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Bank Lending, Geographical Distance, and Credit risk: An Empirical Assessment of the Church Tower Principle

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Abstract

Does the Church Tower Principle, i.e. geographical proximity between borrowing firm and lending bank, matter in credit risk management? If so, the bank might expose itself to a greater risk by lending to distant firms and should therefore respond by rationing them harder. In this paper we incorporate the Church Tower Principle in a simple theoretical model and derive implications that are empirically testable. We use data on corporate loans granted 1994 to 2000 by a leading Swedish bank and find no evidence that the principle applies.

Key words: Asymmetric information, credit rationing, duration model

JEL classification: D82, G21

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1. Introduction

This paper concerns the relevance of geographical distance in the management of credits. Proximity might imply that the bank has good knowledge about the local market on which a potential borrowing firm acts. It might also imply that the bank knows more about the firm's ability to perform an investment, its board, its human capital and so forth. In other words, the degree of information asymmetry, due to information being neither costless for the bank nor perfect, is lower in the vicinity of the bank. Whenever the bank strives at getting close to the firm with the intention of improving its credit management we will speak of the Church Tower Principle (CTP). Figuratively speaking the bank is the church tower and from its outlook it can screen and monitor firms in its proximity.

The CTP does indeed seem sensible but the current trend in banking suggests differently. The bank that is studied in this paper has closed many offices the past decade, and thereby it has increased the distance to its borrowers. Moreover, Degryse and Ongena (2002) report that the average distance between the lending bank and the borrowing firm has approximately doubled lately in both the US and Belgium.

Implicit in the CTP is that the information relevant for screening and monitoring firms is harder to come by the more distant the firm. A sensible response by the bank, as will be shown in this paper, to this information asymmetry would be to assess distant firms harder, which would lead to geographical credit rationing.[1] A consequence could be regions with difficulties in getting access to risk capital, and thereby the local business environment and the labor demand could be affected. Hence, from the society's perspective the current trend of increasing distance between lender and borrower is potentially worrying and should be carefully examined.

The CTP is also relevant from the bank's perspective. If the information asymmetry increases with distance, then it is essential for the bank, to be efficient, to act according to the CTP by, e.g., applying geographical credit rationing. However, if the geographical distance is unimportant, then acting according to the CTP will actually lead to inefficiency. Therefore, it is helpful for bank management to have the CTP thoroughly tested.

According to Herring (1999) bank crises (mainly caused by credit losses) have caused taxpayers around the world high costs. Although the issue of credit management is important, the empirical literature has mainly concentrated on the market for bonds and only a few studies deals with the credit or the loan market.[2] This is noted in a paper by Altman and Suggitt (2000) who compare default rates for bonds and syndicated loans of the size 100 million USD or larger in the U.S.[3] There are also some studies on default probability applied on consumer loan data. One example is Boyes, Hoffman, and Low (1989) who use American data on credit card applicants to estimate the probability of acceptance and the probability of default. Carling, Jacobson and Roszbach (2001) study the dormancy risk and the bank's expected profits with Swedish data on consumer loans. The present paper concentrates on corporate bank loans and contributes to the previous literature by, for the first time, using bank data on granted loans and empirically investigating the importance of geographical distance.

To test the CTP we proceed as follows. We have quarterly data on all loans issued by one of the major banks in Sweden to the corporate sector for the period 1994 - 2000. This means that we do not know anything about loan applications that were rejected, and this fact makes it more difficult to empirically test the existence of the CTP and its application. We begin by outlining a simple theory that incorporates the CTP and derive the bank's rule for approving loan applications. The theory leads to empirical implications that unambiguously either supports or rejects the CTP. Finally, we use standard econometric techniques to draw conclusions about the CTP. We use a rich set of control variables that are at our disposal due to the fact that the bank data has been merged with several other registers of the borrowing firms.

The rest of the paper is organized as follows. The theory that incorporates the CTP and its empirical implications are outlined in Section 2, followed by a description of the register data and the bank's internal risk classification in Sections 3 and 4, respectively. The econometric specification and the results together with interpretations are given in Section 5. Finally, a

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[1] In the pioneering work by Jaffe (1971), Jaffee and Modigliani (1971), and Stiglitz and Weiss (1981) the general issue of credit rationing is discussed in detail.

[2] See Altman and Saunders (1997) for an exposition of credit risk measurement over the last 20 years. They discuss different sets of variables and alternative methods to measure credit risk. Altman (1984) provides a presentation of earlier work on business failure prediction models. The presentation covers the work until 1984.

[3] A syndicated loan is a loan originally issued by a bank which is later sold, undivided or in parts to another bank or financial institution. See Altman and Suggitt (2000).

discussion of the validity of the results and a conclusion is given in Section 6. Descriptive statistics and some miscellaneous results are presented in the Appendix.

2. The theory and its empirical implications

In this section we will present the theoretical framework, investigate how the geographical distance, *k*, enters the bank's decision rule for approving loan applications, and present the implications that will be empirically tested. This exercise will provide a relationship between the bank's internal rating of loans to the corporate sector and *k*, as well as a relationship between observed default rate and *k*. The empirical presence of the two relationships can and will be tested with the data at our disposal.

Following Boyes et al. (1989), we assume that the bank assesses loan applications in order to maximize the profit with respect to maintained balances and the probability of default. Assume that the assessment of a loan application and the repayment of the loan, if granted, occur during one time period. Then there are two possible outcomes of the loan; it will either default or succeed.

