptation" represent the first and second terms, respectively, on the right hand side of equation (2). First, if we look at the whole sample (the first three rows labeled "All"), we can see that figures for "Total" are negative for all cohorts, and that their absolute values are smaller for older generations. These

[10] To obtain equation (2), we use the identity $E_{i \in S(t,\tau)} R_i(t,\tau) - E_{i \in A(t,\tau)} R_i(t,\tau) \equiv \theta(t,\tau)[E_{i \in S(t,\tau)} R_i(t,\tau) - E_{i \in D(t,\tau)} R_i(t,\tau)]$.

findings are consistent with the shape of the age profile we saw in Figure 1: downward sloping and convex. Second, figures in the "Selection" and "Adaptation" rows (the second and third rows) are again negative for all cohorts, indicating that both selection and adaptation play a role in the evolution of borrowing cost. However, if we look at them more closely, we see that the contribution of adaptation tends to be larger than that of selection. For example, the average over cohorts (figures on the upper right corner) show that the contribution of selection is about 36 percent (-0.013 out of -0.036) while that of adaptation is 64 percent (-0.023 out of -0.036).[11] This confirms our casual observation in Figure 2, and is also consistent with empirical findings reported by Cabral and Mata (2003) for the evolution of Portuguese firm size distribution, and Okazaki (2004) for the evolution of the Japanese main bank system.[12] Third, if we look at figures for each industry, we see that the above three regularities hold for each industry, except the real estate industry where borrowing cost tends to increase with age.

3.2 Natural versus Unnatural Selection

The concept of natural selection was first applied to economics by Alchian (1950), which argues that the economy is a system of selection where market forces select against firms that do not earn profits. This idea has been shared by many researchers, including Jovanovic (1982) that models selection mechanism as firms learning process about their efficiency.

Whether selection process properly works or not has been one of the most important empirical issues about the Japanese economy in the late 1990s. Sekine et al. (2003) and Peek and Rosengren (2004, 2005) use firm-level data to investigate whether selection process worked properly for large, publicly traded firms. Using various performance indicators, including productivity, profitability, and debt ratios, to distinguish bad firms from good ones, they find that troubled banks tend to increase

[11] Note that this does not necessary imply that selection and adaptation are independent. In fact, as shown in Figure 4, there exits a positive correlation between the two, suggesting that selection and adaptation are *not* independent. This correlation could be interpreted as showing that selection facilitates adaptation, in the sense that firms try very hard to change their attributes if they face a severe pressure of selection, but otherwise they do not do so.

[12] On the other hand, Baldwin and Rafiquzzaman (1995) reports that selection plays a dominantly important role in the evolution of firm performance (size, productivity, wage, and profitability) for Canadian young firms that has just entered an industry. In a related context, Bergoeing et al. (2002) compares a country with a proper selection mechanism (Chile) to one without it (Mexico), and shows that a proper selection process facilitates economic growth.

(rather than decrease) loans to bad firms in order to avoid a realization of losses on their own balance sheets. They interpret this as an evidence against natural selection, and Peek and Rosengren (2005) dubs this "unnatural selection".[13] Also, Nishimura et al. (2003) finds a tendency in some of Japanese industries during the latter half of the 1990s, that firms with low productivity stay in markets while those with high productivity exit. Furthermore, Caballero et al. (2004) and Ahearne and Shinada (2004) argue that Japanese banks have kept unprofitable firms alive ("zombie firms") by extending loans at an unfairly low level of interest rates, and that these zombies crowd out firms with profitable projects, thereby distorting resource allocations.

One of the common features of this line of researches is to search for unnatural selection mainly in large firms.[14] This is partly because the misallocation of bank loans is believed to occur only for large firms (see, for example, Hosono and Sakuragawa (2003)). However, there is no a priori reason to believe that small firms are free from unnatural selection: in fact, a number of practitioners and researchers argue that misallocation and mispricing of bank loans to small firms is a much more serious issue. Also, given that large parent firms and their subsidiaries are closely related in terms of their activities, it would be possible that unnatural selection in the sector of large firms has some adverse impact on small firms. Based on this understanding, we will look for unnatural selection in small and medium sized firms in the rest of this subsection.

Natural selection implies that firms with lower qualities are required to pay higher borrowing costs, and eventually forced to exit from markets. Therefore, whether selection is natural or unnatural depends on the sign of the first term on the right hand side of equation (2). Specifically, we can say that selection is unnatural if

$$\theta(t,\tau)\left[E_{i\in S(t,\tau)}R_i(t,\tau) - E_{i\in D(t,\tau)}R_i(t,\tau)\right] > 0, \tag{3}$$

[13]Note that, in Peek and Rosengren (2005), selection, whether it is natural or unnatural, does not imply exit from markets: unnaturally selected firms (with poor performance) increase debts but continue to be allowed to stay in markets. This is presumably because their sample is limited to publicly traded firms, which seldom default.

[14]An exception is Nishimura et al. (2003) which uses a data set containing small firms. However, "Basic Survey of Firm Activities," from which they take data, includes no information on default events, so that one cannot identify defaulters and non-defaulters in a reliable way.

and natural otherwise. Similarly, we can say that selection is unnatural if

$$\theta(t,\tau)\left[E_{i\in S(t,\tau)}Q_i(t,\tau)-E_{i\in D(t,\tau)}Q_i(t,\tau)\right]<0, \tag{4}$$

where Q is a variable representing firm's performance (higher Q means better performance), such as operating profit and net worth.

Table 4 presents the results of one-tailed t-test against the null hypothesis that equation (3) holds. Similarly, tables 5 and 6 present the results of t-test against the null hypothesis that equation (4) holds. These tables show that we can reject the null hypotheses not only for the entire sample but also for almost all sub-samples. For the entire sample, defaulters pay higher borrowing costs than survivors by 60 basis points, while they have lower operating profit and net worth by 2.3 percent and 23.3 percent, respectively. One of the few exceptions is the real estate industry, in which we cannot reject the null hypothesis for borrowing costs, although we can safely reject it for operating profit and net worth.

To see the relationship between selection in terms of borrowing cost and that in terms of performance variables, Figure 5 measures the contribution of selection for borrowing cost on the horizontal axis and that for performance variables on the vertical axis. As clearly seen, there is a negative correlation between the two, which indicates that the lower the quality of a defaulting firm, the higher the interest rate it is required to pay. In this sense, we fail to find a clear evidence of mispricing in credit markets.

