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Financial Market Imperfections, Business Cycle Fluctuations and Economic Growth

Caterina Mendicino
to my family, my relatives, my friends
I have given considerable thought to why, quite out of the blue, one day I decided to study economics. The more I think about it the more I believe it may have happened quite by chance or possibly by mistake. In fact, when I enrolled at university I had already devoted 12 years of my life to becoming a professional musician. Perhaps I had quite simply given in my pragmatic father the day I decided to combine my classical music studies with economics. 

You could easily imagine my face the first time I saw a utility function or a profit maximization. I was both astonished and amazed: by then I had never seen anything more bizarre than economics (and economists). Still, it appeared that economics could indeed be very interesting and useful in understanding the world. So, suddenly, one day I started thinking that graduate studies in economics was the only way to go. And, not happy to give a new direction only to my own life I also succeeded in convincing one of my best friends and my ex-boyfriend to join me….guys, I still hope one day you will forgive!!!!!

Very often PhD students like to talk about their graduate studies as an amazing journey. Well, if I have to think about a journey, the Odyssey is the only one that comes to my mind…It took 10 years for Ulysses to reach the shores of Ithaca and well, a few years less for me to arrive to this day, but still no other journeys could resemble these years of PhD. So much has happened during the years and my Ithaca still seems a long way away…especially now that I just decided to take head for Canada…

Anyway, what I can say is that the last six years have been filled with new events and different experiences that tick and fast, followed one other. New things to learn, to love or to hate, exams, courses, professors, fellow PhD students, universities, places, people…

I’m very grateful to the Stockholm University and the Stockholm School of Economics for having opened their doors to me. I could never have imagined
that I would have been given so many opportunities to learn, travel, meet
interesting economists and to experience so many exciting things as I did during
my studies. However, I have to say that it has not always been a “bed of roses”.
In fact, even if I have always been very determined to complete my studies, the
ups and downs have been many during these years. I still remember how
stressful it was when one after the other all the professors working in the field I
had chosen started leaving the country. First Lars Svensson, then Paul Soderlind
and finally Ulf Södestrom….were they moving just to avoid supervising me?
Well, if they were not going to such good places I would have thought so…
And who will ever forget all the times I was shouting at Matlab or insulting
Stata?? Very soon I realized that doing research is very emotionally
demanding….and this thesis would have never been possible without the
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brief on it.

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...to the staff at the SSE...

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About my years in Sweden, after the initial adaptation period, I started loving it. And I have to admit that, although I may give the impression of not really being tied to any one place, I am so attached to Stockholm and many people here that now it is very difficult for me to leave.

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1 Because on top of everything I was really lucky to meet great friends!
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Contents

Acknowledgments

Introduction and Summary

Chapter I  Credit Market and Macroeconomic Volatility

Chapter II  On the Amplification Role of Collateral Constraints

Chapter III  Credit Frictions, Housing Prices and Optimal Monetary Policy Rules (with Andrea Pescatori)

Chapter IV  Financial Liberalization, Bank Crises and Growth: Assessing the Links (with Alessandra Bonfiglioli)
Introduction and Summary

During the centuries economists had very different opinions on the relevance of financial systems for the aggregate real activity. However, since when Modigliani and Miller (1958) demonstrated the independence of real economic decisions from financial structure, financial considerations started disappearing from the macroeconomic literature. The representative agent framework became widely used first in the growth models and subsequently in the real business cycle theory. However, following developments in microeconomic theory dealing with imperfect information provided useful insights into the structure of credit markets: transaction and information costs provided a rational for financial contract, markets and intermediaries to be taken into account by the macroeconomic literature again. Moreover, at the same time an increasing number of studies presented evidence on the link between financial and economic development and the effect of financial factors on real activity and business cycle fluctuations, generating interest on the financial aspects of business cycle propagation and economic growth.

Embedding financial aspects in a dynamic general equilibrium framework has always been a very difficult task since it implies incorporating heterogeneity among agents in a way that should be both interesting and tractable. However, in the last twenty years the business cycle literature has given evidence of a growing interest in exploring the links between financial systems and aggregate macroeconomic behaviour. Most of the theoretical research focuses on determining how the presence of credit market imperfection affect the way in which the economy responds to macro disturbances and how this disturbances are propagated throughout the economy and over time. Bernanke and Gertler (1989), Calstrom and Fuerst (1997), Bernanke, Gertler and Gilchrist (1999) among others, study the relevance of financial factors on firm's investment decisions, emphasizing the role of agency-costs and limited enforceability.

3 See, e.g., Goldsmith (1969) and McKinnon (1973).
Kiyotaki and Moore (1997) and Kiyotaki (1998) show that if debt needs to be fully secured by collateral, small shocks can have large and persistent effects on economic activity.

This dissertation consists of four self-contained papers research paper that focus on the macroeconomic effects (growth, business cycle, monetary policy) of different aspects of the financial system (credit market, financial liberalization, housing prices movements). The first two chapters contribute to the literature on credit frictions and the transmission of shocks over the business cycle. The focus of the third chapter is on how the central bank should conduct monetary policy in an economy with housing prices movements and collateral constraints. The last paper instead deals with the effects of international financial liberalization on economic growth.

"Credit Market and Macroeconomic Volatility"

This paper investigates how the degree of credit market development is related to business cycle fluctuations in industrialized countries. I show that a business cycle model that includes collateral constraints generates a negative relationship between the volatility of the cyclical component of output and the size of the credit market. Furthermore, I identify reallocation of capital as the key factor shaping this relationship. According to the model, increasing the amount of credit extended to the private sector makes output less sensitive to productivity shocks. Thus, the role of credit friction in amplifying the propagation of productivity shocks to output is greater in economies with more credit rationing. I test the predictions of the model on data using a panel of OECD countries over the past 20 years. Empirical evidence confirms that countries with better-developed credit markets experience smoother business cycle fluctuations. Moreover, a larger credit market dampens the propagation of productivity shocks to output and investment.
"On the amplification role of collateral constraints"

Following Kiyotaki and Moore (1997), a big strand of the literature has used models with collateral constraints to amplify the effects of shocks on economic activity. However, recent papers have shown that collateral constraints per se are unable to propagate and amplify exogenous shocks, unless unorthodox assumptions on preferences and production technologies are assumed. In this paper I study how the degree of frictions in the credit market affects the amplification of productivity shocks on output. I show that also using standard assumptions, a very stylized model with collateral constraint can generate amplification of productivity shocks.

Credit Frictions, Housing Prices and Optimal Monetary Policy Rules (with Andrea Pescatori)

We asses the role of housing price movements in the optimal design of monetary policy rules. Even though the relevance of liquidity constraints for consumption behavior has been well documented in the empirical and theoretical literature, little attention has been given to credit frictions at the household level in the monetary business cycle literature. This paper represents the first attempt of a welfare-based monetary policy evaluation in a model with heterogeneous agents and credit constraints at the household level. In order to evaluate optimal monetary policy we take advantage of the recent advances in computational economics by following the approach illustrated by Schmitt-Grohe and Uribe (2003). Our results show that in an optimally designed simple monetary policy rule, housing price movements should not be a separate target variable additional to inflation. Further more, the welfare loss of targeting housing prices becomes quantitatively more significant the higher the degree of access to the credit market.
Financial Liberalization, Bank Crises and Growth: Assessing the Links (with Alessandra Bonfiglioli)

This paper studies the effects of financial liberalization and banking crises on growth. It shows that financial liberalization spurs on average economic growth. Banking crises are harmful for growth, but to a lesser extent in countries with open financial systems and good institutions. The positive effect of financial liberalization is robust to different definitions. While the removal of capital account restrictions is effective by increasing financial depth, equity market liberalization affects growth directly. The empirical analysis is performed through GMM dynamic panel data estimations on a panel of 90 countries observed in the period 1975-1999.

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Credit Market and Macroeconomic Volatility*

Caterina Mendicino¹

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¹Stockholm School of Economics, Department of Economics, BOX 6501, SE 113 83 Stockholm, Sweden. e-mail:caterina.mendicino@hhs.se
Abstract

This paper investigates how the degree of credit market development is related to business cycle fluctuations in industrialized countries. I show that a business cycle model that includes collateral constraints generates a negative relationship between the volatility of the cyclical component of output and the size of the credit market. Furthermore, I identify reallocation of capital as the key factor shaping this relationship. According to the model, increasing the amount of credit extended to the private sector makes output less sensitive to productivity shocks. Thus, the role of credit friction in amplifying the propagation of productivity shocks to output is greater in economies with more credit rationing. I test the predictions of the model on data using a panel of OECD countries over the past 20 years. Empirical evidence confirms that countries with better-developed credit markets experience smoother business cycle fluctuations. Moreover, a larger credit market dampens the propagation of productivity shocks to output and investment.

Keywords: collateral constraint, reallocation of capital, asset prices
JEL codes:E21-E22- E44- G20
1 Introduction

Over the past two decades, financial systems have experienced deep structural changes as a result of regulatory reform and technological innovation. The main goal of these changes was to improve the efficiency of the financial system, but the macroeconomic implications went beyond this. Deregulation contributed to a considerable increase in the amount of bank credit extended to the private sector. A simultaneous decline in output volatility in most OECD countries over the past 20 years has been firmly established\(^1\). Changes in the underlying characteristics of the economy, and thus in the mechanism by which exogenous shocks spread and propagate in the economy, could be the main reason for such a decline. Several studies assign a primary role to the conduct of monetary policy\(^2\). Other studies demonstrate that the decrease in inflation and output volatility is traceable to changes in the variance of exogenous shocks\(^3\). A few studies, however, claim that this decline in output volatility is due to other characteristics of the economy \(^4\). What is the contribution of credit market development to increased macroeconomic stability in industrialized countries?

The business cycle literature do not provide rigorous evidence of the relationship between the degree of credit market development and output volatility for OECD countries. However, several empirical studies using large samples of countries demonstrate that countries with well-developed credit markets experience smoother output fluctuations\(^5\).

\(^{1}\)See, e.g., Blanchard and Sim\(\)on (2000), McConnell and Perez Quiroz (2001), and Stock and Watson (2003)


\(^{3}\)Sims (2001) and Sims and Zha (2001)

\(^{4}\)Hanson (2001), Campbell and Hercowitz (2004), and Justiniano and Primiceri (2006).

\(^{5}\)See Beck et al. (2000), Denizer, Iyigun, and Owen (2002), Da Silva (2002), and Borja (2002)
Preliminary analysis of OECD data reveals that the same kind of relationship holds for industrialized countries. In fact, if one borrows from the literature the notion that credit market size is a good measure of credit market development, a negative correlation with output volatility is evident. Figures 1 and 2 present credit market size (measured as the credit extended to the private sector by banks and other financial institutions as a share of GPD) and output volatility (measured as the standard deviation of the log detrended real output), 1983-2004, for a sample of 22 OECD countries. Both figures indicate significant differences among OECD countries. There is some evidence that smoother fluctuations are associated with higher levels of credit as a share of GDP. Table 1a shows that the credit-to-GDP ratio, both current and at the beginning of the period, is negatively correlated with the standard deviations of output, consumption, and investment. Table 1b presents the mean equality tests of the volatility of output, consumption, investment, and investment in residential properties across the treatment (credit market size below the sample median) and control (credit market size above the sample median) groups of countries, observed for rolling five-year periods, 1983-2004. The results suggest that countries with smaller credit markets experienced on average higher output and investment volatility.

This paper revisits the link between credit market size and macroeconomic fluctuations, with a special focus on industrialized countries. The first part of the paper develops a business cycle model that focuses on how the degree of credit market development affects the sensitivity of output to productivity shocks, and thus its volatility over the business cycle. To the best of my knowledge, very few papers have analyzed such issues. Examining access to the international credit market, Aghion,
Baccheta, and Banerjee (2003) demonstrate that small open economies at an intermediate level of financial development are more vulnerable to shocks. Campbell and Hercowitz (2004) show that the financial reforms of the U.S. mortgage market in the early 1980s coincided with a decline in the volatility of output, consumption, and hours worked. Finally, Aghion, Angeletos, Banerjee, and Manova (2005) examine how credit market development makes growth less sensitive to exogenous shocks. Unlike their papers, here I focus on the development of the domestic credit market to draw more general conclusions concerning industrialized countries from a business cycle perspective. However, I borrow from this literature the notion that collateral requirements can serve as a proxy for credit market development. Tighter collateral constraints that result in smaller credit markets characterize economies with a less-developed credit market.

I develop a full-fledged, two-sector business cycle model based on Kiyotaki and Moore (1997). To generate a reason for the existence of credit flows, two types of agents are assumed, both of whom produce and consume the same type of goods using a physical asset. They differ, however, in terms of discount factors, and consequently, more impatient agents become borrowers. Credit constraints arise because lenders cannot force borrowers to repay. Thus, physical assets, such as land, buildings, and machinery, are used not only as factors of production but also as loan collateral.

Following the lead of Cordoba and Ripoll (2004), my setup differs from that of Kiyotaki and Moore (1997) in that I use more standard assumptions as to preferences and technologies. Kiyotaki and Moore assume that both groups of agents are risk neutral. Moreover, these agents are taken to represent two different sectors of the economy—borrowers being "farmers" and lenders being "gatherers"—that apart
from using different discount factors, also differ in their production technology. In
my model, both groups of agents have a concave utility function and are generally
identical, except that they have different subjective discount factors. Moreover,
aggregate uncertainty is introduced into the model, so asset prices are not perfectly
predicted by the agents. Unlike previous literature, I allow for the existence of
liquidation costs in modeling the collateral constraint, to be able to investigate the
behavior of economies that differ in terms of access to credit financing. Finally, to
allow for capital reproducibility, I develop a model with one type of capital goods
and two sectors – consumption and investment goods production.

The main propagation channel in the model is provided by the reallocation of
capital between different sectors of the economy. Existing literature dealing with
credit markets has shown that credit frictions are a powerful transmission mechanism
that propagates and amplifies shocks. The main focus of this previous literature is on
how credit market frictions affect new capital investment, no role being assigned to
the reallocation of existing capital. However, a few papers do examine the behavior
of capital reallocation from a microeconomic point of view. Among the main results
are that capital flows from less productive to more productive firms\(^6\) and that gains
derived from reallocation appear larger when productivity differences are greater\(^7\).
Moreover, Rampini and Eisfeldt (2005) have recently demonstrated that in the USA
the amount of capital reallocation represents approximately one quarter of total
investment, and that depending on how capital reallocation is measured, between
1.4 and 5.5 of the capital stock turns over each year. Furthermore, the reallocation
of existing productive assets among firms (sales and acquisitions of property, plant,

\(^6\)Maksimovic and Phillips (2001)
\(^7\)Lang, Stulz, and Walkling (1989) and Servaes(1990)
and equipment) is procyclical.

Unlike previous literature, this paper demonstrates that in a model that includes collateral constraints, the reallocation of capital contributes in quantitatively significant terms to amplification. Moreover, such a business cycle model can generate a negative relationship between credit market development and output volatility, as long as the model allows for the reallocation of capital among firms. In fact, only by allowing for the reallocation of capital can credit market development make output less sensitive to productivity shocks.

This finding contributes significantly to the debate concerning the amplification role of collateral constraints. Cordoba and Ripoll (2004) show that adopting standard assumptions about preferences and technologies makes Kiyotaki and Moore's model unable to generate persistent or amplified shocks. Thus, their results call into question the quantitative relevance of credit frictions as a transmission mechanism. In this paper, I show that the magnitude of shock amplification is related to the degree of credit rationing. The findings of Cordoba and Ripoll hold only for economies with the least possible degree of credit rationing allowed by the model. However, the magnitude of amplification is quantitatively more significant the lower the degree of credit market development.

The second part of the paper tests the main predictions of the model on actual data. For this purpose, I use data for a panel of 22 OECD countries over the 1983-
2004 period. I also show that among OECD countries, the degree of credit market development is negatively related to output variability over the business cycle. Moreover, I demonstrate that, in accordance with the predictions of the model, a larger credit market more effectively dampens the propagation of productivity shocks to output.

The paper proceeds as follows. Section 2 presents the model, while section 3 discusses the solution method and calibration. Section 4 discusses the steady-state implications of different degrees of credit rationing. Section 5 presents the dynamics of the model, and Section 6 the relationship between credit market size and business cycle volatility. Section 7 compares model predictions with data for a panel of OECD countries. Section 8 presents the conclusions of the study.

2 The Model

Consider a stochastic discrete-time economy populated by two types of households that trade two kinds of goods, a durable asset and a non-durable commodity. The durable asset, \( k \), is reproducible and depreciates at the rate of \( \delta \). The commodity good, \( c \), is produced using the durable asset and cannot be stored. At time \( t \) there are two competitive markets in the economy: the asset market in which one unit of the durable asset can be exchanged for \( q_t \) units of the consumption good, and the credit market.

I assume a continuum of ex ante heterogeneous households of unit mass \( n_1 \), patient entrepreneurs (denoted by 1), and \( n_2 \), impatient entrepreneurs (denoted by 2). To impose the existence of credit flows in this economy, I assume that the ex ante heterogeneity is based on different subjective discount factors.
Agents of type $i$, $i = 1, 2$, maximize their expected lifetime utility as given by:

$$\max_{\{c_{it}, k_{it}, b_{it}\}} E_T \sum_{t=0}^{\infty} \beta_t^i U(c_{it})$$

with $\beta_1 > \beta_2$ s.t. a budget constraint

$$c_{it} + q_i(k_{it} - (1 - \delta)k_{it-1}) = F_{it} + \frac{b_{it}}{R_t} - b_{it-1}$$

technology

$$F_{it} = y_{it} + q_i h_{it}$$

$$y_{it} = Z_t (k_{it-1}^e)^{\alpha_i^e} h_{it} = Z_t (k_{it-1}^h)^{\alpha_i^h}$$

and a borrowing constraint

$$b_{it+1} \leq \gamma E_t [q_{t+1} k_{it}]$$

Unlike Kiyotaki and Moore (1997), I assume that agents have access to the same concave production technology\(^9\). Kiyotaki and Moore also take the two groups of agents to represent two different sectors of the economy; on the contrary, I assume technology to be the same for both groups of agents ($\alpha_1 = \alpha_2$). Moreover, I also allow for reproducible capital and assume that each agent is able to produce both consumption and investment goods\(^10\). For simplicity, I will assume that both types of production are identical\(^11\).

However, I do follow Kiyotaki and Moore (1997) in assuming that the technology is specific to each producer and that only the household that initiated a particular

\(^9\)See Cordoba and Ripoll (2004) for a discussion of how different assumptions about production technology affect the impact of technology shocks in the modeled economy.

\(^10\)In this way I avoid creating a rental market for capital, and make the model directly comparable to those of Kiyotaki and Moore (1997) and Cordoba and Ripoll (2004).

\(^11\)Assuming decreasing returns in the production of investment goods is similar to the common assumption that investments have convex adjustment costs.
type of production has the skills necessary to complete it. Thus, if agent \( i \) decides not to put effort into production between \( t \) and \( t + 1 \), there would be no production outcome at \( t + 1 \), but only the asset \( k_{it} \). The agents cannot precommit to produce; moreover, they are free to walk away from the production and debt contracts between \( t \) and \( t + 1 \). This results in a default problem that prompts creditors to protect themselves by collateralizing the household's assets. Creditors know that if the household abandons its production and debt obligations, they will still get his asset. However, following Iacoviello (2005), I assume that the lenders can repossess the borrower's assets only after paying a proportional transaction cost, \( [(1 - \gamma)E_t q_{t+1}k_{it}] \). Thus, agents cannot borrow more than a fraction, \( \gamma \), of the expected value of the asset in the next period, as follows:

\[
b_{it} \leq \gamma E_t[q_{t+1}k_{it}]
\]

where \( \gamma < 1 \) and \( (1 - \gamma) \) represent both the cost lenders must pay to repossess an asset and the degree of credit rationing of the economy, respectively. Thus, as in Aghion, Baccheta, and Banerjee (2003) and Campbell and Hercowitz (2004), limiting the borrowing to a fraction of the expected liquidation value of the capital takes into account different degrees of credit market development, a high \( \gamma \) representing a developed financial sector while a low \( \gamma \) represents an underdeveloped system.

2.1 Agents' optimal choices

Step 1: Optimal allocation of capital

I divide the agents' problem into two steps. First, in any given period each agent allocates the existing capital to produce either consumption or investment goods by
solving
\[
\max_{k_{t-1}} Z_t \{ (k_{t-1}^c)^{\alpha} + q_t (k_{t-1} - k_{t-1}^c)^{\alpha} \}
\]

This leads to the first-order condition,
\[
(k_{t-1}^c)^{\alpha-1} = q_t (k_{t-1} - k_{t-1}^c)^{\alpha-1}
\]

It is possible to express the amount of capital allocated to each type of production as a fraction of the total capital owned by each agent, as follows:
\[
k_{t-1}^c = \theta k_{t-1}
\]
where \( \theta(q) = \frac{q^{1-\alpha}}{1+q^{1-\alpha}} \). Thus, the total production of each individual can be expressed as
\[
F_t = k_{t-1}^c Z_t [\theta^\alpha + q_t (1 - \theta)^\alpha]
\]

**Step 2: Utility maximization**

Now it is possible to simplify the maximization problem, obtaining
\[
\max_{\{c_{t},k_{t},b_{t}\}} E_t \sum_{t=0}^{\infty} \beta_t^t U (c_{t} )
\]
s.t. the *budget constraint*
\[
c_{t} + q_t(k_{t} - (1 - \delta) k_{t-1}) = k_{t-1}^c Z_t [\theta^\alpha + q_t (1 - \theta)^\alpha] + \frac{b_{t}}{R_t} - b_{t-1}
\]
and the *borrowing constraint*
\[
b_{t+1} \leq \gamma E_t [q_{t+1}k_{t}]
\]
The agents’ optimal choices are then characterized by
\[
\frac{u_{c_{t}}}{R_t} \geq \beta_t E_t u_{c_{t+1}}
\]
and

\[ q_t - \beta_t E_t \frac{u_{C_{i,t+1}}}{u_{C_{i,t}}} q_{t+1} (1 - \delta) \geq \beta_t E_t \frac{u_{C_{i,t+1}}}{u_{C_{i,t}}} (F_{k_{i,t+1}}) \]

where \( F_{k_{i,t+1}} \) is the marginal product of capital.

The first equation relates the marginal benefit of borrowing to its marginal cost, while the second shows that the opportunity cost of holding one unit of capital,

\[ [q_t - \beta_t E_t \frac{u_{C_{i,t+1}}}{u_{C_{i,t}}} q_{t+1} (1 - \delta)] \]

is greater than or equal to the expected discounted marginal product of capital.

