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Risto Herrala

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Risto Herrala. Essays on the limits of borrowing. Economics and Finance. Université de Strasbourg, 2012. English. NNT : 2012STRAB004 . tel-00780086

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ÉCOLE DOCTORALE \_\_\_\_\_

Laboratoire de Recherche en Gestion et Economie

**THÈSE** présentée par :

**Risto HERRALA**

soutenue le : 15 mai 2012

pour obtenir le grade de : **Docteur de l'université de Strasbourg**

Discipline/ Spécialité : Économie

## ESSAYS ON THE LIMITS OF BORROWING

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**ESSAYS ON THE LIMITS OF  
BORROWING**

**Risto Herrala**

**March 2012**

**PhD Thesis in Economics**

**Thèse de Doctorat ès Sciences Economiques**

**Defended by/Soutenu publiquement par**

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## Essays on the Limits of Borrowing

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### Acknowledgements

The helpful guidance by Laurent Weill and Iftekhar Hasan was crucial for the completion of this PhD project, for which I am very grateful. In addition to Laurent Weill, Zuzana Fungáčová co-authored one of the papers, and also helped with the completion of the project.

I wish to thank Juha Kilponen for oversight on one of the papers and Markku Säylä for data construction. Helpful comments and guidance from, Rajeev K. Goel, Esa Jokivuolle, Jouko Vilmunen, Matti Virén and Karlo Kauko are much appreciated during the project.

I also wish to thank the participants of the INFER –conference in Cork, Higher School of Economics (HSE) International Academic Conference in Moscow, the Household Finance and Consumption Network meeting in Frankfurt, and the various Bank of Finland seminars for constructive criticism and encouragement.

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## Introduction

### The need to understand the limits of borrowing

In the classical Arrow-Debreu world of perfect information and complete markets, credit availability is not a problem. At all times, households and firms can borrow against their whole inter-temporal endowment, and financial structure is irrelevant (Modigliani and Miller 1958). The market mechanism implements Pareto efficient allocations.

In contrast, in the real world of imperfect information and incomplete markets, efficient allocations can only arise by a remarkable coincidence, as stated in the Stiglitz-Greenwald theorem. In general, the functioning of the economy then depends on the ability of the financial system to channel credit. Borrowing opportunities are limited and, in the worst case, credit flows cease altogether, degrading the economy into barter.

To understand real economies, there is then a need to understand the limits of borrowing. The related literature of financial systems has grown fast since the 1970's based on the asymmetric information/incomplete markets paradigm, but much work still remains.

Still relevant is Allen and Gale's (2000) call for further understanding of the role played by financial institutions in overcoming financial frictions. Deep unresolved issues also exist about the role of the public sector in active policy intervention and regulation of financial systems (Devatripont et al 2010). The role of credit availability in economic cyclicity is unclear (Becker and Ivashina 2011), as well as the effect of credit conditions on real behavior such as consumption (Leth-Petersen 2010). Progress on these issues is, inter alia, challenged by methodological shortcomings in testing and measuring the limits of borrowing, and quantifying their effect on macroeconomic behavior.



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The issues are not purely academic. On the contrary, among the policy makers there is an urgent need for more understanding of credit availability to overcome pressing challenges. During the ongoing global crisis, many central banks and governments have been forced to support credit availability to such a degree, that their own solidity is being questioned. Last year, the Irish government had to borrow an amount equal a third of the Irish GDP mainly to cover the costs of the financial crisis. In the USA, the Federal Reserve has spent over a trillion USD to support credit availability.

Each of the four chapters in this thesis is an essay about different aspects of the limits of borrowing. Together, the four chapters contribute to the relevant theory, measurement and empirical understanding of the issue. Thereby, they shed light on the ongoing debate of the role of finance in the macro economy, which has long historical roots. As an introduction to the four essays, the historical debate is reviewed in short.

### The complexity of financial systems

For some time now, the prevailing view in economics has been that financial institutions exist to handle the complicated financial relationships between borrowers and lenders in the presence of asymmetric information and incomplete markets (Freixas and Rochet 2008). In the literature, they arise as an imperfect solution, bringing about a ‘second best’ equilibrium in an economy where inefficiency and inequality still prevail, but much reduced. In the presence of financial institutions, limits of borrowing still weight on welfare, but there is also room for welfare improving transactions.

Theoretical models hint that this second best world is complex. The operation of the financial system and the economy is sensitive to the underlying information structure, as well as the allocation of wealth, and susceptible to instability. The representative agent–view, which conveniently characterizes Arrow-Debreu economies, breaks down.

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Theoretical complexity is indicative of the complex dynamics and structures of financial systems. The historical paths of financial development are very varied, and the process of financial development is still ongoing (Kindleberger 1984). Differences in the financial systems seem highly resilient, with no apparent signs of convergence towards specific kinds of system. (Allen and Gale 2000)

A large variety of financial systems therefore prevails across the world. They are often divided into 'bank based', as in Europe, and 'market based', as in the USA, but this division hides significant variation within the groups. Many combinations of a large spectrum of bank types exists, such as public, private, universal, regional, commercial, co-operative, savings, rural, joint-stock, micro-finance, and Islamic banks to name some. There is an equally impressive variety of other types of financial institutions, including pension funds and different types of investment companies. No consensus exists about the superiority of one type of financial system compared with the other, or how financial structure affects economic development.

### The emergence of central banking

One common element that presently characterizes financial systems is the central bank. In some countries, such as the UK where central banking first originated in the 18<sup>th</sup> century, the modern central bank's predecessor was for a long time a private institution. In others, such as France, the central bank was originally set up as a public institution. The tasks of these institutions varied but a common element, which signifies the contemporary term 'central bank', was that gradually other banks started to rely on them for liquidity management. The central banks effectively became the bankers' banks. One by one, all central banks have become public institutions. Today, a 'two tiered' banking system, where a public central bank operates as a bankers' bank, is the international norm.

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Why a public institution is needed at the hub of financial systems and, more generally, the role of public intervention in financial systems, is still not fully understood. Holmström and Tirole (2011) summarize the current view that, at an abstract level, the role of the public sector is to ‘make up for the missing contracts between consumers and firms’. Governments have the potential to do this, because they have broader powers than private institutions. Public central banks, for example, can manage liquidity in the banking system by imposing reserve requirements on client banks.

From this point of view it is understandable why, coupled with the position of public central banks at the hub of the financial systems, is the responsibility of the stable operation of the system. It has been recognized from early on that the ability of the financial system to channel credit depends at times crucially on central bank actions. Most of the time, central banks can keep financial systems on a stable path relatively uneventfully by standard monetary policy operations, by adjusting interest rates, money growth or exchange rates. However, financial systems are prone to instability. At times like the present, trust in the banking system is undermined. When people no longer trust the banks, then the banking system loses its ability to channel credit. Tightening of the limits of borrowing then threatens to drive the economy back to barter. The central bank is then faced with the difficult challenge of how to use its special powers to keep the credit channel flowing.

### The LOLR debate

Deep divisions exist about what should be done during such episodes. The English debate on the Lender of Last Resort (LOLR) role of central banks in the 1800’s illustrates some of key issues relevant even today. The Bank of England relaxed its money growth targets in several instances during the early 1800’s to help the banking sector overcome liquidity drains, and was hard criticized for such ‘laxity’. In response to the criticism, Walter Bagehot (1873) famously argued that the Bank

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of England should, in crisis situations, not restrict its lending to banks by adhering to strict money growth targets. Rather, it should lend freely to illiquid banks, but not to insolvent banks. The Bagehotian principles for central bank assistance are:

- 1      lend freely during a crisis
- 2      assist any and all sound borrowers
- 3      lend against all acceptable collateral
- 4      apply penalty rates for assistance
- 5      assure the markets in advance

To lend freely to all against good collateral, and to assure the markets of this in advance is, according to Bagehot, necessary to maintain public confidence in the financial system. Collateral should be evaluated at its value in 'normal times'. The reasoning behind imposition of penalty rates is to discourage risk taking, and unnecessary use of the system. This view was strongly opposed by the currency school which wanted stricter standards for monetary expansion. It maintained that the amount of cash in circulation should fluctuate in exact correspondence with gold inflows and outflows, as this in their opinion would best guarantee price stability.

Even today, divisions persist about how central banks should operate when public trust in the financial system falters. However, the center of gravity of the debate has changed, as most central banks no longer apply strict money growth targets in monetary policy. The ongoing crisis demonstrates that many central banks are today ready to go to remarkable lengths along the Bagehotian path. As trust in the financial systems has faltered, central banks around the world have adjusted policy to provide liquidity to banks and thereby maintain banks' ability to channel credit. Governments in many countries have gone beyond the Bagehotian ideal to recapitalized banks with taxpayer money.

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By such means, public intervention has promoted the ability of the international financial system to channel credit during the ongoing crisis. These policy interventions have been highly controversial, and they will likely be debated during the years to come (Dewatripont et al 2010). Disagreements about the proper policy response have surfaced especially in Europe during the second stage of the crisis, when questions about the solvency of some of the governments have surfaced. At present, Europe is deeply divided about the proper response of the ECB to this new development.

### The objective and contents of the thesis

The aim of this PhD dissertation is to provide new insights about the limits of borrowing. It includes four essays which provide theoretical, methodological and empirical results. The first chapter contributes to the theory of limits of borrowing by a study of LOLRs in an original model. The second chapter contributes to methodology by introducing a new approach to test and measure the limits of borrowing econometrically. It also contributes to the empirical understanding of the limits of borrowing by applying the new approach to test the cyclical behavior and the effects of regulation on the limits of borrowing. The third chapter contributes to our empirical understanding of the effect of limits of borrowing on consumption. The fourth chapter yields new insight about the effect of bank ownership on the limits of borrowing during a financial crisis.

The first chapter examines the role of LOLRs theoretically in an original model. It is motivated by the call by Allen and Gale (2000) to study how, in the presence of incomplete markets, intermediaries can help overcome financial frictions. By construction, LOLRs affect the limits of borrowing of financial institutions, their clients and, as demonstrated by the ongoing crisis, even governments.

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In this essay, the operation of LOLRs is studied in an original model that belongs in the tradition of ‘liquidity models’ (Holmström and Tirole 1998). The model views LOLRs as reserve pools of liquid assets. It employs the assumption of market incompleteness. The aim of the study is to increase understanding about how a LOLR should operate in an economy where futures markets are incomplete.

The theoretical analysis indicates that LOLRs can play a useful role in such conditions. In the absence of complete futures markets, agents need some other way to agree ex ante on how prices will be determined when the economy is hit by shocks. Such a commitment mechanism may be built into the statute of the LOLR. The model suggests that voluntary LOLR schemes will not attract sufficient participation. In the presence of non-transparency, special powers usually linked to governments are needed to force participation to secure sufficient coverage of LOLR schemes.

The result that public interference is needed in liquidity provision was first given by Holmström and Tirole (1998). The model analyzed in this paper extends our understanding about the need for public interference in the operation of LOLRs by showing that public interference may welfare improving also under aggregate certainty.

The second chapter presents a novel empirical approach to measure the limits of borrowing, and applies it to tests related theoretical hypotheses. In spite of the high stakes, economists have been unable to present a fully satisfactory method for testing and estimating the limits of borrowing. This shortcoming challenges the efforts of economists to understand the limits of borrowing and the efforts of policy makers to control them.

In the second chapter, a novel approach is presented that allows an econometrician to test the presence of credit supply constraints, and then to estimate them by stochastic frontier techniques

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from a borrower sample. The new approach extends the applicability of the stochastic frontier method in this field, which was pioneered in Chen and Wang's (2008) study of Taiwanese firms.

The method is applied to a set of household surveys from Finland to test two theoretical hypotheses about the limits of borrowing. The estimation results support for the 'cyclical credit policy hypothesis' presented by a number of authors, which states that credit availability tends to develop pro-cyclically. This result implies that development of credit availability may strengthen economic cycles and that public intervention may therefore play a useful role in stabilizing credit availability.

The estimation results also support the controversial and previously untested hypothesis that bank regulation may have counterproductive effects on credit quality. The estimation results imply that, in accordance with Dell'Arricia and Marquez's (2006) previously untested hypothesis, banks may respond to regulatory changes that harmonized banks' credit market information by an aggressive credit expansion and, thereby, an increase in credit risk.

The third chapter extends the empirical approach presented in essay 2 to shed light on the effects of limits of borrowing on real economic activity, in particular durable consumption. LOLR operations are often justified by the belief that a tightening of credit policy by troubled banks effects real economic behavior such as consumption. However, past econometric studies have not found fully conclusive evidence that changes in the limits of borrowing significantly affect aggregate consumer behavior (Leth-Petersen 2010).

In the third chapter, a novel two-step approach is employed to look for such evidence. In the first stage, the methodology presented in the previous essay is employed to estimate credit constraints in a household sample. In the second stage, the credit constraint estimates are employed

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as proxies for the real credit constraints in a regression model to estimate the effect of credit constraints on durable consumption. The estimations are based on a Finnish household survey, which covers a post-deregulation consumer spending spree.

The analysis indicates that the liberalization of credit markets, and the subsequent improvement in credit availability contributed to a consumer spending spree in Finland in the late 1990's. The estimations support the view that changes in the limits of borrowing can have large effects on durable consumption expenditure. The results imply that the limits of borrowing need to be taken into account by economists when modeling consumer behavior and by policy makers as part of macroeconomic stabilization policies.

The fourth chapter contributes to our understanding of how bank ownership affects the banks' propensity to tighten credit supply during an economic downturn. A surprising variety of different kinds of banking systems prevail in different countries. It is therefore important to understand, how the structure of the banking system affects the cyclical development of limits of borrowing.

The essay extends the empirical methodology employed in the second and third chapters of this thesis to estimate credit supply constraints from bank level data. The novel approach contributes to the empirical literature on credit supply, because it is more economical in terms of data requirements than the old approaches used to estimate credit supply by banks (Khwaja et al 2008). The method is employed to data of Russian banks during the global financial crisis. The case of Russia is well suited for the analysis of credit supply of different kinds of banks, because this country has a large number of different kinds of banking institutions: state-owned banks, foreign-owned banks and domestic private banks.



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The findings support the view that bank ownership affected credit supply during the financial crisis and that the crisis led to an overall decrease in the credit supply. Relative to domestic private banks foreign-owned banks reduced their credit supply more and state-controlled banks less. The results imply that banking structure affects the cyclical development of limits of borrowing. The results support the hypothesis by Weill (2003) that foreign banks have a “lack of loyalty” to domestic actors during a crisis, as well as the view that an objective function of state-controlled banks leads them to support the economy during economic downturns. Previous evidence for the hypothesis has been mixed.

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### Chapter 1: Reserve Pools<sup>1</sup>

#### Abstract

In real economies, reserve pools such as lenders of last resort are used as buffers against the negative welfare effects of economic volatility. I study the role of reserve pools theoretically in an original model, in which the demand for reserves is insensitive to prices when the economy is hit by shocks.

In the model, a reserve pool arises as a vehicle for co-operation and commitment, which guarantees a sufficient return on the reserve in the absence of futures markets. Under perfect transparency, reserve pools based on voluntary participation may be utilised to implement the socially optimal outcome. Under non-transparency there is scope for welfare improving government intervention in reserve policy.

The model yields insight into the role played by reserve institutions such as LOLRs at the side of markets. It rationalizes the prominent involvement of the public sector in LOLR activities.

Keywords: liquidity, reserve institutions, lender of last resort, central banking

JEL classification numbers: E58, G21.

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<sup>1</sup> Published in 2008 in 'Public Finance, Monetary Policy and Market Issues', INFER Research Perspectives Vol 5, Edited by Edward Shinnick, LIT Verlag, Berlin.

## 1.1 Introduction

Governments command a prominent role in reserve policy in industrial countries. They hold significant reserves in various types of real commodities and services. They oversee, via central banks, reserve arrangements in payment and settlement systems, and hold the position of the ultimate financial reserve as the lender of last resort. Yet a basic theorem of welfare economics states that a perfect Arrow-Debreu contingent claims market could implement any Pareto optimal allocation in the absence of public interference.

It could be argued that an Arrow-Debreu contingent claims market is not a practicable mechanism in real economies,<sup>2</sup> and that its role in theoretical analysis is to establish the benchmark for practical arrangements. A challenge for economists is to try to understand, whether and how institutional and market based arrangements, observed in real economies, help the economy to reach that ideal.

Below, Lenders of Last Resorts (LOLR) are studied in that spirit. In real economies, LOLRs function as liquidity reserves for the banking sector, and it is therefore of interest to study whether and in what way they can help an economy implement the ideal Arrow-Debreu -outcome. What useful role could LOLRs play at the side of spot markets, which handle most transactions in real economies? How should LOLRs operate? Could they be private institutions?

Our approach to these issues is theoretical. These issues are studied in an original model which owes much to a genre of analysis called 'liquidity models'. These models focus on banking issues and, more generally, issues related to financial intermediation. Like many models in that genre, the model sketched below involves a continuum of individuals in three periods and under aggregate certainty.<sup>3</sup>

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<sup>2</sup> See Allen and Gale (2000) for an extensive discussion of Arrow-Debreu-McKenzie markets (which here are referred to as Arrow-Debreu (AD) markets for shortness) in contrast to market and institution based arrangements observed in practice.

<sup>3</sup> The classic model is Diamond and Dybvig (1983), with numerous applications such as Bhattacharya and Gale (B&G 1987), Bhattacharya and Fulghieri (1994), and Diamond (1997). Allen and Gale (2000b) use a

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The use of a novel model instead of some already established one invites new insights. While Arrow-Debreu analysis is general, economists that study the non-classical case are faced with an embarrassment of riches. This aspect of the literature is reminiscent of the richness of market and institutional arrangements observed in real economies, which Allen and Gale (2000) bring out. Instead of trying to include all that richness in a single model, authors utilise partial models to uncover different aspects of the situation.

The analysis below indicates that centralised reserve institutions can play a useful role aside spot markets, when futures markets are not operational. In their absence, agents may need some other way to agree ex ante on how prices will be determined when the economy is hit by shocks. In the absence of futures markets, such a commitment mechanism may be built into the statute of a LOLR.

In a related vein, the model offers an explanation for the fact that the public sector plays a prominent role in governance of reserve institutions. The analysis indicates that reserve pools, which rely on voluntary participation, only reach the first best under perfect transparency. In the realistic case of non-transparency, there is scope for governments to increase welfare by using their special powers to guarantee a sufficient reserve ratio.

The result that an institutional arrangement may play a useful role in liquidity supply in the absence of Arrow-Debreu markets is not new. The particular view that institutional arrangements may serve to constrain future pricing behaviour has been promoted by Diamond and Rajan (2001) in the context of banking. They propose that the need for such commitment arises to hinder the liquidity supplier (banker) from misusing his/her special position for personal gain vis a vis depositors. In the model studied in this paper, in contrast, the need for commitment arises in the absence of any threat of misuse of market power.

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slightly different model to introduce trading restrictions in between regions to study contagion of shocks from one region to another. Holmström and Tirole's (1998 and 2001) studies of public supply of liquidity and asset prices, and Diamond and Rajan's (2001) study of banking are but a few examples of the genre.

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The result that government involvement may be useful in aggregate liquidity management under non-transparency is at first sight reminiscent of Holmström and Tirole's (1998) finding about the role of the public sector. In contrast to what is proposed here, however, they propose that the private sector is self sufficient when there is no aggregate uncertainty, and public interference is welfare improving only under aggregate uncertainty. In their model economy, the government is a taxation authority. In the case studied below, in contrast, the government is needed to regulate the level of liquidity in the economy by imposing reserve requirements on agents. While both approaches link the role of the public sector to its special rights of implementation, they rationalise different applications of such powers. Both uses are observed in practise.

The following section introduces the main aspects of the model economy under autarky. The ideal Arrow-Debreu outcome is studied in section 3. Section 4 deals with the issue of how a reserve pool may be useful in an economy with a frictionless market for multilateral spot trades. Section 5 concerns the case, where multilateral transactions are ruled out: the only alternatives are autarky and bilateral trading relations with a reserve pool. The final section concludes by a summary of some of the results, and my views on some of the open issues.

### 1.2 Autarky

Consider the problem of some individual  $\mathbf{i} \in (0,1)$  who faces the following order of events:

- At  $t=0$   $\mathbf{i}$  chooses 'reserves'  $Z[\mathbf{i}]$  from the unit line  $I$ .
- In between  $t=0$  and  $t=1$ , nature chooses a 'shock'  $s[\mathbf{i}] \in \{0, B\}$ ,  $B > 0$ . Probability of shock  $B$  is  $\mathbf{i}$ , and probability of shock  $0$  is  $1-\mathbf{i}$ .
- At  $t=1$ , 'early consumption'  $C_1[\mathbf{i}, s] = Z[\mathbf{i}]$ .
- At  $t=2$ , 'late consumption'  $C_2[\mathbf{i}, s] = R(1 - Z[\mathbf{i}])$ ,  $R > 1$ .

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Utility is:

$$C_1[\mathbf{i}, s] + C_2[\mathbf{i}, s] - s[\mathbf{i}] * \max\{1 - C_1[\mathbf{i}, s], 0\} \quad (1.2.1)$$

The parameters  $R$  ('long term return') and  $B$  ('penalty') satisfy:

$$1 < R < 1 + B. \quad (1.2.2)$$

One way to interpret the model sketched above is to think about the initial endowment as some real commodity such as grain, which the individual may either store (put in reserve in which case it is available for early consumption) or plant (in which case it yields a long term return). The individual problem could also be interpreted as a choice between a liquid financial asset (cash) and some long term illiquid financial asset (loan).<sup>4</sup>

Individuals make the initial allocation decision with knowledge of the future possibility of shock  $B$  which increases the marginal utility of early consumption at low consumption levels. In the 'grain economy' this could be a reduction in the amount of nourishment available from nature. In the financial economy, the event could be some real need for reallocation of wealth. A key driver of our results is that, what agents do at  $t=0$  depends crucially on what they expect will happen at  $t=1$ . When they make decisions about the level of reserves they hoard at  $t=0$ , they will take into account the possibilities to trade at  $t=1$ , and the expected price of the single good at that time at the markets.

Under autarky, no possibilities for trade exist by assumption. The order of events gives early and late consumption in terms of reserves. Inserting these, the individual problem at  $t=0$  becomes:

$$\begin{aligned} & \underset{Z[\mathbf{i}]}{\text{Max}} Z[\mathbf{i}] + R(1 - Z[\mathbf{i}]) - \mathbf{i}B(1 - Z[\mathbf{i}]) \\ & \text{s.t.} \\ & 0 \leq Z[\mathbf{i}] \leq 1. \end{aligned} \quad (1.2.3)$$

The solution to the linear program (1.2.3) under autarky is presented in the following Table 1.1 for alternative  $i$ .

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<sup>4</sup> The model abstracts from issues related to the distinction between real and nominal quantities, which is arguably an important issue in the debate of financial reserve institutions. However, the model sheds light on various other issues related the operation of such institutions.

