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Banks, non-bank funding sources and the allocation of credit to firms

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Abstract

This dissertation consists of three essays on banks and firms' funding conditions. The impact of capital reform on credit conditions, the economic impact of shocks to credit conditions and hypotheses over the misallocation of capital towards unproductive uses are covered using econometric techniques.

The first essay considers the extent to which the credit conditions of firms exposed to Basel II capital regulation through their main banking relationship differed from those of firms unexposed to the reform. A key finding is that exposed firms faced a much higher likelihood of facing credit constraints over 2007-2010, particularly when the sample is adjusted for the demand by firms for bank credit. The deterioration is identified to mostly come in the form of an increase in the cost of credit (margins and fees) and, to a lesser extent, the volume of lending (including maturity). At least three-quarters of the difference is attributed to the procyclicality of capital regulation under Basel II, while the results also suggest that banks shifted their portfolios towards low-risk assets and away from riskier customers.

The second essay considers the impact of changes in credit conditions on real economy outcomes. Using an instrumental variable estimation approach, the key finding is that, with the exception of employment, credit constraints played little role in firms' decisions and in turn, the GDP contraction in Finland 2009. The results are consistent with anecdotal evidence of Finnish firms being heavily affected by the collapse in global demand, with funding conditions remaining relatively unaffected particularly compared to many other European countries. Evidence of a relationship between a deterioration in credit conditions and a decline in employment makes intuitive sense: payroll is met with working capital and hence cashflow issues are likely to influence hiring and firing decisions, particularly in the context of predetermined collective bargaining agreements.

The third essay considers zombie firms — that is, mature, unprofitable firms that remain in the market — and their funding sources. The literature has emphasised the role of bank funding as the main reason for zombie survival, with this conclusion being made despite no comparative analysis of the sources of external finance for zombie firms. The third essay provides the first analysis of that sort using Finnish data. The results find a key role for owners (i.e. equity funders) in keeping zombies alive in the (often correct) anticipation of the firm recovering. This result is robust to various measurement and specification issues. Although funding by banks is found to be associated with an increase in zombie lifetime, equity funding and public funding sources are found to decrease the exit rate out of zombie status by substantially more than banks.

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Saara Tuuli

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Chapter 1

Introduction

1.1 Background

The global financial crisis laid bare the importance of the banking sector as a provider of credit to the real economy and in turn, sparked a major legislative effort to increase its resilience to shocks. Prudential regulation has been tightened, with many new instruments and tools (e.g. macroprudential policy, resolution regimes and bail-in rules, deposit insurance) now commonplace. The regulatory effort remains high on the agenda of policymakers, with for example the latest EU Banking Package expected to be implemented in 2025. In the meantime, the EU's Capital Markets Union initiative is aimed at addressing the reliance of corporate finance on banks by deepening capital markets in the European Union.

Estimates of the benefits of financial regulation in the form of avoided bank crises (an exercise in estimating the counterfactual) have been attempted (see e.g. Miles et al 2011, Mendicino et al 2021) although any study is likely to vastly underestimate the benefit of a stable and sound banking system. In 2008, authorities around the world had to step in with emergency support – in the form of e.g. bank bailouts, credit guarantee schemes, liquidity schemes and currency swaps – to avoid the banking sector's collapse. The effects of the crisis were felt long after the global financial crisis and subsequent recession.

While a stable and resilient banking sector provides significant benefits to society, the implementation of these reforms comes at a price. For example, equity and other forms of loss-absorbing capital is costly for banks to hold and increases the margins charged to borrowers, potentially leading to lower investment and economic activity. The impact of changes in regulation are also likely to not be uniform across the economy: policy design can incentivise lending towards particular types of borrowers, potentially leading to a misallocation of capital and a loss in productivity.

This dissertation focuses on the cost side of the cost-benefit analysis and more specifically, on mechanisms through which these costs manifest themselves through the corpo-

rate sector. Much ultimately depends on the way in which banks and firms themselves respond to changes in the regulatory, financial or economic environment. In terms of capital regulation and bank behaviour, for example, banks can increase their risk-adjusted capital ratios in several ways, as discussed in Cohen and Scatigna (2014). Banks can target the liability side of the bank's balance sheet: i) banks can issue new equity or other types of loss-absorbing capital; and/or ii) increase retained earnings by increasing profit (through higher lending spreads or fees) or by reducing dividend payments. On the asset side of a bank's balance sheet, banks can: i) reduce or stop growing their loan portfolios and/or sell assets outright; and/or ii) reduce risk-weighted assets by swapping riskier loans for less risky and lower-weighted loans. New equity issuance and reduced dividend payments, while unfortunate for a bank's shareholders, are likely to have little impact on the wider economy. A reduction in lending could reduce investment, though, with increased lending rates also having an impact, at least at the margin, depending on the extent to which higher funding costs are passed onto borrowers.

This dissertation covers three topics in the literature focused on banks and firms' credit conditions. The impact of capital reform on credit conditions, the economic impact of shocks to credit conditions and hypotheses over the misallocation of capital towards unproductive uses are covered. The first essay considers the effect of capital regulation from the perspective of the asset side of banks' balance sheets and, more specifically, the way in which capital reform under Basel II affected firms' financing conditions via their banking relationships. The reform was hypothesised to lead some banks to specialise in low-risk lending, but the global financial crisis struck at the same time, meaning that capital charges — which are more sensitive to economic conditions under the reform — may have ended up higher than anticipated pre-reform. In the second essay, the real economy impact of credit shocks are considered. The Basel II reform is used for instrumenting credit conditions in studying the impact of shocks to financial conditions on firms' spending decisions. The third essay studies the increase in the incidence of zombie firms, where blame is often attributed to regulation, monetary policy and/or fiscal policy, as well as bank behaviour, to find an unexpectedly small role for banks in keeping zombie firms alive.

1.2 Data sources

This dissertation consists of three self-contained essays. All employ different microeconometric techniques, such as linear probability model estimation (Chapter 2), instrumental variable estimation (Chapter 3) and survival analysis (Chapter 4). Given that the datasets used in all three chapters are closely linked, a brief overview of the data utilised in this dissertation is provided in this section, followed by summaries of each essay.

After the financial crisis, the European Central Bank in particular recognised the

need for additional statistics on credit conditions and lending. Key innovations include the European Commission and ECB's Survey on the Access to Finance of Enterprises (SAFE), first published in 2009, and AnaCredit, initiated in 2011, to collect granular credit and credit risk data in the euro area. Earlier firm-level data included, for example, the Business Environment and Enterprise Performance Survey (BEEPS), of the EBRD and World Bank, Bureau van Dijk databases on firms' financial statements. Various survey, financial statement and credit registry data sources are available at a country level.

The datasets used in this study are on Finnish firms given the unique credit conditions data made available for this dissertation as well as the possibility to merge this with data from the national statistics office, Statistics Finland. All three essays utilise data from i) a credit conditions survey; ii) firms' financial statements; and iii) financial statement data for banks, with the second and third essays including additional data sources as discussed below. A key advantage of the dataset used here arises from the merger of credit conditions survey data with firms' financial statements and other hard data. It is not possible to link survey data to financial statement data in many of the papers that use the ECB's SAFE data, for example, presumably on account of data confidentiality. Credit registry data, on the other hand, includes information at the loan – as opposed to firm – level. Bureau van Dijk databases are commonly used in studies on firms, but geographical coverage is patchy and, while firm's bankers may be identified, the data is mute on the importance of the financial institution on firms' financing needs, firms' other sources of funding and so on.

The first data source of this dissertation is based on a survey of credit conditions conducted since 1994 on behalf of a number of organisations including the Bank of Finland and what are now called the Confederation of Finnish Industries and the Ministry of Employment and the Economy. The survey, typically conducted between late September or early October, covers different (non-financial) industries and locations in Finland and many aspects of credit conditions: details on firms' main funding sources, new applications for external credit, the purpose of new credit applications, changes in the terms of credit (margins, fees, loan volume, maturity, etc), firm-funder relationships and so on. The first and second essays utilise data from 2000 to 2010, whereas a longer time series is used in the third essay. The difference in time period is due to the way in which the survey has evolved and issues around comparability of particular variables between different waves of the survey. In particular, the data available after 2010 excludes information about the particular bank that the firm reports to be predominantly funded by.

The second source of data — Statistics Finland's panel on firms' financial statements — provides data on the profit and loss account and balance sheet data of firms from 1986, covering all firms in almost all industries. The data from 1986 to 1993 is used in this dissertation with caution and only in the third essay for illustration purposes. This is

because the data for that period is based on a Statistics Finland survey and hence covers a much smaller number of firms (between around 4,000 and 6,500 firms as opposed to around 200,000 to 400,000 in subsequent years).

The third source of data — financial statement data for banks — is from S&P's Capital IQ, which — at least at the time this thesis was being written — only covered data for European banks from 2005 onwards. The Aalto University Learning Centre CompaniesInfo directory of annual financial accounts has been used to fill in missing observations. Comparability of banks' financial statements between years is affected by the adoption of the IFRS accounting standard in 2005, with Nordea Bank Finland's sale of its Nordic subsidiaries in 2003 and Sampo Bank Plc's Baltic operations being moved to the consolidation group of Danske Bank A/S in 2007 affecting the comparability of the consolidated financial statements of Nordea Bank Finland and Sampo Bank Plc respectively. This is discussed further in the first essay.

The second essay also utilises patent applications from the Finnish Patent and Registration Office. Patent applications are used in the second essay as a proxy for R&D or innovation activity. Other microdata maintained by Statistics Finland were considered but not used. These include data on the R&D expenditure, as well as the EU's Community Innovation Survey. These surveys and the credit conditions survey proved not to have enough overlap for a meaningful sample.

The third essay also contains variables taken directly from the Business Register, which is also utilised in the compilation of some of the variables of Statistics Finland's financial statement panel on firms. The third essay on zombie firms requires data on firm age and bankruptcy. The Business Register includes data on the start and cessation date of firms.

1.3 Overview of essays

1.3.1 Model-based regulation and firms' access to finance

One of the main goals of financial regulation has been to orient banks' capital requirements towards the underlying risks associated with their assets. Basel II made an important step in this direction by introducing a model-based approach or Internal-Ratings Based Approach (IRBA) to estimating credit risk, with the approach meant to encourage banks to adopt stronger risk management practices. Concerns over the potential impact of the IRBA on lending conditions were, however, raised in the literature early on. For example, as hypothesised by Repullo and Suarez (2004), banks could be encouraged to specialise in particular types of lending: given a lower capital requirement for low-risk loans, banks adopting the IRBA could be encouraged to concentrate their portfolios in low-weighted assets at the expense of other types of lending; this could contribute

to a misallocation of capital in the economy. Furthermore, the procyclicality of the IRBA could intensify this effect. If measures of asset risk are responsive to economic conditions, capital requirements for banks using the approach will increase in a downturn, potentially leading them to deleverage by reducing lending further, particularly relatively bank capital-intensive (i.e. riskier) customers.

The first essay answers the following questions. How did credit conditions differ among firms funded by IRBA-adopting banks and firms unexposed to the reform? To what extent may have changes been driven by procyclicality and what other dynamics, such as specialisation, were at play? These are addressed using the panel dataset described above and by exploiting the institutional details of the Finnish implementation of the reform in 2007. The use of the approach was phased in across the Finnish banking industry, with the timing of banks' adoption of the approach depending on the timing of banks' applications for permission to use the approach and the granting of that permission by the regulator. The banks that were granted permission to use the IRBA during the period under study did so before the onset of the crisis and hence under an expectation of favourable economic conditions. The coexistence of the IRBA and a simpler "Standardised approach", which in practice is very similar to the Basel I approach, allows for the identification of firms exposed to the regulation via their banking relationships and an unexposed group against which the former can be compared.

The results suggest that the IRBA was associated with a deterioration in firms' credit conditions over 2007-2010. Firms primarily funded by banks that adopted the IRBA faced a 6.2 to 6.7 percentage point higher likelihood of facing credit constraints compared to their peers primarily funded by banks using the Standardised approach following the implementation of Basel II. This estimate rises to between 12.2 to 13.1 percentage points when the sample is adjusted for the demand for bank credit. More specifically, the deterioration is driven by an increase in the cost of credit (i.e. in terms of higher margins or fees) and to a lesser extent, the volume of lending (including the maturity of loans) as opposed to changes in other terms and conditions (such as collateral requirements). At least three-quarters of the impact of the IRBA is linked to procyclicality, while the results suggest that banks adopting the approach shifted their portfolios towards low-risk assets and away from riskier customers. The main results are robust to a battery of tests including those that account for the potential effects of i) possible changes in the composition of firms over the sample, ii) firms' secondary banking relationships, and iii) potential differences in the exposed and unexposed group based on observed firm characteristics. The results are also tested against a placebo (nonexistant) reform one and two years before Basel II was implemented, as well as the potential effect of the strong interlinkages between the Nordic banking sectors.

The key difficulty in all empirical papers that study the effects of reform is selection bias. In this study, selection bias may arise from the fact that large commercial banks

and/or banks more exposed to the wholesale funding markets were more likely than small banks to be early adopters of the IRBA. The deterioration in credit conditions could therefore come via the effect of the subprime mortgage crisis or other factors on particular banks instead of the reform. To explore this source of potential bias, model estimates based on a smaller sample are also presented: only borrowers funded by banks that adopted the IRBA, with the exposed group being borrowers of banks that adopted it before the 2008 recession and the unexposed group being borrowers of banks that adopted it for their Finnish business lending portfolios after the period under review (i.e. after 2010).

Studying the Finnish case is interesting for at least three reasons. First, an aggressive use of the IRBA among some Finnish banks means that risk weights attached to mortgage exposures were, on average, the lowest in Europe following the implementation of Basel II (IMF 2016). Indeed, the evolution of risk-weighted assets and loans and advances diverged following the global financial crisis, with the latter continuing to rise and the former remaining broadly stable and even falling after 2012. This led to an intervention by the Finnish Financial Supervisory Authority, with a 15% minimum risk weight on residential mortgage loans effective from January 2018. Second, any effects on the corporate sector as a result of the IRBA are likely to have been heavily influenced by procyclicality. There was a steep decline in Finnish GDP following the onset of the financial crisis. With Finland's economy being heavily bank-based, the procyclicality mechanism is likely to have been more pronounced in Finland for a given fall in output relative to some other economies. Third, the resilience of the Finnish financial sector over the financial crisis lessens the problem of disentangling the effects of the reform from other effects associated with the crisis. Banks were highly capitalised and benefited from flight-to-safety flows: banks' claims at the Bank of Finland increased from EUR3.8bn in December 2006 to EUR8.3bn in December 2009 as other euro area banks hoarded liquidity as interbank deposits with Finnish banks.

1.3.2 The impact of credit constraints on the real economy: the case of the 2009 recession in Finland

The impact of financial shocks on the real economy has also garnered much attention in the literature, particularly since the onset of the 2008-2009 financial crisis. The crisis was followed by a global recession, with most advanced economies experiencing dramatic falls in GDP, investment and employment with wages and productivity still yet to recover in many countries. Standard models of investment with financing frictions (Stiglitz and Weiss 1981 and Holmstrom and Tirole 1997) show that negative shocks to the supply of external finance, coupled with financial frictions, might hamper investment if firms lack sufficient financial slack to fund profitable investment opportunities. As discussed

in e.g. Bentolila et al (2018), credit constraints may also affect employment decisions, for example, because credit constraints can affect a firms' working capital used to finance everyday expenses such as employee wages. The structural problem of access to finance for innovation are well known – returns to innovation may be uncertain, making it riskier to finance (see e.g. Lee, 2015). If shocks to credit supply affect innovation activity, the level of future productivity will be lower, leading to persistently lower productivity and output.

The second essay of this dissertation also studies the impact of credit constraints on the real economy using Finnish data. The key finding is that, with the exception of employment, credit constraints played little role in firms' decisions and in turn, the GDP contraction in Finland in 2009. These results are consistent with anecdotal evidence of Finnish firms being heavily affected by the collapse in global demand, with funding conditions remaining relatively unaffected particularly compared to many other European countries. Evidence of a relationship between a tightening in credit conditions and employment makes intuitive sense through the working capital channel. Contrary to many other studies, no evidence of the investment channel being at play is established. Estimates of the link to productivity and innovation activity produce mixed results. Studying the heterogenous impact of credit constraints on the hiring decisions of different types of firms (e.g. by size, industry and export orientation) is limited by sample size.

The key identification challenge in studying the impact of credit shocks on the real economy is potential omitted variable bias given that firms with poor prospects are also more likely to be credit constrained. That challenge is addressed in this study by exploiting the exogenous variation arising from the implementation of the Basel II reform in 2007. A feature of the reform involved banks being allowed to calculate the risk weights attached to their assets. Given that risk weights help determine a bank's capital adequacy ratio, that is, capital to risk-weighted assets, the reform allowed banks to determine, at least in part, the amount of capital they hold. Basel II capital regulation was agreed at a global level and legislated at an EU level and hence was implemented irrespective of the characteristics of the Finnish banking sector.

Banks were required to apply for permission to use the Internal Ratings Based Approach (IRBA) under which they could calculate the probability of default parameters (and hence the risk weights) of their counterparties. Risk weights calculated using the IRBA were expected to fall given that capital is costly to hold. The IRBA is nevertheless associated with procyclicality: capital requirements of IRBA banks rise in response to increases in credit risk and hence during downturns.

The procyclicality of the IRBA is used to instrument for changes in credit conditions, given that some banks received permission to use the IRBA before the 2009 recession in Finland and some after it. The latter group used fixed weights set by regulators during the downturn and therefore their capital requirements were not sensitive to changes in credit

risk in the way in which IRBA banks were. As described in Chapter 2, this sensitivity was associated with a much higher likelihood of a firm facing credit constraints. This essay departs from much of the existing literature by utilising the exogenous variation arising from the Basel II reform and the IRBA rather than the US subprime mortgage crisis or the ECB's policy measures.

Another point of departure from the existing literature is the use of survey data as a direct measure of credit constraints and to isolate the impact of supply shocks from demand. The outcome variables considered in this study are also much wider than considered in the literature: in addition to real economy variables such as investment, employment and wages, the impact of credit constraints on productivity and their future determinants (innovation activity as proxied by patent applications) are considered.

1.3.3 Who funds zombie firms: banks or non-banks?

Zombie firms – mature firms that are unprofitable but remain in the market rather exiting through bankruptcy or takeover – have attracted increasing attention over the past few years, particularly in the context of whether low interest rates and other policy measures since the global financial crisis have contributed to their rising number. The COVID-19 pandemic has given further impetus to this debate: the large-scale support measures put in place to support the corporate sector through the crisis could shield many firms from the process of creative destruction, leading to a misallocation of resources towards unproductive firms longer term.

The third essay of this dissertation contributes to the literature focused on the role of banks — particularly weak ones — in keeping zombie firms afloat but is unique in three respects. First, the essay considers non-bank sources of external finance. The role of non-bank providers of finance has been extensively studied in the corporate finance literature but has so far been overlooked in the literature on zombie firms. Second, this essay uses survey data as opposed to solely financial statement, credit registry and/or market data. In using survey data, merged with comprehensive business registry and bank and firm financial statement data, it is possible to identify non-bank sources of funding and to identify firms' (self-reported) most important external financing relationships. It is also possible to go a step further in distinguishing between zombie firms and weak firms misclassified as zombies: firms' self-reported purposes for applying for external finance allows the identification of firms with low earnings due to new investment from those with permanently weak balance sheets and cashflow. Third — with the notable exception of Nurmi et al (2022) — this essay considers flows into and out of zombie status as opposed to the stock of zombie firms using survival analysis techniques. The paper by Nurmi et al (2022) is also based on financial statement and business registry data of the Finnish statistics office, Statistics Finland, but the paper by Nurmi et al (2022) does

not link zombie firms to the funders of those firms. Zombie lending is a central concept in the literature on zombie firms, given the hypothesis that zombie firms survive due to subsidised lending. Further, Nurmi et al (2022) differentiate between genuine zombies and weak firms based on whether the firms' employment is growing or not whereas this essay uses firms' self-reported reasons for applying for external finance to do so.

The results of this study show that bank funding may not play a signfiicant role in the zombie phenomenon. Banks are overwhelmingly the largest funder of zombie firms, perhaps justifying the focus of the literature on bank funding. This is, however, perhaps simply due to banks' balance sheet size: banks are broadly similar to other funding sources in terms of their share of zombies as a percentage of all borrower relationships. Contradicting the results of the existing literature, no statistically significant relationship is found between zombie firms and banks or bank characteristics; only the link between equity funding and zombie status is robust across all specifications. The stickiness of the funder-firm relationship and the presence of subsidies is not found to make a difference to the results. The results are also little changed when the definition of a zombie is narrowed to only include zombie firms that applied for external finance for reasons other than for the purposes of new investment to distinguish between genuine zombies and weak firms misclassified as zombies. Changes in the stock of zombie firms is driven equally by entries into and exits out of zombie status, with exits overwhelmingly driven by recoveries as opposed to bankruptcy. Based on non-parametric and semiparametric survival models, all funding sources, except for non-bank financial institutions, are associated with a longer zombie lifetime but no link is found between funding sources and entry into zombie status.

The overlap between the definitions proposed in the literature can, in cases, be small but the results using any definition challenge the perceived wisdom of a link between zombie firms and banks, at least in jurisdictions, such as Finland, that have a highly capitalised banking sector (e.g. IMF 2016) and a relatively efficient insolvency framework (e.g. Becker and Ivashina, 2021). Indeed, the early literature on zombies (Caballero et al 2008 and Peek and Rosengren 2005) was based on a highly unique institutional setting. Instead, the results of the third essay suggest that equity investors continue to fund firms classified as zombies based on definitions proposed in the literature in the (often correct) anticipation of firms recovering. As discussed in Nurmi et al (2022), a firm's exit decision is forward-looking and also based on the present value of future net income as opposed to just current returns.

Where non-bank sources of funding are relevant, tackling the zombie problem for example via regulatory scrutiny of the quality of banks' assets (as argued in e.g. Storz et al 2017) as way to avoid prolonged weakness in long-run growth may not be particularly effective. In addition, calls for policy action under e.g. the EU Capital Markets Union to broaden SMEs' access to funding sources could have unintended consequences for the prevalence of zombie firms or at least in the estimates of them.

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Chapter 2

Model-based regulation and firms' access to finance

[1]

The determination of bank capital requirements is an important and particularly contentious topic in financial regulation. One of the main goals in the past decade has been to better orient banks' capital requirements towards the underlying risks associated with their assets. Basel II made an important step in this direction by introducing a model-based approach or Internal-Ratings Based Approach (IRBA) to estimating credit risk, with the approach meant to encourage banks to adopt stronger risk management practices. Concerns over the impact of the IRBA on the composition of lending were highlighted even before the implementation of Basel II. For example, as hypothesised by Repullo and Suarez (2004), the IRBA may encourage banks to specialise in particular types of lending: given a lower capital requirement for low-risk loans, banks adopting the IRBA have an incentive to concentrate their portfolios in low-weighted assets at the expense of other types of lending, potentially encouraging a misallocation of capital in the economy. Furthermore, the procyclicality of the IRBA could lead to an intensification of this effect. If measures of asset risk are responsive to economic conditions, capital requirements for banks using the approach will increase in a downturn, potentially leading them to deleverage by reducing lending further, particularly relatively bank capital-intensive (i.e. riskier) customers.

This essay aims to answer the following questions. How did the credit conditions of firms predominantly funded by IRBA banks differ from those predominantly funded by non-IRBA banks when Basel II came into force and the global financial crisis hit? To what extent were differences associated with procyclicality and what other dynamics, such as specialisation, may have been at play? Using a panel data set created by merging an annual survey of firms' credit conditions in Finland over 2000-2010 with data from

[1] A version of this essay was published as Bank of Finland Discussion Paper 4/2019. See https://publications.bof.fi/handle/10024/48038

firms' financial statements, this essay attempts to answer these questions by exploiting the institutional details of the Finnish implementation of the reform in 2007. The use of the approach was phased in across the Finnish banking industry, with the timing of banks' adoption of the approach depending on the timing of banks' applications for permission to use the approach and the granting of that permission by the regulator. The banks that were granted permission to use the IRBA during the period under study did so before the onset of the crisis and hence under an expectation of favourable economic conditions. The coexistence of the IRBA and a simpler "Standardised approach", which in practice is very similar to the Basel I approach, allows for the identification of firms exposed to the impact of the regulation via their banking relationships and an unexposed group against which the former can be compared.

The results suggest that the IRBA was associated with a deterioration in firms' credit conditions over 2007-2010. Firms primarily funded by banks that adopted the IRBA faced a 6.2 to 6.7 percentage point higher likelihood of facing credit constraints compared to their peers primarily funded by banks using the Standardised approach. This estimate rises to between 12.2 and 13.1 percentage points when the sample is adjusted for the demand for bank credit. More specifically, the relative increase in the deterioration in credit conditions was due to a deterioration in the cost of credit (i.e. in terms of higher margins or fees) and to a lesser extent, the volume of lending (including the maturity of loans), as opposed to changes in other terms and conditions (such as collateral requirements). At least three-quarters of the difference is attributed to procyclicality, while the results suggest that banks adopting the approach shifted their portfolios towards low-risk assets and away from riskier customers. The main results are robust to a battery of tests including those that endeavour to account for the potential effects of i) possible changes in the composition of firms over the sample, ii) firms' secondary banking relationships, and iii) potential differences in the exposed and unexposed group based on observed firm characteristics. The results are also tested against a placebo (nonexistant) reform one and two years before Basel II was implemented, as well as the potential effect of the strong interlinkages between the Nordic banking sectors.

The key difficulty in all empirical papers that study the effects of reform is selection bias. This makes estimates difficult to attribute to causal relationships as opposed to correlation. In this study, which utilises a dataset that includes borrowers of banks that continue to use the Standardised Approach, selection bias may arise from the fact that large commercial banks and/or banks more exposed to the wholesale funding markets were more likely than small banks to be early adopters of the IRBA. The deterioration in credit conditions could therefore come via the effect of the subprime mortgage crisis or other factors on particular banks. To explore this source of potential bias, model estimates based on a smaller sample are also presented: only borrowers funded by banks that adopted the IRBA, with the exposed group being borrowers of banks that adopted

it before the 2008 recession and the unexposed group being borrowers of banks that adopted it for their Finnish business lending portfolios after the period under review (2000-2010). Given that Finnish banks benefited from flight-to-safety flows during the financial crisis, adding bank control variables — surprisingly — increases the extent to which firms mainly funded by IRBA adopters faced a deterioration in credit constraints relative to their peers funded by late adopters.

There is a growing number of empirical papers studying the impact of bank shocks on lending, with many focusing on the effects of the global financial crisis and others on the impact of the regulatory reforms subsequently introduced to improve the resilience of the banking sector. Two other papers focus on the variation in capital requirements arising from the use of Basel II's IRBA. This essay is closest to Behn et al. (2016), which studies the impact of German banks' use of the IRBA using German credit register loan-level data for 2008-2011 and find that the credit risk shock induced by the collapse of Lehmans led to an increase in capital charges and in turn an around 2-4% higher reduction in the amount of granted loans where capital charges were calculated under the IRBA. Fraisse et al. (2017) study IRBA banks' capital requirements and their variation among corporate exposures by risk rating over 2008-2011. Aggregating to firm level a sample of "active" loans and credit lines extended by six large French banks to French firms over 2008-2011, the authors show that a one percentage point increase in capital requirements reduces bank lending but this can, in part, be offset by increased lending from other banks. This essay departs from Behn et al. (2016) and Fraisse et al. (2017) in important ways, allowing important insights to be gleaned for the design of regulatory reform, particularly in the design of rules for risk weights. First, this chapter uses a longer time series, which is based on survey data. The use of survey data allows demand to be controlled for directly via firms' self-reported demand for external finance. Not having to rely on firm fixed effects to control for demand allows for the inclusion in the sample of firms, particularly smaller ones, that only have one banking relationship. Second, in utilising a more diverse sample of firms, this essay studies the mechanisms through which the differences in credit conditions can be explained. Absent in the existing literature on firms, empirical evidence is found for the role of specialisation in certain types of lending, as hypothesised by Repullo and Suarez (2004), which can lead to variation in the changes in credit conditions faced by low versus high-risk firms. Third, this essay considers outcome variables beyond loan volumes. While the link between the reform and survey-based binary outcome variables are not directly comparable with the link between the reform and loan volumes, the finding that the link between the reform and credit conditions is mostly due to changes in the cost of credit and changes in other lending terms and conditions as opposed to the volume of lending, suggests that the studies focused on loan volumes are capturing only a small proportion of effect of the IRBA and hence may vastly underestimate its effect.

While this essay and the papers by Behn et al. (2016) and Fraisse et al. (2017) focus on an inherent feature of Basel II that led to variation in the capital requirements of banks, other studies focus on the variation in bank capital requirements directly imposed by the regulator. Prior to the implementation of the current regulatory framework (Basel III), regulators in most countries imposed a uniform capital requirement for all banks and hence variation among banks in terms of the level of capital held by banks as a result of the regulatory framework is a fairly recent phenomenon. The lack of historical data means that empirical studies are scarce and studies of the impact of Basel III generally rely on the use of dynamic stochastic general equilibrium models (see e.g. BIS 2011 for a review). Exceptions include the regulatory frameworks of Spain and the UK, where bank capital requirements have varied across banks and/or over time (see e.g. Jimenez et al. 2017 and DeMarco and Wieladek 2015). Poulson and Westergaard-Nielsen (2017) use variation in regulatory capital requirements arising from the Danish regulators' discretion in issuing injunctions to study the impact of credit supply shock on credit availability and employment.

A key challenge in studying the impact of bank shocks is being able to isolate the effects of changes in supply from those in demand as many factors, such as economic downturns, will effect both. This essay controls for demand based on firms' self-reported demand for finance. The loan-level studies of Behn et al. (2016) and Fraisse et al. (2017) rely on firm-time fixed effects to control for credit demand (as pioneered by Khwaja and Mian 2008) and hence only cover firms with multiple banking relationships. This method is also used in related papers on the impact of the financial crisis on lending (e.g. Iyer et al. 2014) and real economy outcomes (e.g. Cingano et al. 2016). As discussed in Degryse et al. (2018), the applicability of this method (and those using large firms in studying real economy outcomes of the financial crisis as in Campello et al. 2010, Ivashina and Scharfstein 2010 and Chodorow-Reich 2014) is limited since multiple-relationship (and large) firms represent a minority of firms in many countries. Notable exceptions include Jimenez et al. (2017) and Puri et al. (2011) who use loan applications to control for demand in studying an early Spanish form of macroprudential policy (dynamic provisioning) on lending and the effects of the financial crisis on retail lending, respectively; Bentolila et al. (2018) consider the impact of reduced credit supply on employment. The use of loan applications identifies which firms applied for a loan, but is not able to capture informal constraints (i.e. firms being discouraged from applying for credit), which can lead to biased results (see e.g. Popov 2016). Other strategies used to isolate the effects of credit supply from demand include i) the use of exogenous shocks (e.g. Japanese stock market decline in Peek and Rosengren 1997; the Russian financial crisis in Chava and Purnanandam 2011; unanticipated nuclear tests in Khwaja and Mian 2008); ii) the estimation of demand and supply equations using data that includes firm-level characteristics in a disequilibrium model (e.g. Kremp and Sevestre

2013, Carbo-Valverde et al. 2016); and iii) bank lending standards as gauged by bank surveys (e.g. the ECB's Bank Lending Survey as in Ciccarelli et al 2015; van der Veer and Hoebericts 2016; Kuchler 2012; Blaes 2011; Del Giovane 2011).