It is possible to show that impatient agents borrow up to the maximum possible amount in the neighborhood of the deterministic steady state. In fact, if we consider the Euler equation for the impatient household in the steady state,

\[ \mu_2 = (\beta_1 - \beta_2) U_c > 0 \]

Where \( \mu_2 \) is the Lagrange multiplier associated with the borrowing constraint. Thus, if the economy fluctuates around the deterministic steady state, the borrowing constraint holds with equality,

\[ b_{2,t} = \gamma E_t [q_{t+1} k_{2,t}] \]

and

\[ k_{2,t} = \frac{W_{2,t} - c_{2,t}}{\beta_t E_t [q_t - \gamma E_t \frac{u_{C_{i,t}}}{u_{C_{i,t}}}]}, \]

where \( W_{2,t} = F_{2,t} + q_t (1 - \delta) k_{2,t-1} - b_{2,t-1} \) is the impatient agent's wealth at the beginning of the period and \( d_t = [q_t - \gamma E_t \frac{u_{C_{i,t}}}{u_{C_{i,t}}}] \) represents the difference between the price of capital and the amount this agent can borrow against a unit of capital, i.e., the down payment required to buy a unit of capital.

Thus, in the neighborhood of the steady state for constrained agents, the marginal benefit is always greater than the marginal cost of borrowing. If I define \( \mu_{i,t} \geq 0 \) as
the multiplier associated with the borrowing constraint, the Euler equation becomes

\[ \frac{U_{c,t}}{R_t} - \mu_{2,t} = \beta_t E_t U_{c,t+1} \]

Moreover, the marginal benefit of holding one unit of capital is given not only by its marginal product but also by the marginal benefit of being allowed to borrow more:

\[ q_t - \beta_t E_t \frac{U_{c,t+1}}{U_{c,t}} q_{t+1} (1 - \delta) = \beta_t E_t \frac{U_{k,t+1}}{U_{c,t}} (F_{k,t+1}) + \gamma E_t q_{t+1} \frac{\mu_{2,t}}{U_{c,t}} \]

In contrast, patient households are creditors in the neighborhood of the steady state. Thus, the lender's capital decision is determined by the point at which the opportunity cost of holding capital equals its marginal product:

\[ q_t - \beta_t E_t \frac{U_{c,t+1}}{U_{c,t}} q_{t+1} (1 - \delta) = \beta_t E_t \frac{U_{c,t+1}}{U_{c,t}} (F_{c,t+1}) \]

### 3 Model Solution

#### 3.1 Benchmark parameter values

I calibrate the model at quarterly intervals, setting the patient households’ discount factor to 0.99, such that the average annual rate of return is approximately 4%, while the impatient households’ discount factor is 0.95. I assume the following utility function:

\[ U(c_t) = \frac{c_t^{1-\theta}}{1-\theta} \]

\(^{12}\text{Lawrance (1991) estimates that the discount factors of poor households are in the 0.95 to 0.98 range, while according to Carroll and Samwick (1997), the empirical distribution of discount factors lies in the 0.91 to 0.99 interval.}\)
and set \( \theta \) to equal 3.3. The productivity parameter, \( \alpha \), is 0.36, as in the tradition of the real business cycle literature\(^{13}\). The baseline choice for the fraction of borrowing-constrained population is set to 50. The parameter representing the degree of credit rationing, \( \gamma \), is in the \([0,1]\) range. Figure 4 shows that by using these parameter values and varying \( \gamma \) between zero and unity, it is possible to reproduce the same private credit-to-GDP as found in the data. Finally, I calibrate the technology shocks according to standard values in the real business cycle literature\(^{14}\). Table 2 summarizes the parameter values.

### 3.2 Dynamics

The agents' optimal choices of borrowing and capital, together with the equilibrium conditions, represent a non-linear dynamic stochastic system of equations. Since the equations are assumed to be well-behaved functions, the solution of the system is found by using standard local approximation techniques. All the methods commonly used for such systems rely on the use of log-linear approximations around the steady state to obtain a solvable stochastic system of difference equations.

By finding a solution, I mean to express all variables as linear functions of a vector of variables, both endogenous state, \( x_{t-1} \), and exogenous state, \( z_t \), variables, i.e., I am seeking the recursive equilibrium law of motion:

\[
\begin{align*}
  x_t &= P x_{t-1} + Q z_t \\
  y_t &= R x_{t-1} + S z_t
\end{align*}
\]

where \( y_t \) is the vector of endogenous (or jump) variables.

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\(^{13}\)See Cooley and Prescott (1995) or Prescott (1986).

\(^{14}\)For technology shock, see chapter 1 in Cooley and Prescott (1995) or Prescott 1986.
To solve for the recursive law of motion, I need to find the matrices $P, Q, R, \text{and } S$, so that the equilibrium described by these rules is stable. I solve this system using the undetermined coefficients method of, for example, McCallum (1983), King, Plosser, and Rebelo (1987), Campbell (1994), and Uhlig (1995).\footnote{See Uhlig (1995), \textit{A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily}, for a description of the solution method.}

4 Credit Market Size and the Deterministic Steady State

Now, I analyze how the degree of credit rationing affects the deterministic steady state of the model. Since total output is maximized when the marginal productivity of the two groups is identical ("first-best allocation"), I examine how the allocation of capital between the two groups varies with $\gamma$. Impatient households are credit constrained in the deterministic steady state, so their capital holdings are less than those of the patient agents. Using the equations representing the households' optimal choice of capital evaluated at the steady state, it is possible to show that as long as $\gamma < \frac{1}{\beta_1}$,

$$\frac{K_1}{K_2} = \left[ \frac{\beta_1}{\beta_2} \frac{1 - \beta_2(1 - \delta) - \gamma(\beta_1 - \beta_2)}{1 - \beta_1(1 - \delta)} \right]^{\frac{1}{1 - \alpha}} > 1$$

The steady-state allocation of capital depends on the subjective discount factors, $(\beta_1 \text{ and } \beta_2)$, the fraction of the two groups of agents, $n$, the depreciation rate, $\delta$, and the degree of credit market development, $\gamma$. Compared to the first-best allocation, the allocation under credit constraints reduces the level of capital held by the borrowers. In fact, as long as $\gamma < \frac{1}{\beta_1} = 1.0101$, it implies a difference in the marginal productivity of the two groups. Figure 5a shows how the steady-state productivity gap in total...
production between the two groups of agents varies with respect to $\gamma$. In fact, less credit rationing allowing for a more efficient allocation of capital between the two groups implies a smaller productivity gap, and thus smaller losses in terms of total production. In the presence of credit frictions it is not possible to reach the efficient equilibrium, but a higher $\gamma$ does reduce the output loss. As Figure 5b shows, the higher the value of $\gamma$ the greater the amount of capital assigned to the production of consumption goods (middle panel), despite a lower share of total capital allocated to this sector (top panel). At the same time, greater access to credit decreases the difference between the amount of capital assigned to the production of both consumption and investment goods by the two groups of agents (bottom panel). However, the difference in the amount of capital assigned to the two sectors is always greater for the production of consumption goods.

Figure 6, a and b, shows how the deterministic steady-state values of the model’s variables change with respect to the degree of credit market development, $\gamma$. Increased access to the credit market implies credit expansion, $ssb$, and thus a rise in the level of investment by borrowers, $ssk2$. With more capital allocated to the most productive group of agents, there is an increase in the production share of constrained agents, and consequently in total production, $ssy$. Hence, the amounts of both total capital, $ssK$, and consumption, $ssC$, are higher as well. Up to a certain value of $\gamma$, borrowers’ consumption also increases. This could be due to both a credit channel effect and a wealth effect. Agents benefit from both greater access to debt financing and the increasing value of their assets. However, as expected, borrowers’ steady-state consumption decreases as $\gamma$ approaches unity. In an environment with relaxed credit restrictions, impatient agents prefer to consume more today than in
the future, thus reducing the steady-state consumption level.

It is important to stress the increasing trend of asset prices in the steady-state ssq. The lenders’ optimal choice of capital gives

\[ q = \frac{\beta_1}{1 - \beta_1} F_k \]

Thus, in a steady state, asset prices depend on the marginal productivity of capital and increase with \( \gamma \).

5 Benchmark Model Dynamics

I now consider the response of the model economy to a productivity shock. I assume that the economy is at the steady-state level at time zero and then is hit by an unexpected 1% increase in aggregate productivity. I assume that the productivity shock follows an AR(1) process given by

\[ \ln(Z_t) = \rho_2 \ln(Z_{t-1}) + \varepsilon_{Z_t}, \quad \varepsilon_{Z_t} \sim \text{i.i.d.} N(0, \sigma_\varepsilon) \]

Figure 7 shows the response of total aggregate output to the productivity shock. As we see, after a 1% increase in aggregate productivity, total output increases by approximately 1.3% in the first period and still further in the second. In what follows I will show that the amplification channel in the first period is given by the reallocation of existing capital between different sectors of production, while in the second period the redistribution of capital between the two groups of agents also contributes to generate amplification.

Looking at the effects of the shock on the two different types of production in aggregate terms, we see that the production of investment goods displays evidence of
significant amplification, while the production of consumption goods reacts much less markedly (Figure 8a). When aggregate productivity exogenously increases, agents optimally reallocate the existing capital between the two sectors. For the agents to smooth the effect of the shock through investment, more capital is allocated to the production of investment goods. Thus, the change of use of the existing productive asset amplifies the effect of the productivity shock on the aggregate production of investment goods. On the other hand, for the same reason, the impact of the shock on the production of consumption goods is reduced (the initial impact is under 1%). The response of $\theta$ indicates that capital is indeed reallocated towards the production of investment goods, coinciding with the two major amplification peaks.

Borrowers that were limited in their capital holding by the existence of borrowing constraints, increase their demand for productive assets. For the capital market to clear, the user cost of holding capital has to increase as shown in Figure 8b. The productivity shocks affect borrowers' decisions not only directly, but also indirectly through asset price dynamics, which contribute to loosening the collateral constraint. In fact, the rise in asset prices implies a credit boom\footnote{\cite{18}}. For the patient agents to be willing to increase the amount of funds offered for borrowing, the interest rate must increase in the first period. Moreover, with asset prices increasing and the production of investment goods strongly reacting to the shock, the response of aggregate real output to the productivity shock is greatly amplified. Figure 8d presents the dynamics of the two groups' production in more detail. Since in the first period the agents all decided to reallocate their own capital optimally in the same

\[ b_{t+1} = \hat{g}_{t+1} + \hat{k}_{t+1} \]
way, independently of ownership, both types of production behaved identically\textsuperscript{17}. In the second period, given the redistribution of capital towards this group of agents, the production specific to constrained agents is more strongly affected by the shock and displays a significant degree of amplification\textsuperscript{18}. In contrast, the amplification of lender production is minimal\textsuperscript{19}. In the second period, the reallocation of capital between the two sectors is still affecting the production behavior of both groups. However, what generates differences in the impact of the shock is the fact that the capital held by constrained agents increases substantially. Constrained agents can smooth the effects of the shock only by buying more capital assets. The rise in current investment expenditures propagates the positive effect of the shock to borrowers' production over time (see Figure 8c). Moreover, since the marginal productivity of capital is higher for borrowers, this generates a persistent effect on aggregate production as well\textsuperscript{20}. While in the first period the only source of amplification was the reallocation of capital in terms of use (to the most relevant sector)\textsuperscript{21}, in the second period both physical and ownership reallocation take place\textsuperscript{22}.

Figure 9 compares the reaction of total aggregate production in the present model with that in the standard Kyotaki and Moore one-sector model. As in Corboda and Ripoll (2004), in this version of the model aggregate capital is fixed in supply and

\textsuperscript{17} Amplification is 0.34% of total production and 0.21% of investment goods production.
\textsuperscript{18} Amplification of 0.86% of total production, 0.78% of investment goods production, and 0.42% of consumption goods production.
\textsuperscript{19} Amplification is 0.07% of total production and 0.03% of investment goods production. The effect on consumption goods production is reduced by 0.31%.
\textsuperscript{20} In fact, when the capital used by the most productive agents increases — as well as their share of production \( \left( \frac{P_{2,t}}{P_t} \right) \) — the effect of the shock is amplified even more.
\textsuperscript{21} As for the individual production, amplification is 0.34% of total production and 0.21% of investment goods production.
\textsuperscript{22} Amplification is 0.45% of total production, 0.36% of investment goods production, and 0.0081% of consumption goods production.
only one consumption good is produced. The two-sector model displays greater amplification and persistence of productivity shocks. In the standard one-sector model, the only source of amplification is the redistribution of capital in favor of the borrowers. Thus, there is amplification of the shock only in the second period. In contrast, in the two-sector model, even in the first period the reallocation of capital towards investment goods production and the increase in the price of these goods already generated significant amplification. In the second period still greater amplification is generated, not only by this mechanism, but also by the redistribution of capital. Thus, the existence of collateral constraints in the two-sector version of the model generates more amplification and persistence of productivity shocks than does the standard Kyotaki and Moore setup.

6 Credit Market Size and Business Cycle

6.1 Benchmark model: quantitative results

Limiting borrowing to a fraction of the expected liquidation value of the collateral takes into account different degrees of development of the banking technology for liquidating collateral\(^\text{23}\). Thus, as in Aghion, Baccheta, and Banerjee (2003) and Campbell and Hercowitz (2004), credit market development is modeled by relaxing credit restrictions. At the same time, the ability of lenders to repossess collateral, and thus their willingness to extend credit, affects the size of the credit market in the model. In what follows, I consider how the reaction to productivity shocks is affected by the size of the credit market. Unlike previous studies, by allowing for the reallocation of existing capital between sectors, my results show that the reaction to

\(^{23}\)Note that \((1-\gamma)\) is the cost of liquidation.
shocks already varies, even in the first period.

Figure 10, a and b, shows the initial impact of productivity shocks — i.e., the reaction intensity for any given value of $\gamma$. As a result, more-developed credit markets display reduced sensitivity of output to productivity shocks. Looking at the decomposition of output, a larger credit market magnifies the reaction of consumption goods production while weakening the response of investment goods production. The difference between the reactions of the two sectors is explained by the dynamics of capital allocation between the two groups of agents. As shown in Figure 10b (top panel), the magnitude of capital reallocation is lower in economies with a more-developed credit market. With less capital flowing to the production of investment goods, the response of this sector decreases even further. Since the decreased reaction intensity of this sector is greater than the amplification of the shock in consumption goods production (note that the response of this sector never reaches 1%), a larger credit market dampens the propagation of productivity shocks to output.

In economies with greater access to credit, ceteris paribus, less capital (as collateral) is needed to be able to borrow the same amount, so less capital is reallocated to the production of investment goods. On the other hand, less capital is needed to fill a smaller productivity gap.

Figure 10c depicts the impact of the shock on asset prices. As we see, reducing financial frictions reduces the sensitivity of asset prices to productivity shocks. This effect contributes to the same shock having a weaker impact on total aggregate production.

Cordoba and Ripoll (2004), assuming $\gamma = 1$, show that the Kyotaki and Moore setup in a standard business cycle framework renders collateral constraints unable
to generate amplification, a finding that still holds in the two-sector setup. However, if we allow for different degrees of credit market development, we see that in the Kyotaki and Moore model the magnitude of the initial amplification impact does vary with credit market size. Thus, the amplification of productivity shocks to output is greater in economies with tighter collateral constraints. Once we allow for \( \gamma \) to be lower than unity, the amplification generated in the model is no longer negligible.

Figure 10d shows how the size of the credit market affects the transmission of productivity shocks in the standard one-sector model. An inverted U-shaped relationship is delivered by the model. As pointed out by Cordoba and Ripoll (2004), in the one-sector model, the elasticity of total output to technology shocks can be written as follows:

\[
\epsilon_y = \epsilon_{y_k} \epsilon_{k_2} \frac{F_{k_2} - F_{k_1}}{F_{k_2}} \alpha \frac{y_2}{y} \epsilon_{k_2} Z
\]

The first term is the productivity gap between constrained and unconstrained agents, \( \alpha \) is the share of collateral in production, \( \epsilon_{k_2} \) is the production share of constrained agents, and \( \epsilon_{k_2} Z \) is the redistribution of capital. In the one-sector model, the fraction of total output produced by constrained agents increases with increasing values of \( \gamma \) because more capital is held by the constrained population. However, for the same reason, the productivity gap decreases with \( \gamma \). Thus, the second impact of productivity shocks on total output depends on these two opposing forces. As a result, the degree of credit market development affects the reaction of output to

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24Since the initial impact of the shock would always be equal to the shock itself, we are now looking at the second-period effect of the shock.

25Regardless as to the shape of the capital reaction to technology shocks, the relationship between \( \gamma \) and the second impact of \( z_t \) on \( y_t \) assumes an inverted U shape; this is, of course, more pronounced when \( \epsilon_{k_2} Z \) is not monotonic.
productivity shocks differently in the two models.

6.2 Credit market size and output volatility: a computational experiment

Now I examine the relationship between the volatility of the cyclical component of output and the size of the credit market delivered by the model. I simulate the model for 1000 values of $\gamma$ in the $[0,1]$ range. The number of simulated series for the calculation of moments is 5000 for any given $\gamma$. The productivity shock follows an AR(1) process, i.e., $\ln(Z_t) = \rho Z \ln(Z_{t-1}) + \varepsilon_{Zt}$, $\varepsilon_{Zt} \sim \text{iid } N(0,\sigma_z)$. The standard deviation of the productivity process is calibrated to match the average standard deviation of the cyclical component of the Solow residual for all sampled countries during the 1983:1-2004:4 period. Thus, I set the standard deviation of the productivity equal the average value ($\sigma_z = 0.9875, \rho_z = 0$), and generate artificial series for asset prices, output, and investment and consumption goods, for any given credit market size.

Figure 11a shows that, according to the model, the standard deviation of total output decreases with the degree of credit friction. The same result holds for asset prices (see Figure 11a, right panel). Less credit friction implies lower volatility of both output and asset prices. This result is in accordance with the findings of Justiniano and Primiceri (2005). To support their explanation that the "Great Moderation" was based on a reduction in financial frictions, they demonstrate that the volatility of the relative price of investment in terms of consumption goods decreased following financial deregulation in the U.S. in the early 1980s. This decline in the volatility of the relative price of investment was simultaneous with the timing of the "Great Moderation."
Table 3c reports the results of a mean equality test of the simulated series. A larger credit market significantly reduces the amplification and persistence of productivity shocks to output, investment, and asset prices. In contrast, the volatility of consumption goods production is higher the greater the degree of credit market development\(^{26}\). When we apply the same test to actual data for OECD countries, we see that the sampled countries with credit markets below the median in size had higher average output and investment volatilities, while there was no significant difference in terms of consumption volatility. Figure 11b indicates the standard deviation of output for both the actual data and the simulated series. In both cases we find a negative relationship between credit market size and output volatility. In both the actual and simulated series we find some evidence that smoother fluctuations in output are associated with higher credit-to-GDP ratios.

Let us compare the predicted relationship between output volatility and degree of credit market development in the two-sector and one-sector models (Figure 11c). Unlike the two-sector model, the one-sector model in unable to generate a negative relationship between credit market size and output volatility found in the data.

To evaluate the performance of the two-sector model still further, I calibrate the amount of credit as a share of GDP and the process of productivity shock as in the data, and test to what extent the model economy can generate artificial data regarding output with the same standard deviation as that of the actual data. I use quarterly data for OECD economies, 1983-2004. Figure 12 displays the behavior of

\(^{26}\)Using the ratio of standard deviation of output to shock as a measure of amplification, I compare two economies with different sizes of credit market (see Table 3b). I refer to a share of credit to the private sector over GDP equal to \(1.11,3.84\). As a result, output is 13.16 more volatile in economies with the smallest credit markets. Furthermore, investment volatility is 70 higher when credit as a share of GDP equals 1.11.
credit market size over the past 20 years for the sampled countries. For each country I have calibrated credit market size according to the amount of credit extended to the private sector as a share of GDP at the beginning of the period (83:1) and the standard deviation of the productivity shock as equal to the standard deviation of the cyclical component of the Solow residual. Table 4 presents the results for seven OECD economies that differ substantially in terms of credit market size. I consider 4 EMU countries – Germany, Spain, Ireland, and Italy – as well as Sweden, the UK, and the USA. The model succeeds in reproducing the actual output volatility for Germany, Spain, Ireland, and Italy and generating fairly accurate results for Sweden.

7 Empirical Analysis

In the following, I analyze the relationship between credit market development and the size of business cycle fluctuations using OECD data. I use a cross-country approach, following existing literature dealing with business cycle determinants; see, for example, Karras and Song (1996), Beck et al. (2000), Denizer et al. (2002), Ferreira da Silva (2002), and Buch et al (2005). The dataset includes quarterly time-series data from 1983 to 2004 for 22 OECD economies27.

The theoretical model developed above asserts that economies with more developed credit markets experience lower macroeconomic volatility. Both correlations (see Table 4a) and mean equality tests (see Table 4b) indicate that smoother fluctuations are indeed associated with higher credit-to-GDP ratios. To test for causality, I present more systematic evidence regarding the relationship between credit market

27All OECD data used are obtained from the OECD database, while the data regarding private credit come from the IFS.
development and business cycle volatility. I test the predictions of the theoretical model using the following simple empirical framework:

$$\sigma_{i,t}^Y = \mu_i + \lambda_t + \beta_1 \text{Credit}_{i,t} + \beta_2 X_{i,t}^{\text{control}} + u_{i,t}$$

where the time index refers to non-overlapping five-year periods, $\sigma_{i,t}^Y$ is the standard deviation of the business cycle component of GDP in real terms for country $i$, $\mu_i$ is a country-specific effect, $\lambda_t$ is a time-specific effect, and $u_{i,t}$ is the variability in output not explained by the regressors. The measure of credit development — $\text{Credit}_{i,t}$ — and additional control variables — $X_{i,t}^{\text{control}}$ — are described below. I use a beginning-of-period measure of credit market development to emphasize how the established credit-to-GDP ratio affects volatility in the following period. All other variables refer to non-overlapping five-year periods. Thus, the dataset contains a panel of 22 countries and 4 time periods.