Table 1.1 **Optimal choice and utility under autarky for alternative i.**

$\mathbf{i}$	$Z[\mathbf{i}]^{autarky}$	$C_1[\mathbf{i},s]^{autarky}$	$C_2[\mathbf{i},s]^{autarky}$	$U[\mathbf{i}]^{autarky}$
$\left(0, \frac{R-1}{B}\right)$	0	0	R	R-Bi
$\frac{R-1}{B}$	[0,1]	$Z[\mathbf{i}]^{autarky}$	$R(1 - Z[\mathbf{i}]^{autarky})$	1
$\left(\frac{R-1}{B}, 1\right)$	1	1	0	1

To translate the individual outcomes into macroeconomic aggregates, it is henceforth assumed that the economy hosts a continuum of individuals. Individual shock probabilities are independent and uniformly distributed across the unit line.<sup>5</sup> By table 1.1, average reserves and consumption  $Z, C_1, C_2$  and average utility  $U$  (denoted by support 'autarky') satisfy:

$$\begin{aligned}
 (a) \quad Z^{autarky} &= 1 - \frac{(R-1)}{B} \\
 (b) \quad C_1^{autarky} &= 1 - \frac{(R-1)}{B} \\
 (c) \quad C_2^{autarky} &= R \frac{(R-1)}{B} \\
 (d) \quad U^{autarky} &= \frac{(R-1)^2}{2B} + 1.
 \end{aligned}
 \tag{1.2.4}$$

### 1.3 The first best

To create positive benchmark for LOLR arrangements, the focus of analysis is now shifted to a situation where transfer of the good across individuals is free. The economy is run by a benevolent dictator that maximises expected aggregate utility. The planner's program is

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<sup>5</sup> To guarantee aggregate certainty, I also assume that the law of large numbers applies. The results in this paper pertain to any continuous distribution of agents. The uniform distribution offers the possibility to explicitly solve for the endogenous variables in the models. Complications related to aggregate uncertainty and discrete distributions of agents are discussed in the final sections.



$$\underset{Z[i], C_1[s,i], C_2[s,i]}{Max} \int_S \left( \int_I (C_1[s,i] + C_2[s,i] - s[i](1 - C_1[s,i])) di \right) ds$$

st.

$$\begin{aligned} (a) \quad & \int_I C_1[s,i] di = Z \quad \forall s \in S & (1.3.1) \\ (b) \quad & \int_I C_2[s,i] di = R(1 - Z) \quad \forall s \in S \\ (c) \quad & C_1[s,i] \leq 1 \quad \forall s \in S, i \in I \\ (d) \quad & C_i[s,i] \geq 0 \quad \forall t \in \{1,2\}, s \in S, i \in I. \end{aligned}$$

where  $s \in S$  denotes the vector of shocks at  $t=1$  (the state), and the variable  $i$  (not boldfaced) has unit domain  $I=(0,1)$ . Given the restriction (1.3.1c), the target in (1.3.1) is simply the individual target (1.2.1), integrated over all individuals and the state space. The domain restriction (c) is made without loss of generality. It may be shown that average welfare is not maximised by any allocation that allows early consumption above unit level.<sup>6</sup> Only aggregate (in contrast to individual) consumption is capped by the amount of liquidity available in the economy (constraints (1.3.1a and b)), establishing free transfer of goods.<sup>7</sup>

The solution to this linear program (denoted by support 'first best') is:

$$\begin{aligned} (a) \quad & Z^{first\ best} = 0.5 \\ (b) \quad & C_1^{first\ best} = 0.5 \\ (c) \quad & C_2^{first\ best} = R * 0.5 & (1.3.2) \\ (d) \quad & U^{first\ best} = \frac{(R+1)}{2}. \end{aligned}$$

By inserting the equilibrium outcome in the objective function, it may be verified that average utility is greater under the first best than under autarky:

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<sup>6</sup> The proof of this proposition is that, given any allocation of consumption in which some agents consume above unity at  $t=1$ , there exists an alternative allocation in which average utility is higher. In this alternative allocation, endowments are transferred from agents that consume above unity at  $t=1$  either to agents that consume below unity at that date, or to late consumption.

<sup>7</sup> Constraints (b) and (d) jointly guarantee that  $Z$  is within the unit line.

$$\begin{aligned}
 U^{first\ best} - U^{autarky} & \stackrel{(2.4),(3.4)}{=} \frac{(R+1)}{B} - \frac{(R-1)^2}{2B} - 1 \\
 & \stackrel{regroup}{=} \frac{(R-1)(1+B-R)}{2B} \\
 & \stackrel{(2.2)}{>} 0.
 \end{aligned} \tag{1.3.3}$$

Welfare gap (1.3.3) arises because individual utilities are state contingent, while the initial allocation is not. It pays off in terms of average welfare to transfer consumable wealth at  $t=1$  to those individuals whose marginal utility of consumption is greatest. This is not possible under autarky by assumption.

The rest of this paper is concerned with the feasibility to implement the first best by a market mechanism, possibly accompanied by a LOLR arrangement. It should be stated at the outset that, according to the first theorem of welfare economics, any Pareto-optimal allocation, such as (1.2.4) may be implemented if individuals trade in a complete set of Arrow - Debreu contingent claims (AD). In this model, the equilibrium price at  $t=0$  of AD's which guarantee one unit of early consumption in any given set of states is  $R$  times the probability of those states.<sup>8</sup>

In real economies, access to AD markets or other markets for state contingent wealth is typically limited or costly for one reason or another. The focus of the study below is, whether and how more crude mechanisms, based on spot trade, could implement the socially optimal allocation in the absence of AD markets.

### 1.4 Frictionless spot market and a LOLR

This section studies the possibility to implement the first best allocation when the economy by a frictionless spot market at  $t=1$ , and a LOLR. The analysis shows that the LOLR can play a useful

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<sup>8</sup> The unit return of supplying one unit of AD at  $t=0$  is, then,  $R$  so that agents are indifferent in between supplying ADs and not supplying them. Equilibrium quantity of ADs supplied is determined by aggregate demand of ADs: each agent wishes to purchase one unit of AD in  $i$  states so that aggregate demand is 0.5, and (1.3.3) is implemented.

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role at the side of such markets in implementing the first best. The analysis also gives insight about why government intervention may be necessary in implementing the first best.

At the spot market, a 'spot trade' is an agreement at  $t=1$  of transfer of period 1 good against a claim on period 2 good. It is assumed that transfer of the good across individuals is frictionless: constraints (1.3.1a and b) concerning aggregate early- and late consumption still apply. These 'liquidity constraints' guarantee market clearing in the economy.

Without loss of generality assumption (1.3.1 c) is also retained.<sup>9</sup> The following additional assumptions are made:

(Assumption 1) Existence of market clearing prices. At  $t=1$  there exists in all states a price of consumable wealth  $r[s] \in [1, 1+B]$  which is observed by all.  $r[s]$  is the amount of period 2 liquidity needed to purchase one unit of period 1 liquidity.

(Assumption 2) Full transparency. Individual early consumption is only constrained by individual total wealth:

$$r[s]C_1[i, s] \leq R - (R - r[s])Z[i] \quad \forall s \in S, i \in I.$$

We will at first study what happens in the absence of a LOLR. Individual behaviour may be solved from the linear program:

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<sup>9</sup> Individual early consumption never exceeds unity in equilibrium. The proof for this assertion may be sketched as follows. Early consumption above unit level would be welfare decreasing for agents unless the price of liquidity were at or below unity at  $t=1$ . By market clearing, the price of liquidity is never below unity, and a price of one for liquidity is only possible if aggregate reserves are at or above 0.5 (the proportion of shock B in the economy). However, if the price of reserves were below R in any states at  $t=1$ , then the expected return of reserves would at  $t=0$  be so low that individuals would not hoard any reserves. Thus, in equilibrium,  $r=1$  cannot be an equilibrium price in the model and, thus, early consumption never exceeds unity in equilibrium.

$$\begin{aligned}
 & \underset{Z[\mathbf{i}], C_1[\mathbf{i}, s]}{\text{Max}} \int_S \{C_1[\mathbf{i}, s] + C_2[\mathbf{i}, s] - s[\mathbf{i}](1 - C_1[\mathbf{i}, s])\} ds \\
 & \text{st.} \\
 & (i) \quad Z[\mathbf{i}] \leq 1 \\
 & (ii) \quad C_1[\mathbf{i}, s] \leq 1 \quad \forall s \in S \\
 & (iii) \quad C_2[\mathbf{i}, s] = R + (r[s] - R)Z[\mathbf{i}] - r[s]C_1[\mathbf{i}, s] \quad \forall s \in S \\
 & (iv) \quad Z[\mathbf{i}], C_1[\mathbf{i}, s], C_2[\mathbf{i}, s] \geq 0 \quad \forall s \in S.
 \end{aligned} \tag{1.4.1}$$

It turns out that the economy is not complete in the absence of a LOLR. Kuhn-Tucker conditions of program (1.4.1) and market clearing (1.3.1 a and b) are not sufficient to fully determine the equilibrium in the model economy.

One problem (which would also arise in the Arrow-Debreu economy) is that, while the assumptions made so far dictate that the only possible equilibrium outcome for aggregate reserves  $Z$  is 0.5, the distribution of reserves across agents is not determined in the vicinity of the equilibrium. The nature of this problem is that of choice from equal alternatives: at the equilibrium level of aggregate reserves, individual agents are indifferent between different allocations of their individual portfolios. To promote intuition, it may be useful to project this problem to the 'grain economy' introduced briefly in section 2. Suppose the farmer is considering how much grain to plant and how much to store. In the neighbourhood of equilibrium  $Z=0.5$ , each plant/store combination yields an equal return for individual farmers, so that there is no economic reason to favour one over another.

A second, arguably more significant shortcoming in the current state of the model economy is that, while in any equilibrium the expected price at  $t=0$  of period  $t=1$  liquidity must equal  $R$ , the economy hosts no mechanism to guarantee that this outcome will be realised at  $t=1$ .<sup>10</sup> This problem

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<sup>10</sup> Stated verbally, other equilibria can be ruled out as follows. Take as a premise that  $Z < 0.5$ . Then  $r > R$  in all states, because the equilibrium at the market for liquidity at  $t=1$  must be at the downward sloping part of AD (see chart). This implies that the expected price at  $t=0$  of liquidity at  $t=1$  is greater than  $R$ . By the Kuhn-Tucker conditions, this implies that all agents choose  $Z[\mathbf{i}]=1$  implying  $Z=1$  which contradicts the premise. In a similar manner,  $Z > 0.5$  can be ruled out as an equilibrium. Using a similar method the analysis establishes that  $Z=0.5$  can be an equilibrium, but only if  $r=R$  in all states.

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does not arise in the Arrow-Debreu case so that analysis of this aspect of the model may uncover real issues to be dealt with in economies with undeveloped futures markets.

To illustrate the nature of the problem visually, Figure 1.1 shows a sketch of the aggregate demand schedule of the good in this economy at  $t=1$  in the absence of a LOLR. The aggregate demand schedule has a horizontal segment: when  $1 < r[s] \leq R$ , aggregate demand equals 0.5.<sup>11</sup> As the equilibrium supply of the good at  $t=1$  is 0.5 (in accordance with the aggregate reserve hoarded at  $t=0$ ), the aggregate demand and supply schedules meet horizontally at  $t=1$ . Accordingly, the price of the good at the spot market is not uniquely determined by market clearing. In line with Kuhn-Tucker conditions of program (1.4.1), the first best can only be implemented if individuals expect at  $t=0$  that the price of liquidity will be  $R$  in all states at  $t=1$ . For the first best to be feasible, some mechanism must be introduced into the model economy, which convinces the individuals at  $t=0$  that the price of liquidity fulfils this requirement!

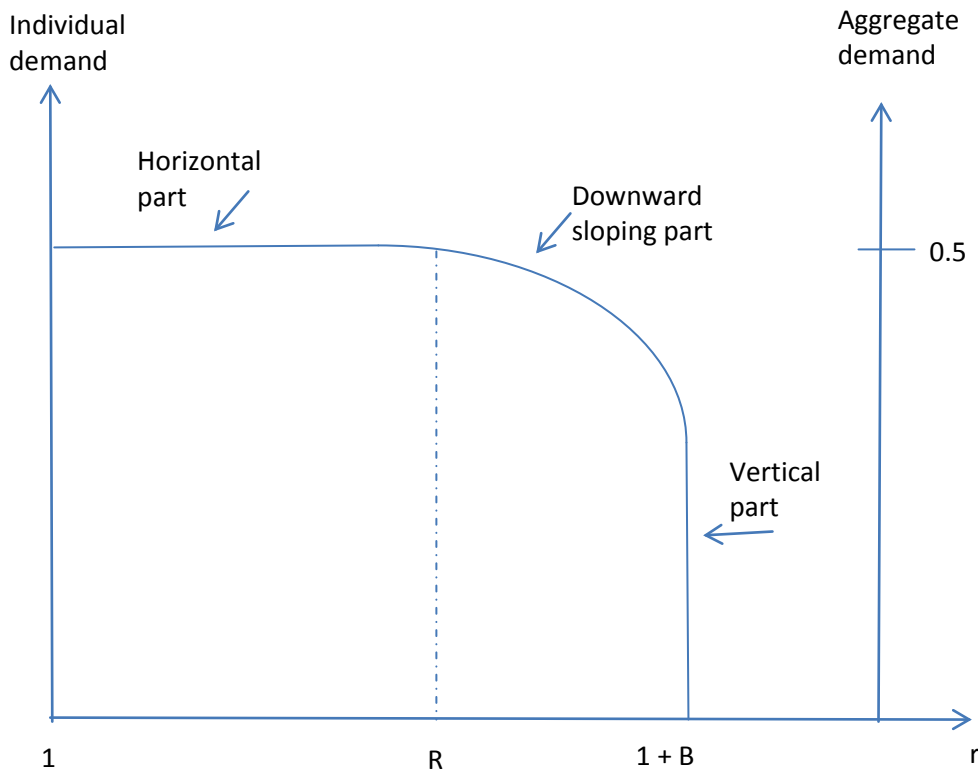
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<sup>11</sup> When  $r[s] > R$ , the aggregate and individual demand schedules slope downwards because individual liquidity constraints bind. At  $r[s] = 1+B$  demand schedules turn vertical: the market price of liquidity equals the marginal benefit from early consumption for individuals  $s[i]=B$  in these states.

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Figure 1.1 **Aggregate demand schedule for liquidity at  $t=1$  (schematic representation).**



It is important to understand that the way this ambiguity about market clearing prices at  $t=1$  is resolved is crucial for the operation of the economy. The expected price of early consumption at  $t=1$  effects ex ante behaviour at  $t=0$ : the price grain at  $t=1$  affects the allocation of grain to reserves at  $t=0$ . Farmers must at  $t=0$  know that  $r=R$  in all states, else they will not voluntarily place the 'right' amount grain in reserve. AD markets would solve this problem by allowing farmers to commit at  $t=0$  to certain supply conditions at  $t=1$  but AD markets are, by assumption, not operational here.

In this simple economy, a LOLR can be viewed as a practical solution to these problems. The first best can be implemented, if the agents jointly collect a reserve pool at  $t=0$ , and agree on the terms and conditions of the use of the reserve at  $t=1$ . If such a possibility exists, then the first best allocation can be implemented if the reserve pool commits to pricing behaviour at  $t=1$  that satisfies  $r=R$ . This can be verified by solving (1.4.1) under this restriction on  $r$ . It is also straightforward to show that the first best outcome is a unique equilibrium, if joining the LOLR is voluntary at  $t=0$ .

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LOLR schemes that apply  $r < R$  are not feasible because, under such pricing policy, no one would voluntarily deposit reserves in the LOLR at  $t=0$ . The policy  $r > R$  is not feasible either because, if agents expect such a price to prevail at  $t=1$ , then there would be excess hoarding of reserves at  $t=0$  and, consequently, excess supply of reserves at  $t=1$ . The LOLR would then not be able to attract any demand for reserves at this price in  $t=1$ .

While the model focuses on an extreme case where the aggregate demand schedule for reserved goods always has a horizontal segment, the general concern is valid. It is not difficult to envision real life contingencies, in which aggregate demand is insensitive to prices: one could even argue that emergency reserves are typically hoarded for just such contingencies. Institutional arrangements such as LOLR:s are offer a practical way to solving the problem. The analysis points to one potentially useful aspect in the operation of real life reserve institutions.

The simple model also offers insight about the role of the public sector in LOLR arrangements. To this end, consider the issue of transparency. The preceding analysis assumes that individual early consumption is only constrained by total wealth (see Assumption 2), i.e. all income at  $t=2$  is pledgeable at  $t=1$ . Only under full transparency, all agents can afford to pay the 'competitive price'  $r=R$  for one unit of liquidity at  $t=1$ . Full transparency is a strong assumption, and an important issue is whether this assumption can be relaxed without jeopardising implementation of the first best.

This issue may be studied by an appropriate adjustment in Assumption 2. The result is that full transparency is required for implementation of the first best. The equilibrium outcome in a non-transparent system depends in a complex way on the distribution of reserves and shocks across individuals.

In such non-transparent systems, there is scope for governments to use their powers on implementation to steer the economy. In particular, I replace the assumption about full transparency (Assumption 2) with the following condition characterising a non-transparent system:

$$\bar{R} \geq 1 \tag{1.4.2}$$

, where  $\bar{R} < R$  is the proportion of period 2 returns that are pledgeable<sup>12</sup> at  $t=1$ . It may be shown that, in this case, the first best may be implemented if the government imposes a reserve requirement on individuals at  $t=0$  which guarantees  $Z=0.5$  (The reserve requirement needs to be forced on individuals: in a system based on voluntary participation individuals would choose zero reserves.). Under (1.4.2), the equilibrium price of liquidity at  $t=1$  is always unity. Condition (1.4.2) is the lowest barrier at which the first best may be implemented with help of a reserve requirement imposed on the agents by a public, government run LOLR.

Result 1 summarises the analysis in this section:

### Result 1

a) Arrow-Debreu markets cannot be replaced by frictionless spot markets in the economy: introduction of perfect spot markets is not sufficient to complete the economy.

b) The first best outcome (1.3.4) is achieved under the further assumption that there exists some 'commitment device' (LOLR) in the economy, characterised by the following abilities:

1. The LOLR may randomly choose individual reserves at  $t=0$  when indifference prevails among individuals, to achieve any desired level of aggregate reserves.
2. The LOLR may commit at  $t=0$  to supply of liquidity at  $t=1$  at any  $r[s]$  that satisfies market clearing (1.3.1a).

c) The first best is only achievable under full transparency (Assumption 2). If individuals are not able to pledge their total wealth against early consumption, then the first best is not achieved in the presence of a voluntary LOLR scheme. If the economy is not too non-transparent, then the first best may be achieved if participation in the LOLR is mandatory and it imposes a reserve requirement on agents.

## 1.5 No markets, LOLR or many LOLRs

The previous section shows that a LOLR may play a useful role in the economy even if individuals have the ability to freely trade with each other at the spot market. The assumption that individuals have the ability to trade with each other at no cost is strong: maintaining multilateral trading

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<sup>12</sup> By pledgeable we mean eligibility as collateral for liquidity.



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relations is seldom an option for individuals on account of transfer, search and other information costs. In real life, individuals have to rely on most accounts on a limited number of centralised trading partners for their transaction needs.

Whether an institutional arrangement arises as a voluntary co-operation mechanism, or whether an institution is the only possible option for agents to trade may affect the outcome in an economy. In the latter case, the powers of an institution to impose outcomes may be greater because individuals are more reliant on them. This section concerns the issue of whether such powers could even in principle be utilised to advance the economy. If agents can transact only with a LOLR, can the LOLR be utilised as an instrument to implement the first best under less demanding conditions than those given in Result 1?

Assume for now that the economy hosts one LOLR within which all individuals may choose to participate. Denote by  $\lambda[\mathbf{i}] \in \{0,1\}$  a binary 'participation indicator' which indicates, whether individual  $i$  chooses to remain in autarky ( $\lambda[\mathbf{i}] = 0$ ) or participate in the LOLR ( $\lambda[\mathbf{i}] = 1$ ) at  $t=0$ . Participation means, that the individual deposits his/her reserves with the LOLR at  $t=0$ , against a unit return  $r$  in terms of period  $t=2$  liquidity. Only participants may utilise the LOLR as a source of liquidity at  $t=1$ : they can at  $t=1$  trade off liquidity against period  $t=2$  liquidity at the specified price  $r$  in the presence of full transparency (Assumption 2).<sup>13</sup>

We assume that the LOLR cannot distinguish between participating individuals and, accordingly, it imposes the same reserve deposit requirement  $\bar{i}$  for all participants at  $t=0$ , and applies the same interest rate  $r$  to them. The focus here is implementation of the first best, so that analysis focuses on LOLRs that offer 'full insurance' to the participants: they collect enough

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<sup>13</sup> One can also envision a reserve pool which transacts with any individual at  $t=1$ , irrespective of whether the individual has made a reserve deposit at  $t=0$ . Analysis of such an 'open club' arrangement is straightforward: the equilibrium outcome is equivalent to the one reached in the previous section. Analysis in this section concentrates on the 'closed club' case, in which certain additional issues arise.

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reserves at  $t=0$  to cover the early consumption needs of all participants that experience shock B.

Under this assumption we may interpret  $\bar{i}$  as the average probability of shock B of individuals participating in the LOLR. The analysis below focuses on the case where  $r$  has some constant value in between one and  $R$  in all states, because this is the maximum price span within which the first best could be implemented without violating individual liquidity constraints.

Agents' behaviour solves:

$$\begin{aligned}
 & \underset{\lambda[\mathbf{i}], Z[\mathbf{i}], C_1[\mathbf{i}, s], C_2[\mathbf{i}, s]}{\text{Max}} \int_S \{C_1[\mathbf{i}, s] + C_2[\mathbf{i}, s] - s[\mathbf{i}](1 - C_1[\mathbf{i}, s])\} ds \\
 & \text{st.} \\
 & (i) \quad (1 - \lambda[\mathbf{i}]) Z[\mathbf{i}] + \lambda[\mathbf{i}] \bar{i} \leq 1 \\
 & (ii) \quad C_1[\mathbf{i}, s] \leq \lambda[\mathbf{i}] + (1 - \lambda[\mathbf{i}]) Z[\mathbf{i}] \quad \forall s \in S \\
 & (iii) \quad C_2[\mathbf{i}, s] = R + (r[s] - R)(Z[\mathbf{i}] + \lambda[\mathbf{i}]) - r[s] C_1[\mathbf{i}, s] \quad \forall s \in S \\
 & (iv) \quad Z[\mathbf{i}], C_1[\mathbf{i}, s], C_2[\mathbf{i}, s] \geq 0 \quad \forall s \in S \\
 & (v) \quad \lambda[\mathbf{i}] \in \{0, 1\}.
 \end{aligned} \tag{1.5.1}$$

This program may be solved in three steps as follows. As a first step take the autarky solution ( $\lambda[\mathbf{i}] = 0$ ) given in (1.2.4). As a second step solve for average utility when the individual participates ( $\lambda[\mathbf{i}] = 1$ ): in this case (1.5.1) is a linear program. Finally, compare the two solutions and choose that value of the participation parameter which gives higher expected utility.

