Empirical Evidence on the Duration of Bank Relationships

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First draft: December 1996

Current draft: March 1997

* Corresponding author. The authors have benefited from discussions with Øyvind Bøhren, Kristian Rydqvist, Bent Vale and seminar participants at the Norwegian School of Management and from the research assistance of Didrik von Haffenbradl and Therese Jørgensen. The research is supported by the Fund for the Advancement of Bank Education and the Research Program in Competitive Enterprises at the Norwegian School of Management (BI).

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Abstract

We present evidence on the duration of firm-bank relationships using a unique panel data set of connections between Oslo Stock Exchange-listed firms and their banks for the period 1979-1994. We focus on the determinants of the duration of a relationship and the causes for ending an existing bank relationship. We find that duration itself does not greatly influence the likelihood of ending a relationship: short-lived relationships are as likely to end as long-lived relationships. We also find firms that maintain simultaneous multiple-bank relationships are more likely to end a bank relationship than a single-bank firm and that small, highly-leveraged "growth" firms are more likely to end a bank relationship than large, low-leveraged "value" firms.

JEL code: G21, C41

Keywords: banking relationships, hazard models, duration analysis.

I. Introduction

We use a panel data set containing annual information on the bank connections for virtually all Oslo Stock Exchange (OSE)-listed companies for the sixteen-year period 1979-1994 to study the duration of bank relationships. The driving motivation behind our study is to shed further light on the notion that (a) banks play a vital role in resolving information asymmetries that hinder some firms from obtaining financing and (b) this role arises through the relationship the bank develops with a firm.

In particular, we focus jointly on the length of bank relationships and the decision a firm takes to end a bank relationship and possibly begin another, an event we term a *switch*. Recent theoretical papers in banking suggest that the duration of a relationship itself may influence the decision to end the relationship. For instance, the repeated provision of bank services through time may reveal valuable private information about the customer to the bank. In so doing, an established relationship increases the array of contracting possibilities, but also increases the possibility that the bank can use the private information it obtains to "lock in" the customer to the bank.[1] Our data set permits us to directly estimate the dependence of the decision to switch banks on the length of the existing relationship and thus yields a novel approach to examining implications from recent theoretical banking papers.

Moreover, the value to a firm of an existing bank relationship may also vary as a function of the degree of asymmetric information between the firm and the public, the availability of alternative monitoring mechanisms and the need and availability of alternative financing sources.[2] To study these possibilities, we widen our analysis to model the duration of bank relationships as a function of a set of exogenous variables meant to proxy for the services offered by competing banks, the level of uncertainty about firm value, the financing needs of the firm and the existence of alternative monitoring sources.

Petersen and Rajan (1994) and Berger and Udell (1995) also study the importance of the duration of bank relationships. Using the 1988-89 National Survey of

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[1] See Greenbaum, Kanatas and Venezia (1989), Sharpe (1991) and Boot and Thakor (1994).

[2] Rajan (1992).

Small Business Finances, a large cross-section of data collected by the U.S. Small Business Administration (SBA), Berger and Udell (1995) find that the interest rate charged and collateral pledged on lines of credit is decreasing in the length of a firm's relationship with its bank. Using the same SBA survey, Petersen and Rajan (1994) find no relationship between the average loan interest rate and the length of a firm-bank relationship, but do find that credit is more readily available to firms with longer bank relationships.[3]

Besides having a focus different from the earlier studies, our paper utilizes a new and interesting data set that complements the detailed survey data used in the Berger and Udell (1995) and Petersen and Rajan (1994) papers. For example, we derive our information on bank relationships from a time-series of annual data. This enables us to observe the beginning, end and evolution of many of the existing bank relationships through time, as well as switches by firms from one bank to another. As one "snapshot" in time, the SBA survey data does not account for the dynamic characteristic of the bank relationship. Further, as opposed to a sample of small, mostly family-owned firms as in the SBA survey, the firms in our data set are publicly traded and include both large and small firms with varying levels of ownership concentration. Finally, because it has inherited characteristics of both a European-styled, "bank-denominated" economy and a regulatory framework similar to the United States, the Norwegian banking environment provides a rich experimental setting. Like many European countries, virtually all debt financing to the corporate sector in Norway comes in the form of "inside" debt from financial institutions. In contrast to other European countries, banks are prohibited from owning large equity positions in the companies they do business with.[4] Thus, although our sample firms are publicly traded, they exist in an environment where the primary debt financing source is "inside" bank debt.

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[3] A related set of papers examine the wealth effects of bank announcements on a firm-customer's shareholders. James (1987), Lummer and McConnell (1989) and Billett, Flannery and Garfinkel (1995) investigate announcements of standby letters of credit, while Shockley and Thakor (1993) focus on announcements of loan commitments. Slovin, Sushka and Polonchek (1993) study the influence of Continental Illinois' bank failure on its firm customers.

[4] Loans from financial institutions in 1994 accounted for 91% of all outstanding debt in the non-financial corporate sector in Norway (*Statistical Yearbook of Norway, 1996*), while banks owned only 1% of the equity in the non-financial sector (Nilsen, 1995). Norwegian law prohibits banks from investing more than 4% of their assets in real estate and/or the equity of non-financial companies (*Forretningsbankloven*, 1961, 24 May, Nr. 2, § 24).

When estimating the duration of a firm-bank relationship, we are also careful to recognize that our sample is *censored*; we are not able to observe the complete history of every relationship. Many of the bank relationships of listed firms begin before 1979 or continue after 1994, censoring our maximum observable relationship duration to sixteen years. Firms also list and delist during the sample period, widening the censoring problem. Not controlling for censoring in the data can severely bias inferences about the length of the relationship. For example, we find that although the average observed firm-bank relationship is seven years, the expected duration of a relationship, after controlling for the presence of censored observations, is at least fifteen years and may be as long as forty years.

Consistent estimation of the duration and likelihood of switching requires an estimator that is robust to the censored sampling distribution. We utilize non-, semi-, and fully-parametric estimators of *hazard functions*, which describe the likelihood of ending a given bank relationship, conditional on the length of the existing relationship. We also analyze the sensitivity of our results to assumptions about the underlying distribution of durations. To the extent that these estimators have seen little use in the financial literature, our paper introduces a relatively novel methodology and provides evidence on the importance of the use of censored-robust estimators.

When the hazard function is initially estimated using censored-robust, non-parametric techniques, we are unable to detect a dependency between the duration of a bank relationship and the likelihood that the relationship will end. In other words, we find that short-lived bank relationships are as likely to be terminated as long-lived relationships. This observed lack of *duration dependence* is inconsistent with the idea that firms become "locked in" to bank relationships as the relationship lengthens.

Parametric estimation of the hazard function yields mixed results on duration dependence. A Weibull specification is unable to reject the null hypothesis of no duration dependence in favor of monotonically increasing or decreasing dependence. However, estimation using a distribution that allows for non-monotonic duration dependence provides some evidence that firms are increasingly more likely to end a bank relationship at short durations and increasingly less likely to end a bank relationship at longer durations.

The parametric techniques also allow us to jointly estimate the influence of firm characteristics on the duration of bank relationships. We find that a firm is more likely to end a relationship, or equivalently, the expected length of a bank relationship is shorter, when firms simultaneously maintain a relationship with more than one bank. This finding is consistent with the argument that competing banks lessen the ability for one bank to maintain monopoly power over a firm.

We also find the likelihood of ending a bank relationship is increasing in the growth potential - as proxied by market-to-book-ratios- of the firm and the proportion of firm asset's financed with debt and decreasing in the inflation-adjusted size of the firm. We observe no statistically significant relationship between the level of ownership concentration in the firm and the decision to switch. Taken together, our latter results suggest that it is the firms most in need of bank services and financing - small, high-leverage, high-growth - that maintain the shortest bank relationships and switch most often. To the extent that this reasoning runs counter to the argument for why bank relationships are valuable, our results present a challenge to the theoretical banking literature.

The rest of the paper is organized as follows. Section II provides an overview of the theoretical literature relevant to our investigation. Section III describes the data used in our analysis. Section IV introduces non-parametric techniques for analyzing duration data and presents preliminary results from the non-parametric estimation of hazard functions. Section V continues the empirical analysis by describing the use of the *proportional hazard model* as a method for studying the influence of exogenous variables on the hazard rate. Section VI concludes.

II. Theoretical Literature

A. Information-based Theories

A distinguishing feature of a bank may be its ability to reduce costly information asymmetries between those seeking financing and those willing to contribute capital. Leland and Pyle (1977), Diamond (1984), Ramakrishnan and Thakor (1984), Fama (1985), and Boyd and Prescott (1986) argue that a bank can monitor and credibly communicate inside information more efficiently than its individual depositors or borrowers. Moreover, a bank can help to reduce the likelihood that a firm will choose poor projects by threatening not to renew future debt contracts (Stiglitz and Weiss, 1983). A firm that establishes a relationship with a bank can thus reduce the uncertainty about future investment projects and obtain debt financing that would otherwise be unavailable or prohibitively expensive.[5]

B. Bank Relationships

It is through the progression of a relationship that a bank learns more about a firm's ability to meet future obligations, both through past payment histories and other services offered by the bank (e.g. deposits, clearing and payment services, lines of credit, etc.). Because of its ability to observe a stream of proprietary information, the bank has the potential to extract monopoly rents from its customer.[6] At any point in time, the bank also has the flexibility to influence a firm's investment choice and to deny the firm continued financing in the future. Greenbaum, Kanatas and Venezia (1989), Sharpe (1990) and Boot and Thakor (1994) examine the association between the temporal nature of a firm-bank relationship and the dynamic nature of loan pricing, the availability of credit and the influence of competition.[7]

In Greenbaum, Kanatas and Venezia (1989) one firm can choose in each period to continue its existing lending relationship or pay a fixed cost to search for a competing bank. In equilibrium, the value of the profit function is increasing in the uncertainty about the firm's future ability to pay. A continuing relationship implies a reduction in uncertainty about the payment ability of the firm, making the firm less valuable to the bank and more likely to switch banks.