A number of more recent papers use surveys of firms to control for demand. For example, Ferrando, Popov and Udell (2017, 2018) use the ECB's Survey on Access to Enterprises (SAFE) to study the impact of sovereign stress and the ECB's unconventional monetary policy measures on euro area small and medium-sized enterprises (SMEs), Popov and Udell (2012) use the EBRD's BEEPS survey to study the impact of average banking conditions on SME credit supply in 16 emerging European countries and Cornille et al. (2019) combine credit registry data with a Belgian central bank survey of firms to study the effect of credit constraints on SMEs' employment. There are some important differences between the surveys used in these studies and that used in this essay. First, compared to the dataset used in this essay, the panel datasets used in these papers include far fewer waves of the surveys and for the most part cover only the post-crisis period. For example, the ECB's SAFE survey covers the post-crisis period, with firms generally only appearing once (at least in the six and four waves utilized in Ferrando et al. 2017 and 2018 respectively). The BEEPS data covers both SMEs and larger firms but the data generally is not presented in panel form and in Popov and Udell (2012) only the years 2005 and 2008 are utilised. The Belgian survey data used in Cornille (2019) covers SMEs over the period 2010-2013. Second, the firm-bank relationship is established in this essay based on firms' self-reported main provider of external finance (whether a particular bank or some other source), whereas the firm-bank relationship in these studies are established outside the survey. Ferrando et al. (2018) identifies the relationship using Bureau van Dijk's Amadeus database and Cornille et al. (2019) based on existing credit lines reported in the Belgian credit registry; these sources are mute over the relative importance of different banking relationships when more than one is reported and provide limited (if any) information about the importance of non-bank sources of external finance, particularly those not covered in credit registries.

Another benefit of using firm-level surveys is the amount of available outcome variables (credit constraints in terms of volumes, margins, fees and other terms and conditions). Many loan-level studies (e.g. Fraisse et al. 2017, Iyer et al. 2014, Puri et al. 2011) focus on loan volumes. Furthermore, in papers by Behn et al. (2016) and Fraisse et al. (2017), for example, the extensive margin (banks ending an existing borrower relationship) is captured by observing a loan existing and then ceasing to exist in a later period. It is unclear, however, that this method adequately captures decisions by banks as distinct from decisions by firms to end a borrowing relationship due to factors such as changes in demand. Other outcome variables (e.g. the cost of credit or other lending terms and conditions) are hardly discussed in some of these papers due to lack of reliable data.

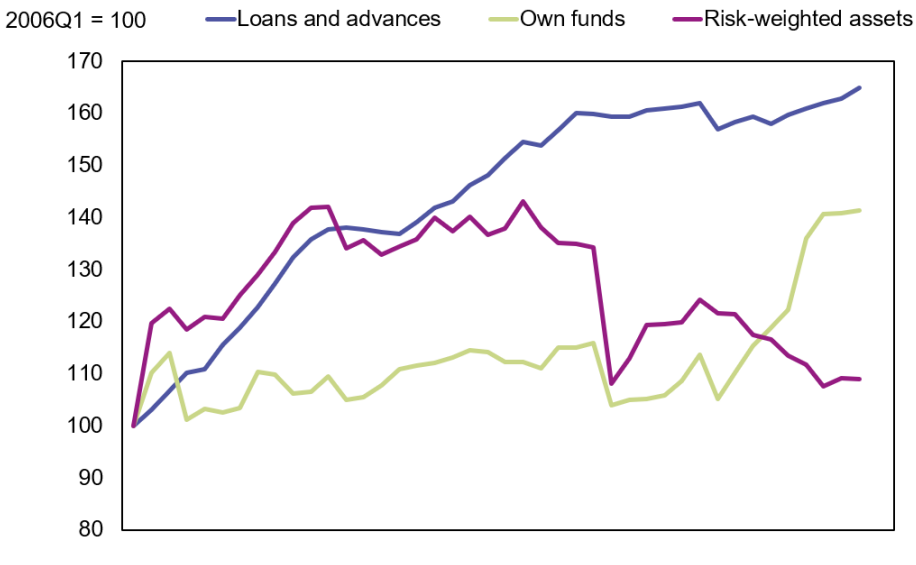
Other related papers include earlier research on the impact of Basel II's IRBA focused

on simulations to estimate its impact in terms of absolute changes in capital requirements, with some of those studies then extrapolating the impact of those changes onto individual portfolios. For example, the results of the Quantitative Impact Study 5 of the Committee of European Banking Supervisors (2006) suggest a significant fall in the minimum required capital for EU banks under Basel II (under the assumption of favourable economic conditions) compared to the previous regime, with a much sharper fall predicted for banks adopting the IRBA compared to those adopting the Standard approach. This relatively large fall is mostly due to a fall in capital requirements against mortgage assets, but also — to a lesser extent — SME retail assets. Other papers such as Altman and Sabato (2005) and Saurina and Trucharte (2004) develop models of the probability of default associated with different types of firms. These authors find that the difference in capital requirements under the IRB, Standardised and Basel I approaches depends on the extent to which corporate sector lending is categorised as corporate as opposed to retail, since the latter attracts a relatively favourable risk weight.

A strand of theoretical literature considers the coexistence of the IRB and Standardised approaches and its impact on the asset allocation among banks and/or competition between banks. In a theoretical analysis, Repullo and Suarez (2004) hypothesise that banks specialise in certain types of lending as a result of the co-existence of the two approaches. IRBA adopters have a competitive advantage in the provision of low-risk loans because the IRBA involves a lower capital requirement for these loans. By contrast, non-adopters have a competitive advantage in high-risk lending because the 'flat rate' approach of lumping borrowers into categories effectively involves low-risk borrowers cross-subsidising high-risk borrowers, which increases the attractiveness of high-risk loans and raises the average credit risk of a bank's loan portfolio. The authors therefore expect low-risk firms to achieve reductions in loan rates by borrowing from banks adopting the IRBA and high-risk firms to avoid increases in their loan rates by borrowing from banks that adopt the Standardised approach. Rime (2005), also using a theoretical model, comes to a similar conclusion. An empirical analysis of this specialism hypothesis should see the competitive advantage of different banks reflected in prices; lower prices for low-risk customers of IRBA banks versus competitors and lower prices for high-risk customers of non-IRBA banks versus competitors. A reduction (increase) in the overall riskiness of customers of IRBA (non-IRBA) banks should also be expected. The only paper to directly test for the Repullo and Suarez (2004) hypothesis is Benetton et al. (2017); this essay considers only mortgage lending. The authors find that the coexistence of the IRB and Standardised approaches led banks to specialise and hence to a "systemic concentration of high-risk mortgages in lenders with less sophisticated risk management". Behn et al. (2016) find that less profitable firms are likely to be more affected by the credit risk shock, implicitly providing support to the specialisation hypothesis.

Another strand of literature focuses on the procyclical effects of bank behaviour and

Figure 2.1: Adjustments to Finnish banks' balance sheets



Source: Financial Supervisory Authority

lending in the economic cycle (see e.g. Goodhart 2005; Goodhart et al. 2004; Kashyap and Stein (2004); Taylor and Goodhart 2004 and Gordy and Howell 2006). Procyclicality in this context refers to the unintended consequence of risk-based capital requirements increasing the amplitude of economic cycles. Capital requirements increase during a downturn to the extent that measures of (perceived) asset risk are responsive to economic conditions. Banks can either raise new equity, which can be more difficult during a downturn than under favourable economic conditions, and/or banks can deleverage by reducing lending, exacerbating the downturn. The extent to which countercyclical capital charges effect loan volumes — particularly risky ones, which are likely to experience a relatively large impact due their relative capital-intensity — remains unclear (adjustments made by banks during the 2008 crisis in response to higher capital requirements are discussed, for example, in Cohen, 2013).

Studying the Finnish case is interesting for at least three reasons. First, an aggressive use of the IRBA among some Finnish banks means that risk weights among mortgage exposures applied by these banks have, on average, been the lowest in Europe (IMF 2016) Indeed, the evolution of risk-weighted assets and loans and advances diverged following the financial crisis, with the latter continuing to rise and the former remaining broadly stable and even falling after 2012 (Figure 2.1). This led to an intervention by the Finnish Financial Supervisory Authority, with a 15% minimum risk weight on residential mortgage loans effective from January 2018. Indeed, Herrala (2014) documents

a significant rise in mortgage lending in Finland as a result of the reform, while the other side of the coin (the impact on the corporate sector) has been less studied. Second, any effects on the corporate sector as a result of the IRBA are likely to have been heavily influenced by procyclicality. There was a steep decline in Finnish GDP following the start of the financial crisis and Finland's economy is also heavily bank-based;[2] therefore the procyclicality mechanism is likely to have been more pronounced in Finland for a given fall in output relative to some other economies (see e.g. Heid 2007, who argues that bank-based economies experience the bigger procyclical effects than financial markets-based economies). Third, the resilience of the Finnish financial sector over the financial crisis lessens the problem of disentangling the effects of the reform from other effects associated with the crisis. Banks were highly capitalised and benefited from flight-to-safety flows: banks' claims at the Bank of Finland increased from EUR3.8bn in December 2006 to EUR8.3bn in December 2009 as other euro area banks hoarded liquidity as interbank deposits with Finnish banks.

This essay is split into six parts. Section 2.1 provides an overview of the implementation of Basel II in Finland. Section 2.2 and Section 2.3 provides a description of the data and the empirical strategy used in this study. Section 2.4 discusses the main results, sensitives around them and robustness checks. Given the problem of selection bias, Section 2.5 presents an alternative model with the unexposed group being narrowed down to only borrowers of banks that have adopted the IRBA approach since the period under study (that is, after 2010). The final section concludes.

2.1 Overview of Basel II implementation in Finland

An obligation for banks to continually meet an 8% risk-weighted capital ratio, defined as the ratio of capital to risk-weighted assets, was established as part of the Basel Accord of 1988 ('Basel I'). Weights were set depending on the institutional nature of the borrower: for example, a zero weight was assigned to an OECD government security, 50% to a loan fully secured by a residential mortgage and 100% for industrial and commercial loans.

A key objective of Basel Capital Accord ('Basel II'), introduced as a revision to the Basel I framework, was to better orient banks' capital requirements towards the actual credit risks associated with their assets. The revision, details of which were released by the Basel Committee on Banking Supervision in 2004 and applied in the EU from 1 January 2007, involved banks being given two broad methodologies to choose from for calculating credit risk weights and hence capital charges: the Internal Ratings-Based approach (IRBA) and the Standardised approach (internal models for market risks arising from trading activities had been introduced as part of an amendment in 1996). Un-

[2]See e.g. Levine (2002) for indicators of the extent to which Finland and other countries are bank-based economies.

der the IRBA, the estimation of credit risk is (at least partially) delegated to banks themselves. The Foundation IRB approach allowed banks to calculate the probability of default parameter based on self-collected quantitative and qualitative criteria, whereas the Advanced IRBA (not used in Finland during the period studied here) allowed banks to also calculate three additional parameters (loss given default, exposure at default and maturity). Under the Standardised approach, risk weights are either based on external rating institutions' assessments or, where external ratings are unavailable, based on Basel I risk weights. With most firms being small and therefore unrated, including 75% of the firms of the dataset used here, the Standardised approach is in principle similar to that of Basel I (Hakenes and Schnabel, 2011).

Within the five broad classes of assets with different underlying risk characteristics (sovereign, bank, corporate, retail and equity), the corporate and retail categories are most relevant for lending to firms. Criticism over the potentially excessively high risk weights for small- and medium-sized enterprises (SMEs) under Basel II led the Basel Committee (Basel Committee on Banking Supervision, 2004) to allow banks to apply the more favourable retail risk weight of 75% to very small businesses, provided the bank's portfolio is diverse and the bank's loan to the SME borrower is less than 1 million euros. Favourable treatment is also applied to SME lending that falls under the corporate category: a special discount is applied for exposures to firms with under 50 million euros in sales (Basel Committee, 2004).

In Finland, banks were invited to apply for permission from the Finnish Supervisory Authority to use the IRBA a minimum of a year before the intended adoption date,[3] with banks allowed to apply it from the beginning of 2007 onwards. Banks needed to prove to authorities that "their rating and risk estimation systems and processes provide a meaningful assessment of borrower and transaction characteristics; a meaningful differentiation of risk; and reasonably accurate and consistent quantitative estimates of risk" (Basel Committee, 2004). The adoption of the approach was therefore staggered among banks, depending on the timing of applications and the granting of permissions for IRBA use. The approach was also implemented in a staggered way by each IRBA-adopting bank: permission to use the new approach was granted on a portfolio basis, with a gradual implementation plan agreed with the supervisor.[4] Non-adopters and late adopters of the IRBA moved to the Standardised approach over 2007.

The Finnish banking system is highly concentrated despite a large number of banks operating in Finland (313 at the end of 2010). In addition to the large market share

[3]Finnish Financial Supervisory Authority, 2005.

[4]Expecting a decrease in capital among IRBA adoptees, the financial supervisor also required the capital requirement of banks using the approach to not fall by more than 5% during the first year, 10% after the second year and 20% after the third year of using the IRBA compared to the Basel I capital adequacy calculation. See Finnish Financial Supervisory Authority, 2006. This was later extended to the end of 2011 (see Finnish Financial Supervisory Authority, 2009

of some commercial banks (at the time called Nordea Bank Finland, Sampo Bank and Svenska Handelsbanken's wholly-owned Finnish subsidiary), a high number of cooperative and savings banks belong to one of the large banking groups, namely OP-Pohjola Group, POP Bank Group and the Savings Bank Group. Other significant domestic players include Aktia Bank Group and the Bank of Åland Group, while lending in Finland by Swedish Skandinaviska Enskilda Banken (SEB) was mostly corporate lending and at the time mostly done through its Finnish subsidiary.

As banks were already using internal ratings models as part of their credit processes, the Basel II reform involved developing these further to meet the requirements of the capital adequacy calculations. Following the Basel Committee's 2001 publication of its proposal for Basel II, banks started to document their preparations for model development: Nordea Bank Finland, OP-Pohjola, Svenska Handelsbanken and Aktia Bank from 2001, Sampo Bank from 2002, SEB from 2003 and Bank of Åland from 2004. For the Swedish banks (Handelsbanken and SEB), model approval for Finnish subsidiaries' portfolios would have been handled jointly between the Swedish and Finnish supervisors (see e.g. IMF 2011) (see Table 2.1).

The three early adopters of the IRBA in Finland were Nordea Bank Finland, OP-Pohjola and Handelsbanken for its Finnish portfolios. Nordea Bank Finland received approval to use the IRBA for corporate and institutional exposure classes in Finland in June 2007 and for their retail portfolio in December 2008. OP-Pohjola was granted permission to use the IRBA for corporate and institutional customers within its corporate lending entity (at the time called Pohjola) in September 2008, with permissions granted in 2011 for retail and credit institution exposures. Having adopted the IRBA for some of its Swedish and Norwegian portfolios in 2007, Handelsbanken started to use it in its Finnish retail and corporate portfolios in early 2008.

The other banks received approval after the financial crisis and the period under review (i.e. after 2010). Sampo Bank, having applied for IRBA use in 2005, received IRB approval for its corporate exposures in 2015. Bank of Åland's and Aktia's annual reports suggest that their IRBA models began being used internally from 2007 onwards, with applications made in 2010 and 2011 respectively. Approvals were granted in 2012 for Bank of Åland's household portfolio, 2016 for its corporate portfolio and in 2015 for Aktia's household portfolio.

Table 2.1: IRBA-approved banks and subsidiaries in Finland

Name as appears in survey	Bank name (2000)	Bank name (2010)	Authority*	IRBA approval date for Finnish retail loans	IRBA approval date for Finnish corporate loans	Changes affecting continuity of financial statements
Merita / Nordea	Merita Bank Plc	Nordea Bank Finland Plc	FI	Dec 2008	Jun 2007	2003: wholly-owned Scandinavian subsidiaries sold to Nordea AB, with income statements no longer incorporated into consolidated statements of Nordea Bank Finland Plc.
OP & member institutions	OKO Bank Group	OP-Pohjola Group	FI	Oct 2011	Sep 2008	
Sampo, Danske	Sampo-Leonia Plc	Sampo Bank Plc	FI	Dec 2016	July 2015	2007: Sampo Bank Plc's Baltic operations moved to the consolidation group of Danske Bank A/S
Handelsbanken	Svenska Handelsbanken AB & Handelsbanken Finans Abp	Svenska Handelsbanken AB, Handelsbanken Finans Abp & Rahoitus Oy	SE / FI	2008 Q1	2008 Q1	Group consolidated figures used due to data availability for Regional Bank Finland and Handelsbanken AB subsidiaries Handelsbanken Finans Abp & Handelsbanken Rahoitus Oy.
Aktia	Aktia Savings Bank Plc	Aktia Bank Plc	FI	Feb 2015	Pending	
Åland	Bank of Åland Plc (Ålandsbanken Abp)	Bank of Åland Plc (Ålandsbanken Abp)	FI	Jan 2012	Jun 2016	
SEB	Skandinaviska Enskilda Banken AB & Finnish subsidiaries	Skandinaviska Enskilda Banken AB & Finnish subsidiaries	SE / FI	2013	2011	Group consolidated figures used due to data availability for SEB's Finnish subsidiaries.

*FI stands for Finanssivalvonta, the Finnish Financial Supervisory Authority. SE stands for Finansinspektionen, the Swedish Financial Supervisory Authority.

A number of banks and other financial institutions reported in the survey by firms as their main provider of external finance, such as POP Bank Group (with around 6% market share of loans to the Finnish public), Savings Bank Group (around 3.5%) and some smaller lenders (e.g. the S-Bank merged with Tapiola Bank), continue to use the Standardised approach (at least at the time of writing). Other frequently mentioned providers of external finance include investment banks, capital markets, pension and insurance funds, leasing companies and publicly-owned institutions such as the Finnvera, TEKES, Municipality Finance, Nordic Investment Bank and the European Investment Bank. Furthermore, 28% of firms stated that they mostly relied on internal funds or were fully funded by another entity (e.g. the parent company) of their organisation.

Although only a small number of banks were IRB certified before 2010, the high degree of concentration in the Finnish banking system means that 31% of private non-financial lending in Finland was undertaken by an IRB-approved institution in end-2007, 69% in end-2008, 81% in end-2015 and 82% in end-2016. [5] Note that only the Foundation IRB approach was in use in Finland during the period studied here and hence no distinction is made between the Foundation and Advanced IRB approaches.

Ahead of implementation and against the expectation of favourable economic conditions, the financial supervisor and banks expected the reform to lead to a fall in capital requirements across all banks, especially for those using the IRBA.[6] Indeed, for banks for which data is available, both corporate and retail exposures were associated with substantially lower risk weights under the IRBA.[7]

While a reduction in capital requirements suggests a positive effect on corporate credit conditions, particularly for firms with relationships with IRBA adopters, portfolio reallocations towards less risky assets and, under unfavourable economic conditions, the procyclicality of IRBA-based capital requirements points to a potential negative effect. There is evidence of Finnish banks shifting their portfolios towards safer assets, such as mortgages, well before the reform was implemented as well as after it when the crisis hit. For example, Herrala (2014), who studies the impact of Basel II on mortgage lending in Finland, finds that, as a result of the reform, banks' practices led to a 20-50% improvement in household credit availability, with banks shifting away from corporate credit in attempts to economise on capital charges. The recession is likely to have played a larger role than the global financial crisis in Finnish banks' further portfolio allocation towards less risky assets following the recession as documented in e.g. IMF (2010) and in Finnish banks' financial statements. Being highly capitalised with low non-performing loan ratios

[5]Based on lending shares in 2010 (the final year of the sample used in this essay) as reported by Finance Finland (2010).

[6]See e.g. Pohjola Bank plc Annual Review 2007, Nordea Bank Finland Annual Report 2005 and FSA Newline 4/2007.

[7]See e.g. Handelsbanken Annual Report 2007 and Nordea Finland Capital Risk Management Reports 2008-2010.

and little exposure to toxic assets, Finnish banks benefited from flight-to-safety flows and remained profitable over the crisis, with demand among corporates for bank loans actually increasing sharply in 2008 as new corporate bond issuance declined (see e.g. Finanssiala 2009 and 2010, IMF 2010). A collapse in demand for Finland's capital-intensive goods exports nevertheless resulted in a sharp contraction in GDP, translating into a major increase in the overall credit risk of borrowers. Indeed, in its 2008 Annual Report, Nordea in particular emphasised i) the effect of a weakening in the credit quality of its corporate loan portfolio; ii) developments in credit quality being reflected in higher margins; and iii) Nordea's subsequent focus on "creditworthy and high-rated corporate customers". By contrast, Nordea's 2008 report documents being able to fund itself normally during the crisis, with average funding costs proving to be among the lowest of major European banks.

2.2 Data description

The data used in this study is based on a merger of three different datasets: survey data on firms' credit conditions and data from firms' and banks' financial statements. The survey is based on an annual survey of credit conditions conducted since 1994 on behalf of a number of organisations including the Bank of Finland and what are now called the Confederation of Finnish Industries and the Ministry of Employment and the Economy. Over the sample used in this study, covering 2000-2010 (excluding 2005),[8] participating firms numbered around 1,000 per year and covered different (non-financial) industries and locations in Finland. The number of observations total 10,705 and cover 3,372 individual firms. Earlier and later years are excluded due to issues around the comparability of surveys[9] and in order to avoid issues associated with the confounding effects of major changes affecting the Finnish banking sector e.g. the adoption of the euro. Statistics Finland's data on firms' financial statements is comprehensive: it covers the period from 1986 onwards and includes all key financial statement variables e.g. turnover, assets, equity, profit, personnel, wages, rent, etc.[10] Financial statement data for banks is taken from S&P's SNL Financial, with the Aalto University Learning Centre CompaniesInfo directory of annual financial accounts used to fill in missing observations.[11] Comparability of banks' financial statements between years is affected by the adoption of the IFRS accounting standard in 2005, with Nordea Bank Finland's sale of its Nordic subsidiaries in 2003 and Sampo Bank Plc's Baltic operations being moved to the consolidation group of Danske Bank A/S in 2007 affecting the comparability of the consolidated financial

[8] Data for the year 2005 was not available for this study.

[9] In particular, the data available after 2010 excludes information about the particular bank that the firm is predominantly funded by.

[10] The list of variables is available on Statistics Finland's website.

[11] See https://web.lib.aalto.fi/en/old/yrityspalvelin/.

statements of Nordea Bank Finland and Sampo Bank Plc respectively (see Table 2.1).

The panel is unbalanced (see Table 2.2) due to the survey panel being unbalanced; the impact of this on the results of this study is considered in Section 2.4. A particular percentage of firms were dropped out of the survey intentionally each year and the response rate varied between 70 and 80% over the period utilised in this study. The 20 to 30% of firms not responding to the survey include those that were initially included in the survey but then not contacted due to reasons such as a merger leading to a double count of a firm, the firm no longer being in operation, bankruptcy, etc. Also contributing to the non-response rate was the inclusion of subsidiaries with financing arrangements determined at group level: where group and subsidiary respondents were the same, the respondent was only interviewed once. There seems to be little difference between the composition of firms that drop out of the survey and those that do not based on characteristics included in the (balanced) financial statement panel such as firm size, Z-score, turnover, profit, return on equity / capital invested / investment, gross value added, employment and fixed assets.

Table 2.2: Panel structure

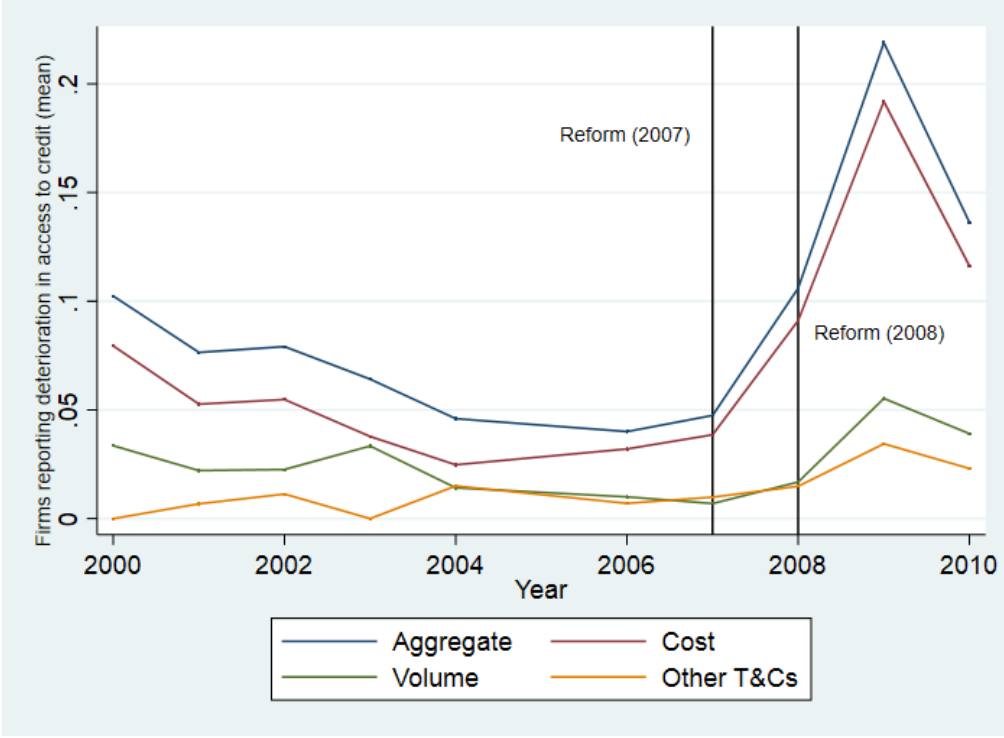
Observations	Frequency	Percent
1	971	9.07
2	1232	11.51
3	1692	15.81
4	1544	14.42
5	1885	17.61
6	936	8.74
7	875	8.17
8	576	5.38
9	504	4.71
10	490	4.58
Total	10,705	100

2.2.1 Dependent variables

Descriptive statistics for the variables utilised in this study are presented in Table 2.3. As discussed below, the key dependent variables for testing the relationship between IRBA adoption and credit conditions relate to various difficulties firms reported to have experienced in accessing finance. The key dependent variable is an aggregate term, $Constrained_{ijt}$, which equals 1 if firm i with a key relationship with bank j at time t reported to have seen a deterioration in their access to credit over the past 12 months and zero otherwise. This is a broad category, which includes issues around the ***cost*** of lending (the firm reporting increases in margins and fees for existing or new credit), the ***volume*** of lending (firms reporting having their loan application denied, being granted

a loan of a smaller size and/or with a shorter maturity than they had applied for) and ***firms reporting tighter other terms and conditions*** (such as a tightening in collateral requirements). The aggregate term is broken down into dummy variables $Cost_{ijt}$, $Volume_{ijt}$ and $Conditions_{ijt}$ respectively, with these disaggregated variables also used as dependent variables in the equations outlined below.[12] In aggregate, firms experiencing a deterioration in their access to credit varied between 5% and 10% ahead of the crisis, followed by a doubling to over 20% in 2009 (Figure 2.2). While the pattern of the time series is similar across the disaggregated variables, the evolution of the aggregate term, $Constrained_{ijt}$, is predominantly driven by developments in the cost of credit, particularly a widening in margins. The number of firms denied credit altogether (1.1%), awarded a smaller loan than applied for (1.3%) or with a shorter maturity (0.5%) or experiencing a tightening in other conditions (1.2%) is of a small magnitude relative to changes in margins (6.1%) and fees (3%).

Figure 2.2: Firms reporting a deterioration in their access to credit (mean)



In testing for the Repullo and Suarez (2004) hypothesis of specialisation, a credit metric based on the Altman (1968) Z-score for predicting bankruptcy is used as the

[12]Behn et al. (2016), Fraisse et al. (2017) and Jimenez et al. (2012 and 2017 distinguish between the 'extensive margin' i.e. the decision to initiate or stop a lending relationship and the 'intensive margin' i.e. conditional on lending, the volume of credit granted. These two terms relating to the volume of lending are aggregated into one term here, given the small number of cases in which these apply.

dependent variable.[13] The Z-score — used as a prototype for many IRBA models (Altman et al., 2017) — is based on a number of financial ratios. The version used here, based on the estimates of the Z-score in a cross-country context in Altman et al. (2017), includes four of them: i) working capital to total assets (as a measure of net liquid assets relative to total capitalisation; ii) retained earnings to total assets (as a measure of earned surplus of a firm over its life); iii) earnings before interest and taxes to total assets (as a measure of the productivity or the profitability of the assets of the firm); and iv) the market value of equity to the book value of total liabilities (as an indicator of the extent to which assets of a firm can decline in value before the liabilities exceed the assets and the firm becomes insolvent). An average of the four best performing models (out of 8) for Finland is used. As discussed in Altman et al. (2017), the Z-score (or logit) has a probability representation but does not represent an empirical probability of default (PD) and does not have a PD interpretation. Instead, it is used here as general metric of the creditworthiness of a firm, where the higher the number between 0 and 1, the more likely the firm is to go bankrupt.

2.2.2 Independent variables

The key independent variables are the dummy variables IRB_{ij} and $Reform_{jt}$. The variable IRB_{ij} equals 1 if the firm i declares their main external financier to be a bank j that adopted the IRBA and zero otherwise.[14] The variable $Reform_{jt}$ represents the time period from the reform onwards and equals 1 on the date the main financing bank moving to the new regulatory regime (be it the IRB or the Standardised approach) and all subsequent periods. The variable $Reform_{jt}$ can therefore only equal 1 from 2007 onwards and only from 2008 onwards for some firms. The interaction term ($IRB_{ij}XReform_{jt}$) is the key variable interest, given that its coefficient estimates the relationship between credit conditions and the reform.

One issue associated with these independent variables is that the dataset only identifies the banking relationship the firm declares to be their main one in any given year. Many firms have more than one banking relationship, particularly large ones. Firms in Finland, like those in other Nordic countries, tend to have a small number of banking relationships as opposed to those in for example southern Europe (see Degryse et al., 2009), however. Indeed, around 45% of firms used in this survey had only one banking relationship and around 75% had two or fewer. These percentages change to 50% and 85% when only

[13]Other recent empirical studies that use the Z-Altman score include, for example Ippolito et al (2016).

[14]The survey was conducted in Finnish and translates into "Who is your main financier (select only one)?" or "What is your most important source of external finance?". Two options are then presented 'bank' or 'other', with the former question leading to another multiple choice question with the option of ticking one of around 14 Finnish banks or filling in an open field for a bank not on the list. The market share of banks implied by survey responses closely reflects the market share of banks based on banks' own financial statements.

SMEs are considered. As discussed further below, the sample can be narrowed to firms with only a small number of banking relationships to investigate the extent to which the presence of multiple relationships might affect the results.

The remaining variables relate to a number of firm and bank control variables (Table 2.3) widely used in the literature on firms' access to credit and banking. These include dummy variables for the size of the firm (using the EU staff headcount-based definition[15]), as well as industry and geographical location. The Z-score or the ratios used in its calculation are not directly used as controls where the dependent variable relates to credit conditions because their inclusion could involve a loss of useful information (the baby out with the bathwater problem discussed in Angrist and Pischke (2009)).[16] Financial statement variables such as logs of the firms' turnover and profit are nevertheless used to control for balance sheet size and as a measure of firm performance, respectively. Other measures of firms' financial health and performance used here include equity ratio (%), liquidity ratio (%), return on capital invested (%), return on investment (%) and return on equity (%).[17] In terms of bank controls, key balance sheet and income statement variables are used, such as Tier 1 capital ratio, funding gap, ratio of liquid assets to total assets, return on average assets (as a measure of profitability) and net interest income to total income (as a measure of revenue stability).