The outcome of this analysis is that an individual prefers participation to autarky (chooses  $\lambda[\mathbf{i}] = 1$ ) if and only if:

$$\mathbf{i} \geq \frac{(R - r)\bar{i}}{1 + B - r}. \tag{1.5.2}$$

To interpret, the participation decision depends (positively) on the shock probability of the individual, and on the price applied by the reserve pool. Individuals with low probability of shock B prefer reserve pools which apply relatively high prices. Such 'low risk' individuals do not attach

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much weight on the possibility that they may have to purchase liquidity at  $t=1$  to finance early consumption. For these individuals it is more important that they get a competitive return on their initial deposit. For individuals with high risk of shock B, the opposite applies.

It is observed from (1.5.2) that  $r=R$  is the only pricing policy, under which all individuals  $\mathbf{i} \in (0,1)$  participate in the reserve pool. In that case and that case only is the first best allocation (1.3.4) feasible. The analysis indicates then that, even when multilateral trade is not possible, the first best allocation is only feasible if the reserve pool follows exactly the same policy as if multilateral trade were possible ( $Z=0.5, r=R$ ).

To establish whether this is a competitive equilibrium, we study reserve pools that apply other pricing policies than  $r=R$ . Assume that there are two reserve pools which offer full insurance to their participants, but apply different pricing policies. Define RP1 by the reserve deposit and pricing parameter pair  $(Z, r) = (\bar{i}1, R)$ , and RP2 by the corresponding parameters  $(Z, r) = (\bar{i}2, r < R)$ . Notice that reserve pool RP1 may implement the first best, while RP2 cannot, because some of the low risk individuals will rather choose autarky than participation in that scheme by (1.5.2).

Comparing the expected utilities of agents in these two schemes we get that agent  $i$  strictly prefers RP2 to RP1 if and only if:

$$\Leftrightarrow \begin{aligned} R + (1 - R)\mathbf{i} &< R - (R - r)\bar{i}2 - (1 - r)\mathbf{i} \\ 0 &< (R - r)(\mathbf{i} - \bar{i}2). \end{aligned} \tag{1.5.3}$$

From the last row of (1.5.3) it is observed that individuals who have higher risk of penalty than the reserve deposit ratio in RP2, prefer RP2 to RP1. Individuals who have lower risk than the reserve ratio in RP2 prefer RP1. However, as the reserve ratio is also the average risk in any full insurance reserve pool, it must be concluded from (1.5.3) that no RP2 can exist in which all of its

participants prefer RP2 to RP1. It is not possible to construct RP2 in which all participants have higher risk than the average in that scheme.

The analysis does not indicate how an economy would evolve toward the socially optimal outcome. However, the analysis above illustrates that, once the economy has reached that outcome, it remains there: socially optimal reserve pools, which implement the first best, cannot be challenged by stable schemes under the given assumptions.

### Result 2

- a) In the absence of spot markets, a LOLR can implement the first best allocation by bilaterally trading with all individuals, imposing a 0.5 reserve ratio, and applying pricing policy  $r=R$ .
- b) No other reserve pool that offers full insurance to participants can be stable in the presence of the reserve pool that implements the first best.

## 1.6 Conclusions

Above, we utilise a variant of 'liquidity models' to study the conditions under which an economy may reach the first best allocation in the absence of Arrow-Debreu contingent claims markets. We study the possibility to implement the first best in the presence of a LOLR and spot markets.

The analysis indicates that one may not be able to fill the gap caused by the absence of Arrow-Debreu markets by introduction of spot markets alone. The economy may not then be complete because, when futures markets are lacking, agents need some mechanism to agree on prices ex ante for periods when the economy is hampered by shocks.

A LOLR which collects reserves at  $t=0$  and commits at that time to some predetermined pricing policy at  $t=1$  may complete the economy. Such an institutional arrangement co-ordinates individual reserve hoarding and achieves pre-commitment to pricing where futures markets are absent. If a reserve pool exists in the economy then the socially optimal allocation is reached under the very

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restrictive assumption of perfect transparency. In general, any non-transparency (inability by agents to pledge their wealth) results in a non-negligible welfare loss. If non-transparency is not too great, a government may implement the first best by imposing a reserve requirement on agents. This outcome holds even in the case when costs of multilateral transactions are so high that the only realistic alternative is transacting via a centralized institution

The model thus sheds light on an important empirical phenomenon, the operation of centralized reserve pools such as LOLRs. The main results are shown to hold under a relatively restricted set of assumptions to promote analytical tractability at the cost that the analysis hides potentially important policy issues. For this reason, the model should be seen as a partial study of issues related to LOLRs. To promote further study, it may be useful to discuss the effect of some of the simplifying assumptions.

Firstly, the assumption about a continuum of agents guarantees that each agent may take the market outcome as exogenous. In real economies, people may have enough clout to significantly affect market prices. It is not clear to what extent this affects the conclusions. The first attempt of this model had discrete individuals, but that line of analysis had to be abandoned for tractability.

Secondly, the shock distribution is binary while in real economies, people face shocks of different magnitude. Under varying shock sizes institutions may have the possibility to discriminate by utilising nonlinear pricing. While this may increase the ability of institutions to affect behaviour, it is not clear to what extent the outcome of the analysis would change.

Another issue related to the assumption of binary distribution of shocks is that, if the empirical shock distribution were always perfectly smooth then the marginal utilities of consumption across agents and, subsequently, the aggregate demand schedule would be well behaved (no horizontal segments). In that case, market clearing would always guarantee a unique market price at the spot market, and a reserve pool would be redundant. While the binary distribution is an extreme case, the

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present analysis makes the relevant point that problems caused by non-smooth aggregate demand may be solved by institutional arrangements.

We have refrained from discussing issues related to governance of reserve pools, which is studied in a companion paper (Herrala 2001). While the study of governance issues gives interesting insight into potential differences in operation of private reserve pools, that analysis does not appear to change the main conclusions of this paper.

Finally, the assumption of aggregate uncertainty is a much used but unrealistic aid to analysis. Some enquiries have been made into the case of aggregate uncertainty elsewhere under relatively similar assumptions about the order of events, the target and the parameter space. It appears that, in that case, the first best is not implemented in the absence of Arrow-Debreu markets by voluntary mechanisms. A study of the case of aggregate uncertainty reinforces the conclusion that public institutions may play a beneficial role in reserve pooling arrangements.

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### Chapter 2: Public Intervention and Financial Crises: An Empirical Study<sup>14</sup>

#### Abstract

We study a financial crisis and a subsequent reregulation to test the effectiveness of public intervention in managing and preventing financial crises. The estimations yield a negative view on the matter, by uncovering significant pitfalls of public intervention. They show that, while public intervention such as quantitative easing may sustain credit supply, loan market activity can be dampened by demand for an extended period. The estimations also support the notion that, by harmonizing banks' credit market information, regulation may drive banks towards more rather than less risk taking.

Keywords: credit policy, credit constraints, stochastic frontier analysis, Basel requirements

JEL: D-14, E-32, E-51, G-21

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<sup>14</sup> Bank of Finland Research Discussion Paper 10/2009



### 2.1 Introduction

The recent financial crisis has witnessed extraordinary public intervention in the global financial system, such as quantitative easing and a major regulatory overhaul (the Basel III). However, the effectiveness of such intervention in managing and preventing financial crises is still not well known. The aim of the chapter is to study a systemic banking crisis and the subsequent reregulation (the Basel II), to test the effectiveness of public intervention.

The estimations are based on a novel econometric approach to quantify credit supply constraints. Much research effort has previously been invested to separate credit supply and demand by a proxy approach (Becker and Ivashina 2011; Jimenéz, Mian, Peydró and Saurina 2010; Vickery 2005). However, the proxy approach yields at best only indicative rather than quantitative estimates of credit availability. In contrast, the novel approach allows testing, estimation and aggregation of credit supply constraints to quantify credit availability in a borrower population. It is based on the insight that credit supply constraints truncate a normal credit demand distribution, thereby inducing a skew. This skew can be revealed and the credit supply constraint estimated by stochastic frontier analysis. The method decomposes borrowing into a credit supply constraint and its ‘utilization rate’, reflecting credit demand, analogously to how it decomposes production into a production frontier and efficiency in standard applications. The new approach extends the applicability of stochastic frontier analysis in this field, pioneered by Chen and Wang (2008). They apply the method to study credit supply to firms in Taiwan.

The estimations are based on household surveys of high statistical quality. The data are representative cross sections of households during the peak of a credit boom, a continued credit contraction after a public salvage operation of the banking system, and two post-crisis periods. Strong cyclicity makes the data well suited for the analysis of credit cycles. The post-crisis period

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is a natural experiment about the effects of regulation of credit policy, because at that time the harmonization of banks' screening methods progressed in anticipation of Basel II regulations.

The statistical tests indicate the presence of binding credit constraints in the estimation samples. Estimations reveal a significant tightening of collateral requirements during a banking crisis, and an unwinding of the collateral policy tightening after the crisis. The results indicate that the public salvage operation supported credit supply during the crisis, but it failed to revive credit market activity, which was dragged by demand for a prolonged period.

The estimations confirm a significant loosening of collateral policy and a marked expansion in credit availability in connection with Basel II preparations. This result supports Dell'Arricia and Marquez's (2006) hypothesis about the negative effects of regulation. They argue that regulation which diminishes the information asymmetries across banks, drives banks towards more risk taking in a competitive environment.

Against the best intentions, Basel II harmonization may have contributed to a significant buildup of credit risk and, thereby, to the vulnerability of the global financial system. While the ongoing Basel III process aims to improve on its predecessor, it suffers from the same shortcoming that may have been its predecessor's Achilles heel. By harmonizing banks' credit market information, regulation may drive banks towards more risk taking.

The estimation results are based on a model that is validated both by in-sample tests, and outside information about credit constraints. The results are robust to alternative specifications of the credit constraints, and assumptions of statistical residuals. The main results do not appear to be sensitive to sampling bias.

The remainder of the paper is structured as follows. The next section presents a formalization of the methodology. This is followed by a discussion of the data and the estimation period. The main estimation results and a robustness analysis are then presented. In the concluding section, we discuss the significant research agenda opened by the new approach.

## 2.2 Methodology

The present study contributes a novel approach for the econometric analysis of credit supply constraints. It opens the possibility to test the presence of such constraints in a borrower distribution and, when they are present, to estimate them by stochastic frontier analysis.

We assume that credit supply constraints are log-linear:

$$l_i \leq \beta x_i \tag{2.2.1}$$

where borrowing  $l$  (all variables in natural logs) of household  $i$  is constrained by banks' credit policy  $\beta$  regarding household characteristics  $x$ . In the literature of household borrowing, wealth and income have been included in the  $x$ -vector, with the respective  $\beta$ -parameters reflecting collateral and loan service requirements. Economic prospects and the credit record have also been proposed. (Zeldes 1989).

The credit channel literature is divided about whether the borrower distribution reaches up to the constraints. This depends, inter alia, on whether binding supply constraints are present at the loan market. Theoretical predictions fall into three qualitatively different cases. All may borrow at the constraint, as in Kiyotaki and Moore (1997). All may borrow strictly below their constraint, as in Bernanke, Gertler and Gilchrist (1998). Some may borrow at the constraint and others below it, as in one of the cases studied by Holmström and Tirole (1997). The credit market may fluctuate between the alternative states (Kehoe and Levine 2001).

To encompass the alternative states of the credit market into an empirical model, denote by  $u$  the (log) inverse 'utilization rate' of credit constraints. It is the distance of borrowing from the credit constraint:

$$u_i = \beta x_i - l_i \tag{2.2.2}$$

Rearranging, and allowing for independent normal observation error  $v$ , we can formulate the empirical relationship between borrowing and the credit constraints in the stochastic frontier form<sup>15</sup>:

$$l_i = \beta x_i + v_i - u_i \quad (2.2.3)$$

In the absence of additional assumptions about  $u$ , equation (2.2.3) is very general in that it encompasses alternative credit market states as different distributions of  $u$ . For example, when all borrow at the constraint, then  $u$  is always zero. In this case, the credit policy parameters can be estimated from (2.2.3) by standard linear regression. When some or all borrow below the constraints, then the distribution of  $u$  reaches to the positive domain. In such cases, the  $-$ distribution of  $u$  must be specified for estimation. We discuss a simple case first, and then generalize.

Assume a standard log-linear credit demand function:

$$l_i = \alpha x_i + \varepsilon_i \quad (2.2.4)$$

, where  $\alpha$  are credit demand parameters and  $\varepsilon$  a normal stochastic demand disturbance. Notice for future reference that, by (2.2.4) and (2.2.1), credit constraints are binding for households characterized by  $\varepsilon_i > (\beta - \alpha)x_i$ . Assume also, like Kehoe and Levine (2001) that households exit the credit market due to personal bankruptcy when credit constraints bind (this assumption will be relaxed at a later stage). The borrower distribution then becomes:

$$l_i = \alpha x_i + \varepsilon_i \quad \forall i: \varepsilon_i \leq (\beta - \alpha)x_i \quad (2.2.5)$$

The implied (by 2.2.2) utilization rates satisfy:

$$u_i = (\beta - \alpha)x_i + \varepsilon_i \quad \forall i: \varepsilon_i \leq (\beta - \alpha)x_i \quad (2.2.6)$$

By (2.2.6), the empirical distribution of  $u$  is either truncated normal or normal, depending on whether binding constraints are present in the borrower sample. We can test this issue from the joint distribution of  $v$ - $u$  in model (2.2.3). In the empirical analysis, we use the test by Coelli (2005) about whether the model reduces into a linear regression model. The intuition is that truncation of a normal credit demand distribution by credit supply constraints creates a skew, which is picked up

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<sup>15</sup> See e.g. Kumbhakar and Lovell (2000).

by the test. In all estimations, we find strong statistical evidence of a skew, indicating the presence of binding constraints in the borrower samples. The credit policy parameters of interest may, then, be estimated by stochastic frontier analysis.

The approach extends to encompass the realistic possibility that some credit constrained households do not exit the credit market. Instead, they may borrow at the constraint or at some level below it, thereby affecting the  $-$ distribution of  $u$ . To allow for this possibility, we explore as alternative distributions of  $u$  the half-normal, the exponential and the gamma. The approach is also consistent with the presence of an interest rate channel. In (2.2.5), they are implicit in the constant term and the idiosyncratic residual.

Since the approach is novel, much emphasis has been placed on validation, also with outside information. A particular focus has been whether the method really reveals supply rather than demand parameters, as would be the case if no-one is credit constrained. Besides the Coelli (2005) test, a number of avenues have been explored, and the supply interpretation passes all of them. The method yields parameter estimates that adhere to a supply interpretation, and indicates an institutional change at the credit market that is known to be supply related. Outside information from the credit markets validates the presence of credit constraints and their relevance to borrowers during the estimation period.

We have also compared the quantitative parameter estimates of the stochastic frontier model with outside information about banks' credit policy. This has not been straightforward, since banks do not publish such information. However, we have managed to confirm that quantitative estimates of banks' collateral policy during one of the estimation periods agrees with outside information about maximum loan-to-value ratios applied by banks (Annex).

The use of stochastic frontier analysis to estimate credit constraints from borrower data was pioneered in Chen and Wang's (2008) empirical study of Taiwanese firms. They use a different approach to specify the estimable model. The main difference is that  $u$  is excess credit supply or

demand rather than the utilization rate of credit constraints. Their approach does not extend to realistic situations in which some agents face excess credit supply and others excess demand. The limitation does not arise with our approach, which thereby extends the application of stochastic frontier analysis in the study of credit constraints. The novel approach also yields a test about whether binding credit constraints are present in the borrower distribution.

### 2.3 The data and the estimation period

The surveys by Statistics Finland are representative cross-sections of the Finnish household sector. The survey samples have been selected by two-stage stratified sampling from the population register. The samples cover 17,326 households, of which 4,783 increased borrowing during one of the estimation years 1988, 1995, 1999, and 2004, thus indicating borrower status. The data supports statistical inference about the underlying population distributions.

Table I shows the variable means in the borrower samples. The loan stock is measured at year end. The main explanatory variables are wealth at year end and monetary income during the year. The main group indicators are age and educational level, which capture differences in the long-term repayment prospects of the households. Socioeconomic, area and family-related indicators, and a proxy for repayment history are utilized in robustness analysis.

In all regressions, the time-varying regression constants capture possible inter-temporal shifts in supply. To investigate the nature of such shifts, two alternative supply shift variables are included. The variable M2 (the ratio of the monetary aggregate M2 to GDP) represents liquidity conditions, and the term spread (the margin between the 10-year bond rate and the 3-month money market rate) the potential economic gain from maturity transformation.

Table 2.1 **Variable means during the estimation years**

	1988	1995	1999	2004
Loans	2.6	2.7	2.7	2.8
Wealth	3.4	3.0	3.1	3.5
Income	3.0	3.0	3.1	3.2
Term spread	0.6	3.0	1.8	2.0
M2	0.18	0.17	0.19	0.19

Note: Sample weighted estimates. Estimation samples: 4,783 households that increased borrowing during the estimation years. The number of households is 1,732, 1,059, 1,057, and 935 in years 1988, 1995, 1999, and 2004 respectively. Loans, income, and wealth are in natural logarithms, and deflated to 1,000 euro of year 1999 by the CPI Index. Term spread (10 y. bond rate - 3 m. market rate) is in percentage points and M2 in proportion to GDP. Data sources: Loans, wealth and income: Statistics Finland; Term spread and M2: Bank of Finland.

Economic developments around the estimation period are illustrated in Figure 2.1. The first part of the estimation period is characterized by extreme cyclicity. The liberalization of credit markets in Finland in 1986 was followed by a classical ‘credit boom’ with high loan, stock and housing market growth. The estimation year 1988 marks the peak of the credit boom. After the boom phase, the economy was shattered by a systemic banking crisis and a deep recession. To hinder a full-blown financial meltdown, the Finnish government undertook a number of unusual measures in the early 1990’s. Among other things, it announced a comprehensive guarantee of the banking system, and made vast capital injections into banks.<sup>16</sup> In the estimation year 1995 the real economy was

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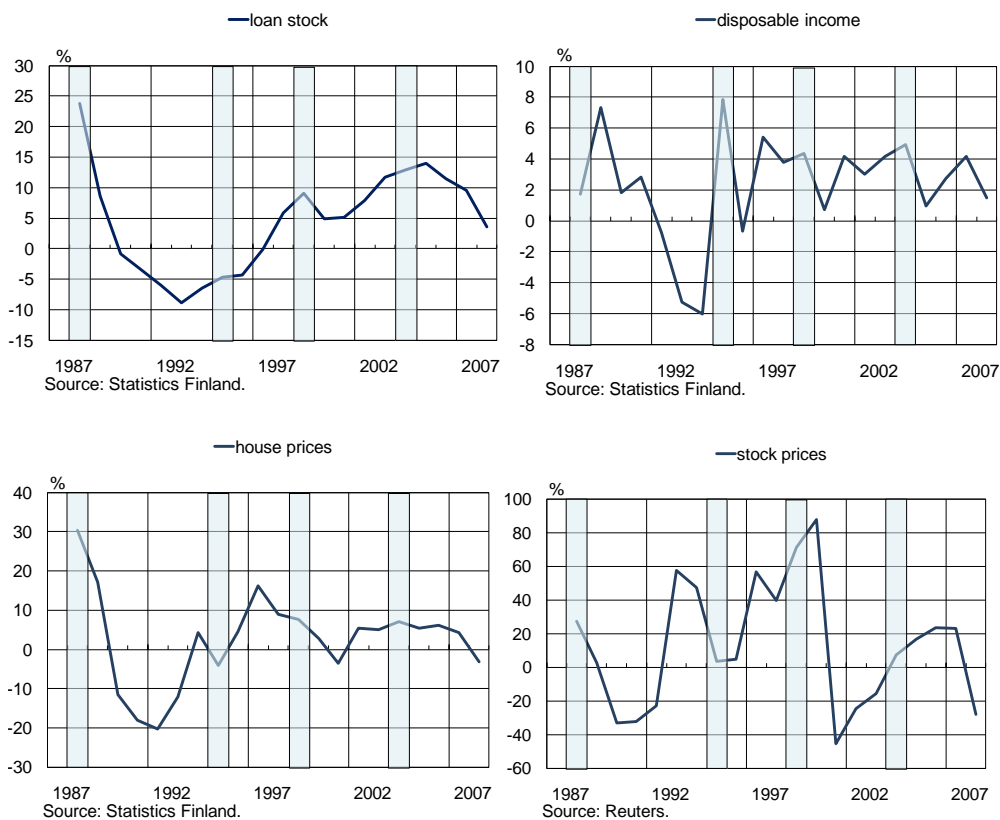
<sup>16</sup> Herrala (1999).

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recovering, but the financial contraction still continued. In 1999, both real and financial growth had returned to positive territory.

The latter part of the estimation period is characterized by preparations for the forthcoming Basel II regulatory requirements. In banks, gradual preparations were ongoing during the early 2000's. The real economy showed relative stability, but loan growth accelerated considerably.

**Figure 2.1 Annual change in the household loan stock, disposable income, house prices, and stock prices, 1987–2007**



Note: Estimation years 1988, 1995, 1999, and 2004 shaded. All variables in logs and deflated by the CPI index. Data sources: CPI, the loan stock, disposable income, and house prices: Statistics Finland; stock prices: Reuters.



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The quality of information about the loan market is variable, but certain tentative generalizations can be made. Finnish household loans originated overwhelmingly from banks, and the traditional liquidity transformation model of banking (from demand deposits to loans) applied. Sound banking practice conditioned credit availability on loan service ability, sufficient collateral and a clean repayment history. In value, fixed term and variable rate housing loans were the largest category. The bulk of housing loans were linked to market interest rates up to one year, but other interest rate linkages and fixed rates were also used. Basel II preparations were accompanied by a significant increase in loan maturities, a reduction in pre-saving for house purchases and a marked increase in household indebtedness.<sup>17</sup>

The existence of credit supply constraints and their relevance for households is not doubtful. Throughout the estimation period, the state of development of the credit market was still relatively low by standards of other developed countries, and the size of the banking sector relative to the economy was still small (European Central Bank 2003). Only limited information exists about the number of constrained households. Between 1995 and 1999, 4 % of surveyed households that did not take a housing loan cited 'insufficient collateral' as the determining factor.<sup>18</sup> In 2006, 4 % of surveyed households living in a rented house had chosen against house ownership because they did not have the necessary pre-savings to get housing finance, and 2% because they could not get credit.<sup>19</sup> The role of credit constraints in crisis dynamics has been widely discussed, but no clear consensus has emerged. Honkapohja (2009) summarizes that prior evidence of a credit crunch in connection with the Finnish and other Nordic crises seems weak.

