Credit Rationing and Business Cycles *

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Abstract

This paper studies the macroeconomic implications of changes in the degree of access to the credit market in an economy with credit frictions. I examine how the provision of credit in connection with collateral assets affects economic performance and the business cycle.

In the framework of an economy in which credit constraints arise because borrowers cannot force lenders to repay, I show that, as expected, facilitating collateralized debt financing implies an increase in production efficiency and welfare. Moreover, I also show how the rise in collateral/asset prices is a direct consequence of credit market development. Last, I demonstrate that the model can reproduce the non linear relation between LTV ratio and output volatility.

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Key Words: Credit Market Development, Credit Frictions, Heterogeneous Agents, Business Cycle.

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1 Introduction

During the past two decades financial systems have experienced deep structural changes as a result of regulatory reforms and technological innovations. Financial market reforms have taken place both in developing and developed countries. Particularly among OECD countries, the United States, the United Kingdom and the Nordic Countries implemented government reforms directed to credit market deregulation.

The main goal was to improve efficiency within the financial system, but the macroeconomic implications could go beyond the main motivation. The deregulation process discouraged household savings and contributed to a considerable increase in bank loans extended to the private sector[1]. The ratio of private outstanding credit over total disposable income therefore reached very high levels in the last years[2]. The high level of credit to the private sector and particularly household indebtedness (see Figure 1), both in absolute terms and relative to their income, has attracted the attention of policy makers and rised concerns about the macroeconomic implications.

Following the process of deregulation not only private sector's borrowing increased but also asset prices have raised rapidly. The increasing trend in housing and property prices has contributed to the rise in the private debt[3]. Should the high levels of private sector indebtedness combined with the increase in asset prices be a reason of worry for the stability of our economy?

The process of deregulation in the credit market took place in many different ways. Various measures have been implemented since the middle 80ths in order to increase competitiveness in the credit market and make easier the access to credit financing. This paper investigates the role played by the provision of credit in connection with collateral assets and its macroeconomic implications. Thus, I restrict the attention to the effects of development in the credit market and particularly in the banking technology of liquidating the collateral assets. A more developed banking liquidation technology results in an improved access to the credit market, that turns out to have relevant implications for the response of aggregate variables to shocks over the business cycle.

In some countries, regulations imposed low values for the maximum loan to value (LTV) ratio in the mortgage markets. Different studies suggest that LTV ratios have been raised over time in most OECD countries. In Italy for instance, until the mid-80 a maximum loan to value ratio of 50% was imposed by regulation. Following the process of deregulation it was increased to 75% in 1986

[1] See among others Gelosos and Werner (1999) for the case of Mexico, Leslie Hull (2003) for New Zealand, Boone, Laurence, Nathalie Girouard and Isabelle Wanner (2001) and Claus, Iris and Grant Scobie (2001) for an international comparison.

[2] Guy Debelle, Household Debt and the Macroeconomy, BIS Quartely Review, March 2004.

[3] Figure 2.a-2.b show the trend in real aggregate asset prices – a weighted mean of housing, property and equity prices – over the last thirty years. These variables show an increasing common trend in most of the countries.

and to 100% in 1995[4]. Figure 2 shows the maximum and average LTV ratio in some countries for the last years. LTV ratios range from 90% in the Netherlands to 55% in Italy. Table 1 reports the current legal and regulatory limit on the LTV ratio in the EU mortgage markets.

In the model the loan to value ratio represents the level of development of the banking liquidation technology and at the same time determines the degree of access to the credit market. Regardless of whether private sector debt is sustainable, the large stock of borrowing could increase the sensitivity of the private sector to fluctuations in income, capital prices (housing, buildings, machinery) and the interest rate. A greater level of indebtedness may reduce the ability to smooth temporary negative shocks due to the burden of debt. In fact, during periods of stable economic conditions an easier access to loans – for instance due to a relaxed ceiling on the loan to value ratio – could improve economic performance. But, on the other hand, an excessive debt accumulation in preceding periods might become burdening for the borrowers if market conditions reverse.