2.3 Empirical strategy

The key difficulty in all empirical papers that study the effects of different reforms is selection bias. In the context of this study, for example, it could be that firms selected into being affected by the reform by their choice of their main financier (the anticipation effect). The survey used here nevertheless suggests that borrowers did not choose a particular bank because of its IRBA or non-IRBA status. In the 2006 survey, firms were asked about their expectations regarding the impact of Basel II on their access to credit. Around three-quarters of firms were unaware of the upcoming changes to banking regulation. Out of the firms that were aware, 78% expected no changes in their ability to obtain credit and 60% expected no changes to their margins. Across the survey, firms cited that the reason behind their selection of a particular bank was due to their existing relationship with the bank (55%), existing prices (21%), available services (11%), location (8%), etc.

[15]The European Commission defines firm sizes as follows: micro (<10 staff), small (<50 staff) and medium-sized (<250).

[16]Model estimates are, however, little changed when the Z-score is included as a dependent variable (see model 25).

[17]All metrics are reported by Statistics Finland, except for the liquidity ratio, which has been calculated as current over total assets.

Table 2.3: Descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
	Survey data					
Constrained	1 if firm experienced a deterioration in their access to finance (as covered by variables, interest, volume and conditions); 0 otherwise.	10,705	0.09	0.29	0	1
Cost	1 if firm's margins or fees increased; 0 otherwise.	10,705	0.07	0.26	0	1
Volume	1 if a smaller-than-applied-for volume of lending was granted compared; 0 otherwise.	10,705	0.03	0.16	0	1
Conditions	1 if other loan terms and conditions became less favourable; 0 otherwise.	10,705	0.01	0.11	0	1
Zscore	Probability of bankruptcy as proxied by Altman Z-score.	10.364	0.49	0.11	N/A	N/A
IRB	1 if firm declares their main external financier to be a bank using the IRBA in that year; 0 otherwise.	10,705	0.46	0.5	0	1
RepaymentsIrregular	1 if firm reported irregularities in their repayment of existing external credit; 0 otherwise.	10,705	0.07	0.26	0	1
Exporter	1 if firm declares more than 50% of their output to be for the export market; 0 otherwise.	10,705	0.14	0.35	0	1
	Firms					
Equityratio*	Sum of equity, value adjustment and optional reserves as a percentage of balance sheet total (%).	10.364	41.97	34.18	0	1
Liquidityratio	Liquidity ratio calculated as current assets over total assets (%).	10.364	0.15	0.19	N/A	N/A
RoCI*,**	Return on capital investment, calculated as the sum of net profit, financial expenses and taxes as a percentage of balance sheet total (%).	10,705	14.78	41.43	N/A	N/A
RoI*,**	Return on investment, calculated as the sum of net profit, financial expenses and taxes as a percentage of the sum of equity, value adjustment, optional reserves and non-current creditors.	10,705	55.03	212.95	N/A	N/A
RoE*,**	Return on equity, calculated as net profit as a percentage of the sum of equity, value adjustment and optional reserves (%).	10,705	44.13	228.90	N/A	N/A
Log(turnover)	Log of turnover.	10,705	15.04	3.89	N/A	N/A
Log(profit)	Log of net profit.	10,705	9.22	5.91	N/A	N/A

Table 2.3 continued

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
	Firms (continued					
Firm Size	1 if firm size is the following; 0 otherwise:					
Micro	*Fewer than 10 employees.*	10,705	0.25	0.44	0	1
Small	*Between 10-49 employees.*	10,705	0.21	0.41	0	1
Medium	*Between 50-249 employees.*	10,705	0.14	0.35	0	1
Geography	1 if firm located in the following; 0 otherwise:					
Helsinki	*Helsinki region.*	10,705	0.43	0.49	0	1
top5	*2nd to 5th largest cities by population after Helsinki region.*	10,705	0.10	0.30	0	1
top10	*5-10th largest cities by population.*	10,705	0.06	0.24	0	1
Industry	1 if firm main activity belongs to following industry; 0 otherwise:					
Industry1	*Agriculture, forestry and fishing.*	10,705	0.00	0.02	0	1
Industry2	*Manufacturing.*	10,705	0.35	0.48	0	1
Industry3	*Construction.*	10,705	0.09	0.29	0	1
Industry4	*Distributive trades, transport, accommodation and food services.*	10,705	0.30	0.46	0	1
Industry5	*Real estate, renting and business activities.*	10,705	0.17	0.37	0	1
Industry6	*Government and other services.*	10,705	0.06	0.24	0	1
	Banks					
Fundinggap	1 - ratio of customer deposits to total funding base	5,911	0.58	0.14	0.32	0.81
Tier1	Tier 1 capital ratio	5,911	0.11	0.03	0.06	0.20
Liquidassets	Ratio of liquid assets to total assets	5,911	0.10	0.07	0.02	0.29
NII	Ratio of net interest income to total income	5,911	0.57	0.11	0.35	0.84
Totalequity	Ratio of total equity to total assets	5,918	0.06	0.02	0.03	0.12
ROA	Return on assets	5,918	0.72	0.50	-1.60	2.56

Maximum and minimum values for some variables are unavailable due to Statistics Finland policy.
**Calculated by Statistics Finland*
***Outliers have been removed.*

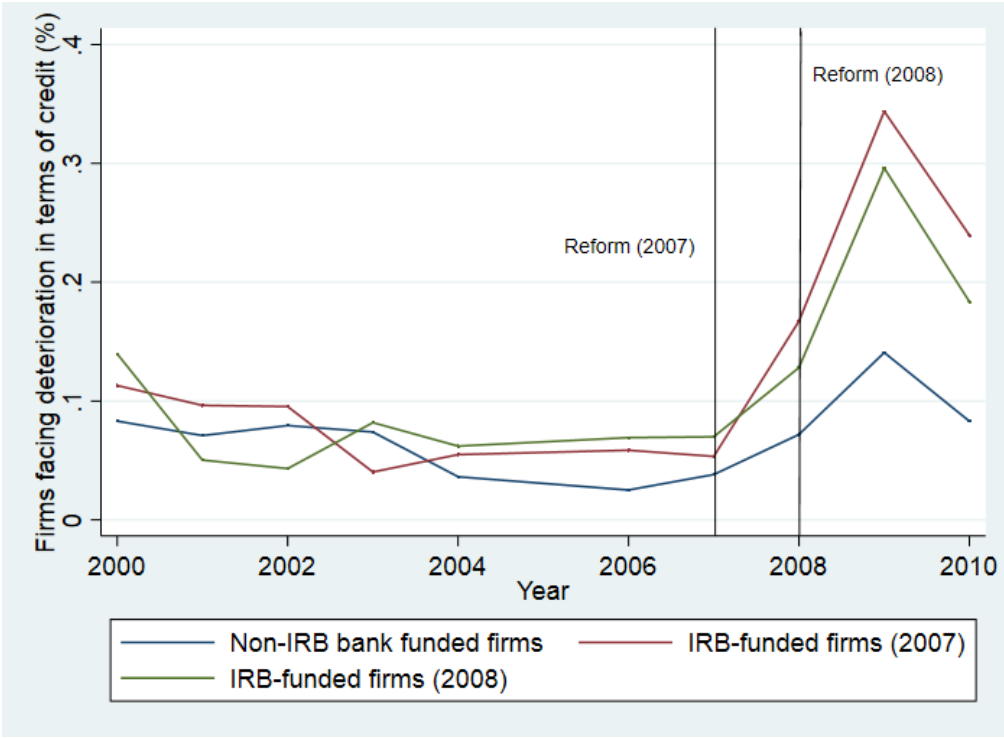
Another important potential source of selection bias arises from banks' decisions to apply for permission to use the IRBA and over the borrowers to whom they extend credit. A type of bank more likely than others to apply for the IRBA may also have responded to the crisis differently in terms of their lending practices than non-IRBA adopting banks due to reasons unrelated to the reform or procyclicality. Indeed, as discussed in e.g. Hakenes and Snabl (2011), large banks are likely to have been early adopters of the reform, given the high fixed cost of risk management technologies. Large banks may have also been more heavily exposed to the interbank markets than their smaller counterparts, with the financial crisis playing a relatively large role in their balance sheet decisions. If so, the OLS coefficient associated with the key variable of interest, the interaction term, would reflect selection bias as well as causal effects. The results outlined below suggest that riskier firms could have been more affected than their less risky counterparts; the negative correlation between selection of firms post reform (lower risk ones) and the dependent variable (more significant deterioration in access to credit) implies a negative bias, working against the findings presented here.

Selection bias arising from banks' decisions may be less problematic in Finland than in other jurisdictions for at least two reasons. Firstly, the Finnish banking sector is highly concentrated and dominated by a few large institutions including groups of credit unions and savings banks. While the adoption of the IRBA was determined by banks (along with the financial supervisory authority), suggesting that banks 'self-select' into being affected by the policy, many of the banks (and most of overall business lending) included in the control group in this study eventually moved under the IRBA suggesting that banks not adopting the IRBA during the period under study were not fundamentally unable to adopt it (and hence fundamentally different to IRBA banks) but were just slower to do so. Indeed, IRBA adopting banks applied for permissions before the onset of the crisis and in the expectation of favourable economic conditions and hence lower risk weights and capital charges that could be achieved under the Standardised approach. Given the recession and the sensitivity of risk weights to the economic environment, capital charges ended up being higher than anticipated by early adopters, reducing incentives among later adopters to speedily apply for permission to adopt the IRBA. Second, the Finnish banking system faired the global financial crisis well due to strong capital buffers and limited exposures to structured products or vulnerable countries (see e.g. IMF 2010 and IMF 2012). Banks became safe havens, overly liquid and hence, a priori, any differences in e.g. interbank exposures between IRBA and non-IRBA banks are unlikely to have a major effect on large banks' lending decisions.

Studying the evolution of the key variables suggests that the group of firms not financed by IRBA banks is likely to be a reasonable counterfactual for those that were. For example, a time series of the key dependent variable, $Constrained_{ijt}$ suggests that, pre-reform, firms financed by IRBA-adopting banks were not more credit constrained

than those not unexposed to the IRBA (Figure 2.3) nor were there any major divergences in the evolution of credit conditions among firms financed by IRBA adopters versus other banks. Indeed, the difference in the averages of these groups in terms of the $Constrained_{ijt}$ variable is close to zero but then increases once the reform is implemented (Figure 2.4). This is also broadly true when the average Z-score is compared among the two groups (Figure 2.5). That is, the evolution of the riskiness of IRBA banks' borrowers were broadly similar to that of non-IRBA banks' borrowers pre-reform.

Figure 2.3: Firms reporting a deterioration in their access to credit (mean), by group



While the exposed and unexposed groups need not be identical in their composition in terms of observables in order for the unexposed group to be used as a valid counterfactual for the exposed group, similar characteristics could suggest that firms are also more likely than not to be similar in terms of unobservables. Studying the characteristics of firms (Table 2.4) ahead of the reform (i.e. the period of 2000-2006) suggests that firms were broadly similar in terms of their main characteristics, particularly in terms of their financials (equity ratio, profit, return on capital invested, return on investment and return on equity), geography and industry. The exposed group nevertheless has a higher liquidity ratio, lower Z-score and a higher proportion of SMEs. In terms of the first two variables, the magnitudes of these differences are small, but statistically significant. The difference in the proportion of SMEs is higher and can help explain the higher liquidity

Figure 2.4: Difference in the share of IRBA and non-IRBA bank funded firms reporting a deterioration in their access to credit (matched data)

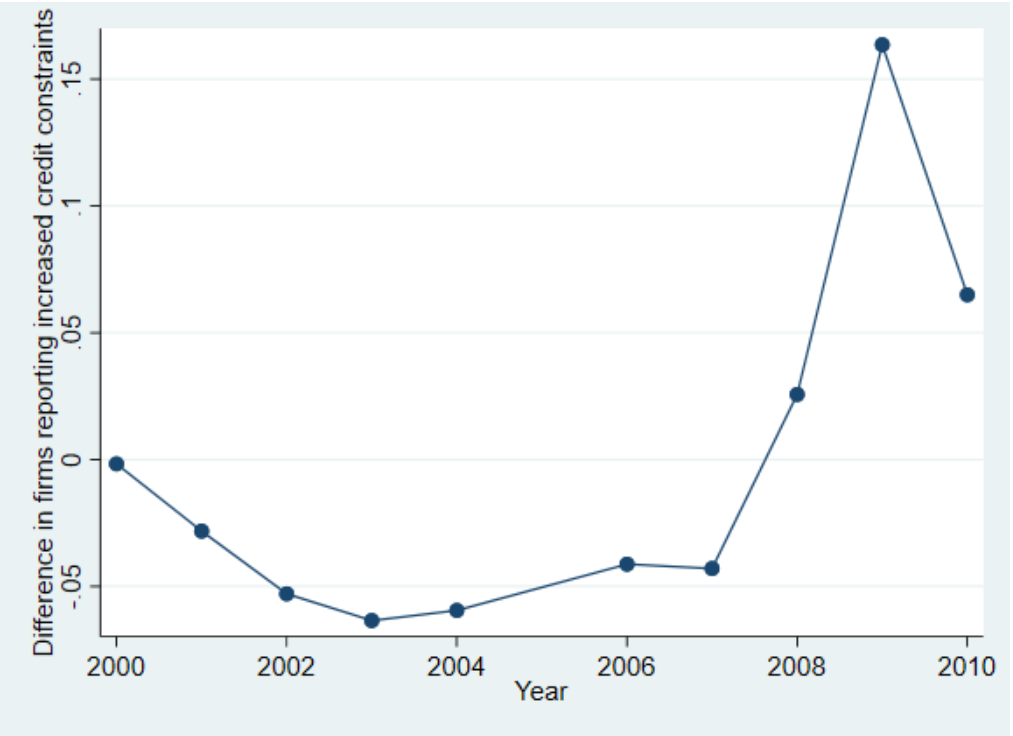


Figure 2.5: Z-score (mean), by group

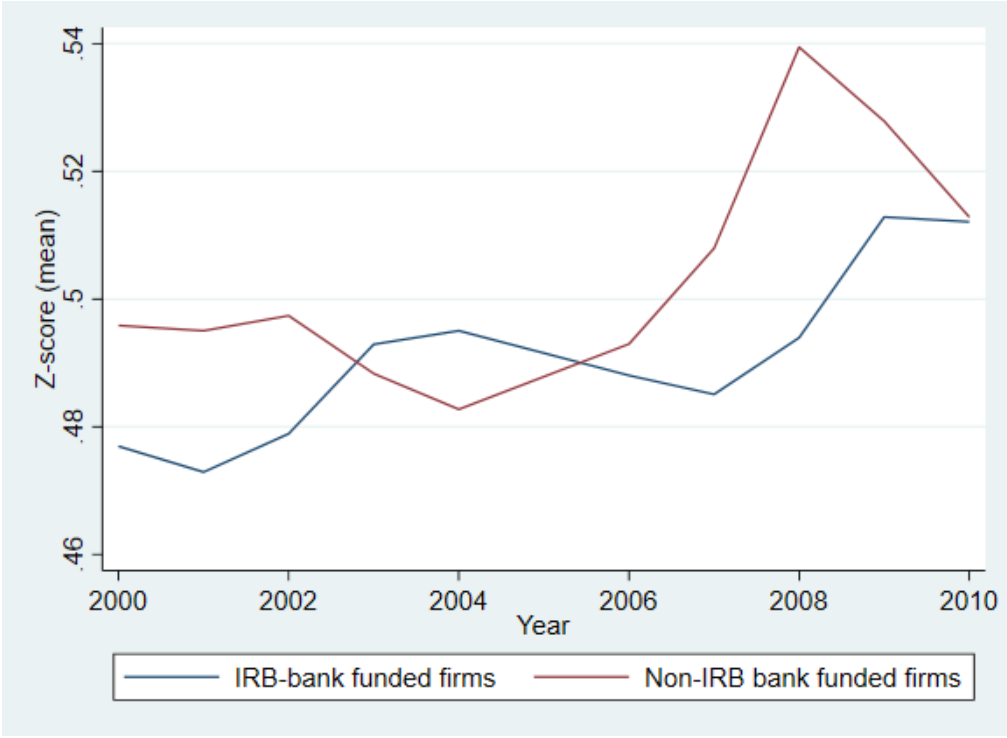


Table 2.4: Descriptive statistics by group

	Non-IRBA bank		IRBA bank			
Variable	Mean	St. Dev.	Mean	St. Dev.	p-value	St. Error
RepaymentsIrregular	0.09	0.29	0.08	0.28	0.48	0.01
Zscore	0.49	0.10	0.48	0.10	0.62	0.00
Exporter	0.12	0.32	0.12	0.33	0.59	0.01
Equityratio	41.8	28.0	41.9	32.5	0.96	1.29
Liquidityratio	0.15	0.18	0.16	0.20	0.02	0.01
Log(turnover)	15.2	3.9	14.8	3.4	0.01	0.14
Log(profit)	9.48	5.83	9.31	5.63	0.47	0.23
RoCI	15.5	39.0	14.7	35.7	0.56	1.47
RoI	49.9	198.6	45.9	179.5	0.58	7.38
RoE	49.2	218.4	38.5	198.1	0.19	8.14
SME	0.58	0.49	0.69	0.46	0.00	0.02
Manufacturing	0.37	0.48	0.39	0.49	0.30	0.02
Services	0.53	0.50	0.51	0.50	0.29	0.02
Geography*	0.49	0.50	0.48	0.50	0.53	0.02

Sample covers data for 2000-2006 and externally-funded firms.
*Geography is equal to 1 if the firm is located in a major urban centre, 0 otherwise.

ratio, given that smaller firms tend to have higher financing costs and therefore tend to hold more liquidity. A regression with IRB_{ij} as the dependent variable suggests that these characteristics, with the exception of the liquidity ratio and firm size, are unable to help predict whether a firm belongs to the exposed group or not (Table 2.5). One way to test for the importance of these differences in firm characteristics is to narrow the sample such that the groups of unexposed and exposed firms are identical in their composition in terms of observable characteristics using a technique called matching. This is discussed further below.

It is not possible to rule out selection bias, however, and hence the results of the main specification are compared with estimates based on a reduced sample including only firms reporting their main provider of external finance to be a bank that adopted the IRBA during the period under review or at a future date (see Section 2.5). This means that the group of banks under study differ in terms of the speed at which they adopted the approach for their Finnish business lending portfolios instead of their ability or desire to do so. Removing firms reporting that their main source of finance is internal funds (possibly through a parent company) reduces the sample from 10,705 observations to 7,880 and removing those financed by institutions other than banks that were early or late adopters of the IRBA reduces the sample to 5,914. Although the group of banks included in this smaller sample do not widely differ, on average, in terms of key balance sheet and performance metrics, control variables are included to account for differences among banks in terms of e.g. capitalisation and reliance on wholesale funding, etc.

Using the basic difference-in-differences set up, the first set of models involve the

Table 2.5: Prediction of IRBA status

Sample	Externally-funded firms that applied for credit	IRBA bank-funded firms that applied for credit
Dependent variable: IRB status		
Repayments_irregular	-0.009	-0.005
	(0.021)	(0.016)
Zscore	0.188	0.113
	(0.151)	(0.133)
Equityratio	0.000	-0.000
	(0.000)	(0.000)
Exporter	0.023	0.009
	(0.028)	(0.024)
Liquidityratio	0.118**	0.069*
	(0.048)	(0.040)
Log(profit)	-0.002	0.001
	(0.001)	(0.001)
Log(turnover)	0.000	-0.006
	(0.005)	(0.004)
RoCI	0.001**	0.001
	(0.001)	(0.001)
RoI	0.000	-0.000
	(0.000)	(0.000)
RoE	0.000	0.000
	(0.000)	(0.000)
SME	0.082***	0.064***
	(0.023)	(0.021)
Geography	-0.021	-0.030
	(0.023)	(0.021)
Manufacturing	-0.014	0.012
	(0.022)	(0.019)
Services	-0.037	-0.012
	(0.036)	(0.034)
Constant	0.517***	0.805***
	(0.110)	(0.094)
Observations	4,131	3,788
Number of firms	1,631	1,449
R-squared	0.0033	0.0029

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

dependent variable being regressed on the key policy variables. In particular, the following linear probability model is estimated:

$$y_{ijt} = \alpha_i + \alpha_t + \beta_1 IRB_{ij} + \beta_2 Reform_{jt} + \beta_3 IRB_{ij} \text{X} Reform_{jt} + X'_{it}\gamma + u_{ijt}$$

where y_{ijt} is the outcome variable for firm i, with a key relationship with bank j at time t. These outcome variables include $Constrained_{ijt}$, $Cost_{ijt}$, $Volume_{ijt}$ and $Conditions_{ijt}$. The α terms are firm and time fixed effects and X_{it} are firm-level control variables. As discussed above, the variables IRB_{ij} and $Reform_{jt}$ are indicator dummies for the adoption of the IRBA approach by the bank j of firm i and the timing of the reform (i.e. when banks transitioned to either the IRBA or Standardised approach). The coefficient on the interaction term (β_3) is the key estimate of interest. Standard errors are clustered at the firm level.

Testing for specialisation hypothesis of Repullo and Suarez (2004) involves estimating the following equation:

$$Zscore_{ijt} = \alpha_i + \alpha_t + \beta_1 IRB_{ij} + \beta_2 Reform_{jt} + \beta_3 IRB_{ij} \text{X} Reform_{jt} + u_{ijt}$$

The sample used to test the Repullo and Suarez (2004) hypothesis is narrower, as it only includes firms that were awarded credit by IRBA and non-IRBA banks and not just those that applied for it.

2.4 Regulation and changes in firms' access to credit

2.4.1 Main regression results

The results of the main regression, which uses $Constrained_{ijt}$ as the dependent variable, is shown in Table 2.6. The results are reported for different combinations of firm fixed effects and control variables. Furthermore, two different samples are used: i) the whole sample and ii) a sample that adjusts for demand by including only firms that both applied for credit and are externally funded, as opposed to their main funding source being internal funds, a parent company, etc.

The results using the whole sample (model 1 and 2) suggests that firms exposed to the IRBA by their main external financier being an IRBA adopter were 6.2 to 6.7 percentage points more likely to face financing constraints following the reform. The result is significant at 1% level across different specifications of the model using the whole sample of firms. The results suggest that firms banking with IRBA adopters did not face less favourable credit conditions pre-reform: the estimate of β_1 is around zero. Instead, less favourable access to credit only kicked in once IRBA practices had been adopted. Controlling for year effects, the post-reform period was generally associated with fewer

problems in accessing credit, although this result is not statistically significant.

Predictably, a higher proportion of firms included in the demand-adjusted sample faced problems in their access to credit: coefficient estimates put this proportion at around 40% as opposed to around 10% of all firms in the whole sample (model 4 and 5). Furthermore, firms reporting an IRBA bank as their main lender faced a 12.2 to 13.1 percentage point higher likelihood of being credit constrained. The confidence interval is wide and includes the estimate for the full sample. One explanation for this higher estimate is that the pool of firms used in the sample includes firms at different ends of the spectrum in terms of their prospects: both firms seeking finance beyond internal funds only to invest or expand operations (around 50% over the survey period) and those seeking finance only to deal with cash flow issues (around 23%). The estimate of β_1 is statistically significant using the smaller sample: firms banking with IRBA adopters faced a smaller probability of being credit constrained pre-reform. This, coupled with the higher estimate of β_3, suggests that firms reliant on external credit faced a much more economically significant deterioration in their access to credit once the reform kicked in if they banked with IRBA adopters instead of non-IRBA adopters.

The models without firm fixed effects (models 3 and 6) both point to exposed firms being 8.5 percentage points more likely to face problems in accessing credit. The estimate of β_1 (the coefficient associated with IRB_j) is relatively large and statistically significant at 1% in model 6 (with only firms that applied for credit): it could be that the fixed effect of IRBA banks absorbs some of the firm-level fixed effects excluded in this version of the model: a small number of banks in the sample and a small number of changes by firms to their main funder could translate into a high degree of correlation between the IRB_ij variable and firm fixed effects. Indeed, the survey reports a 2008 peak amount of firms reporting that they had changed their main financier over the past three years being less than 10% compared to around 7 to 9% in other years. Furthermore, only around a third of the 7-10% of firms switching banks switched from their main external financier being an IRBA adopter to a non-IRBA adopter or vice versa (in other words, switched from being in the exposed group to the unexposed group or vice versa). The coefficient estimate of β_1 is nevertheless not significant with the whole sample included (model 3) and re-estimating the other models (1, 2, 4 and 5) without firm fixed effects makes negligible difference to the results.

Table 2.6: Main regression results

Sample	All			Externally-funded firms that applied for credit		
Dependent variable: Constrained						
Model	(1)	(2)	(3)	(4)	(5)	(6)
IRB	0.001	-0.002	0.010	-0.074*	-0.073*	-0.087***
	(0.010)	(0.010)	(0.007)	(0.043)	(0.044)	(0.027)
Reform	-0.023	-0.016	-0.027	-0.085	-0.078	-0.06
	(0.026)	(0.026)	(0.024)	(0.086)	(0.087)	(0.069)
IRB X Reform	0.062***	0.067***	0.085***	0.122**	0.131**	0.085**
	(0.018)	(0.018)	(0.012)	(0.062)	(0.064)	(0.041)
Constant	0.104***	0.136***	0.085	0.388***	0.459***	0.397
	(0.010)	(0.017)	(0.071)	(0.044)	(0.063)	(0.318)
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	No	No	Yes	No	No	Yes
Firm fixed effects	Yes	Yes	No	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,705	10,364	10,364	2,485	2,429	2,429
Number of firms	3,372	3,268	3,268	1,200	1,172	1,172
R-squared	0.042	0.045	0.0415	0.191	0.198	0.1884

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results of the disaggregated outcomes – $Cost_{ijt}$, $Volume_{ijt}$ and $Conditions_{ijt}$ – are presented in Table 2.7 and shed light on way in which exposed firms experienced a relatively large deterioration in their credit conditions. Contrary to those of Behn et al. (2016)[18], the results suggest that the deterioration in credit conditions was mostly in the form of changes in costs, that is, through increases in the margins or fees charged by the bank. Indeed, the economic significance of the relationship between being predominantly funded by an IRBA adopter and the cost of credit, at 6.5 to 8.7 percentage points using the two different samples, is broadly the same as that associated with the aggregate term $Constrained_{ijt}$. The coefficient estimate using the smaller sample is nevertheless imprecise, with a wide confidence interval of -0.031 to 0.205. The reform is also associated, albeit to a much smaller extent, with a reduction in terms of the volume of lending (including maturity) but this result is not statistically significant when the sample is adjusted for demand. The results suggest that the relationship between the reform and other lending conditions is probably close to zero.

2.4.2 Sensitivity analysis and robustness checks

This section considers the various issues identified above and the extent to which they are relevant for the interpretation of the results. First, results are presented for four different samples (see Tables 2.8 and 2.9). Second, regressions with the key independent variables modified as "placebo" tests are considered, as are the strong banking interlinkages between the Nordic countries.

First, the sample is reduced to exclude firms that appear only in the pre-reform or only in the post-reform sample (model 14). While this cuts the number of observations in half, it allows for a test of the extent to which the results are skewed by firms that drop out of the survey pre-reform or are introduced into the survey post-reform. The result remains significant at 1% level using this smaller sample, with the estimate of the impact of the reform (at 0.093) being somewhat higher than under the full sample.

Second, the sample is restricted to only firms that stick with their main funder in case firms seeking external finance from different sources over time means that the composition of the exposed and unexposed groups changes following the reform: unexposed firms become exposed firms and vice versa (model 15). As discussed above, restricting the sample in this way involves a loss of only 10% of observations, with little change to the coefficient estimates.

Third, since the dataset does not capture the potential offsetting effect of secondary relationships, the sample is restricted to firms reporting that they only have one or two banking relationships. Since a firm facing a negative change to their terms of credit could

[18]Behn et al. (2016) infers the payment structure from quarterly loan amounts given a lack of data on interest rates and finds the impact of the reform to have come through changes in the volume of lending as opposed to other loan conditions, including interest rates.

Table 2.7: Results by disaggregated outcome

Sample	All			Externally funded, applied for credit		
Dependent variable	Cost	Volume	Conditions	Cost	Volume	Conditions
Model	(7)	(8)	(9)	(10)	(11)	(12)
IRB	0.004	-0.004	0.002	-0.046	-0.001	0.004
	(0.009)	(0.005)	(0.003)	(0.041)	(0.026)	(0.014)
Reform	-0.023	0.004	0.002	-0.045	0.026	-0.036
	(0.024)	(0.012)	(0.008)	(0.084)	(0.046)	(0.034)
IRB X Reform	0.065***	0.015*	-0.004	0.087	0.010	0.039
	(0.016)	(0.009)	(0.007)	(0.060)	(0.040)	(0.030)
2001	-0.032***	-0.006	0.007***	-0.100**	-0.008	-0.003
	(0.010)	(0.005)	(0.002)	(0.041)	(0.014)	(0.004)
2002	-0.033***	-0.006	0.011***	-0.106**	-0.009	0.012
	(0.010)	(0.006)	(0.003)	(0.045)	(0.021)	(0.011)
2003	-0.057***	0.006	0.000	-0.222***	0.009	-0.013*
	(0.010)	(0.006)	(0.002)	(0.043)	(0.021)	(0.007)
2004	-0.073***	-0.013**	0.012***	-0.257***	-0.010	0.017
	(0.011)	(0.006)	(0.004)	(0.044)	(0.019)	(0.011)
2006	-0.062***	-0.014*	0.007**	-0.235***	-0.008	0.014
	(0.012)	(0.007)	(0.004)	(0.047)	(0.025)	(0.013)
2007	-0.050**	-0.023*	0.009*	-0.207***	-0.044	0.023
	(0.024)	(0.013)	(0.005)	(0.072)	(0.033)	(0.018)
2008	0.009	-0.019	0.006	0.015	-0.027	0.017
	(0.028)	(0.015)	(0.008)	(0.088)	(0.040)	(0.032)
2009	0.112***	0.018	0.031***	0.372***	0.092**	0.090**
	(0.030)	(0.017)	(0.009)	(0.089)	(0.046)	(0.035)
2010	0.037	0.007	0.023***	0.162*	0.067	0.082**
	(0.029)	(0.016)	(0.009)	(0.092)	(0.046)	(0.038)
Constant	0.084***	0.028***	0.001	0.354***	0.054**	0.012
	(0.010)	(0.006)	(0.003)	(0.043)	(0.022)	(0.011)
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,705	10,705	10,705	2,485	2,485	2,485
R-squared	0.046	0.010	0.007	0.200	0.041	0.031
Number of firms	3,372	3,372	3,372	1,200	1,200	1,200

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 2.8: Sensitivity analysis

Sample	All	Firms that appear pre- and post-reform	Firms reporting no change in external funder	Firms with few relationships
Dependent variable:	Constrained			
Model	(13)	(14)	(15)	(16)
IRB	0.001	-0.003	-0.006	-0.004
	(0.010)	(0.014)	(0.010)	(0.011)
Reform	-0.023	-0.043	-0.030	-0.030
	(0.026)	(0.031)	(0.025)	(0.029)
IRB X Reform	0.062***	0.093***	0.065***	0.046**
	(0.018)	(0.020)	(0.018)	(0.020)
2001	-0.026**	-0.006	-0.030***	-0.045***
	(0.010)	(0.021)	(0.011)	(0.011)
2002	-0.028**	-0.017	-0.028**	-0.045***
	(0.011)	(0.020)	(0.012)	(0.013)
2003	-0.048***	-0.042**	-0.053***	-0.043***
	(0.011)	(0.018)	(0.012)	(0.012)
2004	-0.072***	-0.068***	-0.071***	-0.065***
	(0.011)	(0.017)	(0.012)	(0.013)
2006	-0.066***	-0.063***	-0.069***	-0.051***
	(0.013)	(0.018)	(0.013)	(0.016)
2007	-0.052**	-0.042	-0.050**	-0.029
	(0.025)	(0.032)	(0.025)	(0.029)
2008	0.002	0.011	-0.002	-0.018
	(0.030)	(0.037)	(0.030)	(0.034)
2009	0.121***	0.148***	0.091***	0.072**
	(0.031)	(0.039)	(0.031)	(0.034)
2010	0.041	0.048	0.024	0.018
	(0.031)	(0.038)	(0.031)	(0.035)
Constant	0.104***	0.101***	0.107***	0.101***
	(0.010)	(0.017)	(0.011)	(0.013)
Cluster	Firm	Firm	Firm	Firm
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	10,705	4,800	9,774	8,015
R-squared	0.042	0.068	0.033	0.023
Number of firms	3,372	888	3,254	3,023

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 2.9: Reduced form models

Non-matched data

Time:	Pre-reform	Post-reform	Difference
Group:			
IRB bank-funded firms	0.076	0.197	0.121
Non-IRB bank funded	0.062	0.083	0.022
Difference	0.015	0.114	0.099

Matched data

Time:	Pre-reform	Post-reform	Difference
Group:			
IRB bank-funded firms	0.057	0.193	0.136
Non-IRB bank funded	0.084	0.092	0.008
Difference	-0.028	0.100	0.128

substitute lending from their main financier to other banks, as discussed in Fraisse et al. (2017), the relationship between the reform and credit conditions could be overstated in the results presented above. In line with evidence that Finnish firms tend to have few banking relationships, the sample is reduced by around one-fifth. The smaller sample (model 16) leads to a smaller estimate of β_3 (in other words, the relationship between the reform and credit conditions is smaller in terms of economic significance among firms with few relationships). It is possible that the strength of the borrower-lender relationship is stronger among these firms than on average across the sample: 63% of firms with one or two relationships reported having selected their main external financier due to their existing relationship compared with 57% of firms with three or more. As discussed in, for example, Degryse et al. (2009), empirical evidence suggests that relationship borrowers tend to have better access to credit. If borrowers with few relationships are more likely than other firms to be relationship borrowers, they could have better access to credit and therefore could have experienced a relatively modest change in their access to credit.