3.3 Track Record versus Size

Figure 6 shows the age profile of borrowing costs only for surviving firms. Specifically, we regress

$$E_{i\in A(t+1,\tau)}R_i(t+1,\tau)-E_{i\in S(t,\tau)}R_i(t,\tau), \tag{5}$$

on age dummies to obtain the slopes of the age profile at different ages. Note that the age profile is depicted under a normalization that the value corresponding to age 0 equals to zero, as in Figure

1. If one compares the above expression with equation (1) in section 3.1, one can see that $A(t, \tau)$ is now replaced by $S(t, \tau)$, so that the age profile depicted in Figure 6 represents the contribution of adaptation. One can also see from Figure 6 that the age profile is downward sloping and convex, as we saw in Figure 1. However, the age profile for survivors starts to become almost flat at age 40, while that for all firms continues to decline until age 50 (Figure 1). Also, the difference of borrowing costs between age 0 and age 50 is now 110 basis points, while it was 170 basis points in Figure 1, indicating that 60 basis points are attributable to selection.

Why do survivor's borrowing costs decline with age? There are several hypotheses to explain this. Diamond (1989) proposes the following. Suppose that lenders are not allowed to directly observe the true quality of each borrower, but can observe each borrower's track record of repayment or default for all past periods. In this circumstance, lenders price their loans based on each borrower's history of default. Specifically, borrowers with good track record are likely to be those firms that have access only to a safe project. On the other hand, borrowers with the experiences of defaults are likely to be those firms that have access only to a risky project. Based on this Bayesian inference, lenders offer a low interest rate to the former borrowers while a high interest rate to the latter borrowers. The core of the Diamond's hypothesis lies in borrowers reaction to this lenders' pricing policy. Those firms only with access to a risky project have no alternative to choosing the risky project, so they do not change their behaviors. However, those firms with access to both of safe and risky projects have a stronger incentive to choosing a safe project rather than a risky one, simply because they correctly recognize that they can enjoy the benefits of low interest rates in the present and future periods just by avoiding a default. Importantly, the longer a firm's history of no defaults, the stronger is its incentive to choosing a safe project. This implies that a firm becomes more and more risk averse as it ages, and consequently are required to pay lower and lower interest rates. This is the Diamond's reputation story.[15]

[15] The literature on relationship banking argues that bank-borrower relationship lubricates value-enhancing exchange of information (particularly, private information about borrower's true quality), and that the longer the duration of the

In the reputation story, each firm's track record of repayment or default plays an important role as a "state variable": firms change their choice among projects as they age just because the state variable evolves over time. However, the history of defaults is not the sole state variable we can think of. In fact, the literature on firm dynamics emphasizes the role of firm size as a state variable.[16] Among them, Cooley and Quadrini (2001) obtain an important theoretical prediction about the relationship between the size of a firm and its borrowing cost in a setting with financial frictions. According to their model, a marginal increase of firm size leads to an increase in the volatility of profits, which has a negative impact on the firm's value because of the financial frictions. On the other hand, due to diminishing returns, as the firm increases its size, the marginal expected profits from further increasing the size decrease. Consequently, the firm becomes more concerned about the volatility of profits as it grows to a larger size, and borrows less relative to its equity. This leads to a decline in the probability of default, and finally a decline in borrowing costs. Given that firm size is positively correlated with firm age, such a correlation between firm size and borrowing cost implies a negative association between firm age and borrowing cost.

Which of the two, firm's track record or its size, plays more important role as a state variable? To address this question, Figure 7 divides the entire observations into four subgroups according to the level of total assets, and then repeats a regression that we did in Figure 6, for each of the four subsamples. To be more specific, we reorder the entire observations using the amount of total asset, denoted by $s_i(t, \tau)$, as a key of ordering, and divide the whole sample into four subsamples with equal number of observations: the smallest quartile, the second quartile, the third quartile, and the largest

relationship, the greater the information exchange (see, for example, Petersen and Rajan (1994) and Boot and Thakor (1995)). Also, empirical evidences supporting this argument are provided by Berger and Udell (1995) among others. Importantly, given that firm's age is closely related with the duration of the relationship with a creditor, this argument could explain the downward-sloping age profile. An important difference from the reputation story is that surviving firms do *not* change their behaviors as they age. Instead, lenders change their pricing behavior over time as they learn about the true quality of their customers. We will return to this relationship story later in this section.

[16] For example, Evans (1987a) and Hall (1987) provide empirical evidences that the growth rate of firms and the volatility of growth is negatively correlated with firm size. On the other hand, theoretical researches, such as Hopenhayn (1992), develop models in which firm size is the sole dimension of heterogeneity, and shows that these models can reproduce the firm dynamics-size correlation that is observed in the data.

quartile. Then, we regress

$$E_{i\in A(t+1,\tau)}R_i(t+1,\tau) - E_{i\in S(t,\tau)}R_i(t,\tau),$$

on age dummies to obtain an age profile for each subgroup. Note that four lines in Figure 7 are all depicted under a normalization that the value corresponding to age 0 equals to zero, so that looking at the position of each line is meaningless; the slope of each line is the sole meaningful information one can read from here. Figure 7 shows that the age profile for subsamples labeled "smallest quartile", "second quartile", and "third quartile" are all downward sloping. More importantly, the slope of the age profile, measured by the difference of borrowing cost between age 0 and age 50, is 350 basis points for the "smallest quartile" subsample, and 150 basis points for the "second quartile" subsample, both of which are significantly greater than the slope of the age profile for the entire sample. If the downward sloping age profile is entirely generated by the causality via firm size (i.e., firm age $\rightarrow$ firm size $\rightarrow$ borrowing cost), a smaller slope should be observed when firm size is controlled for; however, as far as the "smallest quartile" and "second quartile" subsamples are concerned, we observe steeper age profiles, implying that one cannot reject the null hypothesis that firm age is an independent determinant of borrowing costs.[17]

An important feature of the reputation story, which distinguishes it from other hypotheses, is that a firm changes its behavior as it ages. Specifically, a firm becomes more risk averse and thus chooses less risky projects as it ages. This is an important testable implication of the reputation hypothesis. To test this, we first have to look for an accurate measure of ex-ante risks taken by a firm. One candidate for such a measure is the ex-post variance of firm's performance. To be more specific, we assume that firm's performance $Q_i(t,\tau)$ follows a simple AR process: $Q_i(t,\tau) = \phi Q_i(t-1,\tau) + \nu_i(t,\tau)$, and then

