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Essays on financial intermediation, stability, and regulation

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Abstract

Modern banking theories provide a host of explanations for the existence of intermediaries, highlight their important influence on economic growth, delineate the risks inherent in the services they provide, and illustrate the market failures and real costs of bank failures that precipitate the need for regulation and oversight of the sector. This thesis is a collection of three essays that looks at three of these key aspects of financial intermediaries – the development of financial intermediaries, the function of the lender of last resort that has emerged as an important part of the safety net afforded to financial intermediaries, and the occurrence of financial crises.

The first chapter of this thesis provides an introduction to the academic literature on financial intermediation covering different theories put forward to explain their emergence, and highlighting the risks inherent in their operation. It emphasizes the crucial functions they perform in the economy and makes a case for regulation and oversight of the sector to reduce the incidence and alleviate the effects of financial crises.

The second chapter seeks to determine the policy and institutional factors that influence the development of financial institutions as measured across three dimensions – depth, efficiency, and stability. Applying the concept of the financial possibility frontier, developed by Beck and Feyen (2013) and formalized by Barajas et al. (2013b), we determine key policy variables affecting the gap between actual levels of development and benchmarks predicted by structural variables. Our dynamic panel estimation shows that inflation, trade openness, institutional quality, and banking crises significantly af-

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fect financial development. We also assess the impact of the policy variables across the different dimensions of development thereby identifying complementarities and potential trade-offs for policy makers.

The third chapter models the role of the lender of last resort (LoLR) in a general equilibrium framework. We allow for heterogeneous agents and a risk-averse banking sector, and incorporate the frictions of endogenous default, liquidity, and money. Adverse supply shocks in monetary endowments trigger default, leading to deterioration in the value of bank assets, and subsequent bank illiquidity in some states of the world. LoLR intervention is then assessed with regards to its economy-wide effect on welfare, bank profitability, and the level of default. The results provide a justification for constructive ambiguity.

The fourth chapter aims to provide an explanation for the incidence of financial crises by combining insights from agency theory and Minsky's financial instability hypothesis (Minsky, 1992) in a model with endogenous default. Our theoretical model shows that the probability of a financial crisis increases as the quality of shareholder information decreases. We then develop a measure for the quality of shareholder information following Simon (1989) and show that the market-wide quality of shareholder information: i) is poor (with no trend) in the Pre-SEC period (1840 to 1934); ii) improves substantially following the SEC reforms; and iii) gradually declines starting in the 1960s/70s until it is now back to pre-SEC levels. This matches up with the standard list of US financial crises (as in Reinhart and Rogoff 2009; Reinhart 2010) and supports our hypothesis that the likelihood of a financial crisis increases with deterioration in the quality of shareholder information.

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Chapter 1

Introduction

The ubiquity of the emergence of financial systems and intermediaries in societies, worldwide and through time, underscores the importance of the services they provide. Jones (2014) provides an excellent survey of studies of the banking and financial systems of ancient civilisations - from the Ur III Empire in Sumer to Athenian Greece. Temin (2004) provides detailed picture of the sophistication of financial intermediation in the early Roman Empire. In his magisterial treatise on premodern financial systems, Goldsmith (1987) studies the financial systems of the ancient Mesopotamians, Periclean Athens, the Roman Empire, the Abbasid caliphate, the Ottomans, the Mughals, Japan under the Tokugawa shogunate, as well as the major empires of medieval Europe - Florence, Elizabethan England, and the United Provinces. The seemingly inevitable emergence of intermediaries in all these civilisations reiterates the role of financial intermediation as the lynchpin of any sophisticated economy.

That banks and other financial intermediaries serve a useful (and essential) economic purpose has been well established in academic literature.[1] Modern banking theories provide a host of explanations for the existence of intermediaries, highlight their important influence on economic growth, delineate the risks inherent in the services they

[1] See Gorton and Winton (2003) for an excellent survey of the literature on financial intermediation.

provide, and illustrate the market failures and real costs of bank failures that precipitate the need for regulation and oversight of the sector. This thesis is a collection of three essays that looks at three of these key aspects of financial intermediaries – the development of financial intermediaries, the function of the lender of last resort that has emerged as an important part of the safety net afforded to financial intermediaries, and the occurrence of financial crises. The first paper seeks to determine the policy and institutional factors that influence the development of financial institutions as measured across three dimensions – depth, efficiency, and stability. The second paper models the role of the lender of last resort (LoLR) in a general equilibrium framework and provides a justification for the policy of constructive ambiguity. The third paper aims to provide an explanation for the recent increase in the incidence of financial crises by combining insights from agency theory and Minsky's financial instability hypothesis (Minsky, 1992).

Initial attempts to justify the existence of intermediaries focused on their role as providers of transaction systems in the economy. Fama (1980) states that the two main functions of banks are (a) the provision and maintenance of a payments and accounting system, and (b) passive portfolio management – buying securities on the asset side and issuing demand deposits as liabilities. Another approach by Benston and Smith (1976) asserts that intermediaries endogenously emerge owing to costly market failures in financial markets but focuses on transaction costs, and economies of scope. The rapid development of the telecommunications and transactions industry and subsequent reduction in costs has forced a revision of this approach. Asymmetric information has since emerged as the key friction in financial markets that necessitates the existence of intermediaries.

Leland and Pyle (1977) posit that financial intermediaries stem as a "natural response to asymmetric information" in financial markets. Moral hazard prevents direct information transfer between borrowers and lenders, but intermediaries act as monitors, gathering costly information. By buying and holding assets based on this specialized information, they provide benefits to depositors who wouldn't have easy access to this information. Diamond (1984) further states that intermediaries achieve diversification and economies of scale by monitoring multiple projects with uncorrelated returns, thereby enabling them to credibly communicate returns on their portfolio to ultimate investors at a lower cost than would occur in a non-intermediated financing system. Allen (1990), and Ramakrishnan and Thakor (1984) assume that the market for such information on entrepreneurial ventures is imperfect, and the issue of credibility of information provides a reason for the existence of intermediaries. In Allen (1990), original sellers of information cannot capture the full value of their information leading the way for intermediaries to take up some of the remaining value. In Ramakrishnan and Thakor (1984), intermediaries (diversified information brokers) emerge as it is profitable for information producers to aggregate when the reliability of their information cannot exactly be known. Campbell and Kracaw (1980) argue that "intermediaries emerge as information producers because the production of information, the protection of confidentiality, the provision of transaction services, as well as other intermediary services, are naturally complimentary services."

James (1987) provides yet another justification for the existence of banks. In this paper, he studies 300 firms' stock price responses to public announcements of bank credit agreements, private placements and public debt offerings. He finds that firms using bank loans and private debt are, on average, 25% smaller than those relying on public debt financing giving banks an important role as credit provider to smaller businesses that do not have the credibility to directly tap into capital markets. Additionally, he finds statistically significant abnormal returns on stocks following bank loan announcements after accounting for loan maturity, loan purpose and bond ratings. This suggests that banks, in issuing credit, perform an active role in monitoring the projects of borrowers, and are seen to be certifiers of risky projects.

Goodhart (1987, p. 78) elucidates the basic idea of a bank's business, "Initially goldsmiths received deposits of gold coin from customers and acted purely as safety vaults. It was the realization that it would be profitable, and under most circumstances relatively safe, to loan out some proportion of these reserves to prospective borrowers, in addition to the loans made on the basis of their own capital, that transformed such entrepreneurs into bankers." As formally modeled in Bryant (1980) and Diamond and Dybvig (1983), fractional-reserve banks, and other such intermediaries, therefore furnish the liquidity needs of agents facing uncertainty with regards to the timing of their consumption by providing demand deposits which may be liquidated instantly and as per Tobin (1985) "are more convenient than currency itself." The bank uses the obtained funds to make out longer term, illiquid loans, and purchase other securities that together comprise its assets. The presence of the intermediary that provides this useful function of maturity transformation yields better *ex-ante* allocations for consumers, but its healthy functioning depends on the fact that the demand for short-term liquidity would not be greater than its current (easily liquidated) assets.

As shown in Diamond and Dybvig (1983), although banks provide better risk-sharing amongst agents, they are also susceptible to runs, even if they are solvent, as this is a Nash equilibrium. The problem of coordination amongst depositors leads to such runs because even though a depositor may earn more if he does not run, given that others do, it is in his best interest to do so too. Since deposits are liquid and paid out first-come-first-serve and are generally backed by illiquid, long-term assets, a run on an otherwise solvent bank would force a 'fire sale' of such assets at depressed prices making the bank insolvent. Diamond & Dybvig dub such an external trigger which causes depositors to believe that others will run on the bank a 'sunspot'. Chari and Jagannathan (1988) model bank runs as equilibrium phenomena. Agents either withdraw deposits based on information about the future health of the bank or to furnish liquidity needs. If the number of agents withdrawing is sufficiently large, uninformed agents start to withdraw too, precipitating a run. But imperfect information implies that there might also be a panic equilibrium where a bank run may occur even though no agent receives any adverse information about the future health of the bank. Calomiris and Gorton (1991) show that banking panics in America were not sunspot phenomena and were foreseeable based on the level of business failures (default) and stock price declines. Morris and Shin (2004) further study the idea of coordination failure under incomplete information. Incomplete information about payoffs to different agents in a coordination game could be seen as a more realistic reason for the incidence of bank runs than mere sunspots. Successful coordination by creditors therefore requires a "forceful facilitator" to orchestrate such an effort.

Solow (1982, p. 238) states, "If a run does occur, there is always a chance that it will cumulate, because any bank failure diminishes confidence in the whole system and brings stronger banks under increased pressure. The consequences of a banking crisis are likely to extend beyond the banking system into the 'real' economy.". Bernanke (1983) studies the Great Depression and argues that in addition to the loss of depositor wealth and rapid contraction of the money supply, financial crises (bank failures, and debtor bankruptcies) in 1929-30 also affected output in the US due to the severe subsequent contraction in lending activity. This credit squeeze affected aggregate demand, turning the "severe but not unprecedented downturn of 1929-30 into a protracted depression." Calomiris and Mason (1997) study the Chicago banking panic of 1932 and find that state income growth had an elasticity of 45% with respect to bank loan supply growth, implying that a credit squeeze has a significant impact on real output. Ashcraft (2005) studies the two separate incidences of bank failure in the US in the late 1980s and notes that the subsequent contagion induced failures of subsidiary banks, and a persistent decline in real economic activity.

Academic literature on relationship banking and the value created by the screening process inherent in the lender-borrower relationship between banks and firms puts forward another detrimental effect of bank failures. As modelled in Diamond (1984, 1989, 1991), Sharpe (1990), and Rajan (1992), there is informative value in the client relationships that banks form with firms that they lend to and this value is lost when these banks fail, implying costs for society in terms of screening effort by new banks and signalling effort by firms. Diamond and Rajan (2005) extend the model in Diamond and Rajan (2001) and show that bank failures can initiate and propagate systemic crises, even when depositors do not panic, i.e. even when their actions are coordinated, and without banks being linked *ex-ante* through contracts. This is because banks make relatively illiquid relationship loans and an individual bank's failure causes a contraction in available aggregate real liquidity which may lead to or intensify a liquidity shortage. Additionally, some smaller borrowers that do not have access to direct capital markets, as shown in Diamond (1991), and James (1987), would be unable to raise funds.

While the literature on asymmetric information and the monitoring role of intermediaries provides a valid explanation for their existence, the question arises, "who monitors the monitors?" – *Quis custodiet ipsos custodes?* As Freixas and Santomero (2003) put it, "with incorrect incentives, market failures will occur in the absence of regulation of individual banks and the banking system as a whole."

Tobin (1985) states, "our monetary and banking institutions have evolved in a way that entangles competition among financial intermediary firms with the provision of transactions media." The need for regulation, however, does not stem solely from the legacy of the evolution of the monetary system. "The use of a common monetary unit of account and the adoption of generally acceptable media of exchange in this numeraire carry important positive externalities. Free market competition by itself cannot protect these social benefits." Market discipline may be one way to solve the agency problems inherent in the depositor-manager relationship, as discussed in Calomiris and Kahn (1991), but this would imply that depositors are able to perfectly monitor the actions of bank managers, which seems unrealistic. In the absence of complete information, it is the perceived confidence in bank managers' prudence that keeps solvent banks from being run on. This, however, is a fairly precarious situation, which Freixas and Santomero (2003) dub "the inherent instability of the banking system". This inherent instability, and the potential contagion that follows from bank failures, mandates a need for external intervention and regulation.

The last century has therefore witnessed the creation of a broad safety net for the financial system including deposit insurance, risk adjusted capital requirements and other regulation, and the lender of last resort (LoLR) facility, that is generally envisaged, supervised and administered in varying degrees by central banks. The ideal administrative structure and burden sharing of such roles between different government agencies varies across nations and is still open to debate. Bordo (1986); Goodhart (1988); Miron (1986) claim that the establishment of central banks and the development of their role as overseers of the banking system have led to a mollification of the fractious nature of the system and reduced incidences of banking crises. That being said, the mere presence of a safety net does not guarantee stability but instead may increase risk taking – a classic case of moral hazard. Kareken and Wallace (1978) and Bhattacharya et al. (1998) find that deposit insurance invites insured banks to seek excessive portfolio risk and keep lower liquid reserves relative to the social optimum and must therefore be coupled with other regulatory restrictions to limit risk taking. Demirgüç-Kunt and Detragiache (2002) study a sample of 61 countries between 1980-1997 and find that explicit deposit insurance schemes increase the incidences of banking crises in countries that do not complement them with effective prudential regulation.

Research in financial intermediation is therefore intimately connected with institutions, regulation, and stability. This thesis is compiled as a set of three essays that study financial intermediation with a focus on these three themes. The first paper addresses the development of financial intermediaries and the role that financial and economic policy plays in this development. The second takes an in-depth look at the role of the lender of last resort in a full-fledged general equilibrium setup and seeks to pin down optimal bailout policy in this framework. The third essay seeks to provide an explanation for the incidence of financial crises that adds to the currently accepted explanations of credit cycles, and investor optimism.

Chapter 2

Policy determinants of financial development and stability

This chapter is based on a paper that was primarily written during my time as an intern at the International Monetary Fund. The paper has been co-authored with my internship supervisors Sami Ben Naceur and Raja M. Almarzoqi. The majority of the work was done by me with my co-authors acting as overseers. The paper was published as an IMF working paper in July 2015 (Almarzoqi et al., 2015).

2.1 Introduction

The debate on the effects of finance on economic growth has been active for decades, raising opinions ranging from inconsequential and "very badly over-stressed" (Lucas Jr, 1988) to seemingly obvious (Miller, 1998). Bagehot (1873) and Schumpeter (1911) have argued, more conservatively, that the interplay between finance and growth is positive and non-trivial. Goldsmith (1969) was the one of first studies to empirically investigate this relationship, finding a positive correlation between financial development (as measured by the size of the financial sector) and long-run growth. He (and later, Bencivenga and Smith, 1991) explained this correlation through the fact that intermediation leads to savings being better channelled into productive investment. In their treatises on financial liberalization, Shaw (1973) and McKinnon (1973) posited that eliminating financial repression would enhance growth, as the elimination of interest rate ceilings would increase the quantity of savings in the economy. However, these studies did not address the issue of causality in either direction.

One of the first attempts at demonstrating that the financial system promotes economic growth was by King and Levine (1993) who found that indicators of financial development were strongly correlated with growth, and that these indicators also had significant power in predicting future growth rates. Rajan and Zingales (1998) found a similar causal link between financial development and growth by showing that the development of financial intermediaries and markets has a disproportionately large positive effect on sectors more dependent on external financing. Levine et al. (2000) provided further evidence of this finance-growth causality through instrumented variable procedures, using the difference in legal and accounting systems across countries as instruments. Beck et al. (2000) incorporated dynamic panel techniques (difference and system GMM estimators) to further strengthen their argument that financial intermediaries exert a large positive impact on factor productivity growth. Furthermore, Levine and Zervos (1998) examine the contribution of the development of financial markets to growth, finding that the development of financial institutions – banks and financial markets – promotes growth, capital accumulation, and increased productivity, even after controlling for economic and political factors.

It is therefore now widely accepted that financial institutions positively influence economic development and growth. A healthy financial system helps channel household savings into value-creating investments, monitors borrowers to increase efficiency, helps agents pool, share and diversify risk, and facilitates trade. Levine (1997), Levine (2005),

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Demirgüç-Kunt and Levine (2008), Beck (2012), and Barajas et al. (2013a) provide detailed surveys of the literature on the finance-growth nexus.

In addition, there is another large body of literature that studies the role financial development in reducing inequality. Beck et al. (2007) find that the long-run impact of financial development on the income of the poorest quintile stems from both an increase in aggregate growth effect and a reduction in income inequality. Jalilian and Kirkpatrick (2002, 2005) find a similar poverty reducing effect of financial development in low-income countries. Jeanneney and Kpodar (2011) argue that financial development helps alleviate poverty through the aggregate growth channel and through the McKinnon (1973) conduit effect. However, they also warn that financial development breeds instability which serves to negate some of the benefits of financial development on poverty reduction, and find evidence for both their hypotheses in a panel of data from developing countries. This highlights another fairly well-accepted theme in the finance-growth literature – that the relationship between financial development and growth is not monotonic.

Academic literature notes several different forms of non-linearity in the relationship between financial development and economic growth. Rioja and Valev (2004) find that the marginal effect of additional financial development on growth is dependent on the current level of financial development with uncertain effects at the very low end of the spectrum (i.e. low levels of development), a large positive effect in economies with an intermediate level of financial development, and a smaller positive effect in developed financial systems. Aghion et al. (2005) similarly find that economies above a certain threshold level of financial development face a positive (and diminishing) return from additional financial development and converge to the same level of long-run growth, whereas those below the threshold attain a lower level of long-run growth. Demetriades and Hook Law (2006) highlight the importance of institutions to the functioning of the finance-growth nexus. Using a panel data set from 72 countries, they find that the magnitude of the effect of financial development on economic growth in an economy is directly related to the quality of the institutional framework in that economy, with the relationship being particularly weak in poor institutional settings.

While a burgeoning financial sector can boost growth opportunities, excessive and rapid expansion can also create instability and lead to crises. The empirical analysis of Arcand et al. (2012) suggests that beyond a certain size, development of the financial sector starts having a significant negative effect on growth, even after controlling for volatility, crises, and other institutional factors. Dabla-Norris and Srivisal (2013) study the relationship between macroeconomic volatility and financial development in a sample of 110 countries and find that financial development acts as a shock absorber against volatility but only up to a point; beyond a certain level, financial systems exacerbate shocks and increase volatility. In a remarkably prescient paper, Rajan (2006) warned that rapid development of the financial sector increases its capacity to bear risk, but also increases the actual level of risk taken, increasing systemic risk and leaving the entire financial sector more vulnerable to left tail events. Beck et al. (2012) analyse micro and macro data from 32 developed economies and find that increased levels of financial innovation between 1996 and 2006 were associated with both increased levels of economic growth, and increased levels of economic volatility and idiosyncratic bank fragility. In light of these trade-offs, recent studies[1] have put forward the idea of an 'optimal' level of financial development for an economy.

Building on the work of Beck and De La Torre (2007) and Beck and Feyen (2013), Barajas et al. (2013b) formalize this idea through the concept of the financial possibility frontier. They posit that the level of financial development in a country depends on both structural characteristics such as income, population, demographics and other fundaments that are outside policy control in the short to medium run, and on policy

[1] See Beck and De La Torre (2007), Beck et al. (2008), Beck and Feyen (2013), and Barajas et al. (2013b).

and institutional variables. To support this argument they construct benchmarks based on such structural variables and relate the gaps between the predicted benchmarks and actual values of financial development, measured by the depth of the financial sector, to a host of policy and institutional variables using cross-country ordinary least squares (OLS) regressions. They also show that sustained overshooting of the benchmark is associated with a significant increase in the probability of a bad credit boom, lending further credence to the idea of optimizing financial development, instead of maximizing it.

Furthermore, financial systems are multidimensional. The very idea of financial development itself merits more elaborate treatment than to just proxy it with financial depth or the size of the banking sector.[2] While financial depth remains the most widely researched and widely reported measure of financial development, recent benchmarking studies[3] outline a more well-rounded approach to assessing financial development by measuring it along four dimensions – depth, access, efficiency and stability.

In this paper, we seek, in two ways, to extend and improve the analysis carried out by Barajas et al. (2013b). Firstly, we extend the analysis to three dimensions of financial development – depth, efficiency, and stability – based on the availability of data and benchmarks. This provides a more rounded assessment of the effects of policy on financial development and also brings to light possible complementarities and trade-offs in the way different policy measures affect the different dimensions of financial development. Our choice of indicator variables for the different dimensions is driven by data coverage and the availability of benchmarks. We use private credit as a percentage of GDP as the indicator for depth, net interest margin as the indicator for efficiency, and non-performing loans as a percentage of total gross loans as the indicator for sta-

[2] Honohan (2004) highlights some of the inadequacies of proxying financial development solely with financial depth and proposes more composite measures of development that better summarize its multidimensionality.

[3] See Beck et al. (2008), Čihak et al. (2012), Beck and Feyen (2013), and Feyen et al. (2013).

bility. While these are standard, widely-used indicators of financial development, for robustness checks (available on request) we also re-ran the regressions reported in tables 2.11-2.13 using other theoretically appropriate indicators, including domestic deposits to GDP, banks' assets to GDP, banks' cost to income ratio, lending to deposit spread, banks' Z-score, and private credit to deposits ratio.[4] The size and the significance of the estimated coefficients vary, but these robustness tests serve to confirm our broad findings.

Secondly, we make use of annual data in order to maximize the data set and better identify the policies of interest. This necessitates the use of a dynamic specification to allow for adjustments towards a steady state. We therefore include a lagged regressand in the right hand side of our specification and employ dynamic generalized method of moments (GMM) estimators, allowing for endogeneity in the model. The current constraint on the availability of benchmarking data limits our analysis to banking institutions, and to indicators of banking sector development. However, the considerable breadth and depth of coverage of the indicators we analyse makes the results of this study relevant to a large set of countries, and in particular, to developing countries where the banking sector makes up a large part of the formal financial sector.

Our dynamic panel estimation shows that inflation, trade openness, institutional quality, and the occurrence of banking crises significantly affect the different dimensions of financial development. Moreover, while most of these policy variables have a complementary effect across the different dimensions some others have a contradictory effect posing a trade-off for policy makers.[5]

This paper contributes to several strands of literature. We further the idea of the finan-

[4] Since we did not have benchmarks available for all these alternate indicators, the regressions done on these indicators are only done using the second model specification discussed in Section 4.

[5] Our analysis assumes that the different dimensions of financial development are orthogonal to each other. Since we regress each dimension with the same set of policy and institutional variables, we assess complementarities and trade-offs based on the signs of the estimated coefficients of each regressor with each of the different dimensions of financial development.

cial possibility frontier, and more broadly of benchmarking, as an important conceptual tool to assess health of the financial systems of counties and to guide the course of policy measures. This builds on the work of Beck and De La Torre (2007), Barajas et al. (2013b), and Beck and Feyen (2013) on the financial possibility frontier, and of Beck et al. (2008), and Feyen et al. (2013) on benchmarking the financial sectors of countries across different dimensions of development. Additionally, we identify the effects of various policy variables on the different dimensions of financial development, thereby providing a more nuanced assessment of their impact on wider financial development and highlighting potential complementarities and trade-offs.[6] This contributes to the large body of literature on the determinants of financial development which we review in section 3 of this paper. Moreover, we employ panel data techniques to better exploit the cross-sectional and time-series variation of recent data and provide a more technically sound analysis of the policy determinants of financial development.

The rest of the paper is organized as follows. Section 2 elaborates on the concept of the financial possibility frontier. Section 3 discusses relevant literature on the determinants of financial development. Section 4 outlines the empirical strategy employed in this paper including the specification of the dynamic model and appropriate estimation techniques. Section 5 describes the data used in the analysis. Section 6 reports the estimation results, and robustness checks employed. Section 7 features our conclusions.

2.2 The financial possibility frontier

Financial intermediaries arise in economies due to the presence of market frictions that restrict the free flow of capital from savers to borrowers. Uncertainty, informational

[6]Our analysis of the complementarities and trade-offs faced by policy makers is admittedly basic. A more detailed study of such complementarities and trade-offs, employing interaction terms and other extensive analysis of correlations among different policy variables, is beyond the scope of our paper but would be an interesting topic for further research.

asymmetries and limited enforceability, transaction costs, and network externalities are some of the frictions that necessitate the presence of intermediaries. The presence of uncertainty in a world of risk-averse agents yields a demand for the pooling and sharing of risk and for diversification and insurance. The costs of assessing and monitoring potential investments, and of drawing out and enforcing contracts, give rise to financial institutions that specialize in these informational and legal services. Fixed costs associated with financial transactions give rise to economies of scale and are another contributing factor to the emergence of specialist intermediaries. However, financial intermediaries do not completely eliminate these market imperfections, and the very frictions that facilitate their emergence and the demand for their services also limit their efficient operation and the supply of such services.

Intermediaries themselves face fixed costs that include the costs involved in setting up physical branches, computer networks, and legal, accounting, security and support services. While the marginal influence of these costs diminishes as the demand for financial services increases, these substantial fixed costs pose an initial hurdle for the emergence and development of intermediaries. Moreover, in light of recent technological advances and an increase in financial globalization, financial services are beginning to exhibit properties of network goods.[7] This network effect acts as a barrier to new entrants and increases the market power of incumbent intermediaries thereby producing an externality in the supply of financial intermediation. Further, intermediaries also face risk, notably that of default, and their ability to diversify such risk is another supply side constraint.

The first use of a frontier framework to denote a constrained optimal level of intermediation based on demand and supply side frictions was in Beck and De La Torre (2007). They study the different constraints on the demand and supply side that influence the access to financial services in an economy and design an access frontier framework.

[7] See Claessens et al. (2003).

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The central tenet of this framework is that the maximum level of financial access that an economy can sustain at a certain point in time is dependent on a number of state variables. Beck and Feyen (2013), and Barajas et al. (2013b) expand this analysis to other dimensions of financial development and formulate the financial possibility frontier. This framework uses the concept of state variables to define the financial possibility frontier as "a rationed equilibrium of realized supply and demand, variously affected by market frictions."[8] To elaborate, the frontier denotes the maximum sustainable level of the development of the financial system of an economy at a given point in time. It may vary, depending on the nature of underlying frictions, for different types of financial markets, and it may be measured across several dimensions of financial development.

Based on the position of a country's financial system relative to the financial possibility frontier, Beck and Feyen (2013), and Barajas et al. (2013b) define three different types of policies to effect long-term financial development. Market developing policies such as legal and structural reforms and long-run changes in fiscal performance help push the financial possibility frontier of an economy outwards. Market enabling policies help push countries towards the frontier, and include short to medium term policies such as macroeconomic policy measures (inflation targets, growth rate, etc.), regulatory reforms (banking regulations, tax and competition policy), and financial and trade openness. Finally, market harnessing policies are measures put in place to ensure that a country does not consistently overshoot its frontier. Such policies include risk oversight and macro-prudential management, and programs to increase financial literacy and the protection of consumers' rights. The focus of our study is primarily on market enabling policies. We seek to understand which short to medium term policy and institutional variables significantly affect the different dimensions of financial development.

While the intuition behind the financial possibility frontier is appealing, mathematically formalizing this concept is a tougher task. To this end the authors use structural bench-

[8] Barajas et al. (2013b), p. 6.

marks, building on earlier work by Beck et al. (2008), and Čihak et al. (2012). These benchmarks employ a large cross-country panel to produce time varying benchmarks for various financial development indicators, based on a number of structural variables that are invariant in the short-run and assumed to lie outside the domain of policy makers. This benchmark is not a direct proxy for the financial development frontier but, instead, isolates the structural element of financial development with the remainder being a function of policy and institutional factors.[9] Barajas et al. (2013b), focus their analysis on financial depth as measured by private credit (extended by banks and other financial institutions) as a fraction of GDP. They calculate benchmarks for a large panel of data and define the financial depth gap as the difference between the benchmark for a given year and the actual value of the indicator for that year. They then run a host of cross-country OLS regressions on the average gap over 2003-07 to identify policy and institutional determinants of financial depth.

This analysis makes a few assumptions that merit clarification. Firstly, the benchmarking exercise and subsequent gap analysis assumes that the benchmark accounts for all key structural variables. This methodology therefore does not account for initial conditions that may affect the path of financial development. In other words, two countries with the same values of structural variables in a year will have the same benchmark, irrespective of their origins. In light of the uniqueness of individual countries' structural and institutional natures, and the occurrence of financial crises and leapfrogging, this assumption may not necessarily hold. Moreover, the benchmarks are based on the notion of (the development path of) the 'median country'. Given the heterogeneity within countries, this implies that the policies identified as influencing financial development (in the gap analysis) may significantly vary in relative importance between countries, and over time. It must therefore be noted that this exercise serves primarily to broadly identify policies that influence financial development. More detailed analyses need to

[9] Including institutional factors in the benchmarking regression would raise the issue of endogeneity, which we address in our analyses by the use of dynamic panel estimators. See section 4 for more details.

incorporate a more nuanced approach, accounting for country-specific factors.

The structural variables used in the benchmarks created by Feyen et al. (2013), which we use in our analyses, are broadly classified as follows:[10]

- Economic Development
  - GDP per capita
  - Square of GDP per capita
- Demographics
  - Population size
  - Population density
  - Age dependency ratio, old
  - Age dependency ratio, young
- Special circumstances
  - Offshore financial centre dummy
  - Oil exporter dummy
  - Transition economy dummy

Economic development influences financial development from both the supply and the demand side. Higher income increases the demand for the amount and variety of financial intermediation. Intermediaries in wealthier economies are also able to exploit economies of scale better. Demographics also affect the various market frictions affecting the demand and supply of financial services. A larger population implies a larger potential market for intermediation and also an increased potential for economies of scale in the provision of such services. A high population density further facilitates the supply of financial services by reducing fixed costs, and through the network effect.

[10] These benchmarks are obtained by quantile (median) regressions, to reduce the impact of outliers.

Age dependency ratios are good indicators of saving and lending patterns that influence the demand for intermediation. Revenues from oil exports tend to increase national income disproportionately as compared to financial development, and this is accounted for by the oil exporter dummy variable. Similarly, offshore financial centres have a disproportionately larger financial sector that needs to be accounted for. In addition, the benchmarks also incorporate time dummies to tease out global cycle effects within the pooled regressions.

2.3 Determinants of financial development

Financial intermediation has been a pervasive feature of economies all over the world and through time. Financial intermediaries have emerged to play a central role in the transfer of an economy's savings into productive investment. This has made financial systems and their development an age old topic of study and research. Moreover, the importance of the financial sector to economic growth and to the distribution of economic opportunities makes understanding and managing its development all the more paramount. There is a vast body of economic literature focusing on the determinants of financial development. As discussed in section 2, the financial possibility framework broadly divides these determinants along two lines: a set of policy-invariant structural variables and policy and institutional variables. The set of structural variables used in our analysis, is highlighted in section 2 above. We survey below, some of the literature on the policy and institutional determinants of financial development.

Institutions and the legal and regulatory environment are one of the most studied factors that promote the development of a healthy financial system. La Porta et al. (1997), Levine (1998), and Levine et al. (2000) find that financial development is stronger in economies where institutions better protect and enforce property rights and reinforce the rights of creditors. Further, Acemoglu et al. (2005), and Demetriades and Andrianova (2005) also find that the existence and quality of institutional checks and balances significantly influences crisis mitigation and the success of financial reforms.

Another strand of literature focusing on the political economy of financial development argues that financial development is constrained in economies where a narrow elite or interest groups exert significant pressures on the shaping of policy and reforms. Rajan and Zingales (2003) hypothesize that opening up an economy to international trade and finance may weaken the political influence of incumbents and promote financial development. They corroborate this hypothesis by showing, in a global sample, that financial development and trade openness are positively correlated when cross-border flows are high. Their work also emphasizes the influence of institutions on the impact of interest group activity and reiterates the importance of institutions on financial development. Chinn and Ito (2006) show that financial openness (capital account liberalization) positively influences financial development, albeit only after a certain level of institutional and legal development has been attained. Baltagi et al. (2009) further examine the Rajan-Zingales hypothesis using data from developing and developed countries, as well as dynamic panel estimation techniques, and find that both financial and trade openness are significant determinants of banking sector development. Girma and Shortland (2008) examine the effects of democracy characteristics and regime change on the financial development of countries using panel data. Their analysis shows that regime stability and fuller democracy promote financial development.

Macroeconomic stability is essential for the smooth functioning of a financial system. Higher inflation reduces real returns and makes investment and saving less attractive. Boyd et al. (2001) find that countries with endemic inflation problems experience significantly lower levels of financial development. Rousseau and Wachtel (2002) similarly find that lower inflation aids financial development, and in economies with inflation rates consistently over 13% the finance growth nexus breaks down. Recent studies have also looked at the importance of remittances in promoting the development of the financial sector, particularly in developing countries. Aggarwal et al. (2011) use a broad panel and dynamic estimates to find evidence of a robust and significant positive influence of remittances on financial development. There is mixed evidence of the impact of competitiveness on development. Beck (2008) concludes that empirical studies focusing on individual countries show ambiguous results whereas cross-country studies (such as Pería and Mody, 2004) find a significant positive effect.

Based on the literature surveyed above, we use the following policy variables in our analyses:

- Macroeconomic variables
  - (Real) growth rate
  - Inflation rate
  - Remittance inflows
  - Banking crisis dummy
- Openness variables
  - (De jure) financial openness
  - Trade openness
- Institutional variables
  - Polity score
  - Composite risk rating
- Market power / competitiveness[11]
  - Lerner index

A more detailed description of the variables and the data follows in section 5.

[11] Used only in the analysis of the efficiency dimension of financial development.

2.4 Methodology

2.4.1 Model specification

The aim of this study is to identify key policy determinants of three different dimensions of financial development. To this end, we attempt to make the utmost use of the depth (time-series) and breadth (cross-section) of the available panel data. Using annual data necessitates the use of a dynamic specification. Moreover, financial development data are usually very persistent, further pushing for the inclusion of dynamics. We therefore specify the following dynamic model, based on the gap analysis of Barajas et al. (2013b):

$$Gap_{i,t} = \alpha Gap_{i,t-1} + \mathbf{P'_{i,t}}\beta + u_{i,t} \tag{2.1}$$

where *Gap* is the relative deviation (from the structural benchmark)[12] of an indicator of a specific dimension of financial development, and **P** is the vector of policy variables outlined in section 3. The error term $u_{i,t}$ has three components:

$$u_{i,t} = \mu_i + \epsilon_t + \nu_{i,t}$$

where μ_i are the fixed effects, ϵ_t are the time varying global components and $\nu_{i,t}$ are the independent, mean zero (idiosyncratic) error terms.

As was mentioned in section 2 above, one of the main criticisms of the gap analysis is the fact that the benchmark assumes that all structural variables are accounted for. The ramifications of this assumption are particularly severe if one of the omitted variables is

[12] $Gap_{i,t} = {}^{(FD_{i,t} - FD^{BM}_{i,t})}/_{FD^{BM}_{i,t}}$
where FD is the level of an indicator of a specific dimension of financial development and FD^{BM} is its benchmark level based on structural variables. ***We reverse the sign in the definition of the gap for efficiency and stability to facilitate the comparison of the influence of policies across the three dimensions.*** For details, see table 2.1 and section 6.

correlated with the policy variables **P** used in the subsequent estimations. As a check against this possibility of biased estimates, we also estimate the model below:

$$FD_{i,t} = \alpha FD_{i,t-1} + \mathbf{S'_{i,t}}\beta + \mathbf{P'_{i,t}}\gamma + u_{i,t} \tag{2.2}$$

where FD is the level of an indicator of a specific dimension of financial development, **S** is a vector of structural variables,[13] and **P** is the vector of policy variables outlined in section 3. The error term again consists of fixed effects, time varying global components and independent, mean zero (idiosyncratic) error terms.

In both specifications, we tease out the time varying global effects ϵ_t through a set of time dummies.

2.4.2 Dynamic panel GMM estimation

In the model specifications above, the lagged regressand included in the right hand side is endogenous to the fixed effects in the error term. The lagged regressand depends on $u_{i,t-1}$ which in turn depends on μ_i – the fixed effect for country i. OLS and fixed effects estimates for such specifications therefore suffer from dynamic panel bias as demonstrated in Nickell (1981). The most popular strategy to circumvent this endogeneity problem is to use the difference GMM estimator outlined in Arellano and Bond (1991). They use the first difference transform to expunge fixed effects, and use higher lags of the endogenous regressors as internal instruments. In unbalanced panels however this transform may cause large data loss and so the forward orthogonal deviations transformation of Arellano and Bover (1995) is more commonly used. Furthermore, Blundell and Bond (1998) find that if the regressand has high persistence (i.e. α has an absolute value close to 1) then difference GMM estimators perform poorly. This is because in the

[13] In our estimations, we use the following four structural variables: real GDP per capita, population size, population density, and age dependency ratio. For details, see table 2.1.

case of high persistence, the regressand behaves like a random walk and so past values are uninformative about future changes. Therefore higher order lags of the regressors are weak instruments for the differenced variables (Roodman, 2009). The preferred estimator in this case is the system GMM estimator developed by Arellano and Bover (1995), and Blundell and Bond (1998). In this case, instead of removing fixed effects through differencing (or forward orthogonalisation) of the regressors, the instruments i.e. higher order lags of regressors are instead differenced to make them exogenous to the fixed effects. These higher order differences now serve as internal instruments for the regressors.

Both difference and system GMM estimators employ moment conditions for the instruments used. These conditions are valid based on the assumption that the disturbances $\nu_{i,t}$ are truly independent, i.e. that they are serially uncorrelated. The Arellano-Bond test therefore checks for serial correlation in the residuals by testing the residuals in the differenced equations for serial correlation. Since the differenced residual $\Delta\nu_{i,t} = \nu_{i,t} - \nu_{i,t-1}$ is related to $\Delta\nu_{i,t-1} = \nu_{i,t-1} - \nu_{i,t-2}$ by definition, finding evidence of first-order serial correlation is to be expected. The key test is therefore to check for second-order serial correlation in the differenced residuals. One needs to be unable to reject the null hypothesis of no second-order serial correlation.

In addition, it is standard in GMM regressions to run the Sargan/Hansen test to check for the joint validity of the instruments. As Roodman (2009) notes, having too many instruments can over fit the endogenous variables and inadequately deal with the endogeneity, leading to an 'excessively large' Hansen statistic. Using the rule of thumb in Roodman (2009), we limit the number of instruments to less than the number of countries in each of our regressions by restricting the number of lags in the GMM-style instruments and by using the collapsing method of Holtz-Eakin et al. (1988).

In our regressions, we run difference (with forward orthogonal deviations) and system GMM estimations on both specifications of our model, as appropriate, and include the standard diagnostic checks highlighted above. We run three separate formulations for each specification of the model treating policy variables are exogenous, predetermined, and endogenous, respectively. The lagged dependent variable is always treated as endogenous. In the first two formulations, wherein we assume the policy variables to be exogenous, and predetermined, we lag the policy variables by one period to make our assumptions less contentious. This ensures that we are immune to biases in our estimates caused by contemporaneous shocks to the regressand and the policy variables. In the second model specification when we include structural variables as controls, these variables are always treated as exogenous and therefore also lagged by one period. For all six of our runs we also include pooled OLS and fixed effects estimations which, while technically incorrect, provide a useful check on our results particularly in regard to the coefficient of the lagged dependent variable.

2.5 Data: measurement and sources

We compiled a data set spanning 180 countries and 28 years (1984-2011) using data from a number of different sources. The final panel was unbalanced and indicator coverage varied for the different dimensions of financial development. The final data set used for the analysis of banking sector depth consisted of 2396 observations across 115 countries between 1984 and 2011. For efficiency and stability the coverage was from 1998-2011 and the data sets consisted of 1179 observations across 103 countries, and 930 observations across 85 countries, respectively.

The financial development indicators and benchmarks were obtained from the FinStats 2014 database compiled by the World Bank.[14] Private credit as a percentage of GDP was used as the indicator for depth, net interest margin as the indicator for efficiency, and non-performing loans as a percentage of total gross loans as the indicator for sta-

[14] See Feyen et al (2013).

bility. From the list of theoretically appropriate candidates, the indicator representing each dimension was chosen based on the availability of benchmarks, the sample size, and breadth (countries) and depth (years) of coverage.

Macroeconomic data[15] were obtained from the World Economic Outlook (WEO) data set at the IMF, the World Development Indicators (WDI) and Global Financial Development (GFDD) data set from the World Bank. The measure of trade openness was constructed as the ratio of real imports to real GDP. We feel that the frequently used definition of trade openness as the ratio of net exports to GDP may be misleading as it overstates the level of openness in the case of countries with large reserves of natural resources which are 'forced' to export once domestic demand is met. The measure for financial openness was chosen to be the 'de jure' measure constructed by Chinn and Ito (2008). We use two measures of political and institutional quality in our analysis – the polity score as calculated by the Polity IV project and the average annual composite risk rating obtained from International Country Risk Guide (ICRG) – a monthly publication of the Political Risk Services (PRS).

Detailed definitions of the variables used in our analyses are provided in table 2.1, while tables 2.2 – 2.7 provide summary statistics of data sets used in the analyses of the different dimensions of banking sector development.

2.6 Empirical analysis

2.6.1 Estimation results

The main results of this paper are presented in tables 2.8 – 2.13. Tables 2.8, 2.9, and 2.10 report the results of estimating equation 2.1 using the development gaps for depth,

[15] Our dataset included a few of episodes of hyperinflation, e.g. Zaire in 1994 (23,773%), Georgia in 1994 (15,606%), and Nicaragua in 1987 (13,109%). These outliers were exponentially larger than the

efficiency, and stability, respectively, whereas tables 2.11, 2.12, and 2.13 report the results of estimating equation 2.2 using the indicators for banking sector depth, efficiency, and stability. In each of the tables we see that the p-values for the Arellano-Bond test for second order serial correlation (AR(2)) is sufficiently high. The p-values for the Hansen tests confirm that the instruments are appropriate in each case. In each of our regressions, we find that lags[16] of the y-variable are significant, validating the choice of a dynamic specification. Finally, comparing the results from the gap analysis, i.e. those fitting equation 2.1, with those from the second specification, we find that the policy determinants of the different dimensions as determined by either specification are largely similar. While a few determinants lose significance when switching from model 1 to model 2, we do not observe a reversal in sign for any of the variables.

Tables 2.8 and 2.11 examine the policy determinants of financial depth. Our indicator for financial depth is the amount of private credit extended as a fraction of GDP. The higher this indicator is, the greater is the depth of the financial sector. Further, given the definition of the financial depth gap[17], a positive gap implies that the financial sector is over-performing with regards to depth. Therefore, in both tables, variables with positive coefficients can be thought of as positively influencing financial depth. First off, we find that financial depth (and depth gap) exhibits a very high level of persistence. We therefore focus more on the results of system GMM estimations. Our results show that growth, banking crises, trade openness and the quality of institutions (as measured by the composite risk rating) influence financial depth. The positive effect of growth rate on financial depth is significant when we treat it as (lagged) exogenous and (lagged) predetermined but it loses significance when endogenised. The occurrence of banking crises significantly reduces financial depth, as expected. Increasing trade openness in an econ-

majority of the inflation data series and grossly skewed results forcing us to drop these observations (top 1% values) from our dataset.

[16] In the case of financial depth, we needed to add second order lags to obtain satisfactory results.

[17] See table 2.1 for detailed definitions of all the variables used in our analyses.

omy also seems to positively influence financial depth, as does having better institutions.

The policy determinants of financial efficiency are assessed in tables 2.9 and 2.12. The indicator for financial efficiency is the net interest margin in the banking sector. As opposed to depth, greater efficiency would mean we observe a lower level of this indicator. In our definition of efficiency gap we *reverse the sign* so as to facilitate comparison of the influence of policies across all three dimensions. Therefore a variable that positively influences financial efficiency would have a positive coefficient in table 2.9 and a negative coefficient in table 2.12. Our results show that higher inflation seems to be detrimental to financial efficiency, which seems intuitive as a more stable macroeconomic environment would promote the cost effectiveness of the financial system. As per the results of table 2.9, banking crises seem to have a positive effect on efficiency, though this loses significance in the alternate specification in table 2.12. This could be explained by the purging effect of crises wherein weaker, inefficient banks are wiped out by a crisis and overall efficiency may end up being improved. The results also seem to suggest that stronger institutions also promote efficiency though the significance of this relationship is lower. Interestingly we find that the Lerner index of the competitiveness of the banking sector is insignificant in the gap analysis but is significant in the second model specification. The relationship is as expected, with greater competitiveness spurring an increase in efficiency.

Finally, tables 2.10 and 2.13 look at the policy determinants of financial stability. The indicator for this dimension is the fraction of total loans that are non-performing. As in the case of efficiency, a more stable financial system would have a lower value of this indicator.[18] Therefore, we *reverse the sign* in the definition of the stability gap as well.

[18] A number of studies (Shubik and Wilson, 1977; Dubey et al., 2005) have studied default in a general equilibrium setting and discuss the notion of the optimal level of default in an economy. Their discussion would suggest that lowering the fraction of non-performing in an economy to zero is in fact welfare reducing. Such arguments further highlight the usefulness of the frontier analysis to guide policy. Working towards a constrained optimal level of financial stability would be more appropriate than trying to increase the level of stability outright.

Financial development and stability

A policy variable seen to positively influence financial stability would therefore have a positive coefficient in table 2.10 and a negative coefficient in table 2.13.[19] Our regressions show that the key policy determinants of financial stability are growth, banking crises, inflation, and to a lesser extent institutions. The positive effect of growth on stability is extremely significant and persists through all specifications. Higher growth would imply an increase in real returns on projects and an increased capacity to repay loans, reducing the amount of non-performing loans. The results in table 2.10 would suggest that an increase in inflation might aid financial stability but this effect all but disappears in the results of second model specification in table 2.13. The effect might be explained by the fact that inflation reduces the real rate of interest on loans thereby easing the debt burden. As expected, banking crises are shown to reduce financial stability though this result also loses significance in the second model specification. Finally, the quality of institutions is yet again a significant factor as an increase in the risk rating is shown to increase financial stability.

2.6.2 Robustness checks

We test the robustness of the results of our analyses by re-running them under three separate limiting situations. For our first robustness check, we trim the sample to low and middle income countries by excluding all data from high income countries – both within and outside the OECD. Our second robustness check limits the data sample to the period before the global financial crisis (i.e. up to 2007). Our final robustness check tests the impact of outliers in the regressand on our results. To this end we repeat the analysis on the middle 95% of the regressand values i.e. we trim out the top and bottom 2.5% values of the y-variable for each of our regressions. The results of our robustness checks are presented in tables 2.14 – 2.19.

[19] In order to obtain statistically satisfactory results we had to use second lags of inflation, remittances, trade openness, and the composite risk rating when treating them as predetermined.

Financial development and stability

In the case of financial depth, we find that most of our results are resilient to the robustness checks. While trimming the sample to developing countries significantly reduces the breadth of the sample, most of the effects observed in the full sample still persist. Growth still plays an important, positive role in increasing financial depth, while institutions become even more important. The level of democracy (polity score) becomes a significant positive factor in some of the specifications for the developing country sample. Remittances seem to have a negative effect on financial depth in our robustness checks but this effect disappears in the second model specification. The pre-crisis sample and trimmed sample show the same general results with growth, banking crises, and institutional quality being the most significant of the explanatory variables.

The robustness checks for financial efficiency also provide validation for the previously reported results. The negative impact of high inflation on financial efficiency holds through the most of the robustness checks. Institutions still seem to play a role though this is not the case for the developing countries sample. The coefficient of the banking crisis dummy variable loses significance, and this is not altogether surprising. Finally, the measure of competitiveness remains significant through most specifications and seems particularly significant in developing countries.

The impact of reduced sample sizes in the robustness checks is most severe for the indicator of financial stability. When the analysis is limited to developing countries, the sample width is almost halved. The implications of this are quite drastic, with only growth and banking crises retaining some explanatory power in developing countries. Our results do better in the trimmed sample and we find that growth, inflation, banking crises and institutional quality are significant determinants of financial stability.

2.7 Conclusions

This paper sought to determine the key policy determinants of financial development as measured across three dimensions – depth, efficiency, and stability. To this end, we employed the financial possibility frontier framework which splits the determinants of financial development into two categories – structural fundamentals, and policy and institutional factors. This framework was operationalized by benchmarking economies based on their structural fundamentals. Analysing the gap between the actual values of indicators of financial development and their values predicted by structural benchmarks, we identified the policy determinants of the different dimensions of financial development. We ran an alternate model specification and a battery of robustness check to thoroughly vet our results. Table 2.20 summarizes the impact of the different policy and institutional variables considered on the three dimensions of financial development studied.[20]

The financial possibility frontier is an intuitively appealing framework to assess the suitability of policy measures targeting financial development. Knowing where a country stands relative to its structural benchmark would point to the appropriate set of policy tools be they market-enabling, market-developing or market-harnessing. Moreover, such analysis must be extended to all dimensions of financial development to offer a more fine-tuned diagnosis of a country's financial development. Finally identifying the effect of individual policy variables on the different dimensions enables us to design the appropriate policy mix to address the needs of an economy.

In conclusion, we reiterate that the main purpose of this study is to identify the policy determinants of financial development across three main dimensions – depth, efficiency and stability. We do not explicitly consider the political economy of financial develop-

[20] An up arrow indicates a postive causal link between the policy variable and the dimension of financial development while a down arrow indicated a negative causal link. Stronger links are shown in black.

ment and financial policy,[21] instead treating policy variables as exogenous in the sense that governments may enforce them in an unconstrained manner to influence financial development along these three dimensions.[22] Finally, it must be stressed once again that even though our analysis is carried out on a broad sample of countries using relatively long time series, our results are meant to guide intuition in country-specific policy analyses rather than to prescribe global solutions for local maladies.

[21] See Girma and Shortland (2008), Haber and Perotti (2008), and Benmelech and Moskowitz (2010) for discussions on the political economy of financial development.

[22] While some of the variables included in our analyses – trade and financial openness, and polity score, act as simplistic indicators of the strength of the political influence of domestic incumbents, as theorised by Rajan and Zingales (2003), and of the transparency and accountability of policy makers, we do not explicitly consider the political calculus of financial policy and reform.

Table 2.1: Analysis variables: definitions, units of measurement and sources

Variable	Definition	Unit of measurement	Source
Financial Development Indicators			
Private Credit	Domestic private credit to the real sector by deposit money banks to GDP. Data obtained from IMF International Financial Statistics.	% of GDP	FinStats
Net Interest Margin	Accounting value of banks' net interest revenue as a share of its average interest-bearing (total earning) assets. Net Interest Revenue (or Income) = Gross interest and dividend income - Total interest expense. Total Earning Assets = Total loans + Total Securities + Investments in property + Other earning assets. Data obtained from Bankscope	%	FinStats
Non-Performing Loans	Non-performing loans to total gross loans. Data obtained from the IMF Global Financial Stability Report.	% of Total Gross Loans	FinStats
Depth Gap	Defined as the difference between actual value of private credit/GDP and the predicted benchmark value divided by the benchmark. Benchmarks are calculated using median regressions of indicators on structural variables (GDP/capita, its square, population, population density, age dependency ratios - old and young, dummies for fuel exporters, transition countries and offshore financial centres, and time dummies), across a large panel. $Gap_{i,t} = (Level_{i,t} - Benchmark_{i,t})/Benchmark_{i,t}$	relative deviation from benchmark	FinStats
Efficiency Gap	Defined as the difference between the predicted benchmark value and the actual value of net interest margin and the benchmark value divided by the benchmark. ***Note the reversal in sign.*** $Gap_{i,t} = (Benchmark_{i,t} - Level_{i,t})/Benchmark_{i,t}$	relative deviation from benchmark	FinStats
Stability Gap	Defined as the difference between the benchmark value and the indicator value of NPL/total gross loans and the benchmark value divided by the benchmark. ***Note the reversal in sign.*** $Gap_{i,t} = (Benchmark_{i,t} - Level_{i,t})/Benchmark_{i,t}$	relative deviation from benchmark	FinStats
Macroeconomic Variables			
Growth Rate	Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2005 U.S. dollars. GDP per capita is gross domestic product divided by midyear population.	% change in real GDP	WDI
Inflation	Annual percentage change in consumer prices	% change in CPI	WEO
Remittance Inflows	Workers' remittances and compensation of employees comprise current transfers by migrant workers and wages and salaries earned by non-resident workers. Data are the sum of three items defined in the fifth edition of the IMF's Balance of Payments Manual: workers' remittances, compensation of employees, and migrants' transfers.	% of GDP	GFDD
Banking Crisis	Dummy variable for the presence of banking crisis (1=banking crisis, 0=none). Obtained from Laeven and Valencia (2012).	Dummy variable	GFDD
Openness Variables			
Financial Openness	A 'de jure' measure of financial openness calculated as the first principal component of four binary dummy variables that codify restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions.	Chinn - Ito Index	Chinn and Ito (2008)
Trade Openness	Calculated as the ratio of real imports to real GDP.	% of GDP	WEO
Institutional Variables			
Polity Score	A codified measure of a country's political regime based on Jaggers and Gurr (1995), and Marshall and Jaggers (2002). Scores can range from -10 to 10, with 10 representing a full democracy.	Polity Index, -10 to 10	Polity IV Project
Composite Risk Rating	The International Country Risk Guide (ICRG) rating comprises 22 variables in three subcategories of risk: political, financial, and economic. A separate index is created for each of the subcategories. The Political Risk index is based on 100 points, Financial Risk on 50 points, and Economic Risk on 50 points. The total points from the three indices are divided by two to produce the weights for inclusion in the composite country risk score. The composite scores therefore ranging from zero to 100 with a higher score implying lower risk.	Risk Score, 0 to 100	ICRG
Market Power			
Lerner Index	A measure of market power in the banking market. It compares output pricing and marginal costs (that is, mark-up). An increase in the Lerner index indicates a deterioration of the competitive conduct of financial intermediaries.	Lerner Index	GFDD
Structural Variables			
Real GDP per capita	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	Thousands of (constant 2005) US $	WDI
Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship–except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The values shown are midyear estimates.	Tens of millions	WDI
Population Density	Population density is midyear population divided by land area in square kilometres. Population is based on the de facto definition of population, while land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones.	People per sq. km of land area	WDI
Age Dependency Ratio	Obtained by adding the old and young age dependency ratios. It is therefore is the ratio of dependents–people younger than 15 or older than 64–to the working-age population–those ages 15-64.	% of working-age population	WDI

Table 2.2: Summary statistics and correlations: banking sector depth (gap analysis) (global sample, annual data: 2,382 observations, 115 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Depth Gap (Private Credit)	PC gap	FinStats	relative deviation from benchmark	0.08	0.67	0.57	0.39	3.78	-0.98
Growth Rate	Growth	WDI	% change in real GDP	2.26	4.07	1.95	3.64	30.34	-29.67
Inflation	Inf	WEO	% change in CPI	9.94	15.44	8.66	12.68	178.70	-8.24
Remittance Inflows	Rem	GFDD	% of GDP	2.63	4.33	4.47	1.91	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.11	0.31	0.11	0.30	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.31	1.57	1.39	0.83	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	37.62	22.29	22.11	10.56	274.39	1.94
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	4.46	6.15	5.85	2.81	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	67.63	11.60	9.68	6.16	92.38	28.29

Correlations matrix

	PC gap	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk
PC gap	1.0000								
Growth	0.0195	1.0000							
Inf	-0.2092	-0.0808	1.0000						
Rem	0.1278	0.0623	-0.0279	1.0000					
Crisis	0.0534	-0.2235	0.1171	-0.0775	1.0000				
FO	0.0237	0.0377	-0.2929	0.0038	0.0100	1.0000			
TO	0.2274	0.1066	-0.1602	0.4391	-0.0092	0.1295	1.0000		
Pol	-0.1474	0.0675	-0.1281	-0.0826	0.0086	0.4267	0.0655	1.0000	
Risk	0.1033	0.1958	-0.3815	-0.1824	-0.0656	0.5866	0.0624	0.4714	1.0000

Table 2.3: Summary statistics and correlations: banking sector efficiency (gap analysis)
(global sample, annual data: 1,176 observations, 103 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Efficiency Gap (Net Int Margin)	NIM gap	FinStats	relative deviation from benchmark	-0.13	0.75	0.47	0.58	1.00	-16.87
Growth Rate	Growth	WDI	% change in real GDP	2.77	4.01	1.92	3.52	30.34	-16.59
Inflation	Inf	WEO	% change in CPI	6.58	9.73	6.56	7.45	168.60	-8.24
Remittance Inflows	Rem	GFDD	% of GDP	3.17	5.09	4.85	1.64	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.10	0.31	0.13	0.28	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.69	1.58	1.52	0.52	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	43.76	24.30	22.65	9.61	274.39	1.94
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	5.73	5.33	5.57	1.48	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	70.75	9.10	8.63	3.35	92.38	32.80
Lerner Index of Banking Sector	Lerner	GFDD	Lerner Index	0.24	0.14	0.10	0.10	0.82	-1.61

Correlations matrix

	NIM gap	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk	Lerner
NIM gap	1.0000									
Growth	0.0318	1.0000								
Inf	-0.2321	0.0111	1.0000							
Rem	0.0722	0.0467	0.0426	1.0000						
Crisis	0.0510	-0.2484	0.0450	-0.1068	1.0000					
FO	-0.0178	-0.0864	-0.2746	-0.0784	0.1074	1.0000				
TO	0.1354	0.1071	-0.0130	0.4832	0.0305	0.1116	1.0000			
Pol	-0.0961	-0.0930	-0.1295	-0.1430	0.1444	0.4439	0.0395	1.0000		
Risk	0.0691	0.0665	-0.3874	-0.3350	0.0611	0.5627	-0.0093	0.3529	1.0000	
Lerner	-0.0239	0.1558	-0.0236	0.0321	-0.1605	-0.1351	0.0694	-0.2605	-0.0823	1.0000

Table 2.4: Summary statistics and correlations: banking sector stability (gap analysis) (global sample, annual data: 927 observations, 85 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Stability Gap (Non-perf Loans)	NPL gap	FinStats	relative deviation from benchmark	-0.32	1.32	0.96	1.02	0.93	-19.04
Growth Rate	Growth	WDI	% change in real GDP	2.77	4.02	1.91	3.57	30.34	-16.59
Inflation	Inf	WEO	% change in CPI	6.32	9.87	5.94	7.72	168.60	-3.66
Remittance Inflows	Rem	GFDD	% of GDP	2.97	4.92	4.95	1.41	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.14	0.34	0.20	0.30	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.96	1.52	1.45	0.52	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	42.21	21.29	20.29	6.35	156.83	6.30
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	6.60	4.92	5.04	1.37	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	72.27	8.52	8.17	3.29	92.38	36.92

Correlations matrix

	NPL gap	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk
NPL gap	1.0000								
Growth	0.2015	1.0000							
Inf	0.0197	-0.0121	1.0000						
Rem	0.0621	0.0873	0.0241	1.0000					
Crisis	-0.3290	-0.3188	0.0908	-0.1155	1.0000				
FO	-0.0088	-0.1526	-0.3214	-0.1176	0.0762	1.0000			
TO	-0.0003	0.1468	-0.0407	0.4499	-0.0129	0.0481	1.0000		
Pol	0.0505	-0.1181	-0.1598	-0.1361	0.1154	0.3387	0.0365	1.0000	
Risk	0.0904	0.0095	-0.4391	-0.3355	-0.0211	0.5004	0.0489	0.3006	1.0000

Table 2.5: Summary statistics and correlations: banking sector depth
(global sample, annual data: 2,396 observations, 115 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Private Credit	PC	FinStats	% of GDP	45.48	41.68	36.01	19.73	294.66	0.30
Growth Rate	Growth	WDI	% change in real GDP	2.27	4.08	1.95	3.65	30.34	-29.67
Inflation	Inf	WEO	% change in CPI	9.91	15.42	8.66	12.66	178.70	-8.24
Remittance Inflows	Rem	GFDD	% of GDP	2.62	4.32	4.47	1.91	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.11	0.31	0.11	0.30	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.31	1.57	1.39	0.84	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	37.69	22.29	21.96	10.62	274.39	1.94
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	4.48	6.15	5.85	2.81	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	67.69	11.62	9.68	6.15	92.38	28.29
Real GDP per capita	GDPPC	WDI	'000s (constant 2005) US $	9.27	12.86	13.26	2.42	66.74	0.12
Population	Pop	WDI	Tens of millions	5.39	16.10	15.21	1.71	134.41	0.07
Population Density	Den	WDI	People per km^2 of land area	106.22	138.78	130.16	20.24	1174.33	1.52
Age Dependency Ratio	Age	WDI	% of working-age population	66.30	18.95	19.15	6.24	115.94	16.83

Correlations matrix

	PC	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk	GDPPC	Pop	Den	Age
PC	1.0000												
Growth	-0.0098	1.0000											
Inf	-0.2886	-0.0826	1.0000										
Rem	-0.1514	0.0598	-0.0269	1.0000									
Crisis	0.1441	-0.2242	0.1177	-0.0767	1.0000								
FO	0.4756	0.0422	-0.2938	0.0021	0.0088	1.0000							
TO	0.1188	0.1104	-0.1615	0.4365	-0.0103	0.1326	1.0000						
Pol	0.3682	0.0710	-0.1296	-0.0842	0.0073	0.4280	0.0682	1.0000					
Risk	0.5961	0.2007	-0.3826	-0.1843	-0.0672	0.5880	0.0668	0.4737	1.0000				
GDPPC	0.6806	-0.0309	-0.2347	-0.2832	0.0874	0.5762	-0.0841	0.4738	0.7041	1.0000			
Pop	0.0866	0.1646	-0.0255	-0.0670	-0.0103	-0.1219	-0.1989	-0.0690	0.0219	-0.0594	1.0000		
Den	0.2023	0.0734	-0.0992	0.1936	-0.0179	0.0560	0.0247	0.1480	0.0620	0.1130	0.1989	1.0000	
Age	-0.5551	-0.2428	0.1667	0.1017	-0.0269	-0.4403	-0.1042	-0.5004	-0.6644	-0.5305	-0.1236	-0.1960	1.0000

Table 2.6: Summary statistics and correlations: banking sector efficiency (global sample, annual data: 1,179 observations, 103 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Net Interest Margin	NIM	FinStats	%	4.64	3.13	2.66	1.68	30.29	0.00
Growth Rate	Growth	WDI	% change in real GDP	2.78	4.02	1.91	3.53	30.34	-16.59
Inflation	Inf	WEO	% change in CPI	6.57	9.72	6.56	7.45	168.60	-8.24
Remittance Inflows	Rem	GFDD	% of GDP	3.16	5.08	4.85	1.64	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.10	0.31	0.13	0.28	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.70	1.58	1.52	0.52	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	43.80	24.31	22.63	9.61	274.39	1.94
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	5.73	5.33	5.57	1.48	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	70.78	9.12	8.64	3.35	92.38	32.80
Lerner Index of Banking Sector	Lerner	GFDD	Lerner Index	0.24	0.14	0.10	0.10	0.82	-1.61
Real GDP per capita	GDPPC	WDI	’000s (constant 2005) US $	11.05	14.68	15.12	1.29	67.80	0.13
Population	Pop	WDI	Tens of millions	5.89	17.70	17.07	0.83	134.41	0.09
Population Density	Den	WDI	People per km^2 of land area	119.99	148.99	145.39	9.19	1174.33	1.54
Age Dependency Ratio	Age	WDI	% of working-age population	60.26	17.57	18.55	3.11	110.59	16.83

Correlations matrix

	NIM	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk	Lerner	GDPPC	Pop	Den	Age
NIM	1.0000													
Growth	0.0313	1.0000												
Inf	0.3819	0.0100	1.0000											
Rem	0.1737	0.0453	0.0430	1.0000										
Crisis	-0.1770	-0.2488	0.0452	-0.1065	1.0000									
FO	-0.2990	-0.0835	-0.2751	-0.0793	0.1067	1.0000								
TO	0.0276	0.1094	-0.0138	0.4816	0.0298	0.1133	1.0000							
Pol	-0.1604	-0.0909	-0.1300	-0.1436	0.1439	0.4447	0.0408	1.0000						
Risk	-0.5314	0.0704	-0.3876	-0.3356	0.0600	0.5639	-0.0061	0.3540	1.0000					
Lerner	0.1532	0.1539	-0.0231	0.0327	-0.1601	-0.1361	0.0680	-0.2611	-0.0840	1.0000				
GDPPC	-0.5149	-0.1594	-0.2584	-0.3271	0.2047	0.5850	-0.1013	0.4247	0.7572	-0.1598	1.0000			
Pop	-0.0993	0.1681	-0.0194	-0.0716	0.0022	-0.1978	-0.2079	-0.1329	0.0013	0.0446	-0.0794	1.0000		
Den	-0.1862	0.0200	-0.0548	0.2371	0.0165	0.0062	0.0292	0.0880	0.0205	-0.0404	0.0811	0.1874	1.0000	
Age	0.4074	-0.1498	0.0759	0.1297	-0.1721	-0.3573	-0.1028	-0.3253	-0.5631	0.1554	-0.4250	-0.1003	-0.1205	1.0000

Table 2.7: Summary statistics and correlations: banking sector stability
(global sample, annual data: 930 observations, 85 countries)

Variable	Abbreviation	Source	Unit of measurement	Mean	Overall Std Dev	Between Std Dev	Within Std Dev	Max	Min
Non-performing Loans	PC	FinStats	% of Total Gross Loans	7.26	7.49	5.96	5.22	48.60	0.10
Growth Rate	Growth	WDI	% change in real GDP	2.78	4.03	1.90	3.58	30.34	-16.59
Inflation	Inf	WEO	% change in CPI	6.32	9.87	5.94	7.71	168.60	-3.66
Remittance Inflows	Rem	GFDD	% of GDP	2.97	4.91	4.95	1.41	34.50	0.00
Banking Crisis	Crisis	GFDD	Dummy variable	0.14	0.34	0.20	0.30	1	0
Financial Openness	FO	Chinn and Ito (2008)	Chinn - Ito Index	0.96	1.52	1.45	0.52	2.44	-1.86
Trade Openness	TO	WEO	% of GDP	42.27	21.31	20.26	6.35	156.83	6.30
Polity Score	Pol	Polity IV Project	Polity Index, -10 to 10	6.61	4.91	5.04	1.37	10	-10
Composite Risk Rating	Risk	ICRG	Risk Score, 0 to 100	72.30	8.54	8.18	3.29	92.38	36.92
Real GDP per capita	GDPPC	WDI	'000s (constant 2005) US $	13.05	15.39	14.84	1.39	67.80	0.24
Population	Pop	WDI	Tens of millions	6.79	19.15	18.45	0.89	134.41	0.11
Population Density	Den	WDI	People per km^2 of land area	117.18	132.10	146.72	7.52	1085.00	2.35
Age Dependency Ratio	Age	WDI	% of working-age population	56.87	14.20	15.01	2.90	108.21	36.04

Correlations matrix

	NPL	Growth	Inf	Rem	Crisis	FO	TO	Pol	Risk	GDPPC	Pop	Den	Age
NPL	1.0000												
Growth	-0.1198	1.0000											
Inf	0.1996	-0.0132	1.0000										
Rem	0.1051	0.0855	0.0245	1.0000									
Crisis	0.1827	-0.3192	0.0911	-0.1150	1.0000								
FO	-0.4107	-0.1493	-0.3218	-0.1185	0.0754	1.0000							
TO	-0.1008	0.1502	-0.0417	0.4475	-0.0140	0.0505	1.0000						
Pol	-0.3174	-0.1158	-0.1602	-0.1367	0.1148	0.3396	0.0383	1.0000					
Risk	-0.5185	0.0144	-0.4391	-0.3362	-0.0224	0.5018	0.0532	0.3019	1.0000				
GDPPC	-0.4082	-0.2085	-0.2698	-0.3512	0.1891	0.5560	-0.0835	0.4008	0.7644	1.0000			
Pop	0.0748	0.1689	-0.0102	-0.0747	-0.0324	-0.2495	-0.2403	-0.1808	-0.0427	-0.1122	1.0000		
Den	0.0925	-0.0013	-0.1069	0.1444	0.0398	-0.0157	0.0211	0.1347	0.0445	0.1080	0.2069	1.0000	
Age	0.2810	-0.0904	0.0949	0.2311	-0.1313	-0.1884	-0.1993	-0.2600	-0.4626	-0.3747	-0.0822	-0.0428	1.0000

Table 2.8: Determinants of banking sector depth (gap analysis)

			Exogenous		Predetermined		Endogenous	
Variables	OLS	FE	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags								
DepthGap_{t-1}	1.1276***	1.0439***	1.1089***	1.1050***	1.0746***	1.0945***	1.1298***	1.1283***
	(0.0189)	(0.0193)	(0.0764)	(0.0623)	(0.0741)	(0.0625)	(0.0551)	(0.0437)
DepthGap_{t-2}	-0.1778***	-0.1672***	-0.1200*	-0.1310**	-0.1035	-0.1435***	-0.1466***	-0.1650***
	(0.0187)	(0.0190)	(0.0654)	(0.0570)	(0.0637)	(0.0532)	(0.0388)	(0.0366)
Policy variables								
Macroeconomic variables								
Growth	-0.0019**	-0.0061***	0.0084***	0.0081***	0.0094***	0.0079***	0.0021	0.0024
	(0.0009)	(0.0010)	(0.0017)	(0.0016)	(0.0020)	(0.0019)	(0.0048)	(0.0056)
Inflation	-0.0010***	-0.0014***	-0.0011	-0.0010	-0.0009	-0.0012	-0.0008	-0.0007
	(0.0002)	(0.0003)	(0.0009)	(0.0007)	(0.0008)	(0.0008)	(0.0007)	(0.0007)
Remittance Inflows	-0.0007	-0.0032*	-0.0025	-0.0010	-0.0049	0.0048	-0.0054	0.0063
	(0.0009)	(0.0018)	(0.0022)	(0.0009)	(0.0055)	(0.0068)	(0.0053)	(0.0082)
Banking Crisis Dummy	-0.0762***	-0.0530***	-0.0860***	-0.0794***	-0.0943***	-0.0567***	-0.0930***	-0.0706***
	(0.0112)	(0.0122)	(0.0181)	(0.0163)	(0.0273)	(0.0189)	(0.0314)	(0.0214)
Openness variables								
Financial Openness	-0.0055**	-0.0015	-0.0019	-0.0003	-0.0358**	-0.0007	-0.0290**	-0.0014
	(0.0027)	(0.0044)	(0.0060)	(0.0033)	(0.0171)	(0.0068)	(0.0146)	(0.0071)
Trade Openness	0.0008***	0.0016***	0.0006	0.0004**	0.0032**	0.0009	-0.0000	0.0011*
	(0.0002)	(0.0004)	(0.0004)	(0.0002)	(0.0013)	(0.0005)	(0.0013)	(0.0006)
Institutional variables								
PolityScore	-0.0004	-0.0027**	-0.0004	0.0005	-0.0094**	-0.0023	-0.0105***	-0.0024
	(0.0006)	(0.0013)	(0.0014)	(0.0008)	(0.0040)	(0.0024)	(0.0040)	(0.0024)
Composite Risk Rating	0.0012***	0.0047***	0.0010	0.0000	0.0040**	0.0012	0.0070***	0.0023*
	(0.0004)	(0.0007)	(0.0009)	(0.0006)	(0.0017)	(0.0013)	(0.0020)	(0.0013)
Constant	-0.0915***	-0.2927***		0.0443		-0.0461		-0.1755**
	(0.0355)	(0.0511)		(0.0437)		(0.0782)		(0.0785)
Observations	2,382	2,382	2,266	2,381	2,266	2,381	2,267	2,382
R-squared	0.9444	0.8497						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		115	114	115	114	115	113	115
Number of instruments			66	69	100	111	100	111
Hansen Test			0.109	0.0745	0.452	0.149	0.207	0.235
AR(1)			1.61E-06	2.86E-07	8.85E-07	1.84E-07	2.10E-09	1.30E-09
AR(2)			0.718	0.798	0.589	0.87	0.597	0.461

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

Table 2.9: Determinants of banking sector efficiency (gap analysis)

			Exogenous		Predetermined		Endogenous	
Variables	OLS	FE	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags								
Efficiency Gap$_{t-1}$	0.4018***	0.0987***	0.2023**	0.1581***	0.2009**	0.1905***	0.1871***	0.1818***
	(0.0264)	(0.0305)	(0.0874)	(0.0542)	(0.0941)	(0.0720)	(0.0690)	(0.0559)
Policy variables								
Macroeconomic variables								
Growth	0.0037	0.0090	0.0067	0.0041	0.0147***	0.0093*	0.0116	0.0197
	(0.0054)	(0.0061)	(0.0041)	(0.0047)	(0.0055)	(0.0054)	(0.0107)	(0.0200)
Inflation	-0.0127***	-0.0067**	-0.0065***	-0.0129***	-0.0040**	-0.0065***	-0.0085*	-0.0055
	(0.0024)	(0.0028)	(0.0016)	(0.0027)	(0.0018)	(0.0020)	(0.0048)	(0.0037)
Remittance Inflows	0.0008	0.0102	0.0031	0.0022	0.0263	0.0097	0.0479*	0.0101
	(0.0046)	(0.0117)	(0.0079)	(0.0056)	(0.0219)	(0.0130)	(0.0264)	(0.0154)
Banking Crisis Dummy	0.1006	0.0255	0.0187	0.0938*	0.2231**	0.1823**	0.0970	0.2987**
	(0.0696)	(0.0750)	(0.0524)	(0.0518)	(0.1059)	(0.0847)	(0.1549)	(0.1236)
Openness variables								
Financial Openness	-0.0236	-0.0804**	-0.0558	-0.0310	0.1056	-0.0469	-0.0753	-0.1147**
	(0.0157)	(0.0385)	(0.0463)	(0.0214)	(0.1006)	(0.0464)	(0.1378)	(0.0544)
Trade Openness	0.0028***	0.0034*	0.0031***	0.0039***	0.0028	0.0010	0.0040	0.0019
	(0.0009)	(0.0021)	(0.0009)	(0.0015)	(0.0041)	(0.0014)	(0.0035)	(0.0019)
Institutional variables								
Polity Score	-0.0122***	-0.0104	0.0029	-0.0132***	0.0222	0.0201	0.0080	0.0134
	(0.0042)	(0.0135)	(0.0082)	(0.0049)	(0.0222)	(0.0199)	(0.0251)	(0.0163)
Composite Risk Rating	0.0028	-0.0086	-0.0100**	0.0040	0.0003	0.0086	0.0030	0.0238***
	(0.0029)	(0.0065)	(0.0047)	(0.0036)	(0.0091)	(0.0078)	(0.0123)	(0.0085)
Market power								
Lerner Index	-0.2638*	-0.4853***	-0.2759	-0.2552*	-0.2326	-0.1145	0.0756	-0.0838
	(0.1490)	(0.1880)	(0.1815)	(0.1419)	(0.2153)	(0.2038)	(0.3606)	(0.3758)
Constant	-0.1797	0.5503		-0.4318		-0.8736		-1.9343***
	(0.2221)	(0.4679)		(0.2716)		(0.6050)		(0.6403)
Observations	1,176	1,176	1,134	1,237	1,134	1,237	1,073	1,176
R-squared	0.2653	0.0526						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		103	102	103	102	103	102	103
Number of instruments			35	37	83	94	92	103
Hansen Test			0.0810	0.121	0.635	0.269	0.552	0.501
AR(1)			0.137	0.158	0.138	0.141	0.169	0.166
AR(2)			0.826	0.410	0.891	0.707	0.589	0.486

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

Table 2.10: Determinants of banking sector stability (gap analysis)

			Exogenous		Predetermined		Endogenous	
Variables	OLS	FE	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags								
Stability Gap$_{t-1}$	0.8976***	0.7713***	0.6039***	0.9356***	0.6224***	0.9403***	0.5247***	0.7655***
	(0.0223)	(0.0300)	(0.1184)	(0.1603)	(0.1369)	(0.1097)	(0.1123)	(0.1938)
Policy variables								
Macroeconomic variables								
Growth	0.0500***	0.0447***	0.0412**	0.0294**	0.0483***	0.0296***	0.0111	0.0592***
	(0.0075)	(0.0087)	(0.0159)	(0.0137)	(0.0165)	(0.0110)	(0.0420)	(0.0182)
Inflation	0.0079**	0.0091**	0.0099	0.0057	0.0103	0.0066*	0.0271	0.0186*
	(0.0036)	(0.0045)	(0.0077)	(0.0045)	(0.0064)	(0.0036)	(0.0165)	(0.0095)
Remittance Inflows	0.0180***	0.0144	0.0176	0.0181**	-0.0542	0.0262	-0.1137	0.0280
	(0.0061)	(0.0197)	(0.0120)	(0.0079)	(0.0665)	(0.0253)	(0.0924)	(0.0478)
Banking Crisis Dummy	-0.3968***	-0.3840***	-0.2975*	-0.0540	-0.3641*	-0.2674*	-0.1952	-0.5720**
	(0.0832)	(0.0945)	(0.1757)	(0.0973)	(0.1906)	(0.1430)	(0.3109)	(0.2533)
Openness variables								
Financial Openness	-0.0039	-0.0729	-0.0453	-0.0091	-0.1658	-0.1401**	-0.1410	-0.0847
	(0.0195)	(0.0505)	(0.0328)	(0.0163)	(0.1847)	(0.0699)	(0.2672)	(0.0581)
Trade Openness	-0.0040***	0.0042	-0.0017	-0.0043*	0.0307	-0.0139**	0.0280	-0.0054
	(0.0013)	(0.0048)	(0.0042)	(0.0024)	(0.0296)	(0.0054)	(0.0232)	(0.0078)
Institutional variables								
Polity Score	0.0096*	-0.0171	-0.0249	0.0045	0.0463	0.0326	0.0756	0.0266
	(0.0054)	(0.0202)	(0.0183)	(0.0060)	(0.0502)	(0.0345)	(0.0731)	(0.0307)
Composite Risk Rating	0.0101**	0.0456***	0.0452	0.0047	0.0676*	0.0286	0.1242	0.0283**
	(0.0042)	(0.0103)	(0.0306)	(0.0047)	(0.0364)	(0.0182)	(0.0750)	(0.0141)
Constant	-0.5990*	-3.8178***		-0.4280		-1.8935		-2.0215**
	(0.3155)	(0.7801)		(0.3818)		(1.3511)		(0.9651)
Observations	927	927	904	989	894	979	842	927
R-squared	0.7172	0.5893						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		85	84	85	84	85	84	85
Number of instruments			34	36	67	77	75	85
Hansen Test			0.401	0.188	0.388	0.240	0.571	0.469
AR(1)			0.0405	0.104	0.118	0.135	0.00213	0.0512
AR(2)			0.818	0.714	0.508	0.549	0.542	0.356

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

Table 2.11: Determinants of banking sector depth

Variables	OLS	FE	Exogenous D GMM	Exogenous S GMM	Predetermined D GMM	Predetermined S GMM	Endogenous D GMM	Endogenous S GMM
Lags								
Private Credit$_{t-1}$	1.2314***	1.1240***	0.9356***	1.2156***	1.0572***	1.2095***	1.0305***	1.2218***
	(0.0187)	(0.0195)	(0.1212)	(0.0444)	(0.0784)	(0.0467)	(0.0619)	(0.0375)
Private Credit$_{t-2}$	-0.2432***	-0.1906***	-0.1119**	-0.2036***	-0.1509***	-0.2070***	-0.1530***	-0.2135***
	(0.0191)	(0.0197)	(0.0563)	(0.0496)	(0.0507)	(0.0497)	(0.0353)	(0.0400)
Policy variables								
Macroeconomic variables								
Growth	-0.0092	-0.0630*	0.0842	0.2241***	0.1676***	0.1982***	-0.1101	0.1023
	(0.0318)	(0.0332)	(0.0674)	(0.0459)	(0.0439)	(0.0489)	(0.1070)	(0.1243)
Inflation	-0.0150*	-0.0271***	-0.0220	-0.0063	-0.0090	-0.0089	0.0056	0.0232
	(0.0084)	(0.0097)	(0.0207)	(0.0164)	(0.0195)	(0.0197)	(0.0233)	(0.0180)
Remittance Inflows	-0.0575*	-0.0844	-0.1218	-0.0373	-0.1833	-0.0216	-0.0781	-0.0733
	(0.0314)	(0.0610)	(0.1112)	(0.0247)	(0.1796)	(0.1286)	(0.2228)	(0.1421)
Banking Crisis Dummy	-2.5798***	-1.9609***	-1.5833	-3.4523***	-1.3365	-2.9428***	-1.2213	-3.4225***
	(0.3854)	(0.4131)	(1.0301)	(0.6433)	(0.8701)	(0.6328)	(1.2510)	(0.8330)
Openness variables								
Financial Openness	-0.0109	0.1443	0.4885	0.0424	0.8238	0.2091	1.0033	0.4213
	(0.0973)	(0.1519)	(0.4146)	(0.0962)	(0.6261)	(0.2448)	(0.7021)	(0.2769)
Trade Openness	0.0261***	0.0426***	0.0601**	0.0148**	0.0765*	0.0347**	-0.0203	0.0408**
	(0.0062)	(0.0119)	(0.0250)	(0.0062)	(0.0431)	(0.0156)	(0.0459)	(0.0201)
Institutional variables								
Polity Score	0.0049	-0.0473	-0.0606	0.0096	-0.0269	-0.0242	-0.1018	-0.0261
	(0.0224)	(0.0453)	(0.0537)	(0.0195)	(0.0951)	(0.0575)	(0.1050)	(0.0660)
Composite Risk Rating	0.0202	0.1345***	0.1144***	0.0040	0.1472***	0.0485	0.2379***	0.1067**
	(0.0182)	(0.0258)	(0.0337)	(0.0202)	(0.0544)	(0.0508)	(0.0703)	(0.0482)
Structural variables								
Income Level	0.0542***	0.5968***	1.0157***	0.0439*	0.6349***	0.0422	0.8044***	-0.0019
	(0.0162)	(0.0685)	(0.3569)	(0.0244)	(0.2147)	(0.0473)	(0.2241)	(0.0435)
Population	0.0038	0.0091	-0.0082	-0.0053	0.0178	0.0041	0.0497	0.0055
	(0.0077)	(0.0703)	(0.0867)	(0.0060)	(0.0482)	(0.0100)	(0.0544)	(0.0128)
Population Density	0.0001	0.0076	0.0151	-0.0005	0.0071	-0.0002	0.0043	0.0006
	(0.0009)	(0.0067)	(0.0109)	(0.0011)	(0.0075)	(0.0017)	(0.0089)	(0.0018)
Age Dependency	-0.0215**	0.0178	0.0373	0.0093	0.0380	0.0154	0.0641	0.0263
	(0.0092)	(0.0268)	(0.0534)	(0.0088)	(0.0363)	(0.0158)	(0.0446)	(0.0188)
Constant	0.2388	-14.6103***		-0.5735		-3.9096		-9.5314**
	(1.7259)	(2.7693)		(1.6130)		(3.9078)		(3.8194)
Observations	2,396	2,396	2,278	2,393	2,278	2,393	2,281	2,396
R-squared	0.9835	0.9346						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		115	114	115	114	115	113	115
Number of instruments			70	73	104	115	104	115
Hansen Test			0.262	0.336	0.455	0.178	0.247	0.120
AR(1)			0.00189	2.90e-05	0.000205	2.79e-05	0.000140	1.12e-05
AR(2)			0.864	0.736	0.968	0.692	0.945	0.623

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

Table 2.12: Determinants of banking sector efficiency

			Exogenous		Predetermined		Endogenous	
Variables	OLS	FE	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags								
Net Interest Margin$_{t-1}$	0.6177***	0.2157***	0.3136***	0.2773***	0.2554**	0.3280***	0.2590***	0.3457***
	(0.0211)	(0.0284)	(0.0893)	(0.0794)	(0.1010)	(0.0845)	(0.0780)	(0.0678)
Policy variables								
Macroeconomic variables								
Growth	0.0084	-0.0165	-0.0274*	-0.0117	-0.0470***	-0.0299*	-0.0197	-0.0278
	(0.0152)	(0.0162)	(0.0144)	(0.0178)	(0.0179)	(0.0164)	(0.0484)	(0.0505)
Inflation	0.0335***	0.0265***	0.0268***	0.0513***	0.0174**	0.0222**	0.0246	0.0112
	(0.0066)	(0.0071)	(0.0067)	(0.0116)	(0.0087)	(0.0090)	(0.0159)	(0.0151)
Remittance Inflows	0.0152	-0.0324	-0.0077	0.0190	-0.1217	0.0079	-0.1410*	0.0255
	(0.0128)	(0.0309)	(0.0310)	(0.0253)	(0.0767)	(0.0459)	(0.0823)	(0.0587)
Banking Crisis Dummy	-0.1240	0.0489	0.0148	-0.3120	-0.5295	-0.6011**	-0.3893	-0.8066**
	(0.1898)	(0.1964)	(0.1695)	(0.2009)	(0.3495)	(0.2615)	(0.5198)	(0.3819)
Openness variables								
Financial Openness	0.0426	0.2420**	0.1583	0.0772	-0.2575	0.0685	0.0523	0.1578
	(0.0432)	(0.0990)	(0.1375)	(0.0852)	(0.3533)	(0.2020)	(0.4626)	(0.2439)
Trade Openness	-0.0031	-0.0149***	-0.0132***	-0.0050	-0.0203	-0.0007	-0.0208	-0.0093
	(0.0025)	(0.0053)	(0.0043)	(0.0047)	(0.0204)	(0.0062)	(0.0194)	(0.0064)
Institutional variables								
Polity Score	0.0316***	0.0582*	0.0167	0.0464**	-0.1315	0.0137	-0.0386	0.0670
	(0.0113)	(0.0349)	(0.0308)	(0.0207)	(0.1021)	(0.0632)	(0.1239)	(0.0566)
Composite Risk Rating	-0.0195*	0.0223	0.0235	-0.0305	-0.0440	-0.0711**	-0.0781	-0.1138***
	(0.0110)	(0.0167)	(0.0177)	(0.0239)	(0.0380)	(0.0338)	(0.0514)	(0.0393)
Market power								
Lerner Index	1.1533***	2.1535***	1.5019**	1.5769**	1.3452*	1.4600*	1.2580	1.2690
	(0.3974)	(0.4797)	(0.7571)	(0.6529)	(0.8007)	(0.8404)	(1.1717)	(1.1144)
Structural variables								
Income Level	-0.0214***	0.0484	0.0512	-0.0491***	0.0099	-0.0298	-0.0182	-0.0254
	(0.0062)	(0.0523)	(0.0363)	(0.0122)	(0.0485)	(0.0225)	(0.0775)	(0.0203)
Population	-0.0033	0.0406	0.0568	-0.0066	0.0541	-0.0054	0.0561	-0.0037
	(0.0031)	(0.0653)	(0.0603)	(0.0044)	(0.0633)	(0.0048)	(0.0672)	(0.0066)
Population Density	-0.0008**	0.0175***	0.0131*	-0.0017***	0.0131*	-0.0017**	0.0146*	-0.0020**
	(0.0004)	(0.0066)	(0.0067)	(0.0006)	(0.0071)	(0.0008)	(0.0078)	(0.0009)
Age Dependency	0.0147***	0.0362*	0.0201	0.0239**	0.0004	0.0129	0.0021	0.0074
	(0.0039)	(0.0215)	(0.0201)	(0.0094)	(0.0251)	(0.0130)	(0.0267)	(0.0133)
Constant	1.6893*	-3.1789		3.9970*		7.5215**		10.3866***
	(0.9096)	(2.1707)		(2.1072)		(3.1407)		(3.3690)
Observations	1,178	1,178	1,136	1,239	1,136	1,239	1,075	1,178
R-squared	0.6988	0.2009						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		103	102	103	102	103	102	103
Number of instruments			39	41	87	98	86	97
Hansen Test			0.00506	0.0233	0.194	0.292	0.330	0.200
AR(1)			0.00855	0.00919	0.0166	0.00901	0.0218	0.0104
AR(2)			0.880	0.657	0.752	0.923	0.815	0.850

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

Table 2.13: Determinants of banking sector stability

Variables	OLS	FE	Exogenous D GMM	Exogenous S GMM	Predetermined D GMM	Predetermined S GMM	Endogenous D GMM	Endogenous S GMM
Lags								
Non-performing Loans$_{t-1}$	0.7471***	0.5739***	0.7054***	0.7843***	0.7248***	0.7530***	0.6647***	0.7294***
	(0.0182)	(0.0232)	(0.0520)	(0.0541)	(0.0653)	(0.0544)	(0.0729)	(0.0503)
Policy variables								
Macroeconomic variables								
Growth	-0.1928***	-0.1674***	-0.1405***	-0.1139***	-0.1462***	-0.1490***	-0.2506*	-0.2249**
	(0.0326)	(0.0358)	(0.0465)	(0.0424)	(0.0482)	(0.0527)	(0.1353)	(0.1033)
Inflation	-0.0243	0.0209	-0.0172	-0.0309	-0.0207	-0.0279*	-0.0251	-0.0454
	(0.0154)	(0.0178)	(0.0246)	(0.0224)	(0.0152)	(0.0153)	(0.0361)	(0.0324)
Remittance Inflows	-0.0121	-0.1532*	-0.0666	-0.0295	0.2684	-0.0451	0.1663	0.1094
	(0.0262)	(0.0786)	(0.0791)	(0.0265)	(0.1981)	(0.1419)	(0.1757)	(0.1805)
Banking Crisis Dummy	1.4175***	1.7326***	0.2565	0.2407	-0.6294	0.9631	0.8527	0.7766
	(0.3473)	(0.3883)	(0.5959)	(0.5961)	(1.0613)	(0.8136)	(1.6745)	(1.0107)
Openness variables								
Financial Openness	-0.1646*	0.5861***	0.1827	-0.1191	-0.6295	0.3345	0.4976	0.1717
	(0.0863)	(0.2003)	(0.2116)	(0.1319)	(0.8694)	(0.2970)	(0.9667)	(0.2667)
Trade Openness	0.0081	-0.0392**	0.0296	0.0157**	0.0083	0.0466*	-0.0868	0.0059
	(0.0060)	(0.0197)	(0.0243)	(0.0069)	(0.1065)	(0.0252)	(0.1033)	(0.0301)
Institutional variables								
Polity Score	-0.0800***	0.1649**	0.1735*	-0.0411	-0.0775	0.1410	-0.0938	0.0793
	(0.0239)	(0.0807)	(0.0957)	(0.0350)	(0.2747)	(0.0981)	(0.3390)	(0.1525)
Composite Risk Rating	-0.1035***	-0.2036***	-0.0682	-0.0688*	-0.0739	-0.1007	-0.1688	-0.2175*
	(0.0251)	(0.0407)	(0.0570)	(0.0412)	(0.0879)	(0.0806)	(0.1384)	(0.1204)
Structural variables								
Income Level	0.0051	0.0972	0.2494**	0.0074	0.3237**	-0.0234	0.0746	0.0234
	(0.0126)	(0.1063)	(0.1101)	(0.0145)	(0.1570)	(0.0330)	(0.1745)	(0.0536)
Population	-0.0019	-0.0187	-0.0053	-0.0020	-0.0053	0.0252**	0.0572	0.0165
	(0.0060)	(0.1312)	(0.1711)	(0.0047)	(0.1926)	(0.0123)	(0.2403)	(0.0149)
Population Density	0.0000	-0.0658***	-0.0425*	-0.0004	-0.0435	-0.0012	-0.0579	-0.0019
	(0.0008)	(0.0184)	(0.0217)	(0.0007)	(0.0406)	(0.0019)	(0.0368)	(0.0020)
Age Dependency	-0.0048	0.0460	0.0979**	0.0083	0.1533**	0.0250	0.0485	-0.0174
	(0.0088)	(0.0487)	(0.0486)	(0.0123)	(0.0761)	(0.0249)	(0.0852)	(0.0336)
Constant	11.0748***	23.0256***		6.4071*		6.9377		18.9677*
	(2.0753)	(4.8616)		(3.4601)		(7.2672)		(10.0003)
Observations	929	929	906	991	896	981	844	929
R-squared	0.8238	0.7113						
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries		85	84	85	84	85	84	85
Number of instruments			38	40	71	81	70	80
Hansen Test			0.224	0.182	0.529	0.376	0.310	0.401
AR(1)			0.00246	0.00248	0.00367	0.00412	0.00167	0.00142
AR(2)			0.198	0.201	0.347	0.314	0.0870	0.0987

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

Table 2.14: Robustness checks: Determinants of banking sector depth (gap analysis)

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Depth Gap$_{t-1}$	1.0790***	1.0719***	1.0111***	1.0358***	1.0674***	1.0831***	1.0993***	1.1188***	1.0602***	1.0791***	1.0922***	1.1319***	1.0609***	1.1081***	1.0191***	1.0956***	1.0291***	1.1011***
	(0.0861)	(0.0719)	(0.0839)	(0.0689)	(0.0679)	(0.0494)	(0.1107)	(0.0769)	(0.0950)	(0.0772)	(0.0617)	(0.0511)	(0.0535)	(0.0432)	(0.0514)	(0.0397)	(0.0509)	(0.0387)
Depth Gap$_{t-2}$	-0.0964	-0.1071*	-0.0786	-0.1015*	0.0111	0.0014	-0.0698	-0.1044	-0.0666	-0.1005	-0.0033	0.0048	-0.1216***	-0.1361***	-0.1215***	-0.1435***	-0.0005	0.0025
	(0.0725)	(0.0631)	(0.0706)	(0.0583)	(0.0121)	(0.0109)	(0.0831)	(0.0679)	(0.0763)	(0.0661)	(0.0058)	(0.0061)	(0.0363)	(0.0345)	(0.0341)	(0.0340)	(0.0046)	(0.0052)
Policy variables																		
Macroeconomic variables																		
Growth	0.0093***	0.0090***	0.0095***	0.0083***	-0.0009	-0.0008	0.0101***	0.0099***	0.0092***	0.0088***	-0.0007	-0.0007	0.0054***	0.0062***	0.0056***	0.0056***	-0.0009	-0.0008
	(0.0020)	(0.0019)	(0.0023)	(0.0022)	(0.0009)	(0.0009)	(0.0022)	(0.0019)	(0.0023)	(0.0024)	(0.0007)	(0.0007)	(0.0012)	(0.0011)	(0.0014)	(0.0016)	(0.0007)	(0.0007)
Inflation	-0.0012	-0.0011	-0.0011	-0.0014	-0.0085	0.0095	-0.0010	-0.0006	-0.0011	-0.0010	-0.0025	0.0034	-0.0002	-0.0003	-0.0001	-0.0003	-0.0035	0.0068
	(0.0009)	(0.0008)	(0.0009)	(0.0009)	(0.0079)	(0.0087)	(0.0009)	(0.0008)	(0.0009)	(0.0008)	(0.0071)	(0.0062)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0037)	(0.0089)
Remittance Inflows	-0.0002	0.0003	-0.0047	0.0096	-0.0695	-0.1091***	-0.0017	-0.0006	0.0036	0.0035	-0.1106***	-0.1132***	-0.0026	-0.0009	-0.0064	0.0064	-0.0704***	-0.0699***
	(0.0023)	(0.0010)	(0.0064)	(0.0072)	(0.0549)	(0.0380)	(0.0031)	(0.0013)	(0.0077)	(0.0052)	(0.0302)	(0.0288)	(0.0020)	(0.0010)	(0.0039)	(0.0078)	(0.0265)	(0.0201)
Banking Crisis Dummy	-0.1180***	-0.1046***	-0.0904***	-0.0893***	-0.0389	-0.0206	-0.1131***	-0.1084***	-0.0977***	-0.1007***	0.0115	-0.0013	-0.0562***	-0.0607***	-0.0481**	-0.0446***	-0.0085	-0.0027
	(0.0277)	(0.0248)	(0.0327)	(0.0291)	(0.0303)	(0.0133)	(0.0249)	(0.0238)	(0.0249)	(0.0231)	(0.0141)	(0.0088)	(0.0126)	(0.0121)	(0.0184)	(0.0163)	(0.0135)	(0.0070)
Openness variables																		
Financial Openness	-0.0106	-0.0057	-0.0316	-0.0208*	0.0011	0.0012	-0.0055	-0.0007	0.0004	-0.0029	0.0030	0.0023***	0.0009	-0.0001	-0.0086	-0.0030	0.0005	0.0010*
	(0.0076)	(0.0042)	(0.0286)	(0.0111)	(0.0027)	(0.0010)	(0.0072)	(0.0041)	(0.0139)	(0.0100)	(0.0018)	(0.0009)	(0.0051)	(0.0034)	(0.0139)	(0.0065)	(0.0011)	(0.0006)
Trade Openness	0.0004	0.0003	0.0036*	0.0006	-0.0029	0.0045	0.0012	0.0003	0.0043*	0.0022**	-0.0015	-0.0017	0.0006**	0.0004**	0.0035***	0.0007	-0.0070**	0.0013
	(0.0005)	(0.0003)	(0.0020)	(0.0008)	(0.0058)	(0.0036)	(0.0009)	(0.0003)	(0.0022)	(0.0010)	(0.0041)	(0.0025)	(0.0003)	(0.0002)	(0.0010)	(0.0005)	(0.0031)	(0.0021)
Institutional variables																		
Polity Score	0.0001	0.0006	-0.0019	0.0008	0.0152***	0.0113***	-0.0001	0.0010	-0.0010	-0.0002	0.0041**	0.0014	-0.0011	0.0002	-0.0040	0.0010	0.0038**	0.0017
	(0.0016)	(0.0010)	(0.0052)	(0.0027)	(0.0036)	(0.0042)	(0.0022)	(0.0010)	(0.0044)	(0.0029)	(0.0017)	(0.0016)	(0.0013)	(0.0007)	(0.0026)	(0.0024)	(0.0017)	(0.0013)
Composite Risk Rating	0.0022*	0.0009	0.0096***	0.0068*	-0.1235***	-0.1383***	0.0008	-0.0002	0.0016	0.0010	-0.1261***	-0.1474***	0.0018**	0.0004	0.0026*	0.0014	-0.1119***	-0.1261***
	(0.0012)	(0.0010)	(0.0030)	(0.0036)	(0.0403)	(0.0389)	(0.0013)	(0.0007)	(0.0016)	(0.0014)	(0.0398)	(0.0392)	(0.0007)	(0.0005)	(0.0014)	(0.0011)	(0.0316)	(0.0339)
Constant		-0.0496		-0.3847**		-0.6389***		-0.0069		-0.1395		-0.1524		0.0064		-0.0728		-0.1463*
		(0.0623)		(0.1849)		(0.2225)		(0.0532)		(0.0967)		(0.0958)		(0.0334)		(0.0673)		(0.0817)
Observations	1,537	1,614	1,537	1,614	1,534	1,611	1,754	1,866	1,754	1,866	1,855	1,967	2,122	2,236	2,122	2,236	2,116	2,230
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	77	77	77	77	76	77	112	112	112	112	112	112	113	114	113	114	112	114
Number of instruments	66	69	64	75	64	75	56	59	95	106	96	107	66	69	100	111	100	111
Hansen Test	0.0646	0.0479	0.319	0.181	0.148	0.103	0.294	0.301	0.282	0.236	0.281	0.222	0.181	0.164	0.454	0.126	0.390	0.173
AR(1)	2.12e-05	6.80e-06	1.15e-05	3.82e-06	4.60e-08	1.26e-08	0.000130	1.04e-05	5.51e-05	9.93e-06	8.98e-08	1.96e-08	1.78e-09	1.35e-10	6.47e-10	6.41e-11	0	0
AR(2)	0.771	0.838	0.611	0.787	0.343	0.540	0.131	0.177	0.129	0.193	0.214	0.580	0.484	0.512	0.481	0.577	0.973	0.745

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

Table 2.15: Robustness checks: Determinants of banking sector efficiency (gap analysis)

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Efficiency Gap_{t-1}	0.3763***	0.3854**	0.3349*	0.4306***	0.3137**	0.4127***	0.6031***	0.1241***	0.5046***	0.1867***	0.4423***	0.1861***	0.3477***	0.3249***	0.3562***	0.4820***	0.3306***	0.4752***
	(0.1321)	(0.1737)	(0.1690)	(0.1497)	(0.1489)	(0.1187)	(0.1981)	(0.0228)	(0.1477)	(0.0262)	(0.1310)	(0.0324)	(0.0553)	(0.0462)	(0.0608)	(0.0502)	(0.0543)	(0.0484)
Policy variables																		
Macroeconomic variables																		
Growth	0.0053	0.0046	0.0095**	0.0070**	0.0164	0.0252	0.0039	0.0116	0.0153**	0.0169	0.0198	0.0255	0.0018	-0.0001	0.0057	0.0020	0.0020	-0.0092
	(0.0034)	(0.0033)	(0.0041)	(0.0034)	(0.0125)	(0.0186)	(0.0060)	(0.0070)	(0.0076)	(0.0104)	(0.0143)	(0.0233)	(0.0028)	(0.0028)	(0.0038)	(0.0033)	(0.0060)	(0.0066)
Inflation	-0.0060***	-0.0108***	-0.0054***	-0.0063**	-0.0078	-0.0038	-0.0043*	-0.0137***	-0.0031	-0.0048*	-0.0038	-0.0035	-0.0037*	-0.0088***	-0.0002	-0.0023	-0.0074	-0.0113**
	(0.0019)	(0.0021)	(0.0017)	(0.0024)	(0.0053)	(0.0056)	(0.0022)	(0.0031)	(0.0033)	(0.0026)	(0.0042)	(0.0044)	(0.0021)	(0.0030)	(0.0026)	(0.0025)	(0.0051)	(0.0043)
Remittance Inflows	-0.0059	0.0056	0.0367	0.0050	0.0354	0.0087	-0.0027	0.0024	-0.0113	0.0307	0.0014	0.0248	0.0029	0.0008	0.0129	-0.0031	0.0204*	-0.0068
	(0.0062)	(0.0045)	(0.0365)	(0.0080)	(0.0318)	(0.0135)	(0.0068)	(0.0072)	(0.0359)	(0.0245)	(0.0320)	(0.0209)	(0.0043)	(0.0040)	(0.0124)	(0.0063)	(0.0108)	(0.0065)
Banking Crisis Dummy	0.0691	0.1321	0.0513	0.2228*	-0.1209	0.2382	0.0223	0.1026	0.1354	0.0109	0.1735	0.2101	0.0308	0.0647*	0.1376	0.0661	0.1067	0.0744
	(0.0949)	(0.0939)	(0.1630)	(0.1134)	(0.2602)	(0.1875)	(0.0891)	(0.0877)	(0.1066)	(0.1240)	(0.2082)	(0.1770)	(0.0337)	(0.0368)	(0.0848)	(0.0434)	(0.0952)	(0.0589)
Openness variables																		
Financial Openness	-0.0846**	-0.0442***	0.0229	-0.0425	-0.0982	-0.0856	-0.0416	-0.0293	0.0546	-0.1177*	-0.1470*	-0.1397**	-0.0164	-0.0140	0.0222	-0.0424*	-0.0406	-0.0750***
	(0.0416)	(0.0162)	(0.0913)	(0.0544)	(0.1115)	(0.0527)	(0.0413)	(0.0328)	(0.1096)	(0.0688)	(0.0879)	(0.0688)	(0.0207)	(0.0129)	(0.0567)	(0.0238)	(0.0502)	(0.0265)
Trade Openness	0.0025*	0.0009	0.0051	0.0004	0.0052	0.0002	0.0045	0.0047*	0.0100	-0.0040	0.0228**	-0.0002	0.0012**	0.0015*	0.0033	0.0011	0.0017	0.0031***
	(0.0013)	(0.0010)	(0.0049)	(0.0012)	(0.0048)	(0.0020)	(0.0035)	(0.0025)	(0.0209)	(0.0047)	(0.0106)	(0.0044)	(0.0005)	(0.0008)	(0.0029)	(0.0007)	(0.0023)	(0.0008)
Institutional variables																		
Polity Score	-0.0056	-0.0109*	0.0097	0.0039	-0.0065	-0.0019	0.0009	-0.0156***	0.0204	0.0210	-0.0288	0.0051	0.0014	-0.0104***	0.0123	-0.0018	-0.0068	-0.0054
	(0.0073)	(0.0057)	(0.0200)	(0.0177)	(0.0231)	(0.0152)	(0.0069)	(0.0059)	(0.0301)	(0.0215)	(0.0372)	(0.0222)	(0.0051)	(0.0034)	(0.0145)	(0.0094)	(0.0166)	(0.0100)
Composite Risk Rating	-0.0055	0.0018	-0.0055	0.0093	-0.0011	0.0199	-0.0101**	0.0028	-0.0020	0.0341***	0.0081	0.0459***	-0.0042	0.0047**	0.0045	0.0061	0.0006	0.0097**
	(0.0041)	(0.0034)	(0.0098)	(0.0133)	(0.0128)	(0.0123)	(0.0045)	(0.0048)	(0.0145)	(0.0125)	(0.0141)	(0.0137)	(0.0031)	(0.0022)	(0.0066)	(0.0047)	(0.0064)	(0.0048)
Market power																		
Lerner Index	-0.6063***	-0.2636*	-0.5443*	-0.3351	-0.7994**	-0.3467	-0.4007**	-0.3818***	-0.2277	-0.4199	-0.0576	-0.0811	-0.2942***	-0.2082**	-0.0129	0.0115	-0.3134	-0.2752
	(0.1575)	(0.1474)	(0.2848)	(0.2609)	(0.3335)	(0.2620)	(0.1801)	(0.1384)	(0.3064)	(0.4452)	(0.5496)	(0.3543)	(0.1053)	(0.0912)	(0.1351)	(0.1309)	(0.2367)	(0.1859)
Constant		-0.1084		-0.7118		-1.3834		-0.2342		-2.3645***		-3.3350***		-0.2720		-0.4489		-0.6030*
		(0.2307)		(0.9507)		(0.8687)		(0.3311)		(0.8777)		(1.0352)		(0.1707)		(0.3367)		(0.3259)
Observations	668	733	712	777	670	735	700	800	698	796	707	807	993	1,095	1,053	1,156	999	1,102
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	65	65	65	65	65	65	98	100	98	98	98	100	102	102	102	103	102	103
Number of instruments	33	35	53	64	52	63	25	27	78	89	88	99	33	35	83	94	92	103
Hansen Test	0.293	0.438	0.493	0.408	0.432	0.364	0.341	0.180	0.680	0.248	0.328	0.178	0.386	0.546	0.842	0.457	0.700	0.404
AR(1)	0.00288	0.0108	0.00490	0.00152	0.00507	0.00244	0.288	0.232	0.272	0.224	0.271	0.215	2.27e-08	1.95e-09	1.27e-07	3.77e-09	1.65e-08	7.44e-10
AR(2)	0.481	0.471	0.464	0.491	0.634	0.730	0.236	0.144	0.230	0.191	0.237	0.213	0.834	0.884	0.963	0.529	0.958	0.704

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

Table 2.16: Robustness checks: Determinants of banking sector stability (gap analysis)

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Stability Gap$_{t-1}$	0.9231***	1.0271***	0.9156***	0.9826***	0.8771***	0.9306***	0.6036***	0.5121	0.4972***	0.6782***	0.5166***	0.5801***	0.8038***	0.9364***	0.7615***	0.8901***	0.7769***	0.8645***
	(0.0978)	(0.0564)	(0.1191)	(0.0707)	(0.0613)	(0.0561)	(0.1015)	(0.3326)	(0.1299)	(0.1670)	(0.0973)	(0.2168)	(0.0663)	(0.0581)	(0.0677)	(0.0559)	(0.0617)	(0.0555)
Policy variables																		
Macroeconomic variables																		
Growth	0.0122	0.0062	0.0092	0.0051	0.0745**	0.0616***	0.0349	0.0461	0.0176	0.0286*	0.0509**	0.0228	0.0183**	0.0140*	0.0232***	0.0256***	0.0504***	0.0606***
	(0.0124)	(0.0111)	(0.0157)	(0.0127)	(0.0288)	(0.0214)	(0.0220)	(0.0281)	(0.0163)	(0.0150)	(0.0221)	(0.0213)	(0.0079)	(0.0071)	(0.0085)	(0.0092)	(0.0188)	(0.0183)
Inflation	0.0019	0.0021	0.0012	0.0039	0.0099	0.0072	0.0000	0.0051	-0.0025	0.0053*	-0.0144	-0.0028	0.0021	0.0027	0.0024	0.0038	0.0052	0.0103**
	(0.0028)	(0.0023)	(0.0041)	(0.0030)	(0.0065)	(0.0051)	(0.0027)	(0.0033)	(0.0030)	(0.0030)	(0.0097)	(0.0069)	(0.0028)	(0.0024)	(0.0020)	(0.0025)	(0.0044)	(0.0048)
Remittance Inflows	0.0064	0.0054	-0.0082	-0.0069	-0.0103	0.0079	0.0078	0.0109	0.0417	0.0045	0.0913	-0.0131	0.0180*	0.0070*	0.0164	0.0333*	0.0117	0.0309*
	(0.0101)	(0.0064)	(0.0512)	(0.0186)	(0.0341)	(0.0281)	(0.0135)	(0.0129)	(0.0405)	(0.0199)	(0.0694)	(0.0251)	(0.0105)	(0.0040)	(0.0335)	(0.0172)	(0.0293)	(0.0173)
Banking Crisis Dummy	-0.0390	-0.0403	-0.3533	-0.2951	-0.0536	-0.4908*	0.1471	-0.0232	-0.3638	-0.1109	-0.7711*	-0.5131	-0.1429*	-0.0619	-0.2341	-0.1422*	-0.1910	-0.1982**
	(0.1365)	(0.1540)	(0.2991)	(0.2010)	(0.2458)	(0.2887)	(0.2537)	(0.2261)	(0.2273)	(0.2058)	(0.4021)	(0.4015)	(0.0742)	(0.0726)	(0.1469)	(0.0854)	(0.1793)	(0.0875)
Openness variables																		
Financial Openness	-0.0415	0.0010	-0.0282	-0.0293	0.0796	-0.0675	-0.0048	0.0292	-0.1314	-0.0619	-0.3292	-0.0038	-0.0462	-0.0117	-0.1596	-0.0336	-0.0672	-0.0413
	(0.0393)	(0.0173)	(0.1692)	(0.0527)	(0.1269)	(0.0457)	(0.0443)	(0.0317)	(0.1458)	(0.0667)	(0.2569)	(0.0960)	(0.0302)	(0.0148)	(0.1449)	(0.0366)	(0.1236)	(0.0427)
Trade Openness	-0.0063	-0.0015	0.0277	-0.0070	-0.0014	-0.0020	0.0028	0.0004	0.0121	0.0036	-0.0021	0.0099	-0.0046	-0.0016*	-0.0081	-0.0041	-0.0085	-0.0033
	(0.0042)	(0.0018)	(0.0281)	(0.0046)	(0.0153)	(0.0039)	(0.0054)	(0.0025)	(0.0142)	(0.0058)	(0.0154)	(0.0069)	(0.0032)	(0.0009)	(0.0145)	(0.0042)	(0.0089)	(0.0026)
Institutional variables																		
Polity Score	-0.0079	0.0030	0.0640	0.0198	0.0228	0.0274	-0.0176	0.0230*	-0.0394	0.0436	-0.0757	0.0268	-0.0106	0.0017	0.0566	-0.0149	0.0624	0.0065
	(0.0115)	(0.0057)	(0.0572)	(0.0232)	(0.0360)	(0.0260)	(0.0160)	(0.0125)	(0.0432)	(0.0309)	(0.0578)	(0.0419)	(0.0109)	(0.0033)	(0.0400)	(0.0201)	(0.0476)	(0.0276)
Composite Risk Rating	-0.0033	-0.0047	-0.0337	-0.0070	0.0233	0.0014	-0.0113	0.0037	0.0032	0.0208	-0.0433	-0.0034	0.0096	0.0025	0.0203	0.0122	0.0298*	0.0311**
	(0.0109)	(0.0060)	(0.0309)	(0.0183)	(0.0292)	(0.0217)	(0.0170)	(0.0070)	(0.0131)	(0.0140)	(0.0333)	(0.0152)	(0.0083)	(0.0032)	(0.0138)	(0.0078)	(0.0169)	(0.0119)
Constant		0.1731		0.7749		-0.0844		-0.9675		-1.8648*		-0.0780		-0.0526		-0.5944		-2.5342***
		(0.3640)		(1.3199)		(1.4481)		(0.7833)		(1.0695)		(1.0630)		(0.2411)		(0.6347)		(0.8527)
Observations	506	555	504	553	472	521	528	610	518	600	531	613	845	929	835	919	793	877
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	48	49	48	49	48	49	81	82	80	82	81	82	83	84	83	84	83	84
Number of instruments	34	36	31	41	39	49	24	26	71	81	71	81	34	36	67	77	66	76
Hansen Test	0.697	0.529	0.111	0.148	0.357	0.159	0.840	0.345	0.386	0.561	0.496	0.181	0.807	0.0146	0.519	0.291	0.660	0.253
AR(1)	0.0128	0.00860	0.00681	0.00424	0.00300	0.00191	0.0251	0.362	0.0173	0.0298	0.103	0.244	0.00373	0.00223	0.00219	0.00180	0.00102	0.000515
AR(2)	0.810	0.799	0.707	0.719	0.285	0.558	0.340	0.257	0.883	0.807	0.306	0.239	0.855	0.831	0.849	0.859	0.551	0.426

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

Table 2.17: Robustness checks: Determinants of banking sector depth

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Private Credit$_{t-1}$	1.0657***	1.0853***	0.9889***	1.0532***	0.9857***	1.1099***	0.9345***	1.2090***	0.9857***	1.1671***	1.0125***	1.2032***	1.0697***	1.1516***	1.0706***	1.1463***	1.1234***	1.1612***
	(0.0962)	(0.0607)	(0.0757)	(0.0627)	(0.0798)	(0.0443)	(0.1250)	(0.0465)	(0.0770)	(0.0464)	(0.0689)	(0.0382)	(0.1044)	(0.0433)	(0.0597)	(0.0443)	(0.0485)	(0.0353)
Private Credit$_{t-2}$	-0.1395**	-0.1483**	-0.1397**	-0.1475**	-0.1726***	-0.1929***	-0.0456	-0.1258**	-0.0651	-0.1250***	-0.1119***	-0.1695***	-0.1285**	-0.1447***	-0.1349***	-0.1574***	-0.1618***	-0.1686***
	(0.0700)	(0.0618)	(0.0690)	(0.0604)	(0.0399)	(0.0412)	(0.0573)	(0.0486)	(0.0477)	(0.0477)	(0.0357)	(0.0379)	(0.0495)	(0.0421)	(0.0412)	(0.0399)	(0.0317)	(0.0314)
Policy variables																		
Macroeconomic variables																		
Growth	0.1728***	0.1830***	0.1472***	0.1656***	-0.3233	0.0689	0.1565***	0.2843***	0.1798***	0.2211***	-0.0249	0.2636*	0.1785***	0.2244***	0.1865***	0.1881***	0.1814	0.1963
	(0.0447)	(0.0488)	(0.0466)	(0.0474)	(0.3137)	(0.2320)	(0.0565)	(0.0579)	(0.0547)	(0.0594)	(0.1123)	(0.1425)	(0.0495)	(0.0447)	(0.0468)	(0.0462)	(0.1189)	(0.1283)
Inflation	-0.0203	-0.0238	-0.0097	-0.0202	0.0111	0.0004	-0.0181	0.0006	-0.0225	-0.0130	-0.0096	0.0090	-0.0189	-0.0140	-0.0135	-0.0172	-0.0036	0.0030
	(0.0198)	(0.0172)	(0.0179)	(0.0191)	(0.0321)	(0.0188)	(0.0198)	(0.0173)	(0.0190)	(0.0194)	(0.0175)	(0.0172)	(0.0229)	(0.0181)	(0.0211)	(0.0216)	(0.0214)	(0.0193)
Remittance Inflows	0.0326	-0.0074	-0.0411	0.0782	0.0120	0.0402	-0.1054	0.0065	0.1631	-0.0227	0.1486	-0.0658	-0.0407	-0.0264	-0.2685*	-0.0243	-0.2053	-0.0591
	(0.0576)	(0.0371)	(0.1357)	(0.1092)	(0.1802)	(0.1263)	(0.1102)	(0.0505)	(0.2181)	(0.1211)	(0.2056)	(0.1162)	(0.0646)	(0.0250)	(0.1550)	(0.1311)	(0.1629)	(0.1384)
Banking Crisis Dummy	-3.0218***	-2.6814***	-1.9922**	-2.4259***	-2.5798*	-3.2879***	-2.8993***	-4.2360***	-2.1853***	-3.7686***	-2.4960**	-4.1873***	-2.4591***	-2.7541***	-1.9953***	-2.4731***	-1.9790**	-2.4245***
	(0.6741)	(0.6229)	(0.7703)	(0.6866)	(1.3158)	(0.8752)	(0.8855)	(0.9147)	(0.7410)	(0.7123)	(0.9839)	(0.9183)	(0.5704)	(0.5097)	(0.6188)	(0.5647)	(0.8662)	(0.7433)
Openness variables																		
Financial Openness	0.0015	0.0132	0.8239	-0.2612	1.4414	-0.0323	0.1911	0.0198	0.4190	0.3646	0.5357	0.4849	0.1620	0.0253	0.3979	0.0339	0.3808	0.2492
	(0.1465)	(0.0978)	(0.6445)	(0.2441)	(0.9692)	(0.2340)	(0.2089)	(0.1438)	(0.4823)	(0.3351)	(0.5355)	(0.3178)	(0.1865)	(0.0952)	(0.4596)	(0.2078)	(0.4261)	(0.2252)
Trade Openness	0.0263*	0.0230**	0.0827**	0.0458***	0.0326	0.0469**	0.0774**	-0.0012	0.0762	0.0747***	0.0295	0.0748***	0.0319*	0.0139**	0.0685**	0.0308*	-0.0299	0.0346*
	(0.0153)	(0.0110)	(0.0415)	(0.0168)	(0.0764)	(0.0232)	(0.0344)	(0.0130)	(0.0546)	(0.0253)	(0.0535)	(0.0249)	(0.0192)	(0.0067)	(0.0341)	(0.0157)	(0.0373)	(0.0182)
Institutional variables																		
Polity Score	-0.0350	-0.0162	0.0052	-0.0530	0.0642	-0.0171	-0.0352	0.0223	-0.0541	0.0218	-0.0880	0.0199	-0.0273	0.0156	-0.0856	-0.0320	-0.1335	-0.0283
	(0.0373)	(0.0290)	(0.1049)	(0.0521)	(0.1291)	(0.0620)	(0.0561)	(0.0303)	(0.1294)	(0.0724)	(0.1232)	(0.0695)	(0.0457)	(0.0191)	(0.0910)	(0.0556)	(0.1047)	(0.0643)
Composite Risk Rating	0.0647**	0.0640	0.1218*	0.1409*	0.2540***	0.2066**	0.1121***	-0.0451	0.1056**	-0.0003	0.1274**	0.0169	0.0844***	0.0112	0.0795	0.0319	0.1895**	0.0847
	(0.0290)	(0.0394)	(0.0624)	(0.0750)	(0.0845)	(0.0910)	(0.0387)	(0.0286)	(0.0439)	(0.0550)	(0.0546)	(0.0507)	(0.0316)	(0.0226)	(0.0657)	(0.0560)	(0.0743)	(0.0516)
Structural variables																		
Income Level	0.6636	0.0480	0.9629**	0.0863	0.9400	-0.1170	0.8224***	-0.0476	0.7176***	-0.0093	0.7832***	-0.0095	0.4150**	0.0466	0.3302***	0.0740	0.4072***	0.0352
	(0.5458)	(0.1173)	(0.4796)	(0.2049)	(0.6000)	(0.2076)	(0.2924)	(0.0513)	(0.2233)	(0.0528)	(0.2341)	(0.0531)	(0.1906)	(0.0304)	(0.1073)	(0.0511)	(0.1258)	(0.0464)
Population	0.0459	0.0164	0.0738	0.0298	0.1401*	0.0239	-0.0136	-0.0316	0.0129	0.0047	0.0327	0.0053	0.0247	-0.0038	0.0066	0.0043	0.0312	0.0034
	(0.0313)	(0.0135)	(0.0510)	(0.0193)	(0.0731)	(0.0213)	(0.0892)	(0.0197)	(0.0809)	(0.0205)	(0.0666)	(0.0198)	(0.0314)	(0.0063)	(0.0414)	(0.0104)	(0.0371)	(0.0117)
Population Density	0.0018	0.0006	0.0067	0.0002	0.0053	0.0008	0.0065	-0.0030	0.0003	-0.0021	0.0032	-0.0016	0.0009	-0.0001	0.0069	0.0003	-0.0005	0.0010
	(0.0048)	(0.0007)	(0.0061)	(0.0017)	(0.0089)	(0.0017)	(0.0088)	(0.0023)	(0.0083)	(0.0026)	(0.0078)	(0.0025)	(0.0058)	(0.0008)	(0.0066)	(0.0015)	(0.0073)	(0.0016)
Age Dependency	0.0078	-0.0363**	0.0234	-0.0415**	0.0400	-0.0384*	-0.0058	0.0214	0.0018	0.0220	-0.0087	0.0269	0.0321	0.0052	0.0342	-0.0022	0.0516*	0.0128
	(0.0234)	(0.0171)	(0.0372)	(0.0200)	(0.0523)	(0.0213)	(0.0480)	(0.0159)	(0.0431)	(0.0242)	(0.0420)	(0.0258)	(0.0337)	(0.0092)	(0.0304)	(0.0143)	(0.0290)	(0.0174)
Constant		0.8710		-3.3513		-6.8778		0.4786		-3.2285		-6.0508		-0.5195		-1.2571		-7.1145*
		(1.7734)		(4.0028)		(4.2353)		(2.3721)		(4.6920)		(4.4530)		(1.7318)		(4.1082)		(3.9581)
Observations	1,537	1,614	1,537	1,614	1,535	1,612	1,766	1,878	1,766	1,878	1,869	1,981	2,141	2,255	2,141	2,255	2,145	2,259
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	77	77	77	77	76	77	112	112	112	112	112	112	113	114	113	114	112	114
Number of instruments	70	73	59	70	59	70	60	63	99	110	100	111	70	73	95	106	95	106
Hansen Test	0.682	0.791	0.0332	0.0355	0.0552	0.127	0.469	0.426	0.784	0.297	0.373	0.301	0.0973	0.115	0.658	0.136	0.251	0.0926
AR(1)	4.01e-05	5.93e-06	3.85e-05	7.14e-06	2.60e-06	1.33e-07	0.0174	0.00131	0.00616	0.00128	0.00252	0.000244	0.00146	0.000159	0.00112	0.000172	0.000277	4.54e-05
AR(2)	0.374	0.389	0.401	0.394	0.314	0.771	0.135	0.410	0.183	0.469	0.333	0.681	0.436	0.425	0.427	0.529	0.928	0.961

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

Table 2.18: Robustness checks: Determinants of banking sector efficiency

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Net Interest Margin$_{t-1}$	0.3345***	0.3461***	0.2697*	0.3768***	0.2684**	0.3779***	0.3377***	0.1375***	0.2289**	0.2463***	0.2463***	0.2858***	0.2836***	0.2951***	0.2979***	0.4269***	0.2991***	0.4167***
	(0.1104)	(0.1230)	(0.1568)	(0.1220)	(0.1285)	(0.0730)	(0.1073)	(0.0470)	(0.1145)	(0.0607)	(0.0901)	(0.0676)	(0.0814)	(0.0733)	(0.0835)	(0.0666)	(0.0746)	(0.0637)
Policy variables																		
Macroeconomic variables																		
Growth	-0.0293*	-0.0138	-0.0623***	-0.0387**	-0.0766	-0.0526	-0.0424**	-0.0437	-0.0879***	-0.0467	-0.0741*	-0.0500	-0.0202	0.0033	-0.0291*	-0.0075	0.0099	0.0218
	(0.0163)	(0.0176)	(0.0203)	(0.0178)	(0.0765)	(0.0751)	(0.0205)	(0.0291)	(0.0290)	(0.0287)	(0.0388)	(0.0690)	(0.0143)	(0.0152)	(0.0166)	(0.0157)	(0.0387)	(0.0349)
Inflation	0.0314***	0.0530***	0.0246**	0.0268**	0.0366	0.0285	0.0269***	0.0594***	0.0221	0.0297**	0.0214	0.0214	0.0147*	0.0340***	0.0025	0.0075	0.0323	0.0364*
	(0.0094)	(0.0115)	(0.0098)	(0.0107)	(0.0225)	(0.0205)	(0.0100)	(0.0172)	(0.0134)	(0.0129)	(0.0150)	(0.0165)	(0.0081)	(0.0110)	(0.0074)	(0.0085)	(0.0221)	(0.0201)
Remittance Inflows	-0.0026	-0.0065	-0.1918	-0.0171	-0.0182	0.0304	-0.0015	0.0092	-0.1184	0.0094	-0.0964	0.0497	-0.0324	0.0235	-0.0718	0.0155	-0.0836	0.0170
	(0.0310)	(0.0271)	(0.1490)	(0.0514)	(0.0988)	(0.0608)	(0.0481)	(0.0351)	(0.1307)	(0.0542)	(0.1242)	(0.0532)	(0.0311)	(0.0249)	(0.0541)	(0.0363)	(0.0519)	(0.0442)
Banking Crisis Dummy	-0.1932	-0.7065*	-0.4162	-0.7824	-0.3436	-0.5997	-0.1963	-0.6712*	-0.5333	-0.3563	-0.7237	-0.4454	-0.0794	-0.2758	-0.5504	-0.2592	-0.4903	-0.4365
	(0.3519)	(0.3953)	(0.6915)	(0.4868)	(1.2158)	(0.7367)	(0.3736)	(0.3670)	(0.4666)	(0.4480)	(0.6119)	(0.5426)	(0.1529)	(0.1753)	(0.3671)	(0.2197)	(0.4650)	(0.2997)
Openness variables																		
Financial Openness	0.2451	0.1885**	-0.2976	0.1671	0.0077	0.2394	0.2122	0.0637	-0.0347	0.5238**	0.2272	0.4063	-0.0246	0.0750	-0.2781	0.0065	0.0600	0.0895
	(0.1690)	(0.0860)	(0.6081)	(0.2448)	(0.5569)	(0.2798)	(0.1728)	(0.1375)	(0.3356)	(0.2482)	(0.3844)	(0.2770)	(0.0861)	(0.0735)	(0.2993)	(0.1662)	(0.3184)	(0.1728)
Trade Openness	-0.0121**	-0.0030	-0.0238	-0.0007	-0.0151	-0.0099	-0.0167	-0.0003	-0.0103	0.0078	-0.0771*	-0.0133	-0.0072**	-0.0033	-0.0158	-0.0045	-0.0193	-0.0102**
	(0.0053)	(0.0056)	(0.0238)	(0.0074)	(0.0214)	(0.0069)	(0.0178)	(0.0092)	(0.0745)	(0.0159)	(0.0456)	(0.0188)	(0.0036)	(0.0041)	(0.0151)	(0.0043)	(0.0178)	(0.0044)
Institutional variables																		
Polity Score	0.0293	0.0617**	-0.1217	0.0538	0.1160	0.0752	0.0382	0.0687**	-0.0568	0.0323	0.0999	0.0741	0.0017	0.0403**	-0.0608	0.0328	-0.0127	0.0809*
	(0.0351)	(0.0277)	(0.1389)	(0.0536)	(0.1671)	(0.0515)	(0.0387)	(0.0273)	(0.0950)	(0.0649)	(0.1463)	(0.0655)	(0.0269)	(0.0185)	(0.0708)	(0.0485)	(0.0994)	(0.0419)
Composite Risk Rating	0.0184	-0.0282	-0.0194	-0.0858	-0.0690	-0.0945	0.0444*	-0.0460	-0.0095	-0.0961*	-0.0646	-0.1137**	0.0219	-0.0185	-0.0293	-0.0360	-0.0491	-0.0668**
	(0.0217)	(0.0272)	(0.0498)	(0.0552)	(0.0734)	(0.0577)	(0.0228)	(0.0343)	(0.0531)	(0.0506)	(0.0572)	(0.0491)	(0.0137)	(0.0178)	(0.0312)	(0.0310)	(0.0372)	(0.0302)
Market power																		
Lerner Index	2.7053**	1.8011*	2.2893*	2.3984**	4.5940***	3.1393**	0.8193	2.0219**	1.6691	1.8721	1.7976	0.8747	0.9703**	0.9089*	0.6910	0.8779	0.5856	0.6775
	(1.0381)	(0.9444)	(1.1944)	(1.1263)	(1.6915)	(1.4282)	(0.9398)	(0.8999)	(1.0850)	(1.3148)	(1.2762)	(1.4295)	(0.4546)	(0.4592)	(0.5437)	(0.5314)	(1.2059)	(0.8508)
Structural variables																		
Income Level	-0.0803	-0.1458	-0.1319	-0.0844	-0.1046	-0.0896	0.0391	-0.0631***	-0.0110	-0.0568**	-0.0477	-0.0490**	-0.0200	-0.0517***	-0.0320	-0.0363**	-0.0361	-0.0317*
	(0.2189)	(0.0962)	(0.4640)	(0.1452)	(0.4132)	(0.1275)	(0.0742)	(0.0200)	(0.0895)	(0.0248)	(0.0936)	(0.0232)	(0.0358)	(0.0128)	(0.0446)	(0.0170)	(0.0591)	(0.0163)
Population	0.0533	-0.0086	0.0411	-0.0057	0.0681	-0.0038	0.0736	-0.0083	0.0353	0.0008	0.1035	-0.0028	0.0165	-0.0053	0.0241	-0.0054	0.0237	-0.0047
	(0.0627)	(0.0057)	(0.0762)	(0.0066)	(0.0800)	(0.0080)	(0.0949)	(0.0050)	(0.1122)	(0.0068)	(0.1004)	(0.0089)	(0.0534)	(0.0036)	(0.0526)	(0.0043)	(0.0538)	(0.0059)
Population Density	0.0126**	-0.0015*	0.0145	-0.0016	0.0128	-0.0022**	0.0088	-0.0030***	0.0098	-0.0028***	-0.0017	-0.0030***	0.0154**	-0.0015***	0.0135	-0.0013**	0.0121	-0.0015*
	(0.0063)	(0.0008)	(0.0102)	(0.0010)	(0.0105)	(0.0010)	(0.0095)	(0.0008)	(0.0111)	(0.0008)	(0.0141)	(0.0009)	(0.0076)	(0.0005)	(0.0084)	(0.0006)	(0.0083)	(0.0007)
Age Dependency	0.0061	0.0111	-0.0116	0.0026	0.0407	0.0003	0.0304	0.0237*	-0.0146	0.0151	-0.0132	0.0071	0.0216	0.0216***	0.0102	0.0120	0.0193	0.0114
	(0.0313)	(0.0100)	(0.0395)	(0.0115)	(0.0408)	(0.0140)	(0.0422)	(0.0134)	(0.0712)	(0.0194)	(0.0518)	(0.0194)	(0.0194)	(0.0080)	(0.0222)	(0.0097)	(0.0245)	(0.0091)
Constant		4.7166*		8.9274*		9.4235**		5.6333*		8.9129*		12.0426**		3.0626*		4.4508		6.3989**
		(2.5254)		(4.7115)		(4.6155)		(2.9055)		(4.7011)		(4.8608)		(1.6151)		(2.7150)		(2.5925)
Observations	712	777	712	777	670	735	700	798	700	798	709	809	1,060	1,163	1,060	1,163	1,002	1,105
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	65	65	65	65	65	65	98	98	98	98	98	100	102	103	102	103	102	103
Number of instruments	39	41	47	58	46	57	29	31	82	93	82	93	39	41	87	98	86	97
Hansen Test	0.168	0.323	0.391	0.172	0.169	0.145	0.0270	0.0552	0.341	0.451	0.658	0.238	0.313	0.186	0.298	0.480	0.414	0.276
AR(1)	6.84e-05	0.000154	0.00173	2.72e-05	0.00119	5.81e-06	0.0546	0.0482	0.0671	0.0302	0.0526	0.0144	1.94e-06	1.24e-07	1.14e-06	5.97e-08	4.03e-08	3.59e-09
AR(2)	0.513	0.487	0.517	0.565	0.746	0.865	0.417	0.176	0.297	0.326	0.534	0.619	0.563	0.532	0.451	0.200	0.735	0.395

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

Table 2.19: Robustness checks: Determinants of banking sector stability

	Developing Countries						Pre-GFC (upto 2007)						Trimmed Sample					
	Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous		Exogenous		Predetermined		Endogenous	
Variables	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM	D GMM	S GMM
Lags																		
Non-performing Loans$_{t-1}$	0.7083***	0.8001***	0.6823***	0.8100***	0.6854***	0.7091***	0.7721***	0.8490***	0.6691***	0.7417***	0.6751***	0.7125***	0.7363***	0.9188***	0.7879***	0.8975***	0.6658***	0.8377***
	(0.0737)	(0.0694)	(0.1337)	(0.0854)	(0.0908)	(0.0848)	(0.0769)	(0.0833)	(0.0725)	(0.0623)	(0.0827)	(0.0626)	(0.0581)	(0.0473)	(0.0844)	(0.0462)	(0.0973)	(0.0533)
Policy variables																		
Macroeconomic variables																		
Growth	-0.0901	-0.0391	-0.0340	0.0269	-0.3211	-0.0737	-0.1149	-0.0784	-0.1891	-0.1137	-0.1296	-0.1050	-0.1375***	-0.1091***	-0.1728***	-0.1572***	-0.2776**	-0.2826**
	(0.0731)	(0.0624)	(0.0785)	(0.0823)	(0.2712)	(0.2263)	(0.0949)	(0.0728)	(0.1428)	(0.1021)	(0.1645)	(0.1103)	(0.0360)	(0.0375)	(0.0449)	(0.0496)	(0.1285)	(0.1208)
Inflation	-0.0081	-0.0286	0.0101	-0.0203	-0.0369	-0.0806	-0.0041	-0.0126	-0.0167	-0.0114	0.0135	0.0303	0.0059	-0.0045	-0.0278**	-0.0255**	-0.0206	-0.0581
	(0.0266)	(0.0228)	(0.0273)	(0.0211)	(0.0489)	(0.0514)	(0.0277)	(0.0224)	(0.0180)	(0.0198)	(0.0380)	(0.0315)	(0.0158)	(0.0143)	(0.0126)	(0.0119)	(0.0562)	(0.0409)
Remittance Inflows	-0.0340	-0.0139	-0.1791	0.0602	0.0355	0.2506	0.0129	0.0058	0.0723	-0.2158*	0.2816	-0.0936	-0.0864	-0.0219	0.2026	-0.0341	0.1853	0.1290
	(0.0786)	(0.0347)	(0.2668)	(0.2099)	(0.2054)	(0.2786)	(0.1607)	(0.0250)	(0.2925)	(0.1268)	(0.2416)	(0.1487)	(0.0770)	(0.0219)	(0.1744)	(0.1424)	(0.1716)	(0.1630)
Banking Crisis Dummy	0.0346	0.5806	2.1513	1.8416	1.0325	1.4625	-0.4731	-1.0871	0.3721	0.0780	1.7203	0.9683	0.2823	0.0881	-0.9528	0.8704	0.1408	0.6562
	(1.3010)	(1.3315)	(2.0189)	(1.6924)	(2.9731)	(3.0218)	(1.2630)	(1.0204)	(1.4185)	(1.1876)	(1.6351)	(1.6678)	(0.5091)	(0.4756)	(0.9221)	(0.7243)	(1.6149)	(0.8647)
Openness variables																		
Financial Openness	0.1073	-0.1458	-0.4186	0.1248	-0.7937	-0.1065	0.0115	-0.1498	0.0716	-0.1298	0.7668	-0.1202	0.2231	-0.0263	-0.6358	0.2485	0.3383	0.0465
	(0.2766)	(0.1681)	(1.2558)	(0.3996)	(1.1375)	(0.5543)	(0.2410)	(0.1285)	(0.6253)	(0.3378)	(0.8150)	(0.3744)	(0.1901)	(0.1044)	(0.8828)	(0.2570)	(0.9895)	(0.2273)
Trade Openness	0.0214	0.0119	-0.0733	0.0583	-0.1205	-0.0355	0.0218	-0.0013	-0.0346	0.0457	-0.0945	-0.0066	0.0302	0.0155**	0.0094	0.0632***	-0.0059	0.0138
	(0.0252)	(0.0115)	(0.1847)	(0.0471)	(0.1647)	(0.0657)	(0.0520)	(0.0071)	(0.1006)	(0.0311)	(0.1282)	(0.0312)	(0.0234)	(0.0061)	(0.0813)	(0.0212)	(0.0709)	(0.0248)
Institutional variables																		
Polity Score	0.2258**	-0.0519	-0.4685	-0.0419	-0.2046	-0.0309	0.1515	-0.0232	0.1486	0.1499	0.2515	0.0266	0.1423*	-0.0108	-0.1856	0.1253	-0.6822	0.1374
	(0.0988)	(0.0447)	(0.4694)	(0.1372)	(0.3912)	(0.1693)	(0.1504)	(0.0505)	(0.2360)	(0.0996)	(0.2724)	(0.1704)	(0.0849)	(0.0229)	(0.2675)	(0.0996)	(0.4604)	(0.1492)
Composite Risk Rating	-0.0950	-0.0401	0.1403	0.0980	-0.1916	-0.3970	0.1098	0.0317	-0.0789	-0.0546	-0.0277	-0.0763	-0.0652	-0.0329	-0.0392	0.0287	-0.3194*	-0.1526
	(0.0750)	(0.0510)	(0.1879)	(0.1740)	(0.2896)	(0.2629)	(0.0799)	(0.0463)	(0.1154)	(0.0996)	(0.1461)	(0.0985)	(0.0580)	(0.0379)	(0.1008)	(0.0748)	(0.1709)	(0.1394)
Structural variables																		
Income Level	1.3374**	0.0049	1.5127	-0.0294	0.8443	0.2535	0.4858**	-0.0116	0.4425**	-0.0202	0.3897*	-0.0106	0.1908*	0.0106	0.3004**	-0.0398	-0.0713	0.0182
	(0.5617)	(0.1100)	(1.1490)	(0.1830)	(1.0743)	(0.4295)	(0.1863)	(0.0167)	(0.1777)	(0.0389)	(0.2197)	(0.0340)	(0.1065)	(0.0134)	(0.1423)	(0.0344)	(0.1591)	(0.0602)
Population	0.0553	-0.0070	-0.0615	0.0095	0.1295	0.0139	-0.0656	-0.0025	-0.0124	0.0201	0.0438	0.0022	0.0938	-0.0034	0.1060	0.0243**	0.1025	0.0164
	(0.1929)	(0.0069)	(0.2915)	(0.0157)	(0.2707)	(0.0167)	(0.1914)	(0.0044)	(0.2523)	(0.0175)	(0.2908)	(0.0176)	(0.0849)	(0.0051)	(0.1106)	(0.0109)	(0.1280)	(0.0125)
Population Density	-0.0428	0.0000	-0.0395	-0.0013	-0.0480	-0.0045	-0.0125	-0.0004	-0.0468	0.0010	-0.0542	0.0015	-0.0487**	-0.0012**	-0.0381	-0.0031*	-0.0242	-0.0040**
	(0.0304)	(0.0010)	(0.0655)	(0.0034)	(0.0513)	(0.0047)	(0.0338)	(0.0010)	(0.0406)	(0.0012)	(0.0445)	(0.0012)	(0.0238)	(0.0005)	(0.0403)	(0.0018)	(0.0394)	(0.0019)
Age Dependency	0.1235	0.0091	0.0318	0.0439	0.1627	-0.0284	0.1179	0.0335*	0.1320	0.0689*	0.1687	0.0319	0.0763*	0.0036	0.1309*	0.0344	-0.0019	-0.0138
	(0.0972)	(0.0159)	(0.1953)	(0.0378)	(0.1743)	(0.0377)	(0.1164)	(0.0174)	(0.1340)	(0.0386)	(0.1206)	(0.0425)	(0.0453)	(0.0083)	(0.0690)	(0.0222)	(0.0971)	(0.0305)
Constant		4.0450		-8.7418		33.6380		-3.0486		1.3064		5.5114		2.4328		-4.5924		11.7252
		(3.8702)		(15.7129)		(20.4669)		(4.3087)		(8.9585)		(8.5080)		(3.0158)		(6.7236)		(11.7403)
Observations	506	555	504	553	472	521	530	612	520	602	533	615	844	929	835	920	784	869
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of countries	48	49	48	49	48	49	81	82	80	82	81	82	84	85	84	85	84	85
Number of instruments	38	40	35	45	34	44	28	30	66	76	66	76	38	40	71	81	70	80
Hansen Test	0.362	0.135	0.185	0.0959	0.205	0.164	0.275	0.251	0.645	0.628	0.414	0.406	0.962	0.00411	0.405	0.177	0.411	0.0317
AR(1)	0.00698	0.00726	0.00528	0.00482	0.0178	0.0127	0.0119	0.0116	0.0248	0.0235	0.0148	0.00965	0.00306	0.00164	0.00123	0.00112	0.00115	0.00332
AR(2)	0.250	0.278	0.313	0.282	0.0948	0.315	0.271	0.245	0.569	0.488	0.160	0.163	0.0175	0.0178	0.0670	0.0326	0.114	0.111

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

Table 2.20: The impact of policy variables on the different dimensions of financial development

	Using Gap Analysis			**Regression with Structural Controls**		
		effect on			*effect on*	
Policy variable	Depth	Efficiency	Stability	Depth	Efficiency	Stability
Macroeconomic variables						
Growth	↑	–	↑	↑	–	↑
Inflation	–	↓	↑	–	↓	–
Remittance Inflows	–	–	–	–	–	–
Banking Crisis Dummy	↓	–	↓	↓	–	–
Openness variables						
Financial Openness	–	–	–	–	–	–
Trade Openness	↑	–	↓	↑	–	↓
Institutional variables						
Polity Score	–	–	–	–	–	–
Composite Risk Rating	↑	↑	↑	↑	↑	↑
Market power						
Lerner Index		–			↓	

Chapter 3

The lender of last resort in a general equilibrium framework

This chapter is based on a sole authored paper written during my DPhil studies. I am greatly appreciative of the feedback received. All remaining errors are mine.

3.1 Introduction

The concept of the lender of last resort traces its origins to the works of Henry Thornton (1802) and Walter Bagehot (1873) who outline measures that the Bank of England need undertake to ensure the sound functioning of the British banking system in times of crisis. As outlined in Humphrey (1989), this classical paradigm of the LoLR as envisioned by Thornton and Bagehot, stressed "(1) protecting the aggregate money stock, not individual institutions, (2) letting insolvent institutions fail, (3) accommodating sound institutions only, (4) charging penalty rates, (5) requiring good collateral, and (6) preannouncing these conditions well in advance of any crisis so that the markets know exactly what to expect."

The vast body of literature on the topic that has since cumulated has been extensively surveyed by Freixas et al. (2000b). Bordo (1990) lists four major schools of thought regarding the role of the LoLR:

1. The classical paradigm of Thornton (1802) and Bagehot (1873) wherein the LoLR has a clearly articulated policy of lending to any bank that is illiquid but solvent, at a penalty rate[1], and against sound collateral (valued at pre-crisis prices). Rochet and Vives (2004) present a modern reformulation of the classical Bagehotian doctrine in a model with a developed interbank market. Unlike standard models of coordination failure, their model does not rely on the multiplicity of equilibria but has a unique Bayesian equilibrium in which an illiquid but solvent bank is, with positive probability, unable to find liquidity assistance in the interbank market. This prompts the need for LoLR intervention coupled with other policy measures.

2. The doctrine prompted by Goodfriend and King (1988) who argue that the LoLR need only intervene to provide aggregate liquidity to the banking sector by way of open market operations. They assert that LoLR assistance to individual institutions is similar to the private provision of line-of-credit services in that it requires costly monitoring. They therefore deem it redundant given the development of the interbank market and assert that it encourages excessive risk taking.

3. Discretionary LoLR assistance to individual institutions, based on the work of Goodhart (1987, 1988, 1999) where he argues that the LoLR cannot disentangle liquidity shocks from solvency shocks and therefore advocates temporary assistance to insolvent banks. He asserts that plummets in asset prices during panic conditions may lead to circumstances when banks become insolvent, though perhaps only temporarily. In the short decision timeframe that central banks are afforded when faced with an LoLR application, there is no effective way to distin-

[1] As noted in Goodhart (1999), Bagehot did not explicitly use the term ‘penalty’ rate. Goodhart asserts that by use of the phrase ‘high rate of interest’, Bagehot meant a rate above the market rate prior to the crisis, but not necessarily higher than that prevailing at the time of LoLR action.

guishing between these shocks, and Goodhart therefore recommends undertaking LoLR lending based on the estimated quality (probability of loss) of the offered collateral. This view is contended by Bordo (1990) who claims that assistance to insolvent banks was the exception rather than the rule until the 1970s, and that "liberal assistance to insolvent banks, combined with deposit insurance which is not priced according to risk, encourages excessive risk-taking, creating the conditions for even greater assistance to insolvent banks in the future."

4. The proposition of free banking with no regulatory intrusion. Goodhart (1988, 1995) states that Bagehot (1873) supported the theoretical idea of a free banking regime with no government intrusion, but felt that it would be too unrealistic to implement and thus sought to reform the Bank of England as the next best option. An analogy with free trade is often made by proponents of free banking who assert that bank crises are caused because of legal restrictions placed on the banking system. Bordo (1990) surveys the literature on free banking and concludes, based on historical evidence, that there is normally a need for a monetary authority to act as the lender of last resort. This would be especially true in the face of a major aggregate shock that produces a wide-spread demand for high powered money, a problem that a laissez-faire, unregulated system of commercial banks cannot adequately tackle.

If depositors run on banks and convert deposits into cash or other non-bank assets, it creates a need for liquidity in the overall banking system that needs to be filled externally. This is where a lender of last resort comes in, injecting liquidity in the banking system a whole. The central bank, with its monopoly on the issue of high-powered money, is ideally suited for this role. In case depositors transfer funds from one bank to another without affecting the aggregate supply of money in the economy, the interbank market ought to, in principle, be able to redistribute the liquidity from banks with a surplus to those with a paucity of liquidity. This however makes strong assumptions about perfect functioning of the interbank market. Information asymmetries and incompleteness raise doubts amongst lender banks about the solvency of banks seeking short term liquidity in the interbank market and may cause it to break down. Additionally, during times of crisis, banks with surplus liquidity may seek to hoard reserves as a precautionary measure. This may lead to a co-ordination failure amongst banks, as modelled in Freixas et al. (2000a), where each bank's best response to other banks' unwillingness to lend to a troubled bank would be to not lend either, to avoid being in a similar situation later. These expectations become self-fulfilling and yield a sub-optimal Nash equilibrium. These failures in the interbank market, coupled with the evidence on the uniqueness of bank loans, deem that the role for the LoLR be extended to providing liquidity assistance to ailing individual institutions. The central bank, again, seems well suited for this role. Given its access to supervisory information, it would appear to be better placed to gauge the health of individual banks than the market, a hypothesis tested by Berger et al. (2000) for the US. Additionally, its monopoly on the issue of the ultimate means of payment implies that it can credibly assure markets that it would be able to offer liquidity assistance, should it be needed. Current literature highlights the preservation of financial stability as one of the key roles of modern central banks (Ortiz, 2009; Goodhart, 2011). The provision of LoLR assistance would be a vital duty under this role.

That such LoLR assistance would raise the issue of moral hazard is readily apparent. However, most current models of the LoLR advocate a cost benefit analysis, prompting discretionary LoLR action when the benefits outweigh the costs of such actions. Freixas (1999) asserts that LoLR intervention is essentially equivalent to extending the benefits of deposit insurance to uninsured claim holders and is therefore distortionary. However, there are externalities generated by bank failures especially in light of the intricate network of interbank relationships, as noted in Allen and Gale (1999), and the LoLR needs to weigh the benefits of curbing a contagious systemic panic in the present against the cost of potential increases in risk taking in the future. Freixas et al. (2004) study optimal LoLR policy in the face of such moral hazard and find that LoLR intervention improves efficiency if the source of moral hazard is in the incentives for banks to screen loans. If instead, the source is in loan monitoring by banks, then the LoLR should not intervene and the interbank markets would discipline banks that engage in excessive risk taking. Goodhart and Huang (2005) develop a partial equilibrium macro-level model of the LoLR in a static setup and extend it to a dynamic, multi-period setup. Their main claim is that financial contagion caused by the failure of a bank induces panic and uncertainty and leads to more volatile financial markets wherein predicting behaviour becomes more difficult. This makes it harder to correctly execute remedial macro-policy. In the static setup, the LoLR weighs the cost of the provision of emergency liquidity assistance (ELA) to an illiquid bank that may turn out to be insolvent, against the loss from getting macro-policy (in this case, the level of high-powered money which is controlled through open market operations) wrong in the face of the failure of the bank. This setup results in it being optimal for the central bank to provide LoLR support to banks larger than a threshold size, since larger banks would induce more uncertainty and hence bring about a larger expected loss due to incorrect macro-policy. This is seen as a theoretical justification for the 'too big to fail' concept. In a dynamic setup, the probability of a future bank failure and the likelihood of an illiquid bank being insolvent are dependent on past LoLR actions and the optimal LoLR policy in this case is found to be non-monotonic in bank size, time varying and dependent on the previous two parameters. This result is seen as a rationalization for the doctrine of 'constructive ambiguity' that is much discussed in LoLR literature.

In practice, 'constructive ambiguity' has been often been used to reduce moral hazard. Introducing uncertainty about the possibility of support could force individual banks to behave more prudently since they would no longer be certain of receiving assistance. Ambiguity would imply higher expected variance prompting risk averse agents to rein in excessively risky behaviour. Further, as Freixas et al. (2000b) note, this uncertainty can be introduced in a variety of styles - uncertainty about whether assistance will be offered at all, about the timing of assistance, and about the conditions that come attached with the offer of assistance. Arguments for such constructive ambiguity in LoLR operations are based on the classic arguments for discretion and the need for flexibility to allow a central bank to retain credibility. Enoch et al. (1997) claim that another justification for ambiguity is that optimal policy is a function of perfect and complete information - something that one almost never finds in banking. On the other hand, following a policy of constructive ambiguity places a large degree of discretion in the hands of the LoLR and this raises the classic time-inconsistency problem of policy making, as studied in Kydland and Prescott (1977). Cordella and Yeyati (2003) provide another theoretical model of the LoLR, and show that contrary to the idea of discretionary LoLR intervention and 'constructive ambiguity', there may be a 'value effect' created by an ex-ante commitment of LoLR intervention that outweighs the moral hazard aspect of such policy and lowers bank risk. The setup they model involves bank managers maximizing expected profits by choosing a preferred risk-return profile that is unobservable to the LoLR. An investment profile with higher risk offers the chance of a higher return but at the cost of a higher likelihood of insolvency. In this setup, the introduction of an ex-ante commitment of LoLR assistance in face of adverse macroeconomic shocks is shown to have two antagonistic effects. There is an increase in moral hazard as the probability of solvency is now less dependent on the risk profile chosen, but the bailout commitment also increases the charter value of the bank which is at stake when choosing a profile, and this increased value incentivizes more prudent decision making, i.e. less risky behaviour.

While there is still much debate about the goals and objectives of a lender of last resort, it seems to have been satisfactorily established that they should exist, and this issue has come to the fore again in light of the recent financial crisis.[2] There has been dissent, particularly because of the issue of moral hazard, dating all the way back to the nascent days of central banking, as evinced in the writings of François-Nicolas Mollien (1845) and Herbert Spencer (1878). However, as Goodhart (1987) and Kindleberger and Aliber (2011) have noted, and empirical evidence cited above has verified, with the evolution of the banking system and the looming spectre of contagion, there is a fairly convincing

[2]See Barrell and Davis (2008); Bordo (2008).

case for intervention. Bordo (1986, 1990) provides extensive historical evidence and asserts that a public body, acting as LoLR serves to abate financial crises. Goodhart and Schoenmaker (1995) study a sample of 104 bank crises across 24 countries between the 1980s and early 90s. Of these, 73 ended up in bailouts, and in 20 of the remaining 31 cases (which ended in liquidation), deposit insurance payments were made. Rosas (2006) studies 46 cases of bank bailouts and develops a model of government policy response based on several key institutional parameters. He finds that good Bagehotian LoLR responses tend to occur in relatively closed economies, under a democratic regime, that suffer a macroeconomic shock. He also stresses the importance of sound institutions to complement such policy responses.

The aim of this study is to address the hitherto unattempted task of modelling of the lender of last resort function in a general equilibrium framework. A general equilibrium approach with its tenets of "agent optimization, market clearing (i.e. perfect competition with flexible prices), and rational expectations" (Geanakoplos and Tsomocos, 2002) is imperative to study the interaction between the real and banking sectors. Additionally, the modelling approach chosen here allows for heterogeneous agents, endogenous default, and liquidity and money – all critical elements in studying a model of financial crises in the tradition of Fisher (1933), Minsky (1377), Allen and Gale (1999, 2000), and Kindleberger and Aliber (2011).

To this end, we design a two-period monetary general equilibrium model with heterogeneous households and a risk averse banking sector, and incorporate the frictions of default and money. The model is based on the work of Goodhart et al. (2010), which itself builds upon earlier works by Goodhart et al. (2004, 2005, 2006a,b), and Tsomocos (2003).

At the outset, we model a strategic game between commercial banks and the LoLR wherein each is unaware of the other's strategy but their payoff functions are common knowledge. Banks choose between an (exogenous) investment profile that has high tail risk, and one that has low tail risk, and this affects their endowments in different states in the future. If it chooses a profile with high tail risk, it ends up with relatively higher endowment in good states of nature but ends being illiquid in bad states of nature. A low tail risk profile on the other hand, ensures that they remain liquid in all future states of nature. The central bank acting as the LoLR, unaware of the exact nature of the bank's balance sheet, may choose *ex-ante* to adopt a dovish stance and bail the distressed bank out or be hawkish and liquidate the bank.[3] The strategic choices of two players determine the set of decision variables and the budget sets of all agents, and the economy subsequently attains the corresponding equilibrium.

The economy modelled is one of exchange without production. Households maximize expected utility from the consumption of a single good, across both time periods and across all states of nature. Banks issue short term loans to provide liquidity in the market, since households are subject to cash-in-advance constraints. They also issue interperiod loans for agents to borrow against expected future earnings. Banks themselves borrow from depositors, and from the central bank in the form of repo loans, pledging their future monetary endowment as collateral. These may be thought of as other (exogenous) assets of the bank. Based the bank's ex-ante choice of risk profile, and the state of nature realised, the bank may end up in a state where its monetary endowment has lower value than its loan obligations, forcing it to default on its repo loan – and depending on the LoLR's stance, it may or may not be bailed out. This has implications for the default decisions of households, and affects the aggregate level of default in the economy. Default between the agents and the commercial bank is modelled as continuous default à la Shubik and Wilson (1977). We study three calibrations of the model under the different combinations of strategies employed by the two players – the commercial bank and the LoLR. The payoffs to the players are tabulated and

[3] Another interesting setup would be to study the game as a sequential one with the LoLR deciding on a tough/soft policy stance and the commercial bank responding with a safe/risky risk profile. One would expect to find the time inconsistency problem with the LoLR not being credibly able to commit to a tough policy stance *ex-ante* analogous to that studied by Kydland and Prescott (1977).

comparative statics are discussed.

The payoff functions of both the LoLR and the bank are based on equilibrium values of the endogenous variables in the GE model and this links the equilibrium of the simultaneous game with that of the GE model. Our contribution is to make a first pass at incorporating some strategic behaviour in the otherwise competitive model. We admit that this is for now rudimentary and we only prove existence and local uniqueness by calibration. Further research needs to be done to establish general existence and uniqueness in this framework.

Section 2 below elaborates the strategic game, the structure of the economy modelled, the sequence of agent actions, and the market structure. Section 3 defines the equilibrium of the model and discusses its properties. A parametrised version of the model is presented in section 4. Section 5 details the comparative statics studied and section 6 concludes.

3.2 The model

3.2.1 Strategic game formulation

We model a strategic game between the commercial bank and the LoLR. The commercial bank borrows from the central bank (a proxy for the interbank market) through a repo loan which is collateralised. The bank's monetary endowment is used to collateralise the loan and depending on its ex-ante choice of risk profile, the bank may end up in a state where its monetary endowment has lower value than its loan obligations

[4] We calibrate our model such that if the bank chooses a low risk profile, it is solvent in all future states of nature, whereas if it chooses a high risk profile, it defaults in bad states of nature.

[5] In our calibration, we choose risk profiles that have the same expected value but differing riskiness (variance). This is in line with the asymmetry of information assumed in our game – the central bank may be able to assess the quality of collateral with regards to expected value but not in terms of riskiness.

forcing it to default on the repo loan.[4] The central bank acting as LoLR is unaware of the risk profile chosen the bank[5], and has to determine its *ex-ante* policy stance without knowledge of the risk profile chosen by the bank. We therefore have the following game tree:

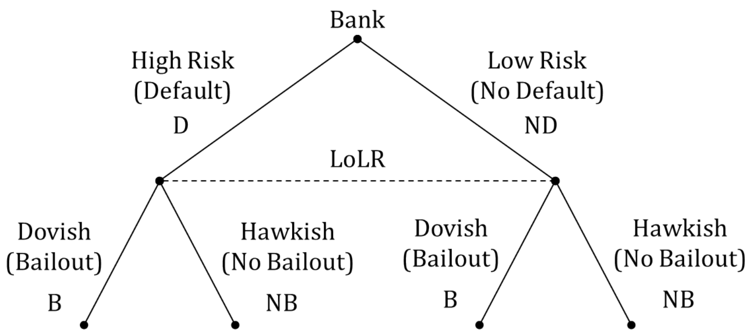

Figure 3.1: Strategic game tree

The payoff function for the commercial bank is its expected lifetime utility as elaborated later in section 3.2.7.3. We assume a plausible payoff function for the Central Bank (as the LoLR), in the spirit of Goodhart et al. (2004) and Tsomocos (2003). In these papers, financial fragility is characterised by an sharp decline in banking sector profitability coupled with a substantial increase in aggregate default. Financial fragility is detrimental since it precipitates welfare losses in the economy. The payoff of the Central Bank (as LoLR) is therefore chosen to be a simple, linear function of bank profitability (increasing) and the level of default in the economy (decreasing) less the non-monetary costs of a bailout.

$$\Pi^{CB} = \xi_1 \sum_{s \in S^*} \theta_s \pi_s^{\gamma} + \xi_2 \sum_{s \in S^*} \theta_s \left(1 - \boldsymbol{\nu}_s\right) - \mathscr{C}$$

Formally, we have a strategic game $\Gamma = \left\langle N, \left(A_i\right)_{i \in N}, \left(F_i\right)_{i \in N} \right\rangle$ with:

The lender of last resort

$$
\begin{array}{llll}
\text{A set of players:} & N & = \{\text{Bank}(\gamma),\ \text{Central Bank - LoLR } (CB)\} & \\
\text{Action sets:} & A_\gamma & = \{\text{Default } (D),\ \text{No Default } (ND)\} & \\
 & A_{CB} & = \{\text{Bailout } (B),\ \text{No Bailout } (NB)\} & \\
\text{Payoff functions:} & F^\gamma(a) & = \Pi^\gamma|_{(\boldsymbol{\eta},(\boldsymbol{\sigma}^h)_{h\in H})^{(a)}} & \forall a \in A_\gamma \times A_{CB} \\
 & F^{CB}(a) & = \Pi^{CB}|_{(\boldsymbol{\eta},(\boldsymbol{\sigma}^h)_{h\in H})^{(a)}} & \forall a \in A_\gamma \times A_{CB}
\end{array}
$$

Central Bank (LoLR) \ Bank	D	ND
B	$(\Pi^{\gamma}{}_{DB}, \Pi^{CB}{}_{DB})$	$(\Pi^{\gamma}{}_{ND}, \Pi^{CB}{}_{NB})$
NB	$(\Pi^{\gamma}{}_{DN}, \Pi^{CB}{}_{DN})$	$(\Pi^{\gamma}{}_{ND}, \Pi^{CB}{}_{NN})$

Figure 3.2: Payoff table for the strategic game

Note that the action Default (D) for the bank signifies choosing an investment profile with high tail risk (which is calibrated to ensure default in bad states of nature), it is not an *ex-ante* choice to default in all future states of nature. The action No Default (ND) has a similar connotation.

The payoffs of both players are themselves determined by the equilibrium values of endogenous variables in the GE model and therefore by the structural parameters. The portfolios choices are continuous and competitively determined in equilibrium and hence they are not strategic choices in the game.

The risk profile chosen by the bank in the game is exogenous to the GE model but is linked to the quality of the collateral against which it borrows from the central bank and determines whether or not it will default in the bad state. The central bank is unaware of this strategic choice ex-ante (and therefore doesn't know *ex-ante* whether the bank will default or not) âĂŞ this is the information asymmetry at the heart of the simultaneous game and this is why even though the two players may not make their moves at the same time, *de facto* the game can be analysed as a simultaneous game the game since each player is unaware of the actions of the other. This asymmetry is resolved by the Nash Equilibrium of the simultaneous game.

3.2.2 The economy

The economy modelled is a two period, static world which includes two agent-households (α, β) and a representative commercial bank (γ). There are two time periods, and S possible states of nature in the second period. State s occurs with probability θ_s. There is a single, perishable consumption good in this model. Households maximize the utility[6] of consumption of this good in each time period $t \in T = \{0, 1\}$, and across each state of nature $s \in S$. Banks maximize their expected profits. The set of all states is denoted $s \in S^* = \{0\} \cup S$. The set of all agents is denoted $h \in H = \{\alpha, \beta, \gamma\}$.

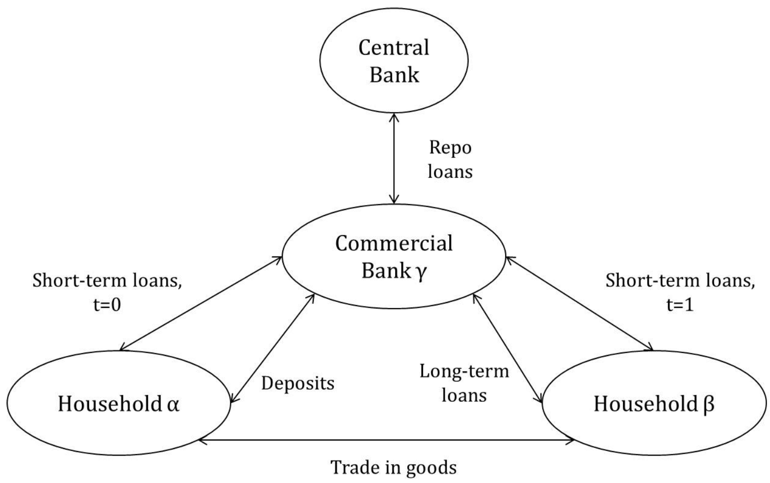

Figure 3.3: Structure of the model

[6]In our simulations, we use a constant relative risk aversion (CRRA) utility function $u(c) = \frac{c^{1-\rho}}{1-\rho}$, to be able to consider wealth effects.

Household α is relatively wealthier at $t = 0$ while household β is relatively wealthier at $t = 1$. The households therefore trade in order to smoothe consumption. Both households interact with the commercial bank γ. There is an exogenous cash endowment given to each household free of any obligation ($m_s \geq 0$, for $s \in S^*$). Endowments in goods and cash are allowed to vary across states of nature.

3.2.3 Money

Money is the stipulated means of exchange and store of value in this model. It is introduced through cash-in-advance constraints, implying that households can only purchase the consumption good by paying in cash. Money is fiat and has no consumption value but its value derives from the fact that it is essential to conduct trade in the goods market. The Central Bank controls the supply of money and injects it into the economy in both time periods. In the first period the commercial bank γ borrows from depositors and extends long term loans. It also uses its future monetary endowment as collateral to take on a repo loan from the Central Bank and provides short-term liquidity at $t = 0$ to allow households to make purchases with cash. In the second period, the bank pays back depositors, the repo loan and issues short-term liquidity that is repaid at the end of the period when all the money exits the economy, since it has no consumption value.

3.2.4 Default

All loan contracts are defaultable in this model. Default, in our model, is endogenous and therefore a decision variable for agents. Short-term (intraperiod) loans, deposits and long-term (interperiod) loans are unsecured in our model. Default in these markets is therefore modelled as a continuous phenomenon as was first studied by Shubik and Wilson (1977) and was extended to a general equilibrium framework by Dubey et al. (2005). In this case, the repayment rate i.e. the fraction of the loan paid back is a decision variable of the debtor. Upon default, agents face a non-pecuniary penalty which reduces utility by a constant rate 'λ' per monetary unit of account not repaid. The default penalties for the short-term loan, long-term loan, and deposit markets are denoted λ_s, $\bar{\lambda}_s$, and λ_s^d, respectively. Each additional monetary unit of account defaulted increases income of the debtor and this has a marginal effect on the agent's utility. However not delivering this additional unit of account also entails a utility loss equal to the default penalty λ. In equilibrium agents therefore decide to default completely, not at all, or partially depending on the marginal gain and marginal loss in utility from defaulting.

Since we assume that expectations are rational in equilibrium, the expected rates of delivery on short-term loans, long-term loans and deposits are equal to the actual rates of delivery. This allows us to establish default as an equilibrium phenomenon that can coexist with the orderly functioning of the financial system.

In addition, repo loans offered by the central bank to the commercial bank are secured by collateral. The commercial bank γ would therefore chooses to default on its repo loan obligation at $t = 1$ when the value of the collateral i.e. the monetary endowment in state $s \in S$ is less than the repo loan amount. In case the commercial bank defaults and the central bank decides to bail it out, it lets the bank continue despite of the default on the repo loan and offers the commercial bank additional funds at a discount window at a discount rate τ. If instead the central bank's stance is to not bail the commercial bank out, in the bad state of nature, when the commercial bank is unable to repay the repo loan in full, the central bank seizes the collateral, liquidates the bank and pays out depositors in order of seniority.

3.2.5 Timing

There are five markets that convene at each time period $t \in T$. The short-term (intraperiod) loan, long-term (interperiod) loan, deposit, and repo loan markets meet at the beginning of each time period, and the goods market meets subsequently in each period. As in Goodhart et al. (2010), this setup is chosen because it "maximizes the number of transactions possible and allows households to borrow in the short-term money market in order to invest in long-term bond or asset markets. It also allows for an explicit speculative motive for holding money." A timeline of the model is provided below in figure 3.4.

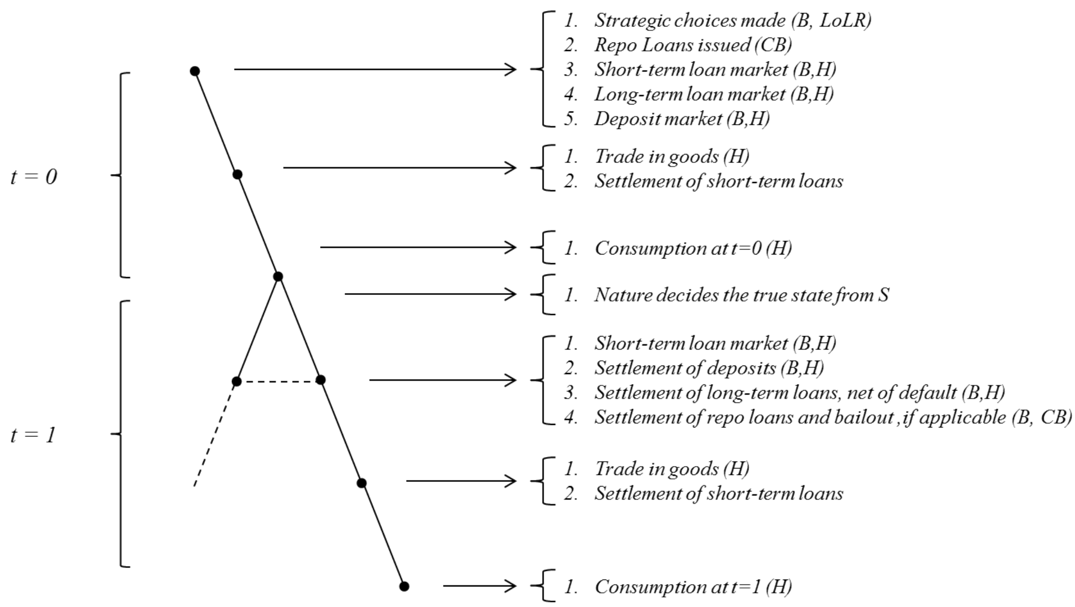

Figure 3.4: Time line of the model

B: Bank, LoLR: Lender of Last Resort, CB: Central Bank, H: Households

3.2.6 Decision variables and budget sets

We denote macro variables, which are determined in equilibrium and which each household takes as fixed, by $\boldsymbol{\eta} = (\boldsymbol{p}, \boldsymbol{r}, r_d, \rho, \bar{r}) \in \mathbb{R}_+^{S^*} \times \mathbb{R}_+^{S^*} \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+$.

The lender of last resort

The vectors of household α and β's decisions are denoted, $\boldsymbol{\sigma}^\alpha \in \boldsymbol{\Sigma}_\alpha(\boldsymbol{\eta})$ and $\boldsymbol{\sigma}^\beta \in \boldsymbol{\Sigma}_\beta(\boldsymbol{\eta})$, respectively. $\boldsymbol{\sigma}^\alpha = (\boldsymbol{b}^\alpha, q^\alpha, \mu^\alpha, d^\alpha, \nu^\alpha) \in \mathbb{R}_+^S \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+$ and $\boldsymbol{\sigma}^\beta = (b^\beta, \boldsymbol{q}^\beta, \boldsymbol{\mu}^\beta, \bar{\mu}^\beta, \bar{\boldsymbol{\nu}}^\beta, \boldsymbol{\nu}^\beta) \in \mathbb{R}_+ \times \mathbb{R}_+^S \times \mathbb{R}_+^S \times \mathbb{R}_+ \times \mathbb{R}_+^S \times \mathbb{R}_+^S$.

The vector of the commercial bank γ's decisions is denoted $\boldsymbol{\sigma}^\gamma \in \boldsymbol{\Sigma}_\gamma(\boldsymbol{\eta})$ where $\boldsymbol{\sigma}^\gamma = (\boldsymbol{\pi}^\gamma, \boldsymbol{m}^\gamma, \bar{m}^\gamma, \mu_d^\gamma, \mu_R^\gamma, \boldsymbol{\nu}^\gamma) \in \mathbb{R}_+^{S^*} \times \mathbb{R}_+^{S^*} \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+^S$.

The variables used in the model are:

p_s	:	Price of the good in state $s \in S^*$
r_s	:	Short-term loan rate offered by the bank in state $s \in S^*$
r_d	:	Interest rate on deposits offered by the bank
ρ	:	Interest rate on repo loans offered by the central bank
$\bar{r}$	:	Long-term loan rate offered by the bank
b_s^h	:	Amount of money spent on goods by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
q_s^h	:	Quantity of goods offered for sale by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
μ_s^h	:	Short-term borrowing by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
ν_s^h	:	Short-term loan repayment rate of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
d^α	:	Deposit by household α at $t = 0$
$\bar{\mu}^\beta$	:	Long-term borrowing by household β at $t = 0$
$\bar{\nu}_s^\beta$	:	Long-term repayment rate of household β in state $s \in S$
c^h	:	Coefficient of risk aversion of agent $h \in H$
θ_s	:	Probability of state $s \in S$
c_s^h	:	Consumption of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
e_s^h	:	Goods endowment of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
m_s^h	:	Monetary endowment of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
$e_{s,i}^\gamma$	:	Monetary endowment of bank γ in state $s \in S^*$, under risk profile $i \in \{H, L\}$
M^{CB}	:	Money supply at $t = 0$
M_s^{CB}	:	Money injection by the central bank in the short-term loan market in state $s \in S$
τ	:	Borrowing rate at the discount window in case of a bailout
λ_s	:	Non-pecuniary penalty for defaulting on short-term loans in state $s \in S^*$
$\bar{\lambda}_s$	:	Non-pecuniary penalty for defaulting on long-term loans in state $s \in S$
λ_s^D	:	Non-pecuniary penalty for defaulting on deposits in state $s \in S$
π_0^γ	:	Bank profits at $t = 0$
m_s^γ	:	Short-term loan extension by the bank in state $s \in S^*$
$\bar{m}^\gamma$	:	Long-term loan extension by the bank at $t = 0$
μ_R^γ	:	Amount borrowed by the bank via repo loans at $t = 0$
μ_d^γ	:	Amount borrowed by the bank via deposits at $t = 0$
ν_s^γ	:	Bank's repayment rate on deposits in state $s \in S^*$
c_0^γ	:	Bank's retained earnings at $t = 0$

3.2.7 Agents' behaviour

3.2.7.1 Household α

Household α maximizes its utility from the consumption of the good in each period, and across each state of nature. Endowed with relatively more of the good at $t=0$ than at $t=1$, and with cash, it smoothes consumption by selling part of its endowment at $t=0$ and depositing part of its wealth with the commercial bank γ. In the second period, it uses its wealth to buy some of the consumption good.

Agent α's optimization problem is as follows

$$\max_{\boldsymbol{\sigma}^\alpha \in \boldsymbol{\Sigma}_\alpha} \Pi^\alpha = \{u(c_0^\alpha) - \lambda_0 \max[0, (1-\nu_0^\alpha)\mu_0^\alpha]\} + \sum_{s\in S} \theta_s u(c_s^\alpha)$$

$$s.t. B^\alpha(\boldsymbol{\eta}) = \{\boldsymbol{\sigma}^\alpha \in \boldsymbol{\Sigma}_\alpha(\boldsymbol{\eta}) : (01^\alpha) - (s1^\alpha)\}$$

Agent α faces the following constraints:

$$(01^\alpha) \quad d^\alpha \leq \frac{\mu_0^\alpha}{1+r_0} + m_0^\alpha$$

$$(02^\alpha) \quad \mu_0^\alpha \nu_0^\alpha \leq p_0 q_0^\alpha$$

$$(s1^\alpha) \quad b_s^\alpha \leq d^\alpha(1+r_d)\nu_s^\gamma + m_s^\alpha$$

(01^α) says that in the beginning of $t=0$, household α borrows short-term and deposits these funds along with its monetary endowment for use in $t=1$.

(02^α) says that at the end of $t=0$, household α repays the short-term loan using the proceeds of good sales.

$(s1^{\alpha})$ says that at the beginning of each state $s \in S$, household α uses the returns on its deposits and its monetary endowment to purchase the good.

Note that household α cannot sell more than its endowment and therefore $q_0^{\alpha} \leq e_0^{\alpha}$. θ_s is the probability of state s occurring, $c_0^{\alpha} = (e_0^{\alpha} - q_0^{\alpha})$ is household α's consumption in state 0 and $c_s^{\alpha} = (e_s^{\alpha} + \frac{b_s^{\alpha}}{p_s})$ is household α's consumption in state $s \in S$.

3.2.7.2 Household β

Household β is endowed with relatively more of the good at $t = 1$ than at $t = 0$, and with cash. In order to smoothe consumption, it takes on an interperiod loan from the bank γ to buy some of the consumption good at $t = 0$. In the second period, it sells some of its endowment to pay back part of its loan.

Household β's optimization problem is as follows

$$\max_{\boldsymbol{\sigma}^\beta \in \boldsymbol{\Sigma}_\beta} \Pi^\beta = u(c_0^\beta) + \sum_{s \in S} \theta_s \{u(c_s^\beta) - \bar{\lambda}_s \max[0, (1 - \bar{\nu}_s^\beta)\bar{\mu}^\beta] - \lambda_s \max[0, (1 - \nu_s^\beta)\mu_s^\beta]\}$$

$$s.t. B^\beta(\boldsymbol{\eta}) = \{\boldsymbol{\sigma}^\beta \in \boldsymbol{\Sigma}_\beta(\boldsymbol{\eta}) : (01^\beta) - (s2^\beta)\}$$

Household β faces the following constraints:

$(01^\beta)\quad b_0^\beta \leq \dfrac{\bar{\mu}^\beta}{1+\bar{r}} + m_0^\beta$

$(s1^\beta)\quad \bar{\mu}^\beta \bar{\nu}_s^\beta \leq \dfrac{\mu_s^\beta}{1+r_s} + m_s^\beta$

$(s2^\beta)\quad \mu_s^\beta \nu_s^\beta \leq p_s q_s^\beta$

(01^β) says that in $t = 0$, household β takes out a long-term loan and uses this along with its monetary endowment to purchase the consumption good.

$(s1^\beta)$ says that at the beginning of each state $s \in S$, household β repays some fraction of the long-term loan using short-term borrowings and irs monetary endowment.

$(s2^\beta)$ says that at the end of each state $s \in S$, household β repays the short-term loan using the proceeds of good sales.

Note that household β cannot sell more than its endowment and therefore $q_s^\beta \leq e_s^\beta . c_0^\beta = (e_0^\beta + \frac{b_0^\beta}{p_0})$ is household β's consumption in state 0 and $c_s^\beta = (e_s^\beta - q_s^\beta)$ is household β's consumption in state $s \in S$. Its utility in state $s \in S$ is subject to a default penalties which are linear in the amount defaulted.

3.2.7.3 Commercial bank γ

The commercial bank γ is risk averse and maximizes expected utility of profits in both periods. It has quadratic preferences over profits i.e. it faces a portfolio allocation problem wherein it tries to diversify idiosyncratic risk. It borrows from depositors and from the central bank via a repo loan collateralized by its future monetary endowment. It uses these funds to extend short term liquidity in both periods and extend long-term credit via an interperiod loan. It faces a liquidity shock that may make it illiquid in the bad state of nature, forcing it to default on its repo loan obligation. Depending on the realization of this shock and the policy stance of the LoLR, which is unknown to it, the commercial bank γ solves one of the following three optimization problems.

The commercial bank γ's optimization problem is as follows

(a) No Default Case

$$\max_{\boldsymbol{\sigma}^{\gamma}\in\boldsymbol{\Sigma}_{\gamma}} \Pi^{\gamma} = \{\pi_0^{\gamma} - c^{\gamma}(\pi_0^{\gamma})^2\} + \sum_{s\in S}\theta_s\{\pi_s^{\gamma} - c^{\gamma}(\pi_s^{\gamma})^2 - \lambda_s^D \max[0,(1-\nu_s^{\gamma})\mu_d^{\gamma}]\}$$

$$s.t. B^{\gamma(ND)}(\boldsymbol{\eta}) = \{\boldsymbol{\sigma}^{\gamma} \in \boldsymbol{\Sigma}_{\gamma}(\boldsymbol{\eta}) : (01^{\gamma}) - (s2^{\gamma})\}$$

In this case, the commercial bank γ faces the following constraints:

$$(01^{\gamma}) \quad m_0^{\gamma} + \bar{m}^{\gamma} \leq \frac{\mu_d^{\gamma}}{1+r_d} + \frac{\mu_R^{\gamma}}{1+\rho} + e_0^{\gamma}$$

$$(02^{\gamma}) \quad \pi_0^{\gamma} \leq m_0^{\gamma}(1+r_0)\nu_0^{\alpha}$$

Let $S^{\gamma} \subseteq S$ denote all the states where the bank is solvent on its repo loan, i.e.

$$e_s^{\gamma} > \mu_R^{\gamma} \quad \forall s \in S^{\gamma}$$

In the No Default case, $S^{\gamma} = S$ and therefore the bank's second period

budget constraints are:

$$(s1^{\gamma}) \quad m_s^{\gamma} + \mu_d^{\gamma}\nu_s^{\gamma} + \mu_R^{\gamma} \leq \Delta(02^{\gamma}) + \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}_s^{\beta} + e_s^{\gamma}$$

$$(s2^{\gamma}) \quad \pi_s^{\gamma} \leq m_s^{\gamma}(1+r_s)\nu_s^{\beta}$$

(01^{γ}) says that in $t = 0$, the commercial bank γ borrows from depositors and from the Central Bank, via a repo loan, and this combined with its monetary endowment is used to fund short-term and long-term loan offerings. The bank's equity (monetary endowment) is used as collateral for the repo loan taken from the Central Bank.

(02^{γ}) says that at the end of $t = 0$, the commercial bank γ uses short-term loan repayment to disburse profits.

$(s1^{\gamma})$ says that at the beginning of each state $s \in S$, where the value of bank equity is greater than that of the repo loan repayment, bank γ uses long term loan repayment, its monetary endowment in state s, and the cash carried over from the first period $(\Delta(02^{\gamma}))$ to pay back depositors and the Central Bank, and issue short-term loans in state s.

$(s2^{\gamma})$ says that at the end of each state $s \in S$, bank γ keeps the short-term loan repayment as profit.

(b) Bailout Case

$$\max_{\boldsymbol{\sigma}^\gamma \in \boldsymbol{\Sigma}_\gamma} \Pi^\gamma = \{\pi_0^\gamma - c^\gamma(\pi_0^\gamma)^2\} + \sum_{s\in S} \theta_s \{\pi_s^\gamma - c^\gamma(\pi_s^\gamma)^2 - \lambda_s^D \max[0, (1-\nu_s^\gamma)\mu_d^\gamma]\}$$

$$s.t. B^{\gamma(DB)}(\boldsymbol{\eta}) = \{\boldsymbol{\sigma}^\gamma \in \boldsymbol{\Sigma}_\gamma(\boldsymbol{\eta}) : (01^\gamma) - (s2^\gamma)^{(DB)}\}$$

In this case, the commercial bank γ faces the following constraints:

(01^γ) $\quad m_0^\gamma + \bar{m}^\gamma \leq \dfrac{\mu_d^\gamma}{1+r_d} + \dfrac{\mu_R^\gamma}{1+\rho} + e_0^\gamma$

(02^γ) $\quad \pi_0^\gamma \leq m_0^\gamma(1+r_0)\nu_0^\alpha$

For all states $s \in S^\gamma$ the bank's second period budget constraints are:

$(s1^\gamma)$ $\quad m_s^\gamma + \mu_d^\gamma \nu_s^\gamma + \mu_R^\gamma \leq \Delta(02^\gamma) + \bar{m}^\gamma(1+\bar{r})\bar{\nu}_s^\beta + e_s^\gamma$

$(s2^\gamma)$ $\quad \pi_s^\gamma \leq m_s^\gamma(1+r_s)\nu_s^\beta$

For all states $s \notin S^\gamma$ the bank's second period budget constraints are:

$(s1^\gamma)^{(DB)}$ $\quad m_s^\gamma + \mu_d^\gamma \nu_s^\gamma \leq \Delta(02^\gamma) + \bar{m}^\gamma(1+\bar{r})\bar{\nu}_s^\beta + \dfrac{\mu_B^\gamma}{1+\tau}$

$(s2^\gamma)^{(DB)}$ $\quad \pi_s^\gamma \leq m_s^\gamma(1+r_s)\nu_s^\beta - \mu_B^\gamma$

(01^γ) says that in $t = 0$, the commercial bank γ borrows from depositors and from the Central Bank, via a repo loan, and this combined with its monetary endowment is used to fund short-term and long-term loan offerings. The bank's equity (monetary endowment) is used as collateral for the repo loan taken from the Central Bank.

(02^γ) says that at the end of $t = 0$, the commercial bank γ uses short-term loan repayment to disburse profits.

$(s1^\gamma)$ says that at the beginning of each state $s \in S^\gamma$, where the value of bank equity is greater than that of the repo loan repayment, bank γ uses long term loan repayment, its monetary endowment in state s, and the cash carried over from the first period $(\Delta(02^\gamma))$ to pay back depositors and the Central Bank, and issue short-term loans in state s.

$(s2^\gamma)$ says that at the end of each state $s \in S^\gamma$, bank γ keeps the short-term loan repayment as profit. $(s1^\gamma)^{(DB)}$ says that at the beginning of each state $s \notin S^\gamma$, where the value of bank equity is lower than that of the repo loan repayment, bank γ defaults on its repo loan but is bailed out and allowed to borrow from the discount window at an interest rate τ and uses this default window borrowing along with long term loan repayment, and the cash carried over from the first period to pay back depositors and to issue short-term loans in state s.

$(s2^\gamma)^{(DB)}$ says that at the end of each state $s \notin S^\gamma$, bank γ uses the short-term loan repayment to repay the discount window borrowing and disburse profits.

(c) No Bailout Case

$$\max_{\boldsymbol{\sigma}^{\gamma}\in\boldsymbol{\Sigma}_{\gamma}} \Pi^{\gamma} = \{\pi_0^{\gamma} - c^{\gamma}(\pi_0^{\gamma})^2\} + \sum_{s\in S^{\gamma}} \theta_s\{\pi_s^{\gamma} - c^{\gamma}(\pi_s^{\gamma})^2 - \lambda_s^D \max[0,(1-\nu_s^{\gamma})\mu_d^{\gamma}]\}$$

$$s.t. B^{\gamma(DN)}(\boldsymbol{\eta}) = \{\boldsymbol{\sigma}^{\gamma} \in \boldsymbol{\Sigma}_{\gamma}(\boldsymbol{\eta}) : (01^{\gamma}) - (s2^{\gamma})\}$$

The commercial bank γ faces the following constraints:

$$(01^{\gamma}) \quad m_0^{\gamma} + \bar{m}^{\gamma} \leq \frac{\mu_d^{\gamma}}{1+r_d} + \frac{\mu_R^{\gamma}}{1+\rho} + e_0^{\gamma}$$

$$(02^{\gamma}) \quad \pi_0^{\gamma} \leq m_0^{\gamma}(1+r_0)\nu_0^{\alpha}$$

For all states $s \in S^{\gamma}$ the bank's second period budget constraints are:

$$(s1^{\gamma}) \quad m_s^{\gamma} + \mu_d^{\gamma}\nu_s^{\gamma} + \mu_R^{\gamma} \leq \Delta(02^{\gamma}) + \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}_s^{\beta} + e_s^{\gamma}$$

$$(s2^{\gamma}) \quad \pi_s^{\gamma} \leq m_s^{\gamma}(1+r_s)\nu_s^{\beta}$$

(01^{γ}) says that in $t = 0$, the commercial bank γ borrows from depositors and from the Central Bank, via a repo loan, and this combined with its monetary endowment is used to fund short-term and long-term loan offerings. The bank's equity (monetary endowment) is used as collateral for the repo loan taken from the Central Bank.

(02^{γ}) says that at the end of $t = 0$, the commercial bank γ uses short-term loan repayment to disburse profits.

$(s1^{\gamma})$ says that at the beginning of each state $s \in S^{\gamma}$, where the value of bank equity is greater than that of the repo loan repayment, bank γ uses long term loan repayment, its monetary endowment in state s, and the cash carried over from the first period ($\Delta(02^{\gamma})$) to pay back depositors and the Central Bank, and issue short-term loans in state s.

($s2^{\gamma}$) says that at the end of each state $s \in S^{\gamma}$, bank γ keeps the short-term loan repayment as profit. Since the bank rationally expects not to be bailed out if it defaults, its maximization problem is restricted to the states $s \in S^{\gamma}$. In this case, when the bank defaults on its repo loan (i.e. in $s \notin S^{\gamma}$), the Central Bank seizes the collateral and hands over all remaining bank assets to depositors who are the senior creditors. We assume costless liquidation of the bank's assets. The depositors have to therefore take a haircut on their deposits. The effective repayment rate on deposits for the states $s \notin S^{\gamma}$ is therefore defined as, $\nu_s^{\gamma} = \frac{\Delta(02^{\gamma})+\bar{m}^{\gamma}(1+\bar{r})\bar{\nu}_s^{\beta}}{\mu_d^{\gamma}} \quad \forall s \notin S^{\gamma}$.

3.2.8 Market clearing conditions

Each of the five markets in the model clears at a price that balances supply and demand in equilibrium. The market clearing conditions are:

$$
\begin{aligned}
&(MC_1) \qquad p_0 = \frac{b_0^\beta}{q_0^\alpha} \\
&(MC_2) \qquad p_s = \frac{b_s^\alpha}{q_s^\alpha}, \quad \forall s \in S \\
&(MC_3) \qquad (1 + r_0) = \frac{\mu_0^\alpha}{m_0^\gamma} \\
&(MC_4) \qquad (1 + r_s) = \frac{\mu_s^\beta}{(m_s^\gamma + M_s^{CB})}, \quad \forall s \in S \\
&(MC_5) \qquad (1 + \bar{r}) = \frac{\bar{\mu}^\beta}{\bar{m}^\gamma} \\
&(MC_6) \qquad (1 + r_d) = \frac{\mu_d^\gamma}{d^\alpha} \\
&(MC_7) \qquad (1 + \rho) = \frac{\mu_R^\gamma}{M^{CB}}
\end{aligned}
$$

(MC_1) and (MC_2) say that in each state $s \in S^*$ the goods market clears when the amount of money offered for the good is exchanged for the quantity of the good offered for sale.

(MC_3) says that at $t = 0$ the short-term loan market clears when the amount of short-term credit demanded by households is exchanged for the amount of short-term credit offered by the bank.

(MC_4) says that in each state $s \in S$ the short-term loan market clears when the amount of short-term credit demanded by households is exchanged for the amount of short-term credit offered by the bank and the amount injected by the central bank.

(MC_5) says that the long-term loan market clears when the amount of long-term credit demanded by households is exchanged for the amount of long-term credit offered by the bank.

(MC_6) says that the deposit market clears when the amount of deposit borrowing demanded by the bank is exchanged for the amount of deposits offered by households.

(MC_7) says that the repo loan market clears when the amount of interbank borrowing demanded by the bank is exchanged for the amount of money supplied by the central bank.

3.3 Equilibrium

There are two equilibrium concepts contained within this model – equilibrium in the strategic game, and a rational expectations equilibrium corresponding to each of the possible combinations of player actions. Their definitions and properties are explained below.

3.3.1 Definition

3.3.1.1 Nash equilibrium

The mixed extension of the (finite) strategic game $\Gamma = \langle N, (A_i)_{i\in N}, (F_i)_{i\in N}\rangle$ is the strategic game $\hat{\Gamma} = \left\langle N, (\Delta(A_i)_{i\in N}), \left(\hat{F}_i\right)_{i\in N}\right\rangle$ wherein $\Delta(A_i)$ is the set of probability distributions over A_i, and for each $\alpha \in \times_{j\in N}\Delta(A_j)$, $\hat{F}_i(\alpha) = \sum_{a\in A}\left(\prod_{j\in N}\alpha_j(a_j)\right)F_i(a)$.

The mixed strategy Nash equilibrium of the strategic game $\Gamma = \langle N, (A_i)_{i\in N}, (F_i)_{i\in N}\rangle$ is the Nash equilibrium of its mixed extension $\hat{\Gamma} = \left\langle N, \left(\Delta (A_i)_{i\in N}\right), \left(\hat{F}_i\right)_{i\in N}\right\rangle$. For the game defined in this paper, it is therefore a distribution over a profile of actions $\alpha^* \in \Delta(A_\gamma) \times \Delta(A_{CB})$ with the property that for every player-type $i \in N$, *every pure strategy in the support of* α_i^* *is a best response to* α_{-i}^*.

3.3.1.2 Monetary equilibrium with commercial banks, default, and the lender of last resort

Based on the strategic choices of the Bank and the LoLR, one of three possible equilibria attains. We say that $(\boldsymbol{\eta}, (\boldsymbol{\sigma}^h)_{h\in H})^{(xx)}, (xx) \in \{ND, DB, DN\}$ is a monetary equilibrium with commercial banks, default, and the lender of last resort (MEBDL) iff:

(1) $\quad \boldsymbol{\sigma}^\alpha \in \underset{\boldsymbol{\sigma}^\alpha \in B^\alpha(\boldsymbol{\eta})}{\arg\max}\ \Pi^\alpha$

(2) $\quad \boldsymbol{\sigma}^\beta \in \underset{\boldsymbol{\sigma}^\beta \in B^\beta(\boldsymbol{\eta})}{\arg\max}\ \Pi^\beta$

(3) $\quad \boldsymbol{\sigma}^\gamma \in \underset{\boldsymbol{\sigma}^\gamma \in B^{\gamma(xx)}(\boldsymbol{\eta})}{\arg\max}\ \Pi^\gamma, \quad (xx) \in \{ND, DB, DN\}$

(4) $\quad$ Equations (MC_1) – (MC_7) hold

Conditions (1), (2) and (3) ensure optimizing behaviour by both households and the commercial bank, and condition (4) implies that all markets clear. An equilibrium is therefore characterized by market clearing, rational expectations (i.e. correct anticipation of current and future prices, interest rates and repayment rates) and by agents optimizing within their budget sets.

3.3.2 Properties

3.3.2.1 Properties of the Nash equilibrium

The simultaneous game between the Bank and Central Bank has no pure strategy Nash equilibrium, so long as we have:

$$\Pi^{\gamma}_{DB} > \Pi^{\gamma}_{ND} > \Pi^{\gamma}_{DN}$$
$$\Pi^{CB}_{DN} > \Pi^{CB}_{DB}$$
$$\text{and, } \Pi^{CB}_{NB} > \Pi^{CB}_{NN}$$

Allowing for mixed strategies, the bank is indifferent between Defaulting or Not Defaulting if the Central Bank plays a mixed strategy wherein it chooses to Bailout with probability

$$\alpha^{*}_{CB}(B) = \frac{(\Pi^{\gamma}_{ND} - \Pi^{\gamma}_{DN})}{(\Pi^{\gamma}_{DB} - \Pi^{\gamma}_{DN})}$$

Similarly, the Central Bank would be indifferent between Bailing out or not if the bank plays a mixed strategy wherein it chooses to default with probability

$$\alpha_{\gamma}^{*}(D) = \frac{(\Pi_{NB}^{CB} - \Pi_{NN}^{CB})}{(\Pi_{DN}^{CB} - \Pi_{DB}^{CB}) + (\Pi_{NB}^{CB} - \Pi_{NN}^{CB})}$$

We therefore have the mixed strategy Nash equilibrium $\alpha^* \in \Delta(A_\gamma) \times \Delta(A_{CB})$ in the game $\Gamma = \langle N, (A_i)_{i\in N}, (F_i)_{i\in N} \rangle$ with:

Action sets:

$A_\gamma = \{\text{Default } (D), \text{ No Default } (ND)\}$

$A_{CB} = \{\text{Bailout } (B), \text{ No Bailout } (NB)\}$

Probability distributions:

$$\alpha^*(A_\gamma) = \left\{ \frac{(\Pi_{NB}^{CB} - \Pi_{NN}^{CB})}{(\Pi_{DN}^{CB} - \Pi_{DB}^{CB}) + (\Pi_{NB}^{CB} - \Pi_{NN}^{CB})}, \frac{(\Pi_{DN}^{CB} - \Pi_{DB}^{CB})}{(\Pi_{DN}^{CB} - \Pi_{DB}^{CB}) + (\Pi_{NB}^{CB} - \Pi_{NN}^{CB})} \right\}$$

$$\alpha^*(A_{CB}) = \left\{ \frac{(\Pi_{ND}^{\gamma} - \Pi_{DN}^{\gamma})}{(\Pi_{DB}^{\gamma} - \Pi_{DN}^{\gamma})}, \frac{(\Pi_{DB}^{\gamma} - \Pi_{ND}^{\gamma})}{(\Pi_{DB}^{\gamma} - \Pi_{DN}^{\gamma})} \right\}$$

3.3.2.2 Properties of the MEBDL

The following properties of the monetary equilibrium with commercial banks, default, and the lender of last resort hold. The existence of a local, stable equilibrium is proved numerically (see appendix). The formal proofs of the properties follow directly from

Tsomocos (2003).

Relative Structure of Interest Rates The relative structure of interest rates is affected by the credit extension of banks and by default by agents. Overall liquidity in the model affects interest rates because it is a finite horizon model and fiat money must exit the system in the final period. Both inside and outside money therefore exit the system in the final period through loan repayments from households to banks and banks to the central bank. Default emerges as an equilibrium phenomenon affecting interest rates because the interest rates that clear the different debt markets price in the corresponding expected repayment rates through rational expectations.

Monetary Policy Non-Neutrality Given the presence of outside money in the model and default in debt markets, we have positive nominal interest rates ensuing since fiat money has a positive value and price. This value is derived from the role of money in facilitating all transactions, enforced through the cash-in-advance constraint. This also highlights the importance of liquidity.

The Quantity Theory of Money This model has a non-trivial quantity theory of money. Nominal changes affect both prices and quantities and therefore have a real effect. In each state $s \in S$, nominal income equals the total money stock since all the liquidity available is pushed through to the goods market.

The Fisher Effect Nominal inter-period interest rates are approximately equal to real interest rates plus expected inflation and a risk premium.

3.4 Calibration

Henceforth, we limit our discussion to the equilibria of a 3-state calibration of the model under the different combinations of *ex-ante* player actions. The exogenous variables used for the calibration of the economy are summarised below in table 3.1. The parameters are chosen to clearly illustrate the effects of the *ex-ante* strategic actions of the two players – the commercial bank, and the LoLR, on the payoffs and decisions of all agents. We allow for three states of nature at $t = 1$, a two 'good' states with probability 0.8 and 0.15 respectively, and a 'bad' state with probability 0.05. Agent α is modelled as being relatively wealthier in the first period and therefore a net lender, whereas agent β is relatively wealthier in the second period and is therefore a net borrower. The exogenous risk profiles of the bank $e^{\gamma}_{s,i}, s \in S, i \in \{H, L\}$ are chosen such that they have the same expected value but differ significantly in riskiness. The high risk profile carries substantial tail risk, with a large reduction in value in the bad state of nature, while the low risk profile is risk free. Default penalties are chosen to allow for partial repayment (i.e. an intermediate level of default) in all states, to clearly observe changes between the different equilibria.

Tables 3.2, 3.3, and 3.4 summarise the values of decision variables and prices that attain at the No Default, Default & Bailout, and Default & No Bailout equilibrium, respectively. To allow for an appropriate comparison of the different equilibria, the exogenous variables used in all three equilibria are the same except for exogenous risk profiles of the bank $e^{\gamma}_{s,i}, s \in S, i \in \{H, L\}$ which differ based on the strategic choice of the bank. The No Default equilibrium is realised when the bank chooses the low risk (riskless) profile, and results in the bank being solvent in all states of nature. The monetary endowments of the bank in this equilibrium are set to be $e^{\gamma}_{s,L}, s \in S$. From the point of view of the bank (and the other agents), the No Default & No Bailout equilibrium is identical to the No Default & Bailout equilibrium, hence we have only one calibration. In the Default equilibria, the only exogenous parameters that are different to the No Default equilibrium are the monetary endowments of the bank which are now set to the high risk profile i.e. $e^{\gamma}_{s,H}, s \in S$. Apart from the change in exogenous parameters, as described in section 3.2.7 the budget sets and choice sets of the agents are different based on the stance of the LoLR assumed.

Table 3.1: Exogenous variables

Risk Aversion		Probabilities		Endowments: Goods		Endowments: Money		Endowments: Banks		Central Bank Parameters		Default Penalties		LoLR Payoff	
c^α	1.2	θ_1	0.80	e_0^α	3	m_0^α	0.5	$e_{0,L}^\gamma$	27	M^{CB}	25	λ_0	0.96%	ξ_1	5
c^β	1.2	θ_2	0.15	e_1^α	1	m_1^α	0.5	$e_{1,L}^\gamma$	27	M_1^{CB}	5	λ_1	0.93%	ξ_2	-10
c^γ	0.006	θ_3	0.05	e_2^α	1	m_2^α	0.5	$e_{2,L}^\gamma$	27	M_2^{CB}	5	λ_2	0.79%	$\mathscr{C}$	1
				e_3^α	1	m_3^α	0.5	$e_{3,L}^\gamma$	27	M_3^{CB}	5	λ_3	0.74%		
				e_0^β	1	m_0^β	3	$e_{0,H}^\gamma$	27	τ	4%	$\bar{\lambda}_1$	1.00%		
				e_1^β	3	m_1^β	2.5	$e_{1,H}^\gamma$	27.5			$\bar{\lambda}_2$	1.00%		
				e_2^β	3	m_2^β	2.2	$e_{2,H}^\gamma$	27			$\bar{\lambda}_3$	1.00%		
				e_3^β	3	m_3^β	0.5	$e_{3,H}^\gamma$	19			λ_1^D	65.00%		
												λ_2^D	77.00%		
												λ_3^D	75.00%		

c^h : Coefficient of risk aversion of household $h \in H$
θ_s : Probability of state $s \in S$
e_s^h : Goods endowment of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
m_s^h : Monetary endowment of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
$e_{s,i}^\gamma$: Monetary endowment of bank γ in state $s \in S^*$, under risk profile $i \in \{H, L\}$
M^{CB} : Money supply at $t = 0$
M_s^{CB} : Money injection by the central bank in the short-term loan market in state $s \in S$
τ : Borrowing rate at the discount window in case of a bailout
λ_s : Non-pecuniary penalty for defaulting on short-term loans in state $s \in S^*$
$\bar{\lambda}_s$: Non-pecuniary penalty for defaulting on long-term loans in state $s \in S$
λ_s^D : Non-pecuniary penalty for defaulting on deposits in state $s \in S$

Table 3.2: Equilibrium values, No Default (ND)

Prices		Interest Rates		Household α Decisions		Household β Decisions		Bank γ Decisions	
p_0	43.02	r_0	6.54%	q_0^α	0.91	b_0^β	39.18	π_0^γ	27.25
p_1	43.70	r_1	8.10%	b_1^α	38.13	q_1^β	0.87	m_0^γ	54.99
p_2	48.42	r_2	26.00%	b_2^α	37.83	q_1^β	0.78	m_1^γ	30.59
p_3	49.59	r_3	35.00%	b_3^α	34.51	q_1^β	0.70	m_2^γ	25.49
		$\bar{r}$	6.88%	μ_0^α	39.17	$\bar{\mu}^\beta$	38.67	m_3^γ	25.12
		r_d	1.33%	d^α	41.19	μ_1^β	38.48	$\bar{m}^\gamma$	36.18
		ρ	1.33%	ν_0^α	95.11%	μ_2^β	38.41	$\bar{\mu}_R^\gamma$	25.33
						μ_3^β	40.67	$\bar{\mu}_d^\gamma$	39.69
						$\bar{\nu}_1^\beta$	98.52%	ν_1^γ	94.83%
						$\bar{\nu}_2^\beta$	84.53%	ν_2^γ	94.08%
						$\bar{\nu}_3^\beta$	75.00%	ν_3^γ	85.71%
						ν_1^β	99.11%	c_0^γ	28.47
						ν_2^β	98.50%		
						ν_3^β	84.87%		

p_s : Price of the good in state $s \in S^*$
r_s : Short-term loan rate offered by the bank in state $s \in S^*$
$\bar{r}$: Long-term loan rate offered by the bank
r_d : Interest rate on deposits offered by the bank
ρ : Interest rate on repo loans offered by the central bank
q_s^h : Quantity of goods offered for sale by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
b_s^h : Amount of money spent on goods by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
μ_s^h : Short-term borrowing by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
ν_s^h : Short-term loan repayment rate of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
d^α : Deposit by household α at $t = 0$
$\bar{\mu}^\beta$: Long-term borrowing by household β at $t = 0$
$\bar{\nu}_s^\beta$: Long-term repayment rate of household β in state $s \in S$
π_0^γ : Bank profits at $t = 0$
m_s^γ : Short-term loan extension by the bank in state $s \in S^*$
$\bar{m}^\gamma$: Long-term loan extension by the bank at $t = 0$
μ_R^γ : Amount borrowed by the bank via repo loans at $t = 0$
μ_d^γ : Amount borrowed by the bank via deposits at $t = 0$
ν_s^γ : Bank's repayment rate on deposits in state $s \in S^*$
c_0^γ : Bank's retained earnings at $t = 0$

Table 3.3: Equilibrium values, Default & Bailout (DB)

Prices		Interest Rates		Household α Decisions		Household β Decisions		Bank γ Decisions	
p_0	42.98	r_0	6.16%	q_0^α	0.91	b_0^β	39.06	π_0^γ	27.25
p_1	43.52	r_1	8.10%	b_1^α	37.66	q_1^β	0.87	m_0^γ	55.06
p_2	47.86	r_2	26.00%	b_2^α	36.36	q_1^β	0.76	m_1^γ	30.45
p_3	49.95	r_3	35.00%	b_3^α	35.48	q_1^β	0.71	m_2^γ	25.05
		$\bar{r}$	7.11%	μ_0^α	39.12	$\bar{\mu}^\beta$	38.62	m_3^γ	29.11
		r_d	1.13%	d^α	41.00	μ_1^β	38.32	$\bar{m}^\gamma$	36.06
		ρ	7.09%	ν_0^α	95.26%	μ_2^β	37.86	$\bar{\mu}_R^\gamma$	26.77
						μ_3^β	46.05	$\bar{\mu}_d^\gamma$	39.56
						$\bar{\nu}_1^\beta$	98.25%	ν_1^γ	93.93%
						$\bar{\nu}_2^\beta$	83.49%	ν_2^γ	90.64%
						$\bar{\nu}_3^\beta$	74.79%	ν_3^γ	88.41%
						ν_1^β	98.28%	c_0^γ	28.44
						ν_2^β	96.05%	μ_B^γ	7.04
						ν_3^β	77.04%		

p_s	: Price of the good in state $s \in S^*$
r_s	: Short-term loan rate offered by the bank in state $s \in S^*$
$\bar{r}$	: Long-term loan rate offered by the bank
r_d	: Interest rate on deposits offered by the bank
ρ	: Interest rate on repo loans offered by the central bank
q_s^h	: Quantity of goods offered for sale by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
b_s^h	: Amount of money spent on goods by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
μ_s^h	: Short-term borrowing by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
ν_s^h	: Short-term loan repayment rate of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
d^α	: Deposit by household α at $t = 0$
$\bar{\mu}^\beta$	: Long-term borrowing by household β at $t = 0$
$\bar{\nu}_s^\beta$	: Long-term repayment rate of household β in state $s \in S$
π_0^γ	: Bank profits at $t = 0$
m_s^γ	: Short-term loan extension by the bank in state $s \in S^*$
$\bar{m}^\gamma$	: Long-term loan extension by the bank at $t = 0$
μ_R^γ	: Amount borrowed by the bank via repo loans at $t = 0$
μ_d^γ	: Amount borrowed by the bank via deposits at $t = 0$
ν_s^γ	: Bank's repayment rate on deposits in state $s \in S^*$
c_0^γ	: Bank's retained earnings at $t = 0$
μ_B^γ	: Additional funds borrowed by the bank at the discount window when bailed out at $t = 1$

Table 3.4: Equilibrium values, Default & No Bailout (DN)

Prices		Interest Rates		Household α Decisions		Household β Decisions		Bank γ Decisions	
p_0	42.92	r_0	1.94%	q_0^α	0.91	b_0^β	38.90	π_0^γ	30.38
p_1	42.72	r_1	8.10%	b_1^α	35.55	q_1^β	0.83	m_0^γ	55.16
p_2	47.25	r_2	26.00%	b_2^α	34.75	q_1^β	0.74	m_1^γ	29.72
p_3	184.63	r_3	542.28%	b_3^α	32.11	q_1^β	0.17	m_2^γ	24.50
		$\bar{r}$	0.87%	μ_0^α	39.07	$\bar{\mu}^\beta$	38.57	$\bar{m}^\gamma$	35.90
		r_d	0.87%	d^α	39.32	μ_1^β	37.53	$\bar{\mu}_R^\gamma$	25.22
		ρ	7.42%	ν_0^α	98.95%	μ_2^β	37.17	$\bar{\mu}_d^\gamma$	39.41
						μ_3^β	32.11	ν_1^γ	88.94%
						$\bar{\nu}_1^\beta$	96.51%	ν_2^γ	86.91%
						$\bar{\nu}_2^\beta$	82.20%	c_0^γ	25.27
						$\bar{\nu}_3^\beta$	16.45%		
						ν_1^β	94.72%	ν_3^γ	80.22%
						ν_2^β	93.49%		
						ν_3^β	100%		

p_s	: Price of the good in state $s \in S^*$
r_s	: Short-term loan rate offered by the bank in state $s \in S^*$
$\bar{r}$	: Long-term loan rate offered by the bank
r_d	: Interest rate on deposits offered by the bank
ρ	: Interest rate on repo loans offered by the central bank
q_s^h	: Quantity of goods offered for sale by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
b_s^h	: Amount of money spent on goods by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
μ_s^h	: Short-term borrowing by household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
ν_s^h	: Short-term loan repayment rate of household $h \in \{\alpha, \beta\}$ in state $s \in S^*$
d^α	: Deposit by household α at $t = 0$
$\bar{\mu}^\beta$	: Long-term borrowing by household β at $t = 0$
$\bar{\nu}_s^\beta$	: Long-term repayment rate of household β in state $s \in S$
π_0^γ	: Bank profits at $t = 0$
m_s^γ	: Short-term loan extension by the bank in state $s \in S^\gamma$
$\bar{m}^\gamma$	: Long-term loan extension by the bank at $t = 0$
μ_R^γ	: Amount borrowed by the bank via repo loans at $t = 0$
μ_d^γ	: Amount borrowed by the bank via deposits at $t = 0$
ν_s^γ	: Bank's repayment rate on deposits in state $s \in S^\gamma$
c_0^γ	: Bank's retained earnings at $t = 0$

As can be seen from the tables above, the no default equilibrium leads to stable prices and reasonable levels of default, with an expected drop in credit extension by the bank in the bad state of nature, and a subsequent increase in default levels. This effect is exacerbated in the two default equilibria since in this case the bad state is characterised by a significant drop in the bank's monetary endowment. In the case of the default & bailout equilibrium, the availability of bailout funds at the discount window allows the bank to borrow in the bad state and extend credit despite the shock in the value of its monetary endowment and this allows for prices to remain stable and at levels comparable to the no default equilibrium. Default levels are slightly higher in this equilibrium since the presence of the discount window in the bad state of nature is rationally expected by all agents and this allows for a shifting in consumption which increases the marginal benefit from defaulting in the good states, thereby increasing the default levels slightly. The default & no bailout equilibrium is much starker in contrast to the other two. In this case the bank defaults in the third state and so credit extension in this state stems solely due to the liquidity injection by the central bank in short-term debt markets. Short term interest rates in this state therefore spike up and this precipitates default by household β in the long-term debt market. This reduces the value of the bank's assets, which are seized by the central bank upon its default, and handed over to the senior creditors – depositors. The depositors therefore end up taking a haircut on their debt. The shortage in credit supply precipitated by the failure of the bank in the bad state also affects the goods market raising prices significantly in this state.

Figure 3.5 lists the payoffs for the two players in the different equilibria. Figure 3.6 illustrates the mixed strategy Nash equilibrium, along with the best response functions for each player. The parameter values of the payoff function of the LoLR are listed in table 3.1. We place a positive weight on bank profitability, a negative weight on the level of aggregate default, and assume a positive non-monetary cost for adopting a dovish stance and being prepared to bail banks out in bad states. We find that for our parametrisation, there exists no pure strategy Nash equilibrium. Instead, both agents play a mixed strategy with the bank choosing a high risk profile with probability $\alpha^*_\gamma(D) = 0.2102$, and the LoLR adopts an *ex-ante* dovish stance (i.e. is amenable to bailing the bank out in case of distress) with probability $\alpha^*_{CB}(B) = 0.3050$. The existence of a mixed strategy Nash equilibrium is resilient to wide range of parameter values as discussed in the comparative statics exercises conducted in section 3.5.

Central Bank (LoLR) \ Bank	D	ND
B	$\Pi^{\Upsilon}{}_{DB} = 47.13$ $\bar{v} = 10.22$ % $\Pi^{CB}{}_{DB} = 298.17$	$\Pi^{\Upsilon}{}_{DN} = 46.69$ $\bar{v} = 8.95$ % $\Pi^{CB}{}_{NB} = 300.70$
NB	$\Pi^{\Upsilon}{}_{DN} = 46.50$ $\bar{v} = 11.17$ % $\Pi^{CB}{}_{DN} = 302.43$	$\Pi^{\Upsilon}{}_{DN} = 46.69$ $\bar{v} = 8.95$ % $\Pi^{CB}{}_{NN} = 300.20$

Figure 3.5: Payoffs of the two players in the strategic game

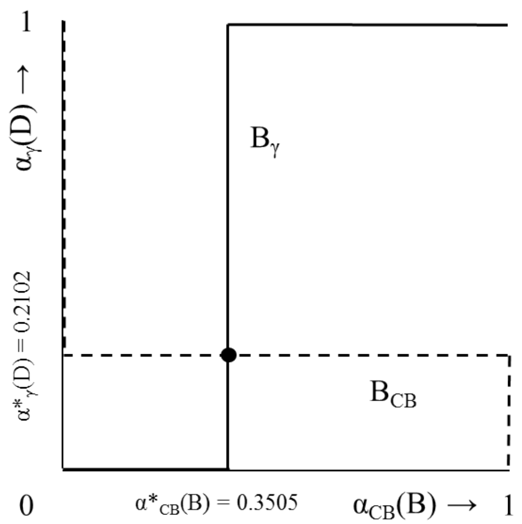

Figure 3.6: Mixed strategy Nash equilibrium in the strategic game
The best response function of the commercial bank is shown by the solid line, whereas that of the LoLR is shown by the dashed line.

We take this mixed strategy Nash equilibrium to be a rationalisation of the policy of constructive ambiguity that has been pursued by most central banks with regards to their stance on bailing out distressed banks.[7] The LoLR in equilibrium commits *ex-ante* to a mixed strategy of bailing out sometimes, and not bailing out other times to induce optimal behaviour by the commercial bank.

3.5 Comparative statics

In this section, we study the effects of changes in the exogenous parameters of the model on its equilibrium. Although the model allows for a variety of such exercises, we present in detail two specific cases that we reckon are the most interesting and pertinent to the analysis carried out in this paper.

3.5.1 Changes in the exogenous risk profile of the commercial bank

For this exercise, we study the effects of varying the riskiness (variance) of the high risk profile available to the bank as an *ex-ante* strategic choice along with the low risk profile, which is calibrated as before to be riskless. In each case, we maintain the same expected value (across the three states) of monetary endowments, varying only the spread between the realisation in the good and bad states. Table 3.5 summarises the results.

[7] See Freixas (1999); Freixas et al. (2000b, 2004); Goodhart and Huang (2005) for an extensive discussion of constructive ambiguity.

Table 3.5: Comparative Statics: Changes in risk profile

$e^{\gamma}_{1,H}$	27.375	27.4375	27.5	27.5625	27.625
$e^{\gamma}_{2,H}$	27	27	27	27	27
$e^{\gamma}_{3,H}$	21	20	19	18	17
ξ_1	5	5	5	5	5
ξ_2	-10	-10	-10	-10	-10
$\mathscr{C}$	1	1	1	1	1
$\alpha^*_{CB}(B)$	0.4201	0.3625	0.3050	0.2476	0.1903
$\alpha^*_{\gamma}(D)$	0.2105	0.2103	0.2102	0.2100	0.2099

In the above exercise, the payoff function of the LoLR remains the same. We find that as the riskiness of the high risk profile increases i.e. as we move from left to right in the table above, the equilibrium mixed strategy of the two players changes in two ways – the equilibrium probability that the LoLR adopts a dovish stance *ex-ante* decreases, and the equilibrium probability that the bank choses the risky profile also slightly decreases. This is because an increase in the riskiness of the high risk profile implies an increased monetary endowment in the good state. Under this profile, it defaults in the bad state and is either bailed out or not. Either way, since it defaults, it does not bear the full costs of a reduced endowment in the bad state and therefore an increase in the riskiness of the high risk profile serves to increase the bank's expected profit. This makes the action to choose the high risk profile (i.e. action D) more attractive to the bank, though not enough to dominate the ND option. This increase in the bank's preference for the high risk profile is countered by a decrease in $\alpha^*_{CB}(B)$, the equilibrium probability with which the LoLR plays B (an *ex-ante* dovish stance), since NB is the LoLR's best response to the bank playing D. Further, we find that the expected aggregate level of default is not very strongly influenced by an increase in the riskiness of the high risk profile. Therefore on the whole, given that the bank profitability increases and aggregate default does not change significantly, the LoLR's payoff also increases under the action D. This serves to slightly decrease the equilibrium value of $\alpha^*_{\gamma}(D)$, the equilibrium probability of the bank adopting a high risk profile.

Therefore we find that an increase in the riskiness of the high risk profile serves to reduce the equilibrium probability of an *ex-ante* dovish stance, and also (through the specification of the payoff function of the LoLR) seems to deter risk taking behaviour by the bank.

3.5.2 Changes in the payoff function of the LoLR

Here, we study the effects of changes in the parameters of the payoff function of the lender of last resort on the equilibrium of the strategic game. Changing the parameters of the payoff function of the LoLR has no effect on the calibration of the equilibrium, and therefore has no effect on the payoffs of the commercial bank for each in the strategic game. The only effect of the parameters is on the payoffs to the LoLR, and there is therefore no change in the equilibrium behaviour of the LoLR. However, since the equilibrium mixed strategy of the commercial bank is dependent on the payoffs of the LoLR, we find that changes in these parameters affect the equilibrium strategy of the commercial bank. Table 3.6 summarises the results.

Table 3.6: Comparative Statics: Changes in LoLR payoff function

$e^{\gamma}_{1,H}$	27.5	27.5	27.5	27.5	27.5
$e^{\gamma}_{2,H}$	27	27	27	27	27
$e^{\gamma}_{3,H}$	19	19	19	19	19
ξ_1	0	2.5	5	10	20
ξ_2	-10	-10	-10	-10	-10
$\mathscr{C}$	1	1	1	1	1
$\alpha^*_{CB}(B)$	0.3050	0.3050	0.3050	0.3050	0.3050
$\alpha^*_{\gamma}(D)$	0.5247	0.3001	0.2102	0.1314	0.0751
ξ_1	5	5	5	5	5
ξ_2	0	-5	-10	-50	-100
$\mathscr{C}$	1	1	1	1	1
$\alpha^*_{CB}(B)$	0.3050	0.3050	0.3050	0.3050	0.3050
$\alpha^*_{\gamma}(D)$	0.2061	0.2081	0.2102	0.2283	0.2558
ξ_1	5	5	5	5	5
ξ_2	-10	-10	-10	-10	-10
$\mathscr{C}$	.5	.75	1	1.25	1.5
$\alpha^*_{CB}(B)$	0.3050	0.3050	0.3050	0.3050	0.3050
$\alpha^*_{\gamma}(D)$	0.3153	0.2627	0.2102	0.1576	0.1051

The first part of table 3.6 illustrates the effects of a change in the parameter ξ_1 on the equilibrium mixed strategy of the bank. An increase in ξ_1, increases the relative importance of bank profitability in the payoff function of the LoLR. As bank profitability becomes relatively more important this makes the NB strategy more attractive to the LoLR, but not enough to dominate B. This in turn reduces the equilibrium probability of the bank choosing a high risk profile since ND is the bank's best response to the LoLR playing NB.

In the second part of the table, we change the value of the parameter ξ_2 thereby increasing the relative importance of default on the LoLR's payoff. Here we see that an increase in the relative importance of the aggregate level of default to the LoLR brings about an increase in the equilibrium probability of the bank choosing a high risk profile. This is akin to the 'too big to fail' problem. The greater the perceived spillover effects of a bank's failure are, the more it can hold the LoLR to ransom and pile on risk. Here, the more important (reducing) default becomes to the LoLR, the more attractive the strategy B becomes to it. Since, D is the bank's best response to the LoLR playing B, we therefore observe an increase in the equilibrium probability of the bank choosing a high risk profile.

Finally, the last part of table 3.6 studies the effects of changes in the perceived non-monetary costs[8], $\mathscr{C}$, of opting for a dovish stance *ex-ante*. We find, intuitively, that as the perceived costs of a bailout increase, all else remaining constant, the LoLR prefers taking a hawkish stance *ex-ante*. This results in the bank reducing its equilibrium probability of choosing a high risk profile since ND is the bank's best response to NB.

3.6 Conclusion

This paper aimed to model the role of the lender of last resort in a general equilibrium framework. To this end we model a strategic (simultaneous) game between banks and the lender of last resort with bank's choosing between high and low (exogenous) risk profiles, and the LoLR choosing to adopt either a hawkish or a dovish stance with respect to bailing banks out in bad states of nature. The strategic choices of the players affect the budget sets of all agents in the economy and therefore influence the rational expectations equilibrium attained. This in turn influences the payoffs of the two players – banks and the LoLR and determines the strategic equilibrium of the game.

We also aimed to formalise an objective function for the lender of last resort in keeping with its role of minimising financial fragility. Following Goodhart et al. (2004) and Tsomocos (2003), we therefore setup an objective function for the LoLR that is increasing in banking sector profitability and decreasing in the aggregate level of default in the

[8]These can be thought of as detrimental effects such as the softening of banks' budget constraints.

economy. Using a suitable parametrisation of the model, we find that there exists no pure strategy equilibrium in the game. The unique Nash equilibrium of the game is one of mixed strategies with the LoLR committing *ex-ante* to a strategy of bailing out banks in some cases, and not in other cases.[9] We take this mixed strategy Nash equilibrium to be a rationalisation of the policy of constructive ambiguity. Our comparative statics exercises show that this mixed strategy equilibrium is resilient to a wide range of parameter values and we also find evidence of behaviour akin to the 'too big to fail problem' in our model.

While this basic model provides us with useful insights, it also opens up several avenues for extension and further study. The bank's risk profile is in this model exogenous to the equilibrium studied and the choice of risk profile currently stems purely from the payoffs of the strategic game. Moral hazard is therefore in a sense exogenously built in to the model.[10] Fully endogenising the choice of risk profile is a non-trivial task but one that would allow for richer inferences to be made. The current two-period model could be extended to a three-period setup with a Diamond and Dybvig (1983) style problem requiring intermediate injections of liquidity in bad states of nature. Kashyap et al. (2014) use such a setup to study the effects of different macroprudential regulations on credit creation, risk taking, and agents' welfare. A similar analysis could be conducted for LoLR policy and intervention. Further, one could also study the design of an optimal contract between banks and the LoLR in the spirit of Townsend (1979) and Mookherjee and Png (1989). Another possible extension would be to setup a dynamic version of the model and study the equilibrium of a repeated strategic game between banks and the LoLR.

[9] Our aim here is to study what the optimal *ex-ante* stance of the LoLR should be towards bailing out distressed banks in this framework. The issue of dynamic inconsistency of LoLR policy is beyond of scope of this study but is an interesting area of study for future work. To study it in a general equilibrium setup would require a more elaborate model.

[10] There is an endogenous element too, since the strategic choices of the bank and LoLR affect payoffs of the players through their influence on the budget sets of all agents and equilibrium values of prices and decision variables.

3.7 Appendix

3.7.1 First order conditions

Household α

$$(01^{\alpha}) \qquad \partial\mathcal{L}/\partial q_0^{\alpha} : u'\left(e_0^{\alpha} - q_0^{\alpha}\right) - p_0\psi_{02}^{\alpha} = 0$$

$$(02^{\alpha}) \qquad \partial\mathcal{L}/\partial b_1^{\alpha} : \theta_1 u'\left(e_1^{\alpha} + \frac{b_1^{\alpha}}{p_1}\right) - p_1\psi_{11}^{\alpha} = 0$$

$$(03^{\alpha}) \qquad \partial\mathcal{L}/\partial b_2^{\alpha} : \theta_2 u'\left(e_2^{\alpha} + \frac{b_2^{\alpha}}{p_2}\right) - p_2\psi_{21}^{\alpha} = 0$$

$$(04^{\alpha}) \qquad \partial\mathcal{L}/\partial b_3^{\alpha} : \theta_3 u'\left(e_3^{\alpha} + \frac{b_3^{\alpha}}{p_3}\right) - p_3\psi_{31}^{\alpha} = 0$$

$$(05^{\alpha}) \qquad \partial\mathcal{L}/\partial d^{\alpha} : \psi_{01}^{\alpha} - (1 + r_d)\left\{\nu_1^{\gamma}\psi_{11}^{\alpha} + \nu_2^{\gamma}\psi_{21}^{\alpha} + \nu_3^{\gamma}\psi_{31}^{\alpha}\right\} = 0$$

$$(06^{\alpha}) \qquad \partial\mathcal{L}/\partial \mu_0^{\alpha} : -\lambda_0\left(1 - \nu_0^{\alpha}\right) + \frac{\psi_{01}^{\alpha}}{1 + r_0} - \nu_0^{\alpha}\psi_{02}^{\alpha} = 0$$

$$(07^{\alpha}) \qquad \partial\mathcal{L}/\partial \nu_0^{\alpha} : \left(\lambda_0 - \psi_{02}^{\alpha}\right)\mu_0^{\alpha} = 0$$

$$(08^{\alpha}) \qquad \partial\mathcal{L}/\partial \psi_{01}^{\alpha} : d^{\alpha} - \frac{\mu_0^{\alpha}}{1 + r_0} - m_0^{\alpha} = 0$$

$$(09^{\alpha}) \qquad \partial\mathcal{L}/\partial \psi_{02}^{\alpha} : \mu_0^{\alpha}\nu_0^{\alpha} - p_0 q_0^{\alpha} = 0$$

$$(10^{\alpha}) \qquad \partial\mathcal{L}/\partial \psi_{11}^{\alpha} : b_1^{\alpha} - d^{\alpha}(1 + r_d)\nu_1^{\gamma} - m_1^{\alpha} = 0$$

$$(11^{\alpha}) \qquad \partial\mathcal{L}/\partial \psi_{21}^{\alpha} : b_2^{\alpha} - d^{\alpha}(1 + r_d)\nu_2^{\gamma} - m_2^{\alpha} = 0$$

$$(12^{\alpha}) \qquad \partial\mathcal{L}/\partial \psi_{31}^{\alpha} : b_3^{\alpha} - d^{\alpha}(1 + r_d)\nu_3^{\gamma} - m_3^{\alpha} = 0$$

The lender of last resort

Household β

$$(01^\beta) \qquad \partial\mathcal{L}/\partial b_0^\beta : u'\left(e_0^\beta + \frac{b_0^\beta}{p_0}\right) - p_0\psi_{01}^\beta = 0$$

$$(02^\beta) \qquad \partial\mathcal{L}/\partial q_1^\beta : \theta_1 u'\left(e_1^\beta - q_1^\beta\right) - p_1\psi_{12}^\beta = 0$$

$$(03^\beta) \qquad \partial\mathcal{L}/\partial q_2^\beta : \theta_2 u'\left(e_2^\beta - q_2^\beta\right) - p_2\psi_{22}^\beta = 0$$

$$(04^\beta) \qquad \partial\mathcal{L}/\partial q_3^\beta : \theta_3 u'\left(e_3^\beta - q_3^\beta\right) - p_3\psi_{32}^\beta = 0$$

$$(05^\beta) \qquad \partial\mathcal{L}/\partial \bar{\mu}^\beta : -\theta_1\bar{\lambda}_1(1-\bar{\nu}_1^\beta) - \theta_2\bar{\lambda}_2(1-\bar{\nu}_2^\beta) - \theta_3\bar{\lambda}_3(1-\bar{\nu}_3^\beta) + \frac{\psi_{01}^\beta}{1+\bar{r}} - \bar{\nu}_1^\beta\psi_{11}^\beta - \bar{\nu}_2^\beta\psi_{21}^\beta - \bar{\nu}_3^\beta\psi_{31}^\beta = 0$$

$$(06^\beta) \qquad \partial\mathcal{L}/\partial \mu_1^\beta : -\theta_1\lambda_1(1-\nu_1^\beta) + \frac{\psi_{11}^\beta}{(1+r_1)} - \nu_1^\beta\psi_{12}^\beta = 0$$

$$(07^\beta) \qquad \partial\mathcal{L}/\partial \mu_2^\beta : -\theta_2\lambda_2(1-\nu_2^\beta) + \frac{\psi_{21}^\beta}{(1+r_2)} - \nu_1^\beta\psi_{22}^\beta = 0$$

$$(08^\beta) \qquad \partial\mathcal{L}/\partial \mu_3^\beta : -\theta_3\lambda_3(1-\nu_3^\beta) + \frac{\psi_{31}^\beta}{(1+r_3)} - \nu_1^\beta\psi_{32}^\beta = 0$$

$$(09^\beta) \qquad \partial\mathcal{L}/\partial \bar{\nu}_1^\beta : (\theta_1\bar{\lambda}_1 - \psi_{11}^\beta)\bar{\mu}^\beta = 0$$

$$(10^\beta) \qquad \partial\mathcal{L}/\partial \bar{\nu}_2^\beta : (\theta_2\bar{\lambda}_2 - \psi_{21}^\beta)\bar{\mu}^\beta = 0$$

$$(11^\beta) \qquad \partial\mathcal{L}/\partial \bar{\nu}_3^\beta : (\theta_3\bar{\lambda}_3 - \psi_{31}^\beta)\bar{\mu}^\beta = 0$$

$$(12^\beta) \qquad \partial\mathcal{L}/\partial \nu_1^\beta : (\theta_1\lambda_1 - \psi_{11}^\beta)\mu_1^\beta = 0$$

$$(13^\beta) \qquad \partial\mathcal{L}/\partial \nu_2^\beta : (\theta_2\lambda_2 - \psi_{21}^\beta)\mu_2^\beta = 0$$

$$(14^\beta) \qquad \partial\mathcal{L}/\partial \nu_3^\beta : (\theta_3\lambda_3 - \psi_{31}^\beta)\mu_3^\beta = 0$$

$$(15^\beta) \qquad \partial\mathcal{L}/\partial \psi_{01}^\beta : b_0^\beta - \frac{\bar{\mu}^\beta}{1+\bar{r}} - m_0^\beta = 0$$

$$(16^\beta) \qquad \partial\mathcal{L}/\partial \psi_{11}^\beta : \bar{\mu}^\beta\bar{\nu}_1^\beta - \frac{\mu_1^\beta}{1+r_1} - m_1^\beta = 0$$

$$(17^\beta) \qquad \partial\mathcal{L}/\partial\psi_{12}^\beta : \mu_1^\beta \nu_1^\beta - p_1 q_1^\beta = 0$$

$$(18^\beta) \qquad \partial\mathcal{L}/\partial\psi_{21}^\beta : \bar{\mu}^\beta \bar{\nu}_2^\beta - \frac{\mu_2^\beta}{1+r_2} - m_2^\beta = 0$$

$$(19^\beta) \qquad \partial\mathcal{L}/\partial\psi_{22}^\beta : \mu_2^\beta \nu_2^\beta - p_2 q_2^\beta = 0$$

$$(20^\beta) \qquad \partial\mathcal{L}/\partial\psi_{31}^\beta : \bar{\mu}^\beta \bar{\nu}_3^\beta - \frac{\mu_3^\beta}{1+r_3} - m_3^\beta = 0$$

$$(21^\beta) \qquad \partial\mathcal{L}/\partial\psi_{32}^\beta : \mu_3^\beta \nu_3^\beta - p_3 q_3^\beta = 0$$

The lender of last resort

Bank γ, ND

$$(01^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial\pi^{\gamma}_0 : 1 - 2c^{\gamma}\pi^{\gamma}_0 - \psi^{\gamma}_{02} = 0$$

$$(02^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_0 : \psi^{\gamma}_{01} - (1+r_0)\nu^{\alpha}_0\psi^{\gamma}_{02} = 0$$

$$(03^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_1 : \theta_1 \left\{1 - 2c^{\gamma}m^{\gamma}_1(1+r_1)\nu^{\beta}_1\right\}(1+r_1)\nu^{\beta}_1 - \psi^{\gamma}_{11} = 0$$

$$(04^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_2 : \theta_2 \left\{1 - 2c^{\gamma}m^{\gamma}_2(1+r_2)\nu^{\beta}_2\right\}(1+r_2)\nu^{\beta}_2 - \psi^{\gamma}_{21} = 0$$

$$(05^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_3 : \theta_3 \left\{1 - 2c^{\gamma}m^{\gamma}_3(1+r_3)\nu^{\beta}_3\right\}(1+r_3)\nu^{\beta}_3 - \psi^{\gamma}_{31} = 0$$

$$(06^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \bar{m}^{\gamma} : \psi^{\gamma}_{01} - (1+\bar{r})\left\{\bar{\nu}^{\beta}_1\psi^{\gamma}_{11} + \bar{\nu}^{\beta}_2\psi^{\gamma}_{21} + \bar{\nu}^{\beta}_3\psi^{\gamma}_{31}\right\} = 0$$

$$(07^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \mu^{\gamma}_R : \psi^{\gamma}_{01} - (1+\rho)\left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21} + \psi^{\gamma}_{31}\right\} = 0$$

$$(08^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \mu^{\gamma}_d : -\theta_1\lambda^d_1(1-\nu^{\gamma}_1) - \theta_2\lambda^d_2(1-\nu^{\gamma}_2) - \theta_3\lambda^d_3(1-\nu^{\gamma}_3) + \frac{\psi^{\gamma}_{01}}{1+r_d}$$
$$- \nu^{\gamma}_1\psi^{\gamma}_{11} - \nu^{\gamma}_2\psi^{\gamma}_{21} - \nu^{\gamma}_3\psi^{\gamma}_{31} = 0$$

$$(09^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \nu^{\gamma}_1 : \left(\theta_1\lambda^d_1 - \psi^{\gamma}_{11}\right)\mu^{\gamma}_d = 0$$

$$(10^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \nu^{\gamma}_2 : \left(\theta_2\lambda^d_2 - \psi^{\gamma}_{21}\right)\mu^{\gamma}_d = 0$$

$$(11^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \nu^{\gamma}_3 : \left(\theta_3\lambda^d_3 - \psi^{\gamma}_{31}\right)\mu^{\gamma}_d = 0$$

$$(12^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial c^{\gamma}_0 : \psi^{\gamma}_{02} - \left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21} + \psi^{\gamma}_{31}\right\} = 0$$

$$(13^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \psi^{\gamma}_{01} : m^{\gamma}_0 + \bar{m}^{\gamma} - \frac{\mu^{\gamma}_d}{1+r_d} - \frac{\mu^{\gamma}_R}{1+\rho} - e^{\gamma}_0 = 0$$

$$(14^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \psi^{\gamma}_{02} : \pi^{\gamma}_0 + c^{\gamma}_0 - m^{\gamma}_0(1+r_0)\nu^{\alpha}_0 = 0$$

$$(15^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \psi^{\gamma}_{11} : m^{\gamma}_1 + \mu^{\gamma}_d\nu^{\gamma}_1 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_1 - e^{\gamma}_1 = 0$$

$$(16^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \psi^{\gamma}_{21} : m^{\gamma}_2 + \mu^{\gamma}_d\nu^{\gamma}_2 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_2 - e^{\gamma}_2 = 0$$

$$(17^{\gamma}_{ND}) \qquad \partial\mathcal{L}/\partial \psi^{\gamma}_{31} : m^{\gamma}_3 + \mu^{\gamma}_d\nu^{\gamma}_3 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_3 - e^{\gamma}_3 = 0$$

The lender of last resort

Bank γ, DB

$$(01^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\pi^{\gamma}_0 : 1 - 2c^{\gamma}\pi^{\gamma}_0 - \psi^{\gamma}_{02} = 0$$

$$(02^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_0 : \psi^{\gamma}_{01} - (1+r_0)\nu^{\alpha}_0\psi^{\gamma}_{02} = 0$$

$$(03^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_1 : \theta_1\left\{1 - 2c^{\gamma}m^{\gamma}_1(1+r_1)\nu^{\beta}_1\right\}(1+r_1)\nu^{\beta}_1 - \psi^{\gamma}_{11} = 0$$

$$(04^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_2 : \theta_2\left\{1 - 2c^{\gamma}m^{\gamma}_2(1+r_2)\nu^{\beta}_2\right\}(1+r_2)\nu^{\beta}_2 - \psi^{\gamma}_{21} = 0$$

$$(05^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial m^{\gamma}_3 : \theta_3\left\{1 - 2c^{\gamma}\left(m^{\gamma}_3(1+r_3)\nu^{\beta}_3 - \mu^{\gamma}_B\right)\right\}(1+r_3)\nu^{\beta}_3 - \psi^{\gamma}_{31} = 0$$

$$(06^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\bar{m}^{\gamma} : \psi^{\gamma}_{01} - (1+\bar{r})\left\{\bar{\nu}^{\beta}_1\psi^{\gamma}_{11} + \bar{\nu}^{\beta}_2\psi^{\gamma}_{21} + \bar{\nu}^{\beta}_3\psi^{\gamma}_{31}\right\} = 0$$

$$(07^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\mu^{\gamma}_R : \psi^{\gamma}_{01} - (1+\rho)\left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21}\right\} = 0$$

$$(08^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\mu^{\gamma}_d : -\theta_1\lambda^d_1(1-\nu^{\gamma}_1) - \theta_2\lambda^d_2(1-\nu^{\gamma}_2) - \theta_3\lambda^d_3(1-\nu^{\gamma}_3) + \frac{\psi^{\gamma}_{01}}{1+r_d}$$
$$- \nu^{\gamma}_1\psi^{\gamma}_{11} - \nu^{\gamma}_2\psi^{\gamma}_{21} - \nu^{\gamma}_3\psi^{\gamma}_{31} = 0$$

$$(09^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\nu^{\gamma}_1 : \left(\theta_1\lambda^d_1 - \psi^{\gamma}_{11}\right)\mu^{\gamma}_d = 0$$

$$(10^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\nu^{\gamma}_2 : \left(\theta_2\lambda^d_2 - \psi^{\gamma}_{21}\right)\mu^{\gamma}_d = 0$$

$$(11^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\nu^{\gamma}_3 : \left(\theta_3\lambda^d_3 - \psi^{\gamma}_{31}\right)\mu^{\gamma}_d = 0$$

$$(12^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial c^{\gamma}_0 : \psi^{\gamma}_{02} - \left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21} + \psi^{\gamma}_{31}\right\} = 0$$

$$(13^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{01} : m^{\gamma}_0 + \bar{m}^{\gamma} - \frac{\mu^{\gamma}_d}{1+r_d} - \frac{\mu^{\gamma}_R}{1+\rho} - e^{\gamma}_0 = 0$$

$$(14^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{02} : \pi^{\gamma}_0 + c^{\gamma}_0 - m^{\gamma}_0(1+r_0)\nu^{\alpha}_0 = 0$$

$$(15^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{11} : m^{\gamma}_1 + \mu^{\gamma}_d\nu^{\gamma}_1 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_1 - e^{\gamma}_1 = 0$$

$$(16^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{21} : m^{\gamma}_2 + \mu^{\gamma}_d\nu^{\gamma}_2 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_2 - e^{\gamma}_2 = 0$$

$$(17^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{31} : m^{\gamma}_3 + \mu^{\gamma}_d\nu^{\gamma}_3 - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_3 - \frac{\mu^{\gamma}_B}{1+\tau} = 0$$

$$(18^{\gamma}_{DB}) \qquad \partial\mathcal{L}/\partial\mu^{\gamma}_{B} : \theta_3 \left\{1 - 2c^{\gamma}\left(m^{\gamma}_{3}(1+r_3)\nu^{\beta}_{3} - \mu^{\gamma}_{B}\right)\right\} - \frac{\psi^{\gamma}_{31}}{1+\tau} = 0$$

Bank γ, DN

$(01^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\pi^{\gamma}_0 : 1 - 2c^{\gamma}\pi^{\gamma}_0 - \psi^{\gamma}_{02} = 0$

$(02^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial m^{\gamma}_0 : \psi^{\gamma}_{01} - (1+r_0)\nu^{\alpha}_0\psi^{\gamma}_{02} = 0$

$(03^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial m^{\gamma}_1 : \theta_1\left\{1 - 2c^{\gamma}m^{\gamma}_1(1+r_1)\nu^{\beta}_1\right\}(1+r_1)\nu^{\beta}_1 - \psi^{\gamma}_{11} = 0$

$(04^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial m^{\gamma}_2 : \theta_2\left\{1 - 2c^{\gamma}m^{\gamma}_2(1+r_2)\nu^{\beta}_2\right\}(1+r_2)\nu^{\beta}_2 - \psi^{\gamma}_{21} = 0$

$(05^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\bar{m}^{\gamma} : \psi^{\gamma}_{01} - (1+\bar{r})\left\{\bar{\nu}^{\beta}_1\psi^{\gamma}_{11} + \bar{\nu}^{\beta}_2\psi^{\gamma}_{21}\right\} = 0$

$(06^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\mu^{\gamma}_R : \psi^{\gamma}_{01} - (1+\rho)\left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21}\right\} = 0$

$$(07^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\mu^{\gamma}_d : -\theta_1\lambda^d_1(1-\nu^{\gamma}_1) - \theta_2\lambda^d_2(1-\nu^{\gamma}_2) + \frac{\psi^{\gamma}_{01}}{1+r_d} - \nu^{\gamma}_1\psi^{\gamma}_{11} - \nu^{\gamma}_2\psi^{\gamma}_{21} = 0$$

$(08^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\nu^{\gamma}_1 : \left(\theta_1\lambda^d_1 - \psi^{\gamma}_{11}\right)\mu^{\gamma}_d = 0$

$(09^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\nu^{\gamma}_2 : \left(\theta_2\lambda^d_2 - \psi^{\gamma}_{21}\right)\mu^{\gamma}_d = 0$

$(10^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial c^{\gamma}_0 : \psi^{\gamma}_{02} - \left\{\psi^{\gamma}_{11} + \psi^{\gamma}_{21}\right\} = 0$

$(11^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{01} : m^{\gamma}_0 + \bar{m}^{\gamma} - \dfrac{\mu^{\gamma}_d}{1+r_d} - \dfrac{\mu^{\gamma}_R}{1+\rho} - e^{\gamma}_0 = 0$

$(12^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{02} : \pi^{\gamma}_0 + c^{\gamma}_0 - m^{\gamma}_0(1+r_0)\nu^{\alpha}_0 = 0$

$(13^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{11} : m^{\gamma}_1 + \mu^{\gamma}_d\nu^{\gamma}_1 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_1 - e^{\gamma}_1 = 0$

$(14^{\gamma}_{DN})\qquad \partial\mathcal{L}/\partial\psi^{\gamma}_{21} : m^{\gamma}_2 + \mu^{\gamma}_d\nu^{\gamma}_2 + \mu^{\gamma}_R - c^{\gamma}_0 - \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_2 - e^{\gamma}_2 = 0$

Additionally, we have $\nu^{\gamma}_3 = \dfrac{c^{\gamma}_0 + \bar{m}^{\gamma}(1+\bar{r})\bar{\nu}^{\beta}_3}{\mu^{\gamma}_d}$

3.7.2 Numerical solutions: Computation residuals

No Default equilibrium (ND)

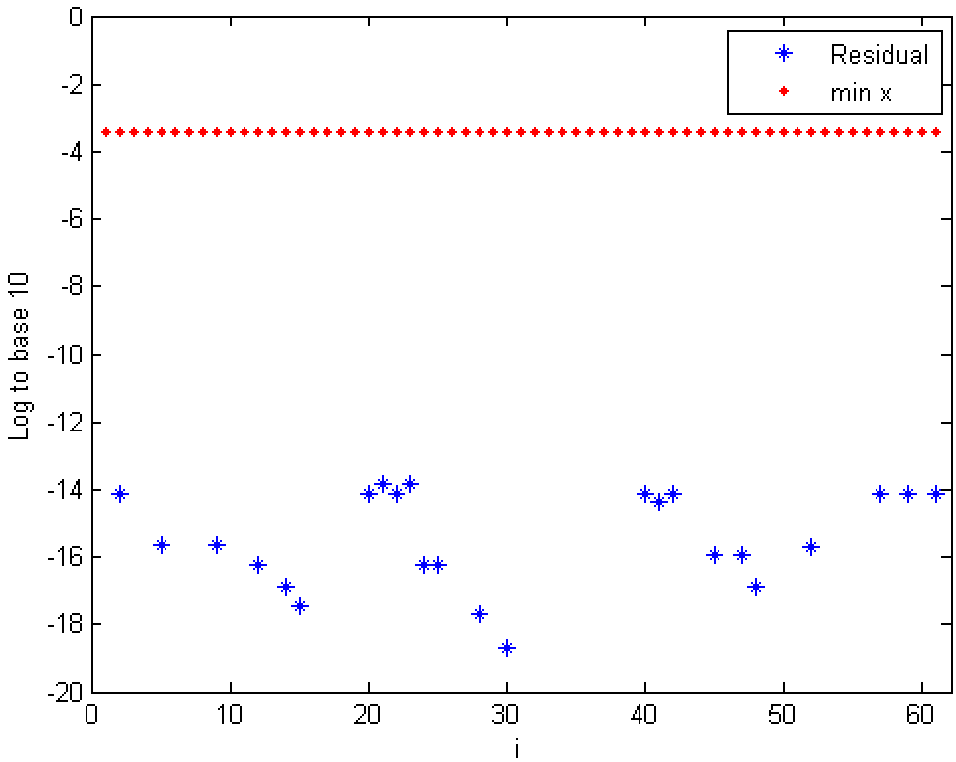

Figure 3.7: Computation residuals, ND equilibrium

The No Default (ND) equilibrium calibration is the solution of a system of 61 simultaneous equations in 61 variables[11], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 61$. The computation residuals of the equations are shown as blue stars.[12] As $|f_i| \leq 10^{-14} \quad \forall i$, and $\min(x_i) > 10^{-4}$, the equilibrium solution is reasonably stable.

[11] 33 endogenous choice variables, 11 prices, and 17 Lagrange multipliers.

[12] A missing blue star corresponds to a residual of 0.

Default & Bailout equilibrium (DB)

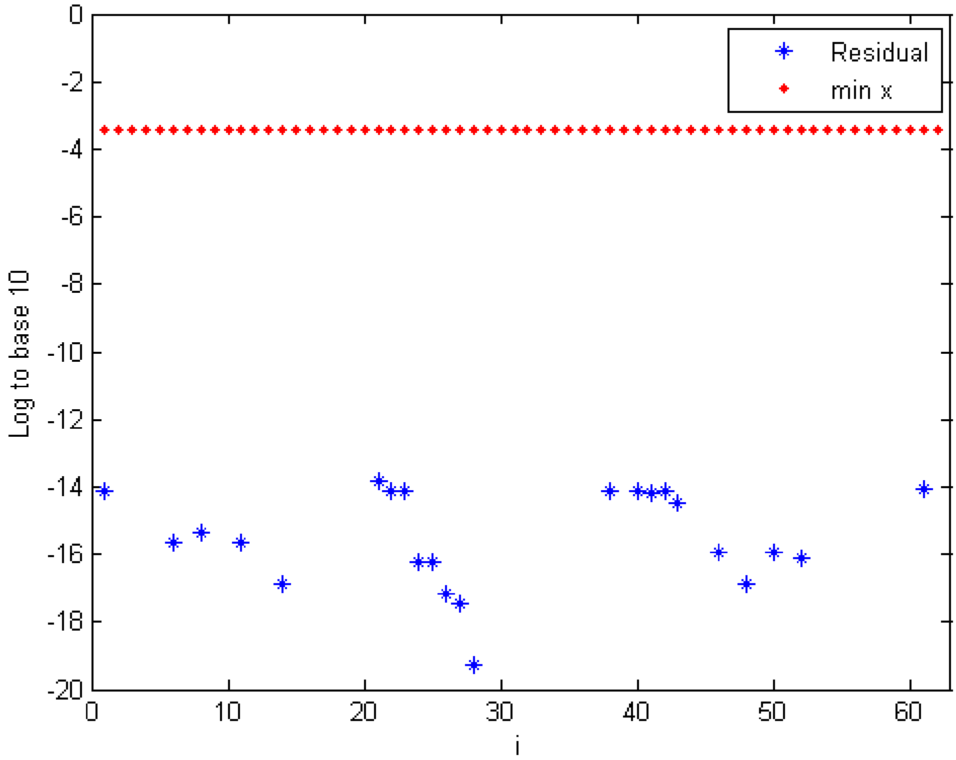

Figure 3.8: Computation residuals, DB equilibrium

The Default & Bailout (DB) equilibrium calibration is the solution of a system of 62 simultaneous equations in 62 variables[13], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 62$. The computation residuals of the equations are shown as blue stars.[14] As $|f_i| \leq 10^{-14} \quad \forall i$, and $\min(x_i) > 10^{-4}$, the equilibrium solution is reasonably stable.

[13]34 endogenous choice variables, 11 prices, and 17 Lagrange multipliers.

[14]A missing blue star corresponds to a residual of 0.

Default & No Bailout equilibrium (DN)

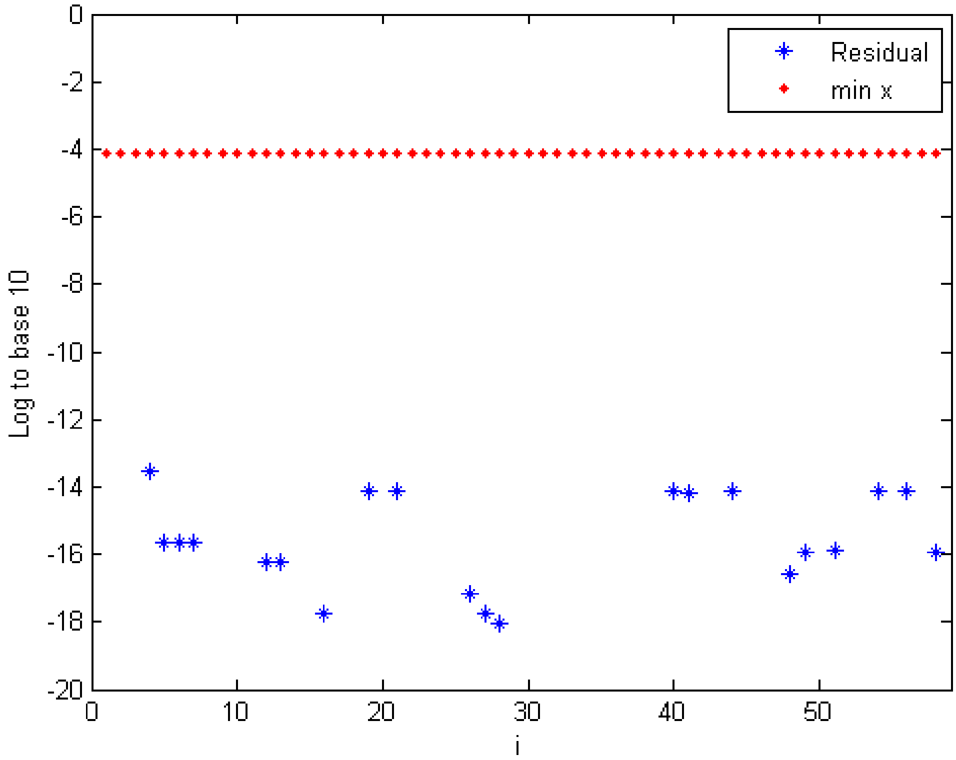

Figure 3.9: Computation residuals, DN equilibrium

The Default & No Bailout (DN) equilibrium calibration is the solution of a system of 58 simultaneous equations in 58 variables[15], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 58$. The computation residuals of the equations are shown as blue stars.[16] As $|f_i| \leq 10^{-13} \quad \forall i$, and $\min(x_i) \approx 10^{-4}$, the equilibrium solution is reasonably stable.

[15] 31 endogenous choice variables, 11 prices, and 16 Lagrange multipliers.
[16] A missing blue star corresponds to a residual of 0.

Chapter 4

Shareholder information, relative performance evaluation and financial crises

This chapter is based on a paper co-authored with Dr. Kevin James at the London School of Economics and the Financial Conduct Authority, and my supervisor, Prof. Dimitrios Tsomocos. I have handled a sizable fraction of the work, with my co-authors acting as supervisors.

4.1 Introduction

The relationship between the financial sector and economic risk has long been studied by economists, notably Keynes (1936), Hayek (1960), Minsky (1992), and

Kindleberger and Aliber (2011). These authors stress the role of expectations on financial and economic decisions. A second strand of literature (Mishkin, 1978; Bernanke, 1983; Moore and Kiyotaki, 1997; Schularick and Taylor, 2012) focusses on the role of the credit channel in the propagation of shocks from the financial sector to the real economy. A third strand () studies the role of asset price bubbles that precipitate crises when they burst. As Claessens and Kose (2013) put it: "The literature has clarified some of the factors driving crises, but it remains a challenge to definitively identify their deeper causes." The second theorem of Minsky's financial instability hypothesis (Minsky, 1992) postulates that in the face of long periods of prosperity, agents become increasingly optimistic about future prospects and invest increasingly in riskier assets. This optimism and subsequent risk taking leaves the economy vulnerable to more severe downturn in case of a negative shock, resulting in crises that manifest themselves with increased levels of default. The last few decades have seen a noticeable increase in the incidence of financial crises. In this paper we aim to provide an explanation for this increase by combining insights from agency theory and Minsky's financial instability hypothesis in a general equilibrium model with endogenous default. We seek to illuminate another channel that serves to distort the incentives of investment managers and precipitate crisis risk.

[1] Investors can be thought of as either firm managers or delegated investment managers investing in projects of differing risk. That being said, the problem we are studying is a portfolio choice problem. We abstract away from any principal-agent issues.

To this end, we build a basic two period model wherein investors[1] face a portfolio choice problem. Investors borrow from a competitive credit market and invest in safe and risky projects that mature after one period. Debt is defaultable, subject to a non-pecuniary penalty, as in Shubik and Wilson (1977); Dubey et al. (2005), and investors endogenously determine repayment rates on debt based on the marginal cost and benefit of defaulting. Endogenous default introduces a pecuniary externality since investors do not account for the impact of their default decision on the cost of debt. Furthermore, we assume that investors' utilities (net of default penalties) also depend on their performance relative to their peers.[2] We find that the presence of a relative performance effect generates herding behaviour, which gets more severe as relative performance becomes more important. Such herding exacerbates the effect of 'Minskian' optimism (modelled as in Bhattacharya et al., 2015) leading to excessive risk taking that exposes the economy to crisis risk in bad states of nature.

The classic literature on agency theory (Lazear and Rosen, 1981; Holmström, 1979, 1982) predicts that optimal contracts for management compensation will use rel-

[2]The agency theory literature (Lazear and Rosen, 1981; Holmström, 1979, 1982; Diamond and Verrecchia, 1982; Mookherjee, 1984) highlights the benefits to using relative performance criteria to negate principal-agent concerns. Morck et al. (1989) show that top management firings are linked with poor performance relative to firms in the same industry, an example of a penalty for relative underperformance. Chevalier and Ellison (1997) and Hvide and Kristiansen (2003) find evidence that mutual funds benefit from 'winning' against competitors by attracting higher funds from an anonymous pool of potential investors. We therefore capture this relative performance effect in reduced form through a linear term in the utility function. Bhattacharya et al. (2007) use a similar relative performance term in a GEI model to study sequential contagion. However, unlike in Bhattacharya et al. (2007), where and increase in relative competition leads to banks specialising and diversification in portfolio choices, in our model, increasing relative competition leads to herding.

ative performance criteria when other firms' results reveal information about the managers' performance. Therefore if shareholders have lower quality information regarding the actions of management, they are more likely to use relative performance criteria in the evaluation of management. Combining this insight with the results of our model therefore implies that the probability of a financial crisis increases as the quality of shareholder information decreases. We test this hypothesis by: i) developing a measure of the quality of shareholder information; ii) estimating the market-wide quality of shareholder information over time; and iii) examining the relationship between this market-wide level of shareholder information quality and the probability of a financial crisis.

The degree to which shareholders can monitor management depends upon the quality of the information they have on firm value. Following Simon (1989), we measure the quality of the information that shareholders have by the standard deviation of idiosyncratic (net of industry / size effects) firm returns. Intuitively, as the amount of information available to shareholders increases, the precision of their estimate of firm value increases. Hence, the arrival of new information will have a relatively small effect upon that estimate. If investors have little information about a firm's value, then a new piece of information will have a bigger effect upon that estimate. So, the standard deviation of idiosyncratic firm returns will increase as the amount of information shareholders have about firm value decreases. We limit our sample to NYSE listed firms as these firms are always subject to the best monitoring technology available. Our sample spans the years 1840 to 2014. We obtain data for the 1840 to 1925 period from Yale's Old New York Stock Exchange project, and we obtain our 1926 to 2014 data from CRSP. We compute a firm's idiosyncratic return by sorting firms into industry (3 digit SIC Code) or size/industry portfolios and subtracting the median portfolio return from the firm's return (analogous to the method used by Campbell et al. (2001) to study idiosyncratic volatility).[3] We then estimate the evolution of idiosyncratic standard deviation using a GARCH estimate and including control variables for market effects, recessions, and other possible explanatory factors.

We find that the market-wide quality of shareholder information: i) is poor (with no trend) in the Pre-SEC period (1840 to 1934); ii) improves substantially following the SEC reforms; and iii) gradually declines starting in the 1960s/70s until it is now back to pre-SEC levels. Using a standard list of US financial crises [4], we find that the probability of crisis in the poor shareholder-information-quality period before the SEC was roughly 7.5%/year. There were no crises during the good information years (1934 to 1995). Assuming that no financial crises were possible during the WWII period, the probability that the US economy would avoid a crisis between 1948 and 2008, if the annual probability of a crisis remained

[3] We do not have sufficient industry data to sort the Old NYSE firms by industry, so we treat these firms as a single industry.

[4] As in Calomiris and Gorton (1991); Reinhart (2010)

at its pre-SEC level, is less than 1%. The number of financial crises in the US since the quality of shareholder information has declined to pre-SEC levels is consistent with the pre-SEC probability of a crisis (one crisis every 13 years).

Section 2 below details our theoretical model. We look at a simplified version of the model in Section 3 obtain closed form solutions to guide intuition about the main channels in play in our model. Calibrated versions of the model are presented and discussed in section 4. Section 5 details the comparative statics studied. Section 6 covers our empirical analysis and section 7 concludes.

4.2 The theoretical model

We consider a multi-period economy consisting of investors of different types $i \in I$. Each type i is comprised of a continuum of identical investors with total mass normalized to one. In the notation below, we consider the optimisation problem of a representative investor of type i. Uncertainty is modelled as in Bhattacharya et al. (2015), wherein at each time period $t = 0, \ldots, T$, the economy can be in one of two possible states – the up/good state u or the down/bad state d. This leads to a (non-recombining) binomial tree structure of states such that at time t the full set of nodes on the binomial tree is $s_t \in S = \{0, u, d, uu, ud, du, dd, \ldots, s_{t-1}u, s_{t-1}d\}$. As in Bhattacharya et al. (2015), agents are Bayesian learners and update their subjective beliefs about the occurrence of the good state based on past realizations of the state of nature, and their prior beliefs.[5] Their conditional probability given past realizations is:

$$
\begin{aligned}
Pr_t(\theta = \theta_1 \,|s_t\,) &= \frac{Pr_t(s_t\,|\theta = \theta_1\,) \cdot Pr(\theta = \theta_1)}{Pr(s_t)} \\
&= \frac{Pr_t(s_t\,|\theta = \theta_1\,) \cdot Pr(\theta = \theta_1)}{Pr_t(s_t\,|\theta = \theta_1\,) \cdot Pr_t(\theta = \theta_1) + Pr_t(s_t\,|\theta = \theta_2\,) \cdot Pr(\theta = \theta_2)} \\
&= \frac{\theta_1^n(1-\theta_1)^{t-n} \cdot Pr(\theta = \theta_1)}{\theta_1^n(1-\theta_1)^{t-n} \cdot Pr(\theta = \theta_1) + \theta_2^n(1-\theta_2)^{t-n} \cdot Pr(\theta = \theta_2)},
\end{aligned}
$$

where n is the number of good realization up to time t. Then,

$$
\begin{aligned}
\pi_{s_t} = &\frac{\theta_1^n(1-\theta_1)^{t-n} \cdot Pr(\theta = \theta_1)}{\theta_1^n(1-\theta_1)^{t-n} \cdot Pr(\theta = \theta_1) + \theta_2^n(1-\theta_2)^{t-n} \cdot Pr(\theta = \theta_2)}\theta_1 \\
&+ \frac{\theta_2^n(1-\theta_2)^{t-n} \cdot Pr(\theta = \theta_2)}{\theta_1^n(1-\theta_1)^{t-n} \cdot Pr(\theta = \theta_1) + \theta_2^n(1-\theta_2)^{t-n} \cdot Pr(\theta = \theta_2)}\theta_2. \qquad (4.1)
\end{aligned}
$$

As the number of good realizations increases, the subjective probability of the good state realizing in the following period increases as well, i.e. given that $s_t = s_{t-1}u$, then $\pi_{s_t} > \pi_{s_{t-1}}$.[6]

Hereafter, to simplify notation, we represent a history of shocks (s_t), simply by

[5] As in Bhattacharya et al. (2015); Cogley and Sargent (2008), we assume that agents have incomplete information about the true probability measure. They learn it by observing realizations of states of nature and updating their priors. This fluctuation of beliefs in finite time leads to intertemporal changes in leverage and portfolio riskiness which converge to the true measure in the limit.

[6] For the detailed proof, see Bhattacharya et al. (2015).

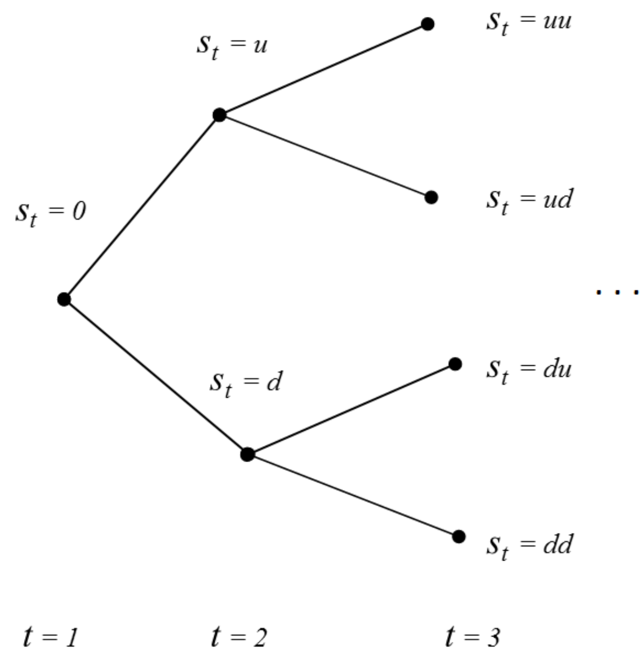

Figure 4.1: Timing of the Model

t. At t, the representative agent of each type i faces the same two possible investment opportunities – a high risk project H, and a low risk project L. Both projects last for one period. They are assumed to be in perfectly elastic supply and their prices are normalised to 1. The payoff for project $j \in \{H, L\}$ in state $s \in \{u, d\}$ is denoted by X_s^j. We assume that the following relationship between the payoffs holds: $X_u^H > X_u^L > 1 > X_d^L > X_d^H > 0$. The expected return and standard deviation of the payoffs of the two investments, (μ_t^H, σ_t^H) and (μ_t^L, σ_t^L), will differ based on changing expectations. Their ex-post payoffs however, remain the same.

Investors are assumed to be risk averse and have utility function which is quadratic in profits (denoted Π_t^i), with a coefficient of risk aversion denoted γ^i. Furthermore, agents face a non-pecuniary reward (or penalty) for outperforming (or underperforming) their peers that is proportional to the amount of outperformance (underperformance) i.e., the difference between their profits and those of their competitors. Investor i's utility is therefore increased (or reduced) by an amount τ for every unit of profit more (or less) than those of her competitors. Investors therefore face a portfolio choice problem and use funds borrowed from credit markets and retained earnings from the previous period to invest in the two different projects available. The amount of borrowing by investor i at node t is denoted w_t^i, and retained earnings are denoted ζ_t^i. The amount invested by agent i at node t in project j is denoted $w_{t,j}^i$.

The credit market is assumed to be perfectly competitive and credit in infinite supply. The interest rate that clears the credit market at time t is denoted r_t. Loans are assumed to be defaultable with each investor i deciding the fraction of the loan to repay, ν_t^i by weighing the costs and benefits of defaulting. The cost of default is assumed to be non-pecuniary penalty modelled as a linear function of the amount defaulted as in Shubik and Wilson (1977) and Dubey et al. (2005). The penalty per unit of the loan defaulted is denoted λ. Since creditors are risk neutral and break even in expectation, the interest rate is inversely related to their expectations of future repayment.

The initial endowment of investor i is denoted $\bar{w}_0^i$, and without loss of generality, we assumed that the endowment of each investor in every subsequent $t = 1, \ldots, T$ is zero. Investor i tries to maximize lifetime expected utility, and therefore solves:

$$\max_{w_{t,j}^i, w_t^i, \nu_{t+1}^i, \Pi_{t+1}^i, \zeta_{t+1}^i} \sum_t \mathbb{E}_t \left[U_{t+1}^i - \lambda \max\left[(1-\nu_{t+1}^i) w_t^i (1+r_t), 0\right] \right]$$

where $\mathbb{E}_t$ is the expectations operator at node t, under the probability measure π_t, when the investment decision is made, and U_{t+1}^i is given by:

$$U_{t+1}^i = \Pi_{t+1}^i - \gamma^i (\Pi_{t+1}^i)^2 - \tau[\Pi_{t+1}^{-i} - \Pi_{t+1}^i, 0]$$

Investors do not derive any utility at $t = 0$ and therefore all the funds go to investment i.e., $w_{0,L}^i + w_{0,H}^i \leq f(\zeta_0^i) + w_0^i$ and $f(\zeta_0^i) = \bar{w}_0^i$ (the initial endowment). $f(\cdot)$ is a concave function which captures a cost of retaining high levels of earnings and assures boundedness of the solution for probabilities of the good state tending

[7] As in Bhattacharya et al. (2015), we set $f(\zeta) = \delta \cdot \sqrt{\zeta}$, and calibrate the value of parameter δ.

to one[7]. Each investor faces the following budget constraints:

$$\Pi^i_{t+1} + \zeta^i_{t+1} \leq w^i_{t,L} X^L_t + w^i_{t,H} X^H_t - \nu^i_{t+1} w^i_t (1 + r_t)$$

i.e., profits disbursed + profits reinvested $\leq$ investments' payouts

- loan repayment in $t+1$.

$$w^i_{t+1,L} + w^i_{t+1,H} \leq f(\zeta^i_{t+1}) + w^i_{t+1}$$

i.e., investment in low and high risk projects $\leq$ reinvested profits

+ additional borrowing at t.

Each investor i also faces the following non-negativity constraints in each time period t:

$$w^i_t \geq 0$$

$$w^i_{t,L} \geq 0$$

$$w^i_{t,H} \geq 0$$

On the supply side of the credit market, we assume that there is a continuum of risk neutral creditors with an infinite supply of funds. They therefore break even in expectation. We assume that they have an outside option with a rate of return $\hat{r}$, and that they have the same information as investors and so form beliefs in the same manner. They have rational expectations about the delivery rate on the loans made out. They will therefore supply credit, at each period t, to clear the credit market at a rate r_t that follows the following zero profit (break-even) condition:

$$(1 + r_t)\mathbb{E}_t \left\{ \sum_{i \in I} \left[\frac{w_t^i}{\sum_{i \in I} w_t^i} \cdot \nu_{t+1}^i \right] \right\} = 1 + \hat{r} \qquad \forall\, t \in T \tag{4.2}$$

The condition above says that in each time period $t \in T$, the expected return per unit of credit supplied in the credit market equals the return per unit on the outside option.

The variables determined in equilibrium which agents take as fixed are given by $\boldsymbol{\eta} = \{\boldsymbol{r}_t\}$, $t = 0, ..., T$. Investor i's decision set is denoted $\boldsymbol{\sigma}^i \in \boldsymbol{\Sigma}_I(\boldsymbol{\eta})$.
$\boldsymbol{\sigma}^i = \left\{ w_{t,j}^i, w_t^i, \nu_{t+1}^i, \Pi_{t+1}^i, \zeta_{t+1}^i \right\}$.

Investor i's optimization problem is therefore formalised as follows:

$$\max_{\sigma^i \in \Sigma_i} \Xi^i = \sum_t \mathbb{E}_t \Big\{ \Pi^i_{t+1} - \gamma^i (\Pi^i_{t+1})^2 - \tau [\Pi^{-i}_{t+1} - \Pi^i_{t+1}, 0]$$
$$-\lambda \max \left[(1 - \nu^i_{t+1}) w^i_t (1 + r_t), 0 \right] \Big\}$$

$$s.t. B^i(\boldsymbol{\eta}) = \{ \boldsymbol{\sigma}^i \in \boldsymbol{\Sigma}_i(\boldsymbol{\eta}) : (01^i) - (t5^i) \}$$

Investor i faces the following constraints:

(01^i) $\quad w^i_{0,L} + w^i_{0,H} \leq f(\zeta^i_0) + w^i_0$

(02^i) $\quad w^i_0 \geq 0$

(03^i) $\quad w^i_{0,L} \geq 0$

(04^i) $\quad w^i_{0,H} \geq 0$

$(t1^i)$ $\quad \Pi^i_{t+1} + \zeta^i_{t+1} \leq w^i_{t,L} X^L_t + w^i_{t,H} X^H_t - \nu^i_{t+1} w^i_t (1 + r_t)$

$(t2^i)$ $\quad w^i_{t+1,L} + w^i_{t+1,H} \leq f(\zeta^i_{t+1}) + w^i_{t+1}$

$(t3^i)$ $\quad w^i_t \geq 0$

$(t4^i)$ $\quad w^i_{t,L} \geq 0$

$(t5^i)$ $\quad w^i_{t,H} \geq 0$

(01^i) says that in the first period, investor i uses its endowment and borrowing in that period to invest in the low and high risk assets.

$(t1^i)$ says that in every subsequent period t, investor i uses the payout from its investments in the previous period to disburse profits, reinvest and make its loan repayment.

$(t2^i)$ says that in every period t, investor i uses available reinvested profits and new borrowing to invest in the low and high risk assets.

(02^i) – (04^i) and $(t3^i)$ – $(t5^i)$ say that investors cannot extend credit, nor short sell either of the projects in any period.

Equilibrium in this model is reached when each investor i optimizes within her budget set and the markets for the projects, and for credit, clear. Interest rates are determined endogenously by the creditors forming rational expectations about loan repayment and correctly anticipating future delivery rates in equilibrium. We say that $\left(\boldsymbol{\eta}, \{\boldsymbol{\sigma}^i\}_{i\in I}\right)$ is an equilibrium of the economy iff:

(a) $\left\{\boldsymbol{\sigma}^i \in \underset{\boldsymbol{\sigma}^i \in B^i(\boldsymbol{\eta})}{\arg\max}\, \Xi^i\right\}_{i\in I}$

(b) Equation (2) holds.

(c) Subjective probabilities π_t are determined by equation (1).

(d) Creditors' expectations are rational i.e., they correctly anticipate the delivery rate ν_t.

Condition (a) ensures optimizing behaviour by the investors, condition (b) implies that the credit market clears, condition (c) implies that agents are Bayesian learners, and condition (d) says that creditors have rational expectations and are correct in their expectation of the default rate on loans. An equilibrium is therefore characterized by market clearing, rational expectations (i.e. correct anticipation of future repayment rates) and by agents optimizing within their budget sets.

4.3 Analytical solution

In this section we solve a simplified version of the model and provide closed form solutions. This is done by making a few assumptions that reduce the problem to a static two period problem. For tractability, we assume that initial endowments of investors is zero and that they do not reinvest any profits, thereby removing intertemporal links and reducing the problem to a two-period consumption smoothing problem. Since there is no reinvestment, the investors' portfolios are fully debt financed. We also assume that $\hat{r} = 0$. This first pass at solving the model is useful to highlight the effects that the relative performance parameter has on the amount of leverage undertaken by each investor and also on her repayment rate and therefore the aggregate default level in equilibrium.

First we solve the model for just one type of investor and using the assumptions made above. The problem now reduces to exactly the same one described in section 3.1 of Bhattacharya et al. (2015) and the same results obtain. The investor's problem is now reduced to solving

$$\max_{\Pi_u^i, \Pi_d^i, w^i, \nu^i} \Xi^i = \mathbb{E}\left[\Pi^i - \gamma^i(\Pi^i)^2 - \lambda \max\left[(1-\nu^i)w^i(1+r), 0\right]\right]$$

subject to the budget constraints:

$$\begin{aligned}
\Pi_u^i \leq\ & a^i \cdot w^i X_u^L + (1-a^i) \cdot w^i X_u^H - w^i(1+r) \\
=\ & w^i\left[a^i\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right] \qquad \ldots\left(\mu_u^i\right) \\
\Pi_d^i \leq\ & a^i \cdot w^i X_d^L + (1-a^i) \cdot w^i X_d^H - \nu^i w^i(1+r) \\
=\ & w^i\left[a^i\left(X_d^L - X_d^H\right) + X_d^H - \nu^i(1+r)\right] \qquad \ldots\left(\mu_d^i\right)
\end{aligned}$$

and the short selling constraints $0 \leq a^i \leq 1$, where w^i is the amount borrowed, and a^i is fraction of that borrowing invested in the low risk project. μ_u^i and μ_d^i are the Lagrange multipliers associated with the respective budget constraints. The probability of the up state occurring is denoted π and full repayment is assumed in this state. The credit market clears when

$$(1+r) = \frac{1}{\pi + (1-\pi)\nu^i}$$

The Lagrangian is therefore:

$$\begin{aligned}
\mathcal{L}^i =& \mathbb{E}\Pi^i - \gamma^i \mathbb{E}\left(\Pi^i\right)^2 - (1-\pi)\lambda \max\left[(1-\nu^i)w^i(1+r), 0\right] \\
&- \mu_u^i \left[\Pi_u^i - w^i \left[a^i \left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]\right] \\
&- \mu_d^i \left[\Pi_d^i - w^i \left[a^i \left(X_d^L - X_d^H\right) + X_d^H - \nu^i(1+r)\right]\right] - \phi^i(a^i - 1) + \psi^i(a^i)
\end{aligned}$$

Since the utility function is concave, we know that the budget constraints will hold with equality and therefore both lagrange multipliers μ_u^i and μ_d^i are positive. Solving the first order conditions and the market clearing condition yields the

[8] This makes assumptions on the value of π, for a more complete analysis see Bhattacharya et al. (2015)

following interior solution:[8]

$$
\begin{aligned}
\mu_d^i &= \lambda(1-\pi) \\
\mu_u^i &= \left(\frac{X_d^L - X_d^H}{X_u^H - X_u^L}\right)\lambda(1-\pi) \\
\Pi_d^i &= \frac{1-\lambda}{2\gamma^i} = \frac{\left(X_u^H - X_u^L\right)\pi - \left(X_d^L - X_d^H\right)\lambda(1-\pi)}{2\gamma^i\left(X_u^H - X_u^L\right)\pi} \\
\Pi_u^i &= \frac{1 - {}^{\mu_u^i}\!/_{\pi}}{2\gamma^i} \\
(1+r) &= \frac{X_u^H \cdot X_d^L - X_d^H \cdot X_u^L}{\left(X_u^H - X_d^H\right) - \left(X_u^L - X_d^L\right)} \\
\nu^i &= \frac{{}^{1}\!/_{(1+r)} - \pi}{1-\pi} = \frac{\left(X_u^H - X_d^H\right) - \left(X_u^L - X_d^L\right) - \pi\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)}{(1-\pi)\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)} \\
a^i &= \frac{\left(X_u^H - (1+r)\right)(1-\lambda) - \left(X_d^H - \nu^i(1+r)\right)\left(1 - {}^{\mu_u^i}\!/_{\pi}\right)}{\left(X_d^L - X_d^H\right)\left(1 - {}^{\mu_u^i}\!/_{\pi}\right) - \left(X_u^L - X_u^H\right)(1-\lambda)} \\
w^i &= \frac{1}{2\gamma^i\left[a^i\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]}\left(1 - \frac{\mu_u^i}{\pi}\right)
\end{aligned}
$$

It is interesting to note that under the assumptions made above, the repayment rate ν^i and asset allocation a^i are independent of the risk aversion parameter γ^i. A decrease in risk aversion, in this framework, therefore has no effect on the fractional allocation of borrowing across the two assets (i.e. the riskiness of the investors' portfolios) nor on the repayment rate but increases profits in both states purely by increasing the amount of leverage taken up.

In order to demonstrate the effects of the relative performance parameter τ, we first need to introduce heterogeneity in the model. We do this in the simplest possible manner by solving for two types of investors $i \in I = \{\alpha, \beta\}$ with differing levels of risk aversion, γ^{α} and γ^{β}, such that $\gamma^{\alpha} > \gamma^{\beta}$. Setting the relative performance parameter τ to zero initially, the Lagrangian for each agent i remains the same as in the previous case, and the market clearing condition now becomes:

$$(1+r) = \frac{1}{\pi + (1-\pi)\left(\frac{w^{\alpha} \cdot \nu^{\alpha} + w^{\beta} \cdot \nu^{\beta}}{w^{\alpha} + w^{\beta}}\right)}$$

The interior solution this time around is:

$$
\begin{aligned}
\mu_d^\alpha = \mu_d^\beta &= \lambda(1-\pi) \\
\mu_u^\alpha = \mu_u^\beta &= \left(\frac{X_d^L - X_d^H}{X_u^H - X_u^L}\right)\lambda(1-\pi) \\
\Pi_d^\alpha &= \frac{1-\lambda}{2\gamma^\alpha} = \frac{\left(X_u^H - X_u^L\right)\pi - \left(X_d^L - X_d^H\right)\lambda(1-\pi)}{2\gamma^\alpha\left(X_u^H - X_u^L\right)\pi} \\
\Pi_d^\beta &= \frac{1-\lambda}{2\gamma^\beta} = \frac{\left(X_u^H - X_u^L\right)\pi - \left(X_d^L - X_d^H\right)\lambda(1-\pi)}{2\gamma^\beta\left(X_u^H - X_u^L\right)\pi} \\
\Pi_u^\alpha &= \frac{1 - {}^{\mu_u^\alpha}\!/_{\pi}}{2\gamma^\alpha} \\
\Pi_u^\beta &= \frac{1 - {}^{\mu_u^\beta}\!/_{\pi}}{2\gamma^\beta} \\
(1+r) &= \frac{X_u^H \cdot X_d^L - X_d^H \cdot X_u^L}{\left(X_u^H - X_d^H\right) - \left(X_u^L - X_d^L\right)} \\
\nu^\alpha = \nu^\beta &= \frac{{}^{1}\!/_{(1+r)} - \pi}{1-\pi} = \frac{\left(X_u^H - X_d^H\right) - \left(X_u^L - X_d^L\right) - \pi\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)}{(1-\pi)\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)} \\
a^\alpha &= \frac{\left(X_u^H - (1+r)\right)(1-\lambda) - \left(X_d^H - \nu^\alpha(1+r)\right)\left(1 - {}^{\mu_u^\alpha}\!/_{\pi}\right)}{\left(X_d^L - X_d^H\right)\left(1 - {}^{\mu_u^\alpha}\!/_{\pi}\right) - \left(X_u^L - X_u^H\right)(1-\lambda)} \\
a^\beta &= \frac{\left(X_u^H - (1+r)\right)(1-\lambda) - \left(X_d^H - \nu^\beta(1+r)\right)\left(1 - {}^{\mu_u^\beta}\!/_{\pi}\right)}{\left(X_d^L - X_d^H\right)\left(1 - {}^{\mu_u^\beta}\!/_{\pi}\right) - \left(X_u^L - X_u^H\right)(1-\lambda)} \\
w^\alpha &= \frac{1}{2\gamma^\alpha\left[a^\alpha\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]}\left(1 - \frac{\mu_u^\alpha}{\pi}\right) \\
w^\beta &= \frac{1}{2\gamma^\beta\left[a^\beta\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]}\left(1 - \frac{\mu_u^\beta}{\pi}\right)
\end{aligned}
$$

As expected, the only effect of the different risk aversion is to change leverage. Since $\gamma^\alpha > \gamma^\beta$, this implies that $\Pi_u^\alpha < \Pi_u^\beta$ and $\Pi_d^\alpha < \Pi_d^\beta$. Therefore, if we introduce a relative performance parameter (of appropriate size), it would impose a penalty on investor α in both states, and a reward to investor β in both states. The

Lagrangian for each investor i is now:

$$\begin{aligned}
\mathcal{L}^i =& \mathbb{E}\Pi^i - \gamma^i \mathbb{E}\left(\Pi^i\right)^2 - \mathbb{E}\tau[\Pi^{-i} - \Pi^i, 0] \\
& - (1-\pi)\lambda \max\left[(1-\nu^i)w^i(1+r), 0\right] \\
& - \mu_u^i \left[\Pi_u^i - w^i\left[a^i\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]\right] \\
& - \mu_d^i \left[\Pi_d^i - w^i\left[a^i\left(X_d^L - X_d^H\right) + X_d^H - \nu^i(1+r)\right]\right] - \phi^i(a^i - 1) + \psi^i(a^i)
\end{aligned}$$

The market clearing condition remains the same:

$$(1+r) = \frac{1}{\pi + (1-\pi)\left(\frac{w^\alpha \cdot \nu^\alpha + w^\beta \cdot \nu^\beta}{w^\alpha + w^\beta}\right)}$$

The interior solution with the relative performance parameter now becomes:

$$
\begin{aligned}
\mu_d^\alpha = \mu_d^\beta &= \lambda(1-\pi) \\
\mu_u^\alpha = \mu_u^\beta &= \left(\frac{X_d^L - X_d^H}{X_u^H - X_u^L}\right)\lambda(1-\pi) \\
\Pi_d^\alpha &= \frac{1-\lambda+\tau}{2\gamma^\alpha} \\
\Pi_d^\beta &= \frac{1-\lambda-\tau}{2\gamma^\beta} \\
\Pi_u^\alpha &= \frac{1-{}^{\mu_u^\alpha}\!/_{\pi}+\tau}{2\gamma^\alpha} \\
\Pi_u^\beta &= \frac{1-{}^{\mu_u^\beta}\!/_{\pi}-\tau}{2\gamma^\beta} \\
(1+r) &= \frac{X_u^H \cdot X_d^L - X_d^H \cdot X_u^L}{(X_u^H - X_d^H) - (X_u^L - X_d^L)} \\
\nu^\alpha = \nu^\beta &= \frac{{}^1\!/_{(1+r)} - \pi}{1-\pi} = \frac{\left(X_u^H - X_d^H\right) - \left(X_u^L - X_d^L\right) - \pi\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)}{(1-\pi)\left(X_u^H \cdot X_d^L - X_d^H \cdot X_u^L\right)} \\
a^\alpha &= \frac{\left(X_u^H - (1+r)\right)(1-\lambda+\tau) - \left(X_d^H - \nu^\alpha(1+r)\right)\left(1-{}^{\mu_u^\alpha}\!/_{\pi}+\tau\right)}{(X_d^L - X_d^H)\left(1-{}^{\mu_u^\alpha}\!/_{\pi}+\tau\right) - (X_u^L - X_u^H)(1-\lambda+\tau)} \\
a^\beta &= \frac{\left(X_u^H - (1+r)\right)(1-\lambda-\tau) - \left(X_d^H - \nu^\beta(1+r)\right)\left(1-{}^{\mu_u^\beta-\tau}\!/_{\pi}\right)}{(X_d^L - X_d^H)\left(1-{}^{\mu_u^\beta-\tau}\!/_{\pi}\right) - (X_u^L - X_u^H)(1-\lambda-\tau)} \\
w^\alpha &= \frac{1}{2\gamma^\alpha\left[a^\alpha\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]}\left(1-\frac{\mu_u^\alpha}{\pi}+\tau\right) \\
w^\beta &= \frac{1}{2\gamma^\beta\left[a^\beta\left(X_u^L - X_u^H\right) + X_u^H - (1+r)\right]}\left(1-\frac{\mu_u^\beta}{\pi}-\tau\right)
\end{aligned}
$$

As can be seen in the solution above, an increase in the relative performance parameter τ serves to distort the choices of both agents, making the more risk averse agent take on more risk and vice versa. Since the do not repay their loans in full in the downs state, their profits in this state are locked in by the default penalty through the on-the-verge condition. Their profit level will be such as to equate the marginal benefit of defaulting to the marginal cost (i.e. the default penalty). An increase in τ brings the profit levels of the investors in each state closer to each other. Furthermore, an increase in tau also affects leverage w^i and risk allocation a^i in symmetric but opposite ways. The presence of a penalty for relative underperformance serves to increase the leverage of the more risk averse investor as she seeks to increase her profit to reduce the amount of underperformance. It has the opposite effect on the less risk averse agent as the outperformance reward serves reduce the amount of pure profit (Π) needed to maximise her utility. The effect of this change in leverage on the allocation across the two assets depends on the relative size of the payoffs of the assets, and the relative performance parameter, but the effect across the two agents is symmetric and in opposite directions. The agents' risk allocations are therefore more similar to each other in the presence the relative performance effect – demonstrating the herding effect of relative performance much discussed in classic contract theory literature (Morck et al., 1989; Scharfstein and Stein, 1990; Zwiebel, 1995; Maug and Naik, 2011).[9]

The effect of optimism in this model (i.e. an increase in π) is the same as that discussed in Bhattacharya et al. (2015). An increase in π serves to increase risk allocation towards the risky asset, and also to reduce the repayment rate in the

[9]Insights on herding go back to Keynes (1936) and his observation that in the world of investment management "Worldly wisdom teaches that it is better for reputation to fail conventionally than to succeed unconventionally." See Devenow and Welch (1996) for an exhaustive survey of economic models on rational herding.

bad state, i.e. to increase default in the face of a negative shock.[10] We now look at the effects of both channels – relative performance, and Minskian optimism – in isolation and then simultaneously, through a calibrated example and comparative statics.

4.4 Calibration

Henceforth, we limit our discussion to the equilibrium of a 3-period calibration of the model. We choose exogenous parameters to obtain realistic equilibrium values of leverage, portfolio allocations, repayment rates, and interest rate spreads. For simplicity, we choose a default penalty that ensures full repayment in all the good states of nature. We report four separate calibrations to highlight the equilibrium effects of both channels under study – Minskian optimism, and relative performance. Table 4.1 reports the equilibrium values for the case where there is no relative performance effect and no updating of beliefs based on realised states. Table 4.2 reports the equilibrium values for the case where there is a relative performance effect but no updating of beliefs based on realised states. In table 4.3 agents update their beliefs and exhibit Minskian optimism but face no relative performance effect, and in table 4.4, both effects are present. The other exogenous parameters remain the same in all four calibrations. Investor α is more risk averse

[10] For a fuller treatment, see Bhattacharya et al. (2015).

than investor β in all calibrations. Finally, in the case where Minskian optimism is present, the priors $\{\theta_1, \theta_2\}$ and their distribution are chosen such that the probability of the good state occurring at $t = 0$ is the same as that in the case of no Minskian optimism. This was done in order to make meaningful comparisons with the no optimism equilibrium.

Comparing table 4.1 with table 4.2 we can see the effect of relative performance on our equilibrium. We see that the relative performance term brings the payouts of both agents closer to each other in all states. Since expectations are unchanged, there is no effect on the repayment rate, nor in the amount of retained earnings. The change is payouts is brought about purely through changes in leverage and changes in portfolio allocations. Investor α increases her profits in each state by taking up higher leverage and shifting allocation towards the less risky asset. Investor β on the other hand takes up less leverage but shifts towards the riskier asset. On the whole, in the presece of the relative performance effect, the payoffs of the two investors are more closely related to each other (the covariance of returns on their portfolio increases) in all states and this makes the economy as a whole more vulnerable to a negative shock. Furthermore, the amount invested as a whole in the riskier asset (as a fraction of total investment) also goes up in all states.

Comparing table 4.1 with table 4.3 we can see the Minskian optimism effect at work. In the presence of Minskian optimism, both agents update their beliefs at the u node and subsequently increase their leverage, reduce retained earnings, and increase allocation to the riskier asset. Default is therefore higher in the ud node as compared to the u node and as compare to the case with no Minskian optimism. A symmetric effect occurs in the the d node, as agents are now tamp down on their expectations and act more conservatively, by increasing retained earnings, reducing leverage, and shifting to the less risky asset.

Table 4.4 combines both these effects and we see that an updating of expectations at the u node implies that both agents increase leverage, shift to the riskier asset, and a result default increases at the ud node on the back of this optimism. Furthermore, the relative performance effect means that both agents' investments are more closely linked to each other and that the fraction of investments going to the riskier asset goes up, and most notably so at the u node. The relative performance effect therefore serves to exacerbate the effects of Minskian optimism and this results in higher leverage and higher risk taking by both investors at the u node and subsequently, in greater levels of default in the ud node, when a negative shock hits after a period of positivity.

Table 4.1: Calibration with no Minskian updating and no relative performance effect

Exogenous Variables				Model Predictions		Agent α's Decisions				Agent β's Decisions			
γ^α	0.7500	θ_1	0.9620	π_0	0.962	Π_u^α	0.3791	$w_{0,L}^\alpha$	43.9290	Π_u^β	0.4739	$w_{0,L}^\beta$	66.7666
$\bar{w}_0^\alpha$	0.3000	θ_2	0.9620	π_u	0.962	Π_d^α	0.1067	$w_{0,H}^\alpha$	1.4926	Π_d^β	0.1333	$w_{0,H}^\beta$	1.7463
γ^β	0.6000	$Pr\left(\theta = \theta_1\right)$	1.0000	π_d	0.962	Π_{uu}^α	0.3791	$w_{u,L}^\alpha$	23.8665	Π_{uu}^β	0.4739	$w_{u,L}^\beta$	46.7041
$\bar{w}_0^\beta$	0.3000	X_u^H	1.0640	$r - \hat{r}$	20bps	Π_{ud}^α	0.1067	$w_{u,H}^\alpha$	1.1003	Π_{ud}^β	0.1333	$w_{u,H}^\beta$	1.3540
δ	0.6830	X_u^L	1.0480	$\mathbb{E}_0\left(\nu_1\right)$	99.80%	Π_{du}^α	0.3791	$w_{d,L}^\alpha$	56.6966	Π_{du}^β	0.4739	$w_{d,L}^\beta$	79.5343
λ	0.8400	X_d^L	0.9930	$\mathbb{E}_1\left(\nu_2\right)$	99.80%	Π_{dd}^α	0.1067	$w_{d,H}^\alpha$	1.0587	Π_{dd}^β	0.1333	$w_{d,H}^\beta$	1.3124
τ	0.0000	X_d^H	0.7850			ζ_u^α	0.1364	ν_d^α	0.9478	ζ_u^β	0.1364	ν_d^β	0.9478
		$\hat{r}$	4.20%			ζ_d^α	0.0360	ν_{ud}^α	0.9478	ζ_d^β	0.0360	ν_{ud}^β	0.9478
						w_0^α	45.1216	ν_{dd}^α	0.9478	w_0^β	68.2129	ν_{dd}^β	0.9478
						w_u^α	24.7145			w_u^β	47.8059		
						w_d^α	57.6258			w_d^β	80.7171		

γ^i : Coefficient of risk aversion of investor $i \in I$
$\bar{w}_0^i$: Initial endowment of investor $i \in I$
δ : Concavity parameter to capture a cost of retaining high earnings
λ : Non-pecuniary penalty for defaulting on loans
τ : Penalty/reward for relative under/outperformance
X_s^j : Payoff for project $j \in \{L, H\}$ in state $s \in \{u, d\}$
$\hat{r}$: Rate of return on outside option available to creditors
π_t : Subjective (Bayesian) belief at node $t \in \{0, u, d\}$ of a good state occurring in the next period
Π_t^i : Profits disbursed by investor $i \in I$ at node t
ζ_t^i : Profits reinvesteded by investor $i \in I$ at node $t \in \{u, d\}$
w_t^i : Amount borrowed by investor $i \in I$ at node $t \in \{0, u, d\}$
$w_{t,j}^i$: Amount borrowed by investor $i \in I$ in project $j \in \{L, H\}$ at node $t \in \{0, u, d\}$
ν_t^i : Repayment rate of investor $i \in I$ at node t

Table 4.2: Calibration with no Minskian updating and a relative performance effect

Exogenous Variables				Model Predictions		Agent α's Decisions				Agent β's Decisions			
γ^α	0.7500	θ_1	0.9620	π_0	0.962	Π_u^α	0.3871	$w_{0,L}^\alpha$	45.9881	Π_u^β	0.4639	$w_{0,L}^\beta$	64.1928
$\bar{w}_0^\alpha$	0.3000	θ_2	0.9620	π_u	0.962	Π_d^α	0.1147	$w_{0,H}^\alpha$	1.4881	Π_d^β	0.1233	$w_{0,H}^\beta$	1.7519
γ^β	0.6000	$Pr\left(\theta = \theta_1\right)$	1.0000	π_d	0.962	Π_{uu}^α	0.3871	$w_{u,L}^\alpha$	25.9256	Π_{uu}^β	0.4639	$w_{u,L}^\beta$	44.1303
$\bar{w}_0^\beta$	0.3000	X_u^H	1.0640	$r - \hat{r}$	20bps	Π_{ud}^α	0.1147	$w_{u,H}^\alpha$	1.0959	Π_{ud}^β	0.1233	$w_{u,H}^\beta$	1.3596
δ	0.6830	X_u^L	1.0480	$\mathbb{E}_0\left(\nu_1\right)$	99.80%	Π_{du}^α	0.3871	$w_{d,L}^\alpha$	58.7557	Π_{du}^β	0.4639	$w_{d,L}^\beta$	76.9604
λ	0.8400	X_d^L	0.9930	$\mathbb{E}_1\left(\nu_2\right)$	99.80%	Π_{dd}^α	0.1147	$w_{d,H}^\alpha$	1.0542	Π_{dd}^β	0.1233	$w_{d,H}^\beta$	1.3180
τ	0.0120	X_d^H	0.7850			ζ_u^α	0.1364	ν_d^α	0.9478	ζ_u^β	0.1364	ν_d^β	0.9478
		$\hat{r}$	4.20%			ζ_d^α	0.0360	ν_{ud}^α	0.9478	ζ_d^β	0.0360	ν_{ud}^β	0.9478
						w_0^α	47.1762	ν_{dd}^α	0.9478	w_0^β	65.6447	ν_{dd}^β	0.9478
						w_u^α	26.7692			w_u^β	45.2376		
						w_d^α	59.6804			w_d^β	78.1488		

γ^i : Coefficient of risk aversion of investor $i \in I$
$\bar{w}_0^i$: Initial endowment of investor $i \in I$
δ : Concavity parameter to capture a cost of retaining high earnings
λ : Non-pecuniary penalty for defaulting on loans
τ : Penalty/reward for relative under/outperformance
X_s^j : Payoff for project $j \in \{L, H\}$ in state $s \in \{u, d\}$
$\hat{r}$: Rate of return on outside option available to creditors
π_t : Subjective (Bayesian) belief at node $t \in \{0, u, d\}$ of a good state occurring in the next period
Π_t^i : Profits disbursed by investor $i \in I$ at node t
ζ_t^i : Profits reinvesteded by investor $i \in I$ at node $t \in \{u, d\}$
w_t^i : Amount borrowed by investor $i \in I$ at node $t \in \{0, u, d\}$
$w_{t,j}^i$: Amount borrowed by investor $i \in I$ in project $j \in \{L, H\}$ at node $t \in \{0, u, d\}$
ν_t^i : Repayment rate of investor $i \in I$ at node t

Table 4.3: Calibration with Minskian updating but no relative performance effect

Exogenous Variables				Model Predictions		Agent α's Decisions				Agent β's Decisions			
γ^α	0.7500	θ_1	0.9650	π_0	0.962	Π^α_u	0.3791	$w^\alpha_{0,L}$	43.9163	Π^β_u	0.4739	$w^\beta_{0,L}$	66.7540
$\bar{w}^\alpha_0$	0.3000	θ_2	0.9550	π_u	0.962022	Π^α_d	0.1067	$w^\alpha_{0,H}$	1.4873	Π^β_d	0.1333	$w^\beta_{0,H}$	1.7409
γ^β	0.6000	$Pr\left(\theta=\theta_1\right)$	0.7000	π_d	0.961447	Π^α_{uu}	0.3793	$w^\alpha_{u,L}$	23.9278	Π^β_{uu}	0.4741	$w^\beta_{u,L}$	46.7590
$\bar{w}^\beta_0$	0.3000	X^H_u	1.0640	$r-\hat{r}$	20bps	Π^α_{ud}	0.1067	$w^\alpha_{u,H}$	1.1045	Π^β_{ud}	0.1333	$w^\beta_{u,H}$	1.3616
δ	0.6830	X^L_u	1.0480	$\mathbb{E}_0\left(\nu_1\right)$	99.80%	Π^α_{du}	0.3747	$w^\alpha_{d,L}$	56.1883	Π^β_{du}	0.4684	$w^\beta_{d,L}$	79.1845
λ	0.8400	X^L_d	0.9930	$\mathbb{E}_1\left(\nu_2\right)$	99.80%	Π^α_{dd}	0.1067	$w^\alpha_{d,H}$	0.8419	Π^β_{dd}	0.1333	$w^\beta_{d,H}$	1.0098
τ	0.0000	X^H_d	0.7850			ζ^α_u	0.1363	ν^α_d	0.9478	ζ^β_u	0.1363	ν^β_d	0.9478
		$\hat{r}$	4.20%			ζ^α_d	0.0370	ν^α_{ud}	0.9472	ζ^β_d	0.0370	ν^β_{ud}	0.9472
						w^α_0	45.1036	ν^α_{dd}	0.9485	w^β_0	68.1949	ν^β_{dd}	0.9485
						w^α_u	24.7801			w^β_u	47.8684		
						w^α_d	56.8988			w^β_d	80.0629		

γ^i : Coefficient of risk aversion of investor $i \in I$
$\bar{w}^i_0$: Initial endowment of investor $i \in I$
δ : Concavity parameter to capture a cost of retaining high earnings
λ : Non-pecuniary penalty for defaulting on loans
τ : Penalty/reward for relative under/outperformance
X^j_s : Payoff for project $j \in \{L,H\}$ in state $s \in \{u,d\}$
$\hat{r}$: Rate of return on outside option available to creditors
π_t : Subjective (Bayesian) belief at node $t \in \{0,u,d\}$ of a good state occurring in the next period
Π^i_t : Profits disbursed by investor $i \in I$ at node t
ζ^i_t : Profits reinvesteded by investor $i \in I$ at node $t \in \{u,d\}$
w^i_t : Amount borrowed by investor $i \in I$ at node $t \in \{0,u,d\}$
$w^i_{t,j}$: Amount borrowed by investor $i \in I$ in project $j \in \{L,H\}$ at node $t \in \{0,u,d\}$
ν^i_t : Repayment rate of investor $i \in I$ at node t

Table 4.4: Calibration with Minskian updating and a relative performance effect

Exogenous Variables				Model Predictions		Agent α's Decisions				Agent β's Decisions			
γ^α	0.7500	θ_1	0.9650	π_0	0.962	Π^α_u	0.3871	$w^\alpha_{0,L}$	45.9754	Π^β_u	0.4639	$w^\beta_{0,L}$	64.1801
$\bar{w}^\alpha_0$	0.3000	θ_2	0.9550	π_u	0.962022	Π^α_d	0.1147	$w^\alpha_{0,H}$	1.4828	Π^β_d	0.1233	$w^\beta_{0,H}$	1.7465
γ^β	0.6000	$Pr\left(\theta=\theta_1\right)$	0.7000	π_d	0.961447	Π^α_{uu}	0.3873	$w^\alpha_{u,L}$	25.9854	Π^β_{uu}	0.4641	$w^\beta_{u,L}$	44.1869
$\bar{w}^\beta_0$	0.3000	X^H_u	1.0640	$r-\hat{r}$	20bps	Π^α_{ud}	0.1147	$w^\alpha_{u,H}$	1.1003	Π^β_{ud}	0.1233	$w^\beta_{u,H}$	1.3668
δ	0.6830	X^L_u	1.0480	$\mathbb{E}_0\left(\nu_1\right)$	99.80%	Π^α_{du}	0.3827	$w^\alpha_{d,L}$	58.2847	Π^β_{du}	0.4584	$w^\beta_{d,L}$	76.5641
λ	0.8400	X^L_d	0.9930	$\mathbb{E}_1\left(\nu_2\right)$	99.80%	Π^α_{dd}	0.1147	$w^\alpha_{d,H}$	0.8301	Π^β_{dd}	0.1233	$w^\beta_{d,H}$	1.0245
τ	0.0120	X^H_d	0.7850			ζ^α_u	0.1363	ν^α_d	0.9478	ζ^β_u	0.1363	ν^β_d	0.9478
		$\hat{r}$	4.20%			ζ^α_d	0.0370	ν^α_{ud}	0.9472	ζ^β_d	0.0370	ν^β_{ud}	0.9472
						w^α_0	47.1582	ν^α_{dd}	0.9485	w^β_0	65.6266	ν^β_{dd}	0.9485
						w^α_u	26.8335			w^β_u	45.3016		
						w^α_d	58.9833			w^β_d	77.4572		

γ^i	: Coefficient of risk aversion of investor $i \in I$
$\bar{w}^i_0$	: Initial endowment of investor $i \in I$
δ	: Concavity parameter to capture a cost of retaining high earnings
λ	: Non-pecuniary penalty for defaulting on loans
τ	: Penalty/reward for relative under/outperformance
X^j_s	: Payoff for project $j \in \{L, H\}$ in state $s \in \{u, d\}$
$\hat{r}$	: Rate of return on outside option available to creditors
π_t	: Subjective (Bayesian) belief at node $t \in \{0, u, d\}$ of a good state occurring in the next period
Π^i_t	: Profits disbursed by investor $i \in I$ at node t
ζ^i_t	: Profits reinvesteded by investor $i \in I$ at node $t \in \{u, d\}$
w^i_t	: Amount borrowed by investor $i \in I$ at node $t \in \{0, u, d\}$
$w^i_{t,j}$	: Amount borrowed by investor $i \in I$ in project $j \in \{L, H\}$ at node $t \in \{0, u, d\}$
ν^i_t	: Repayment rate of investor $i \in I$ at node t

4.5 Comparative statics

Having observed the impact of the two channels we study – Minskian optimism, and relative performance – on the different variables in our model, we now attempt to tease out the individual effects of these channels through a series of comparative statics exercises. We run four different sets of comparative statics – changing the size of the relative performance parameter τ with and without Minskian optimism, and changing the extent of optimism, with and without the presence of relative competition. The results are shown in figure 4.2.

4.5.1 The relative performance channel

In the first two sets of comparative statics, we change the size of the relative performance effect, first in the absence of Minskian optimism, and then in the presence of a fixed degree of Minskian optimism. As we can see in figure 4.2, an increase in the relative performance parameter brings about an increase in the profit (in all states) of the more risk averse agent, and a reduction in profit of the less risk averse agent. Moreover, we see that this is brought about, in case of the more risk averse investor α, through an increase in leverage and an increase in investment in the safe asset, and in the case of the investor β through reduced leverage, and more investment in the risky asset. The presence of Minskian optimism heightens this effect, especially in the *ud* node where a bad shock follows a good state wherein agents update their beliefs. Importantly, the relative performance channel doesn't affect intertemporal linkages and therefore retained earnings remain the same in these simulations. Repayment rates are also unaffected by the size of the relative performance parameter as it doesn't enter the on-the-verge condition that equates the marginal benefit of default to the marginal cost (default penalty).

4.5.2 The Minskian optimism channel

The second pair of comparative statics exercises demonstrate the effects of changing optimism, first in the absence of a relative performance effect and then in the presence of a relative performance parameter of fixed size. An increase in optimism in these exercises implies a change in the priors $\{\theta_1, \theta_2\}$ and their distribution so as to keep the expected value of a good state at node 0 the same but increase the extent of upward/downward revision of expectations at the u/d node is greater. Therefore as we move from left to right in these comparative statics tables, π_0 is unchanged, π_u gets larger, and π_d gets smaller.

Since π_0 is unchanged throughout these simulations, we see no change in the payoffs at $t = 1$ and also in the repayment rate at note d. Payoffs at all down states $\{d, ud, dd\}$ are locked in through the on-the-verge condition which binds since agents partially default at these nodes. As optimism increases we find that agents reduce leverage at $t = 0$ and push profits towards the uu node and away from the du node. At the u node, as expectations are revised upwards, investors increase leverage, reduce retained earnings, and invest more heavily in the riskier asset. While investment in the less risky asset also goes up, the proportional increase is towards the riskier asset and away from the less risky asset. Default is therefore higher at the ud node as compared to the u node, and this difference gets more pronounced as the degree of optimism increases. The presence of a relative performance effect in conjunction with Minskian optimism serves to exacerbate this effect and agents now take up even more leverage, and invest an even greater proportion in the riskier asset, and default in the ud state is even higher than in the case without the relative performance effect.

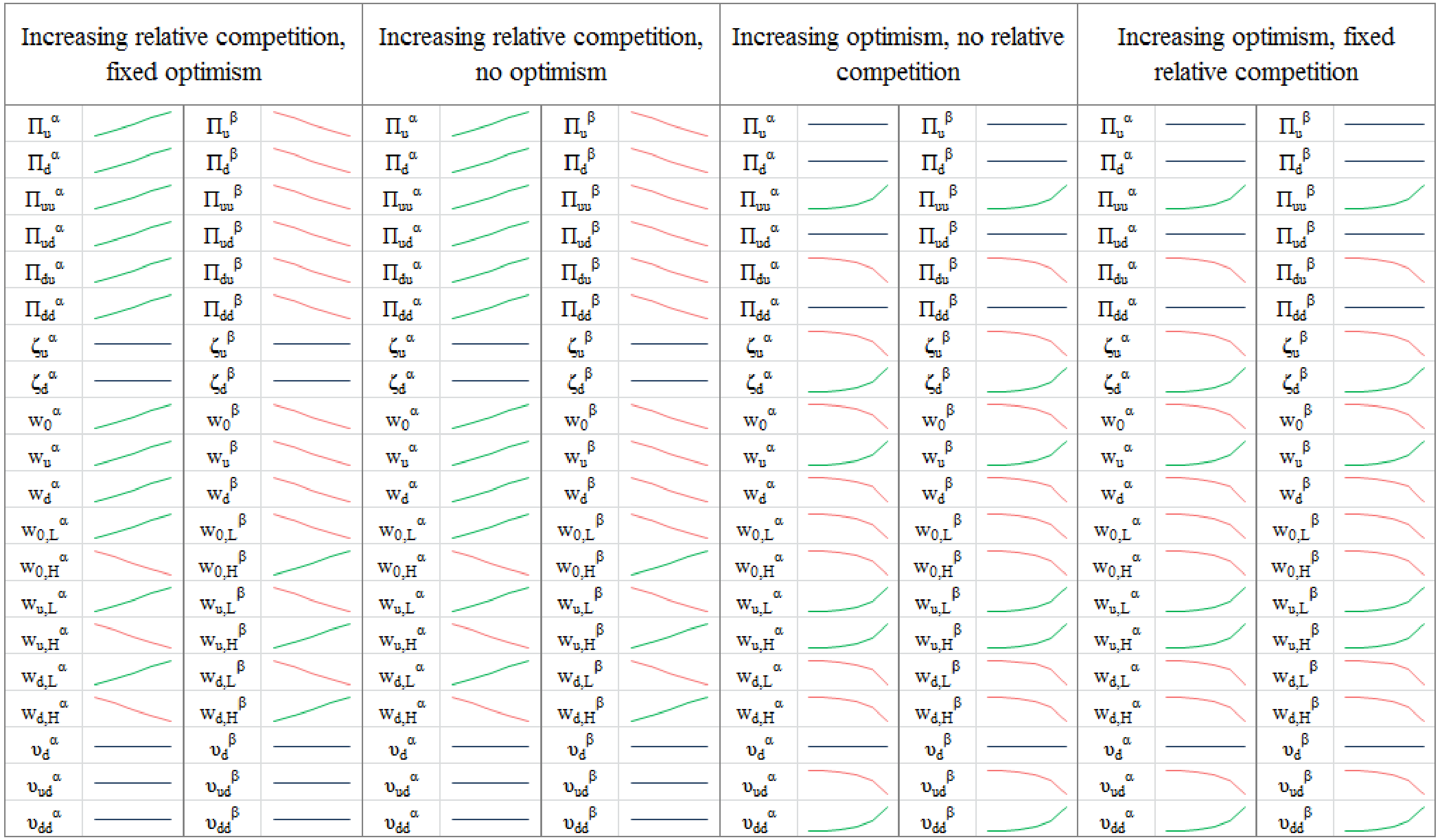

Figure 4.2: Comparative Statics

4.6 Empirical analysis

Our theoretical model implies that an increase in the importance of relative performance (captured in reduced form by the parameter τ) leads to herding amongst agents and serves to exacerbate the welfare reducing effects of a negative shock when this herding is coupled with an increase in leverage brought about by Minskian optimism. We cannot directly observe the evolution of this relative performance parameter through time. However, as the classic literature on agency theory (Lazear and Rosen, 1981; Holmström, 1979, 1982; Mookherjee, 1984) has postulated, optimal contracts for management compensation will use relative performance criteria when other firms' results reveal information about the managers' performance. Therefore if shareholders have lower quality information regarding the actions of management, they are more likely to use relative performance criteria in the evaluation of management. Combining this insight with the results of our model therefore implies that the probability of a financial crisis increases as the quality of shareholder information decreases. We test this hypothesis by: i) developing a measure of the quality of shareholder information; ii) estimating the market-wide quality of shareholder information over time; and iii) examining the relationship between this market-wide level of shareholder information quality and the probability of a financial crisis.

The degree to which shareholders can monitor management depends upon the quality of the information they have on firm value. Following Simon (1989), we measure the quality of the information that shareholders have by the standard deviation of idiosyncratic (net of industry/size effects) firm returns ($SDIR$).[11] Intuitively, as the amount of information available to shareholders increases, the precision of their estimate of firm value increases. Hence, the arrival of new information will have a relatively small effect upon that estimate. If investors have

[11] We use the terms market opacity and shareholder information quality interchangeably in this analysis. As explained later in this section, an increase in market opacity (i.e. a decrease in the quality of shareholder information) is reflected by a decrease in $SDIR$.

little information about a firm's value, then a new piece of information will have a bigger effect upon that estimate. So, the standard deviation of idiosyncratic firm returns will increase as the amount and quality of information shareholders have about firm value decreases. We use idiosyncratic returns rather than raw returns to eliminate the possibility that industry and/or market shocks affect our measure of the quality of shareholder information. We measure a firm's idiosyncratic return as a firm's return minus the median return of firms in its industry in a manner analogous to Campbell et al. (2001).[12]

However, there is one complication: the relationship between market opacity and the $SDIR$ is non-linear. If markets are totally transparent, then $SDIR$ is 0 as all information is immediately priced in. If markets are totally opaque, then $SDIR$ is also 0 as there is no impact of information on firm value at all. This implies a U-shaped relationship between market opacity and $SDIR$. It follows that if one observes an exogenous policy reform that decreases market opacity and leads to a decrease in $SDIR$, then the post-reform economy must be on the left side of the peak. In this region, $SDIR$ decreases as market transparency increases. So, our empirical strategy is to find an exogenous policy reform that decreased market opacity while leading to a decrease in $SDIR$. Our candidate reform is the creation of the SEC in 1934. The SEC was designed to increase market transparency both directly by improving disclosure requirements and indirectly by limiting market abuse and insider trading. Simon (1989) examines the standard deviation of IPO returns before and after the creation of the SEC and finds that the standard deviation of returns decreased. She concludes that the SEC did in fact decrease market opacity. We extend the analysis of Simon (1989) to all NYSE stocks and for a longer time period. If we can confirm these results, then we can indeed use the standard deviation of idiosyncratic firm returns as a measure of the quality of

[12] Bekaert et al. (2012) use a more complicated model to compute idiosyncratic returns, but their method yields essentially the same results as Campbell et al. (2001). Given that the complications Bekaert et al. (2012) introduce do not offer material improvements, we stick with the more parsimonious approach of Campbell et al. (2001).

shareholder information.

Finally, financial crises are rare events: in our 174 year sample spanning the years 1840 to 2014, there have been only 8 major banking crises in the US in total. It follows that any study of shareholder information and financial crises requires a measure of the overall quality of shareholder information that can be estimated using historical data over a long period of time. We compute our measure using stock market returns. While we plan to extend our analysis to more countries in the future, for now the only country for which we could obtain reliable data on stock returns for the long sample period we require is the US. We therefore limit our empirical analysis to the US. The 8 crisis data points that we have for the US sample will enable us to show that the empirical evidence is consistent with our theory, but we freely admit that it is not enough data to yield a dispositive conclusion. Our aim here is to show that the shareholder information/financial crisis link is a promising avenue to explore.

4.6.1 Data

To examine the relationship between shareholder information quality (i.e. market opacity), and financial crises, we need a set of crisis dates, and stock returns (to calculate our measure of the quality of shareholder information). To check the robustness of our measure, we also need to control for other factors that may influence the standard deviation of stock returns. Finally to study the effect of credit booms on the occurrence of financial crises in conjunction with our measure of market opacity, we also need data on credit growth. Table 4.5 lists all the variables used in our analyses along with their definitions and sources, and table 4.6 contains the summary statistics for each of those variables.

4.6.1.1 Crises dates

We use the crisis series for the US from the web appendix of Reinhart and Rogoff (2009) and Reinhart (2010). This is one of the most commonly cited list of financial crises in the US and is consistent with other sources (Calomiris and Gorton, 1991; Bordo et al., 2001; Laeven and Valencia, 2008, 2012; Schularick and Taylor, 2012). We define a crisis as a major banking crisis[13] that did not occur during a war. Our crisis dates are therefore 1841, 1857, 1873, 1884, 1890, 1907, 1929, and 2007.

4.6.1.2 NYSE data

We create a dataset spanning the 1840 to 2014 period by combining CRSP data for the years 1926 to 2014 with NYSE data from the Old New York Stock Exchange Project at the Yale School of Management for the years 1840 to 1925. [14] We use monthly returns to calculate our measure of the quality of shareholder information. We limit ourselves to NYSE data as that is the only market for which we can obtain data over our entire sample period.

For the CRSP data, we include a firm/month observation in the sample if we have data on its return, closing price, and shares outstanding. For each month we first sort firms into industries on the basis of 3 digit SIC codes and compute a median return for each industry. A firm's idiosyncratic return is then its return minus the median return for its industry. We Winsorise returns at the 1% and 99% thresholds.[15]

[13]On the definition of a banking crisis, Reinhart and Rogoff (2009) state: "We mark a banking crisis by two types of events: (1) bank runs that lead to the closure, merging, or takeover by the public sector of one or more financial institutions and (2) if there are no runs, the closure, merging, takeover or large-scale government assistance of an important financial institution (or group of institutions) that marks the start of a string of similar outcomes for other financial institutions.

[14]See Goetzmann et al. (2001) for an overview of the data.

[15]In unreported regressions, we also sorted firms into categories on the basis of size deciles or a

The Old NYSE data consists of share prices. We therefore calculate a firm's monthly return using prices alone rather than prices and dividends. We include a firm in the sample in a given month t if we have a closing price in both month t and $t-1$. Given the small number of observations available for any given month, we treat all firms as if they are in a single industry. We Winsorise returns at the 1% and 99% thresholds.

We include two market control variables in our analysis to capture other possible influences upon our measure of market opacity. These control variables are the median idiosyncratic return (to capture bull and bear market effects) and overall market volatility. Given the differences between the CRSP and Old NYSE datasets, we calculate market volatility in two different ways. We calculate the variable $MVol1$ for the CRSP data alone, and we set $MVol1$ in a month t equal to the sum of the squared daily returns on the equal weighted return index for that month. We calculate the variable $MVol2$ for the entire data series. The value of this for a month t equals the standard deviation of the equal weighted monthly market return index for months t to $t-11$.

We plot the number of Old NYSE observations by month in figure 4.3.

4.6.1.3 Additional control variables

In our model the standard deviation of idiosyncratic stock returns is driven by market opacity (i.e. the quality of shareholder information), and in our view this in turn is driven primarily by the arms race between the regulatory system and the market response to that regulatory system. However, it may also be influenced

combination of two digit SIC code industries and Large (top 5) or Small (bottom 5) size. All three methods of sorting firms into categories yielded similar results.

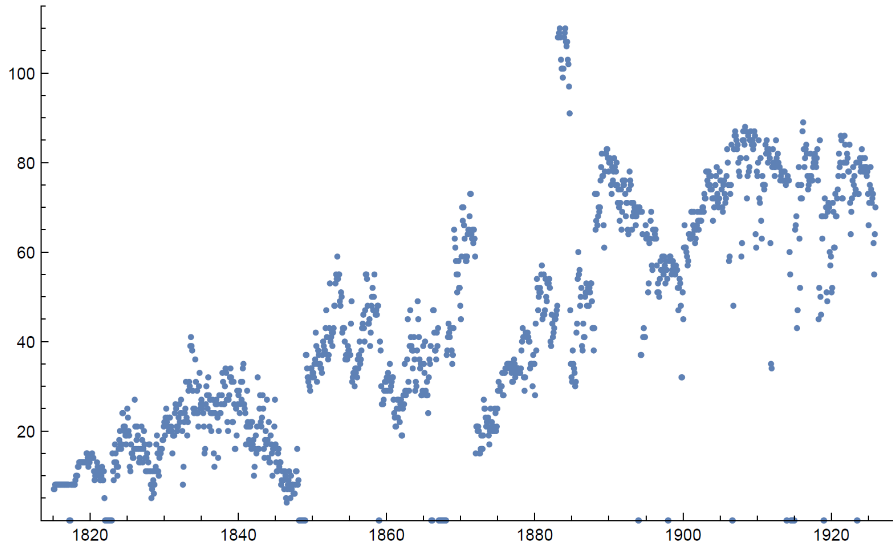

Figure 4.3: Number of observations by month: NYSE data (1840–1925)

by other factors. One possible factor is the cost of producing information on firm value. If the cost of producing information on firms falls, this may lead to an increase in information production about firms that will affect information quality. Of course, the amount of information the financial sector produces about firms (via analyst reports, etc.) is endogenous and so will not provide a good variable. We therefore use the cost of information processing as an instrument, with the idea that the cost of computing (broadly defined) in an important input into the cost of producing financial analysis. We obtain our data on the cost of computing from the web appendix to Nordhaus (2007).

A further possible driver for the time path of the standard deviation of returns is the size of the financial sector. Schularick and Taylor (2012) point to "the spectacular growth of finance and leverage" as a driver of financial instability, and financial instability may in turn lead to a higher standard deviation of firm returns. To control for this possibility, we include a size of the financial system variable in our analysis. We measure financial system size as the income share of the finance industry as reported in Philippon (2012).

We also include recession dummies (using NBER recession dates) as one might expect the $SDIR$ to increase during downturns.

4.6.1.4 Credit growth

We obtain our credit growth data from the web appendix to Schularick and Taylor (2012). This data series is annual and covers (for the US) the years 1870 to 2008. Credit growth in year y equals the Log of Real Bank Assets in year y minus the Log of Real Bank Assets in year $y - 1$. The value for our credit growth variable in year y equals the average of Credit Growth in years $y - 1$ and $y - 2$.

Table 4.5: Analysis variables: definitions, and sources

Variable	Label	Definition	Source
Shareholder Information	$SDIR$	The quality of shareholder information at the aggregate level. Defined as the standard deviation of *idiosyncratic* monthly firm returns. We measure a firm's idiosyncratic return as a firm's return minus the median return of firms in its industry in a manner analogous to Campbell et al. (2001).	NYSE share price data 1840–1925: Old NYSE Project (Goetzmann et al., 2001)
Median Return	$MedianR$	Median idiosyncratic monthly return of all firms in the market.	
Market Volatility version 1	$MVol1$	Monthly market volatility calculated as the sum of the squared daily returns on the equal weighted return index for each month. Calculated for CRSP data only (1926–2014).	1926–2014: CRSP
Market Volatility version 2	$MVol2$	Monthly market volatility calculated as the standard deviation of the equal weighted monthly market return index for the previous twelve months. Calculated for the entire data series (1840–2014).	
Recession Dummy	$Recession$	A dummy variable with value 1 in the months the US economy was in recession as per the Business Cycle Dating Committee of the National Bureau of Economic Research, and 0 in other months.	NBER
Cost of Computing	$CostCompute$	The cost of information processing as defined in Nordhaus (2007). Used as an instrument for the amount of information produced in financial markets.	Nordhaus (2007)
Financial System Size	$FinSysSize$	Income share of the finance industry as a fraction of GDP (excluding defence spending). Used as a measure of the size of the financial system.	Philippon (2012)
Financial Crisis Dummy	$Crisis$	Dummy variable with value 1 in each year the US faced a banking crisis, and 0 in other years. A banking crisis is defined as a period of closure, merging or takeover by the public sector of one or more large financial institutions.	Reinhart and Rogoff (2009); Reinhart (2010)
Average Credit Growth	$AvCreditGrowth$	Average annual credit growth in the US (1870–2008).	Schularick and Taylor (2012)

Table 4.6: Analysis variables: summary statistics

Variable	Coverage	Frequency	Observations	Mean	Std. Dev.	Min	Max
Shareholder Information	1840–2014	Monthly	1975	0.0827	0.0240	0.0147	0.1889
Median Return	1840–2014	Monthly	1975	0.0022	0.0524	-0.3521	0.3279
Market Volatility version 1	1926–2014	Monthly	1068	0.0026	0.0061	0.0001	0.0657
Market Volatility version 2	1840–2014	Monthly	1975	0.0467	0.0340	0.0036	0.3071
Recession Dummy	1840–2014	Monthly	1975	0.2922	0.4549	0	1
Cost of Computing	1840–2014	Monthly	1975	-2.2203	10.0531	-25.4804	6.1269
Financial System Size	1840–2014	Monthly	1975	0.0369	0.0203	0.0104	0.0830
Financial Crisis Dummy	1870–2008	Annual	123	0.0488	0.2163	0	1
Average Credit Growth	1870–2008	Annual	123	0.0458	0.0379	-0.0746	0.1779

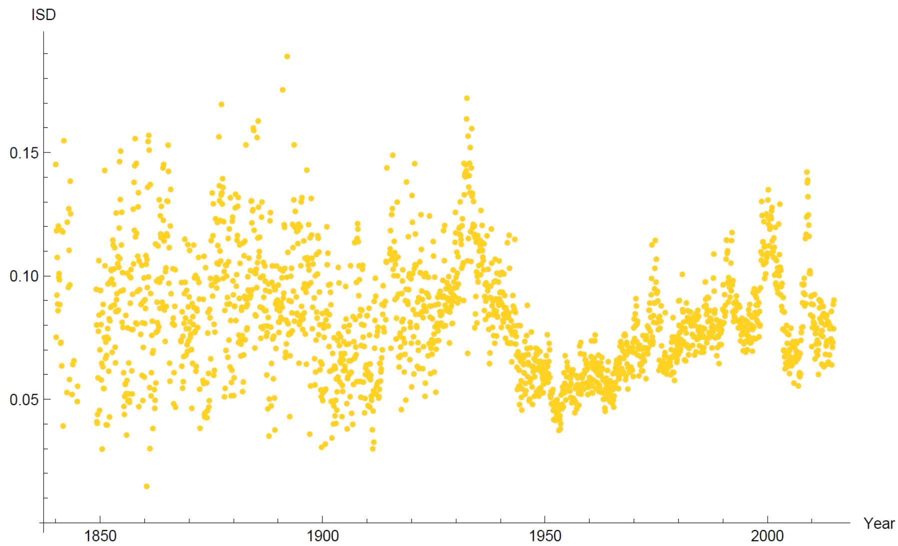

Figure 4.4: The standard deviation of idiosyncratic returns: NYSE (1840–1925)

4.6.2 Measuring the quality of shareholder information

Since the CRSP data set is larger than the Old New York Stock Exchange data set and consistently has a large number of observations per month, we first estimate the quality of shareholder information with CRSP data for the period 1926 to 2014 and then extend our analysis to the entire 1840 to 2014 period. We plot $SDIR$ by month for our entire sample period in figure 4.4.

To begin, we examine the evolution of $SDIR$ over time by estimating it as a function of $MedianR$, $MVol1$, $Recession$, and time dummies for each 5 year period after the creation of the SEC (so the first dummy covers 1935 to 1939, the second 1940 to 1944, etc.). We report this regression in table 4.7. We estimate the $SDIR$ equation as an AR(3)/GARCH(1,1) model.[16] We include the auto-regressive terms to capture persistent shocks to $SDIR$ values, and we include GARCH terms to capture market turmoil effects that lead to periods of high $SDIR$ volatility.

We find that $SDIR$ decreases (i.e., that market opacity goes down) very slightly

[16]The first three AR terms were significant, the fourth was not.

in the immediate interval after the creation of the SEC and in a statistically significant manner for each 5 year interval between 1940 and 1989. The coefficient on $SDIR$ is negative for the rest of the 1990s, and borderline significant for the 1995 to 1999 period before hitting 0 in the 2000 to 2004 period. Our analysis implies that, after an initial implementation phase, the SEC reforms had a significant effect upon the quality of shareholder information (we investigate the consequences of this improvement for financial stability below). The lack of an immediate SEC effect is not too surprising. As Bhattacharya and Daouk (2002) demonstrate, securities market reforms only begin to influence behaviour once they are enforced. One would therefore expect the impact of the SEC to kick in gradually as the market learned about the actual effectiveness of the new regime. One would also expect the effectiveness of the regime to eventually begin to decline with time as either the regulations fail to keep up with market developments and/or market participants find ways to game the rules. The path of $SDIR$ that our analysis reveals is consistent with this view.

To parsimoniously capture the initial effectiveness/long slow decline of the effectiveness of the SEC regime, we replace the 5 year time dummies with an $SEC65$, $LogSEC65$, and $PostSEC65$ terms. The $SEC65$ variable is a trend term that increases by $^1/_{12}$ for each month from January 1935 to December 1999 and then remains constant. The $LogSEC65$ variable is the log of $SEC65$. The $PostSEC65$ variable is a dummy equal to 1 for in each month from January, 2000 to December 2014. We cap the $SEC65$ and $LogSEC65$ variables as our time dummy regression indicates that the SEC regime became largely ineffective by 2000. The results of this specification are consistent with the previous specification. We find that the SEC reforms did significantly reduce market opacity (improve the quality of shareholder information) over the 1935 to 1999 period, with the effectiveness of the regime slowly declining from the 1960s onward. By 2000 the regime had lost effectiveness and the quality of shareholder information fell back to pre-SEC levels.

We examine the robustness of our results by adding $CostCompute$ and $FinSysSize$ to the previous specification to see if the decline and increase in $SDIR$ that we attribute to the SEC reforms was in fact due to the changing cost of information production and/or changes in the size of the financial system. We find that both of these variables are statistically insignificant. The evidence suggests that the rise in $SDIR$ over the last few decades is not due to a decrease in the cost of information production and that the decline in $SDIR$ following the creation of the SEC was not due to the decline in the size of the financial system following the Great Depression. The estimation results for both these specifications are reported in table 4.8.

We now extend our analysis to include the Old New York Stock Exchange data. As above, we estimate $SDIR$ as a function of $MedianR$, $MVol2$, $Recession$, and time dummies. We replace $MVol1$ with $MVol2$ as we can calculate $MVol2$ for the entire sample period, and we use 20 year rather than 5 year time dummies for the Old NYSE data given the small number of observations. We find $SDIR$ was roughly constant in the entire Pre-SEC period. As above, we also find that $SDIR$ falls after the SEC reforms and then gradually increases from the 1960s onwards. The SEC regime loses its effectiveness in the 1990s in this specification. Looking at our results as a whole, we identify three distinct periods in the US: a Pre-SEC era of poor quality shareholder information or high market opacity (1840 to 1934), and SEC era of lower market opacity (1935 to 1999), and a Post-SEC era of high opacity (2000 to 2014).