Fourth, a reduced form of the model is considered using matched data. That is, the sample is reduced so that, in each year, the two groups are composed of an identical set of firms based on a number of observed characteristics such as size, geography and industry. This calculation tests whether or not observed differences between the two groups — such as the exposed group containing more small firms than the unexposed group — can explain the different impact of the reform on these two groups. The reduced form estimate using matched data is 0.128 compared with a reduced form estimate of 0.099 using (the whole sample of) unmatched data (Table 2.9). This suggests that any bias in the results is likely to be negative, as posited above.

A placebo reform is considered for two different periods, a period of one year and two years before the reform took place. These placebo periods are in 2006 or 2007, depending on the firm, for the one-year ahead test and for 2004 and 2006 or 2006-2007, depending on

the firm, for the two-years ahead test. A significant result would suggest that, ahead of the reform, credit conditions were already different between firms with relationships with IRBA banks and non-IRBA banks, calling into question whether the differences in the post-reform period were related to the reform as opposed to other factors. The coefficient estimate on the interaction term is small and negative for the one-year test and is close to zero for the two-year test, with neither estimate being statistically significant.

Another concern relates to the strong banking interlinkages between the Nordic countries. For example, Nordea and Danske, which make up a large share of lending in Finland, were both owned by their respective Nordic banking groups under the period under review. Each banking group had to request permission from the Finnish Financial Supervisory Authority to apply the IRBA to their Finnish portfolios, but it is possible that the strategy and lending behaviour of these banks shifted with permissions granted elsewhere in the group; the timing of these permissions from abroad did not coincide with the timing of those granted in Finland. If IRBA approval from a foreign supervisor had the same effect on Finnish corporate or SME portfolios as that from the Finnish supervisor, this would bring one of the large banks in the sample into the IRBA group in the sample and shift the IRBA approval date by a year for one other. A regression with a new indicator variable for these permissions granted elsewhere leaves the estimate of the relationship between the reform and credit conditions based on Finnish permissions broadly the same as in the baseline model (model 1). The estimate of the impact of non-Finnish Nordic permissions is small and not significant.

2.4.3 Procylicality

A key question is the extent to which the results reflect the procyclicality mechanism (which makes lending relatively bank capital-intensive for IRBA adopters) as opposed to other effects, such as IRBA-adopting banks deciding to "specialise" i.e. shift their portfolios towards low-risk lending (to make their lending less capital-intensive). Inspired by a technique used in Behn et al. (2016), one way to try to isolate the impact of the procyclicality is by focusing on SMEs. As discussed above, a special discount is applied for exposures to firms with under 50 million euros in sales and hence an increase in the probability of default of these firms induces a smaller increase in the associated risk weight compared to firms with sales over 50 million euros. Capital charges for IRBA loans to SMEs are thus less affected than other firms under the IRBA. The greater the difference in estimates of the relationship between IRBA adoption and credit conditions for these types of SMEs versus other firms, the larger the role for procyclicality.

Coefficient estimates are reported for three different samples: firms with turnover[19]

[19]Statistics Finland reports data on turnover as opposed to sales and hence the former is used. Statistics Finland describes turnover as being "comprised of sales income from products and services belong to the enterprise's operations proper from which any granted discounts, value added tax, and

Table 2.10: Test of procyclicality

Sample:	All	<50mn turnover	<25mn turnover	50mn+ turnover
Dependent variable: Constrained				
Model	(17)	(18)	(19)	(20)
IRB	0.001	-0.008	-0.010	0.010
	(0.010)	(0.010)	(0.010)	(0.026)
Reform	-0.023	-0.002	-0.007	-0.064
	(0.026)	(0.029)	(0.031)	(0.066)
IRB X Reform	0.062***	0.038*	0.037*	0.134***
	(0.018)	(0.021)	(0.022)	(0.036)
2001	-0.026**	-0.045***	-0.051***	0.052*
	(0.010)	(0.011)	(0.011)	(0.027)
2002	-0.028**	-0.045***	-0.053***	0.043
	(0.011)	(0.012)	(0.013)	(0.027)
2003	-0.048***	-0.052***	-0.050***	-0.022
	(0.011)	(0.013)	(0.013)	(0.027)
2004	-0.072***	-0.075***	-0.077***	-0.044*
	(0.011)	(0.013)	(0.014)	(0.026)
2006	-0.066***	-0.067***	-0.065***	-0.044*
	(0.013)	(0.015)	(0.016)	(0.026)
2007	-0.052**	-0.065**	-0.056*	-0.018
	(0.025)	(0.027)	(0.029)	(0.069)
2008	0.002	-0.053	-0.050	0.111
	(0.030)	(0.033)	(0.035)	(0.075)
2009	0.121***	0.037	0.037	0.279***
	(0.031)	(0.035)	(0.038)	(0.077)
2010	0.041	-0.015	0.001	0.113
	(0.031)	(0.036)	(0.038)	(0.074)
Constant	0.104***	0.119***	0.116***	0.076***
	(0.010)	(0.012)	(0.013)	(0.022)
Cluster	Firm	Firm	Firm	Firm
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	10,705	7,942	7,122	2,763
R-squared	3,372	0.022	0.022	0.105
Number of firms	0.042	2,703	2,468	892

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

of less than 25 million euros, less than 50 million euros and more than 50 million euros (Table 2.10). The coefficient estimates for firms with less than 50 million euros at 3.76 percentage points is significantly lower than the 6.24 percentage points estimated for the whole sample (model 17 and 18). This difference is starker (3.65 versus 13.37 basis points) when estimates using a sample of firms earning less than 25 million euros in turnover are compared with estimates using firms earning more than 50 million in turnover (models 19 and 20). If the estimate for large corporates is assumed to encompass the relationship between changes in credit constraints and the reform and the estimate for those earning less than 25 million euros is taken to encompass the only changes not related to procyclicality, the results suggest that a large chunk, perhaps close to three-quarters, of the deterioration in lending conditions among firms is associated with the procyclicality mechanism. In other words, of the 13 percentage point change in credit conditions felt by large corporates, just under 10 percentage points can be attributed to procylicality and another 3 percentage points can be attributed to other effects.

2.4.4 Specialisation hypothesis

In terms of the existing pool of borrowers, the market share of IRBA banks and non-IRBA banks is remarkably stable over the period under review, consistent with the market shares discussed in Section 2.1. Around 40-50% of all firms, around 80% of firms financed by banks and around 60-65% of all applicants for external finance reported their main external financier to be an IRBA bank. To gauge the extent to which banks may have expanded or reduced their exposures to particular types of borrowers, the sample is restricted only to firms that were actually awarded new credit by an IRBA bank or a non-IRBA bank (in other words, borrowers with new or renewed lines of credit from banks).

A number of regressions are considered to estimate the extent to which the reform was associated with changes in the riskiness of customers on the balance sheet of IRBA versus non-IRBA banks (Table 2.11). The results are remarkably consistent whether all firms awarded new credit by banks are included or whether this group is reduced further to only include firms that appear in the pre- and post-reform periods (models 21-24). The post-reform period is characterised by firms being, on average, less creditworthy. Another statistically significant result is that the pool of IRBA banks' customers were on average riskier pre-reform. The reform nevertheless is associated with a reduction in the level of IRBA banks' customers' credit risk: coefficient estimates suggest a 3.7 to 3.8 percentage point reduction in the average Z-score.[20] In models without firm fixed effects (models 25-27), this result is slightly more modest at between -2.5 to -3.1 percentage points.

other direct taxes based on sales volume have been deducted".

[20]As discussed above, the Z-score metric, while representing a likelihood of bankruptcy, does not translate into a probability of default, making magnitudes difficult to interpret.

The results provide support for the specialisation mechanism being at play in the Finnish banking sector following the reform. The average creditworthiness of all borrowers (as proxied by the Z-score) is overall lower post-reform, which is predictable given the sharp fall in GDP following the financial crisis. Despite IRBA banks having less creditworthy borrowers than other banks pre-reform, the riskiness of their customer base — while increasing somewhat — remains fairly stable following 2007. By contrast, the creditworthiness of the customers of banks' borrowers decreases post-reform, with a spike in the Z-score metric. This suggests that, in line with the Repullo and Suarez (2004) hypothesis, IRBA banks expanded their exposures to low-risk customers post-reform, while others to higher-risk ones. The deterioration in credit conditions among firms banking with IRBA-adopting banks could — in addition to procyclicality — be attributed to the specialisation mechanism i.e. banks' making a decision to shift their portfolios towards safer assets within the corporate portfolio, in addition to shifting their portfolio towards mortgages as documented by Herrala (2014).

2.5 Selection

As discussed above, selection bias is unlikely to arise from firms choosing banks on the basis of their IRBA status, but selection bias arising from banks' decisions to apply to use the IRBA and in choosing their customers cannot be ruled out. A type of bank more likely than others to apply for the IRBA may also have responded to the crisis differently in terms of their lending practices than non-IRBA banks due to reasons unrelated to the reform or procyclicality. As discussed in Section 2.3, selection bias arising from banks' decisions is less likely to be problematic in the Finnish context compared to other jurisdictions and, based on observables, the unexposed group appears to be a reasonable counterfactual for the exposed group. One way to account for potential selection bias is to narrow the sample to include only firms that were financed by IRBA banks, with the exposed group being taken to be the borrowers of banks that adopted the IRBA during the period under review (2000-2010) and the unexposed group taken to be borrowers of banks that adopted the IRBA for their Finnish portfolios after 2010. This reduces the sample from 10,705 to 5,914.

As in Section 2.3, the unexposed group (borrowers of banks that adopted the IRBA after 2010) studied here appears to be reasonable counterfactual for the unexposed group (borrowers of banks that adopted the IRBA before 2010). The evolution of the key variable $Constrained_{ijt}$ is broadly similar among the two groups (Figure 2.6). The exposed group also has a higher proportion of SMEs, a higher liquidity ratio) and a higher log of firms' turnover (Table 2.12); these differences for the most part disappear when the sample is reduced to include only SMEs (Table 2.13). As in Section 2.3, with the exception of firm size and the liquidity ratio, these characteristics are not able to help predict

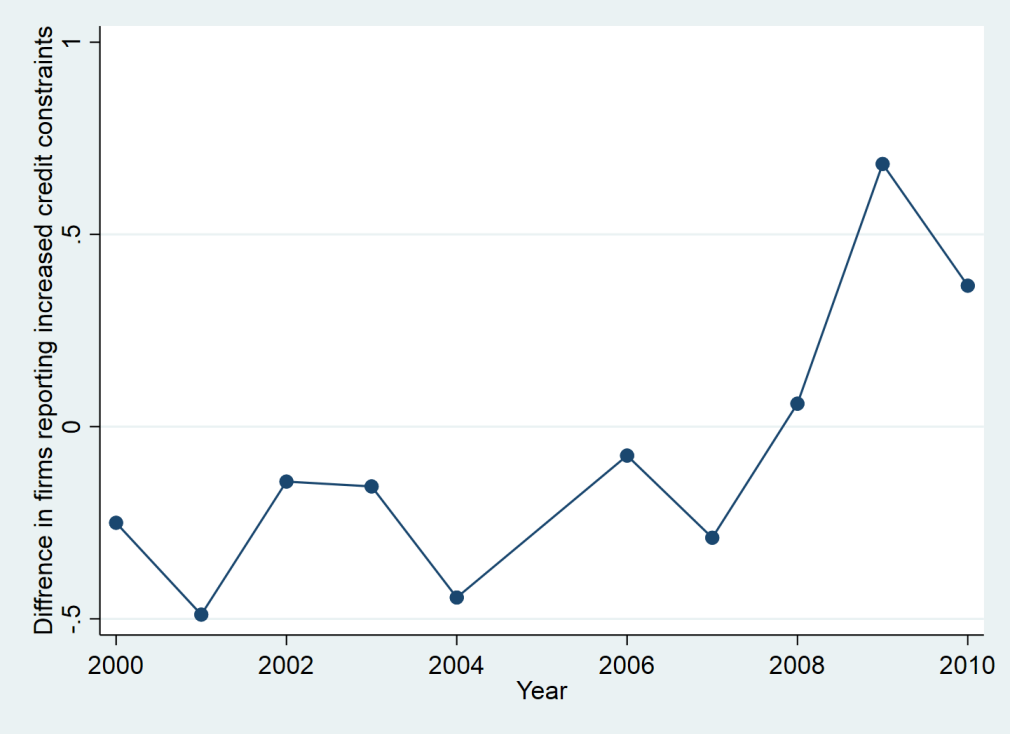
Table 2.11: Test of specialisation hypothesis

Sample:	Awarded credit	of which, appear pre-/ post-reform	Awarded credit	of which, appear pre-/post-reform
Dependent variable: Z-score				
Model	(21)	(22)	(23)	(24)
IRB	0.011*	0.019**	0.006	0.016**
	(0.006)	(0.009)	(0.005)	(0.008)
Reform	0.031**	0.037**	0.016	0.025*
	(0.014)	(0.015)	(0.012)	(0.014)
IRB X Reform	-0.038***	-0.037***	-0.025***	-0.031***
	(0.011)	(0.010)	(0.010)	(0.010)
2001	-0.009*	-0.009	-0.011**	-0.012
	(0.005)	(0.008)	(0.005)	(0.008)
2002	0.002	-0.007	0.001	-0.012
	(0.005)	(0.008)	(0.005)	(0.008)
2003	-0.004	-0.004	-0.003	-0.007
	(0.006)	(0.009)	(0.005)	(0.010)
2004	0.004	0.001	0.002	-0.005
	(0.006)	(0.008)	(0.005)	(0.008)
2006	0.003	-0.003	0.001	-0.008
	(0.008)	(0.010)	(0.007)	(0.010)
2007	-0.000	-0.012	0.000	-0.013
	(0.012)	(0.014)	(0.010)	(0.013)
2008	0.013	0.002	0.014	0.002
	(0.014)	(0.017)	(0.012)	(0.016)
2009	0.032**	0.020	0.036***	0.024
	(0.014)	(0.017)	(0.012)	(0.016)
2010	0.021	0.008	0.024*	0.010
	(0.014)	(0.017)	(0.012)	(0.016)
Constant	0.486***	0.482***	0.490***	0.487***
	(0.007)	(0.011)	(0.006)	(0.011)
Cluster	Firm	Firm	Firm	Firm
Firm fixed effects	Yes	Yes	No	No
Observations	2,159	991	2,159	991
R-squared	0.049	0.081	0.046	0.078
Number of firms	1,077	384	1,077	384

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

whether a firm belongs to the exposed group or not.

Figure 2.6: Difference in the share of firms reporting a deterioration in their access to credit: borrowers of banks adopting the IRBA before the crisis versus those of banks adopting it after the crisis (matched data)



The model is estimated using dummy variables for each year as opposed to a post-reform period to allow for an additional check on the extent to which the results can be associated with procyclicality (although the equivalent of Table 2.6 of the main regression results is provided for the IRBA-bank only sample in Table 2.18 in the Appendix for the sake of comparison). Banks are likely to have responded to the reform well before the reform was implemented, as discussed in Herrala (2014), but banks adopting the IRBA before 2010 would have been much more affected by the sharp contraction in GDP in 2009 unlike the banks adopting it after 2010. Finnish GDP contracted by over 8% in 2009 compared to growth of just under 1% in 2008 and just over 3% in 2010.

The key independent variables are the dummy variables IRB_{ij} and d_t. As in Section 2.3, the variable IRB_{ij} equals 1 if firm i declares their main external financier j to be an IRBA bank and zero otherwise. The variable d_t is a vector of time dummies. The following linear probability model is estimated:

$$y_{ijt} = \alpha_i + \beta_1 IRB_{ij} + \beta_2 d_t + \beta_3 IRB_{ij} \mathrm{X} d_t + X'_{it}\gamma + Z'_{jt}\delta + u_{ijt}$$

Table 2.12: Descriptive statistics by group: IRBA banks only

	Non-IRBA bank		IRBA bank			
Variable	Mean	St. Dev.	Mean	St. Dev.	p-value	St. Error
RepaymentsIrregular	0.09	0.29	0.08	0.28	0.47	0.01
Zscore	0.49	0.10	0.48	0.10	0.61	0.00
Exporter	0.12	0.32	0.13	0.33	0.51	0.01
Equityratio	41.9	28.0	41.9	32.5	0.99	1.29
Liquidityratio	0.15	0.18	0.16	0.20	0.02	0.01
Log(turnover)	15.2	3.9	14.8	3.4	0.01	0.14
Log(profit)	9.45	5.84	9.32	5.63	0.58	0.23
RoCI	15.5	39.1	14.7	35.7	0.56	1.47
RoI	49.9	198.7	45.8	179.4	0.58	7.38
RoE	49.2	218.6	38.4	198.0	0.18	8.14
SME	0.58	0.49	0.69	0.46	0.00	0.02
Manufacturing	0.37	0.48	0.39	0.49	0.24	0.02
Services	0.53	0.50	0.51	0.50	0.24	0.02
Geography*	0.49	0.50	0.48	0.50	0.51	0.02

Sample covers data for 2000-2006 and externally-funded firms.
*Geography is equal to 1 if the firm is located in a major urban centre, 0 otherwise.

Table 2.13: Descriptive statistics of SMEs by group: IRBA banks only

	Non-IRBA bank		IRBA bank			
Variable	Mean	St. Dev.	Mean	St. Dev.	p-value	St. Error
RepaymentsIrregular	0.09	0.29	0.08	0.28	0.66	0.01
Zscore	0.48	0.11	0.48	0.11	0.99	0.01
Exporter	0.08	0.27	0.07	0.26	0.56	0.01
Equityratio	41.5	31.5	40.1	35.7	0.43	1.82
Liquidityratio	0.18	0.20	0.19	0.21	0.58	0.01
Log(turnover)	14.3	1.9	14.2	2.0	0.50	0.10
Log(profit)	8.81	4.91	8.73	4.96	0.75	0.26
RoCI	10.5	20.9	10.1	21.4	0.76	1.11
RoI	16.6	81.2	20.7	91.4	0.38	4.65
RoE	15.4	120.3	10.9	130.1	0.51	6.66
Manufacturing	0.35	0.48	0.34	0.47	0.69	0.02
Services	0.50	0.50	0.53	0.50	0.24	0.03
Geography*	0.40	0.49	0.46	0.50	0.03	0.03

Sample covers data for 2000-2006 and externally-funded firms.
*Geography is equal to 1 if the firm is located in a major urban centre, 0 otherwise.

with the outcome variables $Constrained_{ijt}$, $Cost_{ijt}$, $Volume_{ijt}$ and $Conditions_{ijt}$ defined as in Section 2.3. Bank-level control variables are denoted Z_{jt} (see Table 2.3). The model estimates presented below are based on different combinations of fixed effects and control variables.

The coefficients on the interaction term (IRB_{ij} x $Year2009$) are much higher at between 0.32 and 0.37 when bank control variables are included and unexposed firms are taken to be late adopters (Table 2.14, models 27-29) of the IRBA compared to the estimate of 0.25 when the unexposed group are all other externally-financed firms that applied for credit (model 26). The coefficient on the interaction term (IRB_{ij} x $Year2008$) is also positive (0.19-0.22) but not statistically significant across all specifications of the model (models 27-29).

Interestingly, results based on the sample of only IRBA banks' borrowers does not suggest a general tightening in credit conditions in 2009 (models 27-29) unlike the sample including all externally-funded firms (model 26). Instead, the estimates suggest that only the borrowers of banks exposed to procyclicality through early IRBA adoption faced a higher probability of a tightening in their access to finance, but the borrowers of later adopters did not. This suggests that procyclicality could have played a larger role than discussed above.

In terms of the disaggregated outcomes (Tables 2.15, 2.16 and 2.17), the coefficient estimates associated with the interaction term (IRB_{ij} x $Year2009$) suggest that the tightening in credit conditions is mostly associated with the cost of credit and, to a slightly lesser extent, through changes in the other lending terms and conditions. The coefficient estimates are higher at 0.35 and 0.26 (model 32 and 38) when the unexposed group is taken to be borrowers of late-adopting IRBA banks that applied for credit compared with 0.24 and 0.17 when the unexposed group is taken to be all externally-financed borrowers that applied for credit (model 31 and 37). Mirroring the main results, the model estimates suggest that the increase in the likelihood of facing a deterioration in the cost of credit or a tightening in other terms and conditions did not apply to all borrowers of (late or early adopter) IRBA banks, only borrowers of early adopters.

2.6 Conclusion

The determination of bank capital requirements is an important topic in financial regulation, given its potential to affect lending to the economy and in turn, real economy outcomes. In this essay, a difference-in-differences approach is used to estimate the extent to which the introduction of Basel II's model-based capital regulation via bank-firm relationships was associated with changes in firms' access to finance. The results suggest that the firms whose main external financier adopted the IRBA faced a 6.2-6.7 percentage point higher likelihood of a deterioration in their access to credit once the reform

Table 2.14: IRBA banks: comparisons by year

Sample:	All firms	Externally-funded, applied credit	IRBA funded, applied credit	IRBA funded, applied credit	IRBA funded, applied credit
Dependent variable:	Constrained				
Model	(25)	(26)	(27)	(28)	(29)
IRBA X 2007	-0.005	-0.003	0.070	0.096	0.107
	(0.019)	(0.064)	(0.074)	(0.072)	(0.072)
IRBA X 2008	0.056**	0.019	0.184	0.218*	0.215*
	(0.025)	(0.090)	(0.115)	(0.114)	(0.115)
IRBA X 2009	0.150***	0.247***	0.321**	0.358**	0.365**
	(0.032)	(0.081)	(0.146)	(0.145)	(0.146)
IRBA X 2010	0.065**	0.103	-0.038	-0.059	-0.072
	(0.032)	(0.111)	(0.139)	(0.135)	(0.135)
2001	-0.026**	-0.098**	-0.111**	-0.114**	-0.115**
	(0.011)	(0.042)	(0.055)	(0.057)	(0.057)
2002	-0.026**	-0.102**	-0.138**	-0.155**	-0.160**
	(0.012)	(0.046)	(0.065)	(0.067)	(0.067)
2003	-0.047***	-0.200***	-0.241***	-0.236***	-0.229***
	(0.011)	(0.045)	(0.066)	(0.069)	(0.069)
2004	-0.073***	-0.252***	-0.288***	-0.313***	-0.314***
	(0.012)	(0.047)	(0.074)	(0.076)	(0.077)
2006	-0.069***	-0.213***	-0.275***	-0.301***	-0.309***
	(0.013)	(0.051)	(0.064)	(0.066)	(0.066)
2007	-0.053***	-0.176***	-0.356***	-0.413***	-0.427***
	(0.015)	(0.060)	(0.088)	(0.088)	(0.088)
2008	-0.019	0.022	-0.303**	-0.383***	-0.381***
	(0.017)	(0.089)	(0.138)	(0.137)	(0.138)
2009	0.056***	0.237***	0.001	-0.073	-0.083
	(0.021)	(0.084)	(0.159)	(0.160)	(0.160)
2010	0.013	0.122	0.038	0.023	0.032
	(0.020)	(0.111)	(0.163)	(0.163)	(0.162)
Constant	0.173**	0.553***	0.622***	0.367*	0.549**
	(0.071)	(0.155)	(0.170)	(0.189)	-0.242
Cluster	Firm	Firm	Firm	Firm	Firm
Firm controls	Yes	Yes	No	Yes	Yes
Firm fixed effects	Yes	Yes	No	No	Yes
Bank controls	No	No	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	10,364	2,429	1,731	1,695	1,695
R-squared	0.065	0.206	0.2252	0.2219	0.2259
Number of firms	3,268	1,172	914	896	896

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 2.15: Cost of credit: IRBA banks only

Sample	All firms	Externally-funded firms that applied for credit	IRBA bank-funded firms that applied for credit
Dependent variable:	Cost		
Model	(30)	(31)	(32)
IRBA X 2007	-0.007	-0.001	0.092
	(0.018)	(0.062)	(0.067)
IRBA X 2008	0.060**	-0.013	0.154
	(0.024)	(0.087)	(0.110)
IRBA X 2009	0.168***	0.237***	0.347**
	(0.031)	(0.080)	(0.143)
IRBA X 2010	0.073**	0.070	-0.055
	(0.030)	(0.107)	(0.140)
2001	-0.030***	-0.112***	-0.124**
	(0.010)	(0.042)	(0.056)
2002	-0.029***	-0.111**	-0.157**
	(0.011)	(0.046)	(0.065)
2003	-0.056***	-0.231***	-0.278***
	(0.011)	(0.044)	(0.065)
2004	-0.073***	-0.274***	-0.359***
	(0.011)	(0.045)	(0.073)
2006	-0.063***	-0.255***	-0.330***
	(0.012)	(0.048)	(0.062)
2007	-0.048***	-0.219***	-0.463***
	(0.014)	(0.059)	(0.082)
2008	-0.011	0.030	-0.356***
	(0.016)	(0.086)	(0.131)
2009	0.041**	0.207**	-0.113
	(0.019)	(0.083)	(0.154)
2010	0.009	0.113	-0.042
	(0.018)	(0.106)	(0.164)
Constant	0.134**	0.467***	0.289
	(0.068)	(0.153)	(0.185)
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	10,364	2,429	1,695
R-squared	0.066	0.213	0.2429
Number of firms	3,268	1,172	896

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 2.16: Volume of credit: IRBA banks only

Sample	All firms	Externally-funded firms that applied for credit	IRBA bank-funded firms that applied for credit
Dependent variable:	Volume		
Model	(33)	(34)	(35)
IRBA X 2007	-0.007	0.001	-0.010
	(0.007)	(0.021)	(0.029)
IRBA X 2008	0.014	0.048	0.139**
	(0.010)	(0.044)	(0.056)
IRBA X 2009	0.013	-0.028	0.083
	(0.015)	(0.057)	(0.085)
IRBA X 2010	0.018	0.019	0.053
	(0.015)	(0.059)	(0.102)
2001	-0.008	-0.014	-0.014
	(0.005)	(0.013)	(0.024)
2002	-0.010	-0.017	-0.031
	(0.006)	(0.020)	(0.027)
2003	0.005	0.012	-0.015
	(0.006)	(0.021)	(0.030)
2004	-0.020***	-0.026	-0.032
	(0.007)	(0.017)	(0.030)
2006	-0.017**	-0.019	-0.042
	(0.007)	(0.024)	(0.031)
2007	-0.017**	-0.033	-0.041
	(0.008)	(0.023)	(0.037)
2008	-0.018*	-0.042	-0.168**
	(0.009)	(0.044)	(0.067)
2009	0.007	0.080	-0.043
	(0.011)	(0.055)	(0.085)
2010	-0.002	0.049	0.003
	(0.011)	(0.053)	(0.110)
Constant	0.045	0.157**	0.143*
	(0.029)	(0.061)	(0.079)
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	10,364	2,429	1,695
R-squared	0.028	0.061	0.1087
Number of firms	3,268	1,172	896

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 2.17: Other lending terms and conditions: IRBA banks only

Sample	All firms	Externally-funded firms that applied for credit	IRBA bank-funded firms that applied for credit
Dependent variable:	Conditions		
Model	(36)	(37)	(38)
IRBA X 2007	-0.015	0.035	0.004
	(0.015)	(0.056)	(0.058)
IRBA X 2008	0.022	0.030	0.178**
	(0.018)	(0.075)	(0.084)
IRBA X 2009	0.093***	0.174**	0.256**
	(0.026)	(0.086)	(0.118)
IRBA X 2010	0.011	0.043	-0.156
	(0.023)	(0.095)	(0.132)
2001	0.000	-0.049**	-0.039
	(0.007)	(0.025)	(0.035)
2002	0.009	-0.019	-0.056
	(0.007)	(0.028)	(0.041)
2003	-0.001	-0.018	-0.054
	(0.007)	(0.030)	(0.048)
2004	0.000	-0.014	-0.093*
	(0.008)	(0.032)	(0.055)
2006	-0.004	-0.027	-0.082*
	(0.008)	(0.033)	(0.045)
2007	0.016	-0.018	-0.097
	(0.010)	(0.047)	(0.065)
2008	0.019	0.057	-0.244**
	(0.012)	(0.072)	(0.103)
2009	0.057***	0.244***	0.011
	(0.014)	(0.082)	(0.128)
2010	0.053***	0.178*	0.201
	(0.014)	(0.093)	(0.152)
Constant	0.089**	0.266**	0.061
	(0.045)	(0.117)	(0.154)
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	10,364	2,429	1,695
R-squared	0.044	0.141	0.1477
Number of firms	3,268	1,172	896

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

kicked in compared to firms externally financed by non-adopters. This estimate rises to 12.2-13.1 percentage points when the sample is adjusted for the demand for bank credit.