Sharpe (1990) studies an economy where banks compete for firms of varying unobservable quality requiring financing of two-period projects. Within this

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[5] For recent reviews of the information-motivated literature on banking, see Bhattacharya and Thakor (1993) and Thakor (1995).

[6] The monopoly power is similar to markets where consumers face "switching costs". See Klemperer (1987) and Nilssen (1992, 1994) for a discussion of switching costs in a more general setting.

[7] Petersen and Rajan (1995, p. 5) define the bank-firm relationship to be the "close and continued interaction" between a bank and firm that "may provide a lender with sufficient information about, and voice in, the firm's affairs." The importance of a firm-bank relationship predates the information-based literature, see for example Roosa (1951), Hodgman (1963), Kane and Malkiel (1965), Wood (1975) and Blackwell and Santomero (1982).

environment, a bank has an incentive to lure firms in the first period with below cost loan rates. A privately successful firm with a noisy, but low public signal of success is "captured" by the bank and must pay a high loan rate because the cost of switching banks is too high. The strength of the monopoly power is mitigated by a more accurate public signal of the firm's ability to pay or through the loss of reputation with new customers.

Boot and Thakor (1994) consider an infinite-period contracting framework in which banks require pledged collateral in addition to per-period interest payments. Banks choose the interest rate-collateral combination that dynamically induces the borrower to expend maximal effort towards completing a project, while attempting not to lose the borrower to another bank. Banks offer high interest rate-high collateral contracts in the early part of a relationship to induce optimal effort. Once a firm establishes a successful project, the bank reduces both the interest charges and required collateral on the project.

C. Bank vs. Capital Market Debt

Rajan (1992) studies an economy where a firm may choose to borrow from a bank ("inside debt") or from a outside source such as the bond market ("arm's-length debt"). The advantage to bank debt arises from the bank's ability to monitor the progress of a firm's project, its discretion in continuing the lending relationship and its ability to influence the effort of the borrower. An arm's-length contract, on the other hand, allows for no intermediate discretion in reallocating resources or changing the contract specifications. Rajan (1992) argues that this rigidity can have a beneficial effect on the borrower's incentive to expend effort on the project.

Rajan (1992) obtains several interesting results from his model. First, a firm should forego arm's-length debt in favor of a long term bank contract when the bank exerts strong bargaining power over the firm. A bank could have strong bargaining power when it has strong influence over suppliers, sits on the board of the firm or when the national economy is denominated by several (possibly government controlled) banks. Second, high quality firms will be more likely to forego a bank relationship in favor of the use of arm's-length debt.[8] Third, the ability for a bank to maintain a relationship through its reputation (Sharpe, 1990) may be eroded since high quality firms are more likely to borrow using arm's-length debt. Fourth, public signals of a firm's ability to pay can *increase* the likelihood that a firm remains captured by a bank. Finally, multiple bank relationships may reduce the chance that a firm may be informationally captured, but also may lead to excessive monitoring by the banks.

D. Summary of Empirical implications

To summarize, the theoretical literature provides a stimulus for the study of firm-bank relationships through time and the likelihood that a firm may switch banks. Greenbaum, Kanatas and Venezia (1989) predict that the likelihood of observing a bank switch is increasing in the duration of the firm-bank relationship, while the models of Sharpe (1990) and Boot and Thakor (1994) imply that the incentive for the firm to switch relationships is decreasing in the duration of the relationship. Sharpe (1990) suggests that the likelihood a firm switches banks increases as public signals of the firms ability to pay increases. Competition, in the form of multiple bank relationships (Sharpe, 1990 and Rajan, 1992) or arm's-length debt (Rajan, 1992) can, by making the costs of switching lower, increase the likelihood of observing a switch. Finally, implicit in the moral hazard models of Boot and Thakor (1994) and Rajan (1992) is the idea that a bank's ability to induce value-maximizing effort may be unnecessary if the firm has internal monitoring mechanisms to effectively steer manager' s efforts.

III. Data

A. Characteristics of Bank Relationships

1. Data Collection and Definitions

We obtain annual data on bank relationships of Oslo Stock Exchange (OSE)-listed firms for the years 1979 to 1994 from *Kierulf's Handbook*, an annual handbook published by *Oslo Børs Informasjon AS*, a data-publishing subsidiary of the OSE. The handbook contains financial and accounting information on all listed firms, as well as other firm-

[8] A similar prediction is made by Diamond (1991).

specific information. In particular, as part of the listing requirement, each firms must report on an annual basis its "primary" bank connections, up to a maximum of four. We identify a firm as *switching* banks when it drops one of its banks from the survey or replaces one of its banks with a new bank. We define the *duration* of a relationship to be the number of years we observe a firm maintaining a bank connection.

2. Overview of sample

Table 1 presents an annual overview of the number of firms in our sample along with the number of firms listing, delisting and the number of firms switching. In a given year, our sample on average contains roughly 100 OSE firms, representing 97% of the population of exchange-listed firms. We observe a total of 93 firms switching over the sample period or an average of six per year. The number of switches roughly doubles in the years 1986-1988, a period in which substantial deregulation occurred in both Norwegian financial markets and the Norwegian banking sector.[9] Concurrent with the increase in the number of bank switches during the crisis period was an increase in the number of firms delisting.[10] The number of firms going public increases during the 1983-84 period and later in the early 1990's, roughly matching periods in which the level of the OSE market was high.

Table 2 summarizes some of the characteristics of the bank relationships. The top of Table 2 and Figure 1 provide information on the distribution of the sample firms by the number of bank relationships maintained at a given point in time. A firm is defined as having a *multiple bank relationship* if the firm maintains more than one simultaneous bank relationship during the sample period. Three quarters of the sample firms maintain only one bank relationship over our sample period, with the proportion increasing in the 1990's. Another 17% of the banks maintain two relationships and

[9] Beginning in 1984, interest rate ceilings were removed, an accommodative monetary policy was followed, and government-mandated lending controls were lifted. In 1985 and 1986 annual loans by banks increased 37.5% and 23.4%, respectively. The latter part of the 1986-1988 period also marked the beginning of the Norwegian bank crisis. For example, by 1987 commercial loan losses as a percent of commercial bank loans had quadrupled from their 1984 level (Kaen and Michalsen, 1995).

[10] Quite a few of the recorded delistings during this period were publicly traded banks (Kaen and Michalsen, 1995).

seven percent have three banks. By the end of the sample period, very few firms have more than three bank relationships.[11]

In our analysis to follow, we define a sample observation as one firm-bank relationship. The number of firm-bank observations equals the total number of firms in the sample times the number of bank relationships maintained by each firm over the sample period. Our data set contains 401 firm-bank observations.

The middle section of Table 2 categorizes the proportion of 401 firm-bank observations by their *observed* duration. That is, this section provides a distribution of the length of bank relationships for firms listed on the OSE between 1980 and 1994. The pattern that emerges is interesting. If we only consider the most obvious, end-of-sample censoring, it appears that only a small proportion of relationships (8%) last beyond fifteen years. Furthermore, the median observed relationship lasts six years, a third of the observed relationships do not last past two years and fully 85% of the firms appear to have ended a bank relationship by the tenth year. A first-pass look at the duration data thus seems to suggest that bank relationships are short-lived and that censoring affects only a small proportion of the observations.

The bottom of Table 2 gives a breakdown of the type of banks represented in the sample.[12] The sample firms maintain relationships with 51 different banks. Fourteen of the banks are international banks, 22 are Norwegian commercial banks, while the remaining 15 are Norwegian savings banks.

The pie-charts in Figure 2 provide some insight into the concentration of the relationships within the banking industry, by graphing the proportions of relationships by bank. The charts reveal that, despite the relatively large number of banks represented in the sample, the relationships are concentrated. Most importantly, approximately 75% of

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[11] These proportions are roughly consistent with the SBA Survey sample used by Petersen and Rajan (1994) and Berger and Udell (1995) where the median number of bank relationships is one, the proportion of firms with more than one bank relationship is 18% and the maximum number of banks used by one firm is six (Petersen and Rajan, 1994).

[12] Panel A of Appendix 1 provides a list of the names of the banks. Panel B maps the mergers that occur between the sample banks within the sample period. We assume that customers of merged banks continue their relationship with the combined entity after the merger so that no break in a relationship occurs. In results not reported here, we find that observed bank mergers do not influence the likelihood that a firm will end a bank relationship.

the firms maintain a relationship with at least one of Norway's two largest banks, Den norske Bank and Kreditkassen.[13]

B. Censoring

The clearest circumstance of censoring is created by the beginning and ending dates of our sample. We cannot observe the entire length of relationships that begin before 1979 (a form of *left* censoring), nor can we observe the outcome of relationships that continue as of 1994 (a form of *right* censoring). However, the listing and delisting of firms also represent a form of *random* censoring, since we are not able to observe a firm's bank relationship when it is not listed on the OSE. A left censored observation is created when a firm lists on the OSE, since the company will typically maintain a bank relationship before it goes public. Right censoring occurs when a firm delists, if the delisting is due to a switch to another exchange or if the firm is taken private again. On the other hand, a delisting due to a merger signals the end to a bank relationship (if the merged firm does not use the original bank), as does a delisting due to liquidation.