[17] Another interesting thing one can read from Figure 7 is that the age profile tends to become flatter as firm size increases. One possible interpretation of this tendency is that a firm of large size owns lots of collateralizable assets even at a very young age, so that most of its borrowings are covered by collateral. If this is the case, the borrowing cost is already very low even at a very young age, and declines little as it ages, implying an almost flat age profile. However, such an interpretation is not easy to swallow, given that the firm specific term that could be contained in R_{it}, which represents heterogeneity in terms of the amount of collateralizable assets held by a firm, is already removed by taking a first-order time difference, $R_{it+1} - R_{it}$. Therefore, if one sticks to this idea to explain the outcome in Figure 7, one needs to assume some sort of non-linear relationship between the amount of collateralizable assets and borrowing costs.

calculate the conditional variance of $Q_i(t,\tau)$ over i, which is defined as $CV_i[Q_i(t,\tau)] \equiv Var_i(\nu_i(t,\tau))$. Second, we have to identify age effects in the conditional variance defined above. As we saw in section 2, we can identify age effects for the mean of $R_i(t,\tau)$ just by taking a first-order time difference, because year effects are already removed from the original data. However, the same procedure cannot be applied to the conditional variance: the conditional variance contains year, cohort, and age effects that are linearly dependent. One way to cope with this problem is to assume that cohort effects are absent or negligibly small. Under this assumption, we identify age effects by taking a first-order birth-year difference of the conditional variance. Specifically, we calculate

$$CV_{i\in A(t,\tau)}Q_i(t,\tau) - CV_{i\in S(t,\tau+1)}Q_i(t,\tau+1),$$

for each pair of t and τ.

Table 7 presents the estimated slope of an age profile for the conditional variance of firm performance, measured by operating profits and net worth. The top row labeled "All" represents figures using the entire sample, which shows that the slope is negative for each age. This is consistent with the reputation story. However, if we look at subsample estimates, labeled "smallest quartile", "second quartile" and so on, we see that figures are now very close to zero and sometimes take even positive values, indicating that the negative slopes obtained without controlling for firm size are spurious, and that there is no clear direct correlation, whether it is negative or positive, between firm age and the conditional variance. We see a similar result for net worth.

What do the above empirical results tell us about the mechanism through which surviving firm's borrowing costs decline as it ages? We have found an age dependence of a firm's borrowing costs even when we control for firm size, but, at the same time, we have failed to find an age dependence of its performance volatility once we control for firm size. One candidate consistent with both of these findings is the relationship banking hypothesis. As we stated in footnote 15, the literature on relationship banking argues that bank-borrower relationship lubricates value-enhancing exchange of information, and that the longer the duration of the relationship, the greater the information exchange.

This hypothesis implies a negative correlation between firm age and borrowing costs if the information generated through a bank-borrower relationship is observable even to outsiders (Petersen and Rajan (1994)). That is, if it is possible that the lender could obtain information on the firm's ability to service debts by observing its past transactions with prior creditors, the age of the firm rather than the length of the relationship should determine the borrowing costs. More importantly, according to the relationship banking hypothesis, it is not surviving firms but lenders that change their behaviors as firms age. In this sense, this hypothesis is consistent with the lack of clear correlation between firm age and the conditional variance of firm's performance.

4 Conclusion

We have addressed three empirical questions about the relationship between firm age and the evolution of firm's borrowing cots, using a unique panel data set of more than 200,000 small Japanese firms in 1997 to 2002.

The first question we have addressed is whether selection plays a dominantly important role in the evolution of borrowing costs. The literature on firm dynamics emphasizes the role of selection in the evolution of firm size, so we have been interested in the (un)importance of selection in the evolution of financial variables including borrowing costs. We have found that the contribution of selection is about one third of the total evolution of borrowing costs, indicating that selection plays an important, but not dominantly important role in the evolution of borrowing costs. The remaining two thirds is explained by declines in surviving firms' borrowing costs as they age. This finding echoes with those in recent empirical researches on firm dynamics, such as Cabral and Mata (2003) and Okazaki (2004).

The second question we have addressed is whether selection is natural or unnatural one. As a diagnosis to the Japanese economy that has been in stagnation for more than ten years, some argue that inefficient "zombie" firms are allowed to stay in markets because of perverse incentives of troubled banks, and they crowd out new entrants with profitable investment opportunities. To see whether this argument is supported by the data or not, we have looked at differences in terms of borrowing costs, firm profits, and net worth, between prospective defaulters and survivors in six industries. We have found that defaulters tend to perform worse and pay higher interest rates than survivors, with an exception of real state industry where defaulting firms pay less borrowing costs than survivors. This indicates that unnatural selection, which was detected in large, publicly traded firms by Peek and Rosengren (2005), does not prevail at least among small firms.

The third question we have addressed is about the mechanism through which surviving firm's borrowing costs decline as it ages. We have checked the possibility that this age dependence is caused by the chain via firm size (firm age $\rightarrow$ firm size $\rightarrow$ borrowing costs), but have found a similar regularity even if we control for firm size. We have also checked the possibility that this age dependence stems from the Diamond's (1989) reputation-acquisition mechanism, but we have failed to find a clear regularity between firm age and firm's risk-taking, which is an important theoretical prediction of the Diamond model. Empirical results suggest that age dependence of survivor's borrowing costs comes from bank's learning about borrower's quality over the duration of bank-borrower relationship.

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Table 1: Number of Observations

Year	All Firms	Surviving Firms	Defaulting Firms	Default Ratio (%)
1997	240,384	232,811	7,573	3.150
1998	232,811	224,005	8,806	3.782
1999	224,005	215,404	8,601	3.840
2000	215,404	208,644	6,760	3.138
2001	208,644	203,337	5,307	2.544
2002	203,337	203,337		
Total	1,324,585	1,287,538	37,047	2.797

Table 2: Summary Statistics

Variables:	All Firms Mean Std. Dev.	Surviving Firms Mean Std. Dev.	Defaulting Firms Mean Std. Dev.
Borrowing Cost (%)	2.83	2.82	3.45
	(1.22)	(1.21)	(1.63)
Default Probability (%)	1.94	1.84	5.40
	(3.23)	(3.02)	(6.68)
Prime Rate (%)	2.38	2.38	2.42
	(0.59)	(0.59)	(0.54)
Age	23.16	23.27	19.75
	(13.44)	(13.44)	(12.92)
Assets (1,000 Yen)	594,550.30	600,352.50	389,908.00
	(1,113,733.00)	(1,119,771.00)	(849,531.90)
Number of Employees	23.87	24.18	12.94
	(35.27)	(35.54)	(21.40)
Operating Profit (%)	0.40	0.46	-1.56
	(7.72)	(7.65)	(9.81)
Net Worth (%)	8.95	9.51	-11.49
	(30.17)	(29.71)	(38.56)