### 2.4 Estimation results

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<sup>17</sup> See, for example, FSA: 'Rata tiedottaa 2/2010', and surveys by the Federation of Finnish Financial Services, [www.fkl.fi](http://www.fkl.fi) (both in Finnish).

<sup>18</sup> Federation of Finnish Financial Services (1999) 'Survey of Saving and Indebtedness', available in Finnish at [www.finanssialankeskusliitto.fi](http://www.finanssialankeskusliitto.fi).

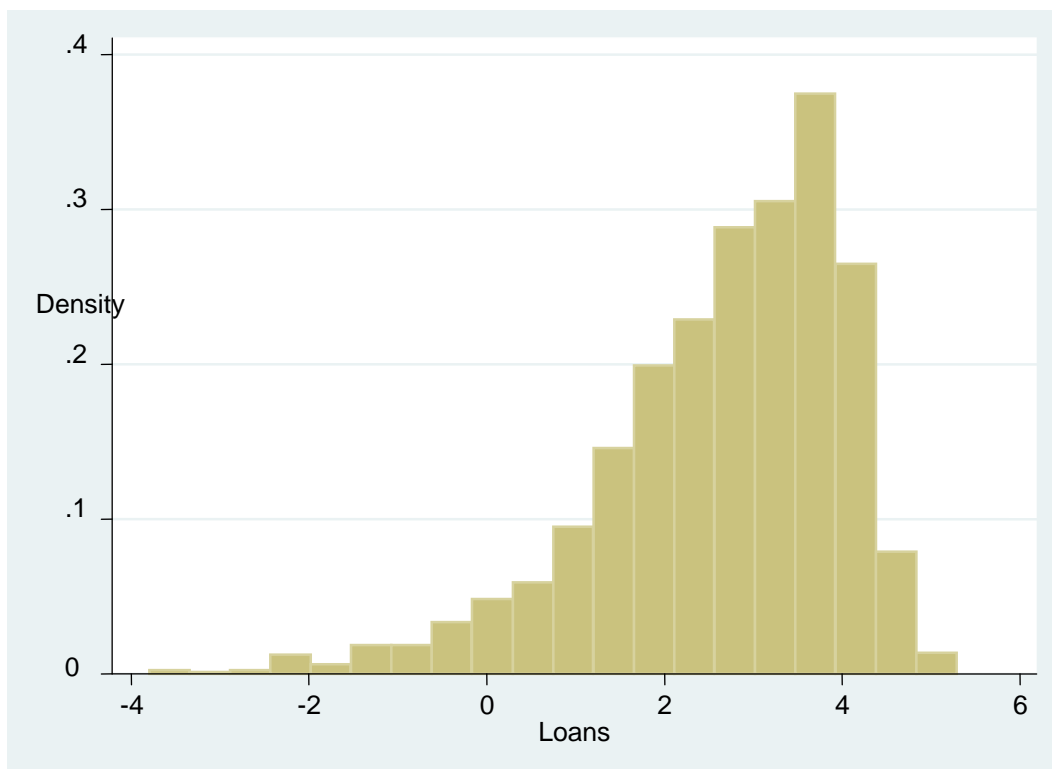
<sup>19</sup> Juntto (2007).

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A graphical analysis of the data is supportive of the presence of credit constraints. Histograms display the appropriate skew (Figure 2.2) and scatter plots appear consistent with the presence of a log-linear, upward sloping stochastic frontier (Figure 2.3). For a graphical illustration, Figures 2.2 and 2.3 also display a credit constraint estimate from a model where credit criteria include just wealth. The skew has been confirmed by the standard  $z$ -test of the variance of  $u$  as well as the test by Coelli (2005). The latter gives a  $p$  value of less than 1 % for the null hypothesis of OLS during all estimation years, thereby strongly rejecting OLS in favor of a stochastic frontier model. Based on the tests and outside information, we conclude that some agents likely were credit constrained in the borrower samples.

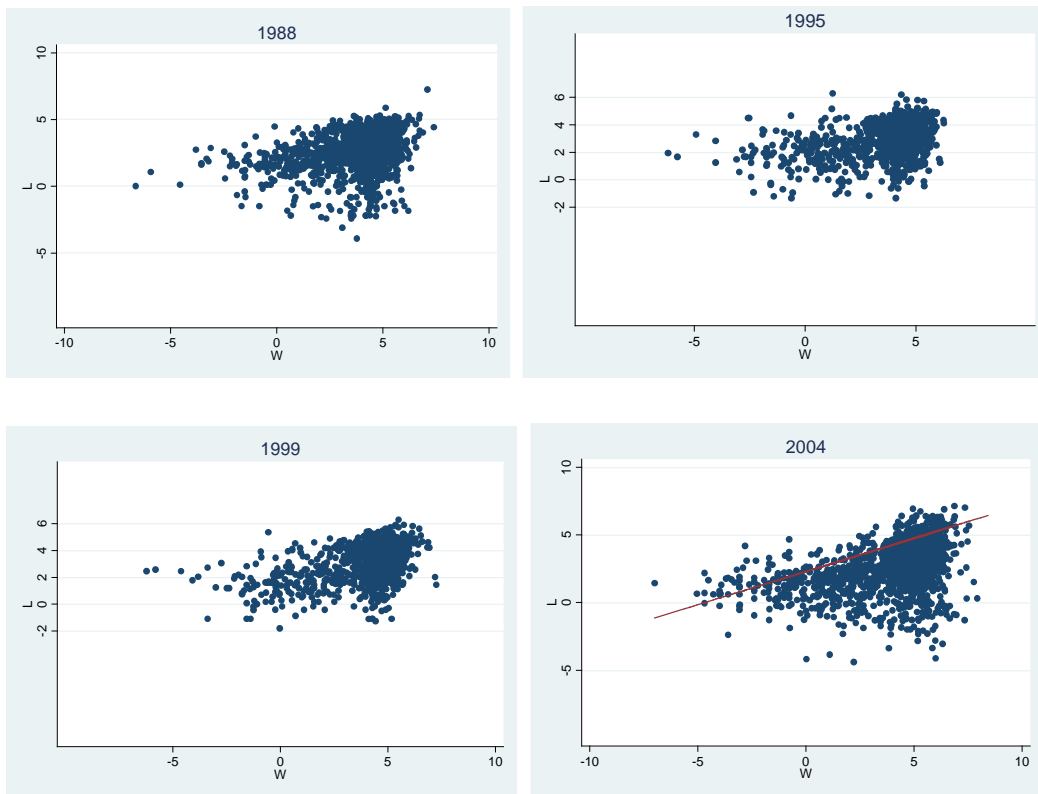
Figure 2.2 A histogram of loans in 2004 at the interval  $4 < \text{wealth} < 5$ .



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Note: All variables in logs and deflated by the CPI index. The position of the frontier marked with a dotted line. Data sources: Statistics Finland.

Figure 2.3 Scatter plots of loans and wealth in four cross sections, and a frontier line



Note: Variables L=Loans; W= Wealth. All variables in logs and deflated by the CPI index. In the frontier model, the endogenous variable was loans, and the exogenous variable was wealth and a constant. Data sources: Statistics Finland.

The five models presented in Table 2.2 utilize alternative assumptions about the distribution of  $u$ , and the set of explanatory variables. Model 1 (Table 2.2, columns 3–6) includes variable effects of wealth and income across time periods and age and educational groups. The supply shift variable is aggregate liquidity (M2). We choose the half-normality assumption here, because the more general

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truncated normal resulted in stability issues. Heteroscedasticity is allowed and confirmed with respect to the main variables and in time.

**Table 2.2 Estimates of the  $\beta$  -vector**

		Model 1				Model 2				Model 3			
		All	1995	1999	2004	All	1995	1999	2004	All	1995	1999	2004
constant	A0	-5.48 (9.69)	-0.53 (0.96)	-1.91*** (0.6)		-4.56 (7.94)	-0.79 (0.85)	-2.17*** (0.54)		3.77*** (0.86)	-0.98 (1.44)	-0.68 (0.77)	
	A1	-6.54 (9.55)	1.62* (0.83)	0.94 (0.78)	0.94 (0.78)	-5.9 (7.8)	1.64** (0.75)	1.24* (0.7)	1.24* (0.7)	3.59*** (1)	0.45 (1.6)	1.54 (1.19)	1.54 (1.19)
	A2	-6.44 (9.54)	0.73 (0.7)	-0.65 (0.62)	-0.65 (0.62)	-5.73 (7.78)	0.67 (0.62)	-0.66 (0.56)	-0.66 (0.56)	4.15*** (0.82)	-0.19 (1.58)	0.21 (1) (1.25)	0.21 (1) (0.93)
	EU	0.59 (0.51)	-0.2 (0.94)	-0.32 (1.19)	-0.79 (0.69)	0.8 (0.52)	-0.29 (0.92)	-0.27 (1.09)	-0.9 (0.69)	0.81 (0.69)	-0.31 (1.01)	-0.19 (1.25)	-0.48 (0.93)
Wealth	A0	0.28*** (0.03)	0.01 (0.06)	0.01 (0.04)	0.14*** (0.06)	0.3*** (0.03)	0.01 (0.05)		0.15*** (0.04)	0.42*** (0.06)	-0.08 (0.07)	0.01 (0.06)	0.03 (0.07)
	A1	0.33*** (0.04)	-0.1** (0.05)	0.02 (0.05)	0.25*** (0.06)	0.34*** (0.03)	-0.11** (0.05)	0.02 (0.05)	0.24*** (0.05)	0.49*** (0.07)	-0.25*** (0.07)	-0.15** (0.07)	0.03 (0.07)
	A2	0.28*** (0.03)	-0.07* (0.04)	0.08* (0.05)	0.07** (0.03)	0.28*** (0.03)	-0.07 (0.04)	0.08 (0.05)	0.05 (0.04)	0.42*** (0.07)	-0.24*** (0.08)	-0.04 (0.08)	-0.08 (0.07)
	EU	-0.28*** (0.07)	0.2 (0.15)	0.16 (0.11)	0.27*** (0.09)	-0.27*** (0.07)	0.21 (0.14)	0.16 (0.11)	0.3*** (0.09)	-0.27*** (0.07)	0.17 (0.14)	0.16 (0.12)	0.21* (0.12)
Income	A0	0.32*** (0.12)	0.31 (0.22)	0.44** (0.17)	-0.25 (0.24)	0.32*** (0.11)	0.39* (0.21)	0.55*** (0.17)	-0.21 (0.19)	-0.37 (0.38)	0.73 (0.69)	0.14 (0.55)	-0.02 (0.47)
	A1	0.54*** (0.13)	-0.21 (0.18)	-0.37* (0.19)	-0.42** (0.18)	0.63*** (0.12)	-0.21 (0.17)	-0.44** (0.18)	-0.46*** (0.16)	-0.41 (0.44)	0.48 (0.75)	-0.32 (0.68)	-0.09 (0.52)
	A2	0.39*** (0.07)	0.1 (0.11)	0.02 (0.11)	0.13 (0.08)	0.47*** (0.08)	0.09 (0.12)	0.03 (0.12)	0.18** (0.09)	-0.62* (0.37)	0.75 (0.73)	-0.05 (0.61)	0.41 (0.45)
	EU	0.24 (0.18)	-0.24 (0.3)	-0.14 (0.38)	-0.18 (0.24)	0.18 (0.18)	-0.23 (0.29)	-0.17 (0.35)	-0.17 (0.23)	0.17 (0.22)	-0.15 (0.32)	-0.16 (0.4)	-0.18 (0.33)
M2	43.83 (53.65)		36.32 (43.79)										
Term spread									0.02 (0.59)				
Inverse Mill's ratio									-0.91*** (0.1)				
Wealth*M2													
Income*M2													
Wealth*Income									-0.06*** (0.02)				
Wealth^2									0.01** (0.01)		0.01 (0.01)	0.02** (0.01)	0.03*** (0.01)
Income^2									0.13* (0.07)		-0.09 (0.12)	0 (0.1)	-0.03 (0.08)
Distribution of u	half normal		exponential						half normal				

Note: Sample weighted estimates. Estimation sample: 4,783 households that increased borrowing during the estimation years. The endogenous variable: loans. Group indicators: A0=age below 31 years; A1= age 31–45 years; A2= age over 45 years; EU= university level. All variables in natural

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logarithms and deflated to 1,000 euro of year 1999 by the CPI Index.  $*/**/**=10\%$   $/5\%$   $/1\%$   
significance. Standard errors in parenthesis.

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Table 2.2 continued

		Model 4				Model 5			
		All	1995	1999	2004	All	1995	1999	2004
constant	A0	2.71*** (0.74)	-2.45* (1.3)	-3.17*** (0.91)		-1.6 (9.65)	-1.11 (1.3)	-0.27 (0.58)	
	A1	2.3** (0.89)	-0.81 (1.47)	-0.52 (1.24)	-0.52 (1.24)	-2.06 (9.72)	0.41 (1.43)	2.16** (0.95)	2.16** (0.95)
	A2	3.17*** (0.75)	-1.81 (1.45)	-2.99*** (1.06)	-2.99*** (1.06)	-0.75 (9.65)	0.56 (1.51)	-0.02 (0.84)	-0.02 (0.84)
	EU	0.84 (0.64)	-0.36 (0.96)	0.46 (1.17)	-0.34 (0.86)	0.69 (0.58)	-0.14 (0.99)	-0.54 (0.96)	-0.39 (0.79)
Wealth	A0	0.37*** (0.06)	-0.09 (0.07)	-0.1* (0.05)	0.06 (0.06)	0.3*** (0.05)	-0.08* (0.04)	0 (0.04)	0.05 (0.04)
	A1	0.43*** (0.06)	-0.25*** (0.06)	-0.24*** (0.07)	0.02 (0.06)	0.35*** (0.06)	-0.21*** (0.04)	-0.18*** (0.05)	-0.01 (0.05)
	A2	0.37*** (0.07)	-0.29*** (0.08)	-0.15** (0.07)	-0.08 (0.06)	0.28*** (0.06)	-0.32*** (0.07)	-0.05 (0.07)	-0.19*** (0.06)
	EU	-0.27*** (0.07)	0.19 (0.13)	0.22** (0.11)	0.24** (0.11)	-0.25*** (0.06)	0.2 (0.13)	0.17** (0.09)	0.16 (0.11)
Income	A0	-0.08 (0.33)	0.84 (0.65)	0.94 (0.59)	-0.5 (0.43)	0.37 (0.34)	0.74 (0.62)	-0.16 (0.47)	-0.32 (0.41)
	A1	-0.04 (0.39)	0.52 (0.72)	0.35 (0.7)	-0.65 (0.5)	0.43 (0.4)	0.37 (0.68)	-0.66 (0.59)	-0.4 (0.48)
	A2	-0.36 (0.34)	0.92 (0.71)	0.94 (0.64)	-0.04 (0.44)	0.07 (0.37)	0.58 (0.71)	-0.27 (0.55)	0.14 (0.46)
	EU	0.17 (0.21)	-0.17 (0.31)	-0.41 (0.36)	-0.25 (0.3)	0.16 (0.19)	-0.22 (0.34)	-0.12 (0.3)	-0.07 (0.28)
M2						19.92 (52.36)			
Term spread		0.5 (0.51)							
Inverse Mill's ratio		-0.87*** (0.09)				-0.29** (0.12)			
Wealth*M2									
Income*M2									
Wealth*Income		-0.04** (0.02)				-0.03* (0.02)			
Wealth^2		0.02** (0.01)	0.01 (0.01)	0.02** (0.01)	0.03*** (0.01)	0.01* (0.01)	0.02*** (0.01)	0.03*** (0.01)	0.05*** (0.01)
Income^2		0.08 (0.06)	-0.09 (0.11)	-0.03 (0.1)	0.06 (0.08)	0.03 (0.06)	-0.09 (0.11)	0.04 (0.09)	0 (0.07)
Distribution of u		exponential				truncated normal			

Note: Sample weighted estimates. Estimation sample: 4,783 households that increased borrowing during the estimation years. The endogenous variable: loans. Group indicators: A0=age below 31 years; A1= age 31–45 years; A2= age over 45 years; EU= university level. All variables in natural

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logarithms and deflated to 1,000 euro of year 1999 by the CPI Index.  $*/**/**=10\%/5\%/1\%$  significance. Standard errors in parenthesis.

Column 3 of Table 2.2 shows the parameter estimates of model 1 during the year of comparison, which is 1988 by exclusion. They indicate the tightness of banks' credit policy at that time. The estimates accord well with expectations. The marginal effects of wealth and income, and aggregate liquidity on credit availability are, in the main, positive. The estimated marginal effect of wealth among non-university educated households was around 0.3, indicating that an increase in wealth by one unit increases credit availability by close to one third. To put this value into perspective, this estimate is below the typical loan-to-value ratios imposed by banks on housing loans, which were typically around 70 %. The difference arises, because not all kinds of wealth are routinely accepted as collateral by banks. Furthermore, households have access to uncollateralized credit (both commercially and through government sponsored schemes) at low levels of borrowing. As they accumulate debt, collateral requirements increasingly reflect their total debt burden.

The negative estimate of the marginal effect of wealth in 1988 in group EU (highly educated households) indicates a specific institutional feature, namely the state sponsored student loan scheme. In 1988, this scheme was still active and, accordingly, the role of collateral in credit availability was significantly diminished among highly educated households. The effect vanished during the 1990's with the overhaul of the scheme. It is a merit to the approach that the model picks up this institutional change in credit supply.

Columns 4–6 of Table 2.2 show the parameters in 1995, 1999 and 2004. These parameters indicate the quantitative change in banks' credit policy relative to the benchmark period 1988. The estimates show a significant tightening of collateral policy between 1988 and 1995, as the marginal effect of wealth decreased in age groups A1 and A2. Based on point estimates, the tightening was about 10 %. The simultaneous increase in the fixed effects suggests that other aspects of credit

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policy, unrelated to borrower characteristics, contributed positively to credit availability. Most likely, the government salvage operation was boosting credit availability across the board. Among the youngest households (A0) credit availability was adversely affected by the fading of the student loan scheme.

The parameter estimates of year 1999 are broadly consistent with an unwinding of the changes in credit policy that had occurred between 1988 and 1995. By 1999, the credit policy parameters had returned towards or beyond the 1988 levels.

Significant changes in credit policy are observed during the Basel II preparations. The broadly based increase in the marginal effects of wealth in 2004 indicates a marked loosening of collateral policy towards household borrowers. In some age groups, the wealth effect on credit availability almost doubled relative to 1988. This result is not inconsistent with outside information about the issue. In 2004, the Financial Supervision Authority expressed concerns about loosening collateral policy in banks (Annex 2). Around that time, the central bank started to monitor banks' credit policy by bank lending surveys, and the early surveys indicate a marked loosening of banks' collateral requirements.

The aggregate impact of changes in credit policy on credit supply may be assessed by comparing the (survey weighted) average values of the credit supply constraints during the four estimation years. The survey methodology allows statistically valid aggregation of the results to the macroeconomic level. Table 2.3, column 2, shows the average levels of credit constraints in model 1, estimated from the four borrower samples. The point estimate of credit availability was 10 % lower in 1995 than in 1988. A decline of this scale is not within the scope of aggregation error. By 1999, credit availability had recovered to the 1988 level. By point estimates credit availability increased by almost 50 % between 1999 and 2004.



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Table 2.3 **Credit availability during the estimation years**

	Model 1	Model 2	Model 3	Model 4	Model 5
1988	4.0	3.7	4.0	3.6	3.9
1995	3.9	3.6	4.0	3.7	3.9
1999	4.0	3.6	3.9	3.4	3.9
2004	4.4	4.1	4.3	4.0	4.2

Note: Sample weighted estimates from the borrower samples. Credit availability is measured by the average fitted values of the constraints. Measurement unit: 1,000 euro of year 1999 in natural logarithms.

Table 2.4 **Average utilization rates**

	Model 1	Model 2	Model 3	Model 4	Model 5
1988	1.3	2.0	1.3	1.0	1.3
1995	1.2	1.5	1.2	1.0	1.2
1999	1.2	1.3	1.2	0.6	1.3
2004	1.4	2.7	1.3	1.5	1.3

Note: Sample weighted estimates from the borrower samples. The standard estimator by Jondrow et al (1982) has been used. Measurement unit: 1,000 euro of year 1999 in natural logarithms.

The method also yields insight about credit demand, which determines the average utilization rates of household credit constraints. It is observed in table 2.4, column 2, that demand contracted in model 1 during the crisis period and remained at low levels during the years 1995-98. By 2004, credit demand had increased beyond the pre-crisis levels. The estimation results, then, indicate that credit demand recovered slowly from the crisis.

All in all, model 1 reveals a dramatic picture of credit market developments. In line with theoretical predictions, a highly significant tightening of collateral policy is observed during the crisis, and a subsequent loosening during the post-crisis recovery. In the midst of tightening collateral requirements, government intervention supported credit supply. Government intervention

did not suffice to revive credit market activity, which was dragged by demand for an extended period. This may explain the much discussed ‘slow recovery’ from the present crisis.

The regulatory response to global financial instability in the 1990’s, the Basel II agreement, aimed to strengthen the global financial system against future challenges. Yet, as we now know, the regulatory overhaul was followed by one of the largest global financial crises of all time. Critics of Basel II agreement, such as Dell’Arricia and Marquez (2006), maintain that, instead of a solution, the regulatory response may have been part of the problem. This claim is supported by the strong evidence of broad-based loosening of credit policy during the Basel II implementation.

### 2.5 Robustness analysis

The robustness of these results with respect to variable selection, the distribution of  $u$ , and sampling can be studied with the help of models 2 - 5 (Table 2.2). Model 2 can be used to investigate the robustness of the estimation results with respect to the distribution of  $u$ : model 2 differs from model 1 in that  $u$  is exponential rather than half normal. To further test robustness with regard to functional form of the frontier, models 3-5 include additional second order effects of the main variables. The effect on the estimation results of adding exogenous explanatory variables to the distribution of  $u$  can be assessed with model 5, where  $u$  is conditioned by lagged wealth per consumption unit, income, age, education, socioeconomic status, and area.

The inverse Mill’s ratio from a Probit model is included in the frontier specification in models 3 - 5 to control for possible sample selection bias, in accordance with the Heckman method. Sampling bias would arise if sampling probability were correlated with credit constraints. Lagged wealth per consumption unit, income, consumption units, the margin between the loan and deposit rate, and

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group indicators for age, education, socioeconomic status and area are used to explain credit market entry in the Probit model.<sup>20</sup>

A consistent finding across all models is that the marginal effect of wealth decreased significantly between 1988 and 1995 and increased during the post-crisis period in age group A1 (Table 2.2). In four out of five models, this is also observed in age group A2. All models show improved credit availability in 2004 (Table 2.3). In all models, average utilization rates of credit constraints are at their lowest in 1998 (Table 2.4).