C. Firm-level Data

Motivated by the theoretical literature on bank relationships, we incorporate firm-specific data that may influence the duration of, and likelihood of ending, a bank relationship. All financial statement and stock price data come from databases maintained by Oslo Børs Informasjon (OBI). Information on equity offerings (both public and private) are obtained from the datasets used by Bøhren, Eckbo and Michalsen (1996) and Bøhren, Eckbo, Michalsen and Smith (1996), while ownership structure information is collected from company annual reports and *Kierulf's Handbook.*

The five firm-specific variables we use later in our analysis our discussed in the following subsections. We match each set of firm-specific variables to a firm-bank observation using the value of firm-specific variable in the year prior to end of the relationship or end the year prior to censoring. Due to data lost in matching the two data

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[13] In the earlier part of the sample period, the concentration is divided across three banks: Bergens Bank, (BB), Den norske Credit and Kreditkassen. In 1990, Bergens Bank and Den norske Credit merged to form Den norske Bank. By 1994, the two remaining banks held 38% of the total commercial and savings banks assets in Norway (Source: *1995 Annual Reports* and *Statistical Yearbook of Norway, 1996*).

sets, we are left with 263 matched firm-bank observations. Table 3 contains summary statistics and pairwise correlation across the 263 observations for the five firm-specific variables.

1. Single and multiple bank relationships

Firms with more than one bank relationship may find the cost of ending one bank relationship to be lower. First, the ability for any one bank to "lock in" a customer will be hindered if other banks also maintain valuable private information on the firm. Second, competition between the banks for loan and clearing services may induce the firm to shift all services to one bank and end services with another. The dummy variable MREL takes the value of 1 when a firm maintains a multiple-bank relationship at some point during the sample period and takes the value 0 otherwise.

2. Ownership Concentration

We may expect that a firm with high ownership concentration will be monitored and disciplined better than a firm with disperse ownership, thus reducing the need for monitoring services from a bank. A highly concentrated firm may also have stronger bargaining power against a bank in negotiating contracts. As a proxy for the concentration of ownership and possible control, we define the variable CONC to be the proportion of a firm's equity owned by the ten largest shareholders.

3. Size

We use the size of the firm as a proxy for the degree of uncertainty about the value of the firm. We posit that larger firms are more likely to be followed by analysts and appear in newspaper articles in Norway and abroad more often. Furthermore, twenty-two of the largest OSE firms are listed on the New York Stock Exchange (NYSE), London Stock Exchange (LSE) and/or NASDAQ trading systems. Listing on a foreign exchange implies greater dispersion of company results and possibly stricter reporting requirements then the OSE. We define the variable SIZE to be the log of end-of-year market value of equity, deflated by the Norwegian consumer price index (CPI).

4. Market-to-book ratios

As a measure of Tobin's Q, market-to-book ratios can proxy for future growth opportunities available to the firm: a high market-to-book indicates that a firm has strong growth opportunities. If a high growth ("growth") firm is more likely to require financing of its projects than a low growth ("value") firm, then a growth firm will find it more costly to end a relationship with the bank as its financing source. In addition, because much of the value of a growth firm is tied up in unrealized investment opportunities, growth firms may face more adverse selection problems and therefore be more reliant on bank financing vis-à-vis the use of arm's length debt. The market-to-book ratio, labeled Q, is measured as the ratio of the end-of-year market value of equity plus book value of assets divided by the book value of assets.

5. Proportion of Debt

The last firm-specific variable incorporated in our analysis proxies for the proportion of the firm's assets financed with debt. Given the heavy reliance in Norway on bank debt, a heavily leveraged firm is more dependent on bank financing then a mostly equity-financed firm, possibly making it costlier for the firm to switch banks. We define DEBT to be the ratio of the book value of debt to the sum of the market value of equity plus the book value of debt.

6. Summary Statistics

As is evident from Table 3, roughly 60% of the 263 firm-bank observations come from firms with multiple relationships.[14] The ten largest shareholders in the average sample firm owns 68% of the equity in the firm. The average firm has a real market value of equity of $18 million (measured in 1994 dollars), finances 54% of its assets with debt and has a market-to-book value of 1.4. Given the method for constructing the variables, it is not surprising that SIZE, Q and DEBT are highly linearly correlated. To what extent this correlation influences the regression estimates remains an empirical issue.

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[14] The high representation of multiple-bank relationships in the set of 263 observations derives primarily from two sources: (1) each firm-bank relationship is counted as one observation, thus one multi-bank firm can enter as several observations and (2) multiple-bank firms are more likely to switch banks in our sample, generating a greater number of firm-bank relationships.

IV. Analysis of Duration Data

A. Introduction

Duration studies focus on the analysis and modeling of data which involve the passage of time before a particular event occurs. For instance, the study of duration data has been applied in the labor economics literature to the length of strikes, the duration of unemployment, and employment and the time before a pay increase.[15] In our paper, we are interested in studying the length of a bank relationship, or the passage of time before a bank relationship ends. The econometrics of duration analysis has developed primarily to estimate the distribution underlying the duration data, to study the dependence of duration on explanatory variables and to obtain estimators that account for censored observations.

To better understand the analysis of duration data, define *T* to be the duration of time that passes before the occurrence of a certain random event. The passage of time is often referred to as a *spell*, while the occurrence itself is often called a *switch*. A simple way to describe the behavior of a spell is through its *survivor function*, $S(t) = \Pr(T \geq t)$, which yields the probability that the spell duration *T* lasts at least to time *t* (i.e., the survivor function equals one minus the cumulative distribution function of *T*). An alternative way of describing the behavior of a spell is with a *hazard function*. The hazard function describes the likelihood that a switch will occur, conditional on the spell surviving through time *t* and is defined by

$$\lambda(t) = \lim_{\Delta t \to o} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} = \frac{-d \log S(t)}{dt} = \frac{f(t)}{S(t)}$$

where $f(t)$ is the density function associated with the distribution of spells. Neither the survivor nor the hazard function provide any additional information that could not be derived directly from $f(t)$, they are simply economically interesting ways of examining the distributions of spell duration.

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[15] For a good overview of the econometrics of duration estimation, see Heckman and Singer (1984) or Kiefer (1988). For more recent applications, see e.g., Sueyoshi (1992), Gritz (1993), Jaggia and Trivedi (1994) and McCall (1994).

The hazard function provides a convenient method for summarizing the relationship between spell length and the likelihood of switching. When $\lambda(t)$ is increasing in *t*, the hazard function is said to exhibit *positive duration dependence*, since the probability of ending the spell is increasing in the spell length. Similarly, n*egative* duration dependence occurs when $\lambda(t)$ is decreasing in *t*. It follows that the case of *constant* duration dependence occurs when $\frac{d\lambda(t)}{dt} = 0$. Under constant duration dependence, no relationship exists between spell length and the likelihood of switching.

B. Non-parametric Estimation of Hazard and Survivor Functions

In this section, we introduce a methodology for summarizing and graphically viewing the sample distribution of bank relationship duration. The methodology employed is intuitive and robust to censored observations. Much of the development is taken from Kiefer (1988).

Let h_{ij} be the number of bank relationships with observed duration *i* and maximum duration *j*, where $i, j \in [0, K]$, K corresponds to the maximum fixed cutoff (fifteen years in our data set) and $i \leq j$. An observed duration of zero ($i = 0$) indicates that a firm listed a bank in one year, while both i and *j* are recorded as zero when a firm is listed for only one year. When $i = j$, the spell is right censored; one cannot distinguish whether the spell ended that year or continued in the unobserved future (h_{ii} is the number of censored spells).

Define $h_i = \sum_{j=0}^{K} h_{ij}$, and n_k to be the number spells that have neither been completed nor censored as of length k, $n_k = \sum_{i \geq k}^{K} h_i$. A natural, non-parametric estimator for $\lambda(k)$, the likelihood that a firm switches banks in the *k*th year given that the relationship has lasted *k* years, is

$$\hat{\lambda}(k) = \frac{h_k}{n_k}, \qquad (1)$$

which is the number of switches in year *k* divided by the number of relationships that have survived to length k. Note that the estimator $\hat{\lambda}(k)$ is robust to right censoring since the denominator in (1) normalizes the number of switches at length *k* by the number of uncensored spells still existing at time *k*.

We define the estimator of the survivor function to be

$$\hat{S}(k) = \prod_{i=0}^{k} (1 - \hat{\lambda}(i)), \qquad (2)$$

which is the Kaplan - Meier (1958) or "product-limit" estimator for the survivor function. An additional benefit of the survivor function is the ability to construct approximate standard errors around the estimates $\hat{S}(k)$. The approximate variance of the survivor estimates is:[16]

$$\text{var}(\hat{S}(k)) = (\hat{S}(k))^2 \sum_{i=0}^{k} \frac{h_i}{n_i(n_i - h_i)}. \qquad (3)$$

C. Estimates of the Survivor Function

1. Estimates using total sample

Table 4 and Figure 3 jointly provide a first look at the distribution of the duration of bank relationships through the non-parametric estimation of the survivor function in equation (2).