Table 3: Decomposition of Total Evolution

		Cohort									
		1950 — 1955	1956 — 1960	1961 — 1965	1966 — 1970	1971 — 1975	1976 — 1980	1981 — 1985	1986 — 1990	1991 — 1995	All
All	Total	-0.010	-0.020	-0.026	-0.031	-0.040	-0.048	-0.046	-0.053	-0.050	-0.036
	Selection	-0.007	-0.009	-0.010	-0.012	-0.012	-0.013	-0.014	-0.018	-0.021	-0.013
	Adaptation	-0.003	-0.011	-0.017	-0.019	-0.029	-0.035	-0.032	-0.036	-0.029	-0.023
Construction	Total	-0.007	-0.021	-0.036	-0.042	-0.056	-0.064	-0.066	-0.076	-0.079	-0.050
	Selection	-0.009	-0.015	-0.014	-0.018	-0.016	-0.021	-0.021	-0.027	-0.030	-0.019
	Adaptation	0.003	-0.005	-0.022	-0.024	-0.040	-0.042	-0.045	-0.049	-0.049	-0.031
Manufacturing	Total	-0.020	-0.020	-0.031	-0.039	-0.053	-0.055	-0.056	-0.075	-0.066	-0.046
	Selection	-0.009	-0.009	-0.010	-0.013	-0.012	-0.013	-0.011	-0.015	-0.018	-0.012
	Adaptation	-0.012	-0.011	-0.021	-0.026	-0.040	-0.042	-0.045	-0.060	-0.047	-0.034
Wholesale	Total	0.002	-0.013	-0.017	-0.018	-0.031	-0.050	-0.049	-0.050	-0.054	-0.031
	Selection	-0.008	-0.014	-0.009	-0.013	-0.012	-0.012	-0.019	-0.017	-0.019	-0.014
	Adaptation	0.010	0.001	-0.008	-0.005	-0.019	-0.038	-0.030	-0.033	-0.036	-0.018
Retail	Total	-0.029	-0.060	-0.048	-0.051	-0.040	-0.039	-0.036	-0.051	-0.038	-0.044
	Selection	-0.006	-0.009	-0.009	-0.010	-0.009	-0.010	-0.011	-0.016	-0.016	-0.011
	Adaptation	-0.023	-0.051	-0.039	-0.041	-0.032	-0.028	-0.025	-0.035	-0.022	-0.033
Real Estate	Total	0.057	0.054	0.024	0.017	0.012	0.000	0.022	0.032	0.019	0.026
	Selection	0.004	0.004	0.010	-0.001	0.004	0.006	0.001	-0.011	-0.013	0.000
	Adaptation	0.053	0.050	0.014	0.018	0.008	-0.006	0.021	0.043	0.032	0.026
Services	Total	0.030	0.008	-0.001	-0.008	-0.015	-0.031	-0.022	-0.016	-0.021	-0.009
	Selection	0.003	-0.004	-0.003	-0.006	-0.007	-0.004	-0.009	-0.009	-0.011	-0.006
	Adaptation	0.027	0.011	0.001	-0.001	-0.009	-0.027	-0.013	-0.007	-0.009	-0.003

Table 4: One-Tailed t-Test for Borrowing Cost

	Cohort									
	1950 – 1955	1956 – 1960	1961 – 1965	1966 – 1970	1971 – 1975	1976 – 1980	1981 – 1985	1986 – 1990	1991 – 1995	All
All	-0.410 a (0.032)	-0.529 a (0.038)	-0.521 a (0.032)	-0.614 a (0.029)	-0.562 a (0.027)	-0.600 a (0.027)	-0.614 a (0.027)	-0.689 a (0.023)	-0.729 a (0.027)	-0.613 a (0.008)
Construction	-0.348 a (0.097)	-0.674 a (0.104)	-0.510 a (0.071)	-0.646 a (0.059)	-0.626 a (0.050)	-0.802 a (0.048)	-0.770 a (0.050)	-0.879 a (0.041)	-0.847 a (0.048)	-0.726 a (0.017)
Manufacturing	-0.529 a (0.054)	-0.521 a (0.058)	-0.568 a (0.052)	-0.748 a (0.052)	-0.618 a (0.050)	-0.614 a (0.055)	-0.531 a (0.058)	-0.649 a (0.051)	-0.706 a (0.069)	-0.612 a (0.015)
Wholesale	-0.401 a (0.058)	-0.598 a (0.076)	-0.418 a (0.071)	-0.587 a (0.065)	-0.616 a (0.067)	-0.535 a (0.066)	-0.689 a (0.068)	-0.559 a (0.064)	-0.623 a (0.076)	-0.570 a (0.020)
Retail	-0.386 a (0.082)	-0.594 a (0.112)	-0.598 a (0.097)	-0.574 a (0.084)	-0.488 a (0.079)	-0.549 a (0.077)	-0.477 a (0.072)	-0.651 a (0.063)	-0.578 a (0.068)	-0.523 a (0.024)
Real Estate	0.404 (0.247)	0.185 (0.201)	0.607 (0.178)	-0.009 (0.126)	0.179 (0.119)	0.279 (0.126)	0.033 (0.124)	-0.511 a (0.106)	-0.865 a (0.175)	-0.050 (0.044)
Services	0.222 (0.151)	-0.318 b (0.167)	-0.227 b (0.134)	-0.464 a (0.113)	-0.406 a (0.098)	-0.278 a (0.092)	-0.516 a (0.080)	-0.437 a (0.064)	-0.521 a (0.072)	-0.405 a (0.029)