For each period, I observe the level of credit development at the beginning of the period (first quarter of the first of the five years) as well as the subsequent fluctuations. $\text{Credit}$ is the value of credit extended to the private sector by banks and other financial intermediaries as a share of GDP. This is a standard variable used as a proxy for financial development in the finance and growth literature.\(^\text{28}\) In the regression, I also control for other potential determinants of business cycle fluctuations, such as the variability of Solow residuals, short-term interest rate, prices, and terms of trade. As is standard in the panel literature dealing with business cycle determinants, I attempt to control for macroeconomic shocks that would cause volatility in GDP. The volatility of the cyclical component of the Solow residuals is often used as a proxy for technology shocks. As in Backus et al. (1992), Karras

\(^{28}\)See, e.g., King and Levin (1993) and Levine, Loyaza, and Beck (2000).
and Song (1996), and Ferreira da Silva (2002), I define this as the change in the log of real GDP minus $1-\alpha$ times the change in the log of employment. I include the standard deviation of the short-term interest rate to control for monetary policy shocks. Following Buch et al. (2005), I also take into account an indicator of volatility on the supply side, measured as the standard deviation of the terms of trade. I also control for price flexibility, measured as the standard deviation of the detrended CPI. Since I am interested in the volatility of the cyclical component of GDP, Solow residuals, and interest rates, the first differencing and the Hodrick-Prescott filter are used to remove the estimated trend of the series. (In these tables only HP)

The simple bivariate regressions presented in Table 5 confirm that, despite the inclusion of country and/or period fixed effects, credit market development is negatively and significantly related to output volatility. Although the fixed-effect specification reduces concern about potentially omitted variables, I introduce into the regression a set of variables that may help to explain volatility. The negative relationship also holds when I control for different sources of business cycle volatility (Table 6). As to the other variables, the results are in accordance with those presented in the literature. Output volatility is strongly related to the volatility of the Solow residual, of the interest rate, and of the terms of trade. The correlation coefficient related to consumer price variability has a negative sign, although the value is not significant. Columns 3 and 5 include terms for interaction between credit market development and the standard deviation of Solow residuals. According to the theoretical model presented above, the impact of a productivity shock should depend on the degree of credit market development. As a result of the estimates, a larger credit market does dampen the propagation of Solow residual volatility. I also use a set of instrumental
variables to correct for potential endogeneity between the size of the credit market and output volatility; these variables are the lagged level of credit to the private sector as a share of GDP and "creditor rights" (La Porta et al. 1998, La Porta et al. 2005). This second instrumental variable is an index aggregating creditor rights, where the rights of secured lenders are defined in laws and regulations; it ranges from 0 (indicating weak creditor rights) to 4 (indicating strong creditor rights), and is constructed from 1978 to 2003 on a monthly base. To increase the variability of the instruments, I measure volatility on a three-year basis and use the value from the beginning of the period. Table 6b shows that the relationship between credit market development and output volatility remains unchanged. The Sargan test of overidentifying restrictions shows that the instruments used are valid (i.e., not correlated with the error term) and are correctly excluded from the regression.

The empirical results, interesting in themselves, confirm that in accordance with the model, a larger credit market does reduce the sensitivity of output to productivity shocks. Thus, even among OECD countries, the size of the credit market is found to be negatively related to output volatility.

8 Concluding Remarks

In this paper I revisit the relationship between credit market development and business cycle volatility. I present some evidence concerning the fact that industrialized countries with better-developed credit markets experience smoother business cycle fluctuations. Relying on a business cycle model that takes account of credit frictions, I demonstrate that a simple model with collateral constraints can generate the same kind of relationship as is found in the data. I develop a two-sector business cycle
model, built on that of Kiyotaki and Moore (1997), to investigate the contribution of credit market development to the decrease in macroeconomic volatility. I introduce aggregate uncertainty and capital reproducibility into the model. To investigate the behavior of economies that differ in terms of access to credit financing, I also allow for the existence of liquidation costs in modeling the collateral constraint. I identify the reallocation of existing capital as the key mechanism shaping this relationship.

In a standard one-sector model, the propagation of shocks is implied by the redistribution of the capital that flows from lenders with lower marginal productivity to borrowers with higher productivity. This effect predicts an inverted U-shaped relationship between credit market size and output volatility. In the two-sector model, the transmission of shocks is amplified not only by the redistribution of capital, but also by the reallocation of capital in terms of use. This second effect generates greater amplification and persistence of shocks for any given credit market size. However, the contribution of reallocation of existing capital is greater in economies with smaller credit markets, and diminishes with increasing credit market size. Thus, the reallocation of capital between sectors shapes the relationship between macroeconomic volatility and credit market size.
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Table 1.a: Correlation Matrix - data

<table>
<thead>
<tr>
<th></th>
<th>$\sigma(y)$</th>
<th>$\sigma(l)$</th>
<th>$\sigma(c)$</th>
<th>credit</th>
<th>credit$_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma(y)$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$\sigma(l)$</td>
<td>0.7145</td>
<td>1</td>
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<td></td>
<td></td>
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<tr>
<td>$\sigma(c)$</td>
<td>0.6773</td>
<td>0.6026</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>credit</td>
<td>-0.3244</td>
<td>-0.2992</td>
<td>-0.2353</td>
<td>1</td>
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<tr>
<td>credit$_{t-1}$</td>
<td>-0.4339</td>
<td>-0.3843</td>
<td>-0.2807</td>
<td>0.9908</td>
<td>1</td>
</tr>
</tbody>
</table>

$\sigma(y)$, $\sigma(l)$, $\sigma(c)$, standard deviation of respectively detrended log real output, investment and consumption. credit stands for credit to the private sector as a share of GDP, is the ratio at the beginning of the period (1983:1). Data on 22 OECD countries. Source: OECD.

Table 1.b: Mean Equality Test - data

<table>
<thead>
<tr>
<th></th>
<th>$\sigma(y)$</th>
<th>$\sigma(c)$</th>
<th>$\sigma(l)$</th>
<th>$\sigma(Ih)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>credit $&lt;$ median</td>
<td>.4485</td>
<td>.00291</td>
<td>.0208</td>
<td>.0208</td>
</tr>
<tr>
<td>vs credit $&gt;$ median</td>
<td>(.13485)</td>
<td>(.0021)</td>
<td>(.0069)</td>
<td>(.0069)</td>
</tr>
</tbody>
</table>

$\sigma(y)$, $\sigma(l)$, $\sigma(Ih)$, $\sigma(c)$, standard deviation of respectively detrended log real output, investment, investment in residential properties and consumption. credit stands for credit to the private sector as a share of GDP, ratio at the beginning of the period (1983:1), 5 percent significant coefficients in bold. Data on 22 OECD countries. Source: OECD.
Table 2: Parameter Values

<table>
<thead>
<tr>
<th>preferences</th>
<th>shock process</th>
</tr>
</thead>
<tbody>
<tr>
<td>discount rate</td>
<td>$\beta_1 = 0.99$</td>
</tr>
<tr>
<td></td>
<td>$\beta_2 = 0.95$</td>
</tr>
<tr>
<td></td>
<td>$\theta = 3.3$</td>
</tr>
<tr>
<td>autocorrelation</td>
<td>$\rho_s = 0/0.95$</td>
</tr>
<tr>
<td>variance</td>
<td>$\sigma_x = 0.0056$</td>
</tr>
<tr>
<td>technology</td>
<td>$\alpha = 0.36$</td>
</tr>
<tr>
<td>borrowing limit</td>
<td>$\gamma \in [0, 1]$</td>
</tr>
<tr>
<td>depreciation rate</td>
<td>$\delta = 0.03$</td>
</tr>
<tr>
<td>population</td>
<td>$n = 0.5$</td>
</tr>
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</table>

Table 3.: Mean Equality Test simulations

<table>
<thead>
<tr>
<th>5-years</th>
<th>$\sigma(y)$</th>
<th>$\sigma(c)$</th>
<th>$\sigma(I)$</th>
<th>$\sigma(Q)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>credit &lt; median vs credit &gt; median</td>
<td>.1675341</td>
<td>-.1058145</td>
<td>.2033866</td>
<td>.2033866</td>
</tr>
<tr>
<td></td>
<td>(.0049298)</td>
<td>(.0035229)</td>
<td>(.0052499)</td>
<td>(.0052499)</td>
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</table>

$\sigma(y), \sigma(I), \sigma(c), \sigma(Q)$, standard deviation of respectively detrended log real output, investment, consumption and asset prices. $credit$ stands for credit to the private sector as a share of gdp, ratio at the beginning of the period (1983:1) 5 percent significant coefficients in bold.
<table>
<thead>
<tr>
<th>Country</th>
<th>credit / $\gamma$</th>
<th>$\sigma_{(solow)}$</th>
<th>$\sigma_{(output)}$</th>
<th>$\sigma_{sim,(output)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEU</td>
<td>2.7829213</td>
<td>0.9175</td>
<td><strong>1.161915</strong></td>
<td>1.1200</td>
</tr>
<tr>
<td></td>
<td>0.800875</td>
<td></td>
<td></td>
<td>(.0864)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[1.0336 - 1.2065]</td>
</tr>
<tr>
<td>ESP</td>
<td>1.4483340</td>
<td>0.8115</td>
<td><strong>1.153786</strong></td>
<td>1.0845</td>
</tr>
<tr>
<td></td>
<td>[0.541954]</td>
<td></td>
<td></td>
<td>(0.0934)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0.9911 - 1.1779]</td>
</tr>
<tr>
<td>UK</td>
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<td>0.5374</td>
<td>1.112685</td>
<td>0.6539</td>
</tr>
<tr>
<td></td>
<td>[0.711735]</td>
<td></td>
<td></td>
<td>(0.0521)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0.6018 - 0.7061]</td>
</tr>
<tr>
<td>IRE</td>
<td>1.5295126</td>
<td>1.4025</td>
<td><strong>1.79738</strong></td>
<td>1.7618</td>
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<tr>
<td></td>
<td>[0.5618406]</td>
<td></td>
<td></td>
<td>(0.1395)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[1.6223 - 1.9014]</td>
</tr>
<tr>
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<td>0.6174</td>
<td><strong>0.842011</strong></td>
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<tr>
<td></td>
<td>[0.715556]</td>
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<td></td>
<td>(0.0651)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0.7385 - 0.8687]</td>
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<td>SWE</td>
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<td>0.8350</td>
<td>1.295511</td>
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<tr>
<td></td>
<td>[0.716292]</td>
<td></td>
<td></td>
<td>(0.0887)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0.9896 - 1.1639]</td>
</tr>
<tr>
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<td>0.969275</td>
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<tr>
<td></td>
<td>[0.875168]</td>
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<td></td>
<td>(0.0568)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0.6048 - 0.7209]</td>
</tr>
<tr>
<td></td>
<td>Pooled Regression</td>
<td>Country Fixed Effect</td>
<td>Time Fixed Effect</td>
<td>Fixed Effect</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>credit</td>
<td>-0.46003</td>
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<td>-0.44495</td>
<td>-1.20046</td>
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<tr>
<td>c</td>
<td>(0.02284)</td>
<td>(0.23833)</td>
<td>(0.06185)</td>
<td>(0.40714)</td>
</tr>
<tr>
<td></td>
<td>2.23392</td>
<td>2.87908</td>
<td>2.20203</td>
<td>3.95013</td>
</tr>
<tr>
<td></td>
<td>(0.13769)</td>
<td>(0.56633)</td>
<td>(0.13076)</td>
<td>(0.91433)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.188302</td>
<td>0.388818</td>
<td>0.405306</td>
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</tr>
<tr>
<td>Countries</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>obs</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>

Dependent Variable, $\sigma(y)$, standard deviation detrended log real output. Panel regressions based on 5-year non-overlapping averages. White-type robust standard errors in parenthesis, 5 and 10 per cent significant coefficients respectively in bold and italics.
Table 6: Credit and Output Volatility. Fixed Effects

<table>
<thead>
<tr>
<th></th>
<th>-1.20046</th>
<th>-0.66897</th>
<th>-0.77225</th>
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<tr>
<td>credit</td>
<td>(-0.40714)</td>
<td>(-0.32778)</td>
<td>(-0.25953)</td>
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<tr>
<td>σ(solow)</td>
<td>0.571645</td>
<td>0.731025</td>
<td>0.558278</td>
</tr>
<tr>
<td></td>
<td>(0.147120)</td>
<td>(0.135090)</td>
<td>(0.142069)</td>
</tr>
<tr>
<td>σ(interest rate)</td>
<td>0.10605</td>
<td>0.15790</td>
<td>0.08656</td>
</tr>
<tr>
<td></td>
<td>(0.06158)</td>
<td>(0.02536)</td>
<td>(0.04668)</td>
</tr>
<tr>
<td>σ(terms of trade)</td>
<td>6.74460</td>
<td>6.84469</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.22843)</td>
<td>(2.31439)</td>
<td></td>
</tr>
<tr>
<td>σ(price)</td>
<td>-0.54431</td>
<td>-0.44162</td>
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</tr>
<tr>
<td></td>
<td>(0.39367)</td>
<td>(0.42719)</td>
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<tr>
<td>credit*solow</td>
<td>-0.0765309</td>
<td>-0.0973101</td>
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<td></td>
<td>(0.0177231)</td>
<td>(0.0305728)</td>
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<tr>
<td>c</td>
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<td>0.53787</td>
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<tr>
<td></td>
<td>(0.91433)</td>
<td>(0.93910)</td>
<td>(0.13736)</td>
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<td>R²</td>
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<td>0.686156</td>
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<td>Countries</td>
<td>22</td>
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</tr>
<tr>
<td>obs</td>
<td>88</td>
<td>88</td>
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</tr>
</tbody>
</table>

Dependent Variable, σ(y), standard deviation detrended log real output. Panel regressions based on 5-year non-overlapping averages. Country and time-fixed effects included. White-type robust standard errors in parenthesis, 5 and 10 per cent significant coefficients respectively in bold and italics.
### Credits and Output Volatility, IV, 2SLS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
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<tr>
<td>$\text{credit}_t$</td>
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<td>0.0674018</td>
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<tr>
<td>$\sigma(\text{sol})$</td>
<td>0.1599957</td>
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<tr>
<td>$\sigma(R)$</td>
<td>0.1711271</td>
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<tr>
<td>$\text{cr}\cdot\text{sol}$</td>
<td>1.742073</td>
<td>1.197494</td>
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<tr>
<td>$c$</td>
<td>1.197494</td>
<td>0.5206834</td>
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<table>
<thead>
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<th>Test</th>
<th>Value</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Sargan</td>
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<tr>
<td>Countries</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>obs</td>
<td>154</td>
<td>154</td>
</tr>
</tbody>
</table>

Instruments for the Size of the Credit Market:
- Lagged level of Credit to the Private Sector as a Share of Gdp.
- Creditor Rights [La Porta et al. (98), La Porta et al. (05)]
Figure 1: size of the credit market measured by the credit to the private sector as a share of GDP over the time period 1983-2004.

Figure 2: volatility of output measured as the standard deviation of the log detrended real output over the time period 1983-2004.
Figure 3 plots the measure of credit market development against the measure of business cycle volatility. Output's standard deviations as well as the average of private credit as a share of Gdp are calculated on quarterly data for 5 non-overlapping years.

Figure 4 ratio of private credit to gdp as in the data reproduced by varying $\gamma$. 
Figure 5a shows how the steady state productivity gap in total production between the two groups of agents varies with respect to $\gamma$. 
Figure 5.6 capital assigned to the production of both consumption and investment goods by the two groups of agents.
Figure 6a shows how the steady state values of the model's variables change with respect to the degree of credit market development.
Figure 6b show how the steady state values of the model's variables change with respect to the degree of credit market development.
Figure 7 shows the response of total aggregate output to a 1% increase in productivity.
Figure 8a shows the responses to a 1% increase in productivity.
Figure 8b shows the responses to a 1% increase in productivity.
Figure 8c shows the responses to a 1% increase in productivity.
Figure 8d responses of the model economy to an unexpected 1% increase in aggregate productivity. The units on the vertical axes are percentage deviations from the steady state, while on the horizontal axes are years.
Figure 6e responses of the model economy to an unexpected 1% increase in aggregate productivity. The units on the vertical axes are percentage deviations from the steady state, while on the horizontal axes are years.
Figure 8f responses of the model economy to an unexpected 1% increase in aggregate productivity. The units on the vertical axes are percentage deviations from the steady state, while on the horizontal axes are years.
\[ F_t = Z_t k_{t-1} \left( \theta_t^\alpha + q_t (1-\theta_t)^\alpha \right) \]

\[ Y_t = Z_t k_{t-1}^\alpha \]

Figure 9 shows the response of total aggregate output to a 1% increase in productivity in the two-sector and one-sector model.
Figure 10a first impact of the shock on production -- i.e., the intensity of reaction for any given $\gamma$. 

The figure illustrates the aggregate total production as a function of sensitivity with respect to $\gamma$. The curve shows how production changes with varying sensitivity levels.
Figure 10b first impact of the shock on production -- i.e. the intensity of reaction for any given $\gamma$
1Dc: first impact of the shock on asset prices—i.e., the intensity of reaction for any given $\gamma$. 

![Graph showing the relationship between asset prices and sensitivity](image)

- **x-axis**: Sensitivity w.r.t. $\gamma$
- **y-axis**: Asset prices
Figure 10d first impact of the shock on production -- i.e. the intensity of reaction for any given $\gamma$
Figure 11.2: Standard deviations given a particular value for $\gamma$. 
Figure 11.b Each point represents the standard deviations given a particular value for $\gamma$. I simulate the model for 1000 value of $\gamma$ in the range $[0,1]$. The length of the simulated series is of 5 years while the number of simulated series for the calculation of moments is 5000 for any given $\gamma$. 
Two-sector

\[ F_t = Z_t k_{t-1} (\theta_t^\alpha + q_t (1-\theta_t)^\alpha) \]

One-sector

\[ Y_t = Z_t k_{t-1}^\alpha \]

Figure 11.c Each point represents the standard deviations given a particular value for \( \gamma \).
Credit to the Private Sector as a Share of GDP

Figure 12: Behavior of the size of the credit market during the last 20 years.
On the amplification role of collateral constraints

Caterina Mendicino*
Abstract

Following the example of Kiyotaki and Moore (1997), a major strand of the literature has used models incorporating collateral constraints to amplify the effects of shocks on economic activity. However, recent papers have demonstrated that collateral constraints per se are unable to propagate or amplify exogenous shocks, unless unorthodox assumptions concerning preferences and production technologies are assumed. In this paper, I examine how the degree of friction in the credit market affects the amplification of productivity shocks to output. I demonstrate that even when using standard assumptions, a very stylized model incorporating collateral constraints can amplify productivity shocks.
1 Introduction

Kiyotaki and Moore (1997) and Kiyotaki (1998) show that if debt needs to be fully secured by collateral, small shocks can have large and persistent effects on economic activity. Kiyotaki and Moore's work has been very influential and a big strand of the literature has used models with collateral constraints despite the fact that recent papers have shown the limited role of these kind of financial frictions in the propagation of exogenous shocks. Kocherlachota (2000) and Cordoba and Repoll (2004) among others have show that collateral constraints per se are unable to propagate and amplify exogenous shocks, unless unorthodox assumptions on preferences and production technologies are assumed. In this paper I study how the degree of frictions in the credit market affects the transmission of productivity shocks to output. I show that the degree of credit frictions helps to generate greater amplification of shocks. Moreover, adding labor supply to the benchmark setup improves significantly the amplification role of collateral constraints.

The paper is organized as follows. Section 2 presents the model and Section 3 presents the results. Section 4 shows the introduction of household work to the benchmark model. Section 5 shows the simulation-based results. Section 6 draws some conclusions.