Both Table 4 and Figure 3 indicate that adjusting for censored observations in the data drastically changes the estimated shape of the survivor function. For instance, the censored-robust estimated median bank relationship is fifteen years, more than double the length implied by directly observing the data over the fifteen year period. Furthermore, when no adjustment is made for censoring, the survivor function decreases at a quick rate. The estimated likelihood of surviving beyond five years is 54% and the estimated chance of surviving past fifteen years is 11%. In contrast, the robust estimator for the survivor function implies that 85% of the relationships will last beyond five years and that 63% of the relationships continue after fifteen years.

Table 4 and Figure 3 also provides some insight into the importance of duration dependence in the non-parametrically estimated hazard function. The heavy-dashed line plots the implied censored-robust estimate for a survivor function calculated under the

[16] The variance measure is especially inaccurate for values of the survivor function close to 0 and 1.

restriction that the likelihood of ending a bank relationship is independent of the duration of the relationship. The two light-dashed lines plot approximate 95% confidence intervals around the restricted estimate.[17] The difference between the restricted and unrestricted estimates is small and lies everywhere within the 95% confidence bands, suggesting that the likelihood of ending a bank relationship is not influenced by the duration of the relationship.

2. Pairwise comparisons of survivor functions

To separately examine their influence of on the conditional likelihood of switching banks, Figure 4 plots pairwise cohort comparisons of survivor functions for each of our five independent variables. In Figure 4a, we plot the cohort of single-bank relationships against the plot of multiple-bank relationships. To construct each of the cohorts in Figures 4b-e, we arrange the data from highest to lowest and split the sample roughly in half to form a “high” and “low” cohort. For each of the figures, we also plot 95% confidence bands around the “low” estimates to gauge the statistical differences in the two categories. Several interesting patterns emerge from the plots.

First, the plots in Figure 4a suggest that firms with multiple bank relationships are more likely to end a given bank relationship than firms with single bank relationships. This result holds uniformly across all intervals of time, with the difference in the rate of ending a relationship increasing toward duration of ten years. For example, the likelihood of a multiple-bank relationship continuing after fifteen years is 55%, compared with 80% for single-bank relationships.

Second, small market value firms are more likely to end a bank relationship than large firms, with the difference in the switching probabilities being most pronounced for intermediate duration (4 to 9 years). In fact, Figure 4b suggests that both size cohorts exhibit non-monotonic duration dependence. For larger firms, the likelihood of ending a bank relationship decreases for intermediate duration, relative to both short (< less than 4 years) and long duration (> 9 years). For smaller firms, the probability of ending a bank relationship increases over the intermediate duration. Measured at the longer duration,

[17] See Appendix 2 for details of the derivation of the point estimates and standard errors of the survivor function under the restriction of constant duration dependence.

no statistically significant difference exists in the survival rate of large versus small firms.

Third, no difference is apparent in the survival rates of the high and low cohorts measured for ownership concentration and market-to-book ratios. Plots of the cohorts lie very near each other, with the large cohort plot lying well within the confidence bands of the plot of the low cohort.

Fourth, Figure 4e shows high debt firms to be more likely to end a bank relationship than a low debt firm for duration out to 12 years, where upon the two cohorts become statistically indistinguishable.

Conclusions regarding the influence of the independent variables in Figure 4 may be misleading since they do not control for common variation among the independent variables. In the next section, we turn to estimating the hazard function within a multiple regression framework. This framework enables us to quantify estimates of duration dependence and allows us to jointly estimate the influence of the independent variables on the conditional likelihood of ending a bank relationship.

V. The Proportional Hazard Model

A. Estimation of the Proportional Hazard Model

1. Introduction

In this section, we introduce semi-parametric and parametric techniques for studying the influence of explanatory variables on the duration of the banking relationship within the context of a *proportional hazard model.* The proportional hazard model assumes that the hazard rate function can be written

$$\lambda(t, X, \beta) = \lambda_0(t)\,\phi(X, \beta), \qquad (4)$$

where X is a set of explanatory variables, β is a vector of unknown parameters associated with the explanatory variables, $\lambda_0(t)$ is a baseline hazard function and $\phi(\bullet)$ is a non-negative function.

Estimation using the proportional hazard model typically requires specification of functional forms of $\lambda_0(t)$ and $\phi(\bullet)$. For example, we could begin by choosing a function that describes the shape of the baseline hazard $\lambda_0(t)$. Define the *integrated baseline hazard* to be $\Lambda_0(T) = \int_0^T \lambda_0(s)ds$ and let $\phi(X,\beta) = \exp(\beta' X)$. Kiefer (1988) shows that, in the absence of censored observations, the proportional hazard model can be written as a log-linear regression:

$$-\ln \Lambda_0(t) = \beta' X + \varepsilon, \qquad (5)$$

where ε follows an extreme value distribution (Johnson and Kotz, 1970). An appealing feature of equation (5) is that the coefficients β have the usual least squares interpretation of reflecting the partial influence of each of the variables in *X* on the conditional likelihood of ending a spell.

2. Specification of the baseline hazard

The *shape* of the distribution of spell lengths arises from the specification of the baseline hazard $\lambda_0(t)$. Two commonly-used specifications are the *Weibull* and the *exponential*. The hazard and integrated hazard functions for the Weibull distribution are:

$$\lambda_0(t) = \lambda \alpha t^{\alpha-1},$$

$$\Lambda_0(t) = \lambda t^{\alpha}. \qquad (6)$$

The Weibull distribution allows for duration dependence. When $\alpha > 1$, distribution exhibits positive duration dependence, while $\alpha < 1$ implies negative duration dependence. The exponential is nested in the Weibull as the case $\alpha = 1$ and represents the testable restriction that the likelihood of switching is independent of the duration of the spell.

Substitution of the expression for the integrated hazard function (6) into equation (5) indicates that estimating a Weibull hazard model is analogous to a linear regression of the log of duration, scaled by α, on the set of variables in *X* plus an intercept, with the coefficient on the intercept representing an estimate of λ. Depending on whether the value is greater than or less than one, the scaling factor α either "speeds up" or "slows down" log duration time. In the exponential case, equation (5) reduces directly to a linear regression of log duration on *X*.

The Weibull model restricts duration dependence to be monotonic over spell lengths. Figures 3 and 4 suggest the likelihood of ending a bank relationship may increase and then decrease over the observed duration. The *log-logistic* distribution, which allows for non-monotonic duration dependence, has the following hazard and integrated hazard functions:

$$\lambda_0(t) = \frac{\lambda \alpha t^{\alpha-1}}{(1+t^{\alpha}\lambda)},$$

$$\Lambda_0(t) = \ln(1+\lambda t^{\alpha}). \qquad (7)$$

When $\alpha > 1$ in the log-logistic specification, the likelihood of ending a spell first increases, then decreases with duration. When $0 < \alpha \leq 1$ the hazard function decreases monotonically with duration. A drawback to the log-logistic distribution is that constant duration dependence is *not* included as a special case.

We use all three parametric specifications (exponential, Weibull, log-logistic) of the baseline hazard to examine the influence of duration and firm characteristics on the likelihood of ending a bank relationship. We also consider one model that does not require specification of a specific baseline hazard.

The Cox (1972) *partial likelihood* model can be used to estimate the parameters in β without specifying $\lambda_0(t)$. Let $t_1 < t_2 < \ldots < t_n$ represent an ordering of the duration from lowest to highest. The conditional likelihood that spell *j* ends after length t_j is given by

$$\frac{\lambda(t_j, X_j, \beta)}{\sum_{i=1}^{n} \lambda(t_i, X_i, \beta)} = \frac{\phi(X_j, \beta)}{\sum_{i=1}^{n} \phi(X_i, \beta)} \qquad (8)$$

under the proportional hazard specification (4). Intuitively, the partial likelihood function estimates the contribution of the *j*th observation to the likelihood that the spell ends at length *j*.

Since the partial likelihood model assumes no specific form for the baseline hazard, it is sometimes referred to as a "semi-parametric" model and benefits from not being susceptible to biases induced by specifying an incorrect hazard function.

3. Incorporating censored data

Accounting for the presence of (right) censored observations can be accomplished using techniques standard in the literature on limited dependent variable analysis.[18]
Let $f(t,X),\theta) = \lambda(t,X,\theta)S(t,,\theta), \theta = \{\beta,\alpha\},$ represent the density function defined over duration and note that $\ln S(t,X,\theta) = -\Lambda(t,X,\theta)$. Estimation of the proportional hazard model in the presence on censored data can be accomplished by maximizing the log-likelihood function $L(\theta)$:

$$L(\theta) = \sum_{i=1}^{n} d_i \ln f(t_i, X_i, \theta) + \sum_{i=1}^{n} (1-d_i) \ln S(t_i, X_i, \theta),$$

or,

$$L(\theta) = \sum_{i=1}^{n} d_i \lambda(t_i, X_i, \theta) - \sum_{i=1}^{n} \Lambda(t_i, X_i, \theta). \qquad (9)$$

where d_k takes on the value of zero if the *k*th observation is censored and one if the duration is fully observed.