In contrast with models 1 and 2, the variable effects of income are mostly insignificant in models 3 - 5. We would tentatively interpret the across-models variation in the income effect as a symptom of a highly nonlinear relationship of income and credit availability across borrowers. For the bulk of households at the middle of the income distribution, the income effect would be weak because collateral constraints were binding before repayment ability became an issue. Credit availability at the lower end of the income spectrum was affected by numerous government sponsored credit schemes for low income households.<sup>21</sup>

Development in credit availability, and whether changes in other supply parameters besides collateral requirements significantly contributed to it during the crisis cycle, also varies across the models. It must be concluded, then, that the difference in credit availability between the credit boom and the post salvage period was not great enough to be unambiguously discernible with the method. The results are robust with respect to family size, labor market status, and socioeconomic status. A Probit model for household payment distress, based on Herrala (2009)<sup>22</sup> was used to construct a proxy of payment history, but addition of this variable did not significantly affect the results. The main results also hold under other distributional assumptions of  $u$ , such as the gamma, and

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<sup>20</sup> See Magri (2007) for a previous econometric study of credit market entry. The fit of the Probit model used in this paper is slightly better than the one estimated by Magri. Comprehensive tabulations of all models are available from the author.

<sup>21</sup> Such programs have included the student loan scheme, and a credit scheme for low income families by the municipalities. The government-sponsored ASP loan scheme for first-time house buyers de facto targeted low income households, as a cap on the maximum price per square meter was imposed.

<sup>22</sup> Herrala (2009), Table 1, model SD.

alternative formulations of the second moments. The results remain valid also after exploration of Greene's (2009) sample selection model.

We find, then, the main results to be robust to alternative specifications of the model, and alternative assumptions about the residual distribution, and sampling error. The underlying assumptions of the model have been validated both by within-sample tests, and outside information about credit supply.

### 2.6 Concluding remarks

We use stochastic frontier analysis to study credit supply to households during a pronounced boom-bust cycle and its aftermath. The empirical analysis supports the presence of binding credit supply constraints in the borrower samples. It indicates that collateral policy towards household borrowers tightened during the crisis years. Even after an extensive public salvage operation, credit market activity remained low for an extended period due to low demand. Towards the end of the sample, the preparations for the Basel II regulation were associated with a credit expansion and a renewed buildup of credit risk. This result is consistent with Dell'Arricia and Marquez's (2006) prediction that regulatory change which harmonizes banks' credit market information may lead to more risk taking.

We see the present analysis as only a first step in a large and, in our view, important research agenda opened up by the new approach. One part of that agenda is validation and supplementation of our test results by further studies. The weakness of the supply shifters is clearly an issue of significant future interest. In our data set the issue may be related to the effects of government intervention during the crisis, which may not be properly captured by a single supply indicator that also works well during the other periods. We tried alternative supply shifters, such as long term interest rates, but their contribution remained negligible. The potential for further study in this data

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is limited by the time dimension (only four periods and no panel). With panel data, one could also test the robustness of the results against more general residual distributions.

More generally, since credit supply constraints have not been previously easily estimable, there is much scope for further study. With the new approach, credit constraints may be estimated by standard statistical techniques from borrower surveys in different sectors, countries, and time. Such studies could raise our understanding of credit availability to a new, quantitative rather than indicative, level. Work is ongoing by us and others along these lines.

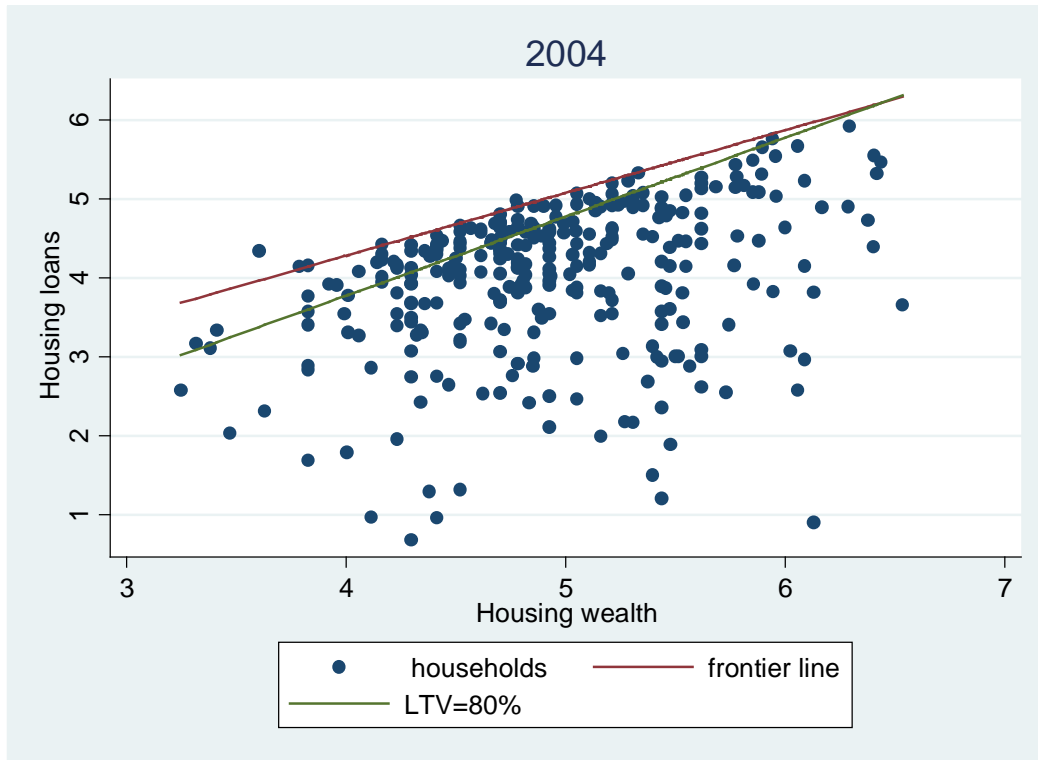
The novel approach also opens possibilities to study behavior outside the credit market. Credit constraints may significantly affect many kinds of economic behavior, such as consumption and investment. Empirical research has been challenged by the absence of satisfactory methods to quantify credit supply constraints. Our ongoing efforts aim to shed light on the relationship between credit constraints and consumption.

In terms of developing the new approach further, an interesting research issue is the interpretation of the distribution of the utilization rate which reflects the interplay of demand and supply at the credit markets. By using this distribution to test alternative theoretical models, one may significantly advance our understanding of the credit market equilibrium. It should also be noted that the approach outlined in this paper can be applied with small adjustments to study other types of constraints besides credit constraints.

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Figure 2.4 (with annex) A scatter plot of housing loans and housing wealth of households that increased housing loans in 2004, with a frontier line and an 80 % Loan-To-Value line



Note: All variables in logs and deflated by the CPI index. In the frontier model, the endogenous variable was housing loans and the exogenous variable was housing wealth and a constant. Loan-To-Value is housing loans divided by housing wealth. Nr. of observations is 313. Data source: Statistics Finland.

### Annex 2

In June 2004, the Financial Supervisory Authority (FSA) surveyed banks' lending practices to assess compliance of credit policy objectives. The survey results were favorable, and the FSA concluded that 'Banks typically apply loan-to-value ratios of 60-80 % on housing loan applicants. Additional uncollateralized finance is only seldom made available'.<sup>23</sup>

The Bank Lending Surveys by the Bank of Finland indicate a loosening of banks' credit policy during the latter half of year 2004. Combined, these sources indicate that the maximum amount of housing loans obtainable by a household during year 2004 as a whole would have been somewhat in excess of 80 % of the value of the house.

Figure 4 shows a scatter plot of the 313 households that increased their stock of housing loans in 2004 in my data. The lower of the two lines is the 80 % Loan- To-Value (LTV) ratio. A significant proportion of borrowers (23 %), in fact, exceeded the 80 % LTV level in the data, which may be explained by the Bank Lending Survey results of a loosening of credit conditions during the latter half of 2004.

The upper line, a frontier estimate from a bivariate model, is in the immediate vicinity of the 'edge' of the scatter plot. It is near the 80 % LTV ratio for large housing loans, and above it for small housing loans. The estimation results, then, are in line with the extra sample information about banks' credit policy. They complement the survey results by providing a quantitative characterization of credit conditions at the housing loan market.

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<sup>23</sup> The Finnish Financial Supervisory Authority: 'RATA Tiedottaa'- Tiedote 5/2004 (In Finnish)



### Chapter 3: Credit Conditions and Durable Consumption: Evidence of a Strong Link<sup>24</sup>

#### Abstract

We study empirically the effect of credit constraints on consumption by a novel method. The analysis provides evidence of a significant marginal effect in micro data, as well as a large macro effect. The estimations indicate that loose credit conditions generated a consumer spending spree in connection with a boom-bust cycle in Finland that ended in a systemic banking crisis. The hypothesis that consumer sentiment contributed to consumer behaviour is not supported.

Keywords: durable consumption, credit constraints, stochastic frontier analysis

JEL: D12, D91, E21

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<sup>24</sup> Bank of Finland Research Discussion Paper 15/2010.

### 3.1 Introduction

Two decades after Zeldes' (1989) pioneering contribution, economists still struggle to quantify the effect of credit constraints on consumption. Past econometric efforts have revealed indirect evidence, including rejections of loan applications, and excess sensitivity of consumption to current income and to credit conditions (Attanasio et al. 2008; Gross and Souleles 2002; Attanasio and Jappelli 2001, Jappelli 1990 among others). In a recent study that is perhaps the closest to our work, Leth-Petersen (2010) presents econometric evidence of a significant albeit small response of household expenditure to a credit market reform in Denmark.

The issue implicates macroeconomics generally, because consumer behaviour affects the macroeconomic equilibrium. However, direct estimation of the quantitative effect of credit constraints on aggregate consumption has been challenged by the difficulty of measuring the credit constraints and thereby, their shadow price. This has left open the possibility that the macroeconomic effect of credit constraints on consumption could still be negligible. Non-classical dynamics in consumption aggregates could primarily reflect other deviations from classical assumptions, such as habit formation (Campbell and Mankiw 1989), impatience (Carroll 1997), and shocks to consumer sentiment (Carroll et al 1994). Leth-Petersen's (2010) results accord with this status quo.

We pioneer a novel approach for estimating the marginal effects of credit constraints on consumption from micro data. By an application to a survey panel that supports inference about the underlying household population, the macroeconomic effect of credit constraints on aggregate consumption can thereby be approximated.

We also contribute to the literature by an empirical application, which reveals quantitative evidence of a significant and large macroeconomic effect of credit constraints on durable consumption. The estimations indicate that loose credit conditions generated a consumer spending spree in connection with a boom-bust cycle that ended in a systemic banking crisis. The results

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compliment the earlier findings by Leth-Petersen (2010), Gross and Souleles (2002), Attanasio and Jappelli (2001) and others by providing the first estimates of the marginal effect in micro data, as well as quantitative evidence of a large macro effect.

Our approach is builds on the analysis of the previous section, where we present an econometric approach for quantifying the credit constraints. In this chapter we show that the ability to measure credit constraints even imperfectly opens the possibility to estimate their marginal effect on consumption by standard regression techniques.

We estimate the marginal effect of credit constraint on consumption in a dynamic empirical model, which encompasses the earlier hypotheses as a special case. The regressions test the credit constrained consumption hypothesis against the classical hypothesis by Hall (1978) and Mankiw (1982), the extensions by Campbell and Mankiw (1989) and Carroll (1997), as well as the empirical hypothesis that consumer sentiment contributed to the spending spree (Carroll et al 1994). We assess the robustness of the results with respect to alternative estimation techniques, and specifications of the dynamic model.

Our estimations also contribute to the understanding of macroeconomic cycles, since our estimation period covers a 'consumer spending spree' in the aftermath of credit market deregulation. In the contemporary discussion, loose credit conditions were blamed for promoting 'reckless' consumer behaviour, and thereby contributing to the adverse economic developments that followed: a classic boom-bust cycle that ended in a systemic banking crisis, widely referenced in international studies.<sup>25</sup> Our estimations are based on the durable consumption behaviour of about 4800 households during the spending spree.

The analysis of credit constraints confirms a marked loosening of credit conditions after credit market deregulation. Regression analysis with a dynamic model confirms a significant effect of

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<sup>25</sup> See Reinhart and Rogoff (2008) and references.

credit constraints on durable consumption, and indicates that the effect was large at the macroeconomic level. The results appear robust to estimation technique and model specification.

The paper is organized as follows. The next section presents the data and the methodology. The econometric estimation of the constraints and their behavioural effect follows. The analysis is completed by a robustness assessment. A short summary and views on the future agenda conclude.

### 3.2 Data and methodology

The estimation data is of particular interest for the study of the effects of credit constraints on durable consumption for three main reasons. Firstly, it covers a sufficiently rich set of variables in a two year panel to allow the testing of the credit constrained consumption hypothesis against the alternative hypotheses discussed above. Secondly, the survey methodology supports aggregation, thereby allowing inference about the macroeconomic aggregates. Finally, the survey period is part of a boom-bust cycle, so that the analysis yields rare insight about the role of credit constraints and consumption on macroeconomic cyclicity.

The estimation data is a rotation panel survey by Statistics Finland from years 1987-8.<sup>26</sup> The sampling method was two-stage stratified sampling from the official population register. The response rate in 1987 was about 80 %, resulting in a sample of 5566 households in 1987, of which 5276 remained in 1988. Our estimation sample is, depending on the model, reduced to about 4800 households due to missing variables.

Compared with the later surveys in the ongoing series, the data set is special in that the two year rotation allows a study of durable consumption in a dynamic model. The complex survey methodology supports aggregation of the results to the underlying population of the Finnish household sector. We use sampling weights by the data provider in estimations and aggregation for

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<sup>26</sup> The 'Survey of saving and indebtedness' was part of the Finnish official statistics by Statistics Finland. See Statistics Finland, *Tulot ja kulutus* 1997:17, and <http://www.stat.fi/meta/til/vtutk.html> (mostly in Finnish).

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inference about the underlying population. Due to the presence of missing observations, we have verified the main results by non-weighted regressions.

The survey covers, inter alia, the income, debt, and wealth (including durable wealth) of the respondents, collected by on-site interviews and the Finnish official registry. The stock of durable wealth in the survey includes real estate (own house, secondary house, and other real estate) and vehicles (cars, caravans, boats, motorcycles, and snowmobiles). Wealth valuation reflects market value at the end of 1987. Wealth in 1988 has been obtained by adding to that value wealth purchases during 1988. Table 3.1 shows the variable means. In estimations, 1988 is treated as the present and 1987 as the past.

Table 3.1 **Variable means**

	Mean	Std. Dev.	95 % confidence	
durable wealth 1987	3.60	0.031	3.54	3.66
durable wealth 1988	3.74	0.030	3.68	3.80
loans 1987	2.24	0.030	2.18	2.30
loans 1988	2.33	0.031	2.27	2.39
wealth 1987	3.77	0.028	3.72	3.83
wealth 1988	3.91	0.026	3.86	3.96
income 1987	2.86	0.011	2.84	2.88
income 1988	2.89	0.012	2.86	2.91

Note: All variables in natural logarithms of 1000 € Data sources: Statistics Finland.

The estimation period covers a boom phase of the Finnish economy after the deregulation of credit markets in 1986. Years 1987 and 1988 were characterized by record real consumption growth of over 5% per annum, not surpassed since then. The speedboat, ill fitted for the Finnish archipelago, became a symbol of excess during the time. A view often presented when discussing the events is that loose credit conditions, brought about by credit market deregulation, contributed to a consumer spending spree.<sup>27</sup>

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<sup>27</sup> See Herrala (1999) for discussion and references.

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Our estimation strategy follows Carroll's (2001) recommendation that empirical growth regressions should be preferred over the estimation of structural parameters of specific theoretical models. Given the measurement issues and model uncertainty, exacerbated in our case by structural changes at the credit market during the estimation period, any structural interpretation of the estimated parameters would be highly suspect.

We study consumption dynamics with an empirical model of the form:

$$C_{i,1988} = \alpha_c C_{i,1987} + \alpha_\pi \pi_{i,1988} + \varepsilon_i \quad (3.2.1)$$

, where  $i$  denotes households,  $C$  the stock of durable wealth,  $\pi$  a credit constraint,  $\alpha$  parameters, and  $\varepsilon$  a standard normal random variable. The analysis proceeds from basic to general. Extensions to the basic model (3.2.1) include lagged constraints, age, education level, socioeconomic status, area, consumer sentiment as well as non-linear effects. The consumer sentiment indicator is a survey response regarding the respondent's expectations about durable consumption ability in 1988 compared with the previous year.

The empirical model (3.2.1) encompasses Mankiw's (1982) classical model of durable consumption as a special case ( $\alpha_c = 1$  and  $\alpha_\pi = 0$ ). A non-zero constant and a below-unity own elasticity can reflect, inter alia, impatience or habit formation (Carroll 2001, Attanasio and Jappelli 2001, and references). The parameter  $\alpha_\pi$ , the marginal effect of constraints on consumption, reflects deviations from classical dynamics due to the influence of credit constraints.

Since credit constraints are not observable, we use estimates instead. The constraint estimates are constructed by the approach by Herrala (2009). He studies credit constraints of the form:

$$\pi_{it} = \beta_t X_{it} + v_{it} \quad (3.2.2)$$

, where  $t$  denotes time,  $X$  household characteristics relevant for credit policy,  $\beta$  credit policy parameters, and  $v$  random normal variation. All variables are in natural logarithms. A critical insight is that observed borrowing  $L$  may be decomposed into the credit constraint and its utilization rate  $-u$ :

$$L_{it} = \pi_{it} - u_{it} \quad (3.2.3)$$

From (3.2.2) and (3.2.3) it follows:

$$L_{it} = \beta_t X_{it} + v_{it} - u_{it} \quad (3.2.4)$$

Equation (3.2.4) is a stochastic frontier model from which the credit policy parameters  $\beta$  can be estimated. Standard estimation techniques apply when  $v$  and  $u$  are independent,  $v$  is standard normal, and  $u$  is either exponential or half normal.

Since banks' credit policy is independent of the actions of individual households<sup>28</sup>, the credit policy parameter estimates  $\hat{\beta}$  can be used to calculate a credit constraint estimate at any level of the  $X$  vector:

$$\hat{\pi}_{it}[X] = \hat{\beta}_t X = \pi_{it}[X] - v_{it} + (\hat{\beta}_t - \beta_t)X \quad (3.2.5)$$

Under the assumption that estimation error  $(\hat{\beta} - \beta)$  is negligible, which is supported by the relatively large sample size,  $\hat{\pi}_{it}[X]$  is an unbiased estimator of the underlying constraint for any  $i$  at  $X$ . The stochastic frontier model also yields an estimate of the measurement error variance, the variance of  $v$ .

Since we are interested in the causal effect of constraints on consumption, we measure the credit constraint estimate (3.2.5) of households at the beginning of 1988, before durable consumption expenditure affected the credit constraints. The constraint estimate used in the dynamic regression is:

$$\hat{\pi}_{i,1988} = \hat{\beta}_{W,1988} Weath_{i,1987} + \hat{\beta}_{O,1988} Other_{i,1988} \quad (3.2.6)$$

, where 'Other' refers to exogenous household characteristics.

The dynamic consumption equation (3.2.1) is, then, estimated by using errors-in-variables techniques. As a robustness check, we use also instrumental variables and standard linear

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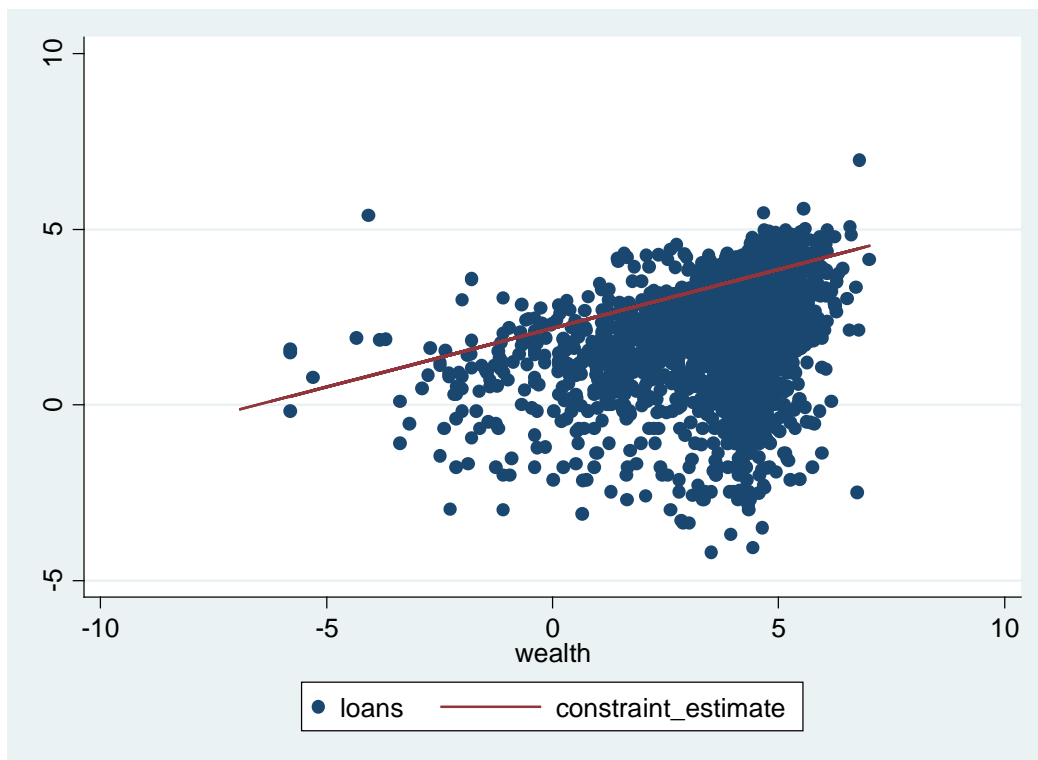
<sup>28</sup> Banks must, by regulation, have a written credit policy which governs credit decisions. It is the main tool through which bank leadership exert influence on the banks credit market behavior. The policy is by nature independent of the behavior of individual borrowers.

regression. The instrumental variables approach corresponds with the idea that consumers have imperfect information about their credit market status and that, therefore, they base their behaviour on proxies of credit constraints rather than the real underlying constraints. Alternative stochastic frontier specifications (3.2.4) can be interpreted as alternative proxies of the credit constraints.

### 3.3 The credit constraints

Figure 3.1 illustrates the novel approach for estimating credit constraints graphically in a simplified case, where the X vector of credit criteria consists only of wealth. The scatter plot displays household loans and wealth, and a stochastic frontier estimate. The estimate is the expected value of credit constraints from a bivariate model. The position of each household vis a vis the frontier is determined jointly by the idiosyncratic component of the frontier  $v$ , and the utilization rate  $u$ . Households above the frontier have a high  $v$ . Households below the frontier have a low  $v$  and/or  $u$ .