2 The Model

Following Kiyotaki and Moore (1997) I consider a discrete time economy populated by two types of households that trade two kinds of goods: a durable
asset and a non durable commodity. The durable asset \((k)\) does not depreciate and has a fixed supply normalized to one. The commodity good \((c)\) is produced with the durable asset and cannot be stored. At time \(t\) there are two competitive markets in the economy: the asset market in which the one unit of durable asset can be exchanged for \(q_t\) units of consumption good, and the credit market. The economy is populated by a continuum of ex-ante heterogeneous households of unit mass: \(n_1\) Patient Entrepreneurs (denoted by 1) and \(n_2\) Impatient Entrepreneurs (denoted by 2). In order to impose the existence of flows of credit in this economy I assume ex-ante heterogeneity based on different subjective discount factor: \(\beta_2 < \beta_1 < 1\). This assumption ensures that in equilibrium patient households lend and impatient households borrow. Both agents produce the commodity good using the same technology

\[ y_t = Z_t k_t^\alpha \]

where \(Z_t\) represents an iid aggregate technology shock. I assume that agents have access to the same concave production technology\(^3\): \(\alpha_1 = \alpha_2 < 1\). Technology is specific to each producer and only the household that started the production has the skills necessary to conclude the production. This means that if household \(i\) decides to not put his effort in the production between \(t\) and \(t+1\) there would be no outcome of production at \(t+1\), and there would only be the asset \(k_t\) at \(t+1\). The household cannot precommit to produce. Moreover, he is free to walk away from the production and the

\(^3\)In Kiyotaki and Moore (1997) the two groups of agents also represent two different sectors of the economy. See Cordoba and Ripoll (2004) for a discussion on how different assumptions about the production technology affect the impact of technology shocks in this economy.
debt contracts between \( t \) and \( t+1 \). This results in a default problem that makes creditors to protect themselves by collateralizing the household’s asset. The creditor knows that in case the household runs away from production and debt obligations, they will get his asset. The debt repayment, \( b_{t+1} \), of the borrower is limited to a fraction of next period expected value of the asset \( \gamma < 1 \) such that:

\[
b_t \leq \gamma E_t [q_{t+1}k_t]
\]

Limiting the borrowing to a fraction of the expected liquidation value of the capital takes into account different degrees of credit frictions. A high \( \gamma \) represents a developed financial sector while a low \( \gamma \) characterizes an under-developed system. Households face the following problem:

\[
\max_{(c_{it},k_{it},b_{it})} E_0 \sum_{t=0}^{\infty} (\beta_t)^t U(c_{it}) \quad i = 1, 2
\]

s.t.

\[
c_{it} + q_t(k_{it} - k_{it-1}) = y_{it} + \frac{b_{it}}{R_t} - b_{it-1}
\]

\[
y_{it} = Z_t k_{it-1}^\alpha
\]

\[
b_t \leq \gamma E_t [q_{t+1}k_t]
\]

where \( k_{it} \) is a durable asset, \( c_{it} \) a consumption good, and \( b_{it} \) the debt level. Agents' optimal choices of bonds and capital are characterized by

\[
\frac{U_{c_{it}}}{R_t} \geq \beta_t E_t U_{c_{it+1}}
\]

and

\[
q_t - \beta_t E_t \frac{U_{c_{it+1}}}{U_{c_{it}}} q_{t+1} \geq \beta_t E_t \frac{U_{c_{it+1}}}{U_{c_{it}}} (F_{k_{it+1}})
\]

where \( F_{k_{it}} = \alpha Z_t k_{it-1}^{\alpha-1} \) is the marginal product of capital. The first equation relates the marginal benefit of borrowing to its marginal cost. For constrained
agents the marginal benefit is always bigger than the marginal cost of borrowing. If $M_{i,t} \geq 0$ is the multiplier associated with the borrowing constraint, then, the euler equation becomes:

$$\frac{C_{i,t}}{R_t} - M_{i,t} = \beta_i E_t U_{c_{i,t+1}}$$

The second equation states that the opportunity cost of holding one unit of capital, $[q_t - \beta_i E_t \frac{C_{i,t+1}}{C_{i,t}} q_{t+1}]$, is bigger or equal to the expected discounted marginal product of capital. For constrained agents the marginal benefit of holding one unit of capital is given not only by its marginal product but also by the marginal benefit of being allowed to borrow more:

$$q_t - \beta_2 E_t \frac{C_{2,t+1}}{C_{2,t}} q_{t+1} = \beta_2 E_t \frac{C_{2,t+1}}{C_{2,t}} (F_{2,t+1}) + \gamma E_t q_{t+1} \frac{M_t}{C_{2,t}}$$

In the deterministic steady state the group of impatient households is credit constrained. Consider the euler equation of the impatient household

$$\frac{u_{c_{2,t}}}{R_t} - M_{2,t} = \beta_2 E_t u_{c_{2,t+1}}$$

in steady state it implies:

$$\mu_2 = \left( \frac{1}{R} - \beta_2 \right) u_{c_2}$$

Since the steady state interest rate is determined by the discount factor
of the patient agent\(^2\)

\[
\mu_2 = \left( \frac{1}{\bar{R}} - \beta_2 \right) u_{c_2} = (\beta_1 - \beta_2) u_{c_2}
\]

As long as \(\beta_2 < \beta_1 < 1\), the lagrange multiplier associated with borrowing constraint for the impatient household is strictly positive. Thus, impatient households are credit constrained in steady state. Following the previous literature, I assume that in a neighborhood of the steady state, impatient households borrow up to the maximum.

\[
b_{2,t} = \gamma E_t [q_{t+1} k_{2t}]
\]

and

\[
k_{2t} = \frac{W_{2,t} - c_{2,t}}{q_t - \gamma E_t \frac{q_{t+1}}{R_t}}
\]

where \(W_{2,t} = y_{2,t} + q_t k_{2,t} - b_{2,t-1}\), is the impatient agent’s wealth\(^3\) at the beginning of time \(t\) and \(d_t = \left[ q_t - \gamma E_t \frac{q_{t+1}}{R_t} \right] \), represents the difference between the price of capital and the amount he can borrow against a unit of capital, i.e. the downpayment required to buy a unit of capital. Patient households are creditors in a neighborhood of the steady state. The creditor’s capital

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\(^2\)In fact, given the euler equation of the patient households:

\[
\frac{U_{c_1,t}}{R_t} = \beta_1 E_t U_{c_1,t+1}
\]

in a deterministic steady state:

\[
R = \frac{1}{\beta_1}
\]

\(^3\)That is his output and the value of the land held the perious period net of debt repayment.
decision is determined at the point in which the opportunity cost of holding capital equals its marginal product:

\[ q_t - \beta_t E_t \frac{U_{c,t+1}}{U_{c,t}} q_{t+1} = \beta_t E_t \frac{U_{c,t+1}}{U_{c,t}} (F_{k_1,t+1}) \]

3 Results

A look to the steady state. Let see how the deterministic steady state of the model is affected by \( \gamma \). Figure 1.a shows how the marginal productivity, and thus efficiency in production, depends on \( \gamma \). Ceteris paribus a higher \( \gamma \) reduces the difference between borrowers’ and lenders’ marginal productivity. As I have already shown, in the deterministic steady state the group of impatient households is credit constrained. Thus, their capital holding is less than the total output maximizing level\(^4\). Using the equations representing the households’ optimal choice of capital evaluated at the steady state it is possible to show that: \( F_{k_1} < F_{k_2} \).

\[
\frac{F_{k_2}}{F_{k_1}} = \frac{\beta_1 [1 - \beta_2 - \gamma(\beta_1 - \beta_2)]}{(1 - \beta_1) \beta_2} > 1
\]

\(^4\)The efficient allocation of capital between the two groups would be given by the equality between the marginal products of the two groups:

\[ F_{k_1,t} = F_{k_2,t} \]

Thus, given the aggregate condition on capital

\[ n_1k_1 + n_2k_2 = K_1 + K_2 = 1 \]

then, since the total population is normalized to be equal to the unit interval

\[ K_1^{eff} = n_2 \quad \text{and} \quad K_2^{eff} = 1 - n_2 \]

This means that if the two groups are equally large, each group gets the same amount of capital in steady state.
Where $F_{ki} = \alpha \left( \frac{K_i}{n_i} \right)^{\gamma - 1}$. The equation above is always bigger than 1 as long as $\gamma < \frac{1}{\beta_1} = 1.0101$. Due to the fact that I'm assuming $\gamma < 1$, this is always the case. The steady state allocation of capital depends on the subjective discount factors, the fraction of the two groups of agents and the degree of credit market development. Calculations in the appendix show that

$$K_2 = \frac{1}{\left\{ 1 + \frac{n_1}{n_2} \left[ \frac{\beta_2(1 - \beta_1)}{\beta_1(1 - \gamma)(\beta_1 - \beta_2)} \right]^{\gamma - 1} \right\}}$$

Compared to the first best allocation, the allocation under credit constraints reduces the level of capital held by the borrowers. Moreover, it implies a difference in the marginal productivity of the two groups so long as $\gamma < \frac{1}{\beta_1}$. Thus, even if it is not possible to reach the efficient equilibrium $(F_{k_1,t}, F_{k_2,t})$ it is possible to reduce the efficiency loss by setting $\gamma$ closer to 1.

Figure 1.b shows that an increased access to the credit market implies a credit expansion and thus a rise in the level of investment by borrowers. As expected this leads to a more efficient allocation of capital between the two groups and consequently to an increase in production. As a result, in the deterministic steady states associated to higher levels of $\gamma$, the level of total output, and thus total consumption, is higher. The price of the collateral/asset is also higher. In the steady state the asset prices depend on the marginal productivity of capital. More specifically, the households’ optimal choice of capital gives

$$q = \frac{\beta_1}{1 - \beta_1} F_{k_1}$$

Impulse Responses. I now consider the response of the model econ-
omy to a technology shock when $\gamma=1$. I assume that the economy is at the steady state level at time zero and then is hit by an unexpected one-time ($\rho = 0$) increase in aggregate productivity of 1%. The results are reported in figures 2.a. An aggregate positive technology shock raises production and thus the earnings of both groups of agents. Since the shock is temporary agents save part of the extra resources to smooth consumption. Constrained agents smooth the effects of the shock by buying more capital. The rise in current investment expenditures propagates the effect of the shock on borrowers' production over time. Since the marginal productivity of capital is higher for borrowers, there is a persistent effect on aggregate production as well. In order for the capital market to clear, lenders have to reduce their demand for capital and thus the user cost of holding capital has to increase. The rise in asset prices, coupled with the increase in investments and a reduction in interest rate implies a credit boom. Thus, constrained agents exploit the direct impact of the technology shock and also the indirect impact through asset prices and interest rate variations.

---

5 I calibrate the model at quarterly frequencies. I set patient households' discount factor equal to 0.99, such that the average annual rate of return is about 4%. I set impatient households' discount factors equal to 0.95. The share of capital in the production $\alpha$ is 0.36 as in the tradition of the real business cycle literature. The baseline choice for the fraction of borrowing constrained population is set to 50%.

6 The decrease in the interest rate is explained by the lenders' euler equation:

$$R_t = \frac{U(c_{t,t})}{\mu_1 E_t U(c_{t,t+1})}$$

A positive technology shock implies an increase in current consumption expenditure but raises expectations of a future decrease. Thus, the interest rate goes down. The dynamic of the interest rate could change according to different calibrations of the parameters of the utility function.
Figure 2.b shows how the response of total output changes with respect to the degree of credit frictions. Going from $\gamma=1$ to any lower value, implies greater amplification and persistence of the shock on output. However these two effects reduce for lower values of $\gamma$. In fact, the results in terms of amplification and persistence reverse when going from $\gamma=1$ to any value below $\gamma=0.3$. This suggests a non-linear relation between the sensitivity of output to shocks and the degree of credit frictions.

**Amplification and Persistence.** How does a technology shock affect total production under different degrees of frictions in the credit market? Figure 3.a shows that, as expected, the sensitivity of output to productivity shocks varies in a non-linear way with respect to the degree of credit frictions. As already pointed out by Cordoba and Ripoll (2004), the elasticity of total output to technology shocks can be written as:

$$
\epsilon y = \epsilon y_2 \epsilon_k z = \frac{F_k z - F_k z_1}{F_k z} \frac{y_2}{y} \epsilon_k z
$$

The first term is the productivity gap between constrained and unconstrained agents, $\alpha$ represents the share of collateral in production while $y_2/y$ is the production share of constrained agents and $\epsilon_k z$ is the elasticity of borrowers' capital to the shock (i.e. the redistribution of capital towards impatient agents). In order to explain the non-linear relationship between output's amplification and the degree of credit friction let's first focus on the behavior of the redistribution of capital in the model ($\epsilon_k z$). Figure 3.b shows the intensity of the reaction of investment decisions by constrained agents.

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7Since the first impact of the shock would always be equal to the shock itself, we now look at the second period effect of the shock.
The impact of the shock on capital expenditure shows an inverted U relationship with the degree of access to the credit market as well. On the same graph is plotted the effect of the shock on the downpayment. The difference between the price of capital and the amount agents can borrow against a unit of capital represent the amount required to buy a unit of capital.

$$DP_t = \left[ q_t - \gamma E_t \frac{q_{t+1}}{R_t} \right]$$

As we see, the reactions of investment decisions and downpayment are symmetrically opposite. The stronger the effect on downpayment, the weaker the reaction of capital. The shape of the relationship between the degree of access to credit market and the effect on downpayment can be explained by the existence of two opposite forces determining the intensity of downpayment reaction.

When a technology shock takes place, the price of capital and the interest rate move in opposite directions (figure 2.a). Moreover, as shown in figure 3.c the higher $\gamma$ the weaker the reaction of $q_t$ and, on the contrary, the stronger the reaction of $R_t$ to the shock. For instance, in economies with higher access to the credit market following a negative technology shock, $q_t$ falls by less and so, also the downpayment required reduces by less. Being more expensive to buy capital, we expect $k_{2t}$ to reduce by more. However, at the same time, $R_t$ increases by less. This reduces the increase in the downpayment. Thus, the reaction of $k_{2t}$ is expected to be weaker. As a result, the intensity of capital response depends on which of the two opposite effect prevails. This explains the inverted U shape of the amplification on output delivered by the
collateral constraint. However, if we look at figure 3.d we see that the same shape is found also when the sensitivity of borrowers' capital to productivity shocks is increasing in $\gamma$. Assume that lenders' utility function is linear in consumption, so that the interest rate is constant over the business cycle and it implies that the effect on downpayment is weaker the higher $\gamma$ (since it only depends on $q$), and thus, the impact of the shock on capital is larger.

Still the relationship between $\gamma$ and the second impact of $z_t$ on $y_t$ has an inverted U shape. As shown in steady state the fraction of total output produced by constrained agents increases with $\gamma$ due to the fact that more capital is held by the constrained population. However, for the same reason, the productivity gap decreases with $\gamma$. Thus, regardless the shape of capital reaction to technology shocks, since the second impact of the shock on total output depends on this two opposite forces it will always show a not linear shape. That is of course more pronounced when $\epsilon_{h2z}$ is not monotonic.

4 Introducing Labor Supply

I now consider the case in which household work is also an input of production. We assume that each household works in his own firm and gets utility from leisure\(^8\). Following Greenwood et al. (1988) I assume that the utility function is

$$U(c_{ut}, L_{ut}) = \frac{1}{1-\sigma} \left( c_{ut} - \frac{L_{ut}^\eta}{\eta} \right)^{1-\sigma}$$

\(^8\)I calibrate the labor supply elasticity to 0.5 ($\eta = 2$) and the weight on leisure is chosen so that hours worked in in the initial steady state is around 1/3 depending on the given $\gamma$ ($\chi = 5.5$).

77
As figure 4.a shows including household work in the model increase both amplification and persistence of productivity shocks to output. Moreover, endogenous amplification of the shocks is already present in the first period. To a 1% increase in productivity, total output increases by 1.4705%. However, it is possible to show that the first period amplification is independent of $\gamma$. Given the household's labor supply

$$y_{it} = Z_t k_{it-1}^{\alpha} L_{it}^{1-\alpha}$$

is it possible to write each individual production only in terms of the capital input

$$y_{it} = Z_t^{\frac{\eta}{\alpha + \eta - 1}} k_{it-1}^{\alpha + \frac{1 - \alpha \gamma}{\alpha + \eta - 1}} \left( \frac{1 - \alpha}{\lambda} \right)$$

Then, when productivity increases by 1%, output increases by $\frac{\eta}{\alpha + \eta - 1} \cdot 1.4705\% = 1.4706\%$. However, the second impact still varies with the degree of credit friction. As figure 4.b shows, adding household work to the benchmark model always increases the endogenous amplification of output to shock for any given $\gamma$. The elasticity of total output to technology shocks can be written as in the previous setup but multiplied by $\frac{\eta}{\alpha + \eta - 1}$

$$\varepsilon_{yx} = \frac{\eta}{\alpha + \eta - 1} \varepsilon_{y_k2} \varepsilon_{k2}$$

5 Conclusion

The aim of this paper is to quantify the amplification generated by collateral constraints in relation to the degree of frictions in the credit market.
To this purpose I analyze a stylized business cycle version of Kyotaki and Moore (1997) model. I show that also using standard assumptions, the model can generate amplification of productivity shocks. Greater amplification is generated by introducing labor supply in the model.
6 References


Appendix .1 Benchmark Model: Equilibrium Conditions

The system of non-linear equations is given by 4 first order conditions:

\[ \frac{U_{c_{1,t}}}{R_t} = \beta_1 E_t u_{c_{1,t+1}} \]  \hspace{1cm} (E.1)

\[ \frac{U_{c_{2,t}}}{R_t} - \mu_{2,t} = \beta_2 E_t u_{c_{2,t+1}} \]  \hspace{1cm} (E.2)

\[ q_t - \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} q_{t+1} = \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} F_{k_{1,t+1}} \]  \hspace{1cm} (E.3)

\[ q_t - \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} q_{t+1} = \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} F_{k_{2,t+1}} + \gamma E_t q_{t+1} \frac{\mu_{2,t}}{U_{c_{2,t}}} \]  \hspace{1cm} (E.4)

4 aggregate conditions:

\[ n_1 k_{1t} + n_2 k_{2t} = K_{1t} + K_{2t} = 1 \]  \hspace{1cm} (E.5)

\[ y_t = n_1 y_{1t} + n_2 y_{2t} \]  \hspace{1cm} (E.6)

\[ n_1 b_{1t} + n_2 b_{2t} = 0 \]  \hspace{1cm} (E.7)

1 budget constraint\(^9\):

\[ c_{2t} + q_t (k_{2t} - k_{2t-1}) = y_{2t} + \frac{b_{2t}}{R_t} - b_{2t-1} \]  \hspace{1cm} (E.8)

1 borrowing constraint:

\[ b_{2,t} = \gamma E_t [q_{t+1} k_{2t}] \]  \hspace{1cm} (E.9)

the resource constraint:

\[ y_t = n_1 c_{1t} + n_2 c_{2t} \]  \hspace{1cm} (E.10)

the two technologies:

\[ y_{1t} = Z_{1} k_{1t-1} \]  \hspace{1cm} \[ y_{2t} = Z_{2} k_{2t-1} \]  \hspace{1cm} (E.11)

12 equations and 12 unknowns: \{\mu_{2,t}, q_t, R_t, y_t\} and \{c_{1t}, k_{1t}, b_{1t}, y_{1t}\}\(^\infty\) for \(i=1,2\).

\(^9\)Using the Walras' Law we can drop at each \(t\) one of the two budget constraints.
Appendix .2 Benchmark Model: Steady State

From E.1 I find the steady state interest rate:

\[ \frac{1}{R} = \beta_1 \]  

(ss.1)

from E.2 the lagrange multiplier:

\[ \mu_2 = (\beta_1 - \beta_2) u_{c2} \]  

(ss.2)

Using E.3 and E.4:

\[ q = \frac{\beta_1}{1 - \beta_1} F_{k_1} = \frac{\beta_2}{1 - \beta_2 - \gamma(\beta_1 - \beta_2)} F_{k_2} \]  

(ss.3)

and substituting for \( K_1 \) using the aggregate condition on capital: \( K_1 = 1 - K_2 \) I find the steady state allocation of capital to the group of borrowers: \( K_2 \)

\[ \frac{\beta_1}{1 - \beta_1} \left( \frac{1 - K_2}{n_1} \right)^{\alpha-1} = \frac{\beta_2}{1 - \beta_2 - \gamma(\beta_1 - \beta_2)} \left( \frac{K_2}{n_2} \right)^{\alpha-1} \]

Thus:

\[ K_2 = \frac{1}{\left\{ 1 + \frac{n_1}{n_2} \left[ \frac{\beta_2(1 - \beta_1)}{\beta_1[1 - \beta_2 - \gamma(\beta_1 - \beta_2)]} \right]^{\alpha-1} \right\}} \]

Thus I find the steady state borrowing level:

\[ b_2 = \gamma [q k_2] = -b_1 \]  

(ss.4)

and the total production:

\[ y = n_1 y_1 + n_2 y_2 \]  

(ss.5)

where

\[ y_1 = k_1^\alpha \quad y_2 = k_2^\alpha \]  

(ss.6)

From E.8 I find the consumption of the borrowers

\[ c_2 = y_2 - b_2 \left( 1 - \frac{1}{R} \right) \]  

(ss.7)

and from the resource constraint the consumption of the group of lenders

\[ n_1 c_1 = y - n_2 c_2 \]  

(ss.8)

83
Figure 1.a: deterministic steady state productivity gap w.r.t. γ and capital allocation.

Figure 1.b: deterministic steady state values of the model's variables for any given γ
Figure 2.a: responses to a 1% increase in productivity
Figure 2.b: total output responses to a 1% increase in productivity for different given $\gamma$.

Figure 3.a: second period total output responses to a 1% increase in productivity w.r.t. $\gamma$. 

86
Figure 3.b: responses to a 1% increase in productivity w.r.t. $\gamma$.

Figure 3.c: second period total output responses to a 1% increase in productivity w.r.t. $\gamma$. 
Figure 3.d: total output and capital response responses to a 1% increase in productivity w.r.t. $\gamma$. Top panel, variable interest rate. Bottom panel constant interest rate.
4. a: total output responses to a 1% increase in productivity for different given $\gamma$.

4. b: total output responses to a 1% increase in productivity w.r.t. $\gamma$. 

89
4c: total output responses to a 1% increase in productivity for different given $y$. 

- Total Output Response $y=1, p=0.95$
- Total Output Response $y=8, p=0.95$
Credit Frictions, Housing Prices, and Optimal Monetary Policy Rules

Caterina Mendicino & Andrea Pescatori

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Department of Economics, BOX 6501, 113 83 Stockholm, Sweden. Email: caterina.mendicino@hhs.se

Universitat Pompeu Fabra, Department of Economics, Ramon trias Fargas 25, Barcelona, Spain. Email: andrea.pescatori@upf.edu
Abstract

We assess the role of housing price movements in influencing the optimal design of monetary policy. Even though the relationship between liquidity constraints and consumption behavior is well documented in the empirical and theoretical literature, little attention has been paid to credit frictions at the household level in the monetary business cycle literature.

This paper represents the first attempt to evaluate welfare-based monetary policy using a model with heterogeneous agents and credit constraints at the household level. In evaluating optimal monetary policy, we take advantage of recent advances in computational economics, by adopting the approach of Schmitt-Grohe and Uribe (2003). Our results indicate that under an optimally designed simple monetary policy rule, housing price movements should not be a separate target variable in addition to inflation. Furthermore, the welfare loss arising from targeting housing prices becomes quantitatively more significant the higher the degree of access to the credit market.
1 Introduction

The recent rise in housing prices in most OECD countries has attracted the attention of policy makers and academics and raised concern as to its macroeconomic implications.\textsuperscript{1} Should asset prices be taken into account when formulating monetary policy?

This paper assesses the relevance of housing prices when formulating monetary policy rules. Since residential property represents the major share of household assets, and since many bank loans are secured by real estate collateral, it is worth investigating whether housing prices have any role, distinct from that of other asset prices, in a model incorporating credit market frictions at the household level. Even though the relevance of liquidity constraints to consumption behavior is well documented in the empirical and theoretical literature (see, e.g., Zeldes 1997 and Jappelli and Pagano 1997), little attention has been paid to credit frictions at the household level in the monetary business cycle literature. This paper represents the first attempt to evaluate welfare-based monetary policy using a model that incorporates heterogeneous agents and credit constraints at the household level.

The model is based on that of Kiyotaki and Moore (1997). To account for the existence of credit flows, we assume two types of agents, differing in terms of discount factors. Consequently, impatient agents, that have a

\textsuperscript{1}See, for example, Borio and McGuire (2004) regarding the relationship between housing and equity prices, Iacoviello (2004) regarding the relevance of housing prices and credit constraints to the business cycle, Giroudard-Blondal (2001) regarding the role of housing prices in sustaining consumption spending in the recent downturn of the world economy, and Case-Quigley-Shiller (2001) for empirical evidence of the housing wealth effect.
higher propensity to consume out of wealth, are borrowers. Physical assets are used as collateral for borrowing. As in Iacoviello (2004), we depart from Kiyotaki and Moore’s framework in two ways. First, unlike Kiyotaki and Moore, we focus on the household sector. In fact, Kiyotaki and Moore’s agents are entrepreneurs that produce and consume the same type of goods using a physical asset. Moreover, agents are risk neutral and represent two different sectors of the economy, borrowers being "farmers" and lenders being "gatherers". In contrast, in our framework, households are risk adverse and, in addition to consumption and leisure, also consider house holdings as a separate argument of their utility function. Housing services are assumed to be proportional to the real amount of housing stock held. Second, we extend the model to include nominal price rigidities and thus a role for monetary policy. To summarize, our model economy is characterized by three types of distortions. First, monopolistic competition in the goods market allows for price setting above the marginal cost (average markup distortion). Second, nominal price rigidities, modeled as a quadratic adjustment cost on goods’ market price setting are adopted as a source of monetary non neutrality. Third, creditors cannot force debtors to repay unless debts are secured by collateral, thus generating a role for housing prices and monetary policy.