Table 5: One-Tailed t-Test for Firm's Quality: Operating Profit

	Cohort									
	1950 – 1955	1956 – 1960	1961 – 1965	1966 – 1970	1971 – 1975	1976 – 1980	1981 – 1985	1986 – 1990	1991 – 1995	All
All	2.113 a	1.897 a	1.973 a	1.264 a	1.596 a	1.879 a	2.170 a	1.993 a	2.291 a	2.320 a
	(0.219)	(0.257)	(0.222)	(0.190)	(0.169)	(0.175)	(0.182)	(0.162)	(0.202)	(0.057)
Construction	0.952 c	0.942 c	1.911 a	0.195	1.249 a	1.193 a	1.457 a	0.927 a	1.322 a	1.448 a
	(0.590)	(0.656)	(0.473)	(0.377)	(0.316)	(0.308)	(0.332)	(0.295)	(0.353)	(0.116)
Manufacturing	2.951 a	3.060 a	2.524 a	1.519 a	1.782 a	1.981 a	3.069 a	2.336 a	2.892 a	2.934 a
	(0.408)	(0.451)	(0.407)	(0.378)	(0.347)	(0.386)	(0.410)	(0.373)	(0.527)	(0.112)
Wholesale	2.084 a	1.144 a	2.068 a	2.132 a	1.413 a	2.637 a	2.267 a	1.831 a	2.089 a	2.171 a
	(0.339)	(0.442)	(0.439)	(0.381)	(0.386)	(0.392)	(0.415)	(0.394)	(0.515)	(0.121)
Retail	1.132 b	1.127 c	1.889 a	0.595	2.454 a	1.908 a	1.811 a	3.131 a	3.172 a	2.388 a
	(0.579)	(0.749)	(0.672)	(0.580)	(0.525)	(0.522)	(0.527)	(0.461)	(0.546)	(0.170)
Real Estate	5.301 a	2.168 b	0.944	3.998 a	2.491 a	2.150 a	1.240 b	0.850 c	4.317 a	2.464 a
	(1.378)	(1.023)	(0.855)	(0.642)	(0.577)	(0.652)	(0.635)	(0.585)	(0.889)	(0.226)
Services	2.645 a	1.793 c	1.715 b	2.021 a	1.351 b	3.447 a	2.338 a	2.976 a	2.974 a	2.797 a
	(1.072)	(1.208)	(0.963)	(0.744)	(0.671)	(0.657)	(0.596)	(0.495)	(0.595)	(0.215)

Table 6: One-Tailed t-Test for Firm's Quality: Net Worth

	Cohort																			
	1950 – 1955		1956 – 1960		1961 – 1965		1966 – 1970		1971 – 1975		1976 – 1980		1981 – 1985		1986 – 1990		1991 – 1995		All	
All	26.693 (1.091)	a	26.772 (1.197)	a	26.896 (1.013)	a	23.584 (0.858)	a	23.119 (0.735)	a	23.263 (0.725)	a	22.686 (0.706)	a	21.166 (0.589)	a	16.291 (0.644)	a	23.323 (0.231)	a
Construction	25.656 (2.647)	a	21.299 (2.666)	a	20.640 (1.900)	a	20.721 (1.522)	a	21.228 (1.243)	a	22.775 (1.161)	a	18.996 (1.196)	a	21.411 (1.031)	a	16.144 (1.108)	a	20.770 (0.423)	a
Manufacturing	28.683 (2.014)	a	30.627 (2.091)	a	31.481 (1.890)	a	25.965 (1.676)	a	26.520 (1.522)	a	25.475 (1.578)	a	26.760 (1.593)	a	21.446 (1.317)	a	19.736 (1.718)	a	27.615 (0.467)	a
Wholesale	24.985 (1.739)	a	24.990 (2.314)	a	25.400 (2.182)	a	18.545 (1.901)	a	22.193 (1.810)	a	18.590 (1.680)	a	19.662 (1.630)	a	19.601 (1.474)	a	12.045 (1.631)	a	21.155 (0.516)	a
Retail	28.635 (3.026)	a	30.270 (3.597)	a	27.899 (3.252)	a	24.705 (2.840)	a	25.975 (2.492)	a	26.661 (2.337)	a	25.152 (2.204)	a	17.305 (1.814)	a	16.219 (1.792)	a	23.652 (0.730)	a
Real Estate	45.155 (9.036)	a	22.041 (6.725)	a	34.216 (5.114)	a	36.087 (4.038)	a	29.550 (3.255)	a	33.371 (3.486)	a	34.845 (3.527)	a	23.311 (2.692)	a	6.501 (3.126)	b	29.103 (1.190)	a
Services	25.348 (5.436)	a	30.296 (5.298)	a	30.718 (3.955)	a	29.456 (3.311)	a	26.750 (2.704)	a	25.797 (2.643)	a	25.526 (2.170)	a	25.507 (1.725)	a	20.781 (1.819)	a	25.030 (0.797)	a

Table 7: The Slope of Age Profile for the Volatility of Firm Performance

		Cohort									
		1950 – 1955	1956 – 1960	1961 – 1965	1966 – 1970	1971 – 1975	1976 – 1980	1981 – 1985	1986 – 1990	1991 – 1995	All
Operating Profit	All	.	-4.152	-8.103	-4.663	-6.676	-10.124	-13.888	-22.291	-26.216	-12.014
	Smallest Quartile	.	-7.893	-26.412	-8.252	-2.239	-7.360	-11.663	-10.911	-10.588	-10.665
	Second Quartile	.	-5.596	-5.694	-0.105	-0.691	1.876	-1.229	-6.950	-1.818	-2.526
	Third Quartile	.	-2.501	-2.206	2.714	0.643	0.272	-0.552	-1.632	-1.466	-0.591
	Largest Quartile	.	-0.453	0.438	-0.494	-0.136	-0.895	-2.386	-1.841	-1.116	-0.860
Net Worth	All	.	7.993	-15.342	2.343	-11.333	-11.483	-20.352	-46.064	-53.457	-18.462
	Smallest Quartile	.	-14.904	-75.694	22.244	-24.342	28.889	-13.525	-29.104	0.683	-13.219
	Second Quartile	.	41.034	-9.510	6.724	15.145	8.314	1.882	-6.553	-1.568	6.934
	Third Quartile	.	-1.272	8.960	12.049	5.261	-0.251	3.528	11.649	-5.824	4.263
	Largest Quartile	.	7.350	-0.958	14.530	-0.569	-1.036	0.797	-6.198	6.206	2.515