This paper is related to the large literature about financial frictions and business cycle. Most of the theoretical research focuses on credit frictions as a transmission mechanism that propagates and amplifies shocks. 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. 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 collateral constraints as an amplification mechanism of shocks. However, in models with collateral constraints little attention has been devoted to the impact of credit market development on economic activity and the business cycle.

An exception is Aghion, Baccheta and Banerjee (2003) who study credit development as a source of instability in a small open economy. They show that small open economies at an intermediate level of financial development are more vulnerable to shocks. They assume that firms can borrow μ times the amount of their current level of investible funds. Where μ represents the degree of development of the financial sector.

Campbell and Hercowitz (2004) study how credit market development affects the volatility in hours, output and household debt. Their model is based on the household sector and the interaction between access to the credit market and labor supply is of great importance in showing that a lower collateral requirement implies lower volatility.

Both Aghion, Baccheta and Banerjee (2003) and Campbell and Hercowitz (2004) use the colateral requirment as a proxy for credit market development and compare macroeconomic volatility

[4] See Jappelli and Pagano 1998

under few different calibrations of the collateral requirement. On the contrary, i analyse the dynamic of the model over a wider range of degree of access to the credit market. In this way I'm able to show that the relationship between credit market development and output volatility is non linear.

More recently, Quadrini and Jerman (2005) show that financial development enables firms to take on more debt making the economy more vulnerable to shocks. But, at the same time it improves the access to alternative sources of funding allowing for greater flexibility in investments. Thus, the business cycle results depend on which of the two mechanisms prevails.

Differently from some of the other models, my focus is on a closed economy model in which both lenders and borrowers sectors are modelled. I use a collateral constraint based on real assets and I thus give a primary role to the asset prices and I focus on credit friction at the firms level where the collateral is also an input of production. I investigate not only the effects of an aggregate technology shock but also the consequences of a shock to the supply of loans. Most importantly I focus on the impact of permanent shocks to the loan to value ratio.

The model is built on Kiyotaki and Moore (1997). In order to generate a motive for the existence of credit flows, two types of agents are assumed. Both of them produce and consume the same good using a physical asset. They differ in terms of discount factors and as a consequence impatient agents are 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 collateral for loans.

The setup differs from Kiyotaki and Moore (1997) in that I use more standard assumptions about preferences and technologies. First, in their paper the two groups of agents are risk neutral. Moreover, they represent two different sectors of the economy – borrowers are "farmers" and lenders are "gatherers" – and thus, apart from using different discount factors, they also differ in their production technology. In the present setup both groups of agents have a concave utility function and are identical, except that they have different subjective discount factors. The setup turns out to be similar to the one used by Cordoba and Ripoll (2004). However, I also introduce aggregate uncertainty in the model. Thus, differently from all the other specifications of the model previously adopted in the literature, asset prices are not perfectly foreseen by agents. Last, but most important I also allow for the existence of liquidation costs in modelling the collateral constraint. Therefore, I can investigate the macroeconomic consequences of structural changes implying an improved access to credit financing.

I show that facilitating collateralized debt financing implies a rise in collateral/asset prices. In fact, an increased access to the credit market implies a credit expansion and thus a rise in the level of investment by borrowers. This leads to a more efficient allocation of capital between the two groups and consequently increases efficiency in production. As a result in the new steady state the level of output, and thus total consumption, would be higher.

Moreover, at an intermediate level of LTV ratio the impact of shocks over the business cycle is stronger. In fact, the model can reproduce the non linear relation between LTV ratio and output volatility.

The paper is organized as follows. Section 2 presents some stylised facts, Section 3 presents the model and Section 4 the solution, Section 5 analyses the relation between improvement in credit market technology and business cycle, Section 6 draws some tentative conclusions.