In evaluating optimal monetary policy we take advantage of recent advances in computational economics, by adopting the approach of Schmitt-Grohe and Uribe (2003). Our results indicate that optimally designed simple monetary policy rules should not take into account current housing price movements. In fact, under normal circumstances, we find that explicitly aim-
ing for housing price stability is not welfare improving, relative to a strict overall price stability policy.

The remainder of the paper is organized as follows. Section 2 briefly reviews the relevant literature, while section 3 describes the role of housing as collateral. Section 4 lays out the model and derives the equilibrium conditions. Section 5 examines model calibration, section 6 analyzes the steady state, while section 7 describes the welfare measure used and the method for evaluating the optimal design of monetary policy. Finally, section 8 comments on the results.

2 Related Literature

Asset prices and monetary policy: welfare-based evaluation vs. inflation-output volatility criterion. A number of papers have tried to understand the extent to which asset price movements are relevant to monetary policy.\(^2\) Cecchetti et al. (2000, 2002) demonstrate that reacting to asset prices reduces the likelihood of bubble formation. On the other hand, Bernanke and Gertler (2001), among others, conclude that inflation-targeting central banks should not respond to asset prices in particular. In fact, conditional on a strong response to inflation, the gain engendered by a response to asset prices is negligible. These studies employ a financial accelerator framework that allows for credit market frictions and exogenous asset price bubbles. The method

adopted for evaluating the performance of different monetary policy rules is based on the implied volatility of output and inflation. Different conclusions as to the desirability of including asset prices as an additional argument in monetary policy rules, depend mainly on different assumptions concerning the stochastic nature of the model, i.e., the shocks considered.

Iacoviello’s analysis (2004) directly relates to housing prices. He shows the relevance of housing prices to the transmission and amplification of shocks to the real sector. Nevertheless, when computing the inflation-output volatility frontiers, it turns out that responding to housing prices does not produce significant gains in terms of output and inflation stabilization.³

The main shortcoming of all this literature is the absence of welfare considerations in evaluating optimal monetary policy. However, mixed results are also presented by more recent studies that rely on a welfare-based approach. In fact, while Faia and Monacelli (2004) demonstrate that reacting to asset prices is not optimal, Dupor (2005) demonstrates that monetary policy should react to asset price fluctuations when they are driven by irrational expectation shocks to the future returns to capital.

Optimal monetary policy in economies with nominal rigidities: distorted vs. non-distorted equilibrium. More broadly, our paper is related to the considerable amount of literature treating optimal monetary policy

³Iacoviello (2004) does not distinguish between residential and commercial properties. Thus, houses are treated not only as a source of direct utility but also as a production input, this asset being used in the credit market to secure both firms' and households' debts. Moreover, he also introduces collateral constraints to the household sector. These modeling choices are consistent with the aim of demonstrating the importance of financial factors to macroeconomic fluctuation. Instead, being interested in the role of housing prices for the optimal design of monetary policy, we restrict our attention to the household sector.
in economies with nominal rigidities. Most of the models consider a dynamic system centered on an efficient non-distorted equilibrium. In practice, the policy maker neutralizes any source of inefficiency present in the economy and unrelated to the existence of nominal rigidities. Thus, the only task left for monetary policy is to offset the distortions associated with price rigidities, so as to replicate the flexible price equilibrium allocation. The motivation behind this modeling choice is purely technical; in fact, it is sufficient for a first-order approximation of the equilibrium conditions to approximate welfare only up to the second order. Following a method introduced by Rotemberg and Woodford (1997), in these kinds of models it is possible to derive a discounted quadratic loss function from the quadratic approximation of the utility function, and compute optimal policy using a simple linear-quadratic method, as in traditional monetary policy theory.

An alternative approach considers optimal monetary and fiscal policy in models evolving around equilibria that remain distorted. In such models different types of distortions, besides price rigidities, provide a rationale for the conduct of monetary policy. To obtain a welfare measure that is accurate to the second order, it is necessary to use a higher-order approximation.

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4 See, for example, Rotemberg and Woodford (1997), Clarida, Gali, and Gertler (1999), King and Wolman (1999), and Erceg, Henderson, and Levin (2000).

5 The literature is divided into two streams on the basis of the fundamental assumption regarding the deterministic equilibrium around which the model economy evolves.

6 See Woodford (2003).

of the model's equilibrium conditions. In fact, up to first-order accuracy, the agents' discounted utility function equals its non-stochastic steady-state value. Since commonly considered monetary policy rules do not affect the non-stochastic steady state, it is not possible to rank different rules on the basis of first-order approximation. Benigno and Woodford (2003) propose an extension of Rotemberg and Woodford's method. Based on computing a second-order approximation of the model's structural equations, it is possible to substitute out the linear terms from the Taylor approximation of the expected utility, obtaining a purely quadratic approximation of the welfare function (containing no linear terms). Once a quadratic function is derived, optimal monetary policy can then be evaluated, using the first-order approximation of the model's equations as constraints. Thus, the linear-quadratic method is introduced again. The method used in this paper is instead the one suggested by Schmitt-Grohe and Uribe (2003). They show that given the first-order terms of the Taylor expansions of the functions expressing the model's solution, the second-order terms can be identified by solving a linear system of equations, the terms of which are first-order terms and derivatives up to the second order of the equilibrium conditions evaluated at the non-stochastic steady state.

3 Housing Prices and Borrowing Constraints

Why should housing prices be relevant to monetary policy in a bubble-free model? Our main hypothesis is that since housing is used as collateral in the loan market, housing prices are related to consumption and economic activ-
ity through both a traditional wealth effect and a credit channel. Increased housing prices contribute to a rise in the value of the collateral, which allows households to borrow and consume more. Consequently, increased household indebtedness could increase the sensitivity of households to changes in interest rates and sudden decreases in housing prices themselves. Thus, housing price movements are relevant to the assessment of how private consumption evolves and of the ability of households to smooth the effect of shocks.

We consider a modified version of the standard business cycle model in which households derive utility from owning houses and use them as collateral in the loan market. We depart from the representative agent framework by assuming two groups of agents, borrowers and lenders. The borrowing constraint is not derived endogenously but is consistent with standard lending criteria used in the mortgage and consumer loan markets. The borrowing constraint is introduced through the assumption that households cannot borrow more than a fraction of the value of their houses. The household borrows, $B_{it}$, against the value of its housing wealth, as follows:

$$B_{it} \leq \gamma E_t[Q_{t+1}h_{it}]$$

where $Q_{t+1}$ is the nominal housing price and $h_{it}$ is the stock of housing. Mortgage loan refinancing takes place every period and the household repays each new loan after one period. The overall value of the loan cannot be higher than a fraction of the expected value of the collateral. This fraction, $\gamma$, referred to as the *loan-to-value ratio*, should not exceed one. This can be explained with reference to the overall judicial costs that a creditor incurs
in case of debtor default. Since housing prices affect the collateral value of the houses, price fluctuations play a large role in determining borrowing conditions at the household level. Borrowing against a higher-valued house is used to finance both consumption and investment in housing.

4 The Model

Consider a sticky price economy populated by a monopolistic competitive goods-producing firm, a monetary authority, and two types of households. To impose the existence of credit flows in this economy, we assume ex ante heterogeneity at the household level, i.e., agents differing in terms of the subjective discount factor. We assume a continuum of households of mass 1: n Impatient households (lower discount rate) that borrow in equilibrium and 1 - n, Patient households (higher discount rate) that lend in equilibrium.

4.1 Households

The households derive utility from a flow of consumption and services from house holding — assumed to be proportional to the real amount of housing stock held — and disutility from labor:

\[
\max_{\{c_{it}, h_{it}, L_{it}\}} E \sum_{t=0}^{\infty} \beta_t^i U(c_{it}, h_{it}, L_{it})
\]

where \(i = 1, 2\) and \(\beta_1 > \beta_2\) s.t. a budget constraint

\[
c_{it} + q_t(h_{it} - h_{it-1}) + \frac{b_{it-1}}{\pi_t} = \frac{b_{it}}{R_t} + w_t L_{it} + f_{it} - T_{it}
\]
and a borrowing constraint

$$b_{it} \leq \gamma E_t[q_{t+1}\pi_{t+1}h_{it}]$$

Except for the gross nominal interest rate, $R$, all the variables are expressed in real terms; $\pi_t$ is the gross inflation ($P_t/P_{t-1}$) and $q_t$ is the price of housing in real terms ($Q_t/P_t$). The household can borrow $b_t$ using as collateral the next period's expected value of real estate holdings (the housing stock). This borrowing constraint holds only for the impatient households, since the patient ones lend in equilibrium. In the budget constraint, $T_{it}$ represent lump-sum taxes imposed by the fiscal authority, and $f_{it}$ represents dividends distributed by firms (we assume that only the patient households own the firms). Thus, $f_{it} = \frac{1}{(1-N)} (D_t/p_t)$ where $D_t$ represents the dividends of the representative firm and $f_{2t} = 0$.

The agents optimal choices are characterized by:

labor supply

$$-U_{L_{it}} = U_{c_{it}} w_t$$

and borrowing condition

$$\frac{U_{c_{it}}}{R_t} \geq \beta_t E_t \frac{U_{c_{i+1},t+1}}{\pi_{t+1}}$$

housing demand

$$U_{c_{it}}q_t - \beta_t E_t U_{c_{i+1},t+1}q_{t+1} \geq U_{H_{i+1}}$$
The second equation relates the marginal benefit of borrowing to its marginal cost. The third equation states that the opportunity cost of holding one unit of housing, \( U_{\alpha,t}q_t - \beta_t E_t U_{\alpha,t+1} q_{t+1} \), is greater than or equal to the marginal utility of the housing services. The above equations hold with equality for patient households. Since the patient households’ borrowing constraint is not binding in the neighborhood of the steady state, these households face a standard problem, the only exception being the existence of housing services in the utility function.

4.1.1 Impatient households

We can show that impatient households borrow up to the maximum in the neighborhood of the deterministic steady state. If fact, if we consider the Euler equation of the impatient household

\[ \mu_2 = (\beta_1 - \beta_2) U_{\alpha_2} > 0 \]

where \( \mu_2 \) is the Lagrange multiplier associated with the borrowing constraint.\(^8\) Thus, the borrowing constraint holds with equality:

\[ b_{2t} = \gamma E_t [q_{t+1} n_{t+1} h_{2t}] \]

And we get the following optimal choices for labor, borrowing, and housing services:

\[ -U_{t+1} = U_{c_{2t}} w_t \]

\(^8\)Once we assume the existence of different discount factors of \( \beta_1 > \beta_2 \) in the deterministic steady state, impatient households are willing to borrow up to the maximum.
\[
\frac{U_{c_{t+1}}}{R_t} - \mu_t = \beta_2 E_t U_{c_{t+1}} \frac{1}{\pi_{t+1}}
\]

For constrained agents, the marginal benefits of borrowing are always greater than the marginal cost:

\[
U_{b_{2t}} + \beta_2 E_t U_{c_{t+1}} q_{t+1} + \mu_t \gamma E_t q_{t+1} \pi_{t+1} = U_{c_{t+1}} q_t
\]

Moreover, the marginal benefit of holding one unit of housing arises not only its marginal utility, but also from the marginal benefit of being allowed to borrow more.

4.2 Firms

4.2.1 The final goods-producing firms

Perfectly competitive firms produce a type of final goods, \( y_t \) using \( y_t(i) \) units of each type of intermediate goods, \( i \in \{0, 1\} \), adopting a constant return to scale, diminishing marginal product, and constant elasticity of substitution technology:

\[
y_t \leq \left[ \int_0^1 y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}
\]

where \( \theta > 1 \). The price of the intermediate goods, \( y_t(i) \), is denoted by \( P_t(i) \) and taken as given by the competitive final goods-producing firm. Solving for cost minimization\(^9\) yields the following constant price elasticity, \( \theta \), demand

\(^9\)Cost minimization implies

\[
\min_{(y_t(i))} \int_0^1 P_t(i)y_t(i)di
\]

s.t. \( y_t \leq \left[ \int_0^1 y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}} \)
function for type of goods $i$, which is homogeneous of degree one in the total final output:

$$y_t(i) = \left[ \frac{P_t(i)}{P_t} \right]^{-\theta} y_t$$

By combining the demand function with the production function, it is possible to derive the price index for intermediate goods:

$$P_t = \left[ \int_0^1 P_t(i)^{1-\theta} \, di \right]^{1/(1-\theta)}$$

### 4.2.2 The intermediate sector

In the wholesale sector there is a continuum of firms indexed by $i \in (0, 1)$ and owned by consumers. Intermediate producing firms act on a monopolistic market and produce $y_t(i)$ units of a differentiated type of goods, $i$, using $L_t(i)$ units of labor, according to the following constant return to scale technology:

$$Z_t L_t(i) \geq y_t(i)$$

where $Z_t$ is the aggregate productivity shock, which follows the following autoregressive process:

$$\ln(Z_t) = \rho Z \ln(Z_{t-1}) + \varepsilon_{Zt}, \quad \varepsilon_{Zt} \sim \text{iid } N(0, \sigma_{\varepsilon^2}), \quad 0 < \rho Z < 1$$

**Cost Minimization** Monopolistic competitive firms hire labor from households in a competitive market on a period-by-period basis. Cost minimization implies the following nominal marginal cost, $s^n_t$:

$$\frac{W_t}{Z_t} = s^n_t(i)$$

104
and thus the total cost could be expressed as follows:\textsuperscript{10}:

\[ W_t L_t(i) = s_t^p(i)y_t(i) \]

**Price Setting** Assume now that intermediate firms set the price of their differentiated goods every period, but face a quadratic cost of adjusting the price between periods:\textsuperscript{11}. The cost is measured in terms of the final goods\textsuperscript{12}

\[
\frac{\phi_p}{2} \left[ \frac{P_t(i)}{\pi P_{t-1}(i)} - 1 \right]^2 y_t
\]

where \( \phi_p > 0 \) represents the degree of nominal rigidity and \( \pi \) is the gross steady-state inflation. Each firm faces the following problem:

\[
\max_{\{P_t(i)\}} E_t \sum_{j=0}^{\infty} \Lambda_{t+j} \left[ \frac{P_{t+j}(i)}{P_t(i)} \right]^{\theta} y_t
\]

\[
y_t(i) = \left[ \frac{P_t(i)}{P_i} \right]^{-\theta} y_t
\]

\textsuperscript{10}In equilibrium, the firm chooses an input such that the marginal product equals the markup times the factor price. In fact, in terms of gross markup, \( (1 + \eta_t) = \frac{1}{s_t} \)

\[
\frac{\bar{y}_t(i)}{L_t^r(i)} = (1 + \eta_t)W_t
\]

\textsuperscript{11}The Calvo setting (most commonly used) and the price-adjustment cost setting deliver the same linearized system of necessary conditions up to reparametrization. For a second-order approximation this is not true: the second-order term in the resource constraint and in the firms’ FOC does not allow a one-to-one mapping between the two models.

The second-order terms in the Calvo setting are ultimately related to the second-order moments of the price distribution, while in the other case they are simply related to the chosen adjustment-cost functional form. However, given the demanding assumptions of the re-setting process in a Calvo-type framework, it is hard to tell which of the two set-ups is quantitatively more reliable.

To save computing time, we have preferred to use the price adjustment cost framework.

\textsuperscript{12}See Kim, JME, 1995.
where $\Lambda_{t+1} = \beta^j \frac{U_{t+1+j}}{U_{t+m}}$ is the relevant discount factor. The firm’s profits in real terms are given by

$$\frac{D_t(i)}{P_t} = \frac{P_t(i)}{P_t} y_t(i) - s_t(i)y_t(i) - \frac{\phi_p}{2} \left[ \frac{P_t(i)}{\pi P_{t-1}(i)} - 1 \right]^2 y_t$$

Using the results of the cost minimization problem, we replaced the real total costs, $w_t L_t(i)$, with a function of real marginal costs and total output. Thus, substituting for the total costs and the firm’s production, the profit maximization problem becomes:

$$\max_{\{P(i)\}} E_t \sum_{j=0}^{\infty} \Lambda_{t+j} y_t \left\{ \left( \frac{P_t(i)}{P_t} \right)^{1-\theta} - s_t(i) \left( \frac{P_t(i)}{P_t} \right)^{-\theta} - \frac{\phi_p}{2} \left( \frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right\}$$

4.3 The fiscal authority

We assume

$$G_t = T_t$$

where $G_t$ is government consumption of the final goods and $T_t$ represents lump-sum taxes/transfers, where $T_t = (1 - \pi)T_t + \pi T_{2t}$. Government consumption evolves according to the following exogenous process:

$$w_t L_t(i) = s_t(i) y_t(i) = \frac{w_t}{E_t} y_t(i)$$

The derivative with respect to the firm’s price, multiplied by the price level, $P_t$, yields:

$$0 = E_t \beta^j \frac{U_{t+j}}{U_{t+m}} \left[ \phi_0 P_t \left( \frac{P_t}{P_t} \right)^{\theta-1} - \phi_p \frac{P_t}{\pi P_{t-1}(i)} \left( \frac{P_t}{P_{t-1}(i)} - 1 \right) \right] + (1 - \theta) \left( \frac{P_t}{P_t} \right)^{-\theta} + \theta s_t(i) \left( \frac{P_t(i)}{P_t} \right)^{-\theta-1} - \phi_p \frac{P_t}{\pi P_{t-1}(i)} \left( \frac{P_t(i)}{P_{t-1}(i)} - 1 \right)$$

106
\[(\ln G_t - \ln G) = \rho_G (\ln G_{t-1} - \ln G) + \varepsilon_{Gt} \quad \text{where} \quad \varepsilon_{Gt} \sim_{\text{iid}} N(0, \sigma_{\varepsilon_G}), \quad 0 < \rho_G < 1\]

where G is the steady-state share of government consumption.

### 4.4 Equilibrium and aggregation

In symmetric equilibrium, all firms make identical decisions, so that

\[y_t(i) = Y_t \quad P_t(i) = P_t \quad L(i) = L_t\]

Consequently, total production becomes

\[Y_t = Z_t L_t\]

while price setting becomes

\[0 = E_t U_{L+1} \left[ \phi_p \frac{\pi_{t+1}}{\pi} \left( \frac{\pi_{t+1}}{\pi} - 1 \right) \right] + U_{Lt} \left\{ y_t \left[ \theta \left( s_t - \frac{\theta - 1}{\theta} \right) \right] - \phi_p \frac{\pi_t}{\pi} \left( \frac{\pi_t}{\pi} - 1 \right) \right\}\]

The market clearing conditions are as follows:

\[(1 - n)L_{1t} + nL_{2t} = L_t \quad (1 - n)c_{1t} + nc_{2t} = C_t \]
\[(1 - n)b_{1t} + nb_{2t} = 0 \quad (1 - n)h_{1t} + nh_{2t} = H_t \]
\[T_t = (1 - n)T_{1t} + nT_{2t} \quad G_t = T_t\]

where \(H_t\) is in fixed supply, normalized to 1. The resource constraint is as follows:

\[Y_t = C_t + \frac{\phi_p}{2} \left( \frac{\pi_t}{\pi} - 1 \right)^2 Y_t + G_t\]

The production of the final sector needs to be allocated according to price adjustment costs and to consumption by households and government.
5 Parameter Values

We set the parameters of the model on the basis of quarterly evidence. The household discount factors are \((\beta_1, \beta_2) = (0.99, 0.965)\). The patient household discount factor implies an average annual rate of return of approximately 4%. Previous estimates of discount factors for poor or young households:\(^{15}\) have been used as references in calibrating \(\beta_2\). We assume a separable utility function, as follows

\[
U(c_{it}, h_{it}, L_{it}) = \frac{c_{it}^{1-\phi_c}}{1-\phi_c} + \nu_h \ln h_{it} - \nu_L \frac{L_{it}^{1+\phi_L}}{1+\phi_L}
\]

As a benchmark case, we assume the log utility of consumption to be \(\phi_c = 1\) (risk aversion), and we set \(\phi_L = 2\) where \(\frac{1}{\phi_L}\) is the Frisch intertemporal elasticity of substitution. The weight on labor disutility, \(\nu_L\), equals 30, such that labor supply is approximately 1/3. The weight on housing is \(\nu_h = 0.09\). This last parameter implies a steady-state value of real estate over annual output of 141%. In line with the literature on nominal rigidities, we set the elasticity of substitution, \(\theta\), to equal 11, which gives a steady-state markup of 10%, in line with empirical evidence. The baseline choice of loan-to-value ratio,\(^{16}\) \(\gamma\), is 60%, and the fraction of borrowing-constrained population is set to 50%. We calibrate the steady-state government consumption value to be 20 of total output. In accordance with Schmitt-Grohe and Uribe (2004), we calibrate the technology and government spending shocks according to

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\(^{15}\)In fact, Lawrance (1991) and Samwick (1998) estimate the discount factors of poor and young households to be approximately 0.97 and 0.98, respectively.

\(^{16}\)Using US data from 1974 to 2003, Iacoviello (2004) estimates the household loan-to-value ratio to be 0.55.
standard values in the real business cycle literature.\textsuperscript{17} Table 1 summarizes the calibrated parameters.