Let *S* denote the loan size upon approval. It is assumed that *S* does not vary over time and, upon approval, the bank will not negotiate the size of the loan. For simplicity, assume that all firms apply for loans of the same size. The loan will pay an interest rate *r*, and the likelihood that a loan defaults is denoted *P*. This probability differs among firms and is therefore indexed by *i*. It is stipulated that the firm knows its default probability, P_i, at the time of the loan application. For defaulted loans the recovery rate is (1-*v*), and the bank's cost for assessing a loan application is denoted *c*.

However, under the assumption that the bank applies credit rationing in order to maximize profits, not all loans are granted. In fact, the bank will only grant loans for which the expected returns exceed the opportunity cost of bank funds. Assume that the bank's alternative is to invest the funds in government bonds to the interest rate r_b. The loan to firm *i* will be granted if

$$(1) \qquad E[p_i] = (1 - P_i)S(r - r_b) - P_i S(v + r_b) - c > 0$$

where p_i denotes the profit. If the recovery rate is assumed to be zero (and hence $v = 1$), then equation (1) can be simplified as

(2) $$E[p_i] = S(r - r_b) - P_i S(1 + r) - c > 0 .$$

Obviously the bank can use the formula to either determine the interest rate as a function of P_i or determine which applications to reject given a predetermined bank optimal interest rate.[4] In our opinion the latter approach, although there is certainly a scope for fine-tuning the interest rate, approximates the actual behavior of the bank and we note that the bank will thus reject applications for which $P_i > [S(r - r_b) - c]/S(1 + r)$.

The basic problem for the bank is that information on the value of P_i is likely to come at substantial costs for the bank, or it might not even be possible to obtain. Thus the bank will resort to an assessment of the parameter, P_i^A. Assume that the bank can obtain such an assessment at the fixed cost c and that the assessment obeys the following; $P_i^A = P_i + \varepsilon_i$, $E[\varepsilon_i] = 0$, and the variance of the error is, in accordance with the Church Tower Principle, increasing in k, $Var[\varepsilon_i] = (\sigma k)^2$. The latter is a consequence of a long distance making the assessment more erroneous at the fixed cost or, in other words, the information asymmetry is increasing in k. In what follows, it will also be assumed that the bank correlates, positively, the interest rate, r_i^A to the assessed default probability P_i^A. If P_i^A substitutes P_i in (2) we get the decision rule as

(3) $$E[p_i] = S(r_i^A - r_b) - P_i^A S(1 + r_i^A) + E[\varepsilon_i]S(1 + r_i^A) - c > 0 .$$

This decision rule is not equally attractive to all firms because they know P_i. Indeed the loan offer will be attractive to firms for which $P_i^A \le P_i$. For the other firms there is hope of a more

[4] Stiglitz and Weiss (1981) show that credit rationing at a bank-optimal interest rate is possible in equilibrium. This is explained by the fact that the interest rate in itself can affect the risk level in the bank's loan portfolio due to an adverse selection and incentive effect. The adverse selection effect arises because the level of the interest rate can be a sorting device and attract a certain type of potential borrowers. The incentive effect is caused by the correlation between the return to the borrower on the loan financed project and the interest rate. See Stiglitz and Weiss (1981).

favorable assessment at another bank or lending institution and, as a consequence, a lower interest rate. Hence we stipulate that these firms will reject the offer.[5] This means that

(4)
$$\begin{aligned} E[p_i] &= S(r_i^A - r_b) - P_i^A S(1 + r_i^A) + E\left[\varepsilon_i \middle| P_i^A \le P_i\right] S(1 + r_i^A) - c \\ &= S(r_i^A - r_b) - P_i^A S(1 + r_i^A) + E[\varepsilon_i | \varepsilon_i \le 0] S(1 + r_i^A) - c. \end{aligned}$$

To study this selection effect we assume the error to follow the Normal distribution.[6] This assumption gives a closed-form expression since $E[\varepsilon_i|\varepsilon_i \le 0] = -\sigma k\, \phi(0)/\Phi(0) = -\sigma k\sqrt{2/\pi}$, where $\phi(\cdot)$ is the probability density function and $\Phi(\cdot)$ is the distribution function for the Normal distribution, respectively. Then equation (4) becomes

(5)
$$E[p_i] = S(r_i^A - r_b) - \left(P_i^A + \sigma k\sqrt{2/\pi}\right) S(1 + r_i^A) - c > 0 .$$

Note that $\sigma\sqrt{2/\pi}$ is simply scaling the distance measure. The decision-rule can thus be simplified as

(6)
$$\left(P_i^A + k\right) < \frac{r_i^A}{1 + r_i^A} - \left(\frac{r_b + c/S}{1 + r_i^A}\right).$$

In the process of making the borrowers reveal themselves the bank must disclose the interest-rate, and, thus, the bank cannot adjust it afterwards. It remains for the bank to reject applications from businesses with a high assessed default probability located far away.[7] So, the probability of getting a loan approved decreases with the geographical distance from the bank.

The CTP can be expressed in terms of two conditions. They are:

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[5] Due to the inherent randomness in the assessment, a second try is sensible, at least if the cost of a second try can be assumed negligible. Note also that the firm may choose not to apply for a loan if it has some way to foresee the bank's assessment.

[6] This assumption makes it theoretically possible for the bank to make assessments greater than one or less than zero. This technical detail could have been overcome by making a restricting the range of the distribution of the error term, but at the expense of complicating the derivation of a closed-form expression.