The interpretation of equation (9) is intuitively straightforward. When the *k*th observation is uncensored, it is used in the estimation of the density component of (9), $f(t, X(t),\theta)$. When the *k*th observation is censored, we utilize the information that the this observation has survived to time *t* to estimate the survivor function $S(t, X(t),\theta)$.

In the next section, we report the results from using the parametric and semi-parametric specifications, adjusted for censoring, to estimate the influence of duration and our firm characteristics on the likelihood of ending a bank relationship.

[18] See for example, Maddala (1988).

B. Estimation Using the Proportional Hazard Model

1. Results with parameterized baseline hazard

We first examine the results of multiple regression estimates of the conditional likelihood of ending a bank relationship using alternative specifications for the baseline hazard. For each specification, the MLE system defined by equations (5) and the censored-robust (9) is estimated using LIMDEP. LIMDEP defines the likelihood function in terms of the transformed variable, $w_i = -\ln t_i - \alpha(\beta' X_i)$, where heuristically $\lambda = \exp(\beta' X)$ is substituted into equations (6) and (7) in order to estimate the hazard function. Table 5 reports the slope estimates $\hat{\beta}$ and baseline hazard parameters $\hat{\lambda}$ and $\hat{\alpha}$ for the exponential, Weibull and log-logistic distributions using all five explanatory variables.

The $\hat{\lambda} = \exp(\hat{\beta}' \bar{X})$ is the estimate of the hazard function at the mean values of *X*. The conditional likelihood of ending a bank relationship in a given year, evaluated at the mean value of the explanatory variables, ranges between 2.6% (exponential) and 4.7% (log-logistic). The median length of a relationship is estimated to be between 26.7 years (exponential) and 21.4 years (log-logistic).

Given the estimate of its standard error (0.178), we cannot reject the hypothesis that the Weibull estimate, $\hat{\alpha} = 1.249$, is equal to one. Moreover, a likelihood ratio test statistic using the difference between the log-likelihood values of the Weibull and exponential cannot reject the exponential distribution as a null model. This suggests that when we restrict the baseline hazard to exhibit monotonic duration dependence, we cannot reject the hypothesis of constant duration dependence.

Under the log-logistic specification, however, the estimate of $\hat{\alpha} = 1.451$ is statistically greater than one (t-value = 2.29), implying that the likelihood of ending a bank relationship first increases in the duration of the bank relationship and then decreases in the duration.

Independent of the baseline hazard specification, an interesting and consistent pattern emerges in the estimates of β. If we use a size of 5% as a measure of statistical significance, then firms are *more likely to end a bank relationship* when they maintain more than one bank relationship, are relatively small and when their market-to-book values are high. Firms with relatively high debt levels also appear to be more likely to switch banks, although the statistical significance of the relationship is weaker (significant at the 10% level). The concentration of ownership appears to exert no influence on the likelihood of switching banks.

Noting that $\ln t = -\beta' X$, we can also interpret the influence of the explanatory variables in terms of their influence on the expected duration of the relationship. For example, the estimate of the intercept (-3.682) in the exponential model implies that the expected length of a bank relationship is $e^{3.682} = 39.73$ years, when all values of X are zero. The estimate $\hat{\beta}_{MREL} = 1.026$ then implies that multiple-bank relationships are expected to last only $e^{(3.682-1.026)} = 14.24$ years. Similarly, $\hat{\beta}_{Q} = 0.837$ from the exponential implies that a 1% increase in the market-to-book ratio of a firm reduces the firm's expected duration of a bank relationship by three years. Likewise, the expected duration of a relationship increases in the inflation-adjusted size of the firm and decreases in the proportion of debt held by the firm.

2. Robustness checks using the partial likelihood model.

In Table 6, we use the semi-parametric, Cox (1972) partial likelihood model to check the robustness of the distributional assumptions made above. We also explore the sensitivity of our results to the adjustment for censoring and to various combinations of the explanatory variables.

The first line (Model 1) in Table 6 contains the full-scale, censored robust estimates of the influence of the explanatory variables on the proportional hazard function. With the exception of the DEBT variable, the magnitude and significance of estimates are similar to the estimates in Table 5, suggesting that the results are not dependent on the specification of the baseline hazard. Multiple-bank relationships and high Tobin's Q tend to reduce the duration of a bank relationship, while large firms tend to maintain longer bank relationships. Both the sign and magnitude of the DEBT variable indicates that the proportion of debt held by a firm does not influence the duration of the bank relationship in the partial likelihood model.

Model 2 is estimated assuming that no censoring occurs, or that all relationships end with the last observed year of the firm-bank relationship. When the model does not account for censoring, inflation-adjusted size remains as a statistically and economically important explanatory variable. Otherwise, the slope estimates are very sensitive to the adjustment. For example, the number of bank relationships is no longer important in estimating the hazard function, nor is the Tobin's Q variable. Thus, as in the non-parametric estimation, not accounting for censoring in the data biases the conclusions of the multiple regression model.

Models 3-6 examine the relative influence of combinations of the explanatory variables, by excluding some of the variables from (censored-robust) estimation. Interestingly, the influence of the multiple bank dummy is diminished when it is the only variable in the regression (Model 3): the point estimate drops from 0.759 to 0.487 and is no longer significant at the 5% level. The value of the log-likelihood statistic (27.22) strongly rejects the null hypothesis that the excluded variables are unimportant in estimation. The estimates in Model 4 suggest that ownership concentration adds no statistical explanatory power to the model. The value of the likelihood ratio test statistic comparing models 3 and 4 is 2.54, which is less than the 5% (one degree of freedom) critical value of 3.84. Adding the inflation-adjusted size variable to the multiple-bank relationship variable (Model 5) adds a much greater degree of explanatory power. The increase in the value of the likelihood ratio statistic comparing Model 5 to Model 3 is 20.2, which is far out in the right tail of chi-squared distribution. A likelihood ratio test comparing Models 5 and 1 indicates that the joint contribution of the ownership concentration, Tobin's Q and proportion-of-debt variables are marginally significant: the value of the statistic is 7.42 with an implied p-value of 0.06.

3. Discussion

Overall, we find that the likelihood of ending a bank relationship is not strongly related to its duration. For instance, we cannot reject constant duration dependence using either non-parametric methods or parametric specifications in which the null of constant duration dependence can be tested. This result does not support the intuition suggested by asymmetric information models in which a bank customer becomes "locked-in" to the relationship. Nor does the result necessarily support the idea that firms will be more likely to leave the bank as the relationship lengthens.

The log-logistic specification provides a potential mitigating explanation for the results on duration dependence. A log-logistic distribution allows for duration dependence to be non-monotonic over different spell lengths, a feature not allowed by the Weibull specification. Estimates based on the log-logistic distribution are able to reject the null hypothesis of decreasing duration dependence in favor of a distribution that first decreases in duration and then increases. This relationship suggests the possibility that firms find it beneficial to search for the "right" bank in the early years of a relationship and then become locked in later in the relationship.[19]

The estimated relationship between the likelihood of ending a bank relationship (or alternatively the duration of the relationship) and the explanatory variables is more stable: we find the likelihood of ending a bank relationship to be increasing (duration of relationship to be decreasing) in a firm's market-to-book ratio, when the firm maintains more than one bank relationship and to a lesser degree, in the proportion of the firm's assets financed by debt. We also find a strong relationship between the firm's real size, as measured by the inflation-adjusted log market value of equity, and the length of a relationship: larger firm's are less likely to switch banks than smaller firms. Moreover, we find no statistical relationship between the duration of the bank relationship and the level of ownership concentration in the firm.

The observation that multiple-bank firms are more likely to end a bank relationship is consistent with the information-based arguments that multiple bank relationships will decrease the value of private information to any one bank, reducing the ability for any one bank to lock in a customer. The results are also consistent with the notion that multiple-bank customers find it less costly to credibly communicate their value to the public, decreasing the value of holding any one bank relationship.

[19] On the other hand, this "hump" could be an artifact of the increased number of bank switches around the financial crisis period of 1988-1991 (Kaen and Michalsen, 1995). However, preliminary regressions suggest the non-monotonicity estimate is robust to inclusion of dummy variables around the financial crisis period.

Our results, however, present a puzzle if we accept that the other explanatory variables served their intended use as proxies that indicate: (1) the level of firm uncertainty, (2) the overall need for financing and (3) the need for bank monitoring.

For instance, we would expect that larger firms would be more likely to have a higher switch rate (and shorter relationship duration), if there is less uncertainty about firm value in large firms and if large firms have a greater array of financing alternatives. Larger firms are less likely to be locked-in by a bank when exposure by analysts, regulators and journalists reveals more information about the firm. For the same reason, a large firm should have greater access to competitive alternatives to bank financing.

High growth firms, other things equal, should be more dependent on bank financing to fund investment opportunities. Moreover, growth firms may be riskier and more susceptible to information problems, since a larger portion of firm value is related to projects not yet realized (Martin, 1996). Thus it is also puzzling that we find that high growth firms are more likely to switch banks if higher risk, growth firms are more likely to be locked in to a bank relationship by information asymmetries with the public. A similar argument holds for firms with high debt financing. A high-debt financed firm within the bank-denominated Norwegian economy should find it costlier to leave a particular bank relationship, if banks maintain monopoly power.

Contrary to the implications from the information-based literature, our results suggest that firms that are in most need of bank financing maintain relatively shorter relationships and are *more likely* to end a bank relationship than firms where bank financing may be of a secondary need.