2 Some Stylized Facts

Is the degree of access to the credit market related to the size of business cycle fluctuations? In the literature there is no rigorous evidence on the relation between credit market development and output volatility. Campbell and Hercowitz (2004) show that in the US, financial reforms of the early 1980's coincided with a decline in volatility of output, consumption and hours worked. Thus, in their paper, lower collateral requirements explain higher macroeconomic stability

The decline in output volatility in the last 20 years is a well-known fact. Changes in the underlying characteristics of the economy and thus in the mechanism through which exogenous shocks spread through and propagate in the economy could be the main reason for such a decline. Several studies give a primary role to the conduct of monetary policy [see e.g. Clarida, Gali and Gertler(2000), Cogley and Sargent (2001, 2003), Boivin and Giannoni (2002), Canova()]. Other studies, show that the decrease in inflation and output volatility is given by changes in the variance of exogenous shocks [Sims(2001, Sims and Zha(2001)]. A few studies claim that instead it depends on other characteristics of the economy [Hanson (2001), Campbell and Hercowitz (2004)].

Is credit market development one of the main reason for the increase in macroeconomic stability? What is the relation between business cycles and credit market development in industrialized countries?

This section presents some stylized facts. The evidence is based on quarterly data for OECD countries over the last ten years. Data on the LTV ratio represent the normal maximum loan to value ratio[5] . To approximate output volatility I use real GDP (OECD sources).

Figure 3 shows the cross-country correlations between business cycles and LTV ratios. The cyclical component of the time series in real terms is calculated implementing the Hodrik and Prescott (1997) filter. Standard deviations of the cyclical components measure the volatility of the series over the time period considered.

[5]Source: Oecd. The European Mortgage Federation also reports the absolute maximum loan to value ratio.

Figure 3 indicates that business cycles are more pronounced at an intermediate level of LTV ratio. Cross country, at an intermediate degree of access to the credit market output volatility is higher. At a first glace there is no evidence of a positive linear relation between credit market development and macroeconomic stability. On the contray, the relation shown is clearly non-linear.

3 The Model

3.1 Economic Environment

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) 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.

I assume a continuum of ex-ante heterogeneous households of unit mass: n_1 *Patient Households* (denoted by 1) and n_2 *Impatient Households* (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.

Assumption 1 : $\beta_2 < \beta_1 < 1$

This assumption ensures that in equilibrium patient households lend and impatient households borrow.

Both agents produce the commodity good using the same technology

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

where Z_t represent an aggregate technology shock. It follows an AR(1) process

$$\ln(Z_t) = \rho_Z \ln(Z_{t-1}) + \varepsilon_{Zt}, \quad \varepsilon_{Zt} \backsim^{iid} N(0, \sigma_{\varepsilon_Z}), 0 < \rho_Z < 1$$

Assumption 2 : $\alpha_1 = \alpha_2 < 1$

Differently from Kiyotaki and Moore (1997) I assume that agents have access to the same concave production technology[6]. In fact, in Kiyotaki and Moore (1997) the two groups of agents also represent two different sectors of the economy. However, I still follow Kiyotaki and Moore (1997) in assuming that the 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

[6] 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.

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_{it} at t+1. The household cannot precommit to produce. Moreover, he is free to walk away from the production and the 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_{it+1}, of the borrower is limited to a fraction of next period expected value of the asset:

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

Assumption 3: $\gamma < 1$

Unlike the rest of the literature, I allow for the existence of liquidation costs in modelling the collateral constraint. Limiting the borrowing to a fraction of the expected liquidation value of the capital takes into account different degrees of development of the credit market technology. A high γ represents a developed financial sector while a low γ characterizes an underdeveloped system.

Households face the following problem:A loan supply shock is modelled as a shock to lenders' preferences (ξ_{1t}):

$$\begin{gathered} \max_{\{c_{it}, k_{it}, b_{it}\}} E_0 \sum_{t=0}^{\infty} \left(\beta_i\right)^t U\left(c_{it}\ \right) \xi_{it} \qquad i = 1, 2 \\ s.t. \\ c_{it} + q_t(k_{it} - k_{it-1}) = y_{it} + \frac{b_{it}}{R_t} - b_{it-1} \\ y_{it} = Z_t k_{it-1}^{\alpha} \\ b_{it} \leq \gamma E_t \left[q_{t+1} k_{it} \right] \end{gathered}$$

Where k_{it} is a durable asset, c_{it} a consumption good, and b_{it} the debt level. ξ_{it} is a preference shock that hits only patient households following an AR(1) process:

$$\ln(\xi_{1t}) = \rho_Z \ln(\xi_{1t-1}) + \varepsilon_{\xi t}, \quad \varepsilon_{\xi t} \backsim^{iid} N(0, \sigma_{\varepsilon \xi}), 0 < \rho_{\xi} < 1$$