[7] Another possibility would be to relate the interest rate to the distance. We have found that the theoretical results are unaffected by this possibility as long as the relationship between interest rate and distance is of moderate strength.

Condition 1 (C1): $Var[\varepsilon_i] = (\sigma k)^2$. The information asymmetry increases with the geographical distance.

Condition 2 (C2): The decision rule in equation (6). The bank acts according to the CTP.

Note that the second condition does not imply that C1 is true, nor does C1 imply that C2 is true. We hope to be able to determine the accuracy of both conditions. It is rather obvious that C2 implies that fewer loans will be granted for distant firms and it would be relatively simple to verify C2 if we had access to non-approved loan applications, which unfortunately we do not. To determine the relationship between P_i and k and P_i^A and k for granted loans is more difficult and we will therefore resort to simulations in the hope of finding implications which enable us to validate C1 and C2.

The simulation generates the model as it has been outlined above and varies the effect of the distance k by setting different values on σ.[8] The results from the simulations are presented in Table 1 and they refer to the relationship between P_i and k and P_i^A and k for granted loans. Note first that if C2 is true, then we should observe that P_i^A is decreasing with the distance. If C2 is false, then there should be no observable relationship between P_i^A and k for granted loans. If C1 is true, then P_i will increase in k.[9] If C1 is false however, then the observed relationship (or absence of it) will depend on the status of C2.

Table 1. Empirical implications for the granted loans according to the simulations

Outcome	Expected result as a function of increasing *k*.			Support for the *CTP*
	The number of approved loan applications	P_i	P_i^A	
C1 and C2 true	Decrease	Increase	Decrease	Strong
C1 false and C2 true	Decrease	Decrease	Decrease	Weak
C1 true and C2 false	-	Increase	-	Weak
C1 and C2 false	-	-	-	No

Note: A dash implies no change in the entities.

The bottom line is that we can empirically assess the two conditions if we have data on P_i, P_i^A, and k for granted loans. In section 3.1 it is explained how k is being measured. We will

[8] P_i^A and k varies uniformly from 0.01 to 0.15 and 0 to 1 respectively, and the error follows the normal distribution with a mean of zero and a standard deviation of 0.01 (We have also experimented with 0.005 and 0.03.). The interest rate equals 6 per cent for the least risky loans and increases with 0.1 percentage points for each increase in the assessed default probability, hence the interest rate varies from 6 to 7.4 per cent, mirroring the 15 assessment categories in the data (cf. section 4).

measure P_i^A as the bank's internal rating of the firm at the time the loan application was approved and P_i as the observed default probability (see section 4).

3. Data

The data set used in the analysis is quarterly data on Swedish limited companies with an outstanding loan at a major Swedish bank sometime during the period 1994 (from the second quarter) to 2000 (to the first quarter). The total number of firms is 53 383 and they represent counter-parties for all corporate loans issued by the bank in the time window. Because the duration of a loan may exceed a quarter and new loans are issued to old customers in the bank, there are sometimes multiple observations from the same firm over time. In total there are 575 768 observations (or loan status reports), which means that on average a firm has an active loan in the bank in (roughly) 10 out of the 24 quarters. For the firms, the total sales range from only slightly more than zero to SEK 60 000 million, though the vast majority of the firms are small and have a total sales of only a few millions and less than 10 employees.

We have been able to link data on geographical distance as well as three types of control variables obtained from *inter alia* national registers to the loan data. The theory implied a relation between default probability and distance as well as initial rating and distance, under the assumption of no other source of selection related to the distance. The control variables are used to make this assumption valid. Below we begin by explaining how the causal variable, distance, was created and then we discuss the control variables.

In order to test the existence of the information asymmetry related to distance (C1) and if the bank applies the decision rule (C2), it was helpful to create two subsets of data from the original data set. The first subset is primarily related to the default probability and the distance and consists of all defaulted loan events and ten percent randomly selected of the non-defaulted loan events. The rationale for discarding 90 per cent of the non-defaulted loans was that computations became feasible, yet very little information was lost. The second subset is related to the question whether the bank applies the decision rule given by condition 2. This subset contains all data on the loan and the firm at the time of the application, that are, when the bank assigned its initial rating. There is 61 106 observations in the first subset and 69 110 observations in the second subset.

[9] We also found that this relationship should be observably stronger if it is conditioned on P_i^A.

3.1 Causal variable

The geographical distance is based on the postcode for the bank offices and the borrowing firms. In order to obtain the geographical distance between the bank office and the firm, the postcode of each party is linked to its geographical co-ordinate. The distance is then measured (in kilometers) between the geographical co-ordinates as the crow flies, given that the bank office located closest to the firm granted the loan. In practice, a computer algorithm (written in Perl) links the postcodes of the firms and the bank offices to geographical co-ordinates. This information is based on the postcode information in our data and a data file from Statistics Sweden. All postal codes in Sweden and the corresponding geographical co-ordinates are available in the latter file. The algorithm then seeks the closest possible combination of firm and bank co-ordinates. The assumption of closest distance was necessitated due to the lack of information in the data; it was not possible to conclude which bank office that granted the loan. However, this assumption is of course in accordance with the Church Tower Principle. It has been a puzzling work to link all the postcodes to geographical co-ordinates, and there was some minor difficulty in finding co-ordinates to a few firms and bank offices. The problem arose when the postcode did not correspond to a street address or post box. In these cases, the closest possible postcode (with a street address and co-ordinates) corresponding to the firm or the bank office in question was used as a substitute. This has no impact on the results because the aberrant postcodes had a very central location in the cities.