VI. Conclusion

Many of the most interesting theories arising from the theoretical banking literature focus on the potential for a bank to mitigate information asymmetries that hinder firms from obtaining valuable financing. An appealing aspect of this literature comes from the idea that both banks and firms gain from their ongoing relationship. Firms which can only credibly communicate valuations at a large cost, gain from a bank's ability to dynamically improve a financing contract once the bank has privately observed the payment ability of the firm. The bank stands to gain from the relationship if it can "lock in" the firm as a customer and extract monopoly rents because of the information it learns about the firm.

The extent to which these theories have been explored empirically is limited. Petersen and Rajan (1994) and Berger and Udell (1995) study the importance of the duration of bank relationships and find somewhat conflicting results. Berger and Udell (1995) find that the interest rate charged and collateral pledged on lines of credit is decreasing in the length of a firm's relationship with its bank and Petersen and Rajan (1994) find that credit is more readily available to firms with longer bank relationships. Both papers argue that the favorable contracts terms to older customers arise through the shared benefits of relationship. On the other hand, Petersen and Rajan (1994) find no relationship between the average loan interest rate and the length of a firm-bank relationship.

Using a new time-series data set based on the bank connections of OSE-listed firms over the period 1979-1994, we explore the importance of bank relationships by studying the determinants of their duration and termination. We first explore the dependency between the length of a bank relationship and the decision to terminate the relationship and find no strong link between the two. This result is important by itself since the relationship-theories typically suggest a link between the duration of the relationship and the contracting possibilities available to the firm. We also explore firm characteristics that may influence the likelihood of ending a bank relationship. We find that the probability of ending a relationship increases when firms maintain more than one bank relationship and as a firm's Tobin Q and debt financing increases. Firms are less likely to end a bank relationship as they become larger.

Our results appear to run counter to the theories that suggest that banks have an ability to lock in customers which have more difficulty in communicating private valuations, already rely on bank financing or which are more likely to require financing in the future. On the contrary, we find that small, highly-leveraged growth firms are more likely to end a bank relationship than large, low debt "value" firms. Moreover, the concentration of ownership in a firm - a proxy for both alternative monitoring abilities and bargaining power - does not appear to influence the decision to end a bank relationship. These results may suggest that the selection of bank services is competitive enough to induce those most needing bank financing to "shop around".

Drawing too many conclusions from our study would be unwarranted, since our data set suffers from a number of shortcomings. First, we are unable to observe the reason for the termination of a firm-bank relationship. In this paper, we have implicitly assumed that any termination is initiated by the firm. It is likely that a bank could also terminate a relationship. A possible avenue for future research would investigate the sensitivity of observed bank switches to changes in the banking environment or to bank characteristics rather than firm characteristics. We are also unable to observe information specific to the contract between each firm and their bank: we can only observe that a relationship exists. Therefore, our study lacks an analysis of the influence of the cross-sectional variation that is sure to exist in the debt contracts held by the firm.

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Appendix 1. Banks and Bank Mergers in the Sample[20]

Barclays Bank Plc., London
Bergens Skillingsbank
Bergen Bank A/S
Brumunddal Ringsaker Sparebanken
Buskerudbanken A/S
Bøndernes Bank A/S
Chase Manhattan Bank, London or NY
Chemical Bank, London, Oslo or NY
Citibank
Credit Lyonnaise
Den norske Bank A/S
Den norske Creditbank A/S
Fellesbanken A/S
Finansbanken A/S
First National Bank of Commerce, NY
Forretningsbanken A/S
Fokus Bank A/S
Gjensidige Bank
Hambros Bank Ltd., London
Handelsbanken
Kreditkassen
Landsbanken A/S
Lazard Brothers & Co. Ltd., London
Manufacturers and Traders Trust Co., NY
Manufacturers Hanover Corporation, NY
Meldal Sparebanken
Midland Bank Mees Pierson N.V.
Morgan Guaranty Trust Co., NY or London
National Westminster Bank
Norges Hypotekinstitutt
Oslo-Banken
Ringsaker Sparebanken
Rogalandsbanken A/S
Royal Bank of Canada, London
Sparebanken ABC
Sparebanken Hedemark
Sparebanken Midt-Norge
Sparebanken Nord-Norge
Sparebanken NOR
Sparebanken Oslo Akershus
Sparebanken Sør
Sparebanken Vest
Sparebanken Vestfold
Sparebanken Østlandet
SR-Bank
Sunnmørsbanken A/S
Sørlandsbanken A/S
Sør-Varanger Sparebanken
Telemarksbanken A/S
Texas Commerce Bancshares, Houston
Trondhjems og Strindens Sparebanken
Vestfoldbanken

Merging banks	into	Year
Den norske Creditbank A/S	Den norske Bank A/S	1990
Bergen Bank A/S	Den norske Bank A/S	1990
Buskerudbanken	Fokus Bank	1987
Bøndernes Bank	Fokus Bank	1987
Forretningsbanken	Fokus Bank	1987
Vestlandsbanken	Fokus Bank	1987
Rogalandsbanken	Fokus Bank	1991
Sørlandsbanken	Kreditkassen	1990
Sunmørsbanken	Kreditkassen	1990
Sparebanken ABC	Sparebanken NOR	1990
Sparebanken Vestfold	Sparebanken NOR	1990
Sparebanken Østlandet	Sparebanken NOR	1990
Texas Commerce Bancshares	Chemical NY Corporation	1987
Chemical NY Corporation	Chemical Banking Corporation	1991
Manufacturers Hanover Corporation	Chemical Banking Corporation	1991

[20] International banks are listed as one bank whether or not they have a branch or subsidiary in Norway.

Appendix 2. Constant Duration Dependence

For each estimator of the integrated hazard function $\overline{\Lambda}(k)$ and for each duration L, $2 \le L \le K$, there exists an integrated hazard function $\Lambda'(k)$ with constant duration dependence, for which the hazard rate is constant and equal to

$$\lambda' = \frac{\overline{\Lambda}(L)}{L},$$

and a survivor function equal to

$$S'(l) = (1 - \frac{\overline{\Lambda}(L)}{L})^{l}.$$

The approximate variance of this survivor function $S'(l)$ with constant duration dependence is

$$\mathrm{var}(S'(k)) = (S'(k))^2 \sum_{i=0}^{k} \frac{h'_i}{n'_i(n'_i - h'_i)},$$

for $i = 0$

$$n'_i = n_i \text{ and } h'_i = \frac{\overline{\Lambda}(L)}{L} n'_i$$

and for $i > 0$

$$n'_i = n'_{i-1} - h'_i - h_{ii} \text{ and } h'_i = \frac{\overline{\Lambda}(L)}{L} n'_i.$$

Hence this specification of the variance takes into consideration the number of observations and the degree of censoring underlying the original survivor function, $\overline{S}(l)$.

To test the null of constant duration dependence against the alternative of negative duration dependence in period l at 5% level of significance, check

$$\overline{S}(l) < S'(l) - 1.96(\mathrm{var}(S'(l)))^{1/2}.$$

TABLE 1. NUMBER OF SAMPLE FIRMS AND NUMBER OF FIRMS SWITCHING BANKS

Year	Number of Firms in the Sample	Lists	Delists	Number of Firms Switching Banks
1979	100			
1980	95	5	10	5
1981	97	4	2	2
1982	102	6	1	6
1983	121	21	2	5
1984	136	21	6	6
1985	129	6	13	3
1986	124	7	12	12
1987	113	5	16	9
1988	105	3	11	12
1989	96	8	17	5
1990	93	6	9	7
1991	105	15	3	6
1992	101	10	14	6
1993	110	14	5	4
1994	122	16	4	5
mean 1979-1994	103	9	8	6

Notes. The third column lists the number of firms in the sample listed for the first time on the OSE. The fourth column lists the number of firms in the sample listed for the last time on the OSE. Notice that firms can switch more than one bank, hence the total number of relationships ending in each year is at least as high as the number in the fifth column in the table.

TABLE 2. SAMPLE CHARACTERISTICS OF BANK RELATIONSHIPS

Proportion of firms with multiple relationships		
	One Bank	0.74
	Two Banks	0.17
	Three Banks	0.07
	Four Banks	0.02
Number of relationships for each firm		
	Mean	1.37
	Median	1
Total Number of Firm Observations		401
Proportion of Observations Censored		0.77
Distribution of Observed Duration of Relationships, by Year		
	< 1	0.08
	1	0.15
	2	0.10
	3	0.08
	4	0.08
	5	0.10
	6	0.08
	7	0.07
	8	0.08
	9	0.03
	10	0.02
	11	0.03
	12	0.02
	13	0.01
	14	0.01
	≥15	0.08
Duration of Observed Relationships, in Years		
	Mean	7.2
	Median	6
Number of Banks in the Sample, by Type		
	Domestic - Commercial	22
	Domestic - Savings	15
	International	14
	Total	51
	Banks involved in mergers	11

TABLE 3. DESCRIPTIVE STATISTICS AND PAIRWISE CORRELATIONS

Variable	Mean	St.Dev	Skewness	Kurtosis	Minimum	Maximum
MREL	0.593	0.492	-0.4	1.1	0.00	1.00
CONC	0.681	0.176	-0.8	3.9	0.00	1.00
SIZE	7.469	1.629	-0.1	2.7	3.44	12.39
Q	1.337	0.479	2.2	11.8	0.48	4.58
DEBT	0.536	0.227	-0.4	2.9	0.00	0.96

Variable	MREL	CONC	SIZE	Q	DEBT
MREL	1.000				
CONC	-0.120	1.000			
SIZE	0.155	-0.083	1.000		
Q	-0.074	0.042	0.313	1.000	
DEBT	0.168	-0.083	-0.148	-0.567	1.000

Notes. Number of observations: 263. MREL takes the value of 1 when a firm maintains a multiple-bank relationship at some point during the sample period and takes the value 0 otherwise. CONC is the proportion of a firm's equity owned by the ten largest shareholders. SIZE is the log of end-of-year market value of equity, deflated by the Norwegian CPI. Q is the ratio of the end-of-year market value of equity plus book value of assets divided by the book value of assets. DEBT is the ratio of the book value of debt to the sum of the market value of equity plus the book value of debt.