Figure 3.1 A scatter plot of loans and wealth, and a credit constraint estimate





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Note: The constraint estimate has been estimated by the Frontier -command in Stata. The exogenous variable was loans in 1988 and the exogenous variables were wealth in 1988 and a constant. All variables in natural logarithms of 1000 euros. Data source: Statistics Finland.

Since the approach by Herrala (2009) of estimating the credit constraints is novel, we have placed much emphasis on investigating the underlying assumptions both with outside information and in-sample diagnostics. Two potential issues deserve particular attention.

Under the standard distributional assumptions of the stochastic frontier model,  $u$  is either exponential or half normal and continuous below the credit constraint. This implies that the empirical borrower distribution must reach up to the constraints, i.e. credit demand must be at least as large as or larger than credit supply for at least a negligible proportion of borrowers. Based on outside information and in-sample tests, this assumption is in our view not in reasonable doubt in our data.

Even though the liberalization of credit markets in 1986 led to a significant improvement in credit availability, the level of development of the loan market was still so low by modern standards that significant constraints to borrowing remained. Finnish household loans originated overwhelmingly from banks, and the traditional liquidity transformation model of banking (from demand deposits to loans) applied. In value, fixed term and variable rate housing loans were the largest category. A particular feature was that loans, also housing loans, were of short maturity, thereby making loan service ability an issue for borrowers. Collateral policy was relatively tight by modern standards especially at the housing loan market, and significant pre-saving for house purchase was the norm.

Only after the surge of foreign banks to the Finnish banking scene in the late 1990's, banks started to offer longer loan maturities to household customers, and at the same time loosen the collateral requirements for borrowing. This shift in banks' credit policy has contributed to a

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doubling of the average maturity of housing loans (from about 10 to 20 years), a significant increase in household indebtedness, and a dramatic fall in the pre-saving for housing purchases among young households during the past decade. The reaction of households to the loosening of banks' credit policy during the past decade is a qualitative indicator of the significance of credit constraints during the earlier times, including our estimation period. Even after these developments, credit constraints are still an issue for households today.

The issue may also be studied with in-sample diagnostics. The data displays the appropriate skew, consistent with the normal/half normal and the normal/exponential assumptions. The test by Coelli (2005) supports the stochastic frontier model over standard OLS, thereby validating the supply constraint interpretation against a credit demand interpretation of the estimated model. The abrupt 'thinning' of the scatter plot (Figure 3.1) in the north-west quadrant gives the impression of a stochastic constraint that is approximately log-linear. Finally, Wald tests validate the variable choice, and the parameter estimates, to be discussed later, are consistent with a supply interpretation.

A second issue is the independence of the residuals, in particular the independence of  $v$  from sampling. The problem arises because we estimate the credit policy parameters from a sub-sample of the original data which includes only households that increased borrowing in 1988. Since these households participated at the credit market, conditions (3.2.2) and (3.2.3) are valid. However, it is likely that some of the constrained households exited the loan market rather than chose some interior level of borrowing. This may cause correlation between sampling probability and the random component of the frontier  $v$ , resulting in sampling bias in the credit policy parameter estimates.

We have used standard econometric methods to study the robustness of estimation results to sampling. In stochastic frontier models the method by Greene (2008) for estimating stochastic frontier models with sampling correction is well motivated in this regard. However, we encountered

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significant and persistent stability issues with the method, in particular flatness of the parameter space of the pseudo likelihood function. These problems persisted under various alternative specifications of the Probit selection model, and the frontier model. A possible cause of this problem is that sampling bias is not severe enough to allow the estimation of the correlation between  $v$  and sampling probability. As a robustness check, we also use the traditional Heckman approach to control for sampling bias.

Table 3.2 lists variants of the econometric model (3.2.4) of the credit constraints, based on stochastic frontier analysis. Models 1-5 are estimates of credit constraints in 1988, and models 6-7 in 1987.<sup>29</sup>

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<sup>29</sup> Estimations with Stata.

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**Table 3.2 Stochastic frontier models of credit constraints**

Loans	model 1	model 2	model 3	model 4	model 5	model 6	model 7
Est year	1988	1988	1988	1988	1988	1987	1987
<b>Frontier</b>							
a0	1.83*** (0.16)	1.57*** (0.16)	2.57*** (0.42)	2.17*** (0.4)	4.02*** (0.44)	1.63*** (0.19)	1.71*** (0.23)
a1	1.06*** (0.35)	0.75** (0.38)	2.24*** (0.69)	1.8*** (0.68)	3.78*** (0.68)	1.07*** (0.3)	0.83*** (0.28)
a2	1.17** (0.48)	0.85* (0.49)	2.04*** (0.64)	1.85** (0.75)	4.24*** (0.82)	-0.14 (0.25)	-0.17 (0.27)
eu	0.75* (0.39)	0.87** (0.38)	0.58 (0.4)	0.74** (0.38)	0.85** (0.42)	0.84*** (0.32)	0.66** (0.28)
a0*wealth	0.28*** (0.03)	0.29*** (0.03)	0.33*** (0.1)	0.29*** (0.1)	0.25*** (0.09)	0.32*** (0.02)	0.51*** (0.04)
a0*income	0.37*** (0.08)	0.34*** (0.08)	-0.29 (0.36)	-0.17 (0.37)	0.24 (0.27)	0.2** (0.08)	-0.05 (0.11)
a1*wealth	0.35*** (0.03)	0.35*** (0.03)	0.36*** (0.12)	0.31*** (0.11)	0.29*** (0.11)	0.34*** (0.04)	0.54*** (0.05)
a1*income	0.51*** (0.13)	0.51*** (0.13)	-0.26 (0.44)	-0.12 (0.46)	0.26 (0.35)	0.36*** (0.1)	0.19* (0.1)
a2*wealth	0.17*** (0.06)	0.18*** (0.06)	0.25** (0.12)	0.21 (0.13)	0.15 (0.13)	0.28*** (0.04)	0.49*** (0.07)
a2*income	0.54*** (0.17)	0.52*** (0.17)	-0.23 (0.39)	-0.19 (0.47)	0.17 (0.36)	0.62*** (0.09)	0.37*** (0.11)
eu*wealth	-0.25*** (0.09)	-0.22** (0.1)	-0.24*** (0.09)	-0.24*** (0.08)	-0.15 (0.1)	-0.21*** (0.08)	-0.21*** (0.06)
eu*income	0.16 (0.17)	0.1 (0.17)	0.19 (0.15)	0.14 (0.15)	-0.01 (0.17)	0.09 (0.13)	0.14 (0.11)
wealth^2			0.03*** (0.01)	0.03*** (0.01)	0.02*** (0.01)		
income^2			0.07 (0.08)	0.04 (0.09)	0.02 (0.07)		
wealth*income			0 (0.04)	0.01 (0.04)	0 (0.04)		
Inverse Mill's					-2.52*** (0.46)		
v							
lsig_2v	-1.44*** (0.18)	-0.99*** (0.13)			-1.29*** (0.18)	-0.9*** (0.1)	
wealth			-0.34*** (0.12)	-0.23** (0.09)			-0.33*** (0.06)
income			0.76* (0.43)	0.56* (0.3)			0.11 (0.18)
_cons			-2.6** (1.02)	-1.95*** (0.7)			-0.3 (0.41)
u							
lsig_2u	0.59*** (0.1)	-0.59*** (0.15)			0.44*** (0.12)	0.25*** (0.07)	
wealth			0.27** (0.11)	0.37** (0.15)			0.3*** (0.07)
income			-0.6*** (0.19)	-0.82*** (0.24)			-0.5*** (0.14)
_cons			1.29*** (0.43)	0.4 (0.53)			0.58** (0.29)
<b>Other</b>							
Model type	N/HN	N/E	N/HN	N/E	N/HN	N/E	N/E
Iterations	6	5	11	10	12	6	8
No of obs	1435	1435	1435	1435	1426	3582	3582
Wald(Chi2)	9175	6567	12460	8575	9858	13931	15970
Log(pseudolik)	-745660	-745129	-734791	-734707.3	-722971	-2126253	-2103268
Prob>Chi2	0	0	0	0	0	0	0

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Notes: The endogenous variable is the loan stock. Group indicators a0=age below 31 years; a1=age 31-45 years, a2=age over 45 years; eu= university level. Inverse Mills ratio from a Probit model of loan market participation on age, education, socioeconomic status, area, consumption units, subjective lending aspirations, income and wealth in 1988. Model type: N/NH =Normal/Half Normal; N/E=Normal/Exponential. The Wald(Chi) test measures probability that all coefficients are zero, Prob>Chi2 is the probability value. Standard errors in parenthesis. \*/\*\*/\*\*=10%/5%/1% significance. All variables in natural logarithms of 1000 € Data source: Statistics Finland.

Models 1-5 of credit constraints in 1988 have been estimated in the sample of about 1400 households that increased borrowing during that year. Models 1, 3 and 5 are normal/half normal, and models 2 and 4 normal/exponential. Models 1 and 2 allow (group specific) fixed effects and variable effects of wealth and income within age and educational groups. Models 3 and 4 include nonlinear effects of wealth and income, and allow for heteroscedasticity in  $v$  and  $u$ . Model 5 includes the inverse Mill's ratio from a Probit model to control for sample selection in accordance with the Heckman approach. In the Probit model, credit market participation was controlled by income, past wealth, age, education, socioeconomic status, area, consumption units, and subjective credit market aspirations (Annex 3). The fit of the Probit model is in line with previous models in the literature.

The credit policy parameter estimates of year 1988 accord with expectations. Wealth is highly significant in all estimations, indicating the central role of collateral in banks' credit policy. The effect of income varies across models. We interpret the across-models variation in the income effect as a sign of the highly non-linear role of income in credit availability across households. At the low end of the income distribution, government sponsored social credit schemes affected credit availability. At high income levels, collateral policy would have been binding before repayment ability became an issue.

Models 6 and 7 generate estimates of past credit policy parameters around year 1987, to be used in robustness analysis. The loan stock of households in 1987 is known, but it is not known which households increased borrowing in 1987. There is, therefore, some uncertainty about whether the

parameter estimates reflect banks' credit policy in 1987 or, more generally, 'the past'. Since the stochastic frontier model catches the maximum of the borrowing distribution, and since the credit markets had been liberalized in late 1986, it is likely that the frontier parameters reflect credit conditions in 1987. Again, the estimated parameters are of expected sign and magnitude.

The average credit constraints also appear realistic (Table 3.3). Model 1, for example, gives a mean credit constraint estimate of 3.5 (32 000 €) for year 1988, which is 75 % of the mean durable wealth at that time. No reliable statistics are available about the maximum loan-to-value ratios imposed by banks at that time, but the estimated figure is certainly realistic in that regard. The estimations indicate a significant increase in credit constraints between 1987 and 1988: credit market liberalization contributed nearly to a doubling of household credit constraints between 1987 and 1988.

**Table 3.3 Constraint estimates**

	Mean	Std. Err.	95 % confidence	
model 1	3.46	0.01	3.44	3.49
model 2	3.14	0.01	3.12	3.16
model 3	3.49	0.01	3.46	3.51
model 4	3.20	0.01	3.18	3.23
model 5	3.32	0.01	3.29	3.34
model 6	2.81	0.01	2.78	2.83
model 7	2.80	0.02	2.76	2.83

Note: All variables in natural logarithms of 1000 €. Data sources: Statistics Finland.

### 3.4 Consumption dynamics

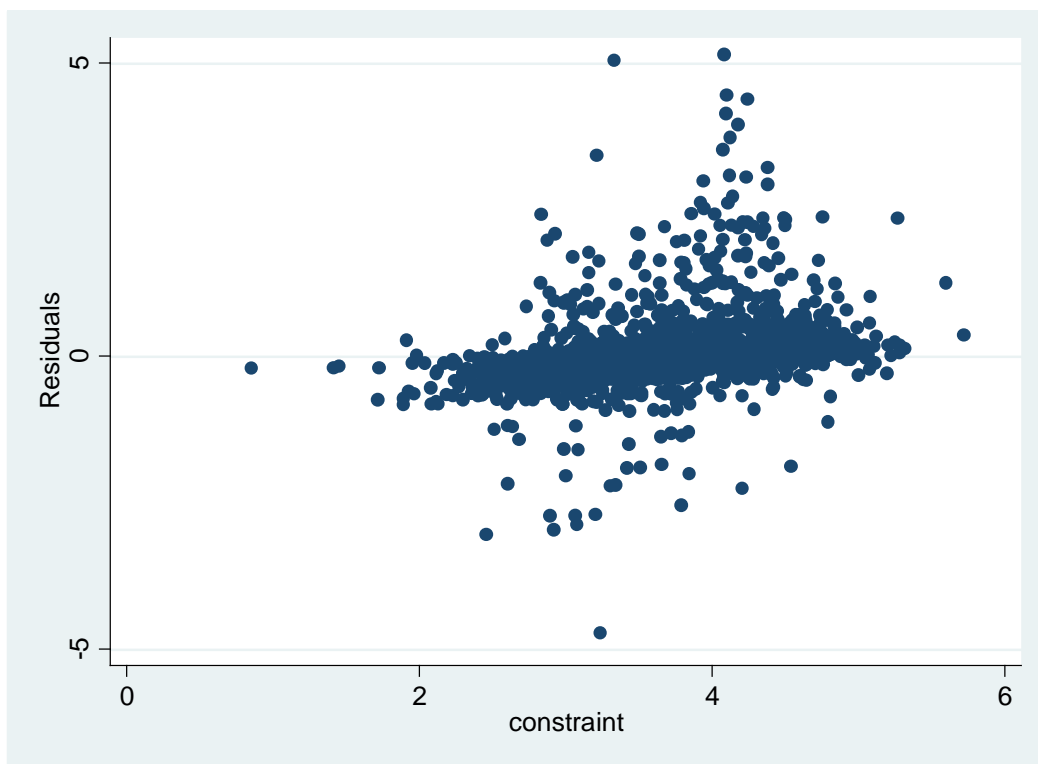
With the credit constraint estimates (3.2.6), we are then able to test the credit constrained consumption hypothesis against the classical hypotheses and its extensions. The analysis reinforces previous findings supporting the credit constrained consumption hypothesis. It adds to the previous findings by providing quantitative estimates of the marginal effect, and evidence of a significant macroeconomic effect of credit constraints on consumption.

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Graphical analysis gives support to the view that, indeed, credit conditions did contribute to consumption dynamics in 1988. A scatter plot of standard Euler equation residuals and the constraint estimates from model 1 (Table 3.2) shows a positive and possibly linear correlation. The visual indicates that durable consumption tended to exceed the classical prediction for households that had a relatively high credit constraint, and vice versa. The econometric analysis of consumption dynamics fully reinforces this finding. Variants of the basic dynamic model (3.2.1) of durable consumption are shown in Table 3.4, and extensions to the basic dynamic model in Table 3.5.

Figure 3.2 **Scatter plot of Euler residuals and the constraint estimates of model 1**



Note: The Euler residuals are from a linear regression of durable wealth in 1988 on a constant term and durable wealth in 1987. See table 3.2 for information on model 1. All variables in natural logarithms of 1000 €. Data source: Statistics Finland.

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Table 3.4 presents seven variants of the basic dynamic model of durable consumption, corresponding with alternative estimation methods and proxies of the credit constraints. Model A is estimated by linear (LR), models B and C by errors-in-variables (EIV), and models D-G the two-stage instrumental variables (IV) regression. In models A,B,D-G, the constraint estimate from the stochastic frontier model 1 (Table 3.2) is used. Model C uses the constraint estimate from stochastic frontier model 2. In models D-G, the constraint estimate from stochastic frontier model 1 is instrumented by the constraint estimates from models 2-5 respectively. In all models, the explanatory variables are jointly highly significant by the F test. The R2 statistics show high explanatory power.

**Table 3.4 Basic models of durable consumption in 1988**

	Model A	Model B	Model C	Model D	Model E	Model F	Model G
C <sub>1987</sub>	0.8*** (0.02)	0.68*** (0.01)	0.63*** (0.01)	0.32*** (0.03)	0.49*** (0.04)	0.48*** (0.04)	0.37*** (0.03)
$\pi$	0.32*** (0.02)	0.83*** (0.03)	1.04*** (0.03)	0.79*** (0.02)	0.76*** (0.02)	0.76*** (0.02)	0.78*** (0.02)
constant	-0.32*** (0.05)	-1.76*** (0.08)	-2.02*** (0.08)	-0.33*** (0.05)	-0.79*** (0.08)	-0.79*** (0.08)	-0.47*** (0.06)
Model type	LR	EIV	EIV	IV	IV	IV	IV
Reliability		53 %	48 %				
Instruments				$\pi_2$	$\pi_3$	$\pi_4$	$\pi_5$
Nr of obs	4766	4766	4766	4766	4766	4766	4766
F	4679	20688	23832	4733	4916	4912	4962
Prob>F	0	0	0	0	0	0	0
R2	87 %	90 %	91 %				

Note: The endogenous variable is the stock of durable wealth in 1988. Variables: C<sub>x</sub>=stock of durable wealth in period x;  $\pi_x$ =credit constraint estimate from model x (see Table 2). Model type: LR=survey based linear regression; EIV=weighted errors-in-variables regression; IV=survey based instrumental variables regression (2SLS). Reliability is  $1-\text{var}(v)/\text{var}(\pi)$ . P<sub>fob>F</sub> refers to the probability of the H<sub>0</sub> of all zero coefficients by the F test. Standard errors in parenthesis. \*/\*\*/\*\*\*=10%/5%/1% significance. Standard errors of LR not corrected for measurement error. All variables in natural logarithms of 1000 € Data source: Statistics Finland.



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In all models, the constraint estimate is highly significant, thereby validating the credit constrained consumption hypothesis. The point estimate of the marginal effect of the constraint varies somewhat across the different models. The smallest estimate is observed in the linear regression model, possibly due to the presence of measurement error in the constraint estimate. In the errors-in-variables and instrumental variables regressions the marginal effect of the constraint is within the range 0.76-1.04. Remarkably, the estimated marginal effect of credit constraints is larger than the own elasticity. This result implies that credit market liberalization changed durable consumption behaviour significantly from what it had been in the past. The result is not at variance with anecdotal evidence of the events.

The robustness of these findings to extensions in the model may be assessed from Table 3.5. Models (i)-(iii) include a consumer sentiment indicator variable, where optimism is inversely related to the group number, i.e. households in group 1 are more optimistic than households in group 4 about their durable consumption ability during the estimation year compared with previous year. Model (iii) includes also non-linear effects of the constraints. Model (iv) includes age and educational groups. Model (v) includes estimates of past credit constraints, as well as socioeconomic and area indicators. Models (ii) and (iv) are estimated with instrumental variables and models (iii) and (v) with linear regression. Model (i) is estimated with errors-in-variables regression. Reliability restricts the use of the errors-in-variables method in the more extensive specifications.

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Table 3.5 Extensions to the basic model

	model i	model ii	model iii	model iv	model v
C1987	0.67*** (0.01)	0.79*** (0.02)	0.79*** (0.02)		
a0C1987				0.6*** (0.05)	0.59*** (0.05)
a1C1987				0.5*** (0.05)	0.5*** (0.05)
a2C1987				0.86*** (0.04)	0.85*** (0.04)
euC1987				0.13*** (0.05)	0.15*** (0.05)
$\pi 1$	0.86*** (0.03)	0.32*** (0.03)	-0.4 (0.68)		
a0 $\pi 1$				-3.49** (1.48)	-3.99** (1.69)
a1 $\pi 1$				-3.54** (1.46)	-4.1** (1.65)
a2 $\pi 1$				-4.45*** (1.46)	-5*** (1.64)
eu $\pi 1$				-0.07 (0.06)	-0.03 (0.06)
$\pi 1^2$			0.28 (0.19)	1.48*** (0.41)	1.65*** (0.46)
$\pi 1^3$			-0.03* (0.02)	-0.15*** (0.04)	-0.17*** (0.04)
a0 $\pi 6$					-0.04 (0.04)
a1 $\pi 6$					0 (0.02)
a2 $\pi 6$					0.03* (0.01)
eu $\pi 6$					-0.08** (0.04)
constant	-1.99*** (0.1)	-0.34*** (0.09)	0.19 (0.78)		
ex1	0.02 (0.04)	-0.05 (0.08)	-0.06 (0.08)		-0.05 (0.07)
ex2	0.16*** (0.04)	0 (0.07)	0 (0.08)		-0.05 (0.06)
ex3	0.1*** (0.04)	0 (0.08)	-0.01 (0.08)		-0.04 (0.07)
ex4	0.21*** (0.04)	0.11 (0.08)	0.1 (0.08)		0.03 (0.07)

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Table 3.5 continued

	model i	model ii	model iii	model iv	model v
a0				1.7 (1.8)	2.41 (2.06)
a1				2.31 (1.73)	3.09 (1.91)
a2				4.63*** (1.68)	5.3*** (1.87)
eu				-0.43** (0.22)	-0.23 (0.22)
sl					-0.25*** (0.08)
se					-0.22*** (0.07)
ss					0.13 (0.13)
sp					-0.17** (0.07)
ta					0 (0.02)
Model type	EIV	IV	LR	IV	LR
Reliability	53 %				
Instruments		$\pi_2$		$a_x\pi_2,$ $\pi_2^2,$ $\pi_2^3$	
Nr of obs	4756	4756	4756	4766	4756
F	7031	1650	1268	98311	51821
Prob>F	0	0	0	0	0
R2	90 %		87 %		99 %

Notes: The endogenous variable is the stock of durable wealth in 1988. Variables:  $C_x$ =stock of durable wealth in period  $x$ ;  $\pi_x$ =credit constraint estimate from model  $x$  (see Table 2). Groups:  $a_x$ =age group  $x$ ;  $a_0$ =age below 3 years;  $a_1$ =31-45 years;  $a_2$ =over 45 years;  $eu$ =university level;  $ex_1$ - $ex_4$ =expectation about durable consumption ability in 1988 ( $ex_1$ =most optimistic;  $ex_4$ =most pessimistic);  $sl$ =labor;  $se$ =entrepreneur;  $ss$ =student;  $sp$ =pensioner;  $ta$ =town like community. Model type: LR=survey based linear regression; EIV=weighted errors-in-variables regression; IV=survey based instrumental variables regression (2SLS).  $P_{fob>F}$  refers to the probability of the  $H_0$  of all zero coefficients by the F test. Standard errors in parenthesis. \*/\*\*/\*\*=10%/5%/1% significance.

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Standard errors of LR not corrected for measurement error. All variables in natural logarithms of 1000 €. Data source: Statistics Finland.

All models (i)-(v) support the credit constrained consumption hypothesis: the credit constraint estimates are highly significant. Models (iv) and (v) indicate nonlinearities and variation across age groups in the marginal effect. Evidence for the hypothesis that consumer sentiment contributed to durable consumption is not found. A significant effect is only present in model (i), but the estimated signs are contrary to the hypothesis. The models yield some evidence about the influence of past credit constraints and socioeconomic status on consumption behaviour.