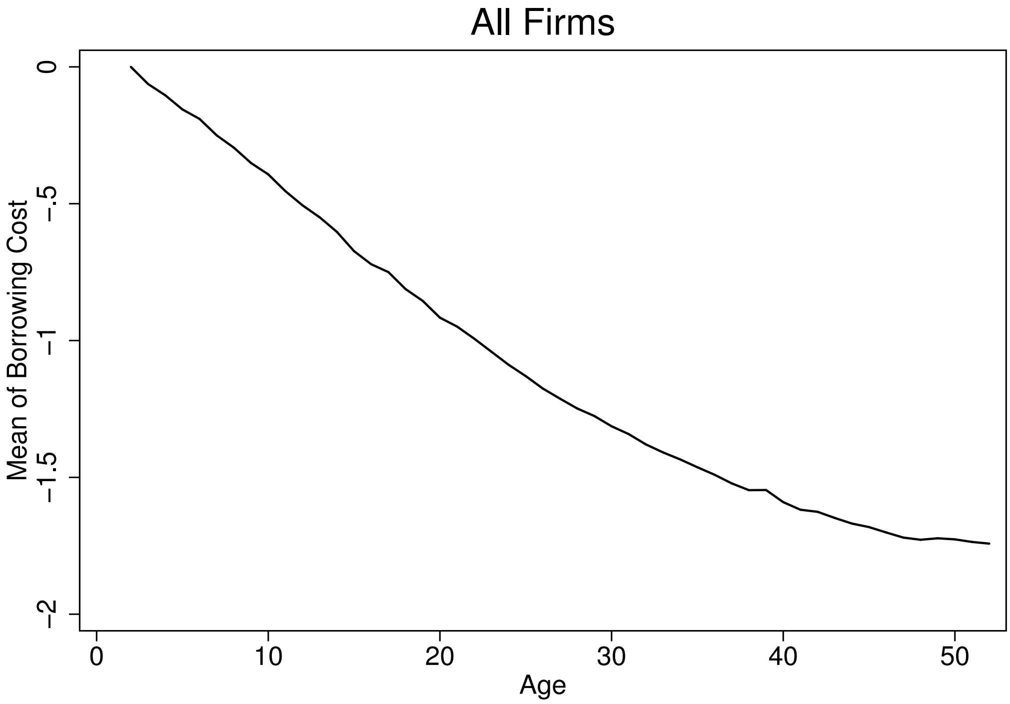

Figure 1: Age Profile of Borrowing Cost

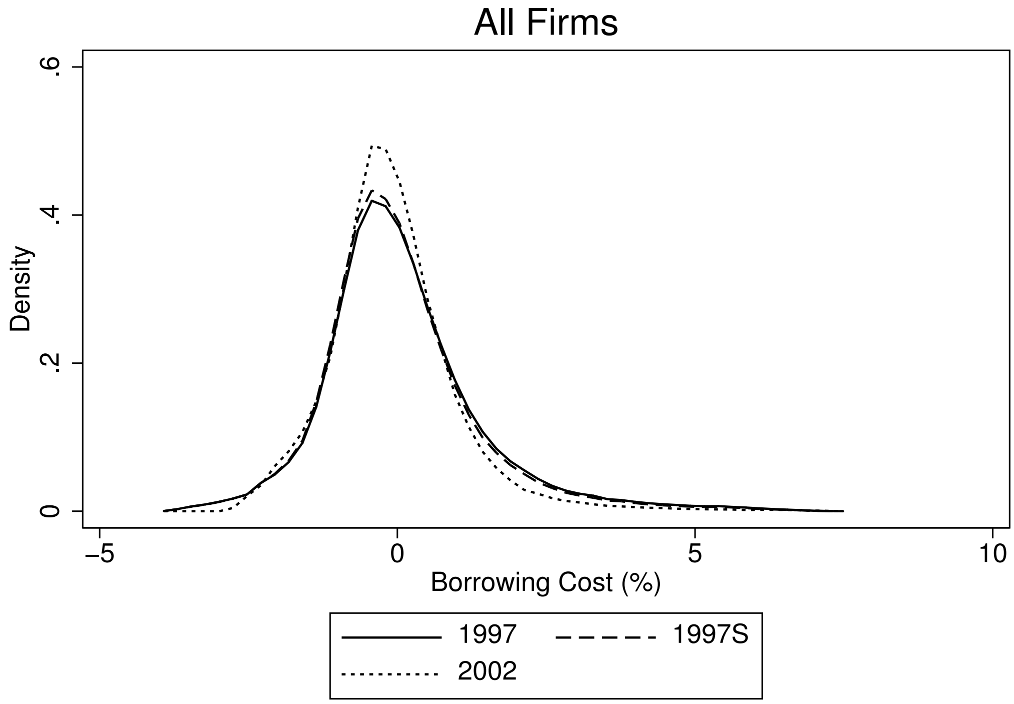

Figure 2: Total Evolution, Selection and Adaptation

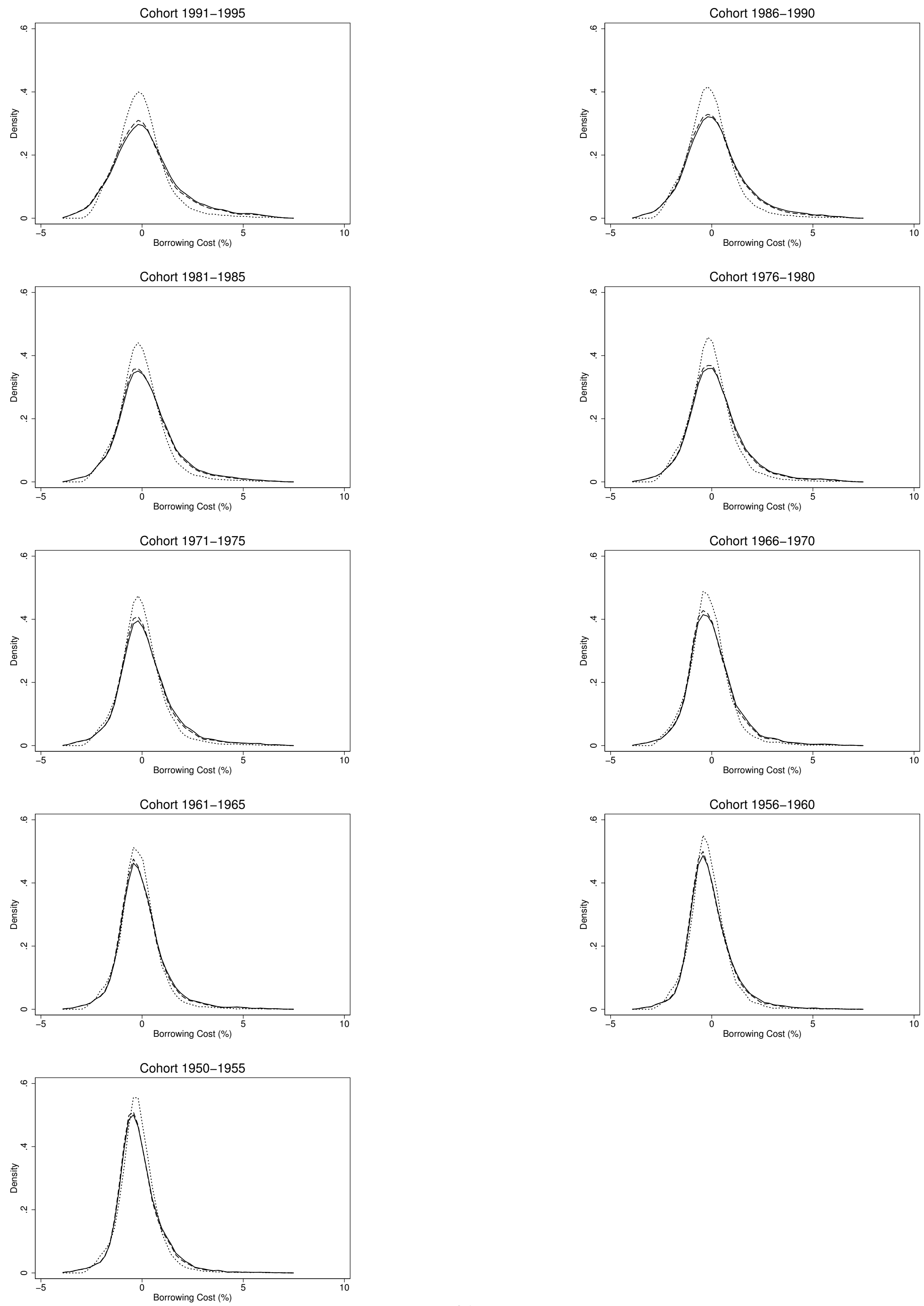