As an alternative to the crow flies distance, the geographical distance by road or in travel time could have been used. The alternatives would raise the question of a correct choice of road network system or travel mode. An additional problem is that travel time based distance matrix measures are available only for distances between municipal centers (or other centers unrelated to the post-code). A majority of the related bank offices and firms are located in the same municipality, and thus the generated distance variable would often be zero. Of course, the geographical distance measured in kilometers could be converted to travel time contingent of a certain speed by for example car. Puu (1997) shows, however, that a regular network, as in our case, serves as a good approximation to real networks (for example road systems).

Table 2. Number of bank offices by year.

Year	Number
1994	314
1995	281
1996	278
1997	260
1998	254
1999	252
2000	248

The bank is concentrated to the major city areas of Stockholm, Göteborg, and Malmö. The share of offices in these three areas is about two thirds. In addition, the bank is also represented in most major cities in the rest of the country, but only in a few smaller towns. Table 2 gives the number of bank offices during the years 1994 to 2000. As shown by the table the number of offices has decreased by 66 during the time period studied. About 30 percent of all outstanding loans are issued to firms located in the Stockholm County. The Göteborgs- and Bohus County and the Malmöhus County host firms that represent about 25 percent of the outstanding loans. See table A3 in the Appendix for more details on geographical distribution of the outstanding loans.

Table 3. Descriptive statistics on the distance variable in kilometers.

Statistics	Subset 1 (default)	Subset 2 (initial rating)
Mean	4.01	4.07
Std. Deviation	10.89	12.00
Percentiles		
Minimum	0	0
25	0	0
50	1	1
75	4	3
90	11	11
95	18	18
99	41	45
Maximum	300	300
Number of observations	61 106	69 110

Descriptive statistics on the distance variable by each subset is presented in Table 3. On average, the distance of the firm to the bank office is 4 kilometers. The distribution of the distance variable is however very skewed, for about 46 percent (subset 1) and 49 percent (subset 2) of the observations the distance between the bank and the firm is measured as being zero kilometers. One explanation to this is the high concentration of bank offices and borrowing firms in the three major city areas mentioned earlier, yet it also indicates that the distance measure, in spite of our efforts, remain a bit crude.

3.2 Control variables

The bank variables: These variables provide information about each business customer's credit history collected by the bank itself and loan specifics (not the interest rate), and information from the Swedish banks' common company information center (UC). The latter describes the firm's payment behavior. Three types of loan categories are defined and will be used in the estimations. These are only short-term loans, only long-term loans, and a category with a combination of short and long-term loans. Mortgages and guarantee loans are included in the long-term loan category. Almost 10 percent of the observations refer to short-term loans. Two indicator variables of payment behavior are created from the UC data. The first is based on the banks' registration of failure in payment, denoted remark type 25. The second indicates remarks of five types (type 8, 11, 16, 25, and 35), where the other four remarks are due to the legal system. About 90 percent of the loans belong to firms with neither of the remarks. The data also contain information about the activity code of the borrowing firm. Table A2 in the Appendix gives the number of observations by industry for the second subset. Other business service activities are the largest industry in the data followed by wholesale and retail trade.

The credit bureau variables consist of the firms' balance sheets and income statement variables. The credit bureau variables that are used in the estimations are total sales (*TS*), a debt ratio, which is total liabilities (*TL*) divided by total assets (*TA*), an earnings ratio, which is earnings before interest, depreciation, taxes and amortization (*EBITDA*) divided by total assets, and finally a ratio describing the inverse of inventory turnover, which is inventories (*I*) divided by total sales. See Table 4 for descriptive statistics on the credit bureau variables.

The total sales variable is used as an indicator of firm size. The debt ratio is assumed to describe the vulnerability of the firm since the ratio includes all liabilities and not only the ones to the bank in question. A high debt ratio would then indicate an initial rating corresponding to a high default probability. The same relationship is probably true for a firm with large stock of inventories in relation to total sales. The earnings ratio is, as mentioned in

Altman (1968) an indicator of the productivity of the firm's assets. A high earnings ratio would lower the default probability and imply a lower risk class in the initial rating. There is a notable, but not surprising, difference in the average of inventory ratio between performing and defaulted loans. This indicates too large inventories in relation to total sales for the firm to be healthy among the defaulted ones. The previous work by Carling et al. (2001) is the base for the choice and definition of the credit variables. These four variables were selected out of 17 variables in a two-step procedure where the correlation and the monotonic relationship between the default probability and the credit bureau variables were mapped out. Another selection criterion was the frequency of these variables in previous studies.

Table 4. Descriptive statistic, credit bureau variables.

Observation type	Statistic				
	N	Min	Max	Mean	Std. Deviation
Performing					
Total sales (MN SEK)	56 176	0	60 000	64.0	771.0
Debt ratio	55 951	0	27 497.4	2.7	134.0
Inverse of inventory turnover	55 031	0	2959.9	0.3	13.5
Earnings ratio	56 048	-81.1	2 945.7	0.2	15.4
Defaulted					
Total sales (MN SEK)	3 084	0	810	8.4	36.5
Debt ratio	3 060	0	677.9	1.7	16.2
Inverse of inventory turnover	2 975	0	13 548.6	4.9	248.4
Earnings ratio	3 066	-299.3	184.1	-0.1	7.5
All					
Total sales (MN SEK)	59 260	0	60 000	61.0	750.8
Debt ratio	59 011	0	27 497.4	2.6	130.5
Inverse of inventory turnover	58 006	0	13 548.6	0.5	57.8
Earnings ratio	59 114	-299.3	2 945.7	0.2	15.1

The macro economic variables: The macro economic variables are the output gap,[10] the yield curve spread, and the Swedish households expectations about the Swedish economy. These are used to capture general economic conditions that can affect the probability of default. The output gap and the households' expectations are lagged two quarters since that is the time delay with which this type of forecasting information is available. The output gap and the households' expectations can be regarded as indicators of the economic activity and possibly reduce the default probability. The yield curve spread is the difference between the nominal interest rate on 10-year government bonds and 3-month treasury bills. It is reasonable to think that there is information about future economic expectations in the yield curve. A downward sloping curve indicates more pessimistic economic expectations and the default rates increase as the difference between long and short run interest rates decreases. The work by Carling et al. (2001) is also the base for the choice of macro economic variables.

4. The internal risk classification

The assessment of a loan results in a rating based on the bank's internal risk classification. The rating corresponds to the default probability according to the assessment, based on quantitative and qualitative criteria, of the bank. A quantitative criterion is, for example, information from the UC on payment behavior or external rating information by Moody's, and Standard & Poor's (S&P), and credit bureau data.[11] Qualitative criteria are formulated from verbal definitions intended to capture information about the firm not necessarily reflected in the other criteria. There are 15 risk classes in the internal risk classification, where a high number is associated with a high default probability. The default probability concept used by the bank refers to the probability of default within the following 24 months. In the data, default is defined as payment default, which occurs when the borrower is more than 60 days late with interest or principal payments. The rating of a firm is reviewed on an annual basis or whenever requested.[12] Table 5 presents the internal risk classification, the corresponding internationally known risk classes used by Moody's and Standard & Poor's, and frequencies by subset and risk class.

It has been noted that risk class 15 is highly correlated with technical default (bankruptcy). This risk class represents a firm in payment default, and it is likely it will be converted into a technical default. About one percent of the loans in the data are initially rated in risk class 15. This might seem strange but can partly be explained by the borrower having transient problems and is being reconstructed. About 30 percent of all observations are classified as belonging to risk class 9, making this the most common risk class. In the initial rating class 9 is even more frequently used, representing about 50 percent of all observations. The classes corresponding to the lowest risk, 1 to 4, are rarely observed in the data. This is due to the fact that the most common firm type in the data are middle market firms[13] and the bank's policy states that it is not likely that loans to these firms will be assigned to risk class 1 to 4. Characteristics of some of the internal risk classes are presented in Table A1 in the Appendix.

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[10] The output gap is defined as the difference between potential and real gross national product.
[11] See Crouhy et al. (2001) for a description of the rating systems applied by Moody's and Standard and Poor's.
[12] According to the bank's manual for risk classification.

Table 5. The bank's internal rating and corresponding rating of Moody's and S&P.

The internal rating	Moody's	S&P	Subset 1 (Default)		Subset 2 (Initial rating)	
			No	Percent	No	Percent
1	Aaa, Aa1	AAA, AA+	28	0	18	0
2	Aa2, Aa3	AA, AA-	1 938	3.2	3201	4.6
3	A1, A2	A+, A	61	0.3	128	0.2
4	A3	A-	3 360	5.5	6845	9.9
5	Baa1	BBB+	4 471	7.3	1478	2.1
6	Baa2	BBB	3 963	6.5	745	1.1
7	Baa3	BBB-	3 267	5.3	3554	5.2
8	Ba1	BB+	5 600	9.2	1417	2.0
9	Ba2	BB	18 363	30.1	36170	52.3
10	Ba3	BB-	3 294	5.4	857	1.2
11	B1	B+	5 180	8.5	1168	1.7
12	B2, B3	B, B-	4 720	7.7	9192	13.3
13	Caa, Ca	CCC, CC	2 604	4.3	3710	5.4
14	C	C	550	0.9	122	0.2
15	D	D	3 607	5.9	537	0.8
Total			61 106	100	69 142	100

5. Econometric models and results

As shown earlier the CTP has empirical implications for the relationship between the bank's internal rating of the loans and the distance as well as between observed default rate and distance. Subset 1 is used to study the latter relationship, where the observed probability of default is the dependent variable. The probability that a loan defaults is treated as a binary choice estimated by a discrete logit model according to

(7) $$\Pr[P_i = 1 \mid \omega_i] = F(\beta'\omega_i) = \frac{\exp(\beta'\omega_i)}{1 + \exp(\beta'\omega_i)}$$

where F(·) is the cumulative distribution function for the logistic distribution. The ω_i vector contains the distance, the bank and payment remark, macro economic, and credit bureau variables described in the data section. The geographical distance is measured in kilometers. It is also reasonable to control for the duration of the loans since this differs among the loans in the portfolio. Therefore the ω_i vector also includes a duration variable. The duration is defined as a year dummy variable that takes the value one if the loan defaults during one of the first four quarters and so forth. The binary logit model is estimated with maximum likelihood. See for example Greene (1997) for more details on the binary logit model.

[13] Middle market firms are characterized by yearly total sales below 1,000 million SEK.

Subset 2 is related to the question if the bank applies the decision rule given in expression (6). If so, the approval rate is decreasing in the distance leading to an acceptance of worse rated loans in the proximity of the bank. Each loan is, from the assessment process, assigned a proper risk class *j=0,…, J*.[14] The probability of ending up in a certain risk class is, due to the ordinal character of the dependent variable, estimated with an ordered probit model. One important feature of the model is that all risk classes must be represented in the data otherwise it is not possible to estimate a threshold parameter (see below) corresponding to the missing risk classes. As shown by Table 5 there are risk classes with very few observations. In order to solve this problem the classification based on 15 classes is coded into only 4 classes based on characteristics of the different risk classes as well as the observed frequency. Similar classes are merged into one risk class in the following way; 1 to 8, risk class 9, 10 to 14, and finally risk class 15. The ordered probit model is a discrete choice model based on the latent regression

(8)
$$\begin{aligned} y_i^* &= x_i'\beta + \varepsilon_i \\ E[\varepsilon_i] &= 0 \\ Var[\varepsilon_i] &= \pi^2/3 \end{aligned}$$

where x_i is a vector with explanatory variables (observable criteria and distance), β is the parameter vector, and ε_i is a random error term that is assumed to be normally distributed. The error term reflects unobservable criteria such as the bank officer's own preferences. The latent variable y_i^*, (in this case the latent initial ranking of a granted loan *i*), is not observed while the indicator variable y_i is, where

(9)
$$\begin{aligned} y_i &= 0 \Leftrightarrow y_i^* \le 0 \\ y_i &= 1 \Leftrightarrow 0 < y_i^* \le \mu_1 \\ y_i &= 2 \Leftrightarrow \mu_1 < y_i^* \le \mu_2 \\ y_i &= 3 \Leftrightarrow \mu_2 \le y_i^*. \end{aligned}$$

---

[14] Previously this index was used for firm *i*, but the observations actually refers to loans.

The μ 's are unobservable threshold values separating the risk classes and will be estimated along with the β parameters. See Greene (1997) for a more detailed presentation of the ordered probit model.

The explanatory variables correspond to those discussed in Subsection 3.2. Regarding the loans, long-term loans is the reference variable, and no payment remarks is the reference category for the payment remarks variables. The x_i vector also includes industry dummy variables as well as a loan size variable. The latter is normalized by the firm's aptitude, measured as equity. Therefore total sales are no longer included in the estimation. Merging industries with the activity codes 030 to 060 into a ”general manufacture” category, activity code 140 to 150 into a ”general transportation” category, and finally holding and investment companies (activity code 260) are included in a “finance, insurance, and bank” industry reduce the number of industry dummy variables. The real estate industry is the reference category. See Table A2 in the Appendix for a full presentation of the activity codes and the corresponding industry category.

The parameter estimate, estimated by maximum likelihood (MLE), for the causal variable from both models and subsets are presented in Table 6. For comparison, the ordinary least square estimate from subset 2 is also presented in the table.

Table 6. Estimation results.

	Model		
Variable	MLE C1 (default)	MLE C2 (initial rating)	OLS C2 (initial rating)
Distance	0.002 (0.363)	-0.000 (-0.055)	-0.000 (-0.072)
Conclusion	False	False	False
N	52 037	54881	54881

Note: *t*-values in parentheses.

The results show that there is no empirical support for the existence of the Church Tower Principle. The distance parameter in the logit-model is statistically insignificant. The obvious conclusion is that the first condition is false. If a variable for the initial rating class is included in the model the distance parameter is unaffected.[15]

[15] The initial rating parameter is significant and positive. An initial rating associated with higher risk increases the probability of default. The likelihood ration index for this model is higher than the first one, 0.27 and the estimated probability of default is higher, 0.006. The duration parameter for the sixth year is no longer significant, otherwise the parameters do not change.

Further, the distance does not affect the initial rating (irrespective of how this is estimated). We can therefore conclude that condition 2 is false and that the bank does not act in accordance with the decision rule given by the CTP. The all in all conclusion is that since both condition 1 and condition 2 are found to be false, there is no empirical evidence for the CTP, neither that the information asymmetry increases with the distance (C1) nor that this bank acts in accordance with the principle (C2).

The coefficients for the control variables show the expected signs and these coefficients are informative about the default probability and initial rating. Complete tables with results are provided in the Appendix.

It can be noted that we have tried a categorical division of the distance variable, but the results were unaffected. This was also the case when we tried an area dummy-variable. The model has also been estimated with six and seven risk classes but this attempt did not work out well. With the same number of degrees of freedom they had lower likelihood values and for some specifications there were difficulties with convergence.

6. Discussion

The Church Tower Principle implies that the difficulty for the lending bank in assessing the default probability of a borrowing firm increases with the distance to it. If so, there will be consequences for both the banks and the society in response. The banks will need to incorporate the principle in the decision rule for granting loans or, alternatively, let the conditions of the loan depend on geographical distance. For the society this might imply a problem because, if the banks apply geographical credit rationing, the supply of risk capital will depend on the access to banks in the region. Consequently, the current trend of an increasing distance between lender and borrower might be alarming.

The empirical results gave, however, no support for the existence of the Church Tower Principle. We could not find any evidence that the information asymmetry increased with the distance nor did we find any evidence that the bank acted as if it was the case. In this perspective, the localization strategy of banks should be based on other factors than credit risk management. Localization (and thereby lender – borrower distance) is, for example, presumably important for competition. Nevertheless, from the society's perspective the current trend of increasing distance caused by decreasing bank office density is apparently not a hindrance for the supply of risk capital from a credit risk management perspective.

Before embracing the current trend however, there are reasons to consider the pitfalls of the present study. In arriving at the conclusion, it was necessary that the theory of the CTP and its two conditions were empirically testable with the data at our disposal. In order to derive the empirical implications, two assumptions are crucial. One is the normality assumption of the assessment error and the other is that unfavorably assessed firms continue their search for a credit in other banks. The latter is, e.g., dubious if the search cost is substantial in comparison with the return of the intended investment upon the loan being granted. The former assumption can be relaxed. We have confirmed the analysis by studying some alternative symmetric distributions, such as the logistic distribution and the t-distribution. It is however possible to arrive at different results if the error distribution is allowed to be markedly asymmetric and poly-modal.

Furthermore, in section 5 it would have been useful to condition on the interest rate. Unfortunately, the bank does not store it electronically more than 12 months, which means that only a very small fraction of the defaulted loan would have had the interest rate appended. Besides, the bank was not willing to disclose it. As a consequence, the assumption of the variability of the interest rate in the simulations in section 2 is somewhat arbitrary (little happened however when we modified its variability).

The pitfalls above are mostly concerned with the internal validity of the results. There is however two issues related to the external validity as well. The first is the variability of the distance. The range of distance variable is 300 kilometers, but, as reported in Table 3, almost none of the loans were granted to firms more distant than some half an hour drive. It is possible that the lack of observed relation between the parameters and the distance, and consequently the lack of support for CTP, is due to too few firms being remotely located to the bank. In any case, it is obvious that the presented results cannot be automatically extrapolated to distances much longer than the ones observed in this study. The second issue is if the CTP applies only to the difficulty in screening loan applications or if it also applies to the monitoring of already existing credits. We have confirmed the analysis for long-term loans. The reason for doing so is that the difficulty in granting such loans is mostly related to screening.

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Appendix

Description of risk classes and frequency tables.

Table A1. Characteristics of some of the internal risk classes.

Risk class	Type of corporation	Characteristics	
		Ownership, structure and management	Financial situation
1	Absolutely lowest risk companies	Listed shares, easy access to additional capital, industry leader, geographically diversified, experienced management.	Steady sales growth, good margins, very solid cash flow.
3	High quality companies	Publicly listed shares, access to additional capital, well established product range, large market shares, experienced management.	Solid growth potential with attractive margins, reasonable solid cash flow.
5	Moderate to high quality companies	Acceptable ownership structure, may have difficulty accessing cash capital, established business in highly competitive or cyclical industry, relatively small market shares, adequate management.	Moderate sales potential, adequate margins, considerable volatility in cash flow.
8	Adequate quality	Just adequate ownership structure, doubts about access to new capital, operates in a highly competitive or cyclical industry recovering from recession or newly established, small market shares, adequate management.	Mediocre sales growth, cyclically in margins, possible over capacity problems, great volatility in cash flows.
12	On the watch list – relatively good chance of survival	Company has relationship to parent or other entity that would have great difficulty or is unwilling to infuse capital prior to default, sector outlook is uncertain or neutral, management with experience of tough decision making.	Needs a bank support group, there is a financial plan presented by the management to the bank.
14	Little or no chance of survival	Not likely to have access to new capital, suspended trading of shares, little chance of survival, inexperienced management in tough decision making, significant management turnover .	Management has no plan for dealing with the financial problems.

Table A2. Number of observations by industry, in accordance with the division by the bank.

Activity code	Industry	No	Percent
010	Agriculture, forestry and fishing	786	1.3
020	Mining and quarrying	95	0.2
030	Manufacture of wood, pulp, and paper	628	1.0
040	Manufacture of chemicals	692	1.1
050	Manufacture of fabricated metal	1650	2.6
060	Manufacture of machinery and equipment	2661	4.3
070	Other manufacture	1524	2.4
080	Electricity, gas, and water supply	176	0.3
090	Construction	5736	9.2
100	Wholesale	8865	14.2
110	Retail trade	8295	13.3
120	Hotels and restaurants	1851	3.0
130	Other service activities, households	1942	3.1
140	Transport	2 845	4.5
150	Shipping	187	0.3
160	Other service activities, business	13951	22.3
170,180,240	Finance, Insurance, bank	1216	1.9
190-210	Real estate, multi family, commercial, management	3441	5.5
220	Other	3274	5.2
230	Municipalities	0	0
250	Private customers	0	0
260	Holding and investment companies	391	0.6
300	Not coded	2764	4.4
Total		62579	100

Table A3. Average number of outstanding loans by year and county.

County	Year						
	1994	1995	1996	1997	1998	1999	2000
Stockholm	689	691	708	817	836	742	899
Uppsala	28	26	28	33	44	43	44
Södermanland	78	87	87	92	96	97	78
Östergötland	57	45	59	69	71	77	83
Jönköping	79	79	75	93	108	106	104
Kronoberg	37	39	43	53	55	50	41
Kalmar	42	40	40	44	42	42	46
Gotland	2		2	1	2	2	2
Blekinge	22	23	21	25	26	29	21
Kristianstad	58	56	61				
Malmöhus/Skåne	342	334	339	443	421	400	402
Halland	81	81	82	94	98	84	83
Göteborgs- & Bohus/Västra Götaland	450	427	469	537	670	643	671
Älvsborg	126	123	133	128			
Skaraborg	38	45	42	52			
Värmland	11	11	17	15	22	27	30
Örebro	23	30	25	32	31	33	33
Västmanland	32	31	28	32	38	41	37
Kopparberg/Dalarna	17	16	18	22	29	28	26
Gävleborg	23	32	35	41	40	35	29
Västernorrland	28	26	33	42	33	33	23
Jämtland	1	4	2	2	2	6	1
Västerbotten	24	23	23	34	30	35	22
Norrbotten	32	31	43	34	33	35	42
Total	2320	2300	2413	2735	2727	2588	2717

Estimation results

Table A4, Maximum likelihood estimates, C1 (default).

	Coefficient	*t*-value
Constant	-7.024	-41.685
Distance (in ten kilometers)	0.002	0.363
Type of loan		
Short term loans	0.980	14.939
Mixed loans	-1.199	-18.260
Credit bureau variables		
Debt ratio	2.080	22.007
Inventory ratio	0.616	2.769
Earn ratio	-0.001	-0.445
Total sales (million SEK)	-0.002	-3.942
Payment remark		
Remark type 25	1.374	8.290
Remark type 8,11,16,25,35	3.213	32.228
Macro economic variables		
Output gap	-0.276	-12.245
Household expectations	-0.012	-6.323
Yield	-0.209	-6.569
Duration		
Second year	0.205	2.809
Third year	0.263	3.182
Fourth year	0.564	6.617
Fifth year	0.512	3.884
Sixth year	0.814	4.356
LogL	-6780.287	
$LogL_0$	-8971.623	
χ^2	4382.672	
N	52037	

The restricted log likelihood value in Table A4, $LogL_0$, is the log likelihood value when the model is estimated with only the constant. The model cannot be rejected since the χ^2 statistic from the likelihood ratio test computed according to $\chi^2[J] = -2(\ln L_0 - \ln L)$ where *J* is the number of possible restrictions is well above the critical value on the 5 percent level. The likelihood ratio index, which is analogous to the R^2 measure, is 0.24.[16] The percentage of correct predictions is 96.5. The predicted probability of default is 0.004, which is in accordance with the observed probability.

[16] The likelihood ratio index is distributed between 0 and 1 and it is computed according to $LRI = 1 - \frac{\ln L}{\ln L_0}$. See Greene (1997).

Table A5.Estimation results, C2 (initial rating).

	Maximum likelihood		OLS	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant	0.077	2.490	0.586	33.768
Distance	-0.000	-0.055	-0.000	-0.072
Type of loan				
Short term loans	-0.100	-8.864	-0.057	-8.846
Mixed loans	0.419	27.098	0.251	27.275
Loan size (granted loan size/equity)	0.001	1.887	0.001	2.040
Credit bureau variables				
Debt ratio	0.622	37.136	0.364	37.902
Inventory ratio	0.243	4.621	0.144	4.588
Earn ratio	-0.019	-3.529	-0.000	-0.651
Payment remark				
Remark type 25	0.949	11.023	0.521	8.872
Remark type 8,11,16,25,35	0.869	14.153	0.514	14.706
Macro economic variables				
Output gap	-0.069	-23.007	-0.041	-24.480
Household expectations	0.013	31.955	0.007	33.217
Yield	-0.188	-25.022	-0.106	-28.840
Industry categories				
Agriculture, mining, electricity, construction etc.	-0.190	-8.725	-0.109	-8.088
Manufacturing	-0.264	-10.790	-0.152	-10.093
Services	-0.708	-3.227	-0.040	-2.946
Transport	-0.133	-4.285	-0.074	-4.233
Finance	-0.077	-1.977	-0.046	-1.944
Other & not coded	0.048	1.888	0.026	1.702
Threshold parameters				
μ_1	1.536	203.091		
μ_2	3.420	140.855		
LogL	-53626.29			
$LogL_0$	-57215.22			
χ^2	7177.857			
Adjusted R^2				0.12
N	54881		54881	

Note: The bank defines 26 original industry categories of which all but two are represented in the data. The grouping used in the estimation turned out best after an evaluation of other specifications of industry categories, both with more different and fewer categories. The one presented 6 turned out to be the best among the ones tried.

The χ^2 statistic in Table A5 shows that this model cannot be rejected and the percentage of correct predictions is 55. The estimated probability for each risk class, computed according to

$$
\begin{aligned}
\Pr[y_i = 0] &= \Phi(-\beta' x_i) \\
\Pr[y_i = 1] &= \Phi(\mu_1 - \beta' x_i) - \Phi(-\beta' x_i) \\
\Pr[y_i = 2] &= \Phi(\mu_2 - \beta' x_i) - \Phi(\mu_1 - \beta' x_i) \\
\Pr[y_i = 3] &= 1 - \Phi(\mu_2 - \beta' x_i)
\end{aligned}
$$

where $\Phi(\cdot)$ is the cumulative distribution function for the standard normal distribution and numerically evaluated in -$\beta'\bar{x}$ and $(\mu - \beta'\bar{x})$, does not diverge that much from the observed probability. See Table A6 for the observed probabilities.

Table A6. Observed and predicted probability of risk class.

Risk class	Observed probability	Predicted probability
0 (actual class 1-8)	0.285	0.269
1 (actual class 9)	0.518	0.550
2 (actual class 10-14)	0.192	0.177
3 (actual class 15)	0.005	0.004

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