The two other papers focused on the variation in capital requirements arising from the use of Basel II's model-based approach (Behn et al 2016 and Fraisse et al 2017) use credit registry data and hence focus mostly on loan volumes. In this essay, a larger outcome variable set is considered. The deterioration in credit conditions is found to have been felt mostly through higher margins and fees and, to a lesser extent, through changes in the volume of lending extended to firms. The implication of this finding is that existing empirical evidence of the impact of model-based regulation may, by focusing only on loan volumes, significantly underestimate the influence on bank behaviour of rules on risk weights.

Absent in the existing literature on firms are direct tests of the mechanisms, such as procyclicality and specialisation, which help shed light on the way in which model-based regulation influences banks' incentives and behaviour. The results of this essay suggest that much of the result is associated with procyclicality, with evidence also found for the hypothesis that model-based approach adopters shifted to low-risk lending and hence, by tightening credit policies, reduced their exposures to riskier firms. These findings have important implications for the design of model-based capital requirements for the banking sector.

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Appendix

Table 2.18: Main regression results: IRBA banks only

Sample	IRBA-bank funded firms that applied for credit					
Dependent variable	Constrained			Cost	Volume	Conditions
Model	(43)	(44)	(45)	(46)	(47)	(48)
IRB	0.252*	0.250	0.354	0.350*	-0.018	-0.044
	(0.153)	(0.158)	(0.226)	(0.208)	(0.069)	(0.211)
Reform	-0.116	-0.111	-0.088	-0.076	-0.014	-0.141
	(0.092)	(0.090)	(0.113)	(0.111)	(0.058)	(0.099)
IRB X Reform	0.161*	0.180**	0.220**	0.194*	0.071	0.144
	(0.084)	(0.086)	(0.112)	(0.108)	(0.063)	(0.094)
2001	-0.119**	-0.123**	-0.077	-0.067	0.011	-0.039
	(0.054)	(0.056)	(0.068)	(0.066)	(0.025)	(0.039)
2002	-0.119*	-0.135**	-0.087	-0.078	-0.013	-0.043
	(0.062)	(0.064)	(0.082)	(0.080)	(0.030)	(0.047)
2003	-0.224***	-0.218***	-0.205**	-0.237***	-0.008	-0.088
	(0.064)	(0.067)	(0.085)	(0.082)	(0.034)	(0.059)
2004	-0.271***	-0.296***	-0.210**	-0.271***	-0.012	-0.083
	(0.073)	(0.076)	(0.098)	(0.093)	(0.035)	(0.070)
2006	-0.275***	-0.300***	-0.281***	-0.301***	-0.044	-0.111*
	(0.064)	(0.067)	(0.087)	(0.080)	(0.037)	(0.059)
2007	-0.325***	-0.381***	-0.345***	-0.402***	-0.077*	-0.096
	(0.090)	(0.089)	(0.116)	(0.108)	(0.042)	(0.090)
2008	-0.137	-0.205*	-0.062	-0.112	-0.064	0.014
	(0.111)	(0.111)	(0.145)	(0.138)	(0.054)	(0.113)
2009	0.258**	0.195	0.295*	0.258*	-0.031	0.315**
	(0.129)	(0.130)	(0.162)	(0.154)	(0.062)	(0.128)
2010	-0.017	-0.071	0.047	-0.017	0.019	0.137
	(0.136)	(0.138)	(0.177)	(0.169)	(0.077)	(0.139)
Constant	0.408*	0.160	0.565	0.388	0.307**	0.599*
	(0.213)	(0.236)	(0.365)	(0.344)	(0.144)	(0.336)
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	No	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	Yes	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,731	1,695	1,695	1,695	1,695	1,695
R-squared	0.2231	0.2195	0.244	0.259	0.154	0.166
Number of firms	914	896	896	896	896	896

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Chapter 3

The impact of credit constraints on the real economy: the case of the 2009 recession in Finland

The impact of financial shocks on the real economy has garnered much attention in the literature, particularly since the onset of the 2008-2009 financial crisis. The crisis was followed by a global recession, with most advanced economies experiencing dramatic falls in GDP, investment and employment with wages and productivity still yet to recover in many countries. Standard models of investment with financing frictions (Stiglitz and Weiss 1981 and Holmstrom and Tirole 1997) show that negative shocks to the supply of external finance, coupled with financial frictions, might hamper investment if firms lack sufficient financial slack to fund profitable investment opportunities. As discussed in e.g. Bentolila et al (2018), credit constraints may also affect employment decisions, for example, because credit constraints can affect a firms' working capital used to finance everyday expenses such as employee wages. The structural problem of access to finance for innovation are well known – returns innovation may be uncertain, making it riskier to finance (see e.g. Lee, 2015). If shocks to credit supply affect innovation activity, the level of future productivity will be lower, leading to persistently lower productivity and output.

This essay studies the impact of credit constraints on the real economy using Finnish data. The key finding is that, with the exception of employment, credit constraints played little role in firms' decisions and in turn, the GDP contraction in Finland in 2009. These results are consistent with anecdotal evidence of Finnish firms being heavily affected by the collapse in global demand, with funding conditions remaining relatively unaffected particularly compared to many other European countries. Evidence of a relationship between a tightening in credit conditions and employment makes intuitive sense through the working capital channel. Contrary to many other studies, no evidence of the invest-

ment channel being at play is established. Estimates of the link to productivity and innovation activity produce mixed results. Studying the heterogenous impact of credit constraints on the hiring decisions of different types of firms (e.g. by size, industry and export orientation) is limited by sample size.

The key identification challenge in studying the impact of credit shocks on the real economy is potential omitted variable bias given that firms with poor prospects are also more likely to be credit constrained. That challenge is address in this study by exploiting the exogenous variation arising from the implementation of the Basel II reform in 2007. A feature of the reform involved banks being allowed to calculate the risk weights attached to their assets. Given that risk weights help determine a bank's capital adequacy ratio, that is, capital to risk-weighted assets, the reform allowed banks to determine, at least in part, the amount of capital they hold. Basel II capital regulation was agreed at a global level and legislated at an EU level and hence was implemented irrespective of the characteristics of the Finnish banking sector.

Banks were required to apply for permission to use the Internal Ratings Based Approach (IRBA) under which they could calculate the probability of default parameters (and hence the risk weights) of their counterparties. Risk weights calculated using the IRBA were expected to fall given that capital is costly to hold. The IRBA is nevertheless associated with procyclicality: capital requirements of IRBA banks rise in response to increases in credit risk and hence during downturns.

The procyclicality of the IRBA is used to instrument for changes in credit conditions, given that some banks received permission to use the IRBA before the 2009 recession in Finland and some after it. The latter group used fixed weights set by regulators during the downturn and therefore their capital requirements were not sensitive to changes in credit risk in the way in which IRBA banks were. As described in Chapter 2, this sensitivity was associated with a much higher likelihood of a firm facing credit constraints. This essay departs from much of the existing literature by utilising the exogenous variation arising from the Basel II reform and the IRBA rather than the US subprime mortgage crisis or the ECB's policy measures.

Another point of departure from the existing literature is the use of survey data as a direct measure of credit constraints and to isolate the impact of supply shocks from demand. The outcome variables considered in this study are also much wider than considered in the literature: in addition to real economy variables such as investment, employment and wages, the impact of credit constraints on productivity and their future determinants (innovation activity as proxied by patent applications) are considered.

An emerging strand of literature uses survey data and firms' self-reported changes in their access to finance to study the impact of financial constraints on real economy outcomes (e.g. Campello et al 2010, Cornille et al, 2019, Ferrando et al 2017 and 2018, Garcia-Posada Gomez, 2019). This approach helps overcome the omitted variable bias

associated with the previous literature, which arises from the way in which credit constraints are measured. Surveys provide direct measures of financial constraints based on firms' self-reported changes in their access to finance, whereas earlier research has relied on indirect or proxy measures of financial constraints such as cash flow, dividend payouts, size or credit rating (e.g Fazzari et al. 1988 and Kaplan and Zingales 1997). The balance sheet metrics of earlier research also proxy other determinants of real economy outcomes such as investment opportunities, meaning that the dependent and independent variables are jointly determined.

The survey-based approach also helps overcome the challenge of isolating the effects of changes in supply to those in demand as many factors, such as economic downturns, with effect both. Firms' self-reported demand for external finance and credit application decisions, for example, allow for demand to be disentangled from supply. Studies relying on fixed effects, such as firm-time fixed effects as pioneered by Khwaja and Mian (2008), require samples being narrowed down to e.g. firms with multiple banking relationships as in Bentolila et al (2018), Cingano et al (2016) and Fraisse et al (2017). As discussed in Degryse et al (2018), the applicability of this method is limited since multiple-relationship firms (and large firms as in Chodorow-Reich, 2014) represent a minority of firms in many countries.

Survey-based studies are of course not immune to concerns around the potential endogeneity of financial conditions as the unobserved determinants of real outcomes such as investment opportunities may also be correlated with survey-based indicators of credit constraints. Various approaches, mainly instrumental variable estimation, have been used to try to account for this. Ferrando et al (2018) for example link the ECB's Survey on Access to Finance (SAFE) to Bureau van Dijk (DvB) data on firms' financial statements, finding that the improvement in credit access resulting from the ECB's OMTs had a positive impact on investment and profitability, with a weaker effect on innovation. Ferrando et al (2017) and Garcia-Posada Gomez (2019) also use the SAFE survey, with exogenous variation derived from sovereign stress and the ECB's TLTRO allocation rule respectively. Other studies include Cornille et al (2019), where banks' financial health is used as an exogenous determinant of Belgian firms' credit access as well as the qualitative analysis of a CFO survey by Campello et al (2010).

Other relevant literature includes that on the effects of bank capital requirements on lending and the real economy. While this essay and those by Behn et al. (2016) and Fraisse et al. (2017) focus on a feature of Basel II that led to variation in the capital requirements of banks, other studies focus on the variation directly imposed by the regulator. Prior to the implementation of the current regulatory framework (Basel III), regulators in most countries imposed a uniform capital requirement for all banks and hence variation among banks in terms of capital (to assets) as the regulatory framework is a fairly recent phenomenon. The lack of historical data means that empirical studies

are scarce and studies of the impact of Basel III generally rely on the use of dynamic stochastic general equilibrium models (see e.g. BIS 2011 for a review). Exceptions include the studies by Jimenez et al (2017), DeMarco and Wieladek (2015), Benmelech et al (2010), Jayaratne and Strahan (1996) and Amore et al (2013).

This essay is organised as follows. Section 3.1 provides a brief overview of the implementation of Basel II in Finland (explained in more detail in Chapter 2) and presents a priori hypotheses around the link between credit constraints and the real economy including in terms of the findings of the survey. Sections 3.2 and 3.3 describe the dataset and empirical strategy used this study. In section 3.4, the main results are discussed. The final section concludes.

3.1 Basel II implementation in Finland and hypothesis development

As discussed in more detail in Chapter 2, a revision to the Basel Capital Accord ('Basel II'), which applied in the EU from 1 January 2007, involved banks being given two broad methodologies to choose from for calculating credit risk weights and hence capital charges: the Internal Ratings-Based approach (IRBA) and the Standardised approach. Under the IRBA, the estimation of credit risk is (at least partially) delegated to banks themselves. The IRBA[1] allowed banks to calculate the probability of default parameter based on self-collected quantitative and qualitative criteria. Under the Standardised approach, risk weights are — where available — based on external rating institution's assessments. Otherwise Basel I risk weights are used. With most firms being small and hence unrated (including 75% of the firms in the dataset used in this study), the Standardised approach in practice marked little change from the Basel I approach.[2]

In Finland, banks were invited to apply for permission from the Finnish Supervisory Authority to use the IRBA a minimum of a year before the intended adoption date,[3] with banks allowed to apply it from the beginning of 2007 onwards. Banks needed to prove to authorities that "their rating and risk estimation systems and processes provide a meaningful assessment of borrower and transaction characteristics; a meaningful differentiation of risk; and reasonably accurate and consistent quantitative estimates of

[1]The IRBA is taken here to refer to the Foundation IRBA, since the Advanced IRBA was not in use in Finland over the period of this study.

[2]Criticism over the potentially excessively high risk weights for small- and medium-sized enterprises (SMEs) under Basel II led the Basel Committee (Basel Committee on Banking Supervision, 2004) to allow banks to apply the more favourable retail risk weight of 75% to very small businesses, provided the bank's portfolio is diverse and the bank's loan to the SME borrower is less than 1 million euros. Favourable treatment is also applied to SME lending that falls under the corporate category: a special discount is applied for exposures to firms with under 50 million euros in sales (Basel Committee, 2004) (Hakenes and Schnabel, 2011).

[3]Finnish Financial Supervisory Authority, 2005.

risk" (Basel Committee, 2004). The adoption of the approach was therefore staggered among banks, depending on the timing of applications and the granting of permissions for IRBA use. Banks not adopting the IRBA in 2007 moved to the Standardised approach that year.

Chapter 2 finds ample evidence that the Basel II reform was associated with a deterioration in the credit conditions faced by firms exposed to the IRBA via their main funding relationship. For the deterioration in financial conditions to influence firms' labour and investment decisions, financial frictions must also be present: if firms can easily switch to other forms of finance when borrowing terms deteriorate, no impact should be expected, all other things being equal. In other words, bank-firm relationships must be sticky: firms must rely on bank finance (and their main funder in particular) to fund their activities.

An a priori hypothesis in terms of the impact of changes in credit conditions on the real economy in Finland is that financial frictions are not prevalent because Finland has a well-functioning financial sector. As discussed in e.g. IMF (2010), firms were able to turn to alternative sources of finance when when financial conditions tightened during the global financial crisis. Large firms turned from capital market issuance to banks for funding in 2008 but returned to the international funding markets in 2009. Medium and large firms faced higher loan margins and shorter maturity terms and increased borrowing from employee pension funds. Small firms faced tighter collateral requirements and increased the drawdown of loans from public funding sources like Finnvera.

There is also evidence, however, that Finnish bank-firm relationships are sticky. For example, the data utilised in this survey suggests that the scale of these changes in external funder is likely to have been fairly small or that these other sources of finance were secondary to firms' main external funding relationship. In the 2007-2010 surveys, 91% of firms reported to have not changed their main source of external funding in the previous three years compared to 92% in 2000-6. Large firms also stuck with their main lender during the crisis period (88% reported to have not changed their main funding source) albeit to a lower degree compared to SMEs (93%).

The survey results more widely provide some qualitative insight into the extent to which changes in credit conditions may have affected firms' decisions. The results show that the percentage of firms reporting a deterioration in their access to finance doubled from between 5-10% before the crisis to over 20% after it. Out of these 20%, around 10% of firms reported they had been unable to carry out planned investment, around 17% reported a cash-flow constraint, around 3% were unable to replace expensive external finance and 0.4% reported some "other" issue. These results point to a deterioration in access to finance acting as a binding constraint on the decisions of particular firms, but these percentages are small in the context of the whole sample: in 2007-2010, 1.3% were unable to carry out planned investment, 2.2% faced a cashflow constraint, 0.4% were unable to replace expensive finance and 1.3% reported some other issue. This suggests

that changes in credit conditions are unlikely to have presented a significant constraint on economic activity for the vast majority of firms.

3.2 Data description

The data used in this study is similar to that used in Chapter 2, but is based on a merger of four different datasets: survey data on firms' credit conditions, data from firms' and banks' financial statements and data on patent applications. The survey data, as well as the financial statement data of firms and banks, are as described in Chapter 2, with a number of factors affecting the comparability of banks' financial statements during 2000-2010 (Table 3.1). The fourth data source, not used in the study described in Chapter 2, is data on patents from the Finnish Patent and Registry Office. Patent applications are used here as a proxy for R&D or innovation activity. Other data sources, such as the EU's Community Innovation Survey data and Statistics Finland's data on R&D spending were also explored as proxies for innovation activity but were found to not have enough overlap with the credit conditions survey of this study for a meaningful sample. As discussed in Chapter 2, the panel is unbalanced due to the survey panel being unbalanced. The additional data used here is available for all observations and hence do not change the structure of the panel.

The key variables utilised in this study are presented in Table 3.1. Given that it is not possible to directly test for the impact of credit constraints on firms' spending decisions due to potential omitted variable bias, instrumental variable estimation is used. The main explanatory variables are the dummy variables IRB_{ij} and $Reform_{jt}$. The variable IRB_{ij} equals 1 if firm i declared their main external financier j to be a bank that adopted the IRBA before the recession and zero otherwise.[4] The variable $Reform_{jt}$ equals 1 in the year t that the main financing bank j moved to the new regulatory regime (be it the IRB or the Standardised approach) and all subsequent periods. The variable $Reform_{jt}$ can therefore only equal 1 from 2007 onwards and only from 2008 onwards for some firms. The term ($IRB_{ij}XReform_{jt}$) is the key variable interest. The term is used as the instrumental variable and in the reduced form model, is the interaction term.

[4]The survey was conducted in Finnish and translates into "Who is your main financier (select only one)?" or "What is your most important source of external finance?". Two options are then presented 'bank' or 'other', with the former question leading to another multiple-choice question with the option of ticking one of around 14 Finnish banks or filling in an open field for a bank not on the list. The market share of banks implied by survey responses closely reflects the market share of banks based on banks' own financial statements.

Table 3.1: Descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
	Survey data					
Constrained	1 if firm experienced a deterioration in their access to finance; 0 otherwise.	10,705	0.09	0.29	0	1
Cost	1 if firm's margins or fees increased; 0 otherwise.	10,705	0.07	0.26	0	1
Volume	1 if a smaller-than-applied-for volume of lending was granted compared; 0 otherwise.	10,705	0.03	0.16	0	1
Conditions	1 if other loan terms and conditions became less favourable; 0 otherwise.	10,705	0.01	0.11	0	1
Zscore	Probability of bankruptcy as proxied by Altman Z-score.	10.364	0.49	0.11	N/A	N/A
IRB	1 if firm declares their main external financier to use the IRBA in that year; 0 otherwise.	10,705	0.46	0.5	0	1
RepaymentsIrregular	1 if firm reported irregularities in their repayment of existing external credit; 0 otherwise.	10,705	0.07	0.26	0	1
Exporter	1 if firm declares more than 50% of their output to be for the export market; 0 otherwise.	10,705	0.14	0.35	0	1
	Firms					
Equityratio*	Sum of equity, value adjustment and optional reserves as % of balance sheet total.	10.364	41.97	34.18	0	1
Liquidityratio	Liquidity ratio calculated as current assets as % total assets.	10.364	0.15	0.19	N/A	N/A
RoCI*,**	Return on capital investment, calculated as the sum of net profit, financial expenses and taxes as % of balance sheet total.	10,705	14.78	41.43	N/A	N/A
RoI*,**	Return on investment, calculated as the sum of net profit, financial expenses and taxes as % of the sum of equity, value adjustment, optional reserves and non-current creditors.	10,705	55.03	212.95	N/A	N/A
RoE*,**	Return on equity, calculated as net profit as % of the sum of equity, value adjustment and optional reserves.	10,705	44.13	228.90	N/A	N/A
Log(turnover)	Log of turnover.	10,705	15.04	3.89	N/A	N/A
Log(profit)	Log of net profit.	10,705	9.22	5.91	N/A	N/A
Firm Size	1 if firm size is the following; 0 otherwise:					
Micro	*Fewer than 10 employees.*	10,705	0.25	0.44	0	1
Small	*Between 10-49 employees.*	10,705	0.21	0.41	0	1
Medium	*Between 50-249 employees.*	10,705	0.14	0.35	0	1

Table 3.1 continued

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
	Firms (continued)					
Geography	1 if firm located in the following; 0 otherwise:					
Helsinki	*Helsinki region.*	10,705	0.43	0.49	0	1
top5	*2nd to 5th largest cities by population after Helsinki region.*	10,705	0.10	0.30	0	1
top10	*5-10th largest cities by population.*	10,705	0.06	0.24	0	1
Industry	1 if firm main activity belongs to following industry; 0 otherwise:					
Industry1	*Agriculture, forestry and fishing.*	10,705	0.00	0.02	0	1
Industry2	*Manufacturing.*	10,705	0.35	0.48	0	1
Industry3	*Construction.*	10,705	0.09	0.29	0	1
Industry4	*Distributive trades, transport, accommodation and food services.*	10,705	0.30	0.46	0	1
Industry5	*Real estate, renting and business activities.*	10,705	0.17	0.37	0	1
Industry6	*Government and other services.*	10,705	0.06	0.24	0	1
Exports	Export share of output.	10,705	13.47	26.94	0	100
Log(employment)	Log of employees.	10,705	3.217	2.14	N/A	N/A
Log(productivity)	Log of value added over employees.	10,705	10.83	0.78	N/A	N/A
Log(fixed investment)	Log of fixed investment.	10,705	13.50	3.03	N/A	N/A
Log(average wages)	Log of the quotient of wages and salaries divided by employees.	10,705	10.25	0.57	N/A	N/A
Patent	1 if the firm applied for at least one patent: 0 otherwise.	10,705	0.04	0.20	0	1
	Banks					
Fundinggap	1 - ratio of customer deposits to total funding base	5,911	0.58	0.14	0.32	0.81
Tier1	Tier 1 capital ratio	5,911	0.11	0.03	0.06	0.20
Liquidassets	Ratio of liquid assets to total assets	5,911	0.10	0.07	0.02	0.29
NII	Ratio of net interest income to total income	5,911	0.57	0.11	0.35	0.84
Totalequity	Ratio of total equity to total assets	5,918	0.06	0.02	0.03	0.12
ROA	Return on assets	5,918	0.72	0.50	-1.60	2.56

Maximum and minimum values for some variables are unavailable due to Statistics Finland policy.
*Calculated by Statistics Finland. **Outliers have been removed.

The measure of a deterioration in credit constraints is an aggregate term, $Constrained_{ijt}$, which equals 1 if firm i with a key relationship with bank j at time t reported to have seen a deterioration in their access to credit over the past 12 months and zero otherwise. This is a broad measure including increases in the cost of lending (the firm reporting increases in margins and fees for existing or new credit), issues around the volume of lending (firms reporting having their loan application denied, being granted a loan of a smaller size and/or with a shorter maturity than they had applied for) and firms reporting tighter other terms and conditions (such as a tightening in collateral requirements). In aggregate, firms experiencing a deterioration in their access to credit varied between 5% and 10% ahead of the crisis, followed by a doubling to over 20% in 2009 (see Chapter 2). While the pattern of the time series is similar across the disaggregated variables, the evolution of the aggregate term, $Constrained_{ijt}$, is predominantly driven by developments in the cost of credit, particularly a widening in margins. The number of firms denied credit altogether (1.1%), awarded a smaller loan than applied for (1.3%) or with a shorter maturity (0.5%) or experiencing a tightening in other conditions (1.2%) is of a small magnitude relative to changes in margins (6.1%) and fees (3%).

The outcome variables, employment, wages and fixed investment are based on the Statistics Finland's firm financial statements register. In the absence of data on hours worked, productivity is calculated as gross value added per employee. Patent Office data are used to calculate a dummy variable which equals 1 if the firm submitted at least one patent application that year and zero otherwise.

The remaining variables relate to a number of firm and bank control variables widely used in the literature on firms' access to credit and banking. These include dummy variables for the size of the firm[5]), as well as industry and geographical location. Financial statement variables such as logs of the firms' turnover and profit are used to control for balance sheet size and as a measure of firm performance, respectively. Other measures of firms' financial health and performance used here include equity ratio (%), liquidity ratio (%), return on capital invested (%), return on investment (%) and return on equity (%).[6] In terms of bank controls, key balance sheet and income statement variables are used, such as Tier 1 capital ratio, funding gap, ratio of liquid assets to total assets, return on average assets (as a measure of profitability) and net interest income to total income (as a measure of revenue stability).

[5]Firm size defined based on the EU staff headcount-based definition. The European Commission defines firm sizes as follows: micro (<10 staff), small (<50 staff) and medium-sized (<250).

[6]All metrics are reported by Statistics Finland, except for the liquidity ratio, which has been calculated as current over total assets.

3.3 Empirical strategy and identification

The key identification challenge in studying the impact of credit shocks on the real economy is potential omitted variable bias given that firms with poor prospects are also more likely to be credit constrained. Instrumental variable estimation is therefore used in this study, with the results cross-checked against OLS estimates of a reduced form linear probability model.

In using two-stage least squares (2SLS), the main assumption is that the instruments used are valid. First, the instrument must be correlated with the causal variable of interest (credit conditions). This relationship is studied in Chapter 2, but tests considered here to this end include the significance of the first stage of the 2SLS equation and F-statistics. The second main criteria for instrument validity, the exclusion restriction, amounts to the assumption that a firm being affected by the IRBA via its main funding relationship has an effect on a firms decisions only through its impact on the causal variable of interest. While the Hansen J test of overidentification provides information on the extent to which instruments are consistent with each other, instrument validity in terms of the exclusion restriction relies on theory. In this study, it is highly unlikely that the implementation of Basel II reform influenced firms' spending decisions directly, instead of indirectly via changes in credit conditions as a result of their banking relationships. For example, in the 2006 survey, firms were asked about their expectations regarding the impact of Basel II on their access to credit. Around three-quarters of firms were unaware of the upcoming changes to banking regulation. Out of the firms that were aware, 78% expected no changes in their ability to obtain credit and 60% expected no changes to their margins. Indeed, across the survey, firms cited that the reason behind their selection of a particular bank was due to their existing relationship with the bank (55%), existing prices (21%), available services (11%), location (8%), etc.

The structural model is estimated by two stage least squares, with the following as a first stage estimating the relationship between the reform and credit constraints:

$$Constrained_{ijt} = \alpha_t + \alpha_i + \beta_1 Reform_{jt} + \beta_2 IRB_{ij} + \beta_3 Reform_{jt} \mathrm{X} IRB_{ij} + \beta_4 X_{it} + \beta_5 Z_{jt} + u_{ijt}$$

The second stage involves estimating the impact of credit constraints on firms' spending decisions:

$$y_{it} = \alpha_i + \alpha_t + \beta_4 \widehat{Constrained}_{it} + \beta_5 X_{it} + v_{it}$$

The reduced form model is estimated by OLS:

$$y_{ijt} = \alpha_t + \alpha_i + \phi_1 Reform_{jt} + \phi_2 IRB_{ij} + \phi_3 Reform_{jt} \mathrm{X} IRB_{ij} + \phi_4 X_{it} + \phi_5 Z_{jt} + \epsilon_{ijt}$$

The outcome variables of the second stage and reduced form y_{ijt} are the log of em-

ployment, wages, fixed investment and a dummy variable for patent applications of firm i predominantly financed by bank j at time t. Given that the influence of decisions on future productivity is of interest, as in Levine and Warusawitharana (2021) and Amore et al (2013), the outcome variable for productivity is taken to be the log of productivity one and two-periods ahead. The terms α_t and α_i are time and firm fixed effects and X_{it} and Z_{jt} are firm- and bank-level control variables. Standard errors are clustered at firm level.

The coefficient (β_4) captures the passthrough from credit constraints to the outcome variables whereas β_3 from the first stage captures the differential impact of a relationship to an IRBA bank on credit conditions. The product of the two is equivalent to ϕ_3 that is, the coefficient associated with the interaction term of the reduced form model. A negative coefficient ϕ_3 would imply that the outcome variable increased by less or decreased by more for the firms financed by IRBA banks compared to those financed by later adopters of the approach.

3.4 Impact of credit constraints on the real economy

The results suggest that, for firms applying for external credit during the downturn, a deterioration in a firms' access to finance was negatively associated with **employment** decisions but not **investment** or **wages**. A tightening in credit access is associated with a reduction in **innovation** activity, as proxied by patent applications, as well as future **productivity**, but it is not possible to trace this link back to the impact of the procyclicality of Basel II regulation in the reduced form of the model, as is possible in the case of employment levels. That is, coefficient estimates are statistically significant in estimating the structural model but not the reduced form model.

The results of the first stages of the structural models (see Tables 3.2 to 3.7) support the finding of Chapter 2, which finds that firms affected by the IRBA were associated with a 6-7 percentage point higher likelihood of facing financing constraints following the reform, with this estimate increasing to 12-13 percentage points when the sample is adjusted for demand and to 16-22 percentage points when the sample is narrowed even further to only include firms who reported their main funder to be an IRBA bank regardless of whether permission was granted before or after the crisis. This result of Chapter 2 is robust to a battery of tests, including those that account for the effect of possible changes in the composition of firms over the sample, of firms' secondary banking relationships, of potential differences in the affected and unaffected group based on observed firm characteristics and the potential effect of interlinkages between the Nordic banking sectors.

The results of the first stage suggest that affected firms were around 16-16.5 percentage points more likely to face credit constraints compared to unaffected firms. F-statistics

Table 3.2: Impact of credit constraints on employment

	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.407**		
	(0.167)		
IRBA X Reform		0.160*	-0.065**
		(0.089)	(0.031)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.644/0.000	
Overidentification test/p-value		30.573/0.167	
Observations	1,184	1,184	1,676
Number of firms	397	397	889

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

of the first stages are all above 10, the reference value suggested by Staiger and Stock (1997), supporting the absence of a weak instrument problem. In terms of instrument quality, the Hansen's overidentification tests support that instrument exogeneity cannot be rejected, supporting instrument validity.

While the results of the first stage (the relationship between the instrument, IRBA adoption, and credit constraints) produces a statistically significant result across all specifications, the second stage and the reduced form models do not. The results point to a fall of 1.6% in **investment** for firms experiencing a deterioration in credit conditions, but this result is found to not be statistically significant in the estimates based on the reduced form and the two-stage least squares models. This is consistent with anecdotal evidence of the collapse in demand and deteriorating sentiment being the main drivers of the contraction in investment. Coefficient estimates suggest that the impact on wages has been close to zero; this is also intuitive result in the context of the collective bargaining agreement that was in place at the time.

A robust relationship cannot be established between a tightening in credit conditions and in **innovation** and **future productivity** (see Tables 3.5 to 3.7). The coefficient estimate is near zero in the model where the log of productivity one-period ahead is the dependent variable. Where the two-period lead for the log of productivity is the dependent variable, the coefficient estimate suggests that a deterioration in credit constraints is associated with a 1.6% deterioration in future productivity but this relationship is not

Table 3.3: Impact of credit constraints on investment

	Structural equation	First-stage	Reduced form
Dependent variable	Log(fixed investment)	Constrained	Log(fixed investment)
Constrained	-0.092		
	(0.067)		
IRBA X Reform		0.163*	-0.016
		(.087)	(0.038)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.457/0.00	
Overidentification test/p-value		28.443/0.288	
Observations	1,191	1,191	1,693
Number of firms	398	398	894

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Impact of credit constraints on wages

	Structural equation	First-stage	Reduced form
Dependent variable	Log(average wage)	Constrained	Log(average wage)
Constrained	0.001		
	(0.088)		
IRBA X Reform		0.158*	-0.001
		(.089)	(0.078)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		11.41/0.00	
Overidentification test/p-value		21.723/0.537	
Observations	1,177	1,177	1,663
Number of firms	394	394	880

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Impact of credit constraints on patent applications

	Structural equation	First-stage	Reduced form
Dependent variable	Patent	Constrained	Patent
Constrained	-0.232*		
	(0.122)		
IRBA X Reform		0.164*	-0.026
		(.0876)	(0.036)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.21/0.00	
Overidentification test/p-value		11.25/0.981	
Observations	1,191	1,191	1,683
Number of firms	398	398	0.078

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.6: Impact of credit constraints on future productivity

	Structural equation	First-stage	Reduced form
Dependent variable	Log(productivity n+1)	Constrained	Log(productivity n+1)
Constrained	0.004		
	(0.009)		
IRBA X Reform		0.164*	-0.009
		(0.088)	(0.011)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.207/0.00	
Overidentification test/p-value		5.225/0.99	
Observations	1,191	1,191	1,695
Number of firms	398	398	896

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.7: Impact of credit constraints on future productivity

	Structural equation	First-stage	Reduced form
Dependent variable	Log(productivity n+2)	Constrained	Log(productivity n+2)
Constrained	-0.097*		
	(0.058)		
IRBA X Reform		0.164*	-0.016
		(0.088)	(0.032)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.21/0.00	
Overidentification test/p-value		20.579/0.607	
Observations	1,191	1,191	1,695
Number of firms	398	398	896

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

statistically significant in the reduced form model. The results suggest a decline in patent activity of -2.6% arising from a deterioration in credit conditions, but this estimate too is not statistically significant in the reduced form model. In any case, the results of Table 3.5 should be interpreted with caution. In addition to the number of patent applications being very small, patent applications can be a lengthy process, reflecting research conducted possibly over several years, and hence a contemporaneous relationship may not be meaningful.