Figure 3: Total Evolution, Selection and Adaptation, by Cohort

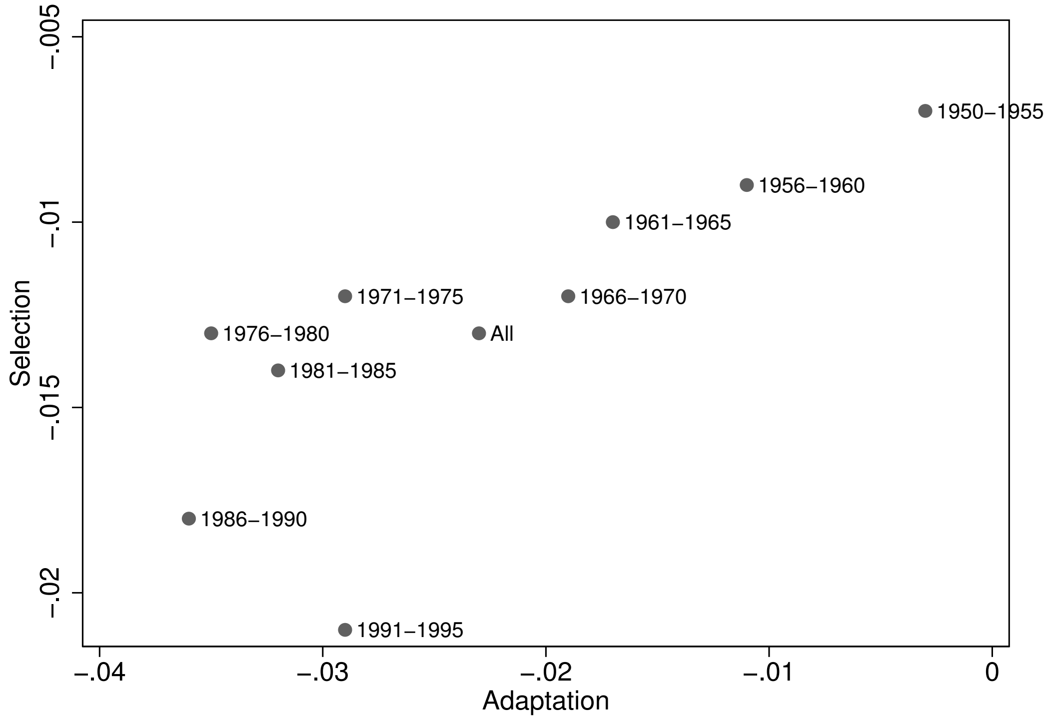

Figure 4: Selection versus Adaptation

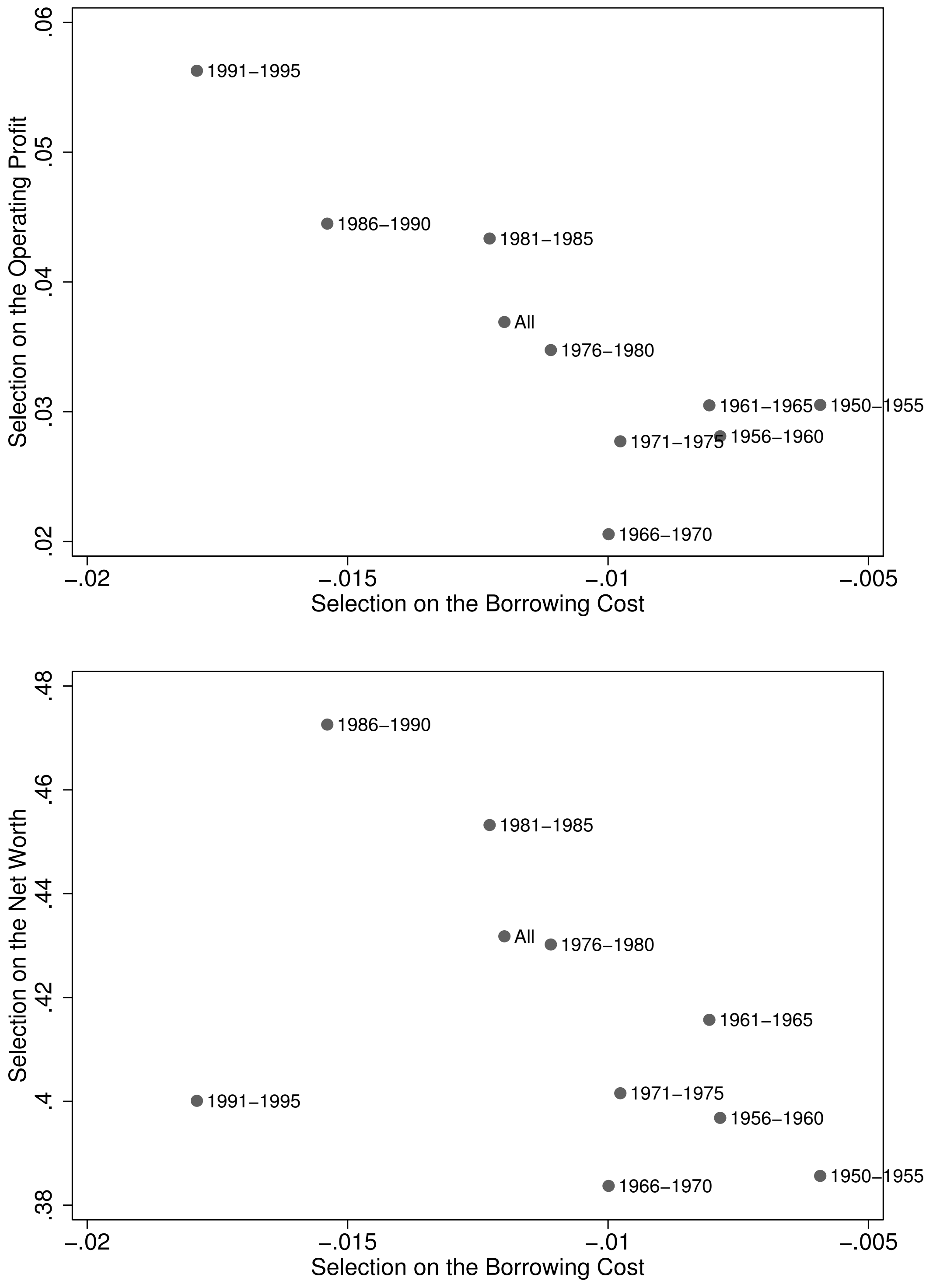

Figure 5: Selection on the Quality