<table>
<thead>
<tr>
<th>Model parameters</th>
<th>Preferences</th>
<th>Technology</th>
<th>BOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1 = 0.99$</td>
<td>$\varphi_c = 1$</td>
<td>$\theta = 11$</td>
<td>$\nu_h = 0.019$</td>
</tr>
<tr>
<td>$\beta_2 = 0.98$</td>
<td>$\varphi_L = 0.01$</td>
<td>$\phi_p = 161$</td>
<td>$\nu_L = 1$</td>
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<td></td>
<td></td>
<td>$\rho_Z = 0.82$</td>
<td>$\rho_G = 0.9$</td>
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<tr>
<td></td>
<td></td>
<td>$\sigma_Z = 0.0056$</td>
<td>$\sigma_G = 0.0074$</td>
</tr>
</tbody>
</table>

Table 1

6 Understanding the Model

A look at the deterministic steady state. To find the deterministic steady state of the model, we solve a nonlinear root-finding problem\textsuperscript{18}

From the Euler equations we have that $R = \Pi / \beta_1$. Given that in the steady state the wage equals the marginal costs, $(\theta - 1) / \theta$, we find $c_i$ as a function of $L_i$:

$$c_i^c \nu_L L_i^c = w$$

Defining $\tilde{\beta} = \beta_2 + \gamma (\beta_1 - \beta_2)$, we can also find the value of the housing stock

\textsuperscript{17}For the technology shock, see Cooley and Prescott (1995, chapter 1 in Cooley 1995)[81], or Prescott 1986.

\textsuperscript{18}In a root-finding problem a function $f$ mapping $\mathbb{R}^n$ to $\mathbb{R}^n$ is given, and one must compute an $n$ vector, $x$, called a root of $f$, that satisfies $f(x) = 0$. In our problem, $f(x)$ is represented by the steady state. We can write the system as an $\mathbb{R}^2 \to \mathbb{R}^2$ function where $L_1$ and $L_2$ are unknowns; in this way we can easily implement a numerical algorithm to solve the system quickly and accurately.
of impatient agents:

\[(qh_2)_{ss} = \nu_H c_H^2 / (1 - \bar{\beta})\]

The borrowing constraint is

\[b_2/\Pi = \gamma(qh_2)_{ss} = \gamma \nu_H c_H^2 / (1 - \bar{\beta})\]

The system is closed by the resource constraint and one of the two budget constraints. So the model shows superneutrality. In fact, we can write the bond holdings as:

\[b_2/\Pi - b_2/R = \gamma(qh_2)_{ss}(1 - \beta_1) = \frac{\gamma \nu_H c_H^2}{(1 - \bar{\beta})}(1 - \beta_1)\]

Thus, the system does not include any nominal variable; in fact, in the steady state the cost of adjusting prices is nil and the inflation rate does not affect any real variable.

We now analyze how the non-stochastic steady state varies under different parametrizations of the model.

First, let us observe how the degree of friction in the credit market affects the deterministic steady state of the model. Figure 1 indicates that housing prices are increasing in terms of \(\gamma\). A higher value of \(\gamma\) implies easier access to the credit market, and consequently, increased demand for housing on the part of borrowers. For the housing market to clear, lenders should be willing to sell part of their housing holdings. Thus, the user cost of housing has to increase. Lower credit friction means that lenders are able to postpone more consumption until the future, while, in contrast, borrowers can consume more

\[\text{For convenience, we choose the one of the impatient.}\]
in the present. Thus, in the long run, the consumption path of the lenders is increasing in terms of $\gamma$, while decreasing for borrowers. Lower consumption implies less leisure for borrowers (i.e., greater labor supply) and more leisure for lenders. Overall, there is an increase in the total labor supply, and thus an increase in total production.

Figure 2 also presents the effect of the gap in discount factors, defined as $\beta_1 - \beta_2$. As far as $\tilde{\beta} < \beta_1$, the value of housing stock as a proportion of total output is increasing in terms of $\gamma$. On the other hand, housing prices are inversely related to the gap in discount factors when $\gamma < 1$. We can consider $\tilde{\beta}$ to be the true discount factor, modified for the credit constraint, that impatient households use to evaluate the decision whether or not to own housing. When households can fully finance their housing investments, i.e., $\gamma = 1$, we have that $\beta_1 = \beta$, and the gap in discount factors plays no role in determining the level of any variable. For values of $\gamma > 1$, the logic is inverted. Generally speaking, higher housing prices imply higher gross or net debt gearing (whichever is measured) for the household sector. In particular, with our calibration, at values of $\gamma$ close to unity, total household debt outstanding is close to 100% of total disposable income\textsuperscript{20}.

Figure 3 compares our model with an equivalent representative agent model.\textsuperscript{21} It is interesting to note that the existence of debtors in the economy creates overproduction, in the sense that the output is greater than

\textsuperscript{20}Which, for some anglo-saxon countries, is not at all far away from actual data.

\textsuperscript{21} $Y_{\text{representative}} - Y_{\text{heterogeneous}}$
that delivered by the representative agent model. However, the existence of heterogeneous agents is not in itself sufficient to generate a level of production greater than that implied by representative agents not subject to the monopolistic competition distortion.\footnote{Also note that the closer competition is to perfect competition the smaller the difference between the representative agent output and ours. This is mainly, but not solely, because the profits are rebated only to the patient agents. So in our model, greater monopoly power exacerbates the wealth inequality.}

Compared to the steady-state level of housing prices, our model implies lower price level than the representative agent model does. For any $\gamma < 1$, in our economy the stock of housing held by patient agents is always greater than the average holdings; in the representative agent model, however, the housing stock of patient agents is clearly constructed to be identical to the average holdings. So, while in the representative agent model the stock of housing held by the agent always equals unity, in our model $h_1 > 1$ and decreases with $\gamma$. This means that $q_{ss}$ is always lower than in the representative agent economy as far as $\gamma < 1$. Moreover, the difference in terms of housing prices is always positive, though decreasing in terms of $\gamma$. At the same time, the wider the discount factor gap, the less the difference in prices.

\textbf{Responses to shocks.} Let us now examine how exogenous shocks are propagated in this economy. To close the model, we assume that the central bank follows a simple rule of this form:

$$\hat{R}_t = \hat{\alpha}_\pi \hat{\pi}_t$$

where $\hat{\alpha}_\pi = 1.5$. Figure 5a displays the reaction to a positive productivity shock. As expected, a positive productivity shock leads to a reduction in the
marginal cost, which implies decreased inflation. Thus the effect of a positive
technology shock has a reduced impact on total production. Since it is costly
to change prices, inflation decreases less than it should, so consumption rises
less than needed, implying reduced total employment. Impatient households
smooth the effect of the shock on consumption by increasing their investment
in housing. Thus, for the housing market to clear, the price of the asset
increases, and consequently, the level of current indebtedness rises.

Let us write the budget constraint on borrowers as a first-order approxi­
mation, as follows:

\[
c_{2,t} + \frac{q h_2}{c_2} \hat{h}_{2,t} (1 - \gamma_{ss} \beta_1) = \frac{q h_2}{c_2} [\gamma_{ss} \beta_1 (\hat{c}_t + \hat{E}_{t+1} - r r_t) +
+ \gamma_{ss} \pi_t + \hat{h}_{2,t-1} - \gamma_{ss} \hat{b}_{2,t-1}] + \frac{w L_2}{c_2} (\hat{w}_t + \hat{L}_{2,t}) - \frac{G}{Y_{c_2}} g_t
\]

Where we define the ex ante real rate as \( r r_t = \hat{R}_t - E_t \pi_{t+1} \). First, we
notice that in a first-order approximation and close to the steady state, the
down payment equals \( 1 - \gamma_{ss} \beta_1 \), recalling that here \( \beta_1 \) is the price of a unit
of debt in steady state. This means that households are able to fully finance
their housing investment using debt only if \( \gamma_{ss} = 1/\beta_1 > 1 \). We can identify
three main channels through which the wealth effect operates. 1) A collateral
effect: an increase in borrowing ability can be driven either by higher housing
price expectations or by higher \( \gamma \). The magnitude of their impact is given by
the discounted steady-state debt-consumption ratio, \( \beta_1 b_2/c_2 \). 2) An interest
rate channel that operates through \( r r_t \): a higher real rate means higher
interest payments on the stock of debt, redistributing wealth from debtors
to creditors. 3) A nominal debt effect that operates through inflation: since
debt is not indexed, unexpectedly higher inflation today redistributes wealth from creditors to debtors. We also notice that in this model, house prices have no traditional wealth effect. More precisely, given that housing investment is zero in the steady state, the direct impact of housing prices subject to the budget constraint is always zero, whatever the approximation order taken.

Figure 5b displays the effect of increased government expenditure. As a result of this increase, labor demand also increases and thus production as well. The consequent increase in marginal costs raises current inflation. Due to higher taxes, individual consumption decreases. This, coupled with the increased real interest rate, induces borrowers to reduce their debt levels by reducing their housing holdings; consequently, housing prices decline.

7 Computation and Welfare Measure

7.1 Computation

Ever since Kydland and Prescott (1982) published their findings, the first-order approximation approach has been the most popular numerical approximation method for solving models too complex to produce exact solutions. However, first-order approximations may produce clearly erroneous results. To compare the welfare effects of implementable policy rules that have no first-order effects on a model’s deterministic steady state, we need to rely on

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23 They applied to a real business cycle model a special case of the method of linear approximation around deterministic steady states developed in Magill (1977).

24 See, for example, Tesar (1992) for an example in which completing asset markets makes all agents worse off, or Kim and Kim (2003), which emphasizes the same results in a two-agent stochastic model.
higher-order approximation methods. As shown by Kim and Kim (2003),\textsuperscript{25} in this context first-order approximation methods are not locally accurate. In general, a second-order accurate approximation of the welfare function requires a second-order expansion to the model's equilibrium conditions. The first-order approximation solution is not always accurate enough, due to the certainty equivalence property, i.e., the coincidence of the first-order approximation of the unconditional means of endogenous variables with their non-stochastic steady-state values. This ignores important effects of uncertainty on the average level of household welfare. A first-order approximation of the policy functions would give an incorrect second-order approximation of the welfare function.\textsuperscript{26}

To overcome this limitation and obtain a second-order accurate approximation, we have adopted a perturbation technique introduced by Fleming (1971), applied to various types of economic models by Judd and various coauthors,\textsuperscript{27} and recently generalized by Schmitt-Grohe and Uribe (2002).\textsuperscript{28}

Second-order approximations are quite convenient to implement since, even

\textsuperscript{25}They show that a welfare comparison based on the linear approximation of the policy functions of a simple two-country economy, may yield the odd result of welfare being greater under autarky than under a condition of full risk sharing.

\textsuperscript{26}See Woodford (2002) for a discussion of situations in which second-order accurate welfare evaluations can be obtained using first-order approximations of the policy functions.

\textsuperscript{27}See Judd and Guu (1993, 1997) for applications to deterministic and stochastic, continuous- and discrete-time growth models in one state variable, Gaspar and Judd (1997) for multidimensional stochastic models in continuous time approximated up to the fourth order, Judd (1998) for a presentation of the general method, and Jin and Judd (2001) for an extension of these methods to more general rational-expectations models.

\textsuperscript{28}They derive a second-order approximation of the policy function of a general class of dynamic, discrete-time rational-expectation models. They show that in a second-order expansion of the policy functions, the coefficients of the linear and quadratic terms of the state vector are independent of the volatility of the exogenous shocks. Thus, only the constant term is affected by uncertainty.
when capturing the effects of uncertainty, they do not suffer from the "curse of dimensionality." In fact, in accordance with Schmitt-Grohe and Uribe, given the first-order terms of the Taylor expansions of the functions expressing the model’s solution, the second-order terms can be identified by solving a linear system of equations the terms of which are the first-order terms and derivatives up to the second order of the equilibrium conditions evaluated at the non-stochastic steady state.

7.2 Welfare measure and optimal rules

How should monetary policy be in a world economy with credit frictions at the household level? To answer this question, we rely on utility-based welfare calculations, assuming that the benevolent monetary authority maximizes the utility of households, subject to the model’s equilibrium conditions. Formally, the optimal monetary policy maximizes lifetime household utility:

$$V_t = E_t \left[ \sum_{i=1}^{2} \eta_i \sum_{j=0}^{\infty} \beta_i^j U(c_{i,t+j}, h_{i,t+j}, L_{i,t+j}) \right]$$

where $\eta_i$ represents the weights on households’ utilities. We choose $\eta_1 = n(1-\beta_1)$ and $\eta_2 = (1-n)(1-\beta_2)$ such that, given a constant consumption stream, the two agents achieve the same level of utility.

We measure welfare as the conditional expectation at time zero, $t = 0$, the time at which all state variables of the economy assume their steady-state values. Since different policy regimes, even those not affecting the non-stochastic steady state, are associated with different stochastic steady states,

\[\text{Models with many state variables can be solved without much computational effort.}\]
so as not to neglect the welfare effects occurring during the transition from one steady state to another, we use a conditional welfare criterion. Thus, we evaluate welfare conditional on the initial state being the non-stochastic steady state.\footnote{An alternative to making the evaluation conditional on a particular initial state could be to make it conditional on a distribution of values of the initial state. In any case, when there is a time-inconsistency problem, the optimality of the rule may depend on the initial conditions. One way to overcome this problem could be to find the rule that would prevail under the commitment of a "timeless perspective" (see Giannoni and Woodford 2002).}

We evaluate the optimal setting of monetary policy in the constrained class of simple interest rate rules. Thus, we assume that the central bank follows an interest rate rule of the form

$$R_t = \Theta(X)$$

where $X$ represents easily observable macroeconomic indicators tested as possible arguments of the rule

$$X = \left[ R_{t-1}, \frac{\pi_{t-s}}{\pi_{ss}}, \frac{y_{t-s}}{y_{ss}}, \frac{q_{t-s}}{q_{ss}} \right]$$

and where $s = \{0, 1\}$. As an implementability condition, the policies are required to deliver local uniqueness of the rational expectations equilibrium. The configuration of parameters satisfying the requirements and yielding the greatest welfare gives the optimal implementable rule. In characterizing optimal policy, we search over a grid considering different ranges of the parameters. Then, we compute the welfare level, $V_0^*$, associated with the optimal rule:

$$V_0^* \equiv E_0 \left[ \sum_{i=1}^{2} \eta_i \sum_{j=0}^{\infty} \beta^j U(c_{i,j}^*, b_{i,j}^*, L_{i,j}^*) \right]$$
where \( c_{i,j}^*, h_{i,j}^* \) and \( L_{i,j}^* \) denote the contingent planes of consumption, housing, and labor, respectively, under the optimal policy regime. To compare different rules, we relate the deviations of the welfare associated with the different rules from the deterministic steady-state welfare.

8 Simple optimal rules

To investigate how monetary policy should optimally be designed in a model that incorporates housing prices, we maximize households' total welfare with respect to the coefficients of a simple monetary policy rule. As in the monetary business cycle literature, we allow the nominal interest rate to respond to inflation, output, and the lagged interest rate. In accordance with the literature on asset prices and monetary policy, we also consider the optimality of responding to current housing price movements. Thus, we search for the optimum value of the coefficient of an implicit interest rate rule \( \alpha_\pi, \alpha_y, \alpha_R \) and \( \alpha_q \) using the following grids: \([1,3]\) for \( \alpha_\pi \), \([0,0.9]\) for \( \alpha_R \), and \([0,2]\) for \( \alpha_y \) and \( \alpha_q \).\(^{31}\) Table 2 summarizes the main findings; we express the welfare loss with respect to the steady-state welfare.

<table>
<thead>
<tr>
<th>Optimal simple rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{R}<em>t = \alpha_R \bar{R}</em>{t-1} + (1 - \alpha_R) \alpha_\pi \bar{\pi}_t + (1 - \alpha_R) \alpha_y \bar{Y}_t + (1 - \alpha_R) \alpha_q \bar{q}_t )</td>
</tr>
<tr>
<td>( \alpha_R = 0 )</td>
</tr>
<tr>
<td>Welfare Loss = 0.00937003</td>
</tr>
</tbody>
</table>

Table 2

The welfare loss represents the loss in terms of consumption with respect to steady-state welfare.

Optimization over this simple rule indicates that the central bank should

\(^{31}\) We consider 25 linearly spaced points for each coefficient.
not take into account variations of housing prices from the steady-state level. This means that the housing price is not an appropriate variable to consider for the optimal design of simple monetary policy rules in this economy. Optimal policy is instead characterized by a strong response to inflation deviations from the target. In fact, $\alpha_r$ equals the upper limit of its parameter space. In contrast, it is not optimal to react to output. These results are consistent with those obtained by Schmitt-Grohe and Uribe (2003). They also show that it is optimal to respond to deviations of output from potential output, but not to output variations per se. While the concept of "output gap" is well understood in models characterized only by inefficiencies related to price stickiness, the definition of potential output in our economy is not clear. Interest rate smoothing also turns out not to be optimal. Given that our model economy is cashless, in the absence of capital, the only motive for smoothing the interest rate would come from the existence of credit friction. However, it turns out that targeting the lagged interest rate is also not optimal.

Figure 6 shows how the two different monetary policy regimes affect the reaction to shocks in this economy. We consider the case of a central bank following the optimal simple rule or, alternately, also targeting housing prices. Thus, we vary the weight on housing prices in the monetary rule, $\alpha_r$, from zero to one. The first thing to notice is the reaction of inflation. Under both shocks, the analyzed inflation is destabilized when the monetary authority targets housing prices. At the same time, real housing prices gain little in terms of stabilization, because, as they are mainly driven by exogenous vari-
ables (i.e., the technology and government spending shocks), they are closely related to fundamentals. This even applies if the credit constraint amplifies the fluctuations of household variables such as consumption, housing stock, and borrowing. On the other hand, in a first-order approximation, aggregate variables such as output and total labor supply remain mainly unaffected by change imposed by the specification of monetary policy rule. Not only inflation, but also the nominal and real interest rates are much more volatile than those prevailing under the optimal rule. Thus, targeting housing prices could in fact even increase the redistribution of wealth among households through the interest rate-inflation channel. To summarize, targeting housing prices seems not to be very effective at reducing the wealth effect stemming from the credit friction mechanism; at the same time, it amplifies the redistributive wealth channel that operates via inflation and interest rates, and increases the relative price dispersion losses. As a result, there is a reduction in the overall welfare of the economy.

It is often argued in the monetary policy literature that implicit rules cannot be implemented in practice. For this reason, we have adopted a simple rule according to which the nominal interest rate reacts to the last period's inflation, output, and housing prices. The result turns out to be the same: targeting housing prices is not optimal.

\[32\] In the IRF of the system approximated to the second order (not shown here), we instead see how targeting housing prices entails lower value for long-term aggregate output and non-zero long-term inflation.
Lagged Interest Rate Rule

\[ \tilde{R}_t = \alpha_R \tilde{R}_{t-1} + (1 - \alpha_R) \alpha_x \tilde{x}_{t-1} + (1 - \alpha_R) \alpha_y \tilde{y}_{t-1} + (1 - \alpha_R) \alpha_q \tilde{q}_{t-1} \]

\[ \alpha_R = 0 \quad \alpha_x = 3 \quad \alpha_y = 0 \quad \alpha_q = 0 \]

Welfare Loss = 0.00937858

Table 3

The welfare loss represent the loss in terms of consumption with respect to the steady state's welfare.

Table 4 compares the optimal implicit simple rule with a number of different ad hoc rules using the welfare-based approach. As explained in section 5.2, to compare different rules, we must relate the deviations of the welfare associated with the different rules from the steady-state welfare.
Table 4

<table>
<thead>
<tr>
<th>Rule</th>
<th>Welfare Loss</th>
<th>% Loss relative to optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Interest Rate Smoothing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tilde{R}_t = \alpha_x \hat{\pi}_t + \alpha_y \hat{\rho}_t$</td>
<td>0.13115</td>
<td>0.1218</td>
</tr>
<tr>
<td>$\alpha_x = 3$</td>
<td>$\alpha_y = 0.5$</td>
<td></td>
</tr>
<tr>
<td>$\alpha_x = 1.5$</td>
<td>$\alpha_y = 0.5$</td>
<td></td>
</tr>
<tr>
<td>$\tilde{R}_t = \alpha_x \hat{\pi}_t + \alpha_q \hat{\rho}_t$</td>
<td>1.07945</td>
<td>1.0701</td>
</tr>
<tr>
<td>$\alpha_x = 3$</td>
<td>$\alpha_q = 1$</td>
<td></td>
</tr>
<tr>
<td>$\tilde{R}_t = \alpha_x \hat{\pi}_t + \alpha_y \hat{\rho}_t + \alpha_q \hat{\rho}_t$</td>
<td>0.98708</td>
<td>0.9777</td>
</tr>
<tr>
<td>$\alpha_x = 3$</td>
<td>$\alpha_y = 0.5$</td>
<td>$\alpha_q = 1$</td>
</tr>
<tr>
<td>Interest Rate Smoothing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tilde{R}<em>t = \alpha_R \tilde{R}</em>{t-1} + (1 - \alpha_R) \alpha_x \hat{\pi}_t + (1 - \alpha_R) \alpha_y \hat{\rho}_t$</td>
<td>0.01551353</td>
<td>0.0061</td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 3$</td>
<td></td>
</tr>
<tr>
<td>$\alpha_R = 0.6$</td>
<td>$\alpha_x = 3$</td>
<td></td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 1.5$</td>
<td></td>
</tr>
<tr>
<td>$\tilde{R}<em>t = \alpha_R \tilde{R}</em>{t-1} + (1 - \alpha_R) \alpha_x \hat{\pi}_t + (1 - \alpha_R) \alpha_y \hat{\rho}_t + (1 - \alpha_R) \alpha_q \hat{\rho}_t$</td>
<td>0.16378627</td>
<td>0.1544</td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 3$</td>
<td>$\alpha_y = 0.5$</td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 1.5$</td>
<td>$\alpha_q = 0.5$</td>
</tr>
<tr>
<td>$\tilde{R}<em>t = \alpha_R \tilde{R}</em>{t-1} + (1 - \alpha_R) \alpha_x \hat{\pi}_t + (1 - \alpha_R) \alpha_y \hat{\rho}_t + (1 - \alpha_R) \alpha_q \hat{\rho}_t + (1 - \alpha_R) \alpha_q \hat{\rho}_t$</td>
<td>1.04395526</td>
<td>1.0346</td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 3$</td>
<td>$\alpha_y = 0.5$</td>
</tr>
<tr>
<td>$\alpha_R = 0.9$</td>
<td>$\alpha_x = 2$</td>
<td>$\alpha_y = 0.5$</td>
</tr>
</tbody>
</table>

The welfare loss represent the loss in terms of consumption with respect to the steady state's welfare. The % Loss is the welfare loss with respect to the optimal rule.

Our results clearly indicate that targeting housing prices tends to reduce welfare. In fact, a unitary response to current housing prices implies a 1% welfare loss with respect to the optimal rule.

It is worth noting that responding to output also tends to reduce welfare.