Agents' optimal choices of bonds and capital are characterized by

$$\frac{U_{c_{i,t}}}{R_t} \geq \beta_i E_t U_{c_{i,t+1}}$$

and

$$q_t - \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} q_{t+1} \geq \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} \left(F_{k_i,t+1}\right)$$

where $F_{k_i,t} = \alpha Z_t k_{it-1}^{\alpha-1}$ 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 I define $\mu_{i,t} \geq 0$ as the multiplier associated with the borrowing constraint the euler equation becomes:

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

The second equation states that the opportunity cost of holding one unit of capital, $\left[q_t - \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} q_{t+1}\right]$, 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:

$$q_t - \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} q_{t+1} = \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} \left(F_{k_2,t+1}\right) + \gamma E_t q_{t+1} \frac{\mu_t}{U_{c_{2,t}}}$$

In a neighborhood of the steady state, Impatient Households borrow up to the maximum. Consequently, they face an always binding borrowing constraint. Thus

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

and

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

where $W_{2,t} = y_{2,t} + q_t k_{2,t} - b_{2,t-1}$, is the impatient agent's wealth[7] 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 decision is determined at the point in which the opportunity cost of holding capital equals its marginal product:

$$q_t - \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} q_{t+1} = \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} \left(F_{k_1,t+1}\right)$$

4 Model Solution

4.1 Deterministic Steady State

The efficient allocation of capital between the two groups would be given by the equality between the marginal products of the two groups:

$$F_{k_1,t} = F_{k_2,t}$$

[7] That is his output and the value of the land held the perious period net of debt repayment.

Thus, given the aggregate condition on capital

$$n_1 k_1 + n_2 k_2 = K_1 + K_2 = 1$$

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

$$K_2^{eff} = n_2 \qquad and \qquad K_1^{eff} = 1 - n_2$$

This means that if the two groups are equally large, each group gets the same amount of capital in steady state[8]. See Figure 4.a.

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

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

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[9]

$$\mu_2 = \left(\frac{1}{R} - \beta_2\right) u_{c_2} = (\beta_1 - \beta_2)\, u_{c_2}$$

As long as Assumption 1 holds, the lagrange multiplier associated with borrowing constraint for the impatient household is strictly positive. Thus, impatient households are credit constrained in steady state. Moreover, their capital holding is $K_2 < K_2^{eff} = K_1^{eff}$.Using the equations representing the households' optimal choice of capital evaluated at the steady state it is possible to show that: $F_{k_1} < F_{k_2}$.

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

Where $F_{k_i} = \alpha \left(\frac{K_i}{n_i}\right)^{\alpha - 1}$. In fact the equation above is always bigger than 1 as long as $\gamma < \frac{1}{\beta_1}$. And due to Assumption 3 this is always the case. The steady state allocation of capital depends

[8] If $n_1 = n_2 = 0.5$ then $K_2^{eff} = 0.5 \qquad and \qquad K_1^{eff} = 0.5$

[9] 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:

$$R = \frac{1}{\beta_1}$$

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

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

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 $\gamma < \frac{1}{\beta_1} = 1.0101$. See Figure 4.b..

In steady state the asset prices depend on the marginal productivity of capital. More specifically, the households' optimal choice of capital gives

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

4.2 Dynamics

The agents' optimal choices of bonds and capital together with the aggregate conditions on capital and bonds and total production and one budget constraint (see appendix 1.1),i.e. equilibrium conditions, represent a non-linear dynamic stochastic system of equations. Since the equations represent well behaved functions, it is possible to adopt standard local approximation techniques to find the solution. All the methods commonly used for this kind of systems rely on log-linear approximations around the steady state to get a solvable stochastic system of difference equations.