To summarize, the estimations yield strong support for the hypothesis of credit constrained consumption during the estimation period. The alternative hypothesis of classical dynamics is rejected at standard significance levels in all models, estimated by alternative methods and under alternative model specifications. The results are also found to be robust to weighting and possible sampling bias. Our estimations contribute to the literature by showing a significant marginal effect and a large quantitative effect of credit constraints on durable consumption aggregates.

The estimations indicate that inclusion of credit constraints into the dynamic equation reduces the coefficient of past consumption markedly, to below 0.5 in some cases. Many alternative interpretations have been given in the literature to a low own elasticity in models in which credit constraints are not included as an explanatory variable (See e.g. Attanassio and Weber 2010, Attanassio and Jappelli 2001, Carroll 2001). It remains an open issue, to what extent the previous arguments hold in the case of binding credit constraints. At this stage, our result with the broader model specification should be taken as an empirical finding, possibly reflecting the special conditions that prevailed after credit market liberalization in Finland. Deeper insight about this finding requires more study about other periods, and theoretical work about credit constrained consumption.

### 3.5 Concluding remarks

The main contribution of the paper is a novel econometric approach to resolve the long standing issue of how to quantify the marginal effect of credit constraints on consumption. An empirical application reveals that credit constraints significantly affected consumer behaviour during post deregulation consumer spending spree. The effect was quantitatively large also at the macroeconomic level.

The present paper is only the first step in applying the new approach to quantify and to increase our understanding about the effect of credit constraints on consumption. Much more study is needed to assess how credit constraints affect consumption in different countries, and how this effect varies in time. It is well known that credit conditions may show significant sensitivity to institutional aspects of the credit market, and cyclicalities.

In line with the recommendation by Carroll (2001), we employ an empirical approach, and largely abstract from theoretical interpretation. Accordingly, there is much scope for future theoretical efforts to increase understanding of the issues by interpreting the estimation results in the context of alternative behavioural models.

It should perhaps be noted that the scope of the approach extends beyond consumer economics. The approach is also well suited for analysis of the effects of credit constraints on other types of behaviour, such as investment.

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### Annex 3 A probit model of credit market participation

	Coef.	Std.err.	z	P>z	95% confidence	
cons unit	0.010	0.003	3.34	0.001	0.004	0.015
a1	-0.167	0.052	-3.21	0.001	-0.269	-0.065
a2	-0.380	0.055	-6.89	0	-0.488	-0.272
eu	-0.038	0.056	-0.67	0.5	-0.148	0.072
sl	0.246	0.148	1.66	0.097	-0.044	0.536
ss	1.111	0.225	4.94	0	0.670	1.551
se	0.095	0.151	0.63	0.531	-0.202	0.391
sp	-0.093	0.151	-0.61	0.54	-0.389	0.204
taa	0.097	0.039	2.49	0.013	0.021	0.173
wealth1987	-0.057	0.013	-4.33	0	-0.083	-0.031
income1988	0.225	0.046	4.88	0	0.135	0.316
loan market aspirations	0.000012	0.000	7.610	0.000	0.000	0.000
_cons	-1.052	0.170	-6.180	0.000	-1.385	-0.718
Nr of obs.	5187		Iterations	4		
LRChi2	481.09		Log likelihood	-3106.2		
ProbChi2	0		Pseudo R2	7 %		

Notes: The endogenous variable is an indicator for increased borrowing in 1988. Variables: cons unit=number of consumption units in 1988; loan market aspirations= amount of aspired borrowing in 1988 in 1000 € or zero if not given. Groups: a1= 31-45 years; a2=over 45 years; eu= university level; sl=labor; se=entrepreneur; ss=student; sp=pensioner; taa=town like community. LRChi2= Chi2 test of the joint significance of the regressors; Pfob>Chi2 refers to the probability of the H0 of all zero coefficients in the LRChi2 test. Wealth and income in natural logarithms of 1000 € Data source: Statistics Finland.

### Chapter 4: The Influence of Bank Ownership on Credit Supply: Evidence from Russia's Recent Financial Crisis<sup>30</sup>

#### Abstract

This study examines how bank ownership influenced the credit supply during the recent financial crisis in Russia, where the banking sector consists of a mix of state-controlled banks, foreign-owned banks, and domestic private banks. To estimate credit supply changes, we employ an exhaustive dataset for Russian banks that covers the crisis period and apply an original approach based on stochastic frontier analysis. Our findings suggest bank ownership affected credit supply during the financial crisis and that the crisis led to an overall decrease in the credit supply. Relative to domestic private banks foreign-owned banks reduced their credit supply more and state-controlled banks less. This supports the hypothesis that foreign banks have a “lack of loyalty” to domestic actors during a crisis, as well as the view that an objective function of state-controlled banks leads them to support the economy during economic downturns.

**JEL Codes:** D14, G21

**Keywords:** bank, credit policy, foreign ownership, state ownership, stochastic frontier analysis

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<sup>30</sup> BOFIT Discussion Paper 34/2011, Co-authored with Zuzana Fungáčová and Laurent Weill.



### 4.1 Introduction

The recent financial crisis has provoked major economic troubles. A key channel of transmission has been the contraction of credit supply by banks. This contraction was primarily caused by a reduction of transactions in the interbank markets and a clear reluctance on the part of banks to lend. The message to the broader global economy was unequivocal: banks were not just having a harder time lending, they were less willing to lend.

Credit supply by banks is of particular importance in emerging countries, where rudimentary financial markets place banks in a fundamental financing role. Foreign-owned banks and state-controlled banks typically hold significant market shares in these countries, so both groups are well poised to influence credit supply in times of crisis.

Our aim in this paper is to examine how bank ownership influences credit supply in troubled times. Our research is motivated by the fact that bank ownership can exert an impact on lending behavior in two ways.

Economic difficulties of the host country may cause foreign-owned banks to pull back on lending more than domestic banks. This is referred to in the literature as a “lack of loyalty” on the part of foreign banks (Weill, 2003). Notably, the empirical literature comparing lending behavior of domestic and foreign banks in emerging markets in the 1990s does not support this hypothesis. In Latin America during the 1990s, for example, Peek and Rosengren (2000) and Dages, Goldberg and Kinney (2000) find that domestic and foreign banks exhibited the same lending behavior during periods of crisis. Arena, Reinhart and Vazquez (2007) also study the impact of lending of foreign banks on the lending channel in emerging countries and find no significant differences in the impacts of foreign and domestic banks.

State-controlled banks, in contrast, may bolster their lending during a crisis to support the economy. This is because the objective function of state-controlled banks is likely to include

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stabilization of the economy, and because the principal of state-controlled banks – the government – may be willing to limit a credit contraction in troubled times to enhance its chances of reelection or avoid potential political unrest. Such lending behavior would seem imprudent if engaged in by private banks wed to the aim of profit maximization to satisfy shareholders.

The literature finds numerous instances in which state-owned banks display lending behavior different from private banks. For example, Dinc (2005) shows how lending of state-owned banks correlates with the electoral cycle in a cross-country study. State-owned banks boost lending in election years relative to private banks, suggesting a different objective function for both types of banks. Micco and Panizza (2006) perform a cross-country analysis to investigate the role of the business cycle in the comparative lending behavior of state-owned and private banks. They find that the lending of state-owned banks is less sensitive to macroeconomic shocks than that of private banks. This finding reinforces the view that state-owned banks consider macroeconomic stabilization in their objective function. In a related vein, Jia (2009) analyzes the relationship between ownership and the prudential behavior of banks in China by comparing state-owned and joint-equity banks. He observes that state-owned banks are less prudent in lending. This finding suggests that in times of crisis state-owned banks are more reluctant to pare back lending than other banks.

This investigation into the role of bank ownership on credit supply in troubled times contributes to the literature on two fronts.

First, Russia's banking industry consists of a mix of state-controlled, foreign-owned and domestic private banks, making it fairly straightforward to compare the lending behavior of foreign banks and state-owned banks against private domestic banks. The magnitude of recent financial crisis further provides an opportunity to analyze shifts in patterns of credit supply according to bank ownership. We employ a rich dataset that includes quarterly data on all Russian banks that allows

us to analyze thoroughly the evolution of credit supply over the period from the first quarter of 2007 to the fourth quarter of 2009.

Second, we employ an original approach to estimating credit supply from bank-level data that allows us to separate credit supply from credit demand without resorting to detailed data on borrowers and lenders. Unlike Khwaja and Mian (2008), we do not need detailed data on all credit market participants to disentangle both sides of the credit market. Our approach derives from the hypothesis formalized by Holmström and Tirole (1997) that credit supply is constrained by bank capital. If at least some banks are capital constrained, then credit supply can be estimated from the observed distribution of bank lending under relatively mild conditions. It is identified as the maximum of the bank lending distribution, and can be estimated in a parametric form using stochastic frontier analysis. To allow inference concerning the impact of bank type on credit supply, we allow credit supply to depend on bank type, bank capital, and idiosyncratic factors.<sup>31</sup> This method has been applied by Chen and Wang (2008) for Taiwan and Herrala (2009) for Finland to estimate credit supply from borrower data. Stochastic frontier analysis has also been widely applied in the banking literature to estimate bank efficiency (most notably, the 2010 study of Karas, Schoors and Weill on Russian banks).

Our results on the link between bank ownership and lending during recession have normative implications for banking policy in emerging markets. A finding in favor of a stronger reduction in lending for foreign banks in comparison to domestic banks supports restricting foreign bank entry. Conversely, an observation of a small reduction in lending for state-owned banks relative to privately owned banks supports the continued existence of state-owned banks.

The rest of the article is organized as follows. Section 4.2 describes the evolution of the Russian banking industry during the recent financial crisis. Section 4.3 explicates our methodology and

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<sup>31</sup> See Berrospide and Edge (2010) for a recent survey on the effects of bank capital on lending.

section 4.4 describes the data. Section 4.5 presents our results, and section 4.6 summarizes with a couple of policy observations.

### 4.2 The Russian banking industry and the crisis

The development of Russia's banking sector in the 2000s mirrored much of what transpired elsewhere in emerging markets. In addition to a rapid expansion of the banking sector (total assets grew on average a more than 35% a year), Russian banks began to provide a wide variety of services to corporate and household clients. The ratios of banking sector assets to GDP and credit to GDP more than doubled during the decade, with these ratios reaching 75% and 40%, respectively, by end-2010 (Central Bank of the Russian Federation, 2011). Despite this significant increase in financial intermediation, however, both ratios were still lower than in most emerging markets.

Russian banks can be divided into three main groups in terms of ownership. The first group consists of the state-controlled banks that dominate the sector. Unlike the emerging economies of Central and Eastern Europe, which used privatization to create banking sectors today dominated by large international players, Russia preserved the dominance of its state banks (resembling in some respects the current arrangement in China). Depending on the definition used, Russia has about 40 state-controlled banks that control slightly more than half of total banking sector assets.<sup>32</sup> Russia's five largest banks are all state-controlled. As state banks, they face lower constraints in financing, hold an abundance of cheap household deposits, and enjoy ready access to refinancing from the Central Bank of the Russian Federation (CBR).

The next group is made up of foreign-owned banks. Their share of the banking sector, while still below 20% of total assets, increased steadily over the past decade (up from 174 foreign-owned banks in 2000 to 220 at the end of 2010). Foreigners hold the majority in about half of banks with

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<sup>32</sup> See Vernikov (2009) for detailed information on state ownership of banks in Russia.

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foreign participation. Three of Russia's top 10 banks were foreign-owned as of end-June 2011. Foreign-owned banks in Russia tend to rely on external funding from their parent companies.

All the other banks operating in Russia are domestic private banks. There are a lot of such banks, about 700 in total. Most are small, but they are in some cases important regional players. They account collectively for about 5% of total banking system assets. Their capital ratios in general exceed the average values in the banking system. Following a stretch of growth that included implementation of reforms and improvement in the legal environment, the Russian banking sector appeared in early 2008 to be in relatively good shape to withstand a crisis. Further, Russian banks were not directly exposed to the financial instruments that triggered the global turmoil. Yet the Russian banking sector, along with the rest of the economy, succumbed to the global financial crisis in mid-2008 with the dual shocks of a sudden lack of access to foreign financing and a significant drop in the price of oil.

As loan growth before the crisis exceeded growth of deposits, banks turned to external sources to finance the resulting gap. Russia has traditionally lacked long-term funding resources, so most funding came from abroad predominantly in the form of short-term borrowing. Banks were joined by Russian non-financial companies in turning to international markets to obtain financing. Thus, when the supply of foreign credit was cut, numerous banks and other companies found themselves in immediate difficulties. This situation was exacerbated by falling oil prices that led to a collapse in Russian share prices. Margin calls were especially hard for those who had used shares as collateral in lending. Capital flows reversed and Russia's trade balance suffered as oil prices slid and the country fell into recession. With intense depreciation pressure on ruble, the CBR implemented an incremental 30% devaluation of the ruble between November 2008 and February 2009.

The official response to the crisis was to move swiftly and go big. Starting in autumn 2008, the Russian government and CBR introduced a variety of measures to support stability of the financial

system and prevent systemic collapse. These measures included a temporary decrease in bank reserve requirements, CBR guarantees of interbank lending to qualified banks, non-collateralized central bank loans, loosening of definition of acceptable collateral at the Lombard window and in repo operations, as well as auctions allocating free budgetary funds to banks. The deposit insurance framework was enhanced by increasing the amounts covered by deposit insurance and Russia's deposit insurance agency assumed the task of restructuring individual troubled banks. Large and systemically important banks were targeted for capital injections. The funds were provided directly by the government or through unsecured subordinated loans from the CBR or the state development bank Vneshekonombank (VEB). The government also made resources available to VEB to help refinance and service foreign debt of Russian firms

All these actions helped stabilize not just the banking system but the economy as a whole. Measures to support liquidity in the banking system were gradually withdrawn in 2010, by which time most banks no longer suffered from liquidity shortfalls. Instead, banks were struggling with rising stocks of nonperforming loans on their balance sheets, a situation that made them reluctant to lend. Most chose to pull back on lending and pursue a less risky course of acquiring government bonds and sitting on them. Bank lending, which had seen growth averaging 45% a year between 2002 and 2007 dropped to -2.5% in 2009. It was not until the second quarter of 2010 that very modest growth returned.

### 4.3 Methodology

Our method of estimating credit supply is based on the model of Holmström and Tirole (1997) for capital-constrained lending. They argue that the loan supply of banks is constrained by bank capital. Accordingly, we assume a stochastic, log-linear loan supply constraint:

$$L_{it} \leq \alpha_t C_{it}^{\beta_t} \exp [v_{it}] \quad (4.1)$$

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In constraint (4.1),  $i$  denotes bank,  $t$  time,  $L$  risk weighted assets,  $C$  capital, and  $v$  a stochastic disturbance. The parameter  $\alpha$  is a ‘proportionality factor’ of the loan supply constraint on capital, and  $\beta$  is the ‘scale effect’ of bank size. If  $\beta=1$ , no scale economies are present in the loan supply constraint. If  $\beta>1$ , then larger banks can supply more loans than smaller banks relative to their capital. The credit supply constraint (4.1) can also be rationalized from the point of view of supervision that imposes capital requirements on bank lending. The Basel II capital requirement is characterized as  $\alpha=12.5$ ;  $\beta=1$ ; and  $v=0$ .

Our aim is to estimate the parameters of the credit supply constraint (4.1), and thereby gain insight about credit supply. To accomplish this, we consider two types of banks. The first is the case studied by Holmström and Tirole (1997)– a constrained bank for which credit demand exceeds the bank’s credit supply constraint. Here, the supply constraint (4.1) holds with equality and observed aggregate lending of the bank is accordingly supply-determined. The second is an unconstrained bank for which credit demand falls short of the credit supply constraint. In this case, observed bank lending is demand-determined.

To account for both types of banks in the analysis, we denote by  $\exp[-u_{it}]$ , the (inverse) distance of a bank from its loan supply constraint:

$$\exp[-u_{it}] = \frac{L_{it}}{\alpha_t C_{it}^{\beta} \exp[v_{it}]} \quad (4.2)$$

Since the loan supply constraint (the denominator) is an upper bound of  $L$  by (4.1), the domain of  $\exp[-u_{it}]$  is the unit line. Constrained banks are characterized by  $\exp[-u_{it}]=1$ . For unconstrained banks,  $u$  falls below unity. We can interpret  $\exp[-u_{it}]$  as an indicator of credit demand relative to supply.

Equations (1) and (2) yield the equation:

$$l_{it} = \alpha_t + \beta c_t^* c_{it} + v_{it} - u_{it} \quad (4.3)$$

where  $l$  and  $c$  are respectively the logged values of risk-weighted assets and capital. Equation (4.3) is a stochastic frontier model. Standard estimation methods apply when  $v$  and  $u$  are independent

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random variables from specific distributions. We employ the standard assumptions in our estimations that  $v$  is normal and that  $u$  is either exponential or half-normal. Our main estimation assumes an exponential distribution, as it provides a greater log-likelihood for the model. In estimations, we allow and confirm heteroscedasticity in both  $u$  and  $v$ .

To investigate how the recent global financial crisis affected the loan supply of banks in Russia, equation (4.3) is estimated with Russian bank data that covers both the pre-crisis and the crisis period. Changes in parameters  $\alpha$  and  $\beta$  reveal changes in loan supply of banks as the crisis progresses. We estimate a pooled cross-section, rather than a panel, because it is important that all model parameters, including residual distributions, can change over time.

We first look to see if bank ownership exerts an impact on credit supply during the financial crisis. To do so, we add dummy variables for government ownership and foreign ownership in the frontier model, i.e. these variables are always viewed relative to domestic private ownership. Further, we include interaction between ownership and time dummy variables for each quarter of the sample period. We add time dummies for all periods except the first one, so all other dummy variables must be interpreted as a comparison with the first quarter of 2007. This setup enables us to analyze the evolution of credit supply behavior for each category of banks by considering the evolution of the interaction variables between ownership and time dummy variables over the period.

The estimated equation takes the following form:

$$l_{it} = \alpha + \alpha_s s_{it} + \alpha_f f_{it} + \beta c_{it} + \sum_{t=1}^{11} (\alpha_t + \alpha_{st} s_{it} + \alpha_{ft} f_{it} + \beta_t c_{it}) + v_{it} - u_{it} \quad (4.4)$$

where  $s$  stands for state ownership dummy variable,  $f$  is a foreign ownership dummy variable,  $i$  is the index for banks, and  $t$  indicates the quarters 0 to 11 corresponding with the period 2007Q1-2009Q4.

To interpret, the  $\alpha$  -parameter is the proportionality factor in 2007Q1 in private banks. Parameters  $\alpha_s$  and  $\alpha_f$  indicate the difference in the proportionality factor of state-controlled and foreign banks relative to private banks at that time. Parameters  $\alpha_t$  indicate changes in the



proportionality factor in private banks relative to 2007Q1. Parameters  $\alpha_{st}$  and  $\alpha_{ft}$  indicate the difference in the change of the proportionality factor of state-controlled and foreign banks relative to private banks. The  $\beta$  parameter is the scale effect in 2007Q1, and  $\alpha_t$  the change in the scale effect relative to that period. Our interest focuses on parameters  $\alpha_{st}$  and  $\alpha_{ft}$ , which reveal, whether credit supply constraints developed differently in state-controlled banks and foreign banks relative to domestic private banks.

### 4.4 Data

Our analysis is based on the detailed bank level dataset of all Russian banks covering the period from the beginning of 2007 to the end of 2009. It contains quarterly balance sheet and income statement information provided by the financial information agency Interfax, which collects and organizes this data from the CBR.<sup>33</sup> The data are further cleaned by dropping observations that fulfill at least one of the following conditions: the ratio of average total loans to total assets is less than or equal to 5%, the sum of deposits is zero, or the capital-to-assets ratio is larger than 100% or less than 2%.<sup>34</sup> We only consider banks that participate in deposit insurance scheme (those outside the scheme are not allowed to collect household deposits). Our final sample consists of over 10,000 bank-quarter observations. For the all-important risk-weighted assets variable, we have available some 6,000 observations. Fortunately, this does not constitute a problem since the data on risk-weighted assets are mostly missing for small banks that are not crucial to systemic stability of the banking sector. The descriptive statistics of capital adequacy ratio for all ownership subgroups are provided in Table 4.1.

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<sup>33</sup> For a more detailed description of the dataset, see Karas and Schoors (2005).

<sup>34</sup> Russian regulations call for withdrawal of a bank's license if its capital ratio falls below 2%.

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Table 4.1 **Capital adequacy ratio by ownership subgroups**

Quarter	State-controlled banks			Foreign banks			Domestic private banks		
	Obs.	Mean	s.d.	Obs.	Mean	s.d.	Obs.	Mean	s.d.
1Q2007	22	16.1	5.6	37	20.2	11.5	423	22.8	17.8
2Q2007	23	16.9	10.3	18	24.7	24.7	401	22.8	19.4
3Q2007	19	14.1	3.3	24	22.9	21.0	381	22.1	15.6
4Q2007	23	17.8	8.9	29	18.6	9.8	395	25.2	24.1
1Q2008	22	16.3	10.3	54	23.3	18.9	458	22.1	13.0
2Q2008	22	17.3	10.6	54	23.6	20.8	436	22.0	15.2
3Q2008	31	15.9	9.5	59	20.1	13.6	413	23.2	16.9
4Q2008	32	18.1	12.5	60	24.7	18.1	407	26.5	16.1
1Q2009	31	20.5	19.1	61	25.1	17.0	413	27.1	16.0
2Q2009	33	19.2	8.6	60	30.0	23.1	403	27.5	17.2
3Q2009	37	20.5	8.1	60	32.1	25.3	428	28.9	20.5
4Q2009	34	19.8	7.0	55	32.1	29.5	371	28.0	25.8

Note: This table presents the descriptive statistics for the capital adequacy ratio in percentage by ownership subgroups.

We distinguish between foreign-owned and domestic banks (which can be either state-controlled or privately held). State-controlled banks are defined as banks that are majority-owned by the government, the central bank, state-controlled companies or municipalities. To identify them, we use the classification of Vernikov (2009). Foreign-owned banks are those that have foreign ownership in excess of 50%, which is in line with how CBR defines a foreign bank. We use CBR data to identify foreign-owned banks.

## 4.5 Results

In this section, we first present results from our main model and then results using alternative specifications.

### 4.5.1 Main estimations

Our main model assumes an exponential distribution for the inefficiency term. The results are presented in Table 4.2. Several striking results are immediately apparent.