With the exception of **employment**, the results depart from much of the academic literature showing strong links between credit constraints and e.g. i) investment in euro area countries (Garcia-Posada Gomez 2019, Ferrando et al 2018) and investment and value added in Italy (Cingano et al 2016); ii) wages in Germany (Popov and Rocholl, 2018), iii) productivity in various euro area countries (Ferrando and Ruggieri 2015) and France, Italy and Spain (Levine and Warusawitharana, 2021); and iv) profitability in the euro area (Ferrando et al 2018) - these authors find the link to innovation to be weaker, however.

In terms of the link between the weakening in credit conditions and **employment**, the results in this study suggest that the weakening in credit conditions was associated with a 6.5% reduction in the log of employment. This translates in a 6.3% decrease in employment for firms that saw their credit conditions deteriorate during the financial crisis. This result in terms of economic significance is in the middle of the pack of the

estimates found in similar studies on the link between credit constraints and employment. On the lower end of estimates, Popov and Rocholl (2018) find a 1.5% reduction in German employment from credit shocks whereas Garcia-Posada Gomez 2019 finds no impact on employment in euro area countries. On the high end, Bentolila et al (2018) attribute 24% of job losses at firms attached to weak banks. In other papers, albeit ones where the instruments are not entirely comparable to that used in this study, a much larger impact is found between credit shocks and employment. For example, Cornille et al (2019) find that credit-constrained Belgian SMEs were 40% more likely to reduce their workforce than unconstrained ones, while Chodorow-Reich (2014) finds the withdrawal of credit following the Lehman bankruptcy to account for one-third to one-half of the employment decline at small and medium firms. The much larger impact in the US compared to Europe is intuitive, given that labour market protection is much weaker in the former than in the latter.

Reducing the sample to subsamples by firm size, by export orientation and by industry allows for the study of heterogeneity in the link between deteriorations in access to credit and employment between different types of firms. This exercise produces no clear results perhaps due to the small sample size; as a starting point, the survey has been reduced to only firms i) whose main financier was a bank that has adopted the IRBA since the beginning of 2007 and ii) within that group, firms applying for credit during the crisis.

Consistent with the results of Chapter 2, the IRBA is linked mostly with the credit conditions of large firms; SME lending attracted a relatively favourable risk weight, as discussed above. The results of the first stage of the structural equation suggests a statistically and economically significant link between the IRBA and credit conditions for large firms (Table 3.9); for SMEs, the relationship is small and not statistically significant (Table 3.8). Interestingly, the result of the second stage suggests that the hiring decisions of SMEs are negatively associated with deteriorations in credit conditions, but the equivalent coefficient for large firms is near zero. This makes intuitive sense since large firms tend to have better access to non-bank alternatives to external finance than SMEs. In the reduced form model, the coefficients associated with the interaction term are statistically significant for both SMEs and large firms. These OLS coefficients are, however, much larger than the 2SLS coefficients, suggesting that the OLS estimates are heavily biased upwards.

The results presented in Table 3.10 suggest a strong link between exporters' hiring decisions, with both the structural and reduced form models producing statistically significant results. The OLS estimate is significant at 10% level, with the size of the coefficient suggesting that a deterioration in credit constraints is associated with a 28.5% reduction in employment. The OLS estimate is much higher than the two-stage least squares estimate, which puts this percent at 10.7%, suggesting a strong upward bias in the OLS estimate. No statistically significant relationship is found for domestic-facing firms; in

Table 3.8: Credit constraints and employment, SMEs only

Sample	SMEs		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.760***		
	(0.290)		
IRBA X Reform		0.021	-0.196**
		(0.100)	(0.092)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		10.09/0.00	
Overidentification test/p-value		25.75/0.263	
Observations	845	845	1,289
Number of firms	302	302	746

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.9: Credit constraints and employment, large firms only

Sample	Large firms		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.001		
	(0.056)		
IRBA X Reform		0.326***	-0.159**
		(0.163)	(0.080)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		19.94/0.00	
Overidentification test/p-value		32.29/0.055	
Observations	312	312	387
Number of firms	97	97	169

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: Credit constraints and employment, exporters only

Sample	Exporters		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.562***		
	(0.262)		
IRBA X Reform		0.202*	-0.336*
		(0.113)	(0.178)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		4.67/0.00	
Overidentification test/p-value		20.16/0.512	
Observations	627	627	839
Number of firms	205	205	417

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: Credit constraints and employment, domestic-facing firms only

Sample	Non-exporters		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	0.674		
	(0.741)		
IRBA X Reform		0.163	0.015
		(0.148)	(0.106)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		109.11/0.00	
Overidentification test/p-value		16.41/0.746	
Observations	498	498	837
Number of firms	181	181	520

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: Credit constraints and employment, manufacturers only

Sample	Manufacturing		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.151		
	(0.191)		
IRBA X Reform		0.112	-0.504*
		(0.186)	(0.278)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		5.09/0.00	
Overidentification test/p-value		20.40/0.433	
Observations	491	491	684
Number of firms	168	168	361

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.13: Credit constraints and employment, services sector only

Sample	Services		
	Structural equation	First-stage	Reduced form
Dependent variable	Log(employment)	Constrained	Log(employment)
Constrained	-0.809*		
	(0.437)		
IRBA X Reform		0.210*	-0.097
		(0.111)	(0.111)
Estimator	2SLS	OLS	OLS
Cluster	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Bank controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
F-statistic / p-value		27.57/0.00	
Overidentification test/p-value		17.83/0.716	
Observations	675	675	992
Number of firms	226	226	543

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

this case, the OLS estimate is much lower than the two-stage least squares estimate, suggesting a strong downward bias in the former (Table 3.11). It seems plausible that exporters were more sensitive to credit constraints than their peers focused on the domestic markets, given the sharp contraction in external demand, although these results do not establish this link in a robust way.

The contraction in industrial output in 2009 was much sharper than that in the services sector, so, a priori, manufacturers could be anticipated to have been more sensitive to credit constraints. The results are difficult to interpret (Table 3.12 and 3.13) given biases in the OLS estimates and a lack of consistency in statistical significance.

3.5 Conclusion

The impact of financial shocks on the real economy has garnered much attention in the literature, particularly since the onset of the 2008-2009 financial crisis. This essay studies the impact of credit constraints on the real economy using Finnish data. The key identification challenge in studying the impact of credit shocks on the real economy is potential omitted variable bias given that firms with poor prospects are also more likely to be credit constrained. That challenge is address in this study by exploiting the exogenous variation arising from the implementation of the Basel II reform in 2007. A feature of the reform involved banks being allowed to choose to calculate the risk weights attached to their assets. Those adopting the approach faced a relatively high increase in capital requirements over the 2009 recession given the sensitivity of the approach to increases in credit risk compared to the fixed weights set by regulators.

The key finding is that, with the exception of employment, credit constraints played little role in firms' decisions and in turn, the GDP contraction in Finland in 2009. These results are consistent with anecdotal evidence of Finnish firms being heavily affected by the collapse in global demand, with funding conditions remaining relatively unaffected particularly compared to many other European countries. Contrary to many other studies, no evidence of the investment channel being at play is established. Estimates of the link to productivity and innovation activity produce mixed results. Studying the heterogenous impact of credit conditions on the employment decisions of different types of firms (e.g. by size, industry and export orientation) produces mixed results and are, in any case, difficult to interpret due to a small sample size.

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Chapter 4

Who funds zombie firms: banks or non-banks?

[1]

Zombie firms — mature firms that are unprofitable but remain in the market rather exiting through bankruptcy or takeover — have attracted increasing attention over the past few years, particularly in the context of whether or not low interest rates and other policy measures have contributed to their rising number. The covid-19 pandemic gave further impetus to this debate: the large-scale support measures put in place to support the corporate sector through the crisis may have shielded many firms from the process of creative destruction, leading to a misallocation of resources towards unproductive firms longer term.

This chapter contributes to the literature focused on the role of banks — particularly weak ones — in keeping zombie firms afloat but is unique in three respects. First, this chapter considers non-bank sources of external finance. The role of non-bank providers of finance has been extensively studied in the corporate finance literature but has so far been overlooked in the literature on zombie firms. Second, this chapter uses survey data as opposed to just financial statement, credit registry and/or market data. In using survey data, merged with comprehensive business registry and bank and firm financial statement data, it is possible to identify non-bank sources of funding; identify firms' (self-reported) most important external financing relationships; and to go a step further in distinguishing between zombie firms and weak firms misclassified as zombies: firms' self-reported purposes for applying for external finance allows for the identification of firms with low earnings due to new investment and those with permanently weak balance sheets and cashflow. Third — with the notable exception of Nurmi et al (2022) — this chapter considers flows into and out of zombie status as opposed to the stock of zombie firms using survival analysis techniques. The paper by Nurmi et al (2022) is also based

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on financial statement and business registry data of the Finnish statistics office, Statistics Finland, but the paper by Nurmi et al (2022) does not link zombie firms to the funders of those firms. Zombie lending is a central concept in the literature on zombie firms, given the hypothesis that zombie firms survive due to subsidised lending. Further, Nurmi et al (2022) differentiate between genuine zombies and weak firms based on whether the firms' employment is growing or not whereas this study uses firms' self-reported reasons for applying for external finance to do so.

The key findings of this chapter are as follows. Banks are overwhelmingly the largest funder of zombie firms, perhaps justifying the focus of the literature on bank funding. This is, however, perhaps simply due to banks' share of the credit market: banks are broadly similar to other funding sources in terms of their share of zombies as a percentage of all firm relationships. Contradicting the results of the existing literature, no statistically significant relationship is found between zombie firms and banks or bank characteristics; only the link between equity funding and zombie status is robust across all specifications. The stickiness of the funder-firm relationship and the presence of subsidies is not found to make a difference to the results. The results are also little changed when the definition of a zombie is narrowed to only include zombie firms that applied for external finance for reasons other than for the purposes of new investment to distinguish between genuine zombies and weak firms misclassified as zombies. Changes in the stock of zombie firms is driven equally by entries into and exits out of zombie status, with exits overwhelmingly driven by recoveries as opposed to bankruptcy. Based on non-parametric and semi-parametric survival models, all funding sources, except for non-bank financial institutions, are associated with a longer zombie lifetime but no link is found between funding sources and entry into zombie status.

The overlap between the definitions proposed in the literature can, in cases, be small, with the choice of definition playing a key role in determining the economic and statistical significance of estimates of the relationship between zombie status and dependent variables. However, the results of this essay, using any definition, challenge the perceived wisdom of a link between zombie firms and banks, at least in jurisdictions, such as Finland, that have a highly capitalised banking sector (e.g. IMF 2016) and a relatively efficient insolvency framework (e.g. Becker and Ivashina, 2021). While many European countries share these characteristics with Finland, the early literature on zombies (Caballero et al 2008 and Peek and Rosengren 2005) was based on a highly unique institutional setting. Instead, the results presented here suggest that equity investors continue to fund firms classified as zombies based on definitions proposed in the literature in the (often correct) anticipation of firms recovering. As discussed in Nurmi et al (2022), a firm's exit decision is forward-looking and also based on the present value of future net income as opposed to just current returns. Equity investors have more skin in the game than other creditors, such as banks, and have the most to lose in the event of liquidation. Indeed, a new equity

injection is typically a precondition for any debt relief by existing creditors (see e.g. FSB 2022 for a discussion).

Where non-bank sources of funding are relevant, tackling the zombie problem for example via regulatory scrutiny of the quality of banks' assets (as argued in e.g. Storz et al 2017) as way to avoid prolonged weakness in long-run growth may not be particularly effective. In addition, calls for policy action under e.g. the EU Capital Markets Union to broaden SMEs' access to funding sources could have unintended consequences for the prevalence of zombie firms or at least in the estimates of them.

This chapter is split into five sections. Section 4.1 provides an overview of the literature, with section 4.2 discussing the definitions of zombies used in different studies. Section 4.3 describes the dataset on Finnish firms used in this study and the estimates of zombie incidence it produces. In section 4.3, the link between zombie status and different funding sources are considered. The final section concludes.

4.1 Related literature

The literature generally finds that the prevalence of zombie firms has increased, with banks rolling over loans to non-viable firms instead of writing them off as being a key factor behind the rise in zombie firms. The impact of an increasing number of zombie firms is reduced aggregate productivity: zombie firms themselves are found to be less productive than their non-zombie peers but they also are found to create congestion effects, crowding out investment and employment growth at healthy firms.

An early contribution to the literature is by Caballero et al (2008) who find that the rise in zombie firms during Japan's lost decade was linked to weakly capitalised banks evergreening loans to avoid charge-offs that would have pushed them against regulatory capital limits. Increased zombie congestion depressed the investment, employment and productivity growth of healthy firms. Similarly, in another paper focused on Japan's lost decade, Peek and Rosengren (2005) find that the greater the financial stress faced by a firm and the weaker a bank's health, the more likely banks were to increase lending. This behaviour was found to be more prevalent among banks reporting capital ratios close to the required minimum. More recent empirical papers, e.g. Schivardi et al (2021) and Bonfim et al (2022), provide support for the role of weak banks in the euro area. Schivardi et al (2021), in using Italian data for the period 2004-2013, find that under-capitalised banks were less likely to cut credit to non-viable firms. Bonfim et al (2022) use Portuguese data for 2011-2014 and find that banks subject to supervisory inspections were less likely to refinance zombie firms, leading to their default.

Another factor brought forward in the literature as a driver of zombie lending is inefficient resolution of insolvency (Becker and Ivashina 2022). As discussed in Acharya et al (2022), zombie lending might emerge in equilibrium if insolvency is a costly undertaking

and lenders are disincentivised from restructuring. In this vein, Andrews and Petroulakis (2019) — in finding a connection between weak banks and zombie firms in Europe — call for an improvement in the design of insolvency regimes to reduce the barriers to restructuring weak firms.

Recent empirical papers on the euro area also highlight the role of monetary policy. While the potential effects of monetary policy on zombie incidence is not covered in this chapter, monetary policy is also hypothesised to drive corporate zombification as low interest rates reduce debt service burdens for firms but also create incentives for risk-taking (such as extending loans to risky debtors) through the risk-taking channel of monetary policy. Acharya et al (2020) likens the euro area "missing inflation puzzle" to Japan's lost decade, with Acharya et al (2019) finding that euro area banks used the capital gains from the ECB's Outright Monetary Transactions to increase credit supply mainly to low-quality firms with which they had pre-existing relationships. Banerjee and Hofmann (2018) find evidence of a positive relationship between low interest rates and the number of zombies, with upward shifts in the share of zombies over economic downturns not fully reversed in subsequent recoveries.

Some empirical papers focus on the negative impact of zombie congestion. Storz et al (2017) finds zombie congestion to be associated with reduced lending to healthy firms. Acharya et al (2020) find that "zombie credit" is associated with a higher misallocation of capital and labour, reduced average net investment and labour productivity. Adalet McGowan et al (2017) and Banerjee and Hofmann (2018) study the OECD countries and 14 advance economies respectively. Both document a rise in the share of zombie firms and find that zombies weigh on economic performance; zombies are less productive, and they also constrain the growth of more productive firms.

Several studies depart from the papers mentioned above. Nurmi et al (2020) study Finnish firms between 1999 and 2017 and find that two-thirds of the firms classified as zombies in the literature actually recover to become healthy firms and that the increase in zombies is driven by cyclical factors as opposed to a secular trend; this is consistent with a similar finding in Banerjee and Hoffman (2022). Nurmi et al (2022) also find that firms in receipt of government subsidies are less likely to die and that their chances of recovery are higher.

4.2 Identifying zombies

The literature on zombie firms is largely empirical and there are two broad approaches in the literature for defining zombie firms. In the studies focused on banks e.g. in the papers by Hoshi (2004) and Caballero et al (2008), the focus is on firm-bank relationships and hence zombies are identified based on the extent to which the firm is in receipt of subsidised credit. In Caballero et al (2008) and Acharya et al (2019, 2020), for example,

subsidised credit is identified observing firms' interest rate payments against a hypothetical lower bound expected for only the most creditworthy borrowers. In the literature focused on zombie incidence and consequences for the real economy, various measures of weak performance are used to identify zombies. According to the leading definition in this literature, proposed by Adalet McGowan et al (2017), a zombie is defined as a firm aged ten or over that has an interest coverage ratio of less than one for at least three consecutive years. The interest coverage ratio is calculated as the ratio of operating profits to interest expenses and the age-related criterion is used to avoid classifying start-ups and other productive young firms as zombies despite negative operating profits.

Some papers, such as Acharya et al (2019, 2020) and Schivardi et al (2021), identify zombies using elements of both approaches. In Acharya et al (2019), a firm is classified as a zombie if three criteria are met. First, the interest rate payments of a borrower must be lower than a hypothetical benchmark based on the median interest rate paid by the most creditworthy (AAA-rated) companies. Second, the firm must be rated BB or below, with credit ratings proxied by the firms' three-year interest coverage ratio relative to the median. Third, the syndicate composition of its lenders must have either remained constant or with banks leaving the syndicate not being replaced by new ones. By using Bureau van Dijk's Amadeus database, the study by Acharya et al (2020) uses a much wider range of firms and hence zombies are defined more generally as meeting two criteria: i) the firms' interest coverage ratio being below the median and the leverage ratio being above the median, where medians are calculated at the industry level and ii) debt financing is at a rate lower than that paid by the most creditworthy (AAA-rated) companies.

Schivardi et al (2021), in also taking a banks' decision as a starting point, define a zombie as a firm for which the expected marginal return of capital is below the risk-adjusted market cost of capital. A zombie firm is thus defined as a firm with a three-year moving average return-on-assets below the cost of capital of the safest firms in the sample. A second criterion is that leverage (used as a proxy for default risk) exceeds 40% with this time-invariant threshold being based on the distribution of leverage in the year 2005 for firms that existed the market in 2006 or 2007. Schivardi et al (2021) also consider an alternative measure of profitability, bringing their definition closer to that of Adalet McGowan et al (2017): a zombie is defined as a firm with the three-year moving average of the interest coverage ratio being below one and with leverage being above the threshold.

Other papers use the definition proposed in Adalet McGowan et al (2017) but drop the age restriction. For example, Banerjee and Hofmann (2018) find it unconvincing that younger firms could not be unviable and mature loss-making firms could not have high growth potential. Indeed, the authors find that zombies as defined by Adalet McGowan et al (2017) have on average a higher Tobin's q than non-zombies, that is, viewed by the markets as having higher profit potential. The authors try capture expected future

profitability, replacing the age restriction with the criterion that zombies have a ratio of their assets' market value to their replacement cost (Tobin's q) that is below the median within their sector in any given year. Another example of the age restriction being dropped is Nurmi et al (2020, 2022), who find that firm age is not a key determinant of zombie status. Instead, the authors impose a "shrinking" condition: that the annual growth rate of the firm in terms of employed workers is not positive on average over a two-year period.

Other definitions include that by Storz et al (2017), who define a zombie as being a firm that, for at least two consecutive years, has a negative return on assets, negative net investment and a debt servicing capacity (earnings before interest, taxes, depreciation and amortisation or EBITDA over financial debt) of under 5%. Bonfim et al (2022) define a zombie as a firm with negative equity in the previous year, arguing that such a firm is technically insolvent and thus risky for a lender to refinance.

4.3 Data and estimates of Finnish zombie incidence

The data used in this chapter builds on the dataset described in Chapters 1 and 2. The same survey data, based on an annual credit conditions survey, is utilised. A longer time series, covering 1998-2015 (but excluding 2005, 2011, 2013 and 2014), is used, however. In Chapters 2 and 3, the study requires the identification of the particular bank that a firm is predominantly funded by and hence, due to the comparability of the data between waves of the survey, only the period 2000-2010 (excluding 2005) is used. Much of the study presented in this chapter requires only e.g. the identification of the funding type but not necessarily the particular institution. Much of the results presented in this chapter are hence based on the longer time series. When it comes to estimations that require the identification of a particular bank, the shorter time series (2000-2010 excluding 2005) is used. Many of the years that are missing from the time series is due to the fact that the survey was not conducted that year, while a few years are missing due to the availability of the data for the purposes of this dissertation.

The survey data (covering different non-financial industries and locations in Finland) is as described in Chapters 1 and 2. The 2012 and 2015 surveys are exceptions in terms of sample size, however. Participating firms numbered around 1,000 per year in earlier waves of the survey, whereas the 2012 and 2015 surveys cover nearly 3,500 and 3,000 firms respectively. In addition to the bank and firm financial statement data, acquired from S&P's SNL Financial database and Statistics Finland, the panel dataset has been supplemented with series from the Finnish Business Register such as firm age and date of bankruptcy. Official statistics can be used for data for firms for years that they do not appear in the survey, allowing for the utilisation of a larger version of the dataset in regressions using lags and/or leads of financial statement data (Table 4.1).

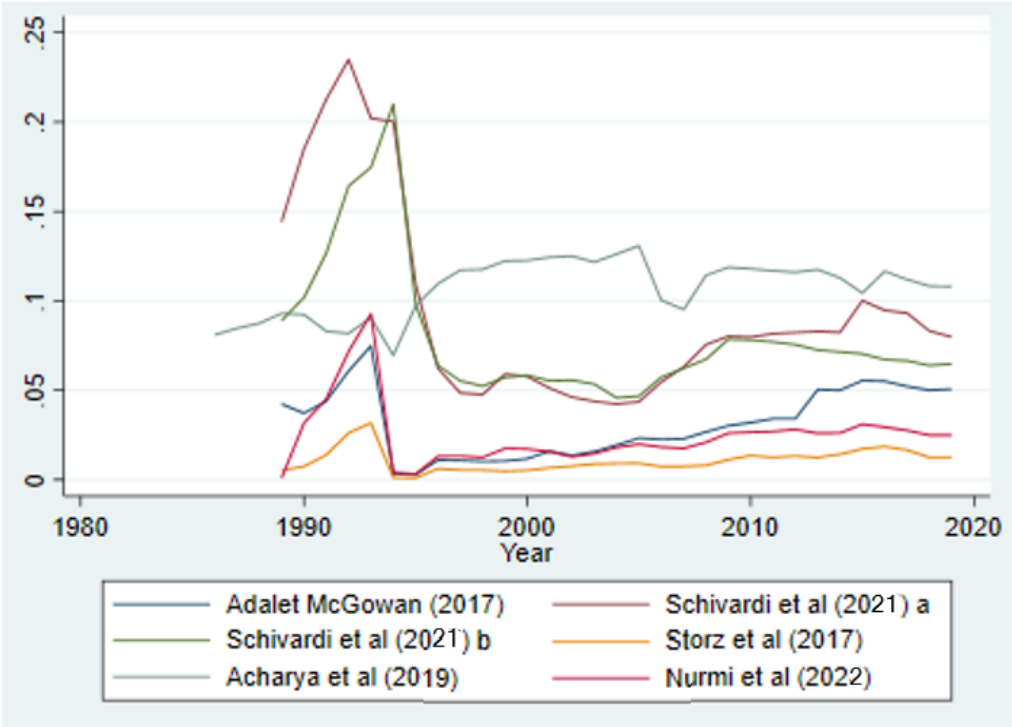
Table 4.1: Panel structure

Number of observations per firm	Frequency	Percent
1	0	0
2	0.05	0.05
3	0.09	0.14
4	0.21	0.35
5	0.3	0.65
6	0.53	1.18
7	0.62	1.8
8	0.83	2.63
9	1.5	4.13
10	1.62	5.75
11	2.06	7.81
12	2.47	10.28
13	2.84	13.13
14	2.51	15.64
15	3.08	18.72
16	2.7	21.43
17	3.04	24.47
18	3.22	27.69
19	3.34	31.04
20	4	35.04
21	3.36	38.39
22	5.3	43.69
23	3.43	47.12
24	4.4	51.52
25	5.96	57.48
26	26.82	84.3
27	2.17	86.48
28	1.6	88.07
29	1.99	90.06
30	2	92.06
31	1.56	93.63
32	0.92	94.55
33	0.91	95.46
34	2.94	98.4
35	1.6	100

Calculating the incidence of zombie firms in Finland using this dataset is not without its problems. The data requirements for calculating the incidence of zombie firms based on subsidised interest rates are large and not met by the survey and financial statement data utilised here. Instead, an implicit interest rate is calculated based on interest expenses as a share of debt and compared with the lowest (implicit) interest rates paid by firms in the sample. The definition by Banerjee and Hoffman (2018, 2022) requires information on stock market valuations and therefore is not explored in this study, which is based on a dataset reflective of the Finnish economy and hence, as in other European countries, consists mostly of SMEs. The measure based on the definition proposed by Bonfim et al (2022) produces estimates unrelated to all of the other measures and therefore is also not considered here.

Most of the estimates suggest that, since the early 1990s banking crisis and recession, the number of zombie firms in Finland has been quite small. These calculations nevertheless produce a wide range of estimates, with the Storz et al (2017) measure producing the smallest estimate (1.3%) and that by Acharya et al (2020) at 11% producing the largest for 2019 (Figure 4.1). Many of the pair-wise correlations between different definitions are weak (Table 4.2).

Figure 4.1: Zombie incidence by definition – all firms



The focus of the remainder of this chapter is on the credit conditions survey sample

Table 4.2: Correlations between zombie definitions

	Adalet McGowan et al ('17)	Schivardi et al ('21)a	Schivardi et al ('21)b	Storz et al (2017)	Nurmi et al ('22)
Adalet McGowan et al ('17)	1				
Schivardi et al ('21)a	0.2822***	1			
Schivardi et al ('21)b	0.3165***	0.8546***	1		
Storz et al ('17)	0.3429***	0.1795***	0.1915***	1	
Nurmi et al ('22)	0.705***	0.2607***	0.2897***	0.3453***	1

****, ** and * indicates statistical significance at 1, 5 and 10 percent level, respectively.*

(Figure 4.2) – descriptive statistics of zombies based on the population of Finnish firms has been discussed elsewhere (e.g. Nurmi et al 2020 and Vanhala and Viren 2018). While being a much smaller set of firms, the survey provides useful information on firms' self-reported funding sources and relationships, applications for credit and subsidies and their outcomes. Information on firms' self-reported reasons for applying for new external finance can also help shed light on the extent to which firms may be misclassified as zombie firms as opposed to viable ones facing temporary credit constraints.

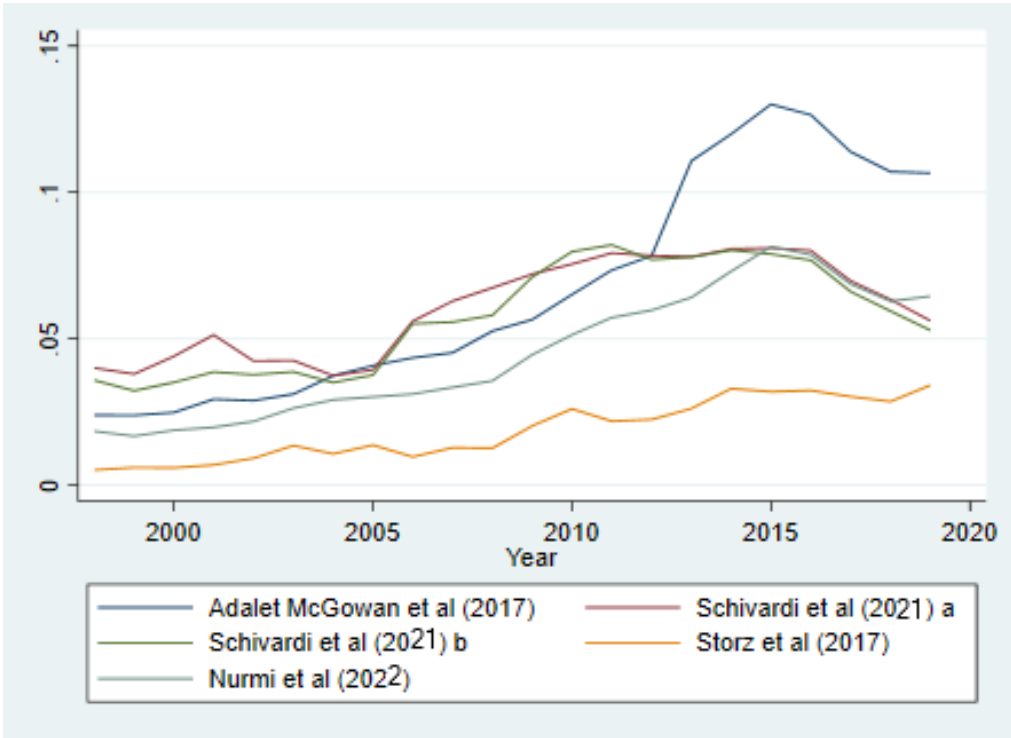
While the choice of zombie definition is not uncontentious, this chapter predominantly utilises the definition proposed by Adalet McGowan et al (2017)[2] in part by virtue of it being the leading definition of the literature to date. While definitions based on subsidised credit would be appropriate in considering zombie firms' lenders, an implicit interest rate (relied on here due to lack of explicit interest rate data) is a rather crude measure on which to base calculations. The potential for Finnish firms being misclassified as zombies under the Adalet McGowan et al (2017) definition is discussed in section 5. Also in section 5, the alternative definitions are considered as robustness checks.

4.4 Who funds zombie firms: banks or non-bank lenders?

The focus of the literature to date on the funders of zombie firms has been limited to banks and the determinants of the type of bank most likely to lend to zombie firms. Consideration of other types of funders has been absent in the literature. As discussed in IMF (2016), Finnish non-financial corporations (NFCs) are not particularly reliant on bank funding. Domestic monetary financial institutions provide about 25% of NFC borrowing, while inter-company loans account for 24% and a third is sourced from abroad,

[2]As discussed in e.g. Rodano and Sette (2019) and Storz et al (2017), using the earnings before interest and taxes (EBIT) numerator for the definition proposed by Adalet McGowan et al (2017) may overstate the scale of the zombie population because companies with high depreciation in a current period tend to have invested heavily in previous years; this would be counterintuitive with the concept of zombie firms, given that they would not be expected to invest. The numerator used here is therefore EBITDA instead of EBIT, as used in many recent papers.

Figure 4.2: Zombie incidence by definition – survey data



primarily in the form of loans (IMF, 2016). Public funding bodies, such as Finnvera, make up an important funding source for SMEs. Equity financing constitutes a larger share of NFCs' total liabilities (52%) than debt (38%) (IMF, 2016).

The funding types cited by firms as making up their *main* source of finance in the survey are grouped into five categories:

1. Internal funding
2. Banks
3. Public funding sources e.g. Finnvera
4. Non-bank private financial institutions e.g. other financial
5. Equity funding.