TABLE 4. NON-PARAMETRIC ESTIMATES OF THE SURVIVOR FUNCTION OF BANK RELATIONSHIPS, WITH AND WITHOUT ADJUSTMENT FOR CENSORING

Length in Years	No Adjustment for Censoring	Adjusted for Censoring		No-Duration Dependence	
			-2 St.Dev.		+2 St.Dev.
0	1.000	1.000	1.000	1.000	1.000
1	0.871	0.960	0.948	0.969	0.990
2	0.764	0.947	0.909	0.939	0.969
3	0.662	0.893	0.873	0.910	0.947
4	0.605	0.877	0.839	0.882	0.925
5	0.544	0.854	0.806	0.855	0.903
6	0.434	0.828	0.775	0.828	0.881
7	0.388	0.813	0.744	0.802	0.861
8	0.327	0.771	0.715	0.778	0.840
9	0.247	0.721	0.686	0.754	0.821
10	0.202	0.709	0.657	0.730	0.803
11	0.175	0.681	0.629	0.708	0.786
12	0.141	0.649	0.602	0.686	0.770
13	0.126	0.649	0.574	0.665	0.755
14	0.114	0.629	0.548	0.644	0.740
15	0.107	0.629	0.523	0.624	0.726
Median duration	6	15		15	

Notes. Number of observations: 263.

TABLE 5. PARAMETRIC ESTIMATION OF CONDITIONAL HAZARD FUNCTIONS

Function	$\hat{\lambda}$	$\hat{\alpha}$	$\hat{\beta}$						Median Duration	Log-likelihood
			Intercept	MREL	CONC	SIZE	Q	DEBT		
Exponential	0.0260	1	-3.682***	1.026***	0.496	-0.366***	0.837**	1.307*	26.67	-151.25
	(0.0044)	-	(1.114)	(0.366)	(0.868)	(0.0928)	(0.364)	(0.780)	(4.52)	(3.64)
Weibull	0.0352	1.249	-3.271***	0.816***	0.413	-0.307***	0.672**	1.034*	21.20	-149.43
	(0.0072)	(0.178)	(0.876)	(0.298)	(0.657)	(0.0770)	(0.279)	(0.618)	(4.36)	
Log-logistic	0.0467	1.451[aa]	-2.875***	0.892***	0.272	-0.354***	0.807**	1.23**	21.43	-148.52
	(0.0087)	(0.197)	(0.881)	(0.290)	(0.714)	(0.0808)	(0.320)	(0.622)	(4.017)	

Notes. Number of observations: 263. MREL takes the value of 1 when a firm maintains a multiple-bank relationship at some point during the sample period and takes the value 0 otherwise. CONC is the proportion of a firm's equity owned by the ten largest shareholders. SIZE is the log of end-of-year market value of equity, deflated by the Norwegian CPI. Q is the ratio of the end-of-year market value of equity plus book value of assets divided by the book value of assets. DEBT is the ratio of the book value of debt to the sum of the market value of equity plus the book value of debt. All estimates are adjusted for censoring. Coefficients are listed on the first row in each cell and standard errors are reported below between parentheses. The last column lists the log of the likelihood $L(\theta)$ and the log likelihood ratio test statistic between parentheses. Based on the log likelihood ratio test statistic, $-2\log(L(\theta_{weibull})/L(\theta_{expo}))$, which is asymptotically $\chi^2(1)$, H_0: $\alpha=1$ cannot be rejected in the Weibull model. *** Significant at 1%, ** significant at 5%, * significant at 10%. [aa] Significantly different from one at a 5% level.

TABLE 6. PARTIAL LIKELIHOOD ESTIMATES OF CONDITIONAL HAZARD FUNCTION

	MREL	CONC	SIZE	Q	DEBT	Medium duration	Log likelihood
Model 1	0.759***	0.758	-0.384***	0.526**	0.0622	15	-382.2
	(0.259)	(0.653)	(0.078)	(0.237)	(0.585)		
Model 2	0.145	-0.007	-0.205***	0.314	0.107	7.040	-1236.0
	(0.134)	(0.334)	(0.042)	(0.153)	(0.374)		
Model 3	0.487*	-	-	-	-	15	-395.8***
	(0.249)						(27.2)
Model 4	0.526**	1.068	-	-	-	15	-394.5***
	(0.250)	(0.687)					(24.7)
Model 5	0.654***	-	-0.310***	-	-	15	-385.9*
	(0.251)		(0.069)				(7.4)
Model 6	0.487*	-	-	0.141	-	15	-395.6***
	(0.249)			(0.211)			(26.8)

Notes. Number of observations: 263. MREL takes the value of 1 when a firm maintains a multiple-bank relationship at some point during the sample period and takes the value 0 otherwise. CONC is the proportion of a firm's equity owned by the ten largest shareholders. SIZE is the log of end-of-year market value of equity, deflated by the Norwegian CPI. Q is the ratio of the end-of-year market value of equity plus book value of assets divided by the book value of assets. DEBT is the ratio of the book value of debt to the sum of the market value of equity plus the book value of debt. The estimates in model 2 are not adjusted for censoring. The estimates in model 1 and 3 to 6 are adjusted for censoring. Coefficients are listed on the first row in each cell and standard errors are reported below between parentheses. The last column lists the log of the likelihood $L(\theta)$ and the log likelihood ratio test statistic between parentheses. The latter statistic is $-2\log(L(\theta_1)/L(\theta_i))$, asymptotically $\chi^2(n)$, with i=3,..., 6, and n=4 if i=3 and n=3 otherwise. *** Significant at 1%, ** significant at 5%, * significant at 10%.

FIGURE 1. SINGLE AND MULTIPLE-BANK RELATIONSHIPS

Proportion of the firms in the sample having one to four relationships.

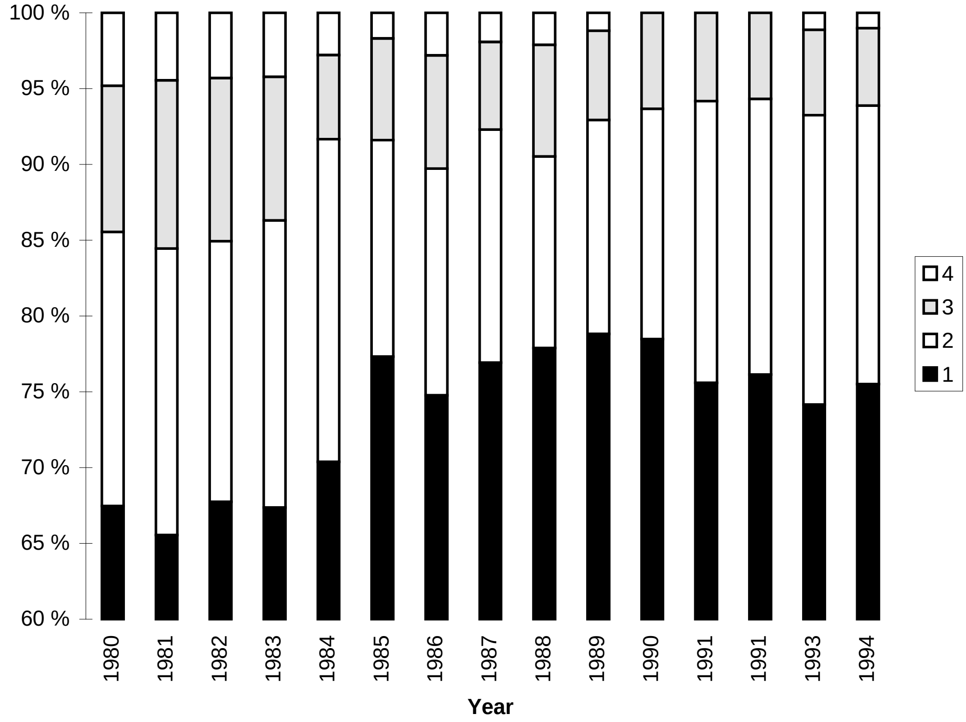
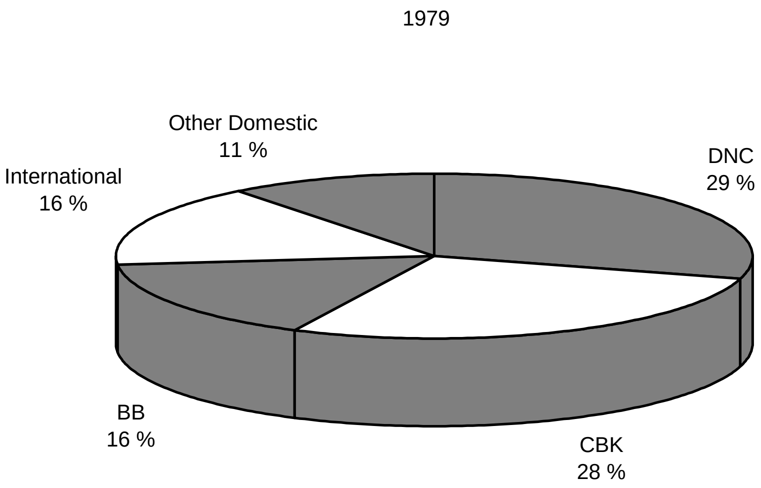