Table 4.7: The evolution of the quality of shareholder information

Variables		Variables	
Median Return	0.0137***	1990–94 Dummy	-0.0065
	(0.0039)		(0.0053)
Market Volatility	0.4162***	1995–99 Dummy	-0.0104*
	(0.0416)		(0.0055)
Recession Dummy	0.0020*	2000–04 Dummy	-0.0023
	(0.0011)		(0.0064)
1935–39 Dummy	-0.0004	2005–09 Dummy	-0.0116*
	(0.0063)		(0.0062)
1940–44 Dummy	-0.0172***	2010–14 Dummy	-0.0126**
	(0.0061)		(0.0064)
1945–49 Dummy	-0.0319***	Constant	0.0924***
	(0.0058)		(0.0038)
1950–54 Dummy	-0.0379***		
	(0.0058)	**AR terms**	
1955–59 Dummy	-0.0352***	L.ar	0.3802***
	(0.0061)		(0.0296)
1960–1964 Dummy	-0.0340***	L2.ar	0.1119***
	(0.0057)		(0.0329)
1965–69 Dummy	-0.0304***	L3.ar	0.3302***
	(0.0054)		(0.0339)
1970–74 Dummy	-0.0220***		
	(0.0057)	**ARCH terms**	
1975–79 Dummy	-0.0256***	L.arch	0.0883***
	(0.0061)		(0.0133)
1980–84 Dummy	-0.0131**	L.garch	0.8913***
	(0.0055)		(0.0153)
1985–89 Dummy	-0.0136***	ARCH constant	0.0000***
	(0.0052)		(0.0000)
Observations			1,068
Wald χ^2 statistic			1545
p-value			0.0000

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

Table 4.8: Shareholder information: with additional controls

Variables	Base model	Additional controls
Median Return	0.0135***	0.0137***
	(0.0038)	(0.0038)
Market Volatility	0.4036***	0.4043***
	(0.0413)	(0.0417)
Recession Dummy	0.0023**	0.0023**
	(0.0010)	(0.0010)
SEC Trend term	0.0012***	0.0015**
	(0.0002)	(0.0007)
log (SEC Trend term)	-0.0204***	-0.0200***
	(0.0027)	(0.0062)
Post SEC Dummy	-0.0052	-0.0024
	(0.0058)	(0.0079)
Constant	0.0960***	0.0848***
	(0.0042)	(0.0208)
AR terms		
L.ar	0.3972***	0.3916***
	(0.0286)	(0.0285)
L2.ar	0.1193***	0.1200***
	(0.0325)	(0.0326)
L3.ar	0.3503***	0.3492***
	(0.0322)	(0.0324)
ARCH terms		
L.arch	0.0842***	0.0847***
	(0.0121)	(0.0121)
L.garch	0.8983***	0.8978***
	(0.0138)	(0.0139)
ARCH constant	0.0000***	0.0000***
	(0.0000)	(0.0000)
Additional controls		
Cost of Computing		0.0011
		(0.0010)
Financial System Size		0.1726
		(0.4280)
Observations	1,068	1,068
Wald χ^2 statistic	1884	1803
p-value	0.0000	0.0000

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

4.6.3 Shareholder information and financial stability

One of the leading explanations for financial crises is that presented by Schularick and Taylor (2012), to wit: a financial crisis is the result of a credit boom that goes bad. Implicit in their analysis is the idea that the probability that a credit boom of a given size causes a crisis is constant (within a country, anyway). Our view is that the probability that a credit boom causes a crisis is endogenous and is a function of the quality of shareholder information, through the relative performance mechanism illustrated in our theoretical model. To provide evidence for this conjecture, we first show that the probability of a crisis is much higher in periods of poor quality shareholder information (i.e. higher market opacity) than in those of good quality shareholder information. We then examine the link between credit growth, shareholder information, and the risk of a financial crisis.

4.6.3.1 Non-parametric analysis

The Pre-SEC period consists of 94 years, and during this period there were 7 major financial crises. The probability of a crisis in this period of high market opacity was therefore 7.4%/year. The SEC period of low opacity lasted 65 years. To be sure, this period included WW2, and during the war years a financial crisis was effectively impossible. So, defining the period of post-War good quality information as 1948 to 1999, this period lasted 52 years. If the probability of a crisis during this period had remained at 7.4%/year, then the probability of at least one crisis occurring is 98%. We can therefore reject the hypothesis that the probability of a crisis in the Pre-SEC period of high opacity equalled that of the SEC era of low opacity. Our analysis shows that the quality of shareholder information in the Post-SEC era is about equal to that of the Pre-SEC era. In this case, the probability of at least one crisis occurring in the Post-SEC period to date (2000 to 2015) is 70%. And we have of course experienced one major crisis in this period.

Our quality of shareholder information variable can therefore explain the transition from the financial instability of the Pre-SEC era to the financial stability of the SEC era. To be sure, it is possible to construct many explanations for the transition from Pre-SEC era instability to SEC era stability (e.g., the Federal Reserve learned the lessons of the Great Depression and began to regulate the banking system in a more effective manner). The shareholder information (market opacity) hypothesis allows us to do more than that, however, as it also predicts the timing of the transition from the SEC era of stability to the current era of financial instability in a completely non-ad hoc manner. That is, our analysis predicts that, given that the quality of shareholder information has fallen to Pre-SEC levels, the probability of a crisis has now risen to Pre-SEC levels. This prediction is consistent with the data (to be sure, we will need several more decades of high opacity to completely pin down the probability of a crisis).

4.6.3.2 Credit growth and shareholder information: linear probability model

The credit growth data of Schularick and Taylor (2012) covers (for the US) the period 1870 to 2008. During this period there were only 6 major financial crises in the US. Given this paucity of crisis events, our analysis of the relationship between credit booms, shareholder information, and crisis risk will necessarily be suggestive rather than dispositive. Schularick and Taylor (2012) begin their analysis of the relationship between credit growth and crisis risk by estimating a linear probability model. We replicate their analysis (albeit with our average credit growth variable rather than theirs) and confirm their results: an increase in average credit growth significantly increases the risk of a financial crisis. Our hypothesis predicts that credit growth creates crisis risk only during periods of poor shareholder information quality. To test this hypothesis, we create a Poor Information dummy variable that equals one for a year in the Pre-SEC or Post-SEC era and that equals 0 for a year in the SEC era. We then interact this dummy variable with *AvCreditGrowth* and then estimate the linear probability model with both variables – *AvCreditGrowth* and the interaction term. We report the results of both specifications in table 4.9.

Table 4.9: Financial crises and credit booms: linear probability model

Variables	Schularick and Taylor (2012)	Our model
Average Credit Growth	0.9965*	-0.1719
	(0.5112)	(0.7392)
Poor Information $\times AvCreditGrowth$		1.5183**
		(0.7031)
Constant	0.0031	0.0114
	(0.0303)	(0.0301)
Observations	123	123
R-squared	0.0304	0.0667
Adjusted R-squared	0.0224	0.0512
Root MSE	0.214	0.211

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

We find that in our specification, *AvCreditGrowth* itself becomes statistically insignificant while the interaction term is highly significant. Of course, this result is not surprising in one sense as all six crises that fall into the Schularick and Taylor (2012) sample period occur during periods of poor information quality. That said, these results do allow us to rule out the possibility that the stability of the SEC era arose simply because there were no credit booms. There were credit booms during the post-War SEC era of low opacity, but these credit booms did not lead to crises. To illustrate this point, we plot average credit growth and financial crises in figure 4.5.

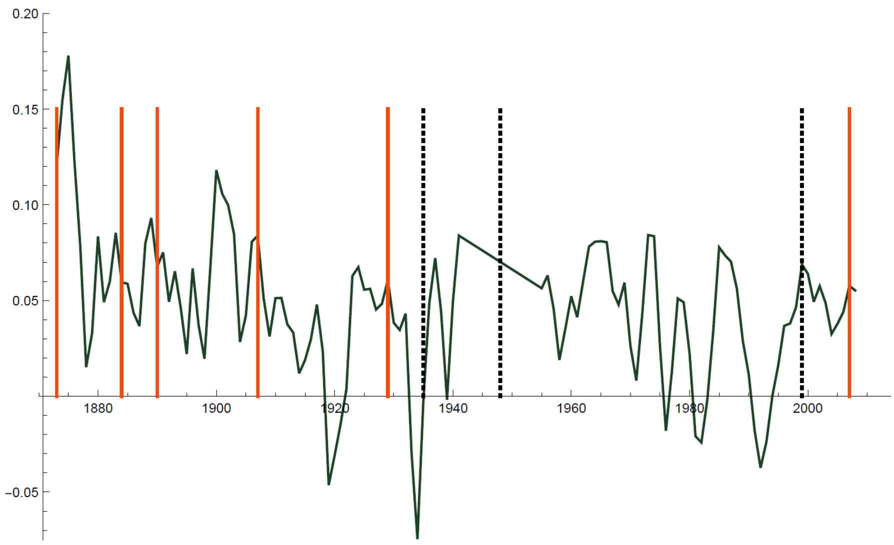

Figure 4.5: Average credit growth and financial crises

4.6.3.3 Credit growth and shareholder information: logit analysis

The defects of the linear probability model are well known (and acknowledged by Schularick and Taylor (2012)). Schularick and Taylor (2012) therefore complement their linear probability model with a logit model. As above, we replicate their analysis by estimating the logit with $AvCreditGrowth$ as the dependent variable and confirm their result that an increase in credit growth increases the probability of a crisis. Unfortunately, since there are no crises during the period of low opacity, we cannot proceed as above by estimating the logit with both $AvCreditGrowth$ and our interaction term as dependent variables. So, we explore our hypothesis by estimating the logit with just the interaction term. The results of both logit regressions are reported in table 4.10.We find that the pseudo-R^2 of the logit increases from 0.076 to 0.138 when we replace $AvCreditGrowth$ with our interaction term, suggesting that including shareholder information effects does improve the explanatory power of the logit. However, we freely admit that the limited number of crisis events prevents us from drawing very strong conclusions from this analysis.

Table 4.10: Financial crises and credit booms: logit model

Variables	Schularick and Taylor (2012)	Our model
Average Credit Growth	20.5655*	
	(10.6298)	
Poor Information $\times AvCreditGrowth$		23.1629**
		(9.0461)
Constant	-4.1788***	-4.0921***
	(0.8667)	(0.7461)
Observations	123	123
Pseudo R-squared	0.0762	0.138
LR χ^2 statistic	3.655	6.609
p-value	0.0559	0.0101

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

4.7 Conclusions

The primary response in the aftermath of the recent financial crisis has been an infusion of liquidity and the heightening of risk adjusted capital requirements for financial institutions.[17] We are of the opinion, that this alone is not the best remedy to preventing further crises. A look at the evolution of capital adequacy ratios in the US as shown in figure 4.6 with crises dates shows that there have been plenty of financial crises in regimes of higher capital requirements. There have of course been several improvements to the regulatory framework within which banks operate since the late 19th century – our point is merely to highlight that capital controls themselves do not necessarily curb excessive risk taking. Our theoretical model highlights how the relative performance effect causes herding amongst investors which exacerbates the effects of Minskian optimism.

[17] See Taylor (2009); Claessens et al. (2014) for a detailed look at the policy response to the financial crisis of 2007–08.

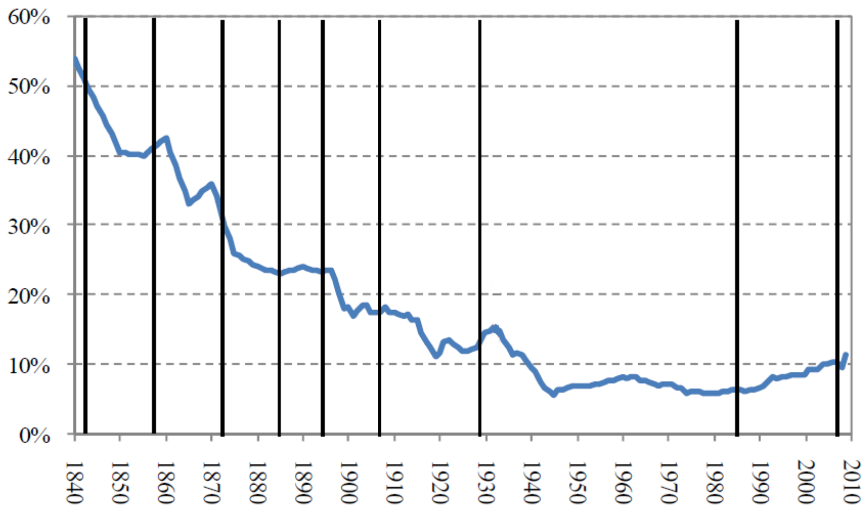

Figure 4.6: Book equity to book assets for US commercial banks, 1840-2009

Source: Kashyap et al. (2010); Crises dates from Schularick and Taylor (2012)

As relative performance becomes more important, investors herd more and when coupled Minskian optimism, this distortion leaves the economy more vulnerable when a bad shock hits after a period of good realisations wherein agents update their outlook. Our empirical analysis (based on the agency theory result that relative performance becomes more important when shareholders' have noisier information on management decisions) confirms that it is the presence of such incentive distorting features, along with a credit boom that increases the risk of crisis. In our view, therefore, policy response to the crisis must focus on markets and not institutions alone. Increasing shareholder informativeness would serve to reduce the distortionary effect that relative competition produces and allow for better diversification of risk amongst investors of different risk profiles.

We reiterate that our aim in this paper is to show that the shareholder information/financial crisis link is a promising avenue to explore. To further strengthen our claims, we intend to extend this analysis using data from other countries, and using alternate measures of shareholder information quality. Furthermore, there are several theoretical extensions that one could incorporate to our model to make richer inferences. The two investments in our framework are assumed to be in perfectly elastic supply. Endogenising the supply side would allow for the study of the effects of optimism and changes in leverage on asset prices. Branch and Evans (2011) construct such a learning model where recursive updating of conditional expectations can lead to asset price bubbles and crashes through an endogenous response mechanism. Additionally endogenising the prices of the investments would also enable the study of the impact of relative competition and herding on asset prices. As Gümbel (2005) shows, herding can have some beneficial features too, such as increasing the informational efficiency of prices of the asset in which herding takes place.

4.8 Appendix

4.8.1 First Order Conditions

Bank α

$$(01^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_u^{\alpha} : \pi_0 \left\{1 - 2\gamma^{\alpha}\Pi_u^{\alpha} + \tau\right\} - \psi_{u1}^{\alpha} = 0$$

$$(02^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_d^{\alpha} : (1-\pi_0) \left\{1 - 2\gamma^{\alpha}\Pi_d^{\alpha} + \tau\right\} - \psi_{d1}^{\alpha} = 0$$

$$(03^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_{uu}^{\alpha} : \pi_0\pi_u \left\{1 - 2\gamma^{\alpha}\Pi_{uu}^{\alpha} + \tau\right\} - \psi_{uu}^{\alpha} = 0$$

$$(04^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_{ud}^{\alpha} : \pi_0 (1-\pi_u) \left\{1 - 2\gamma^{\alpha}\Pi_{ud}^{\alpha} + \tau\right\} - \psi_{ud}^{\alpha} = 0$$

$$(05^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_{du}^{\alpha} : (1-\pi_0)\pi_d \left\{1 - 2\gamma^{\alpha}\Pi_{du}^{\alpha} + \tau\right\} - \psi_{du}^{\alpha} = 0$$

$$(06^{\alpha}) \qquad \partial\mathcal{L}/\partial\Pi_{dd}^{\alpha} : (1-\pi_0)(1-\pi_d) \left\{1 - 2\gamma^{\alpha}\Pi_{dd}^{\alpha} + \tau\right\} - \psi_{dd}^{\alpha} = 0$$

$$(07^{\alpha}) \qquad \partial\mathcal{L}/\partial\zeta_u^{\alpha} : \psi_{u1}^{\alpha} - f'(\zeta_u^{\alpha})\, \psi_{u2}^{\alpha} = 0$$

$$(08^{\alpha}) \qquad \partial\mathcal{L}/\partial\zeta_d^{\alpha} : \psi_{d1}^{\alpha} - f'(\zeta_d^{\alpha})\, \psi_{d2}^{\alpha} = 0$$

$$(09^{\alpha}) \qquad \partial\mathcal{L}/\partial w_0^{\alpha} : \pi_0\lambda(1-\nu_u^{\alpha}) + (1-\pi_0)\lambda(1-\nu_d^{\alpha}) - {}^{\psi_{01}^{\alpha}}\!/_{1+r_0}$$

$$+ \nu_u^{\alpha}\psi_{u1}^{\alpha} + \nu_d^{\alpha}\psi_{d1}^{\alpha} = 0$$

$$(10^{\alpha}) \qquad \partial\mathcal{L}/\partial w_u^{\alpha} : \pi_0\pi_u\lambda(1-\nu_{uu}^{\alpha}) + \pi_0(1-\pi_u)\lambda(1-\nu_{ud}^{\alpha}) - {}^{\psi_{u2}^{\alpha}}\!/_{1+r_u}$$

$$+ \nu_{uu}^{\alpha}\psi_{uu}^{\alpha} + \nu_{ud}^{\alpha}\psi_{ud}^{\alpha} = 0$$

$$(11^{\alpha}) \qquad \partial\mathcal{L}/\partial w_d^{\alpha} : (1-\pi_0)\pi_d\lambda(1-\nu_{du}^{\alpha}) + (1-\pi_0)(1-\pi_d)\lambda(1-\nu_{dd}^{\alpha}) - {}^{\psi_{d2}^{\alpha}}\!/_{1+r_d}$$

$$+ \nu_{du}^{\alpha}\psi_{du}^{\alpha} + \nu_{dd}^{\alpha}\psi_{dd}^{\alpha} = 0$$

$$(12^{\alpha}) \qquad \partial\mathcal{L}/\partial w_{0,S}^{\alpha} : \psi_{01}^{\alpha} - X_u^S\psi_{u1}^{\alpha} - X_d^S\psi_{d1}^{\alpha} = 0$$

$$(13^{\alpha}) \qquad \partial\mathcal{L}/\partial w_{0,R}^{\alpha} : \psi_{01}^{\alpha} - X_u^R\psi_{u1}^{\alpha} - X_d^R\psi_{d1}^{\alpha} = 0$$

$(14^{\alpha})\qquad \partial\mathcal{L}/\partial w^{\alpha}_{u,S} : \psi^{\alpha}_{u2} - X^{S}_{u}\psi^{\alpha}_{uu} - X^{S}_{d}\psi^{\alpha}_{ud} = 0$

$(15^{\alpha})\qquad \partial\mathcal{L}/\partial w^{\alpha}_{u,R} : \psi^{\alpha}_{u2} - X^{R}_{u}\psi^{\alpha}_{uu} - X^{R}_{d}\psi^{\alpha}_{ud} = 0$

$(16^{\alpha})\qquad \partial\mathcal{L}/\partial w^{\alpha}_{d,S} : \psi^{\alpha}_{d2} - X^{S}_{u}\psi^{\alpha}_{du} - X^{S}_{d}\psi^{\alpha}_{dd} = 0$

$(17^{\alpha})\qquad \partial\mathcal{L}/\partial w^{\alpha}_{d,R} : \psi^{\alpha}_{d2} - X^{R}_{u}\psi^{\alpha}_{du} - X^{R}_{d}\psi^{\alpha}_{dd} = 0$

$(18^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{u} : \pi_0\lambda w^{\alpha}_{0}\left(1 + r_0\right) - w^{\alpha}_{0}\left(1 + r_0\right)\psi^{\alpha}_{u1} = 0$

$(19^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{d} : \left(1 - \pi_0\right)\lambda w^{\alpha}_{0}\left(1 + r_0\right) - w^{\alpha}_{0}\left(1 + r_0\right)\psi^{\alpha}_{d1} = 0$

$(20^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{uu} : \pi_0\pi_u\lambda w^{\alpha}_{u}\left(1 + r_u\right) - w^{\alpha}_{u}\left(1 + r_u\right)\psi^{\alpha}_{uu} = 0$

$(21^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{ud} : \pi_0\left(1 - \pi_u\right)\lambda w^{\alpha}_{u}\left(1 + r_u\right) - w^{\alpha}_{u}\left(1 + r_u\right)\psi^{\alpha}_{ud} = 0$

$(22^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{du} : \left(1 - \pi_0\right)\pi_d\lambda w^{\alpha}_{d}\left(1 + r_d\right) - w^{\alpha}_{d}\left(1 + r_d\right)\psi^{\alpha}_{du} = 0$

$(23^{\alpha})\qquad \partial\mathcal{L}/\partial \nu^{\alpha}_{dd} : \left(1 - \pi_0\right)\left(1 - \pi_d\right)\lambda w^{\alpha}_{d}\left(1 + r_d\right) - w^{\alpha}_{d}\left(1 + r_d\right)\psi^{\alpha}_{dd} = 0$

$(24^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{01} : w^{\alpha}_{0,S} + w^{\alpha}_{0,R} - f\left(\zeta^{\alpha}_{0}\right) - w^{\alpha}_{0} = 0$

$(25^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{u1} : \Pi^{\alpha}_{u} + \zeta^{\alpha}_{u} - w^{\alpha}_{0,S}X^{S}_{u} - w^{\alpha}_{0,R}X^{R}_{u} + \nu^{\alpha}_{u}w^{\alpha}_{0}\left(1 + r_0\right) = 0$

$(26^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{d1} : \Pi^{\alpha}_{d} + \zeta^{\alpha}_{d} - w^{\alpha}_{0,S}X^{S}_{d} - w^{\alpha}_{0,R}X^{R}_{d} + \nu^{\alpha}_{d}w^{\alpha}_{0}\left(1 + r_0\right) = 0$

$(27^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{u2} : w^{\alpha}_{u,S} + w^{\alpha}_{u,R} - f\left(\zeta^{\alpha}_{u}\right) - w^{\alpha}_{u} = 0$

$(28^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{d2} : w^{\alpha}_{d,S} + w^{\alpha}_{d,R} - f\left(\zeta^{\alpha}_{d}\right) - w^{\alpha}_{d} = 0$

$(29^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{uu} : \Pi^{\alpha}_{uu} - w^{\alpha}_{u,S}X^{S}_{u} - w^{\alpha}_{u,R}X^{R}_{u} + \nu^{\alpha}_{uu}w^{\alpha}_{u}\left(1 + r_u\right) = 0$

$(30^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{ud} : \Pi^{\alpha}_{ud} - w^{\alpha}_{u,S}X^{S}_{d} - w^{\alpha}_{u,R}X^{R}_{d} + \nu^{\alpha}_{ud}w^{\alpha}_{u}\left(1 + r_u\right) = 0$

$(31^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{du} : \Pi^{\alpha}_{du} - w^{\alpha}_{d,S}X^{S}_{u} - w^{\alpha}_{d,R}X^{R}_{u} + \nu^{\alpha}_{du}w^{\alpha}_{d}\left(1 + r_d\right) = 0$

$(32^{\alpha})\qquad \partial\mathcal{L}/\partial \psi^{\alpha}_{dd} : \Pi^{\alpha}_{dd} - w^{\alpha}_{d,S}X^{S}_{d} - w^{\alpha}_{d,R}X^{R}_{d} + \nu^{\alpha}_{dd}w^{\alpha}_{d}\left(1 + r_d\right) = 0$

Bank β

$$(01^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_u^{\beta} : \pi_0 \left\{1 - 2\gamma^{\beta}\Pi_u^{\beta} - \tau\right\} - \psi_{u1}^{\beta} = 0$$

$$(02^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_d^{\beta} : (1 - \pi_0) \left\{1 - 2\gamma^{\beta}\Pi_d^{\beta} - \tau\right\} - \psi_{d1}^{\beta} = 0$$

$$(03^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_{uu}^{\beta} : \pi_0\pi_u \left\{1 - 2\gamma^{\beta}\Pi_{uu}^{\beta} - \tau\right\} - \psi_{uu}^{\beta} = 0$$

$$(04^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_{ud}^{\beta} : \pi_0 (1 - \pi_u) \left\{1 - 2\gamma^{\beta}\Pi_{ud}^{\beta} - \tau\right\} - \psi_{ud}^{\beta} = 0$$

$$(05^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_{du}^{\beta} : (1 - \pi_0) \pi_d \left\{1 - 2\gamma^{\beta}\Pi_{du}^{\beta} - \tau\right\} - \psi_{du}^{\beta} = 0$$

$$(06^{\beta}) \qquad \partial\mathcal{L}/\partial\Pi_{dd}^{\beta} : (1 - \pi_0) (1 - \pi_d) \left\{1 - 2\gamma^{\beta}\Pi_{dd}^{\beta} - \tau\right\} - \psi_{dd}^{\beta} = 0$$

$$(07^{\beta}) \qquad \partial\mathcal{L}/\partial\zeta_u^{\beta} : \psi_{u1}^{\beta} - f'\left(\zeta_u^{\beta}\right)\psi_{u2}^{\beta} = 0$$

$$(08^{\beta}) \qquad \partial\mathcal{L}/\partial\zeta_d^{\beta} : \psi_{d1}^{\beta} - f'\left(\zeta_d^{\beta}\right)\psi_{d2}^{\beta} = 0$$

$$(09^{\beta}) \qquad \partial\mathcal{L}/\partial w_0^{\beta} : \pi_0\lambda\left(1 - \nu_u^{\beta}\right) + (1 - \pi_0)\lambda\left(1 - \nu_d^{\beta}\right) - {}^{\psi_{01}^{\beta}}/_{1+r_0}$$
$$+ \nu_u^{\beta}\psi_{u1}^{\beta} + \nu_d^{\beta}\psi_{d1}^{\beta} = 0$$

$$(10^{\beta}) \qquad \partial\mathcal{L}/\partial w_u^{\beta} : \pi_0\pi_u\lambda\left(1 - \nu_{uu}^{\beta}\right) + \pi_0(1 - \pi_u)\lambda\left(1 - \nu_{ud}^{\beta}\right) - {}^{\psi_{u2}^{\beta}}/_{1+r_u}$$
$$+ \nu_{uu}^{\beta}\psi_{uu}^{\beta} + \nu_{ud}^{\beta}\psi_{ud}^{\beta} = 0$$

$$(11^{\beta}) \qquad \partial\mathcal{L}/\partial w_d^{\beta} : (1 - \pi_0)\pi_d\lambda\left(1 - \nu_{du}^{\beta}\right) + (1 - \pi_0)(1 - \pi_d)\lambda\left(1 - \nu_{dd}^{\beta}\right) - {}^{\psi_{d2}^{\beta}}/_{1+r_d}$$
$$+ \nu_{du}^{\beta}\psi_{du}^{\beta} + \nu_{dd}^{\beta}\psi_{dd}^{\beta} = 0$$

$$(12^{\beta}) \qquad \partial\mathcal{L}/\partial w_{0,S}^{\beta} : \psi_{01}^{\beta} - X_u^S\psi_{u1}^{\beta} - X_d^S\psi_{d1}^{\beta} = 0$$

$$(13^{\beta}) \qquad \partial\mathcal{L}/\partial w_{0,R}^{\beta} : \psi_{01}^{\beta} - X_u^R\psi_{u1}^{\beta} - X_d^R\psi_{d1}^{\beta} = 0$$

$$(14^{\beta}) \qquad \partial\mathcal{L}/\partial w_{u,S}^{\beta} : \psi_{u2}^{\beta} - X_u^S\psi_{uu}^{\beta} - X_d^S\psi_{ud}^{\beta} = 0$$

$$(15^{\beta}) \qquad \partial\mathcal{L}/\partial w_{u,R}^{\beta} : \psi_{u2}^{\beta} - X_u^R\psi_{uu}^{\beta} - X_d^R\psi_{ud}^{\beta} = 0$$

$$(16^\beta) \qquad \partial\mathcal{L}/\partial w^\beta_{d,S} : \psi^\beta_{d2} - X^S_u \psi^\beta_{du} - X^S_d \psi^\beta_{dd} = 0$$

$$(17^\beta) \qquad \partial\mathcal{L}/\partial w^\beta_{d,R} : \psi^\beta_{d2} - X^R_u \psi^\beta_{du} - X^R_d \psi^\beta_{dd} = 0$$

$$(18^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{u} : \pi_0 \lambda w^\beta_0 \left(1 + r_0\right) - w^\beta_0 \left(1 + r_0\right) \psi^\beta_{u1} = 0$$

$$(19^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{d} : \left(1 - \pi_0\right) \lambda w^\beta_0 \left(1 + r_0\right) - w^\beta_0 \left(1 + r_0\right) \psi^\beta_{d1} = 0$$

$$(20^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{uu} : \pi_0 \pi_u \lambda w^\beta_u \left(1 + r_u\right) - w^\beta_u \left(1 + r_u\right) \psi^\beta_{uu} = 0$$

$$(21^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{ud} : \pi_0 \left(1 - \pi_u\right) \lambda w^\beta_u \left(1 + r_u\right) - w^\beta_u \left(1 + r_u\right) \psi^\beta_{ud} = 0$$

$$(22^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{du} : \left(1 - \pi_0\right) \pi_d \lambda w^\beta_d \left(1 + r_d\right) - w^\beta_d \left(1 + r_d\right) \psi^\beta_{du} = 0$$

$$(23^\beta) \qquad \partial\mathcal{L}/\partial \nu^\beta_{dd} : \left(1 - \pi_0\right) \left(1 - \pi_d\right) \lambda w^\beta_d \left(1 + r_d\right) - w^\beta_d \left(1 + r_d\right) \psi^\beta_{dd} = 0$$

$$(24^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{01} : w^\beta_{0,S} + w^\beta_{0,R} - f\left(\zeta^\beta_0\right) - w^\beta_0 = 0$$

$$(25^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{u1} : \Pi^\beta_u + \zeta^\beta_u - w^\beta_{0,S} X^S_u - w^\beta_{0,R} X^R_u + \nu^\beta_u w^\beta_0 \left(1 + r_0\right) = 0$$

$$(26^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{d1} : \Pi^\beta_d + \zeta^\beta_d - w^\beta_{0,S} X^S_d - w^\beta_{0,R} X^R_d + \nu^\beta_d w^\beta_0 \left(1 + r_0\right) = 0$$

$$(27^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{u2} : w^\beta_{u,S} + w^\beta_{u,R} - f\left(\zeta^\beta_u\right) - w^\beta_u = 0$$

$$(28^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{d2} : w^\beta_{d,S} + w^\beta_{d,R} - f\left(\zeta^\beta_d\right) - w^\beta_d = 0$$

$$(29^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{uu} : \Pi^\beta_{uu} - w^\beta_{u,S} X^S_u - w^\beta_{u,R} X^R_u + \nu^\beta_{uu} w^\beta_u \left(1 + r_u\right) = 0$$

$$(30^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{ud} : \Pi^\beta_{ud} - w^\beta_{u,S} X^S_d - w^\beta_{u,R} X^R_d + \nu^\beta_{ud} w^\beta_u \left(1 + r_u\right) = 0$$

$$(31^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{du} : \Pi^\beta_{du} - w^\beta_{d,S} X^S_u - w^\beta_{d,R} X^R_u + \nu^\beta_{du} w^\beta_d \left(1 + r_d\right) = 0$$

$$(32^\beta) \qquad \partial\mathcal{L}/\partial \psi^\beta_{dd} : \Pi^\beta_{dd} - w^\beta_{d,S} X^S_d - w^\beta_{d,R} X^R_d + \nu^\beta_{dd} w^\beta_d \left(1 + r_d\right) = 0$$

Market Clearing Conditions

$$(01^{MC}) \qquad (1+r_0)\left[w_0^{\alpha}\left\{\pi_0\nu_u^{\alpha}+(1-\pi_0)\,\nu_d^{\alpha}\right\}+w_0^{\beta}\left\{\pi_0\nu_u^{\beta}+(1-\pi_0)\,\nu_d^{\beta}\right\}\right]$$

$$=(1+\hat{r})\left\{w_0^{\alpha}+w_0^{\beta}\right\}$$

$$(02^{MC}) \qquad (1+r_u)\left[w_u^{\alpha}\left\{\pi_u\nu_{uu}^{\alpha}+(1-\pi_u)\,\nu_{ud}^{\alpha}\right\}+w_u^{\beta}\left\{\pi_u\nu_{uu}^{\beta}+(1-\pi_u)\,\nu_{ud}^{\beta}\right\}\right]$$

$$=(1+\hat{r})\left\{w_u^{\alpha}+w_u^{\beta}\right\}$$

$$(03^{MC}) \qquad (1+r_d)\left[w_d^{\alpha}\left\{\pi_d\nu_{du}^{\alpha}+(1-\pi_d)\,\nu_{dd}^{\alpha}\right\}+w_d^{\beta}\left\{\pi_d\nu_{du}^{\beta}+(1-\pi_d)\,\nu_{dd}^{\beta}\right\}\right]$$

$$=(1+\hat{r})\left\{w_d^{\alpha}+w_d^{\beta}\right\}$$

4.8.2 Numerical solutions: Computation residuals

Calibration with no Minskian updating and no relative performance effect

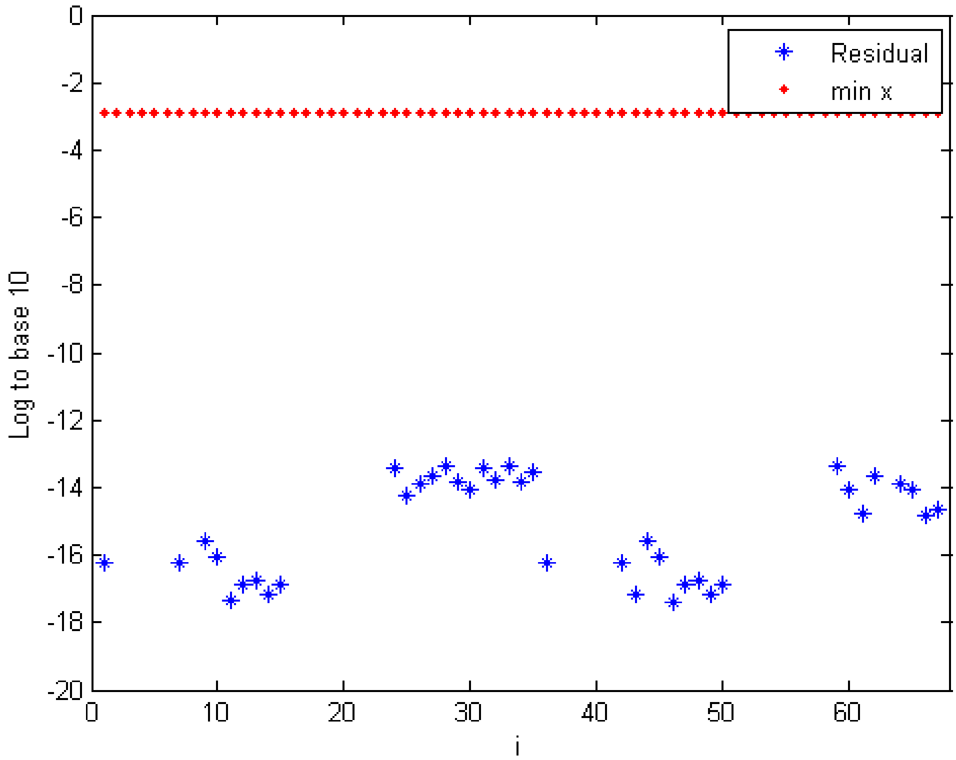

Figure 4.7: Computation residuals, equilibrium with no Minskian updating and no relative performance effect

This equilibrium calibration is the solution of a system of 67 simultaneous equations in 67 variables[18], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 67$. The computation residuals of the equations are shown as blue stars.[19] As $|f_i| \leq 10^{-12} \quad \forall i$, and $\min(x_i) > 10^{-3}$, the equilibrium solution is reasonably stable.

[18] 46 endogenous choice variables, 3 prices, and 18 Lagrange multipliers.
[19] A missing blue star corresponds to a residual of 0.

Equilibrium with no Minskian updating but a relative performance effect

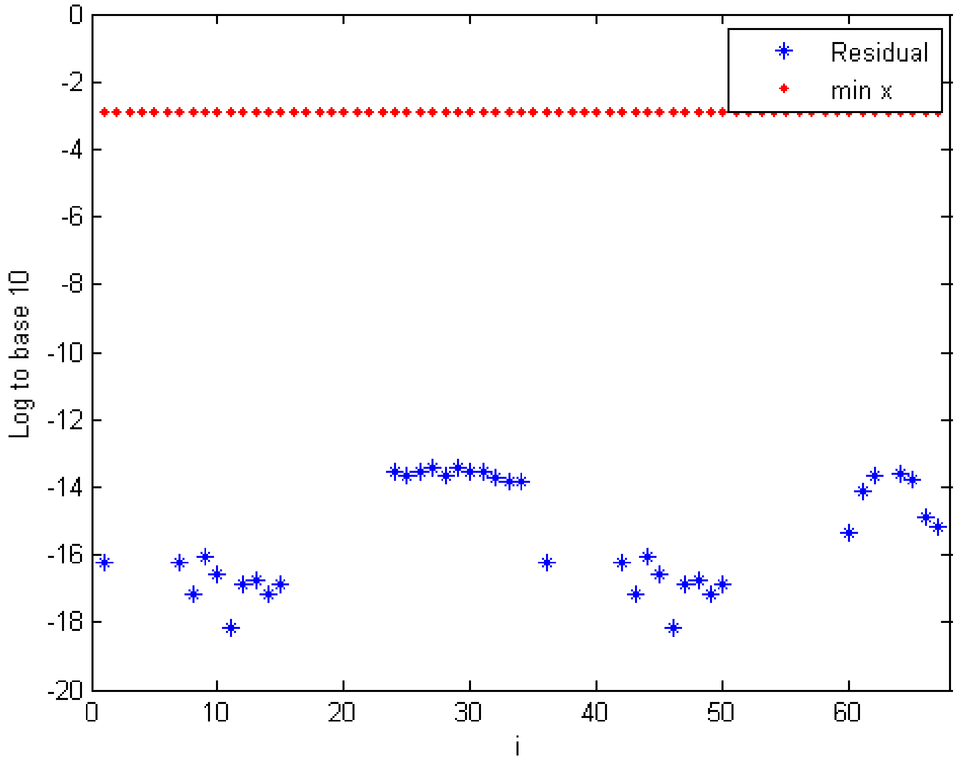

Figure 4.8: Computation residuals, equilibrium with no Minskian updating but a relative performance effect

This equilibrium calibration is the solution of a system of 67 simultaneous equations in 67 variables[20], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 67$. The computation residuals of the equations are shown as blue stars.[21] As $|f_i| \leq 10^{-12} \quad \forall i$, and $\min(x_i) > 10^{-3}$, the equilibrium solution is reasonably stable.

[20] 46 endogenous choice variables, 3 prices, and 18 Lagrange multipliers.
[21] A missing blue star corresponds to a residual of 0.

Equilibrium with Minskian updating but no relative performance effect

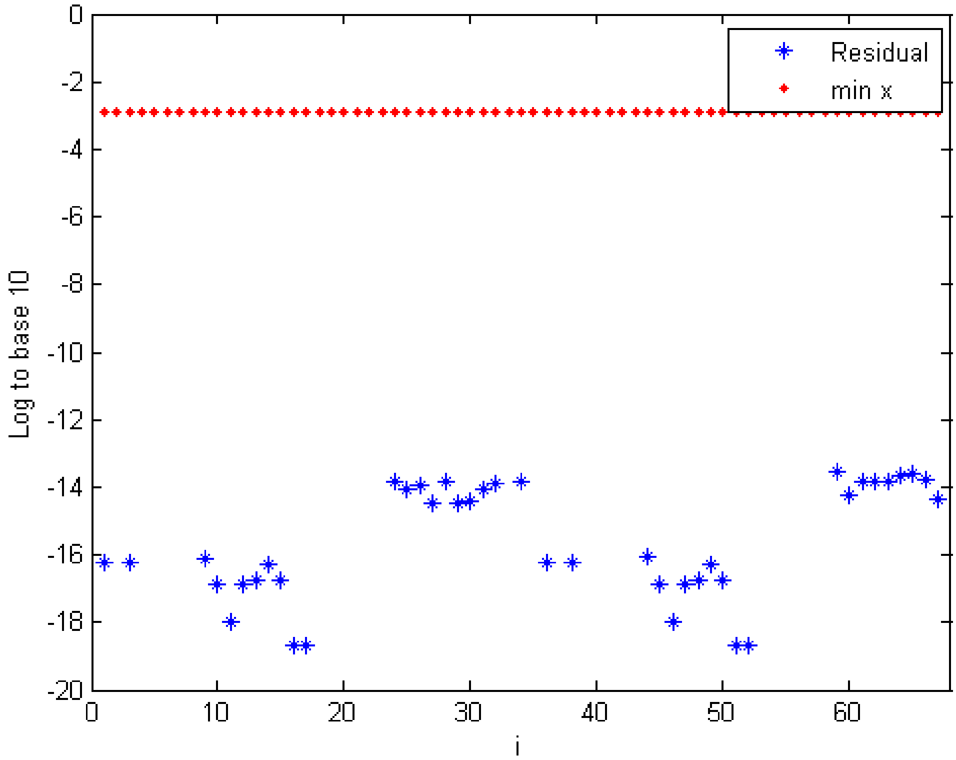

Figure 4.9: Computation residuals, equilibrium with Minskian updating but no relative performance effect

This equilibrium calibration is the solution of a system of 67 simultaneous equations in 67 variables[22], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 67$. The computation residuals of the equations are shown as blue stars.[23] As $|f_i| \leq 10^{-12} \quad \forall i$, and $\min(x_i) > 10^{-3}$, the equilibrium solution is reasonably stable.

[22] 46 endogenous choice variables, 3 prices, and 18 Lagrange multipliers.

[23] A missing blue star corresponds to a residual of 0.

Equilibrium with Minskian updating and a relative performance effect

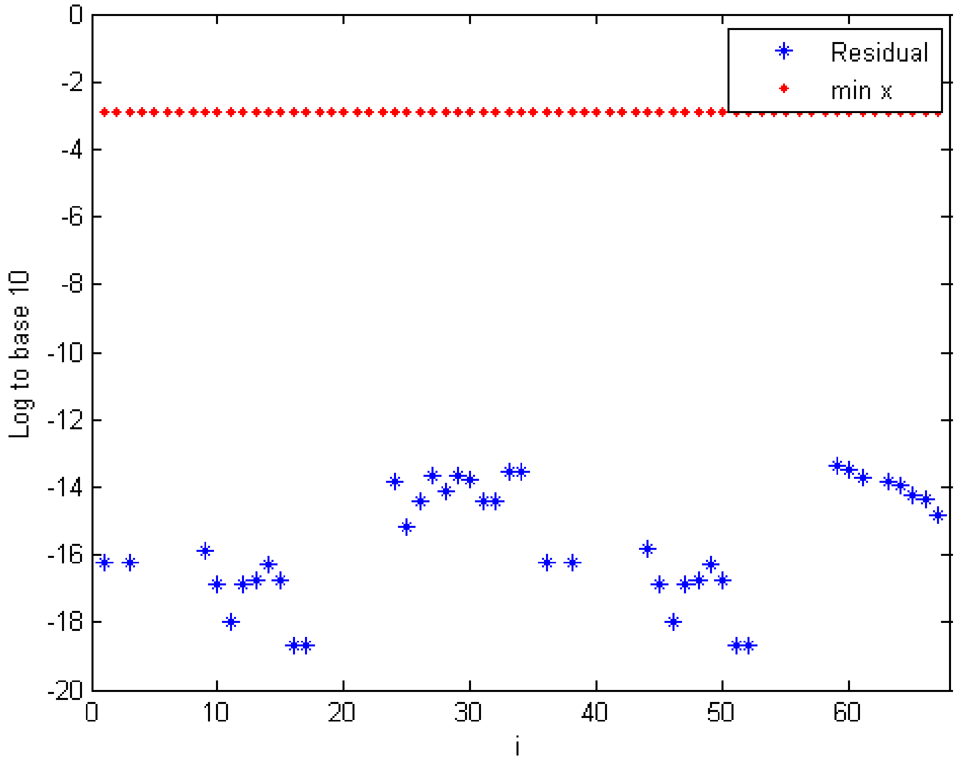

Figure 4.10: Computation residuals, equilibrium with Minskian updating and a relative performance effect

This equilibrium calibration is the solution of a system of 67 simultaneous equations in 67 variables[24], $f_i(x_i) = 0$, for $i = 1, 2, \ldots, 67$. The computation residuals of the equations are shown as blue stars.[25] As $|f_i| \leq 10^{-12} \quad \forall i$, and $\min(x_i) > 10^{-3}$, the equilibrium solution is reasonably stable.

[24] 46 endogenous choice variables, 3 prices, and 18 Lagrange multipliers.
[25] A missing blue star corresponds to a residual of 0.

Chapter 5

Conclusion

This thesis is a collection of essays on three important features of financial intermediaries.

The first paper studies the key policy determinants of financial development as measured across three dimensions – depth, efficiency, and stability. Employing the financial possibility frontier framework we identified the policy determinants of the different dimensions of financial development. Using dynamic estimation techniques on a panel data set spanning over twenty years, and across a hundred countries, our analysis shows that inflation, trade openness, institutional quality, and the occurrence of banking crises significantly affect financial development. Obviously, such broad sweeping statements need to be stated with caution. Since our analysis is carried out on a broad sample of countries using relatively long time series, our results are useful as to guide intuition in country-specific policy analyses which would require further detailed study, as opposed to being taken as immutable facts.

The second paper models the role of the lender of last resort (LoLR) in a general equilibrium framework. We also aimed to formalise an objective function for the lender of last resort in keeping with its role of minimising financial fragility. Following Goodhart et al. (2004) and Tsomocos (2003), we therefore setup an objective function for the LoLR that is increasing in banking sector profitability and decreasing in the aggregate level of default in the economy. Using a suitable parametrisation of the model, we find that optimal *ex-ante* stance of the LoLR should be a mixed strategy randomising over a hawkish and dovish stance. We take this mixed strategy Nash equilibrium to be a rationalisation of the policy of constructive ambiguity. Our comparative statics exercises show that this mixed strategy equilibrium is resilient to a wide range of parameter values and we also find evidence of behaviour akin to the 'too big to fail problem' in our model.

The third paper aimed to illuminate a new channel for the propagation of financial crises through the distortion of incentives of delegated investment managers by combining insights from agency theory and Minsky's financial instability hypothesis (Minsky, 1992) in a model with endogenous default. Our theoretical model shows that presence of a relative performance component in investors' payoffs causes herding which exacerbates the effect of Minskian optimism on leverage, risk taking, and default. Our analysis, combined with standard results from agency theory literature, show that the probability of a financial crisis increases as the quality of shareholder information decreases. We then develop a measure for the quality of shareholder information following Simon (1989) and show that the market-wide quality of shareholder information: i) is poor (with no trend) in the Pre-SEC period (1840 to 1934); ii) improves substantially following the SEC reforms; and iii) gradually declines starting in the 1960s/70s until it is now back to pre-SEC levels. Finally we run an analysis of credit cycles and shareholder information (using US data) and find that it is a credit boom, coupled with poor shareholder information quality, that increases the likelihood of a crisis. While our conclusions hold for US data, we intend to strengthen our claims by replicating our empirical analysis using data from other countries.

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