versus Selection on the Borrowing Cost

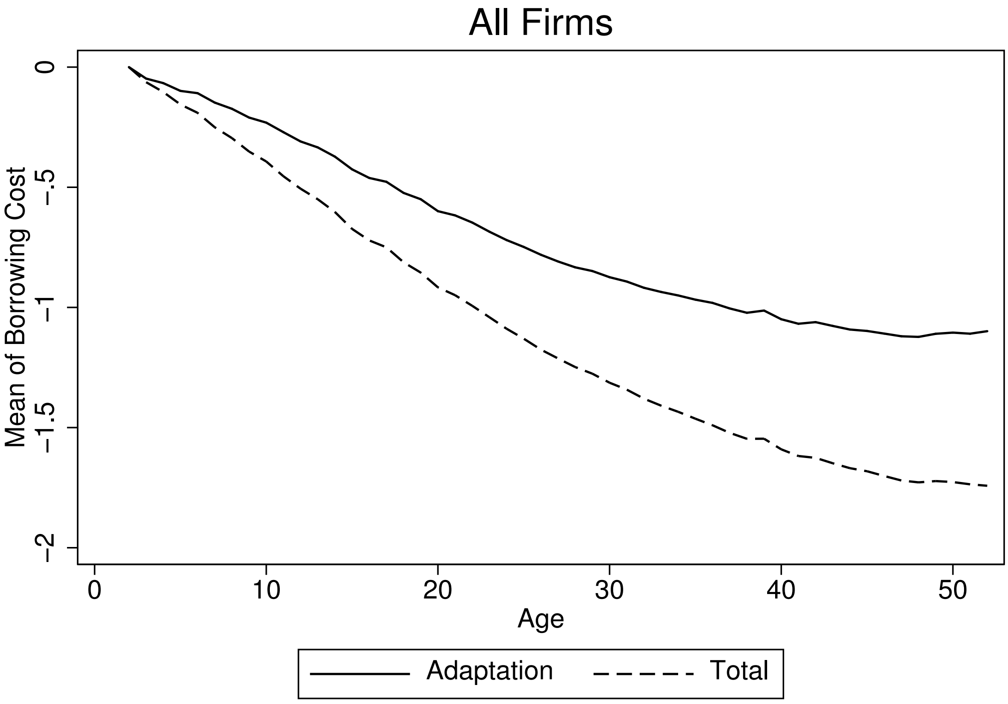

Figure 6: Age Profile of Borrowing Cost: Surviving Firms

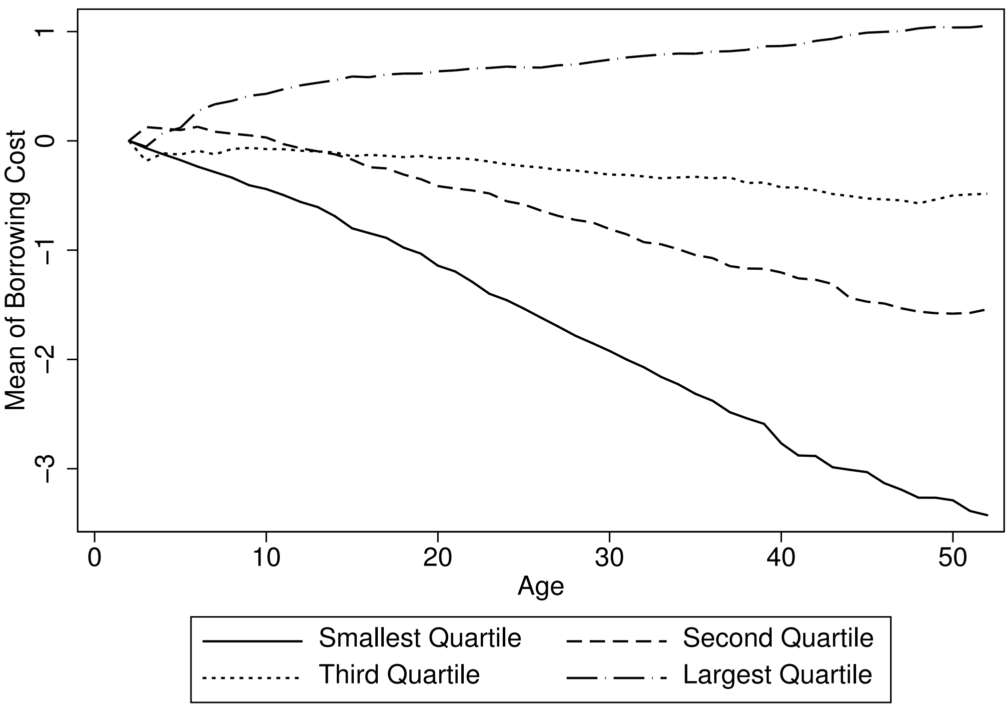

Figure 7: Age Dependence or Size Dependence?