FIGURE 2. CONCENTRATION OF BANK RELATIONSHIPS, BY TYPE OF BANK



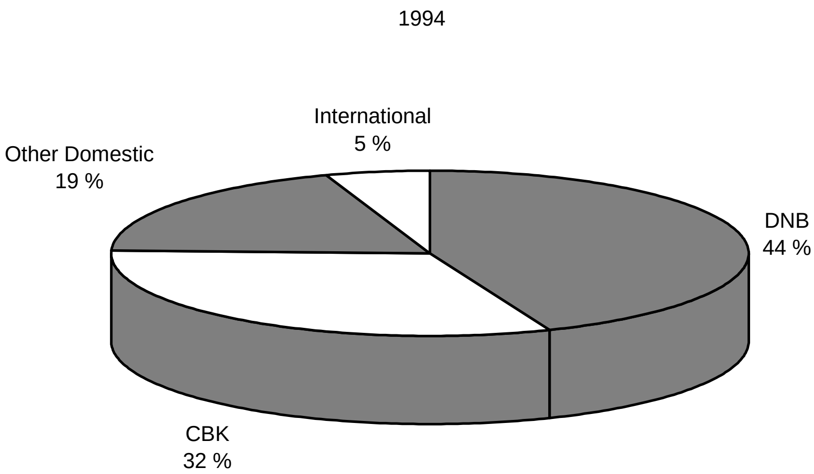


FIGURE 3. NON-PARAMETRICALLY ESTIMATED SURVIVOR FUNCTIONS OF RELATIONSHIPS

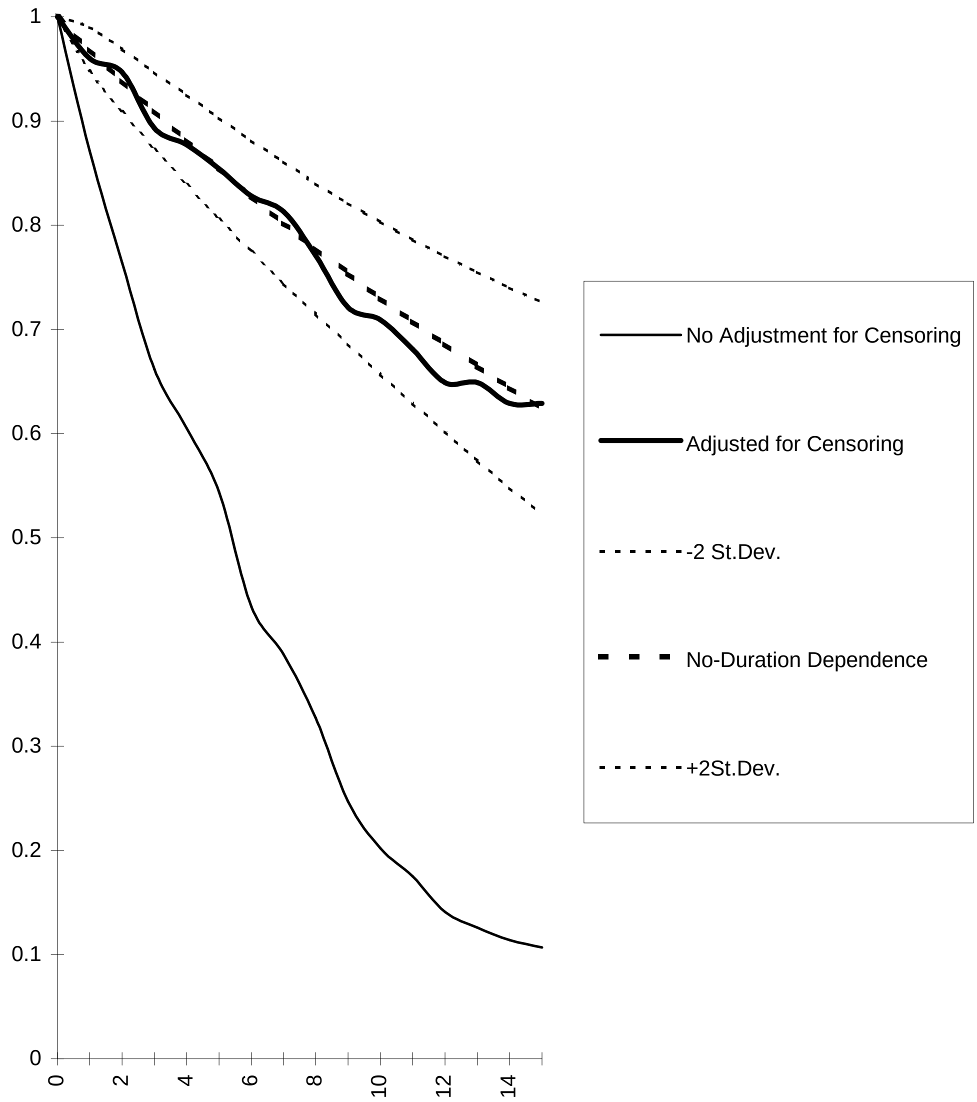
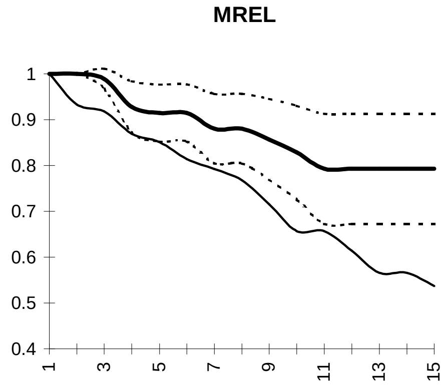
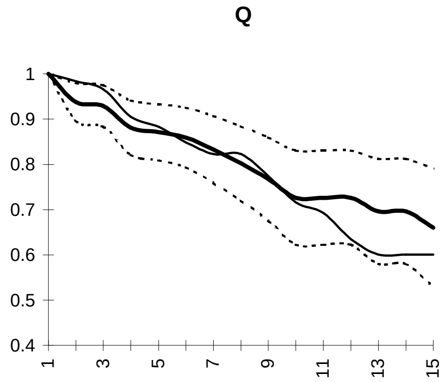
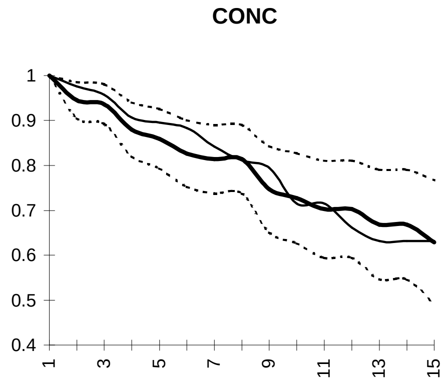
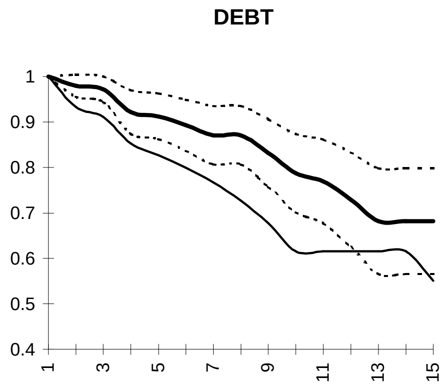


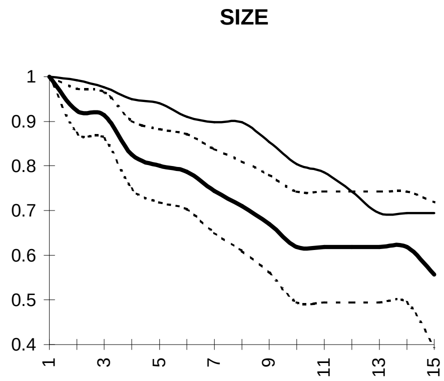
FIGURE 4. ESTIMATED SURVIVOR FUNCTIONS BY DIFFERENT STRATIFICATION SHEMES











	Difference in Cohorts	
	Log Rank	Wilcoxon
MREL	7.6***	6.8***
CONC	0.1	0.5
SIZE	7.3***	10.3***
Q	0.04	0.14
DEBT	4.9**	5.9**

Notes. Number of observations: 263. The bold solid line represents the survivor function of the "low" group of firms, the other solid line represents the survivor function of the "high" group. The dashed lines represent a band of 2 standard deviations around the survivor function of the "low" group. The stratification sheme for MREL has 107 observations in the "low" group. These firms have only one relationship. The cut-off levels in the other stratification shemes are chosen in order to approximately divide the sample in two equally sized groups: there are 132 observations with CONC lower than 0.7, 126 observations with SIZE lower than 7.5, 156 observations with DEBT lower than 0.6, and 135 observations with Q lower than 1.25. *** Significant at 1%, ** significant at 5%, * significant at 10%.