**Table 4.2 Estimation results for the benchmark model**

Explanatory variables		Estimated coefficients
Capital		1.03*** (0.01)
State-controlled		-0.06* (0.04)
Foreign-owned		-0.004 (0.03)
	07Q2	0.05 (0.07)
	07Q3	-0.02 (0.08)
	07Q4	-0.19* (0.1)
	08Q1	-0.08 (0.08)
Time fixed effects	08Q2	-0.15* (0.08)
	08Q3	-0.12 (0.08)
	08Q4	-0.63*** (0.12)
	09Q1	-0.8*** (0.14)
	09Q2	-0.8*** (0.13)

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	09Q3	-0.9*** (0.13)
	09Q4	-0.67*** (0.14)
<hr/>		
	07Q2	0.04 (0.07)
	07Q3	0.07 (0.07)
	07Q4	0.12* (0.06)
	08Q1	0.03 (0.07)
State-controlled	08Q2	0.04 (0.07)
banks time fixed	08Q3	0.07 (0.07)
effects	08Q4	0.25*** (0.09)
	09Q1	0.29*** (0.09)
	09Q2	0.21** (0.09)
	09Q3	0.13 (0.1)
	09Q4	0.11 (0.11)
<hr/>		
	07Q2	-0.07 (0.05)
	07Q3	-0.05 (0.06)
	07Q4	-0.03 (0.06)
	08Q1	-0.09* (0.05)
Foreign-owned	08Q2	-0.1* (0.05)
banks time fixed	08Q3	-0.06 (0.05)
effects	08Q4	0.0002 (0.08)
	09Q1	0.0001 (0.08)
	09Q2	-0.1 (0.08)
	09Q3	-0.2** (0.08)
	09Q4	-0.17** (0.08)
<hr/>		
Observations		5829

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Log-likelihood	-3263.453
Info criterion: AIC	1.144
Finite sample AIC	1.145
Info criterion: BIC	1.227

Note: Estimations by maximum likelihood on a pooled cross-section. All variables are in natural logarithms. Constant terms and time variable effects for capital are included but not reported. All models allow heteroscedasticity of the residuals in time. Residual parameters are not reported. Standard errors appear in parentheses next to estimated coefficients. \*, \*\*, \*\*\* denote an estimate significantly different from 0 at the 10%, 5%, or 1% level. All models converge normally.

First, given the level of capital credit supply falls with the arrival of the crisis. Time dummy variables are all significant and negative from the fourth quarter of 2008, when the world crisis hit Russia, until the end of the sample period. Before that time, most are not significant, even if the ones for 07Q4 and 08Q2 were also significantly negative. These results confirm the impact of the financial crisis with a significantly stronger influence starting in the fourth quarter of 2008.

Second, foreign banks overall reduce their credit supply more than domestic private banks. The interaction variables between foreign ownership and time dummy variables are not significant for 2007, i.e. there is no significant difference in the behaviors of foreign banks and domestic private banks. The estimated coefficients become significantly negative for the first two quarters of 2008 before the crisis reaches Russia. This time period corresponds to turmoil elsewhere in the global markets. It appears the watershed moment for parent companies of foreign banks operating in Russia took place in late March 2008 after the collapse of Bear Stearns. We further find significant estimated coefficients of interaction variables for the last two quarters of 2009. Thus, even if the difference in behavior does not persist for all periods, these results support the view of a “lack of loyalty” on the part of foreign banks, i.e. foreign banks are less committed to assisting the domestic

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economy in troubled times. It is of interest to observe that the contraction of lending for foreign banks is not fully associated with the domestic economic situation in Russia. The fact that foreign banks react before the beginning of the crisis while other banks do not modify their lending behavior provides clear evidence of lack of loyalty. It means that foreign banks reduce their lending in a country even if it is not yet affected by the financial crisis, i.e. without reasons based on the negative macroeconomic situation. This shows a different lending behavior of foreign banks, which can be interpreted as the anticipation of the forthcoming negative economic evolution and does not take into account the possible self-fulfilling effect of such behavior.

These results for foreign banks do not comport with other findings for emerging countries (e.g. Peek and Rosengren, 2000). The differences may result from the fact that the examined crisis was so extreme that it drove foreign banks to such behavior. In other words, foreign banks may not behave differently in credit supply in normal times or during mild downturns. They only engage in disloyal behavior when bigger international crises arise.

Third, state-controlled banks reduce their credit supply less than domestic private banks during the crisis. The interaction variables between state ownership and time dummy variables are all significant and positive for the fourth quarter of 2008 and the first two quarters of 2009, the time when the crisis in Russia reached its peak. They are also significant for one quarter showing the first signs of the crisis, the fourth quarter of 2007, for which we observe a significantly negative time dummy variable showing a general reduction of credit supply.

Thus, our findings affirm the view that state-controlled banks have a different objective function than other banks: they support the economy in troubled times by limiting their reduction of credit supply. These results are in accordance with Micco and Panizza (2006), who show that lending by state-owned banks is less sensitive to macroeconomic shocks than private bank lending at the cross-country level. They are also loosely related to the finding of Jia (2009) on the lower prudence of state-owned banks in China.

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Figure 4.1 shows the time fixed effects in the various banking groups. The time fixed effect for period  $t$  is calculated as  $\alpha + \alpha_t$  for domestic private banks,  $\alpha + \alpha_t + \alpha_s + \alpha_{st}$  for state-controlled and  $\alpha + \alpha_t + \alpha_f + \alpha_{ft}$  for foreign banks. The figure indicates differences in the development of credit supply relative to 2007Q1 across the banking groups. More negative values indicate tighter credit supply constraints and therefore lower credit supply. Since the scale effects do not vary across the different banking groups in this model, they do not affect the comparison.

Figure 4.1 **Proportionality factors of credit policy for different banking groups**



Note: The figure shows the proportionality factors in the various banking groups. More negative values indicate tighter credit supply constraints, and therefore lower credit supply relative to period 2007Q1.

We observe a tightening of credit supply starting from the beginning of the period for all banking groups. This tightening speeds up from the third quarter of 2008 and persists until overall credit

availability starts to improve in 2009Q3 as the effects of the international financial crisis begin to ease.

Significant differences in the development of credit supply constraints across the banking groups are revealed. Credit availability from foreign banks differed from the domestic private banks mainly in terms of timing of the crisis reaction. Foreign banks reacted two quarters earlier: they tightened credit policy relative to the private domestic banks in 2008Q1 and 2008Q2. Afterwards no statistical difference can be observed between foreign and domestic private banks until 2009Q2, when private banks loosen their credit policy and foreign banks retain their tight credit policy stance.

The estimations indicate a significant difference between the crisis reactions of state-controlled banks and private banks. Figure 4.1 shows that credit availability from state-controlled banks was much higher relative to the private banks during the peak of the crisis (2008Q4-2009Q2). Starting from 2009Q3, the gap between private and state-controlled banks narrows as private banks expand credit supply. The gap between domestic and foreign banks is maintained as foreign banks keep their restrictive credit policies in place.

### 4.5.2 Alternative models

We now turn to the alternative models described in Table 4.3. We start with a robustness check to test the sensitivity of our results to the distribution of the inefficiency term. Several possibilities for this distribution have been proposed and applied in the literature on stochastic frontier approach.<sup>35</sup> We consider a half-normal distribution rather than an exponential distribution for the inefficiency term in this robustness check as the half-normal distribution is commonly used in works applying stochastic frontier approach (e.g. Karas, Schoors and Weill, 2010). The log-likelihood is slightly

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<sup>35</sup> See Kumbhakar and Lovell (2000) for the stochastic frontier approach and its different applications.



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lower with this distribution than with the exponential distribution, justifying our choice of the latter for our main model.

**Table 4.3 Estimation results for alternative specifications as robustness check**

Explanatory variables	Specification half-normal distribution	with	Specification with interaction terms between capital and ownership dummy variables
Capital	1.03*** (0.01)		1.03*** (0.01)
State-controlled	-0.06 (0.07)		0.13 (0.11)
Foreign-owned	-0.01 (0.04)		-0.28*** (0.09)
State-controlled* capital			0.04*** (0.01)
Foreign-owned*capital			-0.02*** (0.01)
	07Q2	0.07 (0.13)	0.05 (0.07)
	07Q3	-0.01 (0.11)	-0.01 (0.08)
	07Q4	-0.16 (0.13)	-0.17* (0.10)
	08Q1	-0.05 (0.1)	-0.07 (0.08)
	08Q2	-0.09 (0.11)	-0.13 (0.08)
Time fixed effects	08Q3	-0.07 (0.12)	-0.11 (0.09)
	08Q4	-0.5*** (0.14)	-0.62*** (0.12)
	09Q1	-0.69*** (0.16)	-0.78*** (0.14)
	09Q2	-0.68*** (0.15)	-0.79*** (0.13)
	09Q3	-0.74*** (0.15)	-0.89*** (0.13)
	09Q4	-0.5*** (0.16)	-0.65*** (0.14)
State-controlled banks	07Q2	0.02 (0.14)	0.05 (0.07)

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time fixed effects	07Q3	0.07 (0.12)	0.02 (0.08)
	07Q4	0.12 (0.1)	0.08 (0.08)
	08Q1	0.01 (0.11)	0.01 (0.10)
	08Q2	0.03 (0.12)	0.04 (0.09)
	08Q3	0.07 (0.13)	0.09 (0.08)
	08Q4	0.24** (0.11)	0.25** (0.10)
	09Q1	0.28*** (0.11)	0.30*** (0.10)
	09Q2	0.22* (0.12)	0.22** (0.10)
	09Q3	0.13 (0.13)	0.13 (0.11)
	09Q4	0.11 (0.14)	0.11 (0.11)
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Foreign-owned banks time fixed effects	07Q2	-0.07 (0.09)	-0.16*** (0.05)
	07Q3	-0.07 (0.08)	-0.11* (0.06)
	07Q4	-0.04 (0.08)	-0.05 (0.05)
	08Q1	-0.09* (0.05)	-0.14*** (0.04)
	08Q2	-0.11 (0.06)	-0.17*** (0.05)
	08Q3	-0.05 (0.07)	-0.12*** (0.05)
	08Q4	-0.02 (0.08)	-0.05 (0.08)
	09Q1	-0.01 (0.09)	-0.04 (0.08)
	09Q2	-0.11 (0.08)	-0.15** (0.08)
	09Q3	-0.2** (0.09)	-0.25*** (0.08)
09Q4	-0.17* (0.09)	-0.23*** (0.08)	
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Observations		5829	5829
Log-likelihood		-3266.061	-3246.010
Info criterion: AIC		1.145	1.139
Finite sample AIC		1.146	1.139

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Info criterion: BIC

1.228

1.224

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Note: Estimations by maximum likelihood on a pooled cross section. All variables are in natural logarithms. Constant terms and time variable effects for capital are included but not reported. All models allow heteroscedasticity of the residuals in time. Residual parameters are not reported. Standard errors appear in parentheses next to estimated coefficients. \*, \*\*, \*\*\* denote an estimate significantly different from 0 at the 10%, 5%, or 1% level. All models converge normally.

With few exceptions, this specification does not affect the results. We still observe the reduction of credit supply during the financial crisis with significantly negative time dummy variables for all quarters from the fourth quarter of 2008 until the fourth quarter of 2009, while no time dummy variables are significant before this time.

We show again that foreign banks have reduced their credit supply more than domestic private banks during the financial crisis. The results are similar for the interaction variables between foreign ownership and time dummy variables, which are significantly negative for the two first quarters of 2008 and the three last quarters of 2009. Finally, we still see the lower reduction of credit supply for state-controlled banks relative to domestic private banks. The interaction variables between state ownership and time dummy variables are all significant and positive for the fourth quarter of 2008 and three quarters of 2009.

Second, we test an alternative specification of our model in which we add interaction variables between capital and ownership dummy variables. This allows the sensitivity of the maximum risk-weighted assets-to-capital ratio to vary across bank ownership type. It is important to test this since the scale effect of capital on credit supply constraints may vary significantly across types of banks. Our main results remain unchanged even if we allow the scale effect of capital to vary across types of banks. The reduction of credit supply is again supported by the fact that time dummy variables are significantly negative for the fourth quarter of 2007 and all quarters from the fourth quarter of

2008 to the fourth quarter of 2009. We also observe a greater reduction of credit supply for foreign banks than for domestic private banks with significantly negative coefficients for the interaction variables between foreign ownership and time dummy variables for most quarters. Furthermore, we can still see that state-controlled banks can be characterized by a lower decrease in credit supply during the financial crisis; the interaction terms between state ownership and time dummy variables are significantly positive for the last quarter of 2008 and the two first quarters of 2009. We conclude that even if the scale effect of capital appears to vary across the banking groups, our main findings are robust to such variation.

### 4.6 Conclusion

In this paper, we investigate how bank ownership influenced credit supply during the recent financial crisis in Russia. The Russian banking industry is of particular interest as it is characterized by a mix of foreign-owned banks, state-controlled domestic banks, and privately owned domestic banks. We apply an innovative methodology to analyze credit supply using the stochastic frontier approach that allows assessment of bank credit supply in comparison to the level of capital— a key constraint for the bank.

The literature suggests that the behavior of banks during economic downturns may vary with bank ownership. Specifically, there is an expectation that foreign banks might reduce their lending more than other banks because of a potential “lack of loyalty” to actors in the domestic economy. State-owned banks, in contrast, might tend to keep lending as their objective function might include macroeconomic stabilization.

Our main conclusion is that bank ownership exerted an impact on credit supply during the recent financial crisis in Russia. Whereas credit supply overall diminished during the crisis, we observe that this reduction was greater for foreign banks and lower for state-controlled banks relative to domestic private banks.

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Thus, we find support for the “lack of loyalty” hypothesis, whereby foreign banks are prone to a stronger reduction in lending than domestic banks in troubled times. We also provide evidence in favor of the view according to which the objective function of state-owned banks would lead them to support the economy during economic downturns.

The implications of our findings are that the privatization of state-owned banks and foreign bank entry may contribute to deterioration of the economic situation during an economic downturn. This does not mean that the policies to encourage entry of foreign banks should be abandoned; foreign banks generate many benefits such as efficiency gains in the sector (Karas, Schoors and Weill, 2010).

Looking ahead, our methodology for studying the bank credit channel holds considerable promise. Unlike the approach proposed by Khwaja and Mian (2008) and extended by Jimenez et al. (2010) for estimation of credit supply of banks by analyzing the bank credit channel, our methodology avoids the need for data on borrowers. It simply requires data on banks, and thereby opens avenues for broad research on the lending channel of monetary policy transmission.

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### Conclusions

Through their essential function, financial institutions lift economies from barter towards the ideal of an Arrow-Debreu –equilibrium. They specialize in solving the complex issues that plague lender-borrower relationships in a world of asymmetric information and incomplete markets. Real world financial institutions cannot implement the Arrow-Debreu ideal, but they are able to lift economies towards that ideal to a ‘second best’ level where limits of borrowing still matter, but where significant opportunities for welfare improving transactions nevertheless exist. To understand real economic behaviour in the second best world, economists need to understand the limits of borrowing.

The aim of the dissertation is to increase our understanding about the limits of borrowing. The essays in the four chapters make theoretical, methodological and empirical contributions to the literature.

The first chapter contributes to the theoretical literature by studying the operation of LOLRs in an original model. It views a LOLR as a reserve pool, which operates in the presence of incomplete futures markets. The theoretical analysis indicates that LOLRs can play a useful role in the absence of complete futures markets, because then agents need some other way to agree ex ante on how prices will be determined when the economy is hit by shocks. Such a commitment mechanism may be built into the statute of a LOLR. The model suggests that voluntary LOLR schemes will not attract sufficient participation. In the presence of non-transparency, special powers usually linked to governments are needed to force participation to secure sufficient coverage of LOLR schemes. The model extends our understanding of public intervention in LOLR schemes by showing that it may be welfare improving also under aggregate certainty.

The model has a number of important implications about the ongoing debate about LOLR schemes in Europe. One such implication is the need to establish the conditions for LOLR support



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ex ante, before an actual need for LOLR support arises. Prior commitment is not necessary only to facilitate the negotiations about LOLR support when the need for such support arises. Clarity about how such situations are handled is also a crucial consideration in the ex ante choices of the agents. Too lax conditions for LOLR assistance may contribute to increased risk taking. Too strict conditions, on the other hand, imply unnecessary liquidation costs during a crisis.

The model also yields new insight about the scope of voluntary LOLR schemes, with reference to the ongoing debate in the euro area. According to the theoretical prediction, low risk borrowers are not willing to voluntarily join a LOLR arrangement, which gives liquidity support at an apparent loss to troubled parties. This explains why the euro area countries have such persistent problems in agreeing on the terms and conditions of the European Financial Stability Facility, a LOLR facility for euro area sovereigns. Low risk countries, with established traditions on budget discipline, are not willing to agree on arrangements that are more likely to benefit countries with lax budgetary policy. The chosen policy line to try to agree on common budgetary mechanism might resolve the issue, if it succeeds in equalizing the ex ante crisis probabilities of euro area governments to a sufficient degree. If such an agreement is not reached, the absence of an insurance mechanism between troubled euro area countries remains a weakness in the institutional fabric of the common currency area.

The model opens up a number of important avenues for future research. Taking into account the issue of aggregate uncertainty may yield further insights about the limits of borrowing. In the real world of aggregate uncertainty, liquidity provision by LOLR schemes necessarily falls short of demand in some circumstances, with potentially interesting policy tradeoffs. An explicit modelling of sovereign risk also deserves attention, based on the experiences of the present European crisis.

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The second chapter contributes to the methodology by a novel empirical approach to measure the limits of borrowing. In spite of the high stakes, economists have been unable to present a fully satisfactory method for testing and estimating the limits of borrowing. This shortcoming challenges the efforts of economists to understand the limits of borrowing and the efforts of policy makers to control them.

The new approach extends the applicability of the stochastic frontier method in estimation of credit constraints, which was pioneered in Chen and Wang's (2008) study of Taiwanese firms. It opens the possibility to test and estimate the limits of borrowing from borrower samples under relatively mild assumptions. The method is well suited for the empirical analysis of many other types of constraints in economics, such as capital and liquidity constraints.

In the essay, the method is applied to a set of household surveys from Finland to test two theoretical hypotheses about the limits of borrowing. The estimation results support for the 'cyclical credit policy hypothesis' that the limits of borrowing tend to develop pro-cyclically. This estimation result implies that development of credit availability may strengthen economic cycles. It yields support to the commonly held view that public intervention may play a useful role in stabilizing credit availability.

The estimations also support the controversial and previously untested hypothesis from Dell'Arricia and Marquez (2006) that bank regulation may have counterproductive effects on credit quality. The estimation results imply that, in accordance with this hypothesis, banks may respond to regulatory changes that harmonized banks' credit market information counterproductively, by an aggressive credit expansion and, thereby, an increase in credit risk. This result is critical of the ongoing efforts to tighten bank regulation in accordance with the Basel III negotiations. Against best intentions, the Basel III harmonization may destabilize rather than stabilize the global financial system.

The third chapter contributes to our empirical understanding of the effect of limits of borrowing on consumer behavior. Past econometric studies have not found fully conclusive evidence that changes in the limits of borrowing significantly affect consumer behavior at the macroeconomic level. In this essay, a novel empirical approach is employed to look for such evidence. In the first stage, the methodology presented in the previous essay is employed to estimate credit constraints in a household sample. In the second stage, the credit constraint estimates are employed as proxies for the underlying credit constraints in a regression model to estimate the effect of credit constraints on durable consumption. The estimations are based on a Finnish household survey, which covers a post-deregulation consumer spending spree.

The estimations support the view that changes in the limits of borrowing can have large effects on durable consumption expenditure. The analysis indicates that the liberalization of credit markets, and the subsequent improvement in credit availability contributed to a consumer spending spree in Finland in the late 1980's. This result implies that credit constraints need to be taken into account when analyzing and predicting consumer behavior, and adjusting policy. In particular, the liberalization of financial markets can lead to 'overheating' of the economy, with significant pitfalls in terms of economic stability. If such effects are anticipated, then policy makers may be able to counter them by appropriate policy tightening.

The new approach opens the way for econometricians to test and estimate theoretical and purely empirical models of consumption in the presence of credit constraints. Previous insights about the quantitative effects of credit supply constraints on consumption have been based on simulations of calibrated theoretical models, rather than empirical models. More generally, the approach presented in this paper holds promise in the study of many kinds of economic behavior in

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the presence of credit constraints. A similar approach can, for example, be applied to study the effects of credit constraints on investment.

The fourth chapter contributes to our understanding of how bank ownership affects the banks' propensity to tighten credit supply during an economic downturn. The essay extends the empirical methodology employed in the second and third essays of this thesis to the study of bank level data. It yields estimates of credit supply constraints by banks. The novel approach is employed to data of Russian banks during the global financial crisis.

The findings support the view that bank ownership affected credit supply during the financial crisis and that the crisis led to an overall decrease in the credit supply. Relative to domestic private banks foreign-owned banks reduced their credit supply more and state-controlled banks less. The results imply that banking structure affects the cyclical development of limits of borrowing. The results support the "lack of loyalty" of foreign banks to domestic actors during a crisis, as well as the view that an objective function of state-controlled banks leads them to support the economy during economic downturns. Previous evidence for the hypothesis has been mixed.

The new approach employed in this essay opens the possibility to study the effects of financial structure on economic development more generally. Previously, our understanding about this issue has been limited. Interesting open issues include the credit supply of other types of banks, such as savings banks or Islamic banks. One may also study the issue of whether other factors besides bank type and its capital stock significantly affect lending behaviour.

# Risto HERRALA

## ESSAYS ON THE LIMITS OF BORROWING

### Résumé

Le but de cette thèse de doctorat est de présenter des nouveaux points de vue sur les limites de l'emprunt. Le premier chapitre est une introduction à ce thème. Le deuxième chapitre contribue à la théorie des limites d'emprunt avec une étude sur les prêteurs de dernier ressort dans un modèle théorique. Le troisième chapitre présente une nouvelle approche pour tester et mesurer ces limites de l'emprunt avec une méthode économétrique. Il contribue aussi à nos connaissances de limites d'emprunt en utilisant la nouvelle approche pour tester le comportement cyclique et les effets de la régulation sur les limites d'emprunt. Le quatrième chapitre contribue à nos connaissances sur l'effet des limites d'emprunt sur la consommation. Le cinquième chapitre donne de nouveaux résultats sur les effets de la possession des banques sur les limites de l'emprunt sous la crise financière. Le dernier chapitre conclut et présente quelques remarques.

**Mots-clefs :** les limites de l'emprunt, les prêteurs de dernier ressort, finances des foyers domestiques, banques.

### Résumé en anglais

The aim of this PhD dissertation is to provide new insights about the limits of borrowing. The first chapter serves as an introduction to the theme. The second chapter contributes to the theory of limits of borrowing by a study of LOLRs in an original theoretical model. The third chapter introduces a new approach to test and measure the limits of borrowing econometrically. It also contributes to the empirical understanding of the limits of borrowing by applying the new approach to test the cyclical behavior and the effects of regulation on the limits of borrowing. The fourth chapter contributes to our understanding of the effect of limits of borrowing on consumption. The fifth chapter yields new insight about the effect of bank ownership on the limits of borrowing during a financial crisis. The final chapter concludes with a discussion.

**Key words:** credit constraints, lender of last resort, household finance, banking