The higher the percentage decline in welfare, the lower the response to in-
flation; in fact, a 0.5 response to output reduces welfare by approximately 0.1% when the response to inflation is 3 and by approximately 1% when \( \alpha_\pi \) is set to 1.5. Even worse is the case in which the interest rate also responds to housing prices. The welfare loss is 1.5% in the first case and 5% in the second in the absence of interest rate smoothing, and approximately 2% and 8%, respectively, in the presence of a target for lagged interest rate in addition to inflation, housing prices, and output. Positive interest rate smoothing worsens the welfare performance of the simple rules considered here.

<table>
<thead>
<tr>
<th>Volatility (( \gamma = 0.6 ))</th>
<th>( q )</th>
<th>( \pi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{R}<em>t = \alpha</em>\pi \hat{\pi}_t + \alpha_q \hat{y}_t + \alpha_q \hat{q}_t )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \alpha_\pi = 3 ) ( \alpha_q = 0 )</td>
<td>2.015</td>
<td>0.044</td>
</tr>
<tr>
<td>( \alpha_\pi = 3 ) ( \alpha_q = 1 )</td>
<td>2.104</td>
<td>1.082</td>
</tr>
<tr>
<td>( \alpha_\pi = 3 ) ( \alpha_q = 0.5 ) ( \alpha_q = 1 )</td>
<td>2.089</td>
<td>1.401</td>
</tr>
<tr>
<td>( \alpha_\pi = 1.5 ) ( \alpha_q = 0.5 )</td>
<td>2.128</td>
<td>1.356</td>
</tr>
</tbody>
</table>

Table 4.b. Percent Standard deviation

Finally, we demonstrate how inflation and housing price volatility varies depending on different simple rules. As expected, the lowest inflation volatility is achieved under the optimal rule, and the same holds for housing prices. In fact, all the other rules imply higher volatility for both variables.

### 8.1 Credit rationing and optimal monetary policy

Now we check the robustness of the results under different degrees of access to the credit market. In the baseline model we assume that households can borrow up to 60% of the expected next-period value of their houses. \(^{33}\)

---

\(^{33}\)In Italy, for example, until the mid 1980s a maximum loan-to-value ratio of 50% was imposed by regulation. Following deregulation, this ratio was increased to 75% in 1986.
Independently of the value of $\gamma$, the optimal result remains unchanged (see Table 5). Thus, the degree of access to the credit market does not affect the design of optimal monetary policy. The welfare loss with respect to steady-state welfare decreases with $\gamma$. The lower the collateral requirement the higher the level of welfare.

<table>
<thead>
<tr>
<th>Optimal Simple Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_t = \alpha_R R_{t-1} + (1 - \alpha_R)\alpha_x \hat{p}_t + (1 - \alpha_R)\alpha_y \hat{y}_t + (1 - \alpha_R)\alpha_q \hat{q}_t$</td>
</tr>
<tr>
<td>$\alpha_R = 0$</td>
</tr>
<tr>
<td>$\gamma$</td>
</tr>
<tr>
<td>Welfare Loss</td>
</tr>
</tbody>
</table>

Table 5

The welfare loss represent the loss in terms of consumption with respect to the steady state's welfare.

However, as Table 6 indicates, the welfare cost of deviating from the optimal rule increases with $\gamma$. In fact, the welfare cost of adding a housing price, last period interest rate, or output target, in addition to an inflation target, is greater than the degree of credit market access.

and 100% in 1995
We now look at the volatility of inflation under different rules. As expected, the optimal rule, independently of $\gamma$, implies the lowest volatility. If more variables than simply inflation are targeted, the volatility of inflation increases. Applying a housing price target reduces the effectiveness of the target on inflation, and the same holds for an output target. Targeting the lagged interest rate, in contrast, has a negligible effect on inflation volatility. Consistently with the results concerning the cost of deviating from the optimal rule, over the different rules considered, inflation volatility increases slightly with $\gamma$, the only exception being the optimal rule case. In fact, when the degree of credit market access is higher, monetary policy is more effective. Thus, unless the central bank follows the optimal rule, increasing credit market access, and thus reducing inefficiency, implies an increase in the volatility of inflation.

<table>
<thead>
<tr>
<th>$\gamma$</th>
<th>$\alpha_\sigma = 3$</th>
<th>$\alpha_q = 1$</th>
<th>$\alpha_y = 0.5$</th>
<th>$\alpha_R = 0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma = 0.001$</td>
<td>0.95492812</td>
<td>0.95492812</td>
<td>1.01134530</td>
<td>0.01464221</td>
</tr>
<tr>
<td>$\gamma = 0.3$</td>
<td>0.9590</td>
<td>1.44974618</td>
<td>1.44974618</td>
<td>1.42845289</td>
</tr>
<tr>
<td>$\gamma = 0.4$</td>
<td>1.0022</td>
<td>1.5115</td>
<td>1.5115</td>
<td>1.52065058</td>
</tr>
<tr>
<td>$\gamma = 0.6$</td>
<td>1.52065058</td>
<td>1.52065058</td>
<td>1.52065058</td>
<td>1.52065058</td>
</tr>
</tbody>
</table>

Table 6

The welfare loss represent the loss in terms of consumption with respect to the steady state's welfare. The % Loss is the welfare loss with respect to the optimal rule.
Simple Rules and Inflation Volatility

\[ \bar{R}_t = \alpha_R \bar{R}_{t-1} + (1 - \alpha_R)\alpha_\pi \bar{\pi}_t + (1 - \alpha_R)\alpha_y \bar{y}_t + (1 - \alpha_R)\alpha_\delta \bar{\delta}_t \]

<table>
<thead>
<tr>
<th>( \gamma )</th>
<th>( \gamma = 0.001 )</th>
<th>( \gamma = 0.3 )</th>
<th>( \gamma = 0.6 )</th>
<th>( \gamma = 0.75 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_\pi = 3 ) (optimal simple rule)</td>
<td>0.0513</td>
<td>0.0493</td>
<td>0.0447</td>
<td>0.0406</td>
</tr>
<tr>
<td>( \alpha_\pi = 3, \alpha_q = 1 )</td>
<td>1.0603</td>
<td>1.0656</td>
<td>1.0801</td>
<td>1.0823</td>
</tr>
<tr>
<td>( \alpha_\pi = 3, \alpha_R = 0.9 )</td>
<td>0.0790</td>
<td>0.0798</td>
<td>0.0804</td>
<td>0.0793</td>
</tr>
<tr>
<td>( \alpha_\pi = 1.5, \alpha_y = 0.5 )</td>
<td>1.3410</td>
<td>1.3505</td>
<td>1.3561</td>
<td>1.3568</td>
</tr>
<tr>
<td>( \alpha_\pi = 3, \alpha_q = 1, \alpha_y = 0.5 )</td>
<td>1.3702</td>
<td>1.3787</td>
<td>1.4056</td>
<td>1.4178</td>
</tr>
<tr>
<td>( \alpha_R = 0.9, \alpha_\pi = 3, \alpha_q = 1, \alpha_y = 0.5 )</td>
<td>1.4451</td>
<td>1.4866</td>
<td>1.6121</td>
<td>1.8225</td>
</tr>
</tbody>
</table>

Table 7. Percent Standard deviation

9 Conclusions

We have examined optimal monetary policy rules in an economy that contains credit market frictions at the household level and heterogeneous agents. To assess the potential role of housing price considerations in designing monetary policy, we rely on a model based on that of Kiyotaki and Moore (1997). Thus, two types of agents, differing in terms of their discount factors, are assumed and physical assets must be used as loan collateral.

As a result, housing price movements should not be a separate target variable in addition to inflation in an optimally designed simple monetary policy regime. In fact, making housing price stability an explicit objective is welfare reducing with respect to a strict price stability policy. Our results are in line with the idea that under normal circumstances, asset prices should not be considered to be targets of monetary policy, as has previously been stressed by Svensson (2004).34

34Svensson argues that implementing flexible inflation targeting implies no need for the European Central Bank to take asset price movements into account.
Moreover, the welfare loss engendered by targeting housing prices becomes quantitatively more significant the greater the access to the credit market. Reducing credit market imperfections implies decreasing inflation volatility and improving welfare if and only if the central bank adheres to an optimally designed simple rule.
References


Appendix 1 Steady state

The real wage in the steady state equals the real marginal cost:

\[ w = s = \frac{\theta - 1}{\theta} \] (ss.1)

Given \( \beta_1 \) and assuming \( \pi_{ss} = 1 \), we find the following steady-state value of the interest rate:

\[ R = \frac{1}{\beta_1} \] (ss.2)

Since the deterministic steady states of the other variables are not analytically solvable, a nonlinear root-finding problem arises. In such a problem, a function, \( f \), mapping \( \mathbb{R}^n \) to \( \mathbb{R}^n \) is given, and one must compute an \( n \) vector, \( x \), called a root of \( f \), that satisfies \( f(x) = 0 \). In our problem, \( f(x) \) is represented by the following equations:

\[
\begin{align*}
-U_{l_1} &= U_{c_1} w \\
-U_{l_2} &= U_{c_2} w \\
\frac{U_{b_1}}{q} &= U_{c_1} (1 - \beta_1) \\
\frac{U_{b_2}}{q} &= U_{c_2} (1 - \beta_2) - \gamma \mu \\
\mu &= U_{c_2} (\beta_1 - \beta_2) \\
c_2 &= b_2 \left( \frac{1}{R} - 1 \right) + wL_2 \\
b_2 &= \gamma q h_2 \\
b_1 &= \frac{n b_2}{(1 - n)} \\
q h &= q (1 - n) h_{3t} + n h_{2t} \\
h_1 &= \frac{q h_1}{q} \\
h_1 &= \frac{q h_2}{q} \\
h &= 1
\end{align*}
\]
\[ c = (1 - n)c_1 + nc_2 \quad L = (1 - n)L_1 + nL_2 \]
\[ y = c \quad c = L \]

where
\[ U_{e_t} = c_t^{-\varphi_c} \quad U_{L_t} = -\nu_LL_t^{\varphi_L} \quad U_h = \frac{v_h}{h_t} \]

We implement a numerical algorithms [SS11] to solve the system quickly and accurately.

\[ U(c_{it}, h_{it}, L_{it}) = \frac{c_{it}^{1-\varphi_c}}{1-\varphi_c} + \nu_h \ln h_{it} - \nu_LL_{it}^{1+\varphi_L} \]

**Appendix .2 Solution Method**

The set of equilibrium conditions and the welfare function of the model can be written as:

\[ E_t f(y_{t+1}, y_t, x_{t+1}, x_t) = 0 \]

where \( E_t \) is the expectation operator, \( y_t \) is the vector of non-predetermined variable and \( x_t \) of predetermined variables. This last vector constists of \( x_t^1 \) endogenous predetermined state variables and \( x_t^2 \) exogenous state variables.

In the baseline case of our model we have:
\[ y_t = [\tau_t, q_t, \omega_t, y_t, L_t, c_t, s_t, V_{it}, V_{2t}]' \]
\[ x_t^1 = [b_{2t}, h_{2t}, R_t]' \quad x_t^2 = [Z_t, G_t]' \]

The welfare function is given by the conditional expectation of lifetime utility as of time zero: \( V_{it} \equiv \max E_t \left[ \sum_{j=0}^{\infty} \beta^j U(c_{i,t+j}, h_{i,t+j}, L_{i,t+j}) \right] \). Thus, in the optimum it will be: \( V_{it} = U(c_{i,t}, h_{i,t}, L_{i,t}) + \beta(E_t V_{it+1}) \). We add to the system of equilibrium conditions, two equations in two unknons: \( V_{it} \) and \( V_{2t} \).
The vector of exogenous state variables follows a stochastic process:

\[ x_{t+1}^2 = \Delta x_t^2 + \eta \epsilon_{t+1}, \quad \epsilon_t \sim iidN(0, \Sigma) \]

where \( \eta \) a matrix of known parameters. The solution of the model is given by the policy function and the transition function:

\[ y_t = g(x_t, \sigma), \quad x_t = h(x_t, \sigma) + \eta \epsilon_{t+1} \]

where \( \sigma^2 \) is the variance of the shocks. Following Schmitt-Grohe and Uribe (2003), we compute numerically the second order approximation of the functions \( g \) and \( h \) around the non-stochastic steady state \( x_t = x \) and \( \sigma = 0 \). The solution of the system gives an evolution of the original variables of the form

\[ y_t = \alpha_1 x_t^1 + \alpha_2 x_t^2 + \alpha_3 (x_t^1)^2 + \alpha_4 (x_t^2)^2 + \alpha_5 x_t^1 x_t^2 + \eta \sigma^2 \]

where all the variables are expressed in log deviations. The solution also depends on the variance of the shocks.

Since we evaluate the welfare functions conditional on having at \( t=0 \) all the variables of the economy equal to their steady state values, the second order approximate solution for the welfare functions is given by:

\[ V_{it} = \eta_{\nu_i} \sigma^2 \]

where \( \eta_{\nu_i} \) is a vector of known parameters that depends on the monetary policy used and \( \sigma^2 \) is the variance of the shocks.

---

35 In our model, since the shocks are uncorrelated, \( \eta \) is a vector.

36 Since in the system all the variables are in log-deviation from their steady state values, they equals zero.
Appendix .3 First Order Approximation

The system can be represented by 13 equations in 13 variables, plus exogenous shocks.

\[
\hat{y}_t = (1 - n) \frac{c_1}{y} \hat{c}_{1,t} + n \frac{c_2}{y} \hat{c}_{2,t} - g \hat{y}_t \\
\hat{z}_t = \hat{z}_t + \hat{b}_t \\
\hat{L}_t = (1 - n) \frac{L_1}{L} \hat{L}_{1,t} + n \frac{L_2}{L} \hat{L}_{2,t} \\
(1 - n) \hat{h}_1 \hat{h}_{1,t} + n \hat{h}_2 \hat{h}_{2,t} = 0 \\
\phi_c \hat{c}_{1,t} + \phi_c \hat{L}_{1,t} = \omega_t \\
\hat{b}_{2,t} = \gamma_t + E_t q_{t+1} + E_t \pi_{t+1} + \hat{h}_{2,t} \\
c_2 \hat{c}_{2,t} + q h_2 \Delta \hat{h}_{2,t} = \gamma q h_2 (\beta_1 \hat{b}_{2,t} - \hat{b}_{2,t-1} - \beta_1 \hat{R}_t + \pi_t) + w I_2 (\hat{w}_t + \hat{L}_{2,t}) - \frac{G}{Y} \hat{g}_t \\
\phi_c E_t \Delta \hat{c}_{1,t+1} = \hat{R}_t - E_t \pi_{t+1} \\
\phi_c (\beta_2 E_t \hat{c}_{2,t+1} - \beta_1 \hat{c}_{2,t}) = \beta_1 \hat{R}_t - \beta_2 E_t \pi_{t+1} + (\beta_1 - \beta_2) \hat{\mu}_t \\
(1 - \beta_1) (\hat{h}_{1,t} - \nu_{h,t}) + \phi_c (\beta_1 E_t \hat{c}_{1,t+1} - \hat{c}_{1,t}) = \beta_1 \hat{R}_t - \beta_2 E_t \pi_{t+1} + (\beta_1 - \beta_2) \hat{\mu}_t + \gamma (\beta_1 - \beta_2) (\hat{\mu}_t + \gamma_t + \pi_{t+1}) \\
\pi_t = \beta_1 \pi_{t+1} + \frac{\theta - 1}{\phi_p} \hat{m} C_t \\
\hat{m} C_t = \hat{w}_t - \hat{Z}_t \\
\hat{R}_t = f (\Omega_t)
\]
Figure 1: Deterministic steady state values w.r.t. $\gamma$
Figure 2: Deterministic steady state values w.r.t. $\gamma$ and $\beta_2$
Figure 3: Deterministic steady state values w.r.t. $\gamma$ and $\beta_2$

Figure 4: Deterministic steady state values w.r.t. $\gamma$ and $\beta_2$
Figure 5.a: response of the model economy to an unexpected 1% increase in aggregate productivity
Government Shock

Figure 5.b: response of the model economy to an unexpected 1% increase in government spending
Figure 6: response of the model economy to shocks under the optimal monetary policy rule and the alternative regime targeting housing process stability
Financial Liberalization, Bank Crises and Growth: Assessing the Links

Alessandra Bonfiglioli† and Caterina Mendicino§

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Abstract

This paper studies the effects of financial liberalization and banking crises on growth. It shows that financial liberalization spurs on average economic growth. Banking crises are harmful for growth, but to a lesser extent in countries with open financial systems and good institutions. The positive effect of financial liberalization is robust to different definitions. While the removal of capital account restrictions is effective by increasing financial depth, equity market liberalization affects growth directly. The empirical analysis is performed through GMM dynamic panel data estimations on a panel of 90 countries observed in the period 1975-1999.

*JEL classification:* C23, F02, G15, O11.

*Keywords:* Capital account liberalization, equity market liberalization, financial development, institutions, dynamic panel data.
1 Introduction

In the last two decades an increasing number of countries have eliminated controls on international capital movements. However, the global economic crises of recent years have led many economists to reconsider the beneficial effects of financial liberalization on economic performance. Although the issue has been widely debated, there are no conclusive results on the effects of financial integration on growth.

In theory, international financial liberalization softens financing constraints and improves risk-sharing, thereby fostering investments. It may also have a positive impact on the functioning and development of financial systems, and on corporate governance. These arguments suggest that we should expect a positive relation between international financial liberalization and economic growth. However, the presence of distortions may reduce the positive effects of liberalization. In fact, information asymmetries may lead to a bad allocation of capital, and weak financial and legal systems could induce capital flights towards countries with better institutions. Moreover, banking crises may come along with financial liberalization, as it is well documented in the literature.

Table 1 shows mean equality tests for growth, financial development and the occurrence of banking crises across different treatment (open, bank crises) and control (closed, no crises) groups of countries, observed annually be-

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1 See Edison et al. (2003) for a review of the empirical literature.
3 Evidence on the positive relation between financial development and growth is provided by a large literature (see Demirguc-Kunt and Levine, 2001 for a survey). The results in La Porta et al. (1999) suggest that good corporate governance spurs growth.
4 See Kaminsky and Reinhart (1999) and Aizenmann (2002) for a survey.
tween 1975 and 1999. The results suggest that countries without restrictions on capital account or equity market transactions had, on average, higher growth rates and financial development (as measured by credit to the private sector as a ratio of GDP). The occurrence of banking crises is associated with lower growth rates and financial development. However, it is not clear whether there is correlation between openness and the occurrence of bank crises. When we consider an overall index there is no significant difference in the frequency of crises between countries with and without restrictions on capital account transactions. The picture becomes clearer once we split the index between “systemic” and “non-systemic” banking crises. Open countries experienced a lower number of systemic crises but a higher number of non-systemic crises. The higher frequency of non-systemic crises may be a reason for the concern of economists and governments on the effects of financial liberalization on economic performance.

In this paper we assess empirically the effects of international financial liberalization and banking crises on growth. We admit the possibility that banking crises come along with financial liberalization, as shown by previous works and by row 5 of Table 1, and investigate their joint impact on growth\(^5\). Kaminsky and Schmukler (2002) and Tornell et al. (2004) suggest in different ways that institutional quality may matter at shaping the relationship between financial liberalization, crises and long-run growth\(^6\). Therefore, we

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\(^5\)Causality between financial liberalization and banking crises is left aside from our empirical analysis.

\(^6\)Kaminsky and Schmukler (2002) show evidence that equity market liberalization brings about financial chaos in the short-run, but has positive long-run effects, since it induces changes in institutions supporting the functioning of the domestic financial market. Tornell et al. (2004) suggest that liberalization and crises affect growth through financial development; given financial openness, good institutions make bank crises less likely, and foster capital inflows.
control for institutions and their interactions with financial openness and crises. To have a better understanding of the mechanism that links the variables of our interest, we assess whether liberalization and crises affect growth through financial depth. Also in this case, we control for institutional quality. Inspired by the results in Acemoglu and Johnson (2003)\textsuperscript{7}, we distinguish between institutions aimed at contractual as opposed to property rights protection.

The empirical analysis is performed on a panel dataset that covers 90 countries over the period 1975-1999. We adopt the Dynamic Panel Data approach proposed by Arellano and Bover (1995) and Blundell and Bond (1998). We use two indicators of financial liberalization, that distinguish between capital account and equity market liberalization.

Our results show that capital account liberalization has a positive effect on growth, once we control for banking crises, whose impact is negative. The absence of capital account controls is good for growth because it fosters financial development and mitigates the harmful effects of banking crises. Capital account liberalization allows firms to raise funds more easily on the international financial markets, and thus suffer less from domestic crises. Moreover, banking crises turn out to be less harmful for growth in countries where property and contractual rights are better protected. Equity market liberalization instead has a strong direct effect on growth and does not interact with banking crises.

There are many contributions in the literature on the effects of financial

\textsuperscript{7}Acemoglu and Johnson (2003) show that contractual protection affects financial structure more than property rights protection, but has limited effects on economic performance. Vice versa, property right protection affects GDP growth, productivity and investments, but not the financial structure.
liberalization on long-run growth. Bekaert, Harvey and Lundblad (2003) is the closest work to this paper. These authors as well consider both capital account and equity market liberalization, and control for bank crises. They also allow for heterogeneity in the effects of liberalization depending on cross-country differences in institutional quality. The main elements that distinguish our contribution are the attention to the interaction between financial liberalization and bank crises, the analysis of the mechanism that links them to growth through financial development and the use of a different dynamic panel data technique.

The remainder of the paper is organized as follows. Section 2 describes the econometric model and the variables we used. Section 3 reports the estimation results and comments on them. Section 4 concludes.

2 Data and empirical strategies

2.1 The econometric model

We assess the growth effects of financial liberalization and banking crises by adding these variables to a dynamic version of the standard growth regression\(^8\). We follow the dynamic panel data approach suggested by Arellano and Bover (1995) and Bond and Blundell (1998)\(^9\). This methodology is preferred to the cross-sectional regressions because it allows to account for the impact of the policy changes, imbedded in the indexes of financial liberalization and of crisis episodes, on growth. This dynamic panel technique is also helpful to

\(^8\)See among others, Barro (1997) and Barro and Sala-i-Martin(1995).

\(^9\)The system-DPD methodology dominates the difference-DPD proposed by Arellano and Bond (1991) because it amends problems of measurement error bias and weak instruments, arising from the persistence of the regressors (as pointed out by Bond et al., 2001).
amend the bias induced by omitted variables in cross-sectional estimates, and the inconsistency caused by endogeneity both in cross-sectional and static panel (fixed and random effects) regressions.