By finding a solution I mean to write all variables as linear functions of a vector of state variables, both endogenous state x_{t-1} and exogenous state $z_t$variables, i.e. I are looking for the *recursive equilibrium law of motion*:

$$x_t = Px_{t-1} + Qz_t$$

$$y_t = Rx_{t-1} + Sz_t$$

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

In order to solve for the recursive law of motion I need to find the matrices P, Q, R, S so that the equilibrium described by these rules is stable. I solve this system via the method of undetermined coefficients (McCallum (1983), King, Plosser and Rebelo (1987), Campbell (1994), Uhlig (1995) among others)[10].

[10] See Harald Uhlig "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily" for the description of the solution method.

4.3 Calibration

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 calibrate impatient households' discount factors according to Lawrance (1991) and Samwick (1998) that estimate discount factors, respectively, for poor and young households in the range (0.97, 0.98). The share of capital in the production α is 0.36 as in the tradition of the real business cycle literature[11]. The baseline choice for the fraction of borrowing constrained population is set to 50%.Following the literature on collateral constraint, technology shocks are assumed to have zero persistence. I also assume no persistence in the preference shock while the *Loan to Value Ratio* shock is assumed to be permanent. I calibrate the technology shocks according to standard values in the real business cycle literature[12]. Tab. 1 summarizes the calibrated parameters.

Basic Calibration		
preferences		**shock process**
discount rate	$\beta_1 = 0.99$	autocorrelation
	$\beta_2 = 0.97$	$\rho_z = 0$
technology		$\rho_G = 0$
capital share	$\alpha = 0.36$	$\rho_\xi = 0$
		$\rho_\gamma = 1$
population	$n = 0.5$	

Tab. 1

5 Credit Market Development and Business Cycle

5.1 A Look to the Steady State

Limiting borrowing to a fraction of the expected liquidation value of the capital takes into account different degrees of development of the banking technology in liquidating the collateral. High γ represents a developed credit sector while a low γ characterizes an underdeveloped system. Note that (1-γ) is the cost of liquidation. Thus, as in Aghion, Baccheta and Banerjee (2003), the way credit market development is modelled is through relaxing credit restrictions. The parameter γ, representing the loan to value ratio, affects the steady state allocation of capital, the determination of the level of borrowing and the asset price. A permanent increase in γ rises the level of capital held in the new steady state by borrowers. In fact, the derivative of K_2 with respect to γ is strictly positive. Moreover, a permanent increase in γ raises the steady state asset price level. As long as

[11] See Cooley and Prescott (1995) or Prescott (1986).

[12] For the technology shock see, Cooley & Prescott (1995, chapter 1 in Cooley's book), or Prescott 1986.

$\alpha < 1$ the marginal productivity for lenders is increasing in K_2. Thus, in the new steady state asset price is settled to a higher level.

Figure 4.b shows how γ affects the marginal productivity and thus efficiency in production. *Ceteris paribus* a higher γ reduces the difference between borrowers' and lenders' marginal productivity. 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 γ closer to 1.

Changes in steady state values due to credit market development are shown in Figure 4. 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 new steady state the level of output, and thus total consumption, is higher. The price of the collateral/asset is also higher.

Up to a certain value of γ, borrowers' consumption also increases. This could be due to both a credit channel effect and a wealth effect. Agents benefit of both a larger access to debt financing and an increasing value of their assets.

As expected for high values of γ borrowers' steady state consumption decreases to reach very low values as γ approaches 1. In an environment with relaxed credit restrictions impatient agents prefer to consume more today than in the future reducing in this way the steady state level of consumption.

Easing the liquidity constraints faced by households leads to a rise not only in the household indebtedness level but also in the ratio of household liabilities to production. Indebtedness increases more than production. Moreover, borrowers' wealth decreases while total wealth increases.

5.2 Degree of Credit Financing and Technology Shocks

I now consider the response of the model economy to a negative technology shock. In order to analyze the role of credit market development as a source of instability over the business cycle I compare the responses of economies with different degrees of access to the credit market.

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 8-9. The units on the vertical axes are percentage deviations from the steady state, while on the horizontal axes are years.

An aggregate positive technology shock affects positively 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 on borrowers' production over time. Since the marginal productivity of capital is higher for borrowers, there is a persistent effect on agregate 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 collateral price dynamics equation shows that this price is directly affected by marginal productivity of the collateