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Predictors of Bank Distress: The 1907 Crisis in Sweden*

Anna Grodecka†
Seán Kenny‡
Anders Ögren§

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Abstract

This paper contributes to literature on bank distress using the Swedish experience of the international crisis of 1907, often paralleled with 2008. By employing previously unanalyzed bank-level data, we use logit regressions and principal component analysis to measure the impact of pre-crisis bank characteristics on the probability of their subsequent distress. The crisis was characterized by "creative destruction," as those banks with weaker corporate governance structures, wider branching networks, operating with lower cost efficiency were more likely to experience distress. We find that poor credit allocation rather than foreign borrowing, as often stressed, were associated with ultimate demise.

Keywords: Bank Distress, Financial Crises, Swedish Banks, Lender of Last Resort

JEL-Classification: E58, G21, G28, H12 N23

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† Sveriges Riksbank, e-mail: anna.grodecka@riksbank.se.
‡ Lund University, sean.kenny@ekh.lu.se
§ Lund University, anders.ogren@ekh.lu.se

1. Introduction

A growing volume of literature aims to isolate key predictors of bank distress, driven by renewed interest amongst policy makers and the economic costs associated with banking crises (Reinhart and Rogoff, 2009; Jalil, 2015). Researchers have drawn on an array of historical episodes to guide them in determining common "early warning indicators" (see e.g. Demirgüç-Kunt and Detragiache, 1998; Schularick and Taylor, 2012; Fahlenbrach, Prilmeier, and Stulz, 2012; Betz, Oprică, Peltonen, and Sarlin, 2014; Drehmann and Juselius, 2014; Colvin, de Jong, and Fliers, 2015; Postel-Vinay, 2016). Amongst policy makers and academics, the global financial crisis of 2008 has been continuously referenced as an "obvious parallel" to the international crisis of 1907 (Bordo, 2008; Krugman, 2008, p.160; Bordo and Landon-Lane, 2010; Bernanke, 2013; Frydman, Hilt, and Zhou, 2015; Fohlin, Gehrig, and Haas, 2016).

As with the recent episode, the crisis of 1907 originated amongst (an old equivalent of) shadow banks in the U.S., was characterized by international spillovers, transmitted through and enhanced by the reactions of global financial markets as short term liquidity dried up (Frydman et al., 2015). Novel forms of bank lending against new types security instruments were a prominent feature of both crises. The international spread of the financial crisis of 1907 has already been emphasized by subsequent scholars (Kindleberger, 1979; Bruner and Carr, 2007; Krugman, 2008; Reinhart and Rogoff, 2009). As a small open economy with extensive international banking links, in 1907, Sweden experienced one of the most extensive financial crises of its existence (Schön, 2010, p. 226) as almost one quarter of banks were either liquidated or absorbed in distress takeovers in its aftermath. However, the Swedish experience of 1907 has received only limited attention, usually on a comparative basis, the most consistently cited culprit typically being banks' exposure to foreign currency debt (Schön, 1989; Hagberg and Walldov, 2000; Hagberg and Jonung, 2009; Edvinsson, 2010; Schön, 2010).

In this paper, we augment the literature on banking crises by using previously unexplored data consisting of individual balance sheets and corporate governance statistics for Swedish banks to identify ex-ante factors that increased the probability of bank distress in the 1907 crisis. Analyses similar to ours have been conducted for Dutch banks during the 1920s crisis (Colvin et al., 2015) and for the Chicago banks during the Great Depression (Postel-Vinay,

2016).

The Swedish crisis of 1907 offers researchers and policy makers an opportunity to study and understand factors relevant for bank distress for a variety of reasons. First, the 1907 crisis marks the highpoint of the Swedish commercial bank population in the last century and a half, offering the largest possible sample in the last two centuries. Second, 1907 is traditionally perceived as an exogenous shock to the Swedish banking sector, as it was triggered by external developments, as in 2008. Third, the rapid geographical spread of Swedish banking prior to the 1907 crisis mirrors the prelude to 2008, in which Swedish banks expansion into Baltic regions contributed to difficulties (see Ingves, 2010), a parallel which provides contemporary policy makers with a relevant case study. Fourth, during this period banks were uniquely diverse in terms of capital structures, size and shareholder liability regimes and so provide current legislators with historical lessons relevant to emerging debates on extending shareholder liability, appropriate capital legislation and questions pertaining to corporate governance.

We test a number of models based upon previous literature and commonly applied distress predictors suggested by economic theory. In addition to employing the use of logit regressions for our analysis as other similar studies have (Colvin et al. 2015; Postel-Vinay, 2016), we apply a robustness check with principal component analysis which allows us to reduce the dimensionality of our variable space while keeping all variables of interest (including those which are highly correlated) and somewhat mitigates against the limited number of observations. We focus exclusively on within sample predictions.

In contrast to the standard account emphasizing the role of foreign borrowing, our findings suggest that the crisis exhibited elements of "creative destruction" in the banking sector through ridding it of banks which had expanded their credit and geographical scope in a cost inefficient way. As such, our testing supports Cassel's (1908, p. 24) opposition to the popular view, as we find that most of the problems were associated with the asset side of banks' balance sheets, particularly the expansion of lending against shares (Schön, 2010).

Comparing average features of distressed and non-distressed banks, we outline that those banks which experienced distress in the early phase of the crisis shared the characteristic of being relatively new on the scene: they were on average younger, smaller and tended to experi-

ence more pronounced growth in leverage. Moreover, they tended to offer lower share prices at original subscription and concentrated a higher share of lending against equities than their non-distress competitors. This group also tended to have smaller boards of directors with limited liability for shareholders.

In our formal tests we find, similarly to Colvin et al. (2015), that weak internal corporate governance increases the probability of distress, reflected by smaller boards and more widely extended branch structures, which may be linked to increases in monitoring costs due to branch diversification (Acharya, Hasan, and Saunders, 2006; Laeven and Levine, 2007; Berger, Hasan, and Zhou, 2010; Goetz, Laeven, and Levine, 2013). This interpretation is supported by our finding that higher operating costs in the year before the crisis associated with a high share of assets contingent on legal outcomes are increasing the probability of distress.

Additionally, we examine the Special Minutes of the Board of the Riksbank and its balance sheets to consider its oft-debated role during this crisis, revisiting in particular the criticisms of Cassel (1908). In contrast to the view that downplays or omits lender of last resort (LOLR) activities of the Riksbank (Cassel, 1908; Wendschlag, 2012, p. 42; Ögren, 2017), our research supports that school which suggests that it intervened as LOLR (Hagberg and Walldov, 2000; Wetterberg, 2009; Fregert, 2018), though operating with strict prudence (Flux, 1910). No archival evidence, contemporary reporting or subsequent research suggests any chosen crisis strategy admitting to preferential support for targeted banks. Given banks' poor capital allocation choices, liquidity support from the Riksbank does not transpire as an important characteristics differentiating distressed from non-distressed banks.

The paper proceeds as following. In section 2, we provide the historical context which includes both a brief description of the development of the Swedish banking system and a short narrative of the outbreak of the domestic banking crisis in 1907. We then revisit the role of Sveriges Riksbank throughout the period in light of both contemporary accounts and by utilising balance sheet information available to us. In section 3, we provide a description of the data and present the results of the regressions, reserving a separate subsection for a discussion on the interpretation and implications of the new results. We conclude in section 4.

2. Historical context

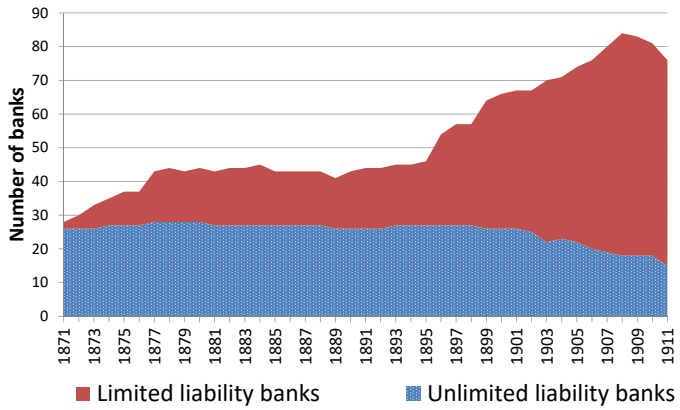
2.1. Banking developments in Sweden before 1907

In what follows, we briefly sketch key developments which affected the Swedish banking system before the crisis of 1907. Prior to the Government Act of 1864, Swedish commercial banks' progress had remained "unimpressive" (Jonung, 1983) as a Royal Proclamation of 1824 decreed that interest rates would be capped at 6 per cent, incentivizing depositors to leave funds with brokers instead, who offered higher interest payments (Sandberg, 1978). The new legislation opened the system up to limited liability banking and removed the old interest rate restrictions.[1] After the Act, banks competed for deposits as Sweden's capital needs grew dramatically with the times (Lilja, 2010, p. 59). The new limited liability banks (*bankaktiebolag*) were not authorized to issue notes, unlike the old unlimited *enskilda banks*, which suffered relatively more regulation as a result. Indeed, until 1911 legislators largely ignored deposits as risky liabilities (Ögren, 2006; Lilja, 2010, p. 56).

In 1897, the Riskbank was granted a monopoly on note issuance and *enskilda banks* were obliged to withdraw all of their notes by 1903, the same year as the Bank Law which effectively placed unlimited and limited liability banks on an equal footing in all aspects, save their shareholder liability structure (Larsson, 2010, p. 177).

The Swedish banking system had undergone an important wave of banking establishments from the mid-1890s, see Figure 1. The number of banks had almost doubled from 46 in 1895 to 79 on the eve of the crisis in April 1907. Many of these banks were smaller entities and a new wave of such establishments was encouraged by the Banking Act of 1903 which allowed them, based on their smaller size, to hold only 20% of the minimum capital requirement of the larger banks (SFS, 1903:101). The growth in the number of limited liability banks contrasts starkly with the gradual decline in the population of unlimited liability banks, particularly from the mid-1890s. By April 1907, there were 19 unlimited and 60 limited liability banks extant, reflecting a distinctive shift towards limited liability banking which enjoyed lower thresholds

[1] Since 1864, unlimited liability banks had the right to issue a fraction of limited liability shares, to owners which held only limited voting rights. However, only an insignificant minority of unlimited liability banks decided to issue such shares (see Flux, 1910; Grossman, 2010).



Source: Sammandrag af Bankernas Uppgifter, 1871-1911. Note: Annual figures are taken from the month of December each year.

Figure 1: The Swedish bank Population, 1871-1911

for entry, presented less risk to investors and suffered no regulatory attention regarding its liability management.

The growth in the banking population placed additional pressure on the strained resources available to banking supervision. Since 1868, this had been under the remit of the Minister of Finance in the "Banking bureau" (*Bankbyrån*) which had consisted of a single assistant responsible for focusing on the banks. In 1906, a Parliamentary Committee proposed the establishment of an independent Banking Inspectorate, which was only instituted on the eve of the crisis in January 1907 (Wendschlag, 2012).

2.2. The 1907 crisis in Sweden

While the dramatic growth in the population of banks set the stage for an expansion of credit, from the turn of the century growing capital demand was increasingly satisfied by channeling domestic and foreign savings into the kind of investments "*for which companies lacked their own assets, i.e., it ensured that enough capital was available*" (Schön, 2010, pp. 219-20). The need for foreign borrowing was recognized by contemporaries such as Cassel (1908, p . 19), who wrote: "*our foreign borrowing earns extraordinary returns in productivity during times in which our own resources are already operating at full capacity*". Nonetheless, he admitted that some of this borrowing "*was partly of worrisome character*" as it consisted of "*temporary*

debt".

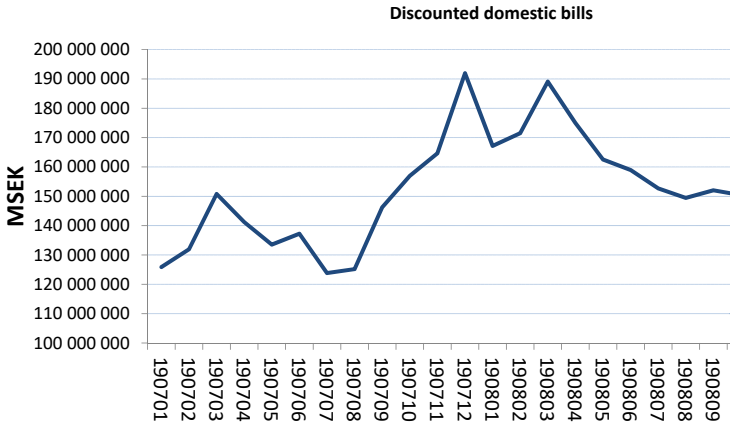
The insurance payouts stemming from the San Francisco earthquake of 1906 drew gold from Europe, whose central banks began raising rates as it left their vaults (Kindleberger and Aliber, 2011, p. 167). In March 1907, a "*rich man's panic*" occurred on the U.S. stock market at the same time that credits from Paris and London to the U.S. were effectively cut off (Kindleberger and Aliber, 2011, p. 167). The U.S. entered a recession in the spring of 1907 and by the early summer, in contrast to the Riksbank's neutral stance, Swedish commercial banks began increasing rates as they too experienced problems in rolling over their foreign debt. Much of the foreign debt called in was return flows to Norway where the public were led to believe that Norway's private banks had held their large reserves in "*first class Swedish banks*" (Øksendal, 2007). In the summer, growing difficulties in the U.S. economy (Hagberg and Jonung, 2009, p. 167) led to further rises in international interest rates. This created a "*shortage of capital*" in Sweden and produced a"*restrictive effect on lending*" (Larsson, 2010, p. 173). The most acute phase of the crisis was October 1907, when a panic on Wall Street occurred and the crisis truly became an international one.

These factors combined - a strained supervisory framework, a rapidly expanding domestic credit market, increased reliance on foreign capital and a rise in international rates - exposed Swedish banks that had taken excessive risks during the pre-crisis period. As we will see in section 3, almost a quarter of the Swedish banking population suffered distress as a result of the 1907 crisis in terms of liquidations and takeovers in the subsequent years.

2.3. Sveriges Riksbank's role in the 1907 crisis

It is important to consider the role of Sveriges Riksbank in the 1907 crisis, as the liquidity help provided by the central bank may have impacted banks' probability of bank distress. Some authors claim that the 1907 crisis was the first in which Sveriges Riksbank acted as a modern central bank and lender of last resort (Wetterberg, 2009). However, during the crisis of 1878/79, the Riksbank provided liquidity by discounting bills and instigated a toxic fund launched and administered by the National Debt Office (NDO). The NDO also provided the capital which it raised on the international market.

During the summer of 1907, the NDO borrowed 65 million French francs, responding to the Riksbank's growing concerns about the weakness of Sweden's balance of payments position (Hagberg and Walldov, 2000, p. 32) and the consequent distress in the Swedish money markets. The Riksbank in its turn followed the same approach applied in 1878/79 by markedly increasing discounting of bills of exchange presented by banks between September and December 1907 (Söderlund, 1964, pp. 303-304; Fregert, 2018, p. 117). Hagberg and Walldov (2000, p. 36) explain that if banks had been unable to rediscount bills, they would have been forced to approach the Riksbank with cash in exchange for gold or foreign currencies. The commercial banks' cash reserves were entirely insufficient to liquidate all foreign loans and a panic sale of bank assets to acquire the necessary cash could have resulted in a collapse in the price of securities (see Figure 2).



Source: *Sammandrag af Bankernas Uppgifter* 1907 and 1908. Monthly data in MSEK.

Figure 2: Domestic bills discounted by the Riksbank 1907-1908

By all accounts, throughout the crisis period the Riksbank acted in accordance with the law (Sveriges Riksbank Law, 1897, §41) and provided liquidity to banks which presented collateral deemed trustworthy during normal times (Riksbank, 1907a). Indeed, at the end of 1907 and 1908, the Riksbank approved more than 90 per cent of the applications for total rediscounting facilities available to each bank for the coming year (Riksbank, 1907c; Riksbank, 1908). In a minority of cases, temporary extensions of credit were granted but only for what was considered sound collateral (Riksbank, 1907b, §3). This is supported by the conclusions of Flux (Flux, 1910, pp. 128-9): *"It is doubtless true that, at a time of pressure, the rules requiring careful*

scrutiny of bills offered for discount at the Riksbank were more scrupulously observed than at regular times. (...) Had such scrutiny not been strictly maintained, the Riksbank would have failed in its duty".

We formally test the importance of liquidity support provided by the Riksbank to Swedish banks in influencing heir probability of distress in the 1907 crisis in the following section.

3. Data and empirical strategy

3.1. Data description

Our principal source is the "Summary of Bank Activities" which comprise individual balance sheets of the commercial banks published on a monthly basis (in particular Sammandrag, 1904 and Sammandrag, 1907). The reports contain the principal balance sheet items for all banks. Every December, an Annual Report or Bokslut (1906, 1907, 1908) supplemented the "Summary" which included profit and loss items that were not a feature of the monthly and annual balance sheets. We hand-collect data from these sources.

We complement the information from these reports with information relating to the institutional structure of each bank from *Bankmatrikeln*, two volumes of which were published in 1906 and 1911 (Sveriges Bankmatrikel, 1906 and Sveriges Bankmatrikel, 1911). Moreover, we utilize archival material and newspapers in order to add robustness to our classification of banks as distressed or otherwise. When possible, we supplement these primary sources with the conclusions and views of subsequent scholarship where we find direct references to individual banks.

We choose April 1907 as our reference point. Though the 1907 crisis is often stated as having occurred in the autumn (Hagberg and Jonung, 2009, p. 167), the aggregate balance sheets reveal strain on the banking system by early summer when banks could no longer roll over their foreign debt. By May, all categories of bank were experiencing declines in their foreign borrowing and all experienced losses of their cash reserves by the end of that month. We are supported in our choice of month by the timing of the international loan in the summer of 1907 taken on by the NDO. Furthermore, the U.S. entered a recession in May (NBER, 2018).

April 1907 is thus considered the final month in which Swedish banks are operating in pre-crisis norm.[2]

We also wish to observe changes in certain variables which may help explain distress and we use April 1904 as a reference point, in line with Colvin et al. (2015) who adopt a baseline of three years. We choose not to consider data before 1904, as it was only in 1903 that *enskilda banks* lost their privilege to issue banknotes, which will impact certain financial ratios. Furthermore, by 1904 changes in the Bank Act of 1903 had fully removed the remainder of legislative differences between unlimited and limited liability banks in all aspects, except shareholder liability (Larsson, 2010, p. 173). At the juncture of April 1907, 79 banks comprised the bank population. Appendix A presents the list of banks included in our sample and discusses how the sample was adjusted once we extend our analysis to 1904.

3.2. Descriptive evidence on distressed banks

A number of primary sources survive for us to draw upon, including documents of those figures in prominent positions at the time of the crisis in 1907. We have compiled a list of distressed banks based on the "Summaries" of the period, the writings of the Banking inspector Benckert (1976) who was very active during the crisis and in its aftermath and complement this with the list provided by Söderlund (1964). Furthermore, we scanned and reviewed archival material and contemporary newspapers in order to gather information pertaining to each individual bank's experience.

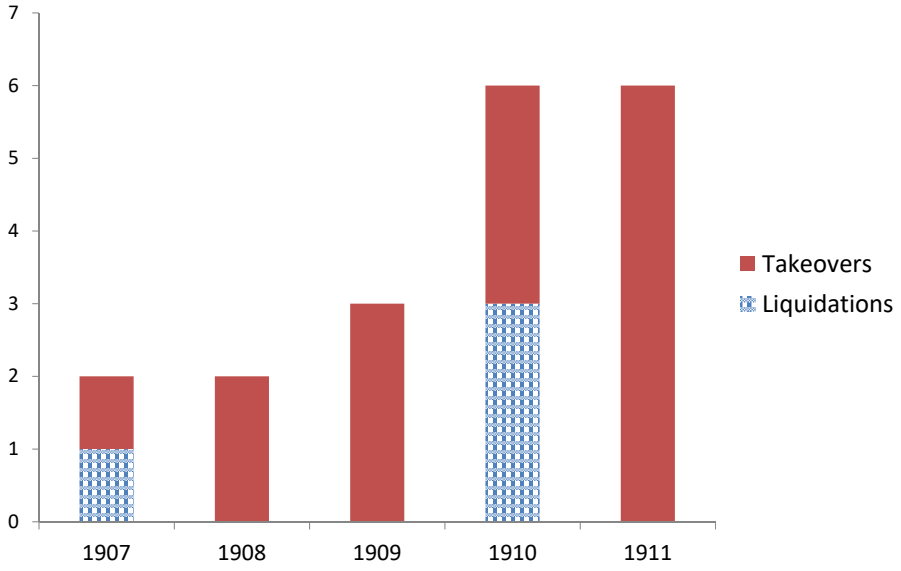
Surprisingly, the number of banks which experienced distress is not verified in subsequent literature, as it is often unclear whether authors are referring to the number of liquidations or takeovers and the time horizon they consider is not specified. In this sense, we are the first to use bank specific information and well-defined time frame in order to document the fate of affected banks. Tracking bank liquidations, mergers and acquisitions from 1907 to 1913 (following Colvin et al., 2015, who consider a 7-year horizon while defining distressed banks), we identify 22 such events.[3] However in the Swedish case, extending the time horizon for such

[2] While December 1906 may also have provided a strong point of departure, we find evidence of window dressing by banks towards the end of each calendar year when reserve ratios temporarily spike.

[3] Schön (2010), who considers the 1907 crisis among the most extensive that the Swedish financial system had

a long period for the purpose of empirical analysis is not advisable, for at least two reasons. First, by 1910 economic growth in Sweden had resumed (Hagberg and Jonung, 2009) and second, on 22 June 1911, a banking act was passed in Sweden which materially transformed the banking infrastructure and increased minimum capital requirements (Söderlund, 1978, p. 87). The law entered into force on the 1 January 1912 (Söderlund, 1978, p. 4).

In order to test the power of banks' balance sheet characteristics in "predicting the past" distress (Colvin et al., 2015), we need to consider a time period that is reasonably close to both the crisis event (autumn 1907) and the resulting mergers and liquidations that can be reliably linked to the crisis (e.g. in 1907, *Industriekreditaktiebolaget i Stockholm* and in 1910, *Skånes Enskilda Bank* underwent a merger, but as reported in Söderlund, 1964, the banks were not in distress). Like Söderlund (1978, p. 79) we find that most of the banks which were acquired were "in need of support" as we document in Appendix B.



Source: Sammandrag af Bankernas Uppgifter 1907-1912.

Figure 3: Swedish bank takeovers and liquidations, April 1907-December 1911

Considering the period until the end of 1910, we arrive at a total of 10 distressed banks, out of an aggregate banking population of 79 banks (in April 1907). If we extend the time

experienced, mentions the liquidation of four banks, the reconstruction of five banks and credits the crisis with fifteen distress takeovers. This produces a total of 24 distressed banks. At the lower end of the scale, Larsson (2010), p. 173 states that "*seven commercial banks failed*". Hagberg and Jonung (2009) suggest that the crisis claimed a total of 16 banks.

period until the 1st of January 1912, we identify 17 distressed banks, see Table A4 in Appendix B. However, due to the lack of data for *Linköpings Bank* before 1908, our sample only includes 16 distressed banks, which corresponds to the number provided by Hagberg and Jonung (2009). The overall number of liquidations and takeovers which occured between April 1907 and before the 1912 Act are displayed (including the *Linköpings Bank*, *Skånes Enskilda Bank* and *Industriekreditaktiebolaget i Stockholm*) in Figure 3. Appendix B provides a complete list of liquidations, mergers, acquisitions and takeovers in the period spanning April 1907 to 1 January 1912, providing our rationale for the classification of each bank as "distressed" or "non-distressed".

In section 3.3 we run separate regressions considering two groups: banks that were distressed before the end of 1910 ("Early Distress") and the whole population of banks that are defined as distressed until the 1st January 1912 ("Late Distress", including the early distress sample). Being closer to the crisis event, the "Early Distress" regressions provide more robust estimates and have a better predictive power. We thus focus on them in our description. However we also present results for the alternative distress specification, "Late Distress", moving some of its results to appendices.

Table 1 provides information on the number of liquidations and mergers/acquisitions in our early and late distress samples, with distinctions between the unlimited and limited liability banks, as well as big and small banks (for which, as mentioned, different capital standards applied). Note that the fraction of distressed limited liability banks is higher for both distress periods when compared to the unlimited liability banks. In particular, though some unlimited liability banks experienced distress, none were liquidated in the wake of the 1907 crisis in Sweden, which may suggest that shareholder liability plays a material role in survival. When it comes to the distinction between big and small banks which were exposed to alternative capital requirements, the fractions of distressed banks across these two categories seem to be broadly similar, with small banks exhibiting a slightly higher share of failures. We formally test how these institutional features affected the probability of banks' distress in our regressions in section 3.3.

Based on commonly used ratios in predicting bank distress, narrative studies on the 1907

	Early distress definition		
	Distress	Liquidations	Mergers/Acquisitions
All banks (N=79)	10 (13%)	4 (5%)	6 (8%)
Unlimited liability banks (N=19)	1 (5%)	0 (0%)	1 (5%)
Limited liability banks (N=60)	9 (15%)	4 (7%)	5 (8%)
Small banks (N=33)	4 (12%)	2 (6%)	2 (6%)
Big banks (N=46)	6 (13%)	2 (4%)	4 (9%)
	Late distress definition		
	Distress	Liquidations	Mergers/Acquisitions
All banks (N=79)	16 (20%)	4 (5%)	12 (15%)
Unlimited liability banks (N=19)	3 (16%)	0 (0%)	3 (16%)
Limited liability banks (N=60)	13 (22%)	4 (7%)	9 (15%)
Small banks (N=33)	7 (21%)	2 (6%)	5 (15%)
Big banks (N=46)	9 (20%)	2 (4%)	7 (15%)

Source: *Sammandrag af Bankernas Uppgifter*. Note: The percentages in parentheses refer to the fraction of affected banks relative to the number of banks in a given category (e.g. 1 out of 19 unlimted liability banks were distressed according to the early distress definition, which corresponds to 5% of all unlimited liability banks.)

Table 1: Number of liquidations and mergers/acquisitions in the 1907 Swedish crisis

crisis in Sweden (Flux, 1910; Wetterberg, 2009; Hagberg and Jonung, 2009; Edvinsson, 2010), as well as previous historical studies on bank distress, we consider the following bank-specific variables as potentially increasing the probability of distress (the original Swedish translation is provided in Appendix C): (1) capital ratio, (2) leverage (defined as total liabilities over equity), (3) bank age (log of age in months as of April 1907), (4) bank size (log of total assets), (5) foreign funding ratio (share of foreign funding to demand liabilities), (6) share lending ratio (share of lending against equities to total lending), (7) property lending ratio (share of lending against property to total lending), (8) average loan size, (9) Riksbank borrowing ratio (share of borrowing from the Riksbank to demand liabilities), (10) rediscounted bills share (share of rediscounted bills of exchange to discounted bills of exchange), (11) liquidity ratio (share of liquid assets to liquid liabilities), (12) cash ratio (cash holdings to demand liabilities), (13) contingent assets share (ratio of assets contingent on legal proceedings and foreclosures to total assets), (14) deposit finance (sum of deposits to demand liabilities), (15) average deposit size (16) share of customer credit drawn (Share of cash/travel credits used by customers to total granted), (17) ROA (return on assets in 1906), (18) ROE (return on equity in 1906), (19) cost

ratio (defined as operating costs to gross income in 1906), (20) number of branches (log), (21) local branch concentration (the share of bank's branches located in a given *län* (county) as a share of each bank's total branches), (22) the number of board members and (23) the original nominal share price.

As mentioned above, we also test the magnitude of changes in certain variables between April 1904 and April 1907 (with the exclusion of banks that participated in the acquisition of other banks in that time period). We analyze growth rates in (24) foreign funding, (25) lending against stocks, (26) leverage, (27) deposit finance. We also consider (28) the liability structure (a dummy variable that takes the value of 1 if a bank was an unlimited liability bank, and 0 otherwise). Additionally, in some regressions, we address variable *capital regime*, which is a dummy variable taking the value of 1 when a bank belonged to the small banks group which were only obliged to hold 20% of the total capital required for larger banks.

Table 2 provides descriptive statistics (median, mean and standard deviation) for the indicators defined above for the full sample of 79 banks, categorized by experience of distress or non-distress in the 1907 crisis. The cross-sectional data, unless otherwise stated, refers to April 1907. We consider early and late distress (upper and lower panel of the table), which encompasses 10 and 16 distressed banks respectively. In addition, in order to capture the differences between the distressed and non-distressed banks, we report the normalized differences (defined as in Imbens and Wooldridge, 2009) and the results of a two-tailed T-test. Normalized differences provide a scale-free assessment of the differences between two groups, and a normalized difference exceeding one quarter is considered significant.

The summary statistics yield a number of interesting generalized patterns to consider before formal econometric testing. Across both sample periods, the T-statistics indicate that distressed banks tended ex-ante to have a lower average loan size per customer, lower ROAs, and a higher share of contingent assets (pending legal outcomes). Further, their customers tended to draw higher proportions of their allocated credits than the non-distress banks. Additional characteristics across distressed banks emerge when considering the normalized differences as in both periods, the distressed banks ex ante had lower ROEs, higher operating cost ratios and less local branch concentration.

Banks experiencing distress in the early phase after the crisis (early distress) share the characteristic of being new entrants into the market: they were on average younger, smaller and tended to experience more pronounced growth in leverage. Moreover, they tended to have lower share prices at original subscription and to concentrate a higher share of loans against equities than their non-distress competitors. This group also tended to have smaller boards of directors with limited liability for shareholders. Including the later distress phase, the share of rediscounted bills was higher among distressed banks.

Interestingly, while foreign funding is often flagged as an important factor in the crisis, the descriptive statistics suggest that banks that experienced distress first (early distress) actually had lower average shares of foreign funding and lower growth rates in foreign funding over the three years preceeding the crisis. In the late distress sample, the share of foreign funding among distressed banks is slightly higher, but not statistically different from the non-distressed group.

3.3. Baseline regression analysis

In our baseline quantitative analysis, we mirror the approach of Colvin et al. (2015). We test the validity of standard narratives about the variables influencing the probability of bank distress by estimating a logit model. In particular, we examine whether the pre-crisis characteristics of individual banks was associated with their fate in the 1907 crisis.

We estimate the following regression:

$$ln\frac{\pi_i(Distress)}{1-\pi_i(Distress)} = \alpha + \beta_i x_i + \varepsilon_i, \tag{1}$$

where α is a constant, x_i are bank-specific variables (tested separately and jointly) and ε_i is the bank-specific prediction error. Coefficients β_i represent the contributions of considered bank-specific variables to the probability of bank distress. Negative coefficients suggest that a lower realization of variable increases the probability of distress, while positive coefficients indicate that higher values of considered variables are increasing the distress probability. We first test each variable considered separately and we show the regression tables A6 and A7 for early and

	Early distress							
	Non-distressed banks (N=69)			Distressed banks (N=10)			Equality of means	
Variable	Median	Mean	St. dev.	Median	Mean	St. dev.	Norm. diff.	T-statistics
Capital ratio	0.158	0.19	0.104	0.196	0.216	0.114	-0.172	-0.695
Leverage	4.521	4.548	1.484	4.247	4.465	1.535	0.039	0.16
Log(age)	4.934	5.036	1.392	4.016	3.782	1.473	0.618⋆	2.531**
Log(size)	15.83	16.087	1.681	15.209	15.384	1.299	0.331⋆	1.535
Foreign funding	0	0.047	0.065	0.0001	0.038	0.055	0.097	0.434
Share lending ratio	0.249	0.28	0.177	0.358	0.354	0.238	-0.251⋆	-0.950
Property lending ratio	0.462	0.466	0.167	0.423	0.437	0.259	0.094	0.342
Average loan size	4422.7	7985	9652	3522	4249	2257	0.377⋆	2.740***
Borrowing from the Riksbank	0	0.02	0.089	0	0.003	0.009	0.188	1.520
Share of rediscounted bills	0.115	0.195	0.231	0.219	0.219	0.192	-0.082	-0.369
Liquidity ratio	2.225	2.447	1.291	2.583	2.897	2.171	-0.178	-0.639
Cash ratio	0.02	0.027	0.032	0.024	0.026	0.012	0.032	0.201
Contingent assets share	0.0002	0.001	0.001	0.008	0.009	0.009	-0.829 ⋆	-2.643**
Deposit finance	0.826	0.805	0.138	0.832	0.809	0.098	-0.023	-0.110
Average deposit size	1107	1297	902	894	1184	1167	0.076	0.293
Share of customer credit drawn	0.749	0.754	0.102	0.837	0.842	0.081	-0.675⋆	-3.099***
ROA	0.015	0.016	0.008	0.013	0.010	0.008	0.542 ⋆	2.157*
ROE	0.069	0.065	0.018	0.062	0.044	0.036	0.522⋆	1.732
Cost ratio	0.036	0.038	0.012	0.041	0.053	0.025	-0.539 ⋆	-1.762
Log(branches)	0.693	1.058	1.096	0.693	1.098	1.348	-0.023	-0.070
Local branch concentration	1	0.862	0.250	0.875	0.752	0.326	0.268 ⋆	0.805
Board members	7	8.632	3.464	6.5	7.167	2.483	0.344⋆	1.336
Share price	200	343	317	200	233	150	0.314⋆	1.518
Growth in foreign funding	0.999	4.464	10.609	0.151	2.090	4.746	0.204	0.820
Growth in lending against stocks	0.312	1.11	3.166	0.132	3.267	8.605	-0.235	-0.784
Growth in leverage	-0.021	0.054	0.368	0.071	0.268	0.558	-0.320⋆	-1.172
Growth in deposit finance	0.001	0.053	0.233	0.056	0.067	0.153	-0.048	-0.237
Liability structure	0	0.261	0.442	0	0.1	0.316	0.296⋆	1.420

	Late distress							
	Non-distressed banks (N=63)			Distressed banks (N=16)			Equality of means	
Variable	Median	Mean	St. dev.	Median	Mean	St. dev.	Norm. diff.	T-statistics
Capital ratio	0.158	0.19	0.106	0.182	0.206	0.102	-0.106	-0.543
Leverage	4.521	4.587	1.51	4.247	4.344	1.390	0.118	0.613
Log(age)	4.905	5.003	1.44	4.638	4.382	1.450	0.304⋆	1.532
Log(size)	15.831	16.080	1.7	15.209	15.675	1.401	0.184	0.986
Foreign funding	0	0.044	0.063	0.0001	0.054	0.069	-0.106	-0.519
Share lending ratio	0.237	0.277	0.18	0.358	0.335	0.207	-0.212	-1.029
Property lending ratio	0.478	0.466	0.174	0.445	0.446	0.207	0.073	0.350
Average loan size	4348	8217	10067	3971	4734	2072	0.339⋆	2.542**
Borrowing from the Riksbank	0	0.020	0.093	0	0.007	0.014	0.146	1.128
Share of rediscounted bills	0.111	0.179	0.223	0.276	0.273	0.227	-0.295⋆	-1.482
Liquidity ratio	2.164	2.380	1.27	2.813	2.992	1.874	-0.270⋆	-1.235
Cash ratio	0.021	0.028	0.033	0.020	0.023	0.011	0.164	1.140
Contingent assets share	0.0002	0.001	0.001	0.001	0.006	0.008	-0.602⋆	-2.430**
Deposit finance	0.828	0.806	0.142	0.825	0.805	0.096	0.007	0.043
Average deposit size	1107	1319	933	963	1141	943	0.134	0.677
Share of customer credit drawn	0.749	0.752	0.103	0.827	0.819	0.089	-0.494⋆	-2.606**
ROA	0.015	0.016	0.008	0.013	0.011	0.006	0.466⋆	2.468**
ROE	0.070	0.066	0.019	0.062	0.048	0.029	0.500⋆	2.195**
Cost ratio	0.036	0.038	0.0121	0.040	0.045	0.022	-0.271⋆	-1.152
Log(branches)	0.693	1.044	1.077	0.693	1.148	1.299	-0.061	-0.258
Local branch concentration	1	0.879	0.231	0.875	0.722	0.336	0.386⋆	1.551
Board members	7	8.645	3.502	7	7.833	2.887	0.179	0.859
Share price	200	333	314	200	342	281	-0.020	-0.096
Growth in foreign funding	0.969	4.765	11.179	0.706	2.004	3.684	0.234	1.082
Growth in lending against stocks	0.308	1.186	3.323	0.288	2.190	6.821	-0.132	-0.569
Growth in leverage	0.013	0.069	0.376	-0.022	0.136	0.490	-0.109	-0.512
Growth in deposit finance	0.007	0.062	0.243	-0.007	0.031	0.134	0.111	0.664
Liability structure	0	0.254	0.439	0	0.187	0.403	0.111	0.578

Note: A ⋆ by the normalized differences indicates when the normalized difference is above a rule-of-thumb threshold of 0.25. Significance levels for the two-tailed T-statistics are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In the case of variables referring to the growth rate, we excluded from statistics banks that acquired other banks between April 1904 and April 1907.

Table 2: Univariate statistics for distressed and non-distressed banks, with distinction between early and late distress

late distress banks respectively in Appendix D.[4] If we restrict our attention to the early distress events, it transpires that banks with lower ROAs, ROEs, ages and loan sizes were more likely to become distressed. Higher shares of contingent assets, customer drawings on credit granted and higher cost ratios were also increasing the probability of distress. When we extend the time period and consider the later distress definition, lower local branch concentration becomes statistically significant as well.

In what follows, we move to a multivariate logit regression in order to test which groups of variables are most associated with the Swedish banks' distress in the 1907 crisis. Here, we consider a number of regressions, taking into account alternative combinations of predictors. In order to avoid the overfitting of our logit regression, we need to reduce the number of explanatory variables (van Smeden, de Groot, Moons, Collins, Altman, Eijkemans, and Reitsma, 2004; Bursac, Gauss, Williams, and Hosmer, 2008). We choose to group our variables according to their characteristics, considering logit regressions with up to eight controls.[5] In addition to our baseline analysis, to test the robustness of our choice, in section 3.4, we apply principal component analysis to reduce the large number of potentially relevant explanatory variables to a number of relevant principal components, and run the logit regression in turn on the identified principal components. We abstain from model selection on the basis of various stepwise techniques due to their common critique and inability to handle interrelated data (Harrell, 2006).[6]

We run regressions for groups of variables based on commonly used ratios and the crisis narrative. We exclude from regressions variables whose correlation with other controls is higher than 60%. Given our small sample size and limited number of distressed banks, inclusion of such variables could result in highly unstable coefficients. Whenever a choice between highly

[4] Due to space constraints, we choose to report only the statistically significant coefficients; for all remaining variables in Table 2, which are absent from the Tables A6 and A7, the logit regression results for the variables considered in isolation are not statistically significant.

[5] A consistent rule of thumb applied in the medical literature prescribes that ten events per variable in a logit regression is the ideal number. That would reduce our number of variables to one in the early distress model (given ten distressed events) and to a maximum of two in the late distress model (given sixteen distressed events). However, in recent literature targeting banking distress, a higher ratio has been applied (Colvin et al., 2015; Fahlenbrach, Prilmeier, and Stulz, 2012), which is supported by new medical and epidemiological literature that permits the relaxation of the conservative "ten events rule" (Vittinghoff and McCulloch, 2007; van Smeden, de Groot, Moons, Collins, Altman, Eijkemans, and Reitsma, 2016).

[6] Harrell (2006, p. 8) calls the stepwise variable selection *"one of the most widely used and abused of all data techniques"*. Among the issues related to this type of variable selection appear: biased standard errors of regression coefficient estimates, too small p-values, biased regression coefficients, problems with dealing with collinearity issues, biased R2.

correlated variables is possible, we include the variable into our regression whose inclusion results in the highest pseudo R2 and area under the ROC curve(AUC).[7] In the principal component analysis presented in section 3.4, we include the variables that were omitted in the baseline regressions due to their substitutability with other variables, allowing us to bring them back into the picture.

The results for early distressed banks sample and eight different specifications are presented in Table 3. Model (1) takes into account the institutional setup of banks and their geographical diversification: we look at age, number of board members, share price, as well as the local branch concentration. We also include the dummy *capital regime* into this regression, that takes a value of 1 if a given bank was below the threshold imposing higher absolute capital requirements. The size and liability status of the banks are excluded from this specification due to their high correlation with other variables: size is highly correlated with age and share price, unlimited liability status is highly correlated with share price and age. Colvin et al. (2015) find that banks with low age, high number of branches and international activities, as well as with smaller boards had a higher probability of suffering distress. Low nominal share prices have been linked to bank failures in the U.K. through the mechanism of enabling poorer classes of proprietors endowed with limited experience in risk monitoring and less capacity to meet further calls on their wealth (Hickson and Turner, 2005). We find in model (1) that banks subject to higher nominal capital requirements, banks with smaller boards, lower share prices and lower branch concentration were more likely to experience distress.

Model (2) examines the statistical significance of variables mentioned in the narratives about the 1907 crisis in Sweden. We take into account the following variables: foreign funding ratio, growth in lending against stocks, property lending ratio, growth in deposit finance, growth in foreign funding and liquidity ratio. We exclude the share lending ratio from this regression as it

[7] The AUC, the so-called area under the receiver operating characteristic curve, was borrowed by the economic literature (see e.g. Schularick and Taylor, 2012, Betz et al., 2014, Drehmann and Juselius, 2014 and Colvin et al., 2015) from the medical literature. An ROC, or receiver operating characteristic curve plots the true positive rate (on the y-axis) against the false positive rate (on the x-axis) for every possible classification threshold of our model. The true positive rate in our case answers the question "when a bank is distressed, how often does the model predict a positive outcome [distress]?" The false positive rate addresses the question "when a bank is not distressed, how often does the model incorrectly predict positive? [distress]" (type I error), with both rates ranging from 0 to 1. The AUC, or the area under the curve, measures the area under the ROC curve, where a bigger area indicates better predictive power of the model. In a "coin toss" choice of model, variables would have an expected AUC of 0.5 and would be represented by a 45-degree line on the ROC axes.

is highly correlated with the property lending ratio and results in a weaker predictive power of the model. Model (2) suggests that high growth in lending against stocks, low share of property lending (inversely related to lending against shares' collateral), high growth in deposit finance, as well as low liquidity ratios increase the probability of distress. Interestingly, foreign funding, often mentioned in the literature as one of the main factors in the crisis, is not statistically significant.

In model (3), we include all variables from Table 2 with significant T-statistics: age, average loan size, contingent assets share, share of customer credit drawn and ROA. This model suggests that the share of contingent assets, as well as share of customer credit drawn increase the probability of distress, indicating that problems on the borrowers' side may have been the issue for Swedish banks in the 1907 crisis.

In model (4), we include commonly used indicators in describing bank conditions: liquidity ratio (that can be interpreted as liquidity coverage ratio), contingent assets share (that is a measure similar in spirit to nonperforming loans), ROA, leverage, cash ratio, as well as growth in leverage. It transpires that low leverage, low ROA and high share of contingent assets raise the distress probability. Low leverage implies that distressed banks had high capital-asset ratios, which is in line with what regression (1) indicates, suggesting that banks subject to higher absolute capital requirements were more likely to experience distress. It coincides with the descriptive statistics presented in Table 2.

In models (5) and (6) we test whether examining the liability or asset structure of Swedish banks would generate better in-sample distress predictions. In model (5), we include the foreign funding share, growth in deposit finance, growth in foreign funding, leverage and growth in leverage, as well as borrowing from the Riksbank and average deposit size. Higher growth rates in leverage were associated with subsequent distress, despite low leverage also showing up as significant. This latter result might imply an under utilisation or inefficient deployment of capital amongst some distressed banks. Smaller average deposit sizes were also a significant feature of failed banks.

In model (6), we take into account growth in lending against shares, average loan size, contingent assets share, share of customer credit drawn, cash ratio, share lending ratio. We find

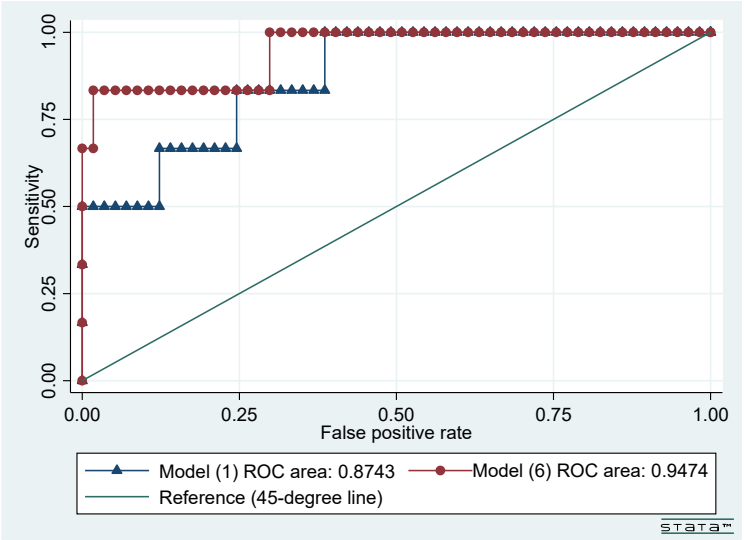


Figure 4: ROC comparison for model 1 and 6 given the early distress definition

that banks with a high share of contingent assets, high ratio of lending against shares and in the growth rate of that ratio were more likely to be distressed.

Model (7) tests the robustness of our previous specifications, by combining models (1) and (5) (excluding the coefficients that were never statistically significant in other models). Similarly, model (8) combines models (1) and (6) (excluding the coefficients that were never statistically significant in other models and the variable contingent assets share that is throughout very strongly correlated with distress and would made a fair comparison between models 7 and 8 difficult.)

Table 3 allows us to draw preliminary conclusions for the early distressed banks. It seems that the model combining variables linked to the institutional setup of the banks and their asset structure performs best in distress prediction (as defined by pseudo R2 and AUC). Throughout different specifications, we find that banks subject to higher absolute capital requirements, banks with lower number of board members, low local branch concentration (indicating domestic geographical diversification), high growth in lending against stocks, high contingent assets share and low average deposit size were more likely to experience distress.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Early distress definition								
Log(age)	-0.478		0.270					
	(0.42)		(0.44)					
Capital regime	-2.867*						-4.042**	-35.92**
	(1.64)						(1.97)	(16.84)
Board members	-0.462*						-0.606**	-1.421*
	(0.27)						(0.30)	(0.78)
Share price	-0.00511*						-0.00898	-0.0266**
	(0.00)						(0.01)	(0.01)
Local branch concentration	-4.225*						-9.718*	-30.42**
	(2.20)						(5.69)	(13.86)
Foreign funding		-14.08			-1.768			
		(21.21)			(12.91)			
Growth in lending against stocks		0.874*				0.120*		1.418**
		(0.45)				(0.07)		(0.63)
Property lending ratio		-12.20**						
		(4.84)						
Growth in deposit finance		6.784**			0.0817		2.101	
		(3.02)			(3.18)		(3.44)	
Growth in foreign funding		-0.0500			-0.547			
		(0.06)			(0.40)			
Liquidity ratio		-1.930***		-0.174				
		(0.74)		(0.22)				
Average loan size			-0.0000625			-0.0000852		
			(0.00)			(0.00)		
Contingent assets share			520.5***	585.5***		670.9***		
			(138.25)	(136.53)		(221.62)		
Share of customer credit drawn			19.28*			18.35		75.05**
			(10.73)			(13.68)		(36.66)
ROA			-68.97	-76.43*				
			(94.57)	(43.29)				
Leverage				-0.927***	-2.658***		-0.466	
				(0.26)	(1.01)		(0.39)	
Cash ratio				-14.92		-6.783		
				(11.31)		(6.07)		
Growth in leverage				1.576	7.043**		-1.017	
				(1.20)	(3.00)		(1.61)	
Borrowing from the Riksbank					9.736			
					(7.70)			
Average deposit size					-0.00684***		-0.00362**	
					(0.00)		(0.00)	
Share lending ratio						9.906***		3.973
						(3.63)		(5.88)
_cons	9.224***	8.790***	-19.24**	2.100	18.94***	-22.02*	19.61***	-24.67*
	(3.01)	(3.38)	(8.24)	(1.67)	(6.59)	(13.18)	(7.56)	(13.89)
N	71	34	77	73	34	71	66	63
pseudo R^2	0.307	0.500	0.576	0.549	0.627	0.678	0.462	0.718
AUC	0.8744	0.9241	0.9363	0.9236	0.9655	0.9639	0.9111	0.9825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Logit regression for early distressed banks

We repeat our regressions including all banks that were distressed prior to the implementation of the new banking law in January 1912 ("Late Distress", including the early distress sample). We present the regression table A8 in Appendix E. In short, when we extend our early distress definition to include banks that defaulted in 1911 ("Late Distress"), the explanatory power of our models falls considerably. There are only three variables that are significant throughout all specifications: low local branch concentration, high share of contingent assets and low average deposit size.

3.4. Robustenss analysis: Logit regression with principal components

In order to test the robustness of our baseline regressions, we repeat our main logit regressions with principal components as explanatory variables. This allows us to reduce the dimensionality of our variable space while including interrelated variables. Principal component analysis transforms the original variables into a new set of variables, called principal components. Principal components are ordered so that the first principal components account for most of the variation present in all of the considered original variables (Jolliffe, 2002).[8] While applying this linear transformation to the dataset is fairly straightforward, the use of principal components makes the interpretation of results more difficult.

In order to ease the interpretation of the logit regressions with principal components as explanatory variables, we consider five groups of variables. First, we run the logit regression for each group of variables, focusing on the first six principal components that explain the majority of variance in the data. Subsequently, we combine the statistically significant principal components from previous regressions to obtain a model that takes into account several important groups of variables. The regression results for the early distress definition are presented in Table 6 and in order to interpret variables behind the principal components denoted as PC, one has to combine the information from Tables 4 and 5, presenting the loadings of each of the component.

In model (1), we focus on variables that represent the institutional setup of the bank: age, size, number of branches, local branch concentration, number of board members, the share

[8] Note that the ordering of principal components is not decisive for their predictive power. Given this, we look at several principal components, not only the first ones.

price, liability status and the capital regime. Model (2) focuses on the capital structure of the bank and takes into account the capital regime of the bank, its capital ratio, growth in leverage in three years preceding the crisis, and growth in deposit finance. In model (3), we take into account the profitability ratios of banks: ROA, ROE and cost ratio. Specification (4) relates to the structure of assets and lending choices of banks, including the ratio of lending against shares, property lending ratio, average loan size, contingent assets share, growth in lending against stocks and share of customer credit drawn. Group (5) relates to the financing side and liquidity of the bank. We group together foreign funding, share of rediscounted bills, liquidity ratio, cash ratio, deposit finance, average deposit size and borrowing from the Riksbank.[9] Finally, model (6) combines all principal components that were statistically significant in models 1-5. Among six components, five remain statistically significant.

The statistical significance of PC3 indicates extended branch networks and smaller boards as increasing the probability of distress. The negative coefficient on PC6 is mainly driven by low share prices and high number of branches. PC1B suggests that banks with low ROA, low ROE and high cost ratios were more likely to be distressed. Statistically significant PC2C is driven by higher shares of customer credit drawn and higher growth in lending against stocks. PC3C in turn indicates high contingent asset share as associated with distress. Interestingly, we do not find any statistically significant results for principal components formed from variables taken into account in models (2) and (5). As such, we conclude that the capital structure of Swedish banks and their financing (including foreign borrowing), as well as liquidity ratios, were not associated with probability of distress in the 1907 crisis. Models (6), (4) and (1) have the best predictive powers, as measured by pseudo R2 and AUC, indicating the importance of the institutional setup and credit management of Swedish banks in the 1907 crisis and confirming our conclusions from the analysis of regressions presented in Table 3.

Once we consider the late distress definition, PC3, PC2C, PC3C and PC4D emerge as statistically significant. Lower local branch densities and smaller boards, high shares of contingent assets and of customer credit drawn, high growth in lending against stocks and low cash ratio all increase distress probability. We present the regression results in Appendix E in Table A9.

[9] We exclude the growth in foreign funding from this regression since its inclusion would more than halve the number of banks due to data availability.

There is a number of variables that are statistically significant both in our baseline regressions and in the principal component analysis. We summarize and discuss our findings, relating them to the literature, in section 3.5.

3.5. Discussion

The results presented above yield a number of findings concerning individual bank outcomes during the 1907 crisis in Sweden, relevant to current policy debates.

Principally, we find that certain bank characteristics related to institutional setup as well as credit allocation behaviour in the pre-crisis period, increased banks' probability of distress in the 1907 crisis. The first wave of distressed banks tended to have less dense branching (also later distress banks) with smaller boards, engaged in faster rates of lending against stocks and had more assets pending legal outcomes (also later distress banks).

Our first set of results confirms some of the findings in Colvin et al. (2015), suggesting the role of the geographical extension of banks and small boards in distress prediction. Our measure considers the proportion of branches outside of the home county of any given bank. Söderlund (1978, pp. 60-62), referring to the period preceding crisis observed that "*greater involvement outside the hometown region was associated with risks that were difficult to predict for the management of a small local bank. Small banks that took such risks therefore became highly sensitive to business cycles.*"

Our results corroborate the literature emphasizing the risks and costs associated with geographical diversification (Laeven and Levine, 2007; Kim and Mathur, 2008) and lend legitimacy to the concerns of contemporary supervisory authorities regarding extended operations of domestic banks into virgin banking territory (Ingves, 2010; Bernhardstson and Billborn, 2010). The geographical expansion of branching which preceded 1907 can be related to the Swedish bank activity in the Baltic region prior to 2008, when over 60 per cent of loan losses amongst the affected banks stemmed from Baltic credit (Ingves, 2010a). Similar to 1907, before 2008 "*the explicit objective of the banks was to gain market shares in the region*" and as such extension "*increases the risk of subjective judgments*" (see Bernhardstson and Billborn, 2010, p. 19). In 1907, such judgments were given greater legitimacy by the 1903 Law (40

Variable\Principal component	PC1	PC2	PC3	PC4	PC5	PC6	PC1A	PC2A	PC3A	PC4A	PC1B	PC2B	PC3B
Variance explained by PC	0.58	0.16	0.08	0.06	0.05	0.03	0.4	0.26	0.21	0.13	0.61	0.25	0.14
Log(age)	0.33	0.32	0.38	-0.69	0.14	0.24							
Log(size)	0.43	-0.12	0.14	-0.15	-0.21	0.04							
Log(branches)	0.43	-0.13	-0.1	0.11	0.13	-0.49							
Local branch concentration	-0.29	0.39	0.69	0.32	-0.29	-0.12							
Board members	0.24	-0.55	0.56	0.3	0.36	0.07							
Share price	0.37	0.29	-0.18	0.5	0.05	0.68							
Liability structure	0.31	0.56	-0.03	0.2	0.32	-0.46							
Capital regime	-0.39	0.08	0.01	-0.06	0.78	0.12	0.33	0.69	0.61	0.21			
Capital ratio							0.41	0.51	-0.73	-0.22			
Growth in leverage							0.6	-0.35	0.29	-0.66			
Growth in deposit finance							0.61	-0.38	-0.13	0.69			
ROA											0.64	-0.01	0.77
ROE											0.54	0.71	-0.44
Cost ratio											-0.55	0.7	0.46
N	0	71	71	71	71	71	74	74	74	74	78	78	78

Table 4: The loadings of variables in the principal components PC1-PC3B

Variable\Principal component	PC1C	PC2C	PC3C	PC4C	PC5C	PC6C	PC1D	PC2D	PC3D	PC4D	PC5D	PC6D
Variance explained by the component	0.34	0.23	0.17	0.14	0.1	0.03	0.32	0.17	0.16	0.14	0.1	0.07
Share lending ratio	-0.65	0.18	-0.11	0.1	-0.07	0.72						
Property lending ratio	0.6	-0.25	0.06	0.12	0.39	0.63						
Average loan size	-0.31	-0.4	0.3	0.73	0.28	-0.2						
Contingent assets share	0.19	0.18	-0.81	0.52	-0.07	-0.08						
Growth in lending against stocks	0.29	0.44	0.48	0.42	-0.55	0.11						
Share of customer credit drawn	-0.03	0.72	0.13	0.03	0.67	-0.12						
Foreign funding							0.51	0.2	-0.09	-0.39	-0.11	-0.56
Share of rediscounted bills							0.42	-0.08	-0.4	-0.36	0.24	0.68
Liquidity ratio							0.16	0.37	0.66	-0.14	0.6	0.05
Cash ratio							0.18	0.39	-0.37	0.72	0.33	-0.04
Deposit finance							-0.55	0.34	0.07	-0.16	-0.07	0.3
Average deposit size							0.33	0.49	0.23	0.15	-0.67	0.32
Borrowing from the Riksbank							0.3	-0.56	0.45	0.35	-0.06	0.17
N	71	71	71	71	71	71	79	79	79	79	79	79

Table 5: The loadings of variables in the principal components PC1C-PC6D

	(1)	(2)	(3)	(4)	(5)	(6)
Early distress						
PC1	-0.295					
	(0.46)					
PC2	-0.118					
	(0.42)					
PC3	-1.590***					-3.868***
	(0.53)					(1.47)
PC4	-1.022					
	(1.05)					
PC5	-1.481					
	(1.03)					
PC6	-1.655**					-5.480*
	(0.81)					(3.16)
PC1A		0.212				
		(0.17)				
PC2A		-0.137				
		(0.32)				
PC3A		-0.125				
		(0.39)				
PC4A		-0.661				
		(0.42)				
PC1B			-0.646***			-1.254**
			(0.22)			(0.57)
PC2B			0.0791			
			(0.42)			
PC3B			0.319			
			(0.42)			
PC1C				-0.185		
				(0.21)		
PC2C				2.788**		6.036***
				(1.33)		(1.48)
PC3C				-2.426***		-2.896***
				(0.82)		(0.82)
PC4C				1.433**		0.781
				(0.69)		(1.27)
PC5C				0.339		
				(1.01)		
PC6C				0.537		
				(0.77)		
PC1D					-0.0881	
					(0.23)	
PC2D					0.191	
					(0.39)	
PC3D					-0.0491	
					(0.30)	
PC4D					-0.222	
					(0.31)	
PC5D					0.408	
					(0.45)	
PC6D					0.139	
					(0.66)	
_cons	-3.588***	-1.977***	-2.316***	-4.397**	-2.010***	-10.53***
	(0.95)	(0.39)	(0.43)	(2.03)	(0.37)	(2.90)
N	71	74	78	71	79	63
pseudo R^2	0.294	0.057	0.162	0.674	0.029	0.742
AUC	0.8718	0.6266	0.7440	0.9607	0.5754	0.9825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

§37) which allowed banks extra discretion to value loans based on internally estimated future income streams, which themselves largely depended upon various underlying assumptions on the future state of the economy (Söderlund, 1978, p. 73). This somewhat mirrors the contemporary trend amongst regulators moving towards the internal valuation based models of Basel II and Basel III which have created "*substantial freedom for less scrupulous banks*" (Tirole, 2010, pp. 49-50). However when reviewing 1907, Söderlund (1978, p. 73) observed the "*shortage of candidates with the suitable qualifications to run a bank*" due to the speed of the pre-crisis expansion. Perhaps this explains why banks with a lower number of board members are found to be more likely to experience distress. Our findings on the importance of institutional setup in bank distress lead support to the literature emphasising the link between bank complexity and stability (Cetorelli and Goldberg, 2014; Krause, Sondershaus, and Tonzer, 2017).

While our finding showing higher contingent asset shares as reliable forerunners of distress may on face value seem rather obvious, it places emphasis of the difficulties originating on the asset side of banks' balance sheets. Assets pending legal outcomes suggest problems with non-performing loans as opposed to runs on deposits or foreign debt. Further, it is strongly correlated with higher cost ratios of distressed banks which also increases the probability of distress.[10] High operating costs resulting from non-performing assets can in turn explain why distressed banks are characterized by lower ROA and ROE before the crisis. Söderlund (1978, p. 73) observes "*the number of smaller banks possessing less resources, operating with lower levels of efficiency became excessive*" and Wendschlag (2012, p. 41) cites a "*lack of oversight by banks of individual borrowers' assets*". Therefore, while the standard narrative of the Swedish experience has emphasized foreign currency borrowing as playing a leading role in bank distress (Schön, 1989; Hagberg and Walldov, 2000; Hagberg and Jonung, 2009; Schön, 2010; Edvinsson, 2010), this study does not confirm it. These results lead us to conclude with Cassel (1908, p. 24) that "*responsibility for the crisis lies not primarily, as some have argued, in their [banks'] foreign borrowing...but in the manner in which they conducted their domestic lending.*"

[10] We excluded cost ratio from the baseline regression presented in Table 3 due to its high correlation with contingent assets share and the fact that contingent assets share is a better predictor. The univariate logit regression and logit regression with principal components indicate the cost ratio as statistically significant.

Lastly, high growth in lending against stocks increased the probability of bank distress in the 1907 crisis in Sweden. This finding is in line with the historical narrative of the crisis (see Schön, 2010 and Wendschlag, 2012) and indicates the need for regulators to track the changes in variables in addition to stationary ratios.

4. Conclusions

This paper set out to offer a further set of "early warning signals" of banking instability by drawing upon the experience of the 1907 crisis. We use previously un-analyzed balance sheet data of the Swedish commercial banks, which had extensive international links, to document differences between distressed and non-distressed banks and examine which ex-ante bank characteristics had a significant impact on banks' probability of experiencing distress in the crisis. Based on the literature and archival newspapers, we also provide an account of the distress events and discuss the role of Riksbank as the lender of last resort in the crisis, referring to internal central bank's documents.

Our main analysis tool is the logit regression which indicates those banks' characteristics that increased the probability of experiencing distress. Given the historical nature of our dataset and limited observations, as well as a large number of potentially interesting distress predictors, we accompany the baseline regressions with principal component analysis to reduce the dimensionality of our variable space.

We find that certain institutional characteristics and banks' lending choices before the crisis impacted on their probability of distress in the 1907 crisis. Specifically, banks with wider branching structures and smaller boards to oversee activities were significantly more likely to experience distress, which points to the importance of monitoring bank complexity in supervision. Moreover, banks that had a high share of contingent assets and higher cost ratios before the crisis, were more likely to experience demise. While often mentioned in the narrative literature growth in lending against share collateral seems to have played a role, we do not confirm the crisis narrative about the importance of foreign lending in influencing the chances of distress.

Our findings suggest that the crisis acted as a form of "creative destruction" in the Swedish banking system by ridding it of relatively inefficient banks which had extended their geographical scope too rapidly and failed to monitor risks sufficiently.

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A. Appendix A - Commercial Bank Population in Sweden

The principal primary source which was utilised in this analysis was the *Sammandrag af Bankernas Uppgifter*. As the source translates, it was effectively a summary of commercial banking activities in Sweden during the period of analysis. It was first made available on a quarterly basis as the *Sammandrag af Ensklilda Bankernas Qvartals-uppgifter* between 1866 and 1874 and thereafter it was published on a monthly basis. The source presented the list of commercial banks operating in Sweden and presented balance sheet information pertaining to each individual bank in a standardized format which varied slightly over time in granularity. At the juncture of April 1907, 79 banks comprised the bank population and these are listed with their date of establishment and corporate governance structure in Table A1.

Table A1: Commercial Bank Population in Sweden, April 1907

Bank	Date of Establishment	Shareholder Liability
Aktiebolaget arbetarerings bank	October 1883	Limited
Aktiebolaget Avesta folkbank	February 1904	Limited
Aktiebolaget Bergsjö folkbank	June 1902	Limited
Aktiebolaget Bergslagsbanken	September 1896	Limited
Aktiebolaget Blekinge bank	September 1872	Limited
Aktiebolaget Bollnäs folkbank	October 1894	Limited
Aktiebolaget Dalarnes bank	December 1903	Limited
Aktiebolaget Eksjö folkbank	December 1898	Limited
Aktiebolaget Filipstads bank	November 1902	Limited
Aktiebolaget Fränsta bank	January 1900	Limited
Aktiebolaget Föreningsbanen i Stockholm	April 1897	Limited
Aktiebolaget Gäfle folkbank	October 1905	Limited
Aktiebolaget Gäfle handelsbank	June 1905	Limited
Aktiebolaget Göteborgs bank	January 1858	Limited

Aktiebolaget Göteborgs folkbank	February 1871	Limited
Aktiebolaget Göteborgs handelsbank	April 1897	Limited
Aktiebolaget Halmstads folkbank	January 1906	Limited
Aktiebolaget Hjo folkbank	November 1906	Limited
Aktiebolaget Hudiksvalls Bank	May 1889	Limited
Aktiebolaget Hudiksvalls folkbank	September 1904	Limited
Aktiebolaget Härnosands folkbank	October 1905	Limited
Aktiebolaget Jämtlands folkbank	January 1874	Limited
Aktiebolaget Jämtlands kreditbank	June 1900	Limited
Aktiebolaget Kristdala folkbank	August 1906	Limited
Aktiebolaget Ljusdals folkbank	January 1899	Limited
Aktiebolaget Luleå folkbank	July 1899	Limited
Aktiebolaget Malmö folkbank	March 1905	Limited
Aktiebolaget Medelpads landtmannabank	March 1906	Limited
Aktiebolaget Mora folkbank	December 1903	Limited
Aktiebolaget Mälareprovinsernas Bank	January 1847	Limited
Aktiebolaget Nordiska kredibanken	May 1896	Limited
Aktiebolaget Norrköpings folkbank	January 1872	Limited
Aktiebolaget Nylands folkbank	April 1903	Limited
Aktiebolaget Skånska handelsbanken	March 1896	Limited
Aktiebolaget Sollefteå folkbank	May 1896	Limited
Aktiebolaget Stockholms Diskontobank	November 1898	Limited
Aktiebolaget Stockholms folkbank	September 1906	Limited
Aktiebolaget Stockholms handelsbank	May 1871	Limited
Aktiebolaget Stockholms kreditbank	October 1906	Limited
Aktiebolaget Stockholms köpmannabank	April 1905	Limited
Aktiebolaget Ströms folkbank	March 1899	Limited

Aktiebolaget Sundsvalls folkbank	January 1907	Limited
Aktiebolaget Sundsvalls handelsbank	June 1874	Limited
Aktiebolaget Sundsvalls köpmansbank	August 1902	Limited
Aktiebolaget Söderhamns folkbank	October 1899	Limited
Aktiebolaget Tjänstemannabanken	November 1899	Limited
Aktiebolaget Varbergs folkbank	May 1906	Limited
Aktiebolaget Västerviks handelsbank	September 1901	Limited
Aktiebolaget Ängelholms landtmannabank	June 1905	Limited
Aktiebolaget Örebro folkbank	April 1905	Limited
Aktiebolaget Östersunds diskontbank	August 1900	Limited
Bankaktiebolaget Stockholm öfre Norrland	April 1898	Limited
Bankaktiebolaget södra Sverige	December 1901	Limited
Borås Enskilda Bank	November 1865	Unlimited
Enskilda Banken i Vänersborg	September 1864	Unlimited
Folkärna folkbank	June 1868	Unlimited
Gäfleborgs ensklida Bank	October 1864	Unlimited
Halmstads Bankaktiebolag	November 1895	Limited
Hälsninglands Enskilda Bank	May 1873	Unlimited
Härnösands Enskilda Bank	June 1869	Unlimited
Industrikreditaktiebolaget i Stockholm	November 1864	Limited
Kopparbergs Enskilda Bank	November 1835	Unlimited
Kristinehamns Enskilda Bank	March 1865	Unlimited
Mellersta Hallands Bankaktiebolag	July 1900	Limited
Norrköpings Enskilda Bank	September 1856	Unlimited
Skandinaviska kreditaktiebolaget	November 1863	Limited
Skaraborgs läns Enskilda Bank	September 1864	Unlimited
Skånes Enskilda Bank	October 1830	Unlimited

Smålands Enskilda Bank	May 1837	Unlimited
Stockholms Enskilda Bank	July 1856	Unlimited
Stockholms Inteckningsgarantiaktiebolaget	April 1869	Limited
Sundsvalls Enskilda Bank	June 1864	Unlimited
Sydsvenska kreditaktiebolaget	August 1896	Limited
Södermanlands enskilda Bank	January 1867	Unlimited
Tranås bankaktiebolag	December 1890	Limited
Upplands Enskilda Bank	September 1864	Unlimited
Värmlands Enskilda Bank	May 1832	Unlimited
Örebro Enskilda Bank	April 1837	Unlimited
Östergötlands Enskilda Bank	February 1837	Unlimited

Sources: Sammandrag (1907), Sveriges Bankmatrikel (1906), Sveriges Bankmatrikel (1911).

In all cases where a bank had existed under another name or corporate governance structure prior to its appearance in the *Sammandrag*, we choose the earlier establishment date. We relied upon the Sveriges Bankmatrikel (1906) and Sveriges Bankmatrikel (1911) and the Svensk Rikskalender (1908) as the determining sources regarding the date of establishment as it was often the case that banks only appeared later in the *Sammandrag af Bankernas Uppgifter*. In three instances, it was apparent that Bankmatrikeln referred to recent establishment dates of limited liability banks which had actually existed prior to this, operating as unlimited liability *enskilda banks*. Svensk Rikskalender (1908) provided those earlier dates of establishment for these establishments.

In our period of interest between April 1904 and April 1907, it was necessary to track those banks which exited the population in the interim in order to remove them from the crisis population. These reductions in the population are masked in the overall growth observed in Figure 1. In all but 2 out of the 11 cases, the *Sammandrag* provided footnotes detailing the fate of each acquired bank with the appropriate dates while for the remainder Söderlund (1978) was used to provide the acquiring bank name. Table A2 presents bank exits from population between April

Bank Name	Date of Exit	Fate
Aktiebolaget Göteborgs köpmansbank	July 1905	Acquired by Skånes Enskilda Bank
Aktiebolaget Jönköpings bank	March 1906	Acquired by AB Göteborgs Handelsbank
Aktiebolaget Oskarhamns folkbank	March 1906	Acquired by Bank AB Södra Sverige
Aktiebolaget Vimmerby folkbank	March 1906	Acquired by AB Stockholms Diskonto Bank
Aktiebolaget Örebro handelsbank	May 1905	Acquired by Härnosands Enskilda Bank
Bohusläns Enskilda Bank	June 1905	Acquired by Bohusläns Enskilda Bank
Gamleby folkbank	April 1906	Acquired by AB Stocholms Diskonto Bank
Gottlands Enskilda Bank	March 1907	Taken over by Bankaktiebolaget södra Sverige
Hallands Enskilda Bank	June 1905	Acquired by Aktiebolaget Göteborg Bank
Hvetlanda bankaktiebolag	December 1906	Acquired by Sydsvenska kreditaktiebolaget
Kalmar Enskilda Bank	March 1906	Acquired by Bank AB Södra Sverige

Sources: Sammandrag (1904), Sammandrag (1907), Söderlund (1978).

Table A2: Banks exits from population between April 1904 and April 1907

1904 and April 1907.

Similarly, it was necessary to identify the newly established banks which emerged after April 1904 and formed part of the benchmark April 1907 population. A total of 18 additions to the population were observed, all of which were limited liability enterprises, see Table A3. Though Folkärna folkbank, a small bank which had unlimited liability, appeared for the first time in the *Sammandrag* in 1905, when crosschecked with the Svensk Rikskalender (1908) and the Sveriges Bankmatrikel (1906), it was confirmed that its date of establishment was June 1868. Of these additions, we record the first month of the bank's appearance as the April 1904 correspondent to the exisiting bank population. However, in cases where the growth of assets exceeded 25 per cent in the first three months of a new bank's appearance, we chose the figures which appear three months subsequently. Such a greater rate of change over the initial period might reflect the relatively larger growth of a smaller bank upon establishment and therefore may overstate the normal growth rate between the baseline and April 1907.

B. Appendix B - Evidence on distressed banks

Bank Name	Date of Establishment	Shareholder Liability
Aktiebolaget Gäfle handelsbank	October 1905	Limited
Aktiebolaget Stockholms köpmannabank	January 1906	Limited
Aktiebolaget Stockholms kreditbank	October 1906	Limited
Aktiebolaget Malmö folkbank	June 1905	Limited
Aktiebolaget Ängelholms landtmannabank	December 1905	Limited
Aktiebolaget Avesta folkbank	January 1905	Limited
Aktiebolaget Hudiksvalls folkbank	May 1905	Limited
Aktiebolaget Örebro folkbank	January 1906	Limited
Aktiebolaget Gäfle folkbank	January 1906	Limited
Aktiebolaget Medelpads landtmannabank	June 1906	Limited
Aktiebolaget Härnosands folkbank	July 1906	Limited
Aktiebolaget Halmstads folkbank	September 1906	Limited
Aktiebolaget Sundsvalls folkbank	January 1907	Limited
Aktiebolaget Varbergs folkbank	January 1907	Limited
Aktiebolaget Kristdala folkbank	January 1907	Limited
Aktiebolaget Hjo folkbank	March 1907	Limited
Aktiebolaget Stockholms folkbank	March 1907	Limited

Sources: Sammandrag (1904), Sammandrag (1907), Sveriges Bankmatrikel (1906) Svensk Rikskalender (1908).

Table A3: Additions to the population between April 1904 and April 1907

Table A4: Classification of liquidations, mergers and acquisitions and takeovers for the purpose of empirical analysis, 04.1907-07.1911

Name of the bank	Event type	Year	Distressed	Comment
IndustrikreditAB i Stockholm	Merger	1907	NO	The bank's assets and liabilities were merged on the 29th of June 1907 by Skandinaviska kreditaktiebolaget due to the latter's desire to increase access to funds according to Söderlund (1978, p. 72). Söderlund (1964, p. 323) notes that when the merger decision was taken, Industrikreditaktiebolaget i Stockholm could have without doubt continued as an independent bank.
Aktiebolaget Stockholms kreditbank	Liquidation	1907	YES	On the 29th of August, the bank declared at an extraordinary shareholder meeting that it was going into liquidation. Stockholms kreditbank was with "liquidators" in October 1907, as Sjöberg as a shareholder could not repay private debts accumulated to the bank. There was also concern on the part of the Bank Inspectorate that Sjöberg's own interests could come in conflict with interests of creditors of the banks and co-owners, see Benckert (1976, p. 65).The bank is listed under "failures" in Benckert (1976) and this is supported by newspapers (SvD, 25 February 1910; Tidningen Kalmar, 9 Augusti 1907, 2 September 1907; Östgötaposten, 10 May 1910, 11 October 1907).
Aktiebolaget Dalarnes bank	Takeover	1908	YES	Aktiebolaget Dalarnes bank was prevented from paying dividends by the Bank Inspectorate and was subsequently incorporated into Stockholm Öfre Norrland's Bank on the 15th of May 1908 (Benckert, 1976, p. 22; Dalpilen, 3 December 1907).

Härnösands Enskilda Bank	Takeover/ Reconstruction	1908	YES	The bank's assets and liabilities were reconstructed on the 30th of September in the form of Bankaktiebolaget Norra Sverige. It had been reconstructed in January 1908, occasioning significant losses for shareholders (Tidningen Kalmar, 8 January 1908). It had *"exended excessive long term credit to a major mining project"* (Schön, 2010, p. 226). When it had taken over Norbottens Enskilda Bank in 1903, it took on *"uncertain claims of some hundreds of thousands on Nautanens copper field"* (Benckert, 1976, p. 37).
Aktiebolaget Västerviks handelsbank	Takeover	1909	YES	Aktiebolaget Västerviks handelsbank experienced liquidity problems stemming from large amounts of assets which were locked into "development credit" (Söderlund, 1978, p. 76). At one point, the bank was on the verge of being taken over by Östergötlands Enskilda Bank (Tidningen Kalmar, 14 December 1907) but was subsequently acquired by Skånska handelsbanken on the 29th of March 1909 (Tidningen Kalmar, 12 March 1909, 31 March 1909).
Aktiebolaget Fränsta bank	Takeover	1909	YES	The bank's assets and liabilities were taken over on the 1st of July by Sundsvalls köpmansbank. Aktiebolaget Fränsta bank was prevented from paying dividends due to bad loans and "subsequently went into liquidation." It was acquired by Sundsvalls Köpmansbank which in turn went into liquidation (Benckert, 1976, p. 21, see also Tidningen Kalmar, 11 March 1910).
Aktiebolaget Ströms folkbank	Takeover	1909	YES	The bank's assets and liabilities were taken over on the 15th of July by Jämtlands folkbank. Aktiebolaget Ströms folkbank had a weak portfolio which was among a number of banks listed by Söderlund (1978, pp. 77-78), which had lent excessively to a number of industrial companies within a single geographical area. They did not have the resources to cover the eventual necessary write-offs against these loans.

Aktiebolaget Sundsvalls Köpmansbank	Liquidiation	1910	YES	On the general shareholder meeting on the 15th of March the bank declared that it was going into liquidation. The failure of the bank is confirmed by Benckert (1976, p. 46). The demise of Aktiebolaget Sundsvalls Köpmansbank was linked to the Stockholms kreditbank and Gäfle handelsbank, with whom it was involved in a "triumvirate through certain co-operation." Benckert (1976, pp. 47-57) describes a Director H.A. Sjöberg as a man whose business principles were questionable and corrupt, enjoying a life of luxury such as "fine dining and elegant racehorses." When Sjöberg gained control of the board, the bank began expanding and became a "base for Sjöberg's speculative enterprises." The bank acquired the majority stakeholder in the newly formed Stockholms kreditbank, to which Sjöberg owed money. That the bank was liquidated and involved in suspicious banking practices is supported by newspapers at the time (SvD, 25 February 1910, Tidningen Kalmar, 11 March 1910, 10 September 1910, Östgötaposten, 25 March 1910).
Aktiebolaget Sundsvalls folkbank	Liquidation	1910	YES	At the general shareholder meeting on the 21st of March it was decided that the bank was going into liquidation. Sundsvalls folkbank had been involved in illegal lending and by 1908, all profits had to be written off against bad loans (Benckert, 1976, p. 83). By the end of 1909, it was obvious with losses mounting to SEK 200,000 that the bank would fail and liquidators were involved by early 1910. Only one bank put in a low offer of SEK 100,000 to take Sundsvalls folkbank over, but the offer was declined as too low (Benckert, 1976, pp. 83-84). The liquidation was also followed in the press (Tidningen Kalmar, 28 February 1910).

Aktiebolaget Hudiksvalls folkbank	Liquidation	1910	YES	During a shareholder meeting on the 6th of April, the bank declared that it was going into liquidation. The bank's director had "not even an elementary understanding of book-keeping" and problems were noted by the Bank inspectorate as early as August 1906 about the directors "incredible unfamiliarity with the bank's extensive business" (Benckert, 1976, p. 79). The losses of the bank are also mentioned in the newspapers (Dalpilen, 24 March 1910).
Aktiebolaget Linköpings bank	Takeover	1910	YES	The bank's assets and liabilities were taken over on the 20th of April 1910 by Sydsvenska kreditaktiebolaget. Aktiebolaget Linköpings bank was closely linked with to the speculators and other businessmen that founded Stockholms Folkbank in 1906. When such bankowners' businesses got into difficulty, it became impossible to keep the connected banks as an independent solvent company (Söderlund, 1978, p. 76; Östgötaposten, 25 March 1910, 8 April 1910).
Aktiebolaget Gäfle handelsbank	Reconstruction	1910	YES	The bank was reconstructed on the 1st of July as aktiebolaget Gäfleborgs handelsbank. Gäfle handelsbank suffered from unsuited directorship of H. Stenberg who was described as an "adventurous salesman" (Benckert, 1976, p. 69). The bank's primary borrowers were well known stockbrokers in Stockholm who acquired debts of up to SEK 475,000- the bank held nominal capital of SEK 2,000,000. By November 1908 an examination was carried out which revealed that Gäfle handelsbanken was quickly moving towards failure (Benckert, 1976, p. 71). It was subsequently reconstructed with new directorship (Benckert, 1976, p. 77). The bank was also hit by the failure of Sundsvalls Köpmansbank in which Gäfle handelsbank lost ten percent of its paid up capital (Dalpilen, 25 February 1910; SvD, 25 February 1910).

Skånes Enskilda Bank	Merger	1910	NO	On the 29th November 1910, the bank merged with Skandinaviska Kreditaktiebolaget. Skånes Enskilda Bank is not described as distressed, the takeover being instead initiated for competitive reasons (Schön, 2010, Söderlund, 1964). Nonetheless, it was involved in a prominent bankruptcy of a merchant in 1910 (Tidningen Kalmar, 12 September and 2 November 1910). The question is thus to what extent this affected the situation of the bank. As Skånes Enskilda Bank balance sheet does not reveal substantial credit losses, and it maintained a dividend payment of 12 percent as late as 1910, it seems unlikely that it was experiencing solvency concerns.
Tranås bankaktiebolag	Takeover	1911	YES	The bank was prevented from paying dividends by the Bank Inspectorate and was subsequently liquidated and incorporated into Malmö folkbank on the 4th of March (Benckert, 1976, p. 22; Tidningen Kalmar, 15 July 1910, 8 August 1910). Excessive credit had been granted to a single business in the locality according to Söderlund (1978, p. 78).
Kristinehamns Enskilda Bank	Takeover	1911	YES	The bank's assets and liabilities were taken over on the 22nd of May 1911 by Värmlands Enskilda Bank. Kristinehamns bank came into difficulty through having bad loans on its books. It had shown difficulties for some years because of two large engagements which transpired as poor investments. By the end of 1910, its difficult position crystallized and the Banking inspection on 7 January 1911 confirmed that the entire profits for 1910 and all of the disposable funds were required to write off the bad loans. Värmlandsbanken acquired the bank at a more reasonable offer than which had been proposed in 1908, as it also acquired the bad debts of Kristinehamns bank (Benckert, 1976, p. 21-22). The takeover was reported by contemporary newspapers (Dalpilen, 24 March 1910, 29 March 1910, 1 April 1910, 7 February 1911; Tidningen Kalmar, 4 March 1911, 16 February 1912).

Halmstads Bankaktiebolag	Takeover	1911	YES	The bank's assets and liabilities were taken over on the 31st of May by aktiebolaget Göteborgs handelsbank (Tidningen Kalmar, 19 September 1910). Halmstads Bankaktiebolag had a notably weak portfolio which was amongst a number of banks listed by Söderlund (1978, pp. 77-78), that had lent excessively to a number of industrial companies within a single geographical area. They did not have the resources to cover the eventual necessary write-offs against these loans.
Aktiebolaget Sollefteå folkbank	Merger	1911	YES	The bank's assets and liabilities were acquired on the 31st of May by Sundsvalls Enskilda Bank. Aktiebolaget Sollefteå folkbank had limited investment opportunities in the locality and "preferred a merger to bankruptcy," taking the initiative when it became known that Sundsvalls Enskilda Bank planned to establish a branch in the area (Söderlund, 1978, p. 78). The merger is reported by contemporary newspapers (Tidningen Kalmar, 9 September 1910, 16 February 1912).
Bankaktiebolaget Stockholm Öfre Norrland	Takeover	1911	YES	The bank's assets and liabilities were taken over on the 30th of June 1911 Norrlandsbanken AB. AB Stockholm Öfre Norrland (aka Norrlandsbanken) became "notorious" as a "large bank failure" (Benckert, 1976, p. 77). It extended "excessive long term credit" to an enterprise involved in the "development of metallurgical inventions" (Schön, 2010, p. 226). Its liquidation was also widely reported in the newspapers (Dalpilen 25 October 1910).
Gäfleborgs ensklida Bank	Takeover	1911	YES	Gäfleborgs ensklida Bank suffered distress due to "a lack of leadership" (Söderlund, 1978, p. 78). The bank received a severely critical letter from the Bank Inspectorate in 1909 warning that "more energy and interest among the bank's leadership" was required (SvD, 25 February 1910; Söderlund, 1978, p. 78). Söderlund (1978, p. 78) remarked that the letter from Benckert was "as in almost all cases in Benckert's writing, a carefully constructed understatement" and the bank's "distress" resulted in its takeover on 30 September 1911, by Bankaktiebolaget norra Sverige.

C. Appendix C - Swedish denomination of variables used for analysis

English translation	Swedish (original) correspondent
Total liabilities	Summa Skulder
Capital ratio	Grundfond/Summa Skulder
Equity	Summa Fonder
Leverage	Summa Skulder/Summa Fonder
Bank size (Total assets)	log(Summa Tillgångar)
Foreign funding	Skulder på räkningarna med utländska banker och bankirer
Demand liabilities	Summa Skulder - Summa Fonder
Total lending	Utestående lån
Lending against share collateral	Tillgångar utestående lån mot hypotek af aktier
Lending against property collateral	Tillgångar utestående lån mot hypotek af inteckning i fast egendom
Borrowing from the Riksbank	Upptagna lån från Sveriges riksbank
Rediscounted bills of exchange	Hos annan bank eller bankir rediskonerade växlar
Discounted bills of exchange	Diskonerade och köpta växlar
Liquid assets	Kassa + Fordringar på inhemska banker och utländska banker och bankirer + Invisningar och växlar + T. utestående å kassa- och resekreditivräkning + Utgifts- och diverse tillfälliga räkningar
Liquid liabilities	Utelöpande postremissväxlar + upp- och afskrifningsräkning + löpande räkning
Share of customer credit drawn	Tillgångar utestående å kassa- och resekreditivräkning
Granted customer credit	Beviljad kredit å kassa- och resekreditivräkning
Assets contingent on legal proceedings	Tillgångar beroende på lagsökning
Assets contingent on foreclosures	Tillgångar beroende på utredning under konkurs eller administration
Income	Bruttobehållning
Operating costs	Driftkostnad

Table A5: Swedish denomination of variables used for analysis

D. Appendix D - Univariate logit regressions

E. Appendix E - Benchmark logit regression for the late distress definition

The results are presented in Table A8. In model (1), we look at the institutional characteristics of banks. In model (2) for late distressed banks, we include share lending ratio instead of property lending ratio as it has a higher predictive power. Model (3) takes into account variables with significant T-statistics for late distress definition, including ROE instead of ROA due to its better predictive properties. Models (4)-(8) include identical controls as for the early distress sample only.

	Early distress						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Early distress							
Log(age)	-0.567***						
	(0.20)						
Average loan size		-0.0000996*					
		(0.00)					
Contingent assets share			486.6***				
			(119.93)				
Share of customer credit drawn				11.12***			
				(4.16)			
ROA					-150.6**		
					(69.07)		
ROE						-34.61**	
						(15.07)	
Cost ratio							56.49***
							(18.64)
_cons	0.584	-1.381***	-3.220***	-10.84***	-0.132	-0.111	-4.504***
	(0.91)	(0.44)	(0.62)	(3.49)	(0.77)	(0.79)	(1.00)
N	79	79	79	78	78	78	78
pseudo R^2	0.103	0.038	0.398	0.128	0.113	0.109	0.122

Standard robust errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6: Logit regression of bank distress for singular statistically significant variables in the early distress model

	Late distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Late distress								
Log(age)	-0.286*							
	(0.17)							
Average loan size		-0.0000731**						
		(0.00)						
Contingent assets share			380.3***					
			(99.83)					
Share of customer credit drawn				7.768**				
				(3.32)				
ROA					-114.9**			
					(47.20)			
ROE						-31.72**		
						(12.44)		
Cost ratio							28.36*	
							(16.88)	
Local branch concentration								-2.027*
								(1.08)
_cons	-0.0277	-0.929***	-2.124***	-7.471***	0.112	0.409	-2.603***	0.0302
	(0.84)	(0.34)	(0.39)	(2.69)	(0.63)	(0.75)	(0.81)	(0.88)
N	79	79	79	78	78	78	78	72
pseudo R^2	0.029	0.032	0.220	0.078	0.076	0.088	0.032	0.051

Standard robust errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Logit regression of bank distress for singular statistically significant variables in the late distress model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Late distress definition								
Log(age)	-0.201							
	(0.27)							
Capital regime	-0.370						-1.129	-0.0351
	(1.12)						(1.07)	(1.13)
Board members	-0.208*						-0.174	-0.208
	(0.12)						(0.15)	(0.14)
Share price	-0.00106						-0.000993	-0.000449
	(0.00)						(0.00)	(0.00)
Local branch concentration	-3.460**						-5.294***	-3.820**
	(1.35)						(1.79)	(1.48)
Foreign funding		2.922			12.01			
		(8.37)			(16.15)			
Growth in lending against stocks		1.096				0.0212		0.0615
		(0.79)				(0.05)		(0.07)
Share lending ratio		4.686*				4.823**		2.404
		(2.69)				(2.36)		(2.37)
Growth in deposit finance		2.542			-3.311		0.515	
		(2.27)			(3.25)		(1.64)	
Growth in foreign funding		-0.0297			-0.259**			
		(0.04)			(0.10)			
Liquidity ratio		-0.673		0.239				
		(0.49)		(0.22)				
Average loan size			-0.0000469			-0.0000700*		
			(0.00)			(0.00)		
Contingent assets share			386.5***	426.5***		405.3***		
			(114.95)	(117.53)		(150.45)		
Share of customer credit drawn			7.562			6.619		8.224
			(5.07)			(4.35)		(6.04)
ROE			-28.85*					
			(14.99)					
Leverage				-0.954**	-0.879		-0.531**	
				(0.37)	(0.81)		(0.23)	
ROA				-115.0*				
				(61.71)				
Cash ratio				-42.43		-13.88		
				(26.61)		(9.86)		
Growth in leverage				0.785	4.071**		-0.133	
				(0.97)	(1.81)		(0.87)	
Borrowing from the Riksbank					1.366			
					(3.39)			
Average deposit size					-0.00316***		-0.00226***	
					(0.00)		(0.00)	
_cons	4.411**	-1.717	-6.091	4.023	6.444	-8.060**	9.793***	-3.854
	(2.24)	(1.42)	(3.93)	(2.95)	(5.06)	(3.93)	(3.19)	(4.28)
N	71	34	77	73	34	71	66	63
pseudo R^2	0.115	0.196	0.335	0.367	0.480	0.354	0.270	0.224
AUC	0.8472	0.7768	0.7500	0.7692	0.8269	0.8747	0.9231	0.8568

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8: logit regression for the late definiction of distress

	(1)	(2)	(3)	(4)	(5)	(6)
Late distress						
PC1	-0.0674					
	(0.15)					
PC2	-0.0871					
	(0.28)					
PC3	-1.088***					-0.730*
	(0.37)					(0.44)
PC4	-0.450					
	(0.44)					
PC5	-0.106					
	(0.60)					
PC6	-0.191					
	(0.61)					
PC1A		0.0226				
		(0.18)				
PC2A		0.0468				
		(0.30)				
PC3A		-0.0451				
		(0.30)				
PC4A		-0.456				
		(0.38)				
PC1B			-0.531***			-0.393
			(0.18)			(0.36)
PC2B			-0.281			
			(0.35)			
PC3B			0.00426			
			(0.36)			
PC1C				0.0839		
				(0.18)		
PC2C				1.266***		1.481**
				(0.39)		(0.64)
PC3C				-1.629***		-0.866*
				(0.61)		(0.47)
PC4C				0.563		
				(0.40)		
PC5C				0.0242		
				(0.41)		
PC6C				0.423		
				(0.71)		
PC1D					-0.0160	
					(0.25)	
PC2D					0.124	
					(0.51)	
PC3D					-0.0290	
					(0.35)	
PC4D					-0.745*	-2.135**
					(0.43)	(0.88)
PC5D					0.553	
					(0.38)	
PC6D					0.168	
					(0.56)	
_cons	-1.857***	-1.319***	-1.583***	-1.654***	-1.566***	-2.773***
	(0.35)	(0.29)	(0.32)	(0.46)	(0.34)	(0.87)
N	71	74	78	71	79	63
pseudo R^2	0.112	0.019	0.100	0.341	0.093	0.411
AUC	0.7458	0.5841	0.7090	0.8455	0.7004	0.8922

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Sveriges Riksbank
Visiting address: Brunkebergs torg 11
Mail address: se-103 37 Stockholm

Website: www.riksbank.se
Telephone: +46 8 787 00 00, Fax: +46 8 21 05 31
E-mail: registratorn@riksbank.se