We formulate the standard neoclassical growth model in a dynamic panel data form, and estimate the following dynamic system:

\[ \Delta y_{it} = \alpha \Delta y_{i(t-1)} + \beta' \Delta X_{it} + \delta \Delta Flib_{it} + \gamma \Delta Bcr_{it} + \Delta \nu_t + \Delta \epsilon_{it} \]  

\[ y_{it} = \alpha y_{i(t-1)} + \beta' X_{it} + \delta Flib_{it} + \gamma Bcr_{it} + \eta_t + \nu_t + \epsilon_{i,t}, \]  

where time indexes refer to non-overlapping five-year periods. \( \Delta y_{it} \) is the average annual growth rate of real per capita GDP over five years. \( y_{it} \) is the logarithm of real per capita GDP, and the coefficient on its lag, \( \alpha = e^{b\lambda} \), supports conditional convergence if it implies \( \lambda < 0 \). Variables indexed by \( t - 1 \) are observed at the beginning of the five-year period, and covariates are expressed in period averages. Matrix \( X_{it} \) contains determinants of GDP growth, such as human capital, population growth and other factors that account for different long-run per capita output across countries. \( Flib_{i(t+k,t)} \) and \( Bcr_{i(t+k,t)} \) are indicators of financial liberalization and banking crises. \( \eta_t, \nu_t \) and \( \epsilon_{it} \) are respectively the unobservable country- and time-specific effects, and the error term. The presence of country effect in equation (2) corrects the omitted variable bias. The differences in equation (1) and the instrumental variables estimation of the system are aimed at amending inconsistency problems\(^{10}\). We instrument differences of the endogenous and predetermined variables with lagged levels in equation (1) and levels with differenced variables in equation (2). For instance, we take \( y_{i(t-3)} \) as instrument for \( \Delta y_{i(t-1)} \) and \( Flib_{i(t-2)} \) for \( \Delta Flib_{it} \) in (1) and \( \Delta y_{i(t-2)} \) as instrument for

\(^{10}\)See Temple (1999) for a survey on the methodologies used in growth regressions.
\( y_{it-1} \) and \( \Delta \text{Lib}_{it-1} \) for \( \text{Lib}_{it} \) in (2). We estimate the system by Generalized Method of Moments with moment conditions \( E[\Delta y_{it-s} (\epsilon_{it} - \epsilon_{it-1})] = 0 \) for \( s \geq 2 \), and \( E[\Delta z_{it-s} (\epsilon_{it} - \epsilon_{it-1})] = 0 \) for \( s \geq 2 \) on the predetermined variables \( z \), for equation (1); \( E[\Delta y_{i,t-s} (\eta_i + \epsilon_{i,t})] = 0 \) and \( E[\Delta z_{i,t-s} (\eta_i + \epsilon_{i,t})] = 0 \) for \( s = 1 \) for equation (2). We treat all regressors as predetermined. The validity of the instruments is guaranteed under the hypothesis that \( \epsilon_{it} \) are not second order serially correlated. Coefficient estimates are consistent and efficient if both the moment conditions and the no-serial correlation are satisfied. We can validate the estimated model through a Sargan test of overidentifying restrictions, and a test of second-order serial correlation of the residuals. As pointed out by Arellano and Bond (1991), the estimates from the first step are more efficient, while the test statistics from the second step are more robust. Therefore, we will report coefficients and statistics from the first and second step respectively.

2.2 Financial liberalization and financial fragility: the data

To explore the impact of financial liberalization and banking crises on growth we need to measure these variables. The literature on financial liberalization has proposed different indicators that differ along several directions. The major distinctions are based on the \textit{de iure} vs \textit{de facto} definition criterion, the characterization on a zero-one vs continuous scale, and the market they refer to.

In our analysis we construct an index of liberalization of both capital account and equity market based on two different sources\textsuperscript{11}. The first one is

\textsuperscript{11}We focus on \textit{de iure} zero-one measures, that classify a country as financially liberalized if there are no legal restrictions to international trade of financial instruments.
a dummy variable provided by the IMF in its Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), that is available for a maximum of 212 countries starting from 1967\(^{12}\). This is the most commonly used measure of restrictions on international financial transactions. It takes value 1 if a country has experienced restrictions on capital account transactions during the year, and zero otherwise. Our yearly measure of financial liberalization, \(op_{IMF}\), equals 1 and 0 when the IMF dummy is respectively 0 and 1. The second indicator is based on Bekaert et al.'s (2003) chronology of official equity market liberalization, that is available for 95 countries from 1980. Our variable \(op_{BHL}\) differs from \(op_{IMF}\) because it only accounts for equity market liberalization, but not for globalization of the credit market for instance. Moreover, differently from the AREAER, Bekaert et al.'s measure does not contemplate policy reversals, so that a country is labeled as open ever since its first year of liberalization. As the IMF-based indicators, it takes value 1 and zero in case of internationally open and closed country-years, respectively. Both \(op_{IMF}\) and \(op_{BHL}\) are expressed as five-year averages, thereby taking values in the \([0,1]\) interval.

There are alternative measures that are able to account for different degrees of liberalization instead of just the presence or absence thereof. Quinn's (1997) index scores the intensity of capital account controls on a scale from 0 to 4 with steps of 0.5. However, it is hardly suited for panel studies since it is available for a significant number of countries only for four years, 1958, 1973, 1982 and 1988. Other contributions have used \textit{de facto} measures, as

\(^{12}\)Classification methods have changed in 1996, so that there are 13 separate indexes now, that can hardly be compared to the previous single indicator. Miniane (2000) harmonized the classifications, though for a limited number of countries, and over a short time span. Therefore, the last observation for \(op_{IMF}\) in our dataset dates back to 1996.
data on international capital flows as a ratio of GDP. The idea is that actual international capital flows are a good proxy for the degree of financial openness. A more comprehensive discussion on the available indicators can be found in Edison et al. (2002).

Banking crises are subject to various classifications as well. As for liberalization, we adopt a zero-one anecdotal indicator of bank crises, proposed by Caprio and Klingebiel (2001). The authors keep record of 117 systemic and 51 non-systemic crises occurred in 93 and 45 countries respectively, from the late Seventies on. On a yearly base, our variable $Bcr$ takes value 2 if the country has experienced a systemic banking crisis, meaning that much or all of a bank's capital has been exhausted; 1 if the banking crisis involved less severe losses; and 0 otherwise. We use two alternative data reductions for robustness analysis: $Bcr012$ takes value 2 if $Bcr$ equals 2 at least once over the period, 1 if at least a 1 is scored, zero otherwise. $Bcr012av$ instead accounts also for the duration of crisis episodes, since it equals the period average of $Bcr$.

The other covariates in our growth regressions are variables commonly accounted for in the empirical growth literature (see Barro, 1997), such as secondary school attainment, the growth rate of population, government expenditure and investments as a ratio of GDP. Other factors that we want to take into account are financial development, proxied by the ratio of credit to the private sector over GDP, and, at a further stage of the analysis, institutional quality, as measured by the government anti-diversion policy index (Hall and Jones, 1999) and by the indicator of efficiency of the judiciary system (see La Porta et al. 2003). The first indicator mainly accounts for property rights protection, while the other refers more to contractual rights.
The sample consists of data for a maximum of 90 countries over the period 1975-1999 or 1980-1999 depending on the indicator of financial liberalization adopted. Since keeping the larger sample gives us a longer time-series in the panel analysis, we will go on reporting results from the 1975-99 sample for \textit{opIMF} and from 1980-99 for \textit{opBHL}. Since we average over non-overlapping five-year periods, either four or five observations for each country are available. More detail on the countries in our sample and on all variables is given in the appendix.

3 Empirical evidence

3.1 Liberalization, banking crises and growth

Table 2 reports results from dynamic-panel estimations of the augmented growth regression, which includes the usual control variables (initial GDP, secondary school attainment, population growth, government spending and investments over GDP) plus indicators of financial liberalization, financial development, and banking crises. Consistently with the previous cross-country growth studies (see Barro, 1997 and Barro and Sala-i-Martin, 1995), we find significant evidence that countries with lower initial real per capita GDP have grown faster than the initially richer ones, conditional on the other variables. Our estimates imply a convergence rate of about 1.5% per year\footnote{The convergence rate is computed as $\lambda = \frac{\ln(\gamma)}{\gamma}$.}. Population growth and investments have the signs predicted by growth theory (respectively negative and positive) in most of the estimates, though not always significant.

Capital account openness has zero-effect on growth. Equity market lib-
eralization instead exhibits a significant positive coefficient (columns 1 and 5). These results are in line with Bekeart et al.'s (2003) findings. Using the same measure of financial liberalization, they show that equity market liberalization significantly affects growth, while the relation between the IMF measure and growth is fragile.

As a wide strand of literature (see Aizenmann, 2002 for a survey) points out, the removal of restrictions on capital flows may expose financial systems to turmoil and possibly crises\textsuperscript{14}. If that is the case, the costly impact of financial crises\textsuperscript{15}, brought about by liberalization, could be responsible for the coefficient estimates for $opIMF$ in column 1. To control for this hypothesis, we include the bank crisis indicator in the regression of columns 2. Once we control for the occurrence of bank crises, the positive coefficient for $opIMF$ becomes significant. As expected, banking crises strongly restrain growth. Moreover, the interaction between capital account openness and crises in column 3 is positive. This suggests that, irrespective of whether financial liberalization triggers instability in the banking sector, countries without capital account restrictions are less prone to the negative effects of banking crises than financially closed economies. Thus, capital account liberalization has no strong direct effects on growth, but it is important to mitigate the negative effects of banking crises.

The results are slightly different if we restrict the focus on equity market liberalization. As in Bekeart et al., equity market openness and banking

\textsuperscript{14} Among others, Kaminsky and Reinhart (1999) show that financial liberalization often precedes banking crises, Glick and Hutchison (1999) find that financially liberalized emerging market economies are more likely to experience twin crises, Demirgüç-Kunt and Detragiache (1998) show that banking crises occur more often in liberalized financial systems.

\textsuperscript{15} A number of papers try to quantify the output costs of financial crises. See among others Edwards (1999), Honohan and Klingebiel (2001), and De Gregorio and Lee (2004).
crises have indeed strong opposite effects, respectively positive and negative, but the introduction of the crises variable does not affect the effectiveness of equity market liberalization on growth. Moreover, we find no interaction between the two variables (see column 7). In fact, it is not so surprising that free international equity trade alone can be less of help in case domestic banks get into troubles. Firms that rely on credit may be severely hurt by banking crises, and find it difficult to shift abruptly to equity financing, even if they can sell shares on the international market. If instead they have free access to international credit markets, they might raise funds more easily there, and thus suffer less from domestic crises.

Opposite results are obtained by Eichengreen and Leblang (2002). They show that the negative effects of domestic crises are neutralized by the presence of controls on capital controls. One reason could be that they use a different indicator of crises (by Bordo et al., 2001) that encompasses both exchange and banking crises.

As a robustness check, we replicate the estimations in Table 2 using an indicator of Banking crises that accounts also for the duration of banking crises, $Bcr012av$. Table 5 reports coefficients only for liberalization, bank crises and their interaction. The results are not remarkably different from the ones we obtained using the discrete crisis indicator.

3.2 Institutions, Financial Liberalization and Growth

After Hall and Jones’ (1999) seminal paper, a wide strand of growth literature has focused on institutions as a primary determinant of economic performance. Alfaro et al. (2004) have shown that institutions are an important determinant of capital inflows. Tornell et al. (2004), in line with this
argument, suggest that in financially open countries institutional quality affects both the occurrence of banking crises and the extent of capital inflows. Banking crises may occur as a by-product of openness, as credit markets get thicker, especially if there is a poor legal environment. In open economies, the presence of good institutions facilitates capital inflows from abroad, when domestic banking crises reduce the amount of credit available to firms\(^{16}\). As a result, banking crises are expected to be less harmful for growth in countries where property and contractual rights are better protected. Symmetrically, financial liberalization might turn out to be growth-restraining in countries with worse institutions. In order to assess empirically these implication we include interactive terms in our dynamic growth regressions.

Table 3 shows results from system-GMM estimations that include the same regressors in columns 1-3 of Table 2, plus the interactions of capital account liberalization with indicators of institutional quality. We also investigate the relation between liberalization, financial development and overall economic development\(^{17}\). Institutional quality is proxied here by the government antidiversion policy index constructed by Hall and Jones (1999). This measure varies between \([0,1]\) and takes higher values for governments with more effective policies for supporting production\(^{18}\).

Growth is positively affected by financial liberalization and negatively by bank crises under every specification of the model. As reported in column 4, the effect of bank crises is indeed different across countries with good and

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\(^{16}\)In Tornell et al. this mechanism works to a different extent across tradables and nontradables sectors. We leave this aspect aside of the analysis.

\(^{17}\)Financial development is measured by credit market depth, while the index of overall economic development is taken from the classification in World Development Indicators.

\(^{18}\)The index is an equal-weighted average of 5 variables: (i) law and order (ii) bureaucratic quality (iii) corruption (iv) risk of expropriation (v) government repudiation of contracts.
bad institutions. The term that controls for bank crises in institutionally
developed countries is strongly positive. Thus, the cost of banking crises in
terms of growth is reduced by good institutions. The interaction with capital
account openness, in column 3, is negligible.

As the interaction with credit market development in Column 1 shows, fi­
nancial liberalization restrains economic growth in countries with small credit
markets. Thus, studying the effects of capital account openness on financial
development might be of help in understanding the transmission to economic
growth. Column 2 shows that banking crises have a bigger impact in coun­
tries with high levels of credit market development. In fact, if firms rely more
heavily on credit financing, they are more severely hurt by banking crises.

Table 3b replicates the exercise of Table 3 using the equity market liber­
alization index. The most significant result, in column 5, points in the same
direction as column 5 in Table 3. Good institutions reduce the destructive
effects of bank crises.

Hall and Jones' (1999) indicator of institutional quality accounts mainly
for property right protection, i.e. the degree of private property protec­
tions against government and elite expropriations. Inspired by Acemoglu
and Johnson (2003), we assess the role of institutions aimed at protecting
private contracts. Thus, we replicate the exercise in Tables 5 and 6 using
the degree of efficiency of the judiciary as a different measure of institutional
quality. This variable, built by La Porta et al. (2003), captures the legal
costs of contract enforcement and takes values in [0,7].

The evidence in columns 1 and 2 of Table 6 shows that contractual pro­
tection does not bring heterogeneity in the effects of financial liberalization
and crises on growth, which remain respectively positive and negative.
3.3 Liberalization, crises and financial development

The evidence in the previous sections suggests that bank crises tend to restrain growth, but to a lesser extent if good institutions and financial openness help channelling funds into the economy. Moreover, column 4 in Table 2 indicates that capital account liberalization becomes uninfluential for growth, once we control for financial depth. These results suggest that the effect of capital account liberalization on growth is generally positive, and is possibly transmitted through the credit market. In this section, we assess how financial development \((FD)\) is affected by international liberalization and bank crises. To this end, we estimate the following dynamic system

\[
\Delta FD_{it} = a\Delta FD_{it-1} + b\Delta Flib_{it} + c\Delta Bcr_{it} + g\Delta interaction_{it} + \Delta u_t + \Delta e_{it}
\]

\[
FD_{it} = a(FD_{i,t-1}) + b(Flib_{i,t}) + c(Bcr_{i,t}) + g(interaction_{i,t}) + h_i + u_t + e_{it}
\]

with two-step GMM. The coefficients in column 1 of Table 4 strongly support the hypothesis that capital account liberalization boosts financial depth\(^{19}\). The estimates in columns 2 and 4 show that financial liberalization has the same effects across countries with different institutional and economic development. Column 1 does not support the view that bank crises slow down the process of financial development \(^{20}\). However, column 3 suggests that feedback from banking crises to credit market depth may indeed take place, with the expected positive and negative signs, respectively in countries with high and low degrees of property rights protection.

Columns 3 and 4 of Table 6 instead suggest that contractual protection

\(^{19}\)This result is consistent with previous evidence by Levine (2001) and Klein and Olivei (2000).

\(^{20}\)Demirguc-Kunt and Detragiache (1998) also show that financial liberalization tend to push financial development while financial fragility slows down the process.
plays a role in shaping the effect of openness and bank crises on financial
depth. A good legal environment for business turns bank crises into expan­
sions of the credit markets, consistent with the “bumpy path” proposed by
Tornell et al. (2004). Vice-versa, where contractual rights are weak, credit
markets are restrained by both openness and banking crises.

4 Conclusion

This paper provides an empirical evaluation of the effects of financial liberal­
ization and banking crises on growth. Our analysis accounts for the interac­
tion between liberalization and crises, and allows for unequal effects across
countries with different degrees of institutional and economic development.

We also investigate the transmission of these effects through financial depth.

The overall lesson we draw from the results in section 3 is that the removal
of capital account restrictions boosts growth mainly through indirect effects.
In fact, financial liberalization has not only a beneficial impact on financial
development but also allows to smooth the destructive effects of financial
distress. Banking crises are indeed extremely harmful for economic perfor­
manence. The cost of crises is higher in countries with bad institutions, as well
as in the closed ones, while they have less impact in liberalized economies
and in countries with higher quality of institutions. The effect of banking
 crises on growth is mainly a direct one, even though we show that feedbacks
on credit market development are also possible.

The positive effects of financial liberalization are robust to different de­
definition. In fact, we also show a positive relation between equity market
liberalization and growth. Our results, consistent with Bekaert et al.(2004),
point towards a direct effect of equity market integration. However, equity
market openness and banking crises have strong opposite effects but do not interact. This evidence can be partly reconciled with the mechanism proposed by Tornell et al. (2004). In fact, firms that rely on credit may be severely hurt by banking crises, and find it difficult to shift abruptly to equity financing, even if they can sell shares on the international market. If instead they have free access to international credit markets, they might raise funds more easily there, and thus suffer less from domestic crises.
References


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164


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This table reports the differences in mean between treated (open, bank crisis) and control (closed, no bank crisis) groups, and their standard errors (in parenthesis). *** and ** indicate rejection of the null of zero-difference at 1 and 5 % significance level. The test is performed on annual data for the countries in Table A. The variables of interest are the growth rate of real per capita GDP, the growth rate of credit to the private sector, and the 0-1 indicators of occurrence of bank crises.
Table 2. Financial Liberalization, Bank Crises and Growth

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System-GMM estimates. Dependent variables: log and log-difference of real per capita GDP. Regressors are log and log-differences of: lagged real per capita GDP, secondary attainment, government and investments share of GDP, indicators of financial liberalization and bank crises. Instruments: lagged levels for differences, lagged differences for levels. Two-steps estimations. Coefficients and standard errors (in parenthesis) are from the first step. 5 and 10 per cent significance coefficients in bold and italics. P-values for Sargan overidentification test and $m_2$ test for second-order serial correlation of residuals are from the second step.
### Table 3. Capital Account Liberalization, Bank Crises and Growth

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<td>( opIMF * LDC )</td>
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<td>( Bcr012 * (1 - LDC))</td>
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<td>(.043)</td>
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Countries: 89
Period: 1975-99
\( m_2 \): .108
Sargan: .670

System-GMM estimates. Dependent variables: log and log-difference of real per capita GDP. Regressors are log and log-differences of: lagged real per capita GDP, secondary attainment, government and investments share of GDP, capital account liberalization, bank crises and interactions with financial development, institutional quality, economic development. Subscripts \( l \) and \( h \) indicate that the variable is below and above cross-sectional average. Instruments: lagged levels for differences, lagged differences. Two-steps estimations. Coefficients and standard errors (in parenthesis) are from the first step. 5 and 10 per cent significant coefficients in bold and italics. P-values for Sargan overidentification test and \( m_2 \) test for second-order serial correlation of residuals are from the second step.
Table 3b. Equity Market Liberalization, Bank Crises and Growth
Dynamic Panel Data - System GMM - Interactions

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<td>( m_2 )</td>
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<td>.218</td>
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<td>.458</td>
<td>.245</td>
<td>.342</td>
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System-GMM estimates. Dependent variables: log and log-difference of real per capita GDP. Regressors are log and log-differences of: lagged real per capita GDP, secondary attainment, government and investments share of GDP, capital account liberalization, bank crises and interactions with financial development, institutional quality, economic development. Subscripts l and h indicate that the variable is below and above cross-sectional average. Instruments: lagged levels for differences, lagged differences. Two-steps estimations. Coefficients and standard errors (in parenthesis) are from the first step. 5 and 10 per cent significant coefficients in bold and italics. P-values for Sargan overidentification test and \( m_2 \) test for second-order serial correlation of residuals are from the second step.
Table 4. Capital Account Liberalization, Bank Crises and Financial Development - Dynamic Panel Data - System GMM

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<tr>
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Countries 79 78 78 79 79
m2 .216 .275 .384 .276 .185
Sargan .394 .501 .451 .432 .411

System-GMM estimates. Dependent variables: log and log-difference of private credit to GDP. Regressors are log and log-differences of: lagged private credit to GDP, capital account liberalization, bank crises and interactions with financial development, institutional quality, economic development. Subscripts l and h indicate that the variable is below and above cross-sectional average. Instruments: lagged levels for differences, lagged differences. Two-steps estimations. Coefficients and standard errors (in parenthesis) are from the first step. 5 and 10 per cent significant coefficients in bold and italics. P-values for Sargan test and m2 test for second-order serial correlation of residuals from the second.
Table 5. Financial Liberalization, Bank Crises and Growth

Robustness analysis

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<tr>
<th></th>
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<th>Bcr012av</th>
<th>opIMF*</th>
<th>opBHL</th>
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OLS rows replicate Table 1 (columns 2-3, 6-7) with Bcr012av instead of Bcr012, FE rows Table 2 (columns 2-3, 6-7), GLS Table 2b (columns 2-3, 6-7), diff-GMM Table 3 (columns 2-3, 6-7), sys-GMM Table 4 (columns 2-3, 6-7). Standard errors within parenthesis, 5% and 10% significant coefficients respectively in bold and italics.

Table 6. Capital Account Liberalization, Bank Crises Financial Development and Growth

<table>
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<td>(.184)</td>
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<td>.019</td>
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<td>.500</td>
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<td>(.045)</td>
<td>(.045)</td>
<td>(.184)</td>
<td>(.184)</td>
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</table>

Estimates in column 1-2 replicate columns 4-5 of Table 5, with eff_jud instead of GADP; column 3-4 replicate columns 2-3 of Table 6. Standard errors in parenthesis, 5 and 10 per cent significant coefficients respectively in bold and italics.
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