Figure 4.3 shows, using the Adalet McGowan et al (2017) definition, the share of zombies out of all firms reporting their *main* source of finance to be internal funds, a bank, a public funding source, a non-bank financial institution and equity funding. The data suggests that banks are overwhelmingly the largest funder of zombie firms, perhaps justifying the focus of the zombie literature on bank lending. The data is also consistent with anecdotal evidence of e.g. SMEs turning away from banks and seeking funding from public sources during the 2008-2009 financial crisis. Since then, the proportion of zombies predominantly financed by internal sources has increased and zombies predominantly financed by equity has decreased.

Although banks are the largest funder of zombies, public funding sources, at around 8.2%, have the highest share of zombies as a percentage of firms citing them as their main funding source (see Figure 4.4). This is followed by banks 6.6% and equity 5.5%. Zombies make up a much smaller share of firms predominantly financed by non-bank financial institutions 4.4% and by internal funds 3.5%. While there are important similarities and differences in the characteristics among zombie and non-zombie firms in general (Table 4.9 in the Appendix), zombie firms also differ by type of funder (Tables 4.10-4.14, Appendix). For example, based on Altman Z-scores, the creditworthiness of zombies predominantly financed by equity or public sources is poorer than those financed by banks or non-bank financial institutions.

Due to a small number of zombie firms, linear probability (as opposed to logit) models are estimated to test the relationship between zombie status and different funding sources. Firms predominantly financed by internal funds are used as a reference group and, unless otherwise specified, 1998 is used as the reference year.

In estimating the relationship between zombie status and difference funding sources, the baseline specification is as follows:

$$Zombie_{ijt} = \alpha_i + \alpha_t + \beta_1 Funder_{ijt} + X'_{it}\gamma + u_{ijt} \tag{4.1}$$

Figure 4.3: Zombie firms, breakdown by funder type

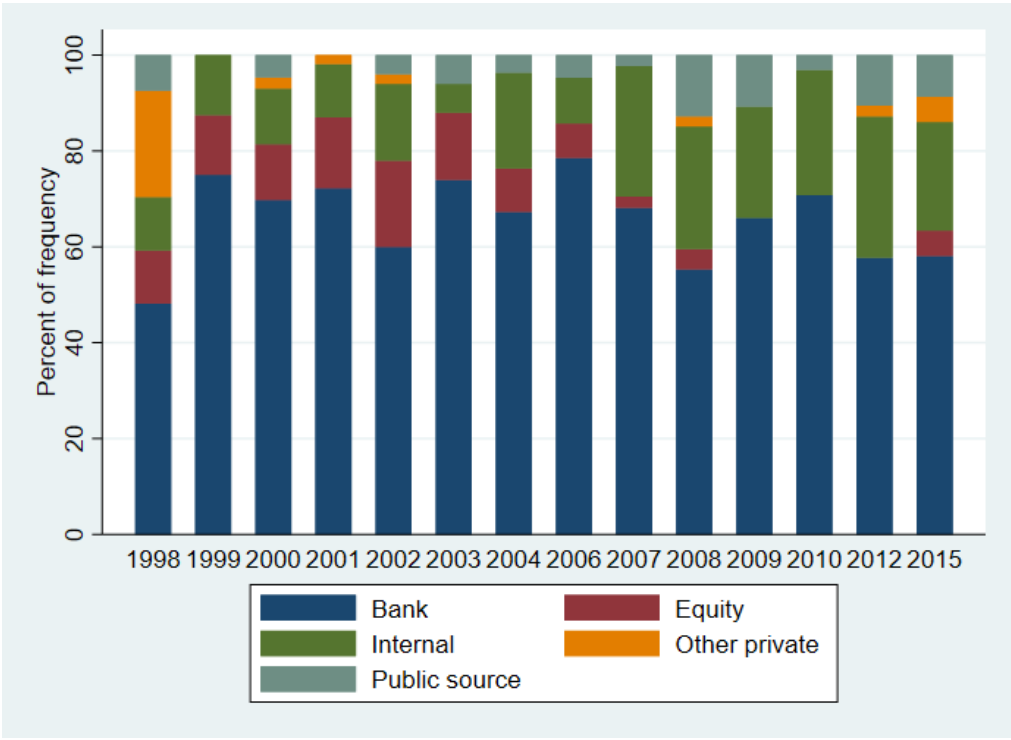
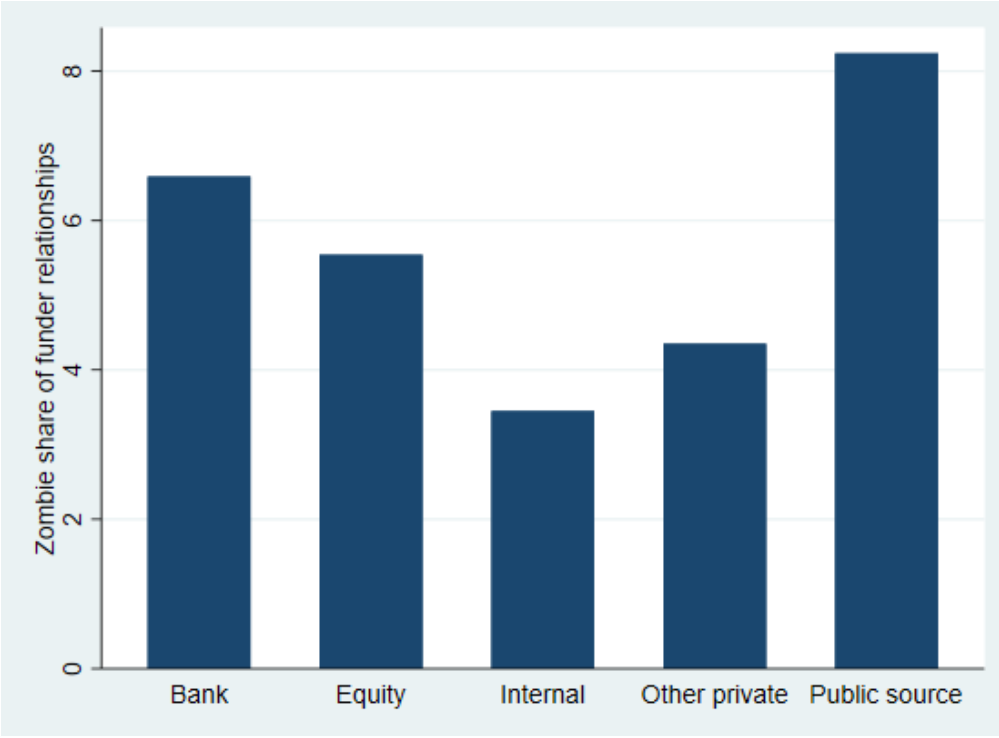


Figure 4.4: Zombie firms as share of total firm relationships by funder type



where $Zombie_{ijt}$ is a dummy variable for zombie status. The dummy variable equals 1 if firm i, with its main source of funding granted by funder j at time t is a zombie firm based on the Adalet McGowan et al (2017) definition and zero otherwise. The term $Funder_{ijt}$ refers to the type of funder j that firm i identifies as its main source of external finance[3] at time t - h: a bank, a public funding source, non-bank financial institutions or equity as discussed above. The α terms are firm and time fixed effects and X_{it} are firm-level controls. The coefficient β_1 is the key estimate of interest. Standard errors are clustered at the firm level.

The results suggest (Table 4.3) that the presence of a bank as a firm's main funding relationship is not significant and close to zero (models 1-2). Only the presence of equity funding as the main source of funding is statistically significant and this relationship is significant across all specifications. In the baseline specification (models 1-2), being funded predominantly by equity is associated with a 3% higher likelihood of zombie status than those predominantly financed by internal funds.

A central concept in the forbearance argument is that funder-firm relationships matter. The literature on Japan, in a unique institutional setting, centres around banks with existing relationships with zombie firms having the incentive to keep zombies afloat to avoid loss recognition; banks with no previous exposure to the zombie firm do not. This is implicitly accounted for in this study given that the identified funding type is based on firms' self-reported main source of external finance as opposed to any source of finance.

As discussed in Alvarez et al (2023), however, banks may also want to preserve valuable relationships and/or roll over loans due to an informational advantage over other funders (see also Hu and Varas, 2021). If so, controlling for funder relationships may make a difference to the results: only firms with a strong relationship with a bank are likely to their loans rolled over by their main bank. The logic is that, without the existing banking relationship, the zombie firm would not have been able to pay back existing credit and would have exited zombie status through bankruptcy.

The survey results suggests that funding relationships are indeed very sticky, but no more so among firms and banks than firms and other funding sources. The lowest percentage of firms replying "no" to having changed their main source of finance over the past three years is high at 81% and 82% among zombies predominantly funded by public sources and banks respectively. In a similar vein, firms, particularly non-zombies, across all funding types had few banking relationships: the vast majority (76% of non-zombies and 61% of zombies) reported only one or two banking relationships. The average number of banking relationships held by non-zombies is two and those held by zombies three.

The baseline specification is modified to include interaction terms between the funder

[3]The survey was conducted in Finnish and translates into "Who is your main financier (select only one)?" or "What is your most important source of external finance?". Multiple choices are presented as well as an open field for institutions not on the list.

Table 4.3: Baseline regression, funding relationships and subsidies

Model	(1)	(2)	(3)	(4)
Dependent variable: Zombie				
Bank	0.000	0.001	0.030	0.000
	(0.007)	(0.007)	(0.026)	(0.007)
Public	-0.008	-0.007	0.000	-0.005
	(0.018)	(0.019)	(0.080)	(0.017)
NonBank	-0.001	0.003	-0.008	0.001
	(0.012)	(0.011)	(0.025)	(0.012)
Equity	0.030***	0.032***	0.062*	0.029***
	(0.011)	(0.012)	(0.034)	(0.011)
Relationship			0.022	
			(0.025)	
Bank X Relationship			-0.039	
			(0.027)	
Public X Relationship			-0.001	
			(0.076)	
NonBank X Relationship			-0.012	
			(0.029)	
Equity X Relationship			-0.038	
			(0.031)	
Subsidied				0.015
				(0.015)
Bank X Subsidised				0.000
				(0.017)
Public X Subsidised				-0.015
				(0.029)
NonBank X Subsidised				-0.021
				(0.019)
Equity X Subsidised				0.008
				(0.026)
Constant	-0.010	-0.002	-0.008	-0.011
	(0.012)	(0.014)	(0.026)	(0.013)
Estimator	OLS	OLS	OLS	OLS
Cluster	Firm	Firm	Firm	Firm
Firm controls	No	Yes	No	No
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	18,278	17,173	10,705	18,278
R-squared	0.025	0.032	0.015	0.025
Number of firms	8,536	7,945	3,372	8,536

Models (1) and (2) show the results of the estimation of equation (1) and models (3) and (4) show the results of the estimation of equations (3) and (4) respectively.
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

type and the funder-firm relationship, proxied by a dummy variable, $Relationship_{ijt}$, that equals 1 if a firm i reports at time $t - h$ to have not changed its main source of funding j over the past three years and zero otherwise:

$$Zombie_{ijt} = \alpha_i + \alpha_t + \beta_1 Funder_{ijt} + \beta_2 Relationship_{ijt} + \beta_3 Funder_{ijt} X Relationship_{ijt} + X'_{it}\gamma + u_{ijt} \tag{4.2}$$

In terms of equation (2), the presence of a sticky relationship (defined as the firm citing no change to their main funding source over the past three years) is not statistically significant for any type of funding source (model 3). This is an intuitive result, given that there is not much variability between funding types in the extent to which funding relationships are sticky.

Another possible explanation for the relationship between zombie status and equity funding (and lack thereof between zombie status and bank funding) is government subsidies. Nurmi et al (2022) find, for example, that government subsidies are related to the presence of zombie firms. In a study using Swedish data (albeit on start-ups), Söderblom et al (2015) find that subsidies signal legitimacy of new ventures, leading them to be able to attract more financial capital. The link found between funding sources and zombie status could possibly therefore be explained by the possibility of the supply of particular types of funding being more sensitive than others to the presence of subsidies.

In testing the potential role for subsidies, a dummy variable for subsidies is used: the variable equals 1 if firm i reported to have been in receipt of subsidised funding (either in the form of loans or equity) in the past twelve months and zero otherwise.

Equation (1) becomes:

$$Zombie_{ijt} = \alpha_i + \alpha_t + \beta_1 Funder_{ijt} + \beta_2 Subsidies_{ijt} + \beta_3 Funder_{ijt} X Subsidies_{ijt} + X'_{it}\gamma + u_{ijt} \tag{4.3}$$

The regression results (Table 4.3, model 4) suggest that self-reported support via subsidies contributes little to zombie status – the coefficients are not statistically significant and have low economic significance.

4.4.1 Zombie firms and bank characteristics

The results discussed above are based on zombie firms and banks in general. The academic literature, however, identifies weak banks (defined in various ways) as driving an increase in zombie incidence instead of banks in general. The logic is that weak banks – closer than other banks to their minimum regulatory capital requirements – forbear on loans to avoid taking a capital hit by writing them off. The external validity of the Finnish case to other jurisdictions may depend on the asset quality and capitalisation of the banking sector, both of which is very high in Finland. The sample used in this section includes only firms

predominantly funded by banks and includes the years 2000-2010 given that the naming of a particular bank as a main external funding source is available on a consistent basis only for those years.

The following model is estimated:

$$Zombie_{ijt} = \alpha_i + \alpha_t + Z'_{jt}\delta + X'_{it}\gamma + u_{ijt} \tag{4.4}$$

where Z_{jt} are bank-level characteristics that the literature (e.g. Storz et al 2017) and credit rating agencies like S&P[4] use in describing the health of a bank: tier 1 capital ratio; total equity to assets as a measure of leverage or equity unweighted by risk; return on average assets; deposits to assets and loan-to-deposit ratios (as a measures of a bank's funding gap and exposure to the wholesale funding markets); liquidity ratio; and profitability metrics – net interest income to total income as a measure of stable revenue and cost-to-income as a measure of operational efficiency (see Table 4.15).

The results support a statistically significant increase in zombie incidence among bank-funded firms since 2000 but no statistically significant relationship between zombie status and bank characteristics (Tables 4.4-4.5, models 5-20).

A results using one- and two-year lags of the independent variables (as in Andrews and Petroulakis, 2019) does little to change the results due to the stickiness of relationships.

4.4.2 Survival analysis: does external finance increase entry to zombie status or decrease zombie exit or both?

The linear probability models above suggest that zombie status is associated with equity funding but not other funding sources but say little about the dynamics behind it. That is, does equity funding increase the entry rate from non-zombie into zombie status? Or does it decrease the rate of zombie exit? Or both? To help answer this question, this section considers non-parametric and semi-parametric survival models.

In terms of flows, Figure 4.5 shows that changes in the stock of zombies are driven by both entries into and exits out of zombie status. Exits out of zombie status are overwhelmingly due to recovery from zombie status as opposed to exit via bankruptcy (Figure 4.6).

The Kaplan-Meier survival rate, a non-parametric estimate of survival probability, gives an indication of survival probabilities (or hazard rates) before the inclusion of any explanatory variables. The area below the survivor function shows the mean duration of zombie status. The Kaplan-Meier survival estimate (Figure 4.7) suggests that less than half of zombie firms remain zombies beyond three years; only a quarter persist as zombies

[4]see e.g. S&P Global Ratings, 2022, "How We Rate Financial Institutions" `https://www.spglobal.com/ratings/_division-assets/pdfs/070813_howweratebanks.pdf`

Table 4.4: Zombie status and bank characteristics — without firm control variables

Model	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable: Zombie								
Tier1 capital	-0.010	-0.004	-0.007	-0.011	-0.015	-0.016	-0.008	-0.008
	(0.012)	(0.022)	(0.023)	(0.024)	(0.024)	(0.026)	(0.029)	(0.029)
Total equity to assets		-0.012	-0.008	-0.002	-0.002	-0.001	-0.003	-0.003
		(0.039)	(0.041)	(0.041)	(0.041)	(0.044)	(0.045)	(0.045)
Return on assets			-0.003	-0.002	0.001	0.001	-0.003	-0.003
			(0.005)	(0.005)	(0.007)	(0.007)	(0.010)	(0.011)
Deposit-to-asset ratio				-0.020	-0.029	-0.032	-0.013	-0.016
				(0.054)	(0.055)	(0.058)	(0.069)	(0.076)
Deposit-to-loan ratio					-0.010	-0.010	-0.001	-0.002
					(0.017)	(0.017)	(0.021)	(0.022)
Liquidity ratio						0.015	-0.000	-0.003
						(0.183)	(0.186)	(0.189)
Net interest income							-0.054	-0.054
							(0.063)	(0.063)
Cost-to-income								0.006
								(0.075)
Constant	0.026*	0.029*	0.031**	0.039	0.057	0.057	0.066*	0.065
	(0.013)	(0.015)	(0.015)	(0.027)	(0.039)	(0.040)	(0.039)	(0.040)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	No	No	No	No	No	No	No	No
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,911	5,911	5,911	5,911	5,911	5,911	5,911	5,911
R-squared	0.015	0.015	0.015	0.015	0.015	0.015	0.016	0.016
Number of firms	2,132	2,132	2,132	2,132	2,132	2,132	2,132	2,132

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. See Table 15 for variable definitions.*

Table 4.5: Zombie status and bank characteristics — with firm control variables

Model	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Dependent variable: Zombie								
Tier1 capital	-0.016	-0.014	-0.016	-0.021	-0.027	-0.024	-0.018	-0.019
	(0.012)	(0.023)	(0.023)	(0.024)	(0.024)	(0.027)	(0.030)	(0.030)
Total equity to assets		-0.005	-0.002	0.006	0.007	0.003	0.002	0.002
		(0.039)	(0.041)	(0.042)	(0.042)	(0.045)	(0.045)	(0.045)
Return on assets			-0.002	-0.001	0.002	0.001	-0.002	-0.001
			(0.005)	(0.005)	(0.007)	(0.008)	(0.010)	(0.012)
Deposit-to-asset ratio				-0.028	-0.039	-0.028	-0.016	-0.020
				(0.054)	(0.054)	(0.060)	(0.070)	(0.077)
Deposit-to-loan ratio					-0.013	-0.013	-0.007	-0.008
					(0.018)	(0.018)	(0.022)	(0.023)
Liquidity ratio						-0.066	-0.077	-0.080
						(0.184)	(0.187)	(0.190)
Net interest income							-0.036	-0.036
							(0.063)	(0.063)
Cost-to-income								0.008
								(0.074)
Constant	0.032**	0.034**	0.035**	0.046*	0.070*	0.071*	0.077*	0.076*
	(0.015)	(0.017)	(0.016)	(0.028)	(0.041)	(0.042)	(0.041)	(0.042)
Estimator	OLS	OLS	OLS	OLS	Firm	OLS	OLS	OLS
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730
R-squared	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Number of firms	2,067	2,067	2,067	2,067	2,067	2,067	2,067	2,067

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

Figure 4.5: Entries and exits out of zombie status

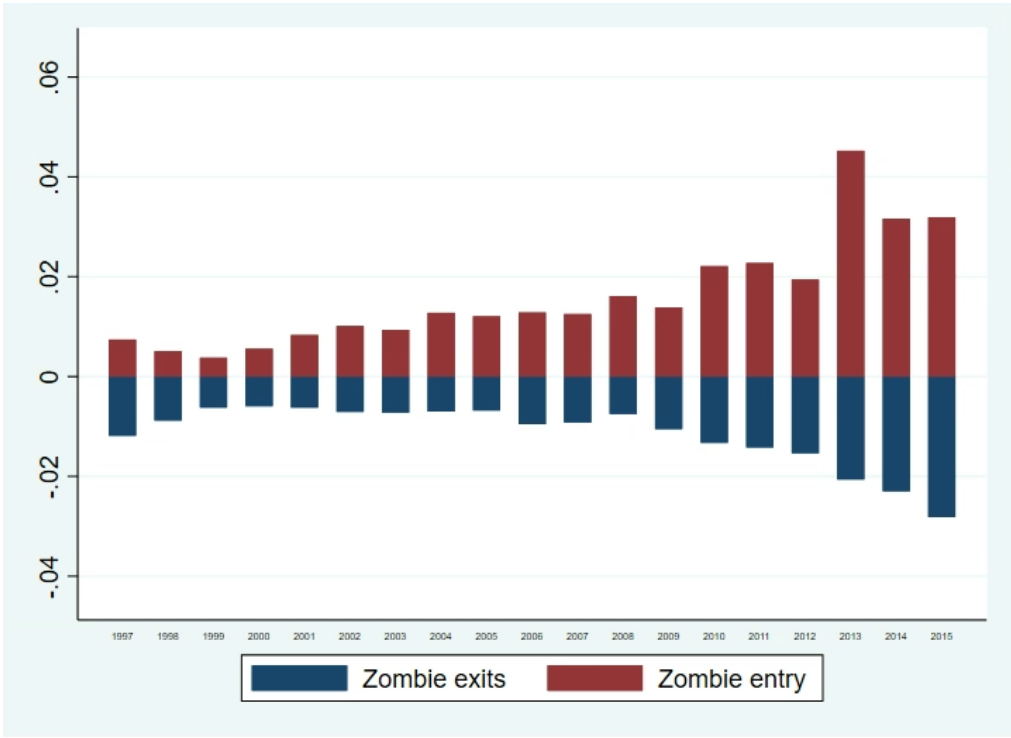


Figure 4.6: Exits out of zombie status: recoveries and bankruptcies

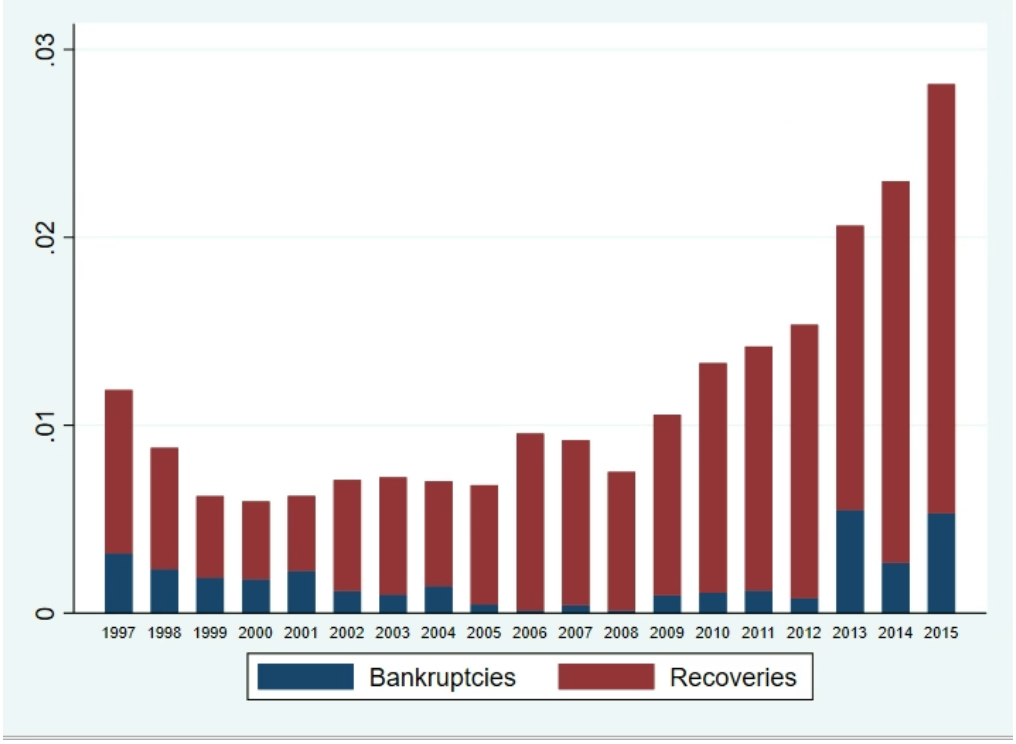


Figure 4.7: Kaplan Meier estimate of zombie survival

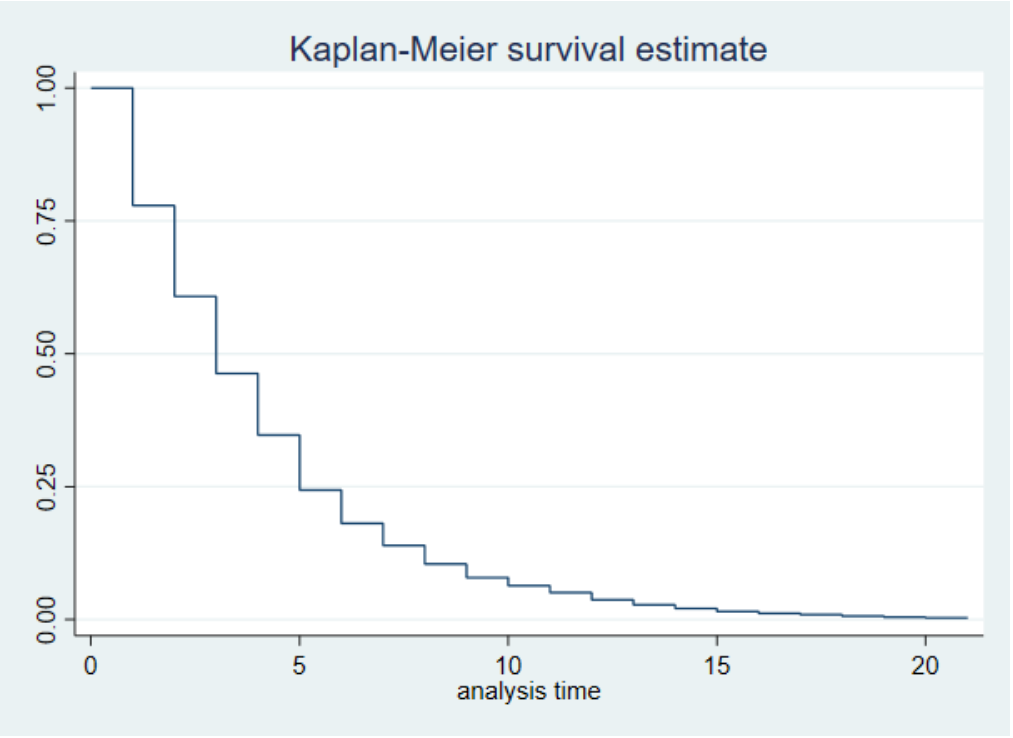
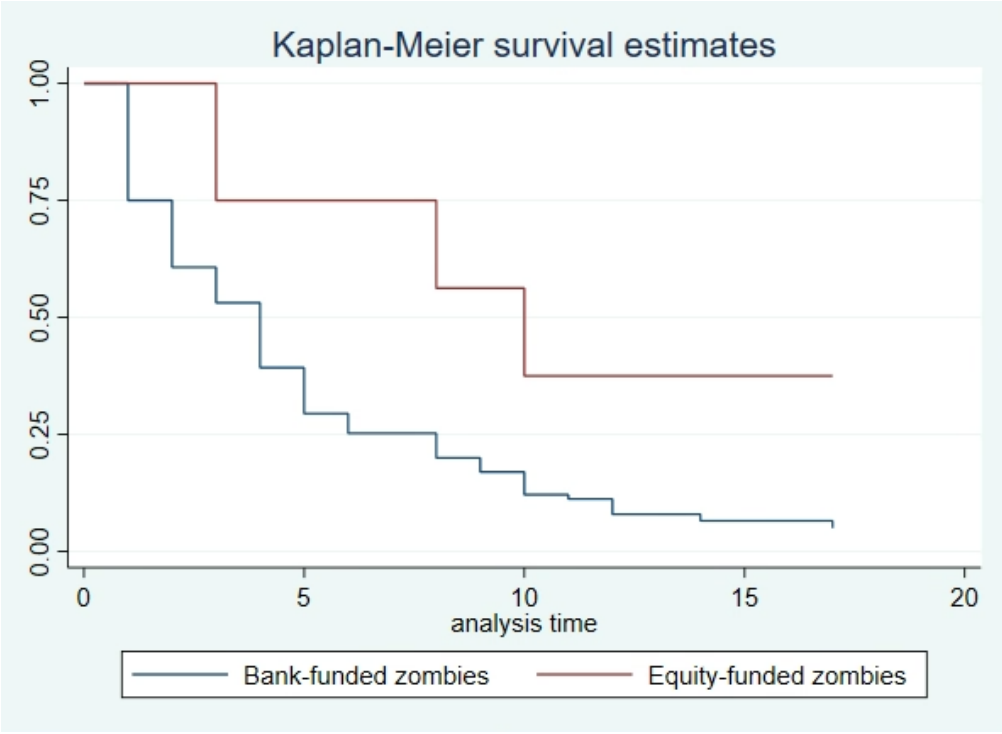


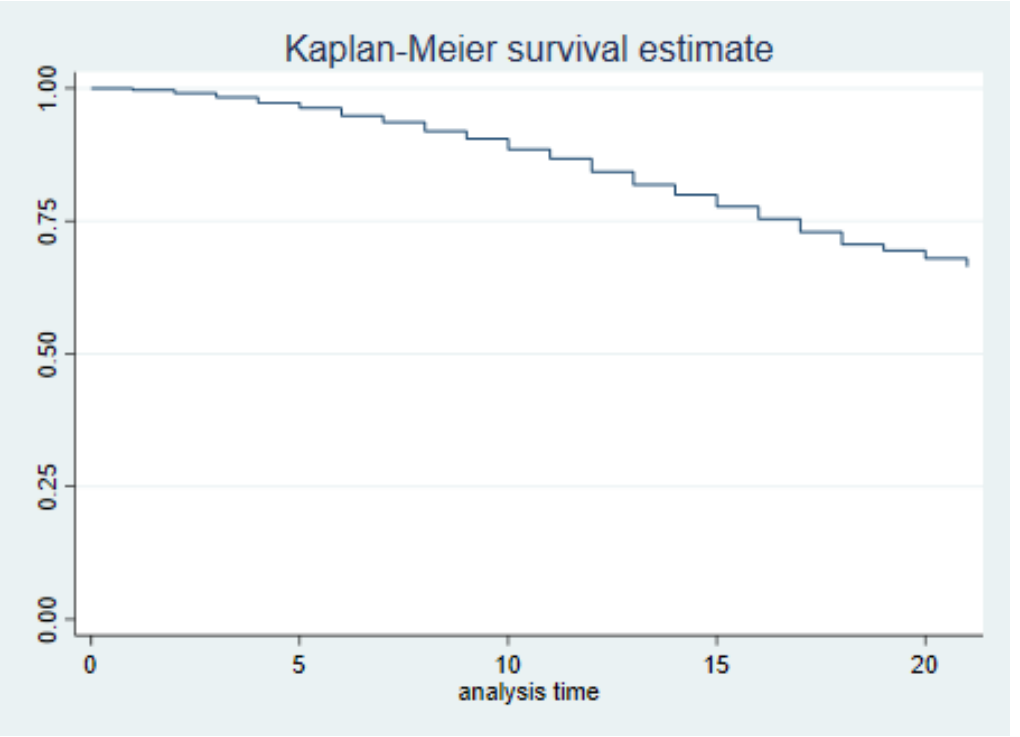
Figure 4.8: Kaplan Meier estimate of zombie survival: bank- and equity-funded zombies



beyond five years. This is broadly the profile for zombies funded by banks, while equity-funded zombie firms persist as zombies for a much longer period, with three-quarters of equity-funded zombies surviving past the five-year mark (Figure 4.8).

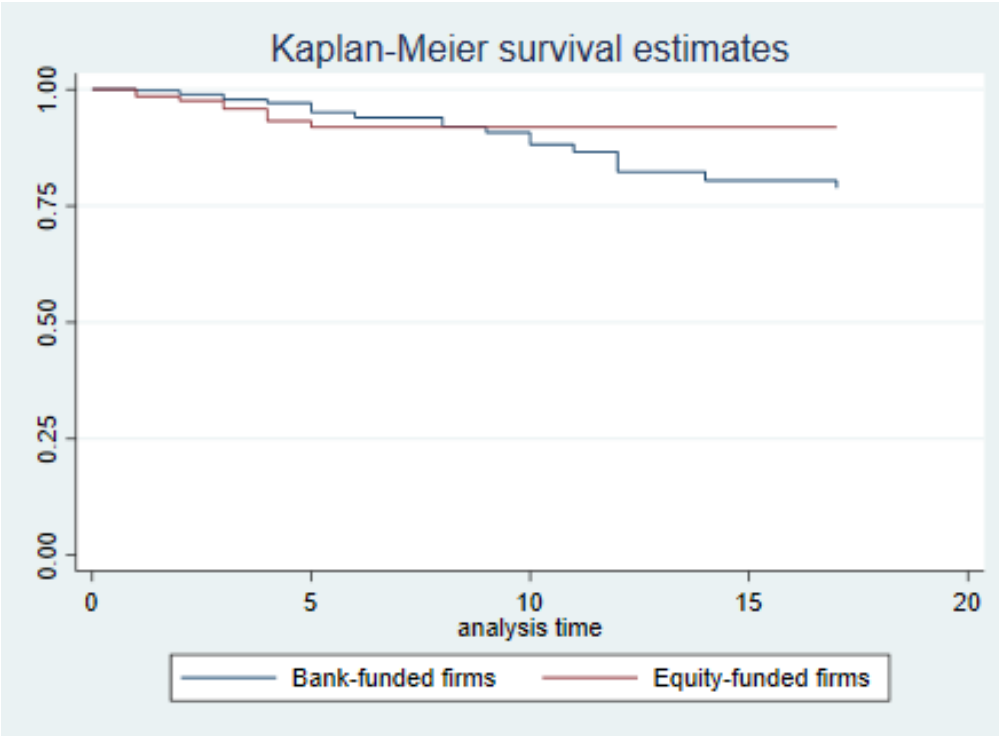
A similar exercise can be conducted for firms where the "failure" event is entry into zombie status. The probability of entry into zombie status is low, as expected based on the estimates of zombie incidence reported above. The risk of zombification increases over time, with the probability of remaining a non-zombie falling to 75% after a lifespan of 20 years (Figure 4.9). Equity-funded firms are more likely than bank-funded firms to fall into zombie status in their first eight years in the survey, but beyond that, the risk of zombification is higher for bank-funded firms than equity-funded firms (Figure 4.10). Given the overlap in the survival curves and the lack of evidence for a statistically significant difference between the distributions based on the logrank test, entry is not explored further in this chapter.

Figure 4.9: Kaplan Meier estimate of firm survival as a non-zombie



The semi-parametric Cox (1972) proportional hazards model can be used to estimate the relationship between different types of funders and the probability of exiting or entering zombie status. The Cox proportional hazards model employs a maximum partial

Figure 4.10: Kaplan Meier estimate of firm survival as a non-zombie: bank- and equity-funded zombies



likelihood estimation method and has the following form (Cox 1972):

$$h_i(t) = h_0(t)exp(X_i'\beta) \tag{4.5}$$

where $h_i(t)$ is the time-t hazard of firm i (t = 1998 – 2015 in this study) which is the probability that firm i will exit zombie status in year t, conditional on the firm i remaining in zombie status in time t. The term $h_i(t))$ is the baseline hazard function that corresponds to the probability of an event when all explanatory variables are zero and controls for the evolution of risk common to all firms in a particular year such as changes in GDP. The term X_i is a vector of explanatory and control variables.

The estimates of the Cox proportional hazards model suggests that all external funding sources, apart from non-bank financial institutions, are associated with a statistically significant increase in the duration or lifetime of a zombie (Table 4.6). The economic significance of the result is the highest for equity and public funding sources, which are associated with a decrease in the exit rate out of zombie status of 72% and 70% respectively. Being predominantly funded by a bank is associated with a 42% decrease in the exit rate. Being funded by a non-bank financial institution is associated with a decrease of 5% in the exit rate but this result is not statistically significant and may be due to the low number of firms reporting non-bank financial institutions as a main funding source. Controlling for funder relationships and subsidies makes little difference to the results. The Schonefeld residuals provide support that the proportionality assumption holds (Table 4.6).

These results are, of course, driven mostly by recovery out of zombie status as opposed to exit through bankruptcy and hence specifying the failure event to be recovery produces similar results (Table 4.6). Being funded by a bank, public funding source or by equity is associated with a longer zombie lifetime. Equity and public funding sources are associated with a decrease in the zombie recovery rate of just under 70%, whereas bank funding decreases the recovery rate of a zombie by 29%. Being funded by a non-bank financial institution is associated with a decrease of 3% in the recovery rate but this result is not statistically significant. Controlling for funder relationships and subsidies makes little difference to the results.

4.4.3 Sensitivity analysis and robustness checks

The results in the previous section suggest that changes in the stock of zombie firms is driven as much by exits as entries into zombie status. This observation brings into question the extent to which the Adalet McGowan et al (2017) definition captures genuine zombie firms as opposed to viable firms facing temporary liquidity squeezes and/or credit constraints; it would be desirable for a bank or non-bank lender to continue to fund firms of the latter sort.

Table 4.6: Cox proportional hazards model results

	Exit			Recovery		
	(21)	(22)	(23)	(24)	(25)	(26)
_t						
Bank	-0.548***	-0.595***	-0.538***	-0.496***	-0.490***	-0.482***
	(0.156)	(0.178)	(0.156)	(0.160)	(0.180)	(0.160)
Public	-1.217**	-1.256**	-1.169**	-1.142**	-1.135**	-1.072**
	(0.510)	(0.512)	(0.520)	(0.516)	(0.520)	(0.526)
NonBank	0.045	-0.052	0.048	0.267	0.266	0.274
	(0.439)	(0.459)	(0.442)	(0.394)	(0.415)	(0.397)
Equity	-1.247**	-1.302**	-1.239**	-1.179**	-1.183*	-1.168*
	(0.605)	(0.612)	(0.604)	(0.601)	(0.607)	(0.600)
Relationship		0.164			0.104	
		(0.347)			(0.328)	
Subsidies			-0.099			-0.154
			(0.194)			(0.201)
Estimator	MLE	MLE	MLE	MLE	MLE	MLE
χ^2 p-value*	0.7956	0.8882	0.8399	0.872	0.9352	0.9356
Observations	580	557	580	607	584	607
χ^2 p-value*	0.7956	0.8882	0.8399	0.872	0.9352	0.9356

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
*P-value for proportional-hazards assumption test based on Schoenfeld residuals.

One way to try to distinguish zombie firms from viable, financially distressed firms is to add the criterion to the zombie definition that the firm has received new credit from a bank in that year, as proposed by Alvarez et al (2023). The authors consider zombie firms as a subset of distressed firms under this condition.

Narrowing the definition of zombies to include only firms that were awarded new credit in that year reduces the number of zombies by around half. Estimates of equation (1) using this narrower definition has little effect on the results apart from reducing the relationship between equity funding and zombie status from around 3% to around 2.5% (Table 4.7, models 29-30).

Table 4.7: Sensitivity analysis

	(27)	(28)	(29)	(30)	(31)	(32)
Dependent variable	Zombie	Zombie	Zombies awarded credit	Zombies awarded credit	Zombies non-investment credit	Zombies non-investment credit
Bank	0.000	0.001	-0.001	-0.001	-0.004	-0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.06)	(0.006)
Public	-0.008	-0.007	-0.010	-0.009	-0.016	-0.013
	(0.018)	(0.019)	(0.016)	(0.017)	(0.012)	(0.013)
NonBank	-0.001	0.003	-0.002	0.003	-0.005	0.000
	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)
Equity	0.030***	0.032***	0.023**	0.025**	0.018*	0.019*
	(0.011)	(0.012)	(0.010)	(0.011)	(0.010)	(0.011)
Constant	-0.010	-0.002	-0.009	-0.002	-0.005	0.000
	(0.012)	(0.014)	(0.012)	(0.013)	(0.011)	(0.012)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	Yes	No	Yes
Observations	18,278	17,173	18,278	17,173	18,278	17,173
R-squared	0.025	0.032	0.023	0.031	0.0178	0.024
Number of firms	8,536	7,945	8,536	7,945	8,536	7,945

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

The self-reported main purpose for applying for new credit provides stronger support, however, for the argument that the Adalet McGowan et al (2017) definition — even when EBIT is replaced with EBITDA — may overstate the zombie problem: low earnings (and hence interest coverage ratio) may reflect higher capital investment. Indeed, the most popular reason for applying for new credit was investment among both zombies (26%) and non-zombies (18%). This holds true particularly for zombie firms predominantly funded by public sources, with 50% reporting that demand for new credit was for the purposes of investment. Firms relying predominantly on their internal funds are the other end of the scale at 9%, suggesting that the share of zombies in this subset of firms is less likely to constitute an overestimate.

Another popular reason for applying for new credit was for cash flow reasons as in e.g. Acharya et al (2019). This was reported much more frequently among zombies (22%) than non-zombies (10%), particularly among firms funded by public sources. This result is unsurprising given that non-zombies would intuitively be expected to have fewer cashflow problems. Similarly, the share of zombie firms citing the need for new credit for replacing existing credit and strengthening their balance sheet was four times higher than that for non-zombie firms.

Narrowing the definition of zombie firms to include only firms that were awarded new credit in that year for purposes other than new investment reduces the number of zombies by another quarter. Estimates of equation (1) using this narrower definition does not change the statistical significance of any of the funder – firm relationships but the economic significance of the relationship between equity funding and zombie status reduces further to just under 2% (Table 4.7, models 31-32).

As robustness checks, the other zombie definitions discussed in section 3 are considered (see Table 4.8), given that the overlap between the definitions can be small. As can be anticipated a priori based on the correlations between different measures (Table 4.2), results using the definition used by Nurmi et al (2022) are very similar to those using the leading measure by Adalet McGowan et al (2017). Equity funding is found to be associated with zombie status, but no other external funding types. Results using the zombie measured proposed Storz et al (2017) also suggest a relationship between equity funding and zombie status but bank funding is also found to have a statistically significant relationship with zombie status. Indeed, the economic significance is higher than that associated with equity. The relationship between bank financing and zombie status is, unlike that between equity financing and zombie status, not robust to the inclusion of control variables, however.

No strong conclusions can be drawn from results using the zombie measures proposed by Schivardi et al (2021). These results (models 39-42) seem to have little in common with each other and with the measures proposed by Adalet McGowan et al (2017), Nurmi et al (2022) and Storz et al (2017). As discussed above, consideration of the Acharya et

al (2020) definition is excluded here, given that the dataset used in this study only allows for a calculation of zombie incidence based on that definition using a very crude measure of implied interest rates as opposed to actual interest rates and hence the definition proposed in Acharya et al (2020) is not considered.

Table 4.8: Robustness checks — alternative definitions

Model	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(42)
	Adalet McGowan et al ('17)		Storz et al ('17)		Nurmi et al ('22)		Schivardi et al ('21a)		Schivardi et al ('21b)	
Bank	0.000	0.001	0.008**	0.005	0.011	0.011	0.052	0.008	0.001	-0.001
	(0.007)	(0.007)	(0.004)	(0.004)	(0.008)	(0.008)	(0.050)	(0.006)	(0.007)	(0.007)
Public	-0.008	-0.007	0.030***	0.024*	0.018	0.021	0.071	0.024	-0.008	-0.008
	(0.018)	(0.019)	(0.012)	(0.012)	(0.018)	(0.018)	(0.053)	(0.016)	(0.018)	(0.018)
NonBank	-0.001	0.003	0.012**	0.008	0.013	0.012	0.074	0.030**	0.023	0.021
	(0.012)	(0.011)	(0.006)	(0.006)	(0.011)	(0.011)	(0.051)	(0.014)	(0.015)	(0.014)
Equity	0.030***	0.032***	0.015**	0.014**	0.033**	0.032**	0.053	0.009	0.015	0.012
	(0.011)	(0.012)	(0.007)	(0.007)	(0.013)	(0.013)	(0.051)	(0.011)	(0.012)	(0.012)
Constant	-0.010	-0.002	-0.020***	-0.009	-0.005	0.007	0.002	0.088***	0.048***	0.077***
	(0.012)	(0.014)	(0.007)	(0.008)	(0.014)	(0.015)	(0.051)	(0.017)	(0.011)	(0.015)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Firm controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,278	17,173	17,405	14,578	14,925	14,673	16,963	16,629	14,434	14,289
R-squared	0.025	0.032	0.008	0.022	0.012	0.019	0.005	0.047	0.005	0.032
Number of firms	8,536	7,945	8,077	6,188	7,204	7,035	7,868	7,670	6,695	6,613

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The dependent variable in each model is zombie status, based on the definitions described in Section 4.2.*

4.5 Conclusions

The literature of zombie firms often identifies bank forbearance (i.e. banks rolling over loans to non-viable firms) as a key factor behind the rise in the incidence of zombie firms. This chapter contributes to the literature on the funding of zombie firms but is unique in considering non-bank sources of finance. The role of non-bank providers of finance has been extensively studied in the corporate finance literature but has so far been overlooked in the literature on zombie firms. To the extent that the implications of the presence zombie firms for productivity — as opposed to just the financial stability — is of interest, the non-bank funding sources of firms — particularly in jurisdiction where these make up a large percent of the credit market — should matter. In using survey data, this chapter goes a step further than other papers in trying to distinguish between genuine zombie firms and viable firms facing temporary liquidity squeezes and/or credit constraints. Self-reported purposes for applying for new credit is used to differentiate between firms trying to overcome cashflow and balance sheet problems from those pursuing new investment projects. This study is also unique in considering the relationship between funding sources and flows into and out of zombie status.

Using Finnish data, banks are found to overwhelmingly be the largest funder of firms classified as zombies using the definitions proposed in the literature, perhaps justifying the focus of the literature on bank funding. This finding may, however, just reflect banks' share of the funding market. Indeed, banks are found to be in the middle of the pack when it comes to the share of zombies as a percentage of all borrower relationships. Out of the firms reporting to be predominantly funded by publicly owned financial institutions, over 8% were classified as zombies compared to around 6.5% and 5.5% among firms funded by banks and by equity, respectively. Further, no statistically significant link can be found between zombie firms and banks, including weakly capitalised banks. Only the relationship between equity funding and zombie status is found to be robust across all specifications. The choice of zombie definition — of which there are many in the literature — is not uncontentious. The stickiness of the funder-firm relationship and the presence of subsidies is not found to make a difference to the results. The results are also little changed when the definition of a zombie is narrowed to only include firms seeking new finance for purposes other than investment.

Changes in the number of zombie firms are found to be driven equally by the number of firms becoming zombies and the number of firms leaving zombie status. No funding source is found to be associated with a higher risk of a healthy firm becoming a zombie. However, all external funding sources, apart from non-bank financial institutions (so called shadow banks), are found to be associated with a longer zombie lifetime. Further, equity funders (that is, the firm's owners) are found to prolong zombie lifetime by more than any other source. The results show, for example, that only a quarter of zombies

financed by banks persist beyond five years, whereas three-quarters of equity-financed zombies make it beyond the five-year mark. Exit out of zombie status is overwhelmingly due to recovery and becoming a healthy firm as opposed to bankruptcy.

The results challenge the perceived wisdom of a link between zombie firms and banks, at least in jurisdictions, such as Finland, that have a highly capitalised banking sector (e.g. IMF 2023) and a relatively efficient insolvency framework (e.g. Becker and Ivashina, 2021). The early literature on zombies (Caballero et al 2008 and Peek and Rosengren 2005) was based on a highly unique institutional setting. In practice, at least in many advanced economies, banks do not tend to roll over loans without the participation of relatively optimistic and/or less risk averse providers of (lower-ranking) financing (see e.g. FSB 2022 for a discussion). Indeed, the results suggest that equity investors continue to fund firms classified as zombies based on definitions proposed in the literature in the (often correct) anticipation of firms recovering. As discussed in Nurmi et al (2022), a firm's exit decision is forward-looking and also based on the present value of future net income as opposed to just current returns. Where non-bank sources of funding are relevant, tackling the zombie problem for example via regulatory scrutiny of the quality of banks' assets as way to avoid prolonged weakness in long-run growth may not be particularly effective. In addition, calls for policy action under e.g. the EU Capital Markets Union to broaden SMEs' access to funding sources could have unintended consequences for the prevalence of zombie firms or at least in the estimates of them.

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Appendix

Table 4.9: Characteristics of zombie and non-zombie firms (all funder types)

Variable	Description	Non-zombie		Zombie		p-value*	St. Error
		Mean	St. Dev.	Mean	St. Dev.		
	Survey data						
Relationship	1 if firm did not change its main funding source in the past three years; 0 otherwise.	0.92	0.28	0.85	0.36	0.00	0.01
Demand	1 if the firm applied for new credit in the past 12 months; 0 otherwise.	0.26	0.44	0.43	0.50	0.00	0.02
AppliedBank	1 if the firm applied for new credit in the past 12 months from a bank; 0 otherwise.	0.20	0.40	0.34	0.47	0.00	0.01
AppliedOther	1 if the firm applied for new credit in the past 12 months from non-bank source; 0 otherwise.	0.14	0.35	0.27	0.44	0.00	0.01
Supply	1 if the firm applied for new credit and was granted it in the past 12 months; 0 otherwise.	0.26	0.44	0.42	0.49	0.00	0.02
Constrained	1 if the firm experienced a deterioration in their access to finance in the past 12 months; 0 otherwise.	0.10	0.30	0.23	0.42	0.00	0.01
Volume	1 if the firm was granted a smaller loan or of shorter maturity than applied for in the past 12 months; 0 otherwise.	0.02	0.14	0.07	0.25	0.00	0.01
Conditions	1 if other loan terms and conditions became less favourable in the past 12 months; 0 otherwise.	0.04	0.19	0.09	0.29	0.00	0.01
Cost	1 if the firm's margins or fees were increased in the past 12 months; 0 otherwise.	0.07	0.25	0.16	0.36	0.00	0.01
Subsidised	1 if the firm was in receipt of subsidised funding over the past 12 months; 0 otherwise.	0.14	0.00	0.21	0.01	0.00	0.01
Denied	1 if the firm had applied for credit but not granted it in the past 12 months; 0 otherwise.	0.03	0.00	0.08	0.01	0.00	0.01

Table 4.9 continued

Variable	Description	Non-zombie Mean	Non-zombie St. Dev.	Zombie Mean	Zombie St. Dev.	p-value*	St. Error
	Survey data continued						
Purpose1: new investment	1 if an application for new credit in the past 12 months was for the purposes of undertaking new investment; 0 otherwise.	0.18	0.38	0.26	0.44	0.00	0.01
Purpose2: cash flow	1 if an application for new credit in the past 12 months was for cash flow reasons; 0 otherwise.	0.10	0.30	0.22	0.42	0.00	0.01
Purpose3: replace existing credit	1 if an application for new credit in the past 12 months was to replace existing credit; 0 otherwise.	0.03	0.18	0.12	0.32	0.00	0.01
Purpose4: strengthen balance sheet	1 if an application for new credit in the past 12 months was to strengthen the firm's balance sheet; 0 otherwise.	0.02	0.14	0.08	0.27	0.00	0.00
Purpose5: other	1 if an application for new credit in the past 12 months was for another purpose; 0 otherwise.	0.05	0.21	0.10	0.30	0.00	0.01
Banking relationships	Actual number of banking relationships (domestic and foreign).	2.02	1.40	2.97	2.47	0.00	0.07
One relationship	1 if the firm reported to have only one banking relationship; 0 otherwise.	0.43	0.50	0.28	0.45	0.00	0.02
Few relationships	1 if the firm reported to have one or two banking relationships; 0 otherwise.	0.76	0.43	0.61	0.49	0.00	0.02
	Financial statement data						
Altman Z-score	Measure of firm creditworthiness.	0.46	0.14	0.62	0.14	0.00	0.00
Return on equity	The ratio of net profit to the sum of equity, value adjustment and optional reserves.**	0.08	42.12	-1.49	20.59	0.00	0.44
Debt to equity ratio	The ratio of non-current creditors to the sum of equity, value adjustment and optional reserves.**	4.21	18.86	1.46	10.86	0.00	0.20

*P-value for the test for equality of the means of the variable between zombie and non-zombie firms.
**Calculated by Statistics Finland.

Table 4.10: Characteristics of zombie and non-zombie firms (internally funded firms)

	Non-zombie		Zombie			
Variable*	Mean	St. Dev.	Mean	St. Dev.	p-value**	St. Error
Survey data						
Relationship	0.96	0.20	0.93	0.25	0.21	0.02
Demand	0.07	0.25	0.13	0.34	0.02	0.03
AppliedBank	0.04	0.21	0.08	0.27	0.01	0.01
AppliedOther	0.05	0.21	0.06	0.23	0.57	0.02
Supply	0.07	0.25	0.15	0.36	0.00	0.03
Constrained	0.04	0.20	0.07	0.26	0.02	0.01
Volume	0.01	0.09	0.01	0.10	0.84	0.01
Conditions	0.01	0.09	0.02	0.15	0.17	0.01
Cost	0.01	0.11	0.05	0.23	0.00	0.01
Subsidised	0.09	0.00	0.12	0.02	0.22	0.02
Denied	0.02	0.00	0.03	0.01	0.26	0.01
Purpose1: new investment	0.05	0.22	0.09	0.29	0.01	0.02
Purpose2: cash flow	0.03	0.18	0.06	0.24	0.02	0.01
Purpose3: replace existing credit	0.01	0.08	0.02	0.14	0.03	0.01
Purpose4: strengthen balance sheet	0.00	0.07	0.01	0.10	0.36	0.01
Purpose5: other	0.02	0.15	0.02	0.15	0.95	0.01
Banking relationships	1.83	1.22	2.15	1.58	0.01	0.13
One relationship	0.50	0.50	0.42	0.50	0.10	0.05
Few relationships	0.81	0.40	0.75	0.44	0.16	0.04
Financial statement data						
Altman Z-score	0.47	0.15	0.65	0.15	0.00	0.01
Return on equity	0.33	9.48	-1.60	17.54	0.01	0.70
Debt to equity ratio	7.21	25.63	1.50	11.05	0.00	1.77

*Variables as defined in Table 3.

**P-value for the test for equality of the means between zombie and non-zombie firms.

Table 4.11: Characteristics of zombie and non-zombie firms (bank funded firms)

	Non-zombie		Zombie			
Variable*	Mean	St. Dev.	Mean	St. Dev.	p-value**	St. Error
Survey data						
Relationship	0.90	0.30	0.82	0.38	0.00	0.02
Demand	0.36	0.48	0.52	0.50	0.00	0.03
AppliedBank	0.32	0.47	0.45	0.50	0.00	0.02
AppliedOther	0.17	0.38	0.30	0.46	0.00	0.02
Supply	0.36	0.48	0.50	0.50	0.00	0.03
Constrained	0.13	0.34	0.25	0.43	0.00	0.01
Volume	0.03	0.16	0.07	0.25	0.00	0.01
Conditions	0.05	0.23	0.10	0.30	0.00	0.01
Cost	0.09	0.29	0.19	0.39	0.00	0.02
Subsidised	0.15	0.00	0.20	0.02	0.00	0.01
Denied	0.03	0.00	0.07	0.01	0.00	0.01
Purpose1: new investment	0.25	0.44	0.28	0.45	0.15	0.02
Purpose2: cash flow	0.15	0.35	0.27	0.44	0.00	0.01
Purpose3: replace existing credit	0.05	0.22	0.15	0.36	0.00	0.01
Purpose4: strengthen balance sheet	0.03	0.17	0.10	0.30	0.00	0.01
Purpose5: other	0.06	0.25	0.13	0.33	0.00	0.01
Banking relationships	2.08	1.42	3.19	2.64	0.00	0.08
One relationship	0.41	0.49	0.25	0.43	0.00	0.03
Few relationships	0.74	0.44	0.58	0.49	0.00	0.02
Financial statement data						
Altman Z-score	0.48	0.11	0.59	0.12	0.00	0.00
Return on equity	-0.99	49.48	-0.80	7.77	0.92	1.97
Debt to equity ratio	4.33	19.40	1.42	9.91	0.00	0.78

*Variables as defined in Table 3.

**P-value for the test for equality of the means between zombie and non-zombie firms.

Table 4.12: Characteristics of zombie and non-zombie firms (firms funded by public sources)

	Non-zombie		Zombie			
Variable*	Mean	St. Dev.	Mean	St. Dev.	p-value**	St. Error
Survey data						
Relationship	0.90	0.30	0.81	0.40	0.16	0.06
Demand	0.47	0.50	0.69	0.47	0.03	0.10
AppliedBank	0.19	0.39	0.27	0.45	0.11	0.05
AppliedOther	0.35	0.48	0.59	0.50	0.00	0.06
Supply	0.48	0.50	0.65	0.49	0.09	0.10
Constrained	0.22	0.42	0.56	0.50	0.00	0.05
Volume	0.05	0.21	0.08	0.27	0.52	0.04
Conditions	0.06	0.25	0.35	0.49	0.00	0.06
Cost	0.12	0.33	0.35	0.49	0.00	0.07
Subsidised	0.40	0.02	0.60	0.06	0.00	0.06
Denied	0.08	0.01	0.17	0.05	0.02	0.04
Purpose1: new investment	0.31	0.46	0.51	0.50	0.00	0.06
Purpose2: cash flow	0.17	0.38	0.37	0.49	0.00	0.05
Purpose3: replace existing credit	0.02	0.15	0.13	0.34	0.00	0.02
Purpose4: strengthen balance sheet	0.02	0.15	0.09	0.28	0.00	0.02
Purpose5: other	0.08	0.27	0.14	0.35	0.07	0.03
Banking relationships	1.98	1.44	3.35	2.35	0.00	0.31
One relationship	0.44	0.50	0.12	0.33	0.00	0.10
Few relationships	0.79	0.41	0.54	0.51	0.00	0.09
Financial statement data						
Altman Z-score	0.50	0.16	0.63	0.13	0.00	0.02
Return on equity	1.83	51.81	-0.34	2.49	0.73	6.20
Debt to equity ratio	8.31	26.80	2.08	13.44	0.06	3.24

*Variables as defined in Table 3.

**P-value for the test for equality of the means between zombie and non-zombie firms.

Table 4.13: Characteristics of zombie and non-zombie firms (firms funded by non-bank private financial institutions)

	Non-zombie		Zombie			
Variable*	Mean	St. Dev.	Mean	St. Dev.	p-value**	St. Error
Survey data						
Relationship	0.84	0.36	1.00	0.00	0.39	0.18
Demand	0.29	0.45	0.25	0.50	0.87	0.23
AppliedBank	0.17	0.38	0.32	0.48	0.05	0.07
AppliedOther	0.31	0.46	0.43	0.50	0.17	0.09
Supply	0.30	0.46	0.25	0.50	0.85	0.23
Constrained	0.13	0.34	0.23	0.43	0.20	0.08
Volume	0.04	0.19	0.00	0.00	0.70	0.09
Conditions	0.05	0.23	0.00	0.00	0.63	0.11
Cost	0.11	0.32	0.00	0.00	0.48	0.16
Subsidised	0.12	0.01	0.04	0.04	0.18	0.06
Denied	0.03	0.01	0.07	0.05	0.15	0.03
Purpose1: new investment	0.33	0.47	0.29	0.46	0.61	0.09
Purpose2: cash flow	0.09	0.28	0.18	0.39	0.10	0.06
Purpose3: replace existing credit	0.04	0.19	0.11	0.31	0.08	0.04
Purpose4: strengthen balance sheet	0.03	0.18	0.11	0.31	0.04	0.04
Purpose5: other	0.05	0.22	0.11	0.31	0.17	0.04
Banking relationships	2.44	1.66	1.75	0.96	0.41	0.83
One relationship	0.30	0.46	0.50	0.58	0.40	0.23
Few relationships	0.66	0.48	0.75	0.50	0.70	0.24
Financial statement data						
Altman Z-score	0.47	0.10	0.58	0.11	0.00	0.02
Return on equity	0.28	5.52	0.56	4.57	0.79	1.06
Debt to equity ratio	8.11	26.85	0.35	4.29	0.13	5.08

*Variables as defined in Table 3.

**P-value for the test for equality of the means between zombie and non-zombie firms.

Table 4.14: Characteristics of zombie and non-zombie firms (equity funded firms)

	Non-zombie		Zombie			
Variable*	Mean	St. Dev.	Mean	St. Dev.	p-value**	St. Error
Survey data						
Relationship	0.90	0.29	0.90	0.30	0.93	0.05
Demand	0.14	0.35	0.20	0.41	0.29	0.06
AppliedBank	0.04	0.20	0.18	0.39	0.00	0.03
AppliedOther	0.15	0.35	0.22	0.42	0.13	0.05
Supply	0.15	0.35	0.25	0.44	0.07	0.06
Constrained	0.06	0.24	0.28	0.45	0.00	0.04
Volume	0.01	0.08	0.18	0.38	0.00	0.02
Conditions	0.01	0.12	0.05	0.22	0.08	0.02
Cost	0.03	0.16	0.03	0.16	0.94	0.03
Subsidised	0.10	0.01	0.22	0.05	0.00	0.04
Denied	0.01	0.00	0.13	0.04	0.00	0.02
Purpose1: new investment	0.10	0.30	0.25	0.44	0.00	0.04
Purpose2: cash flow	0.08	0.27	0.18	0.39	0.00	0.04
Purpose3: replace existing credit	0.02	0.15	0.10	0.30	0.00	0.02
Purpose4: strengthen balance sheet	0.01	0.08	0.07	0.25	0.00	0.01
Purpose5: other	0.03	0.17	0.05	0.22	0.36	0.02
Banking relationships	2.23	1.60	2.83	2.44	0.03	0.27
One relationship	0.38	0.49	0.30	0.46	0.28	0.08
Few relationships	0.69	0.46	0.65	0.48	0.60	0.08
Financial statement data						
Altman Z-score	0.49	0.10	0.62	0.14	0.00	0.01
Return on equity	0.11	4.36	-0.32	3.28	0.45	0.57
Debt to equity ratio	7.97	26.61	0.58	4.52	0.03	3.44

*Variables as defined in Table 3.

**P-value for the test for equality of the means between zombie and non-zombie firms.

Table 4.15: Characteristics of survey firms' main bank financiers

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Tier1 capital	Tier 1 Capital as % of total risk-weighted assets	5,911	0.11	0.03	0.06	0.20
Total equity to assets	Average total equity as % of average total assets	5,918	0.06	0.02	0.03	0.12
Return on assets	EBIT as % of average of total assets as of time t and t-1	5,918	0.72	0.50	-1.60	2.56
Deposit-to-asset ratio	Customer deposits as % of total assets	5,918	0.41	0.14	0.19	0.68
Deposit-to-loan ratio	Customer deposits as % of gross loans	5,911	0.58	0.14	0.32	0.81
Liquidity ratio	Cash and cash-equivalents as % of total assets	5,911	0.10	0.07	0.02	0.29
Net interest income	Net interest income as % of total revenue	5,911	0.57	0.11	0.35	0.84
Cost-to-income ratio	Operating income as % of total operating income	5,911	0.52	0.11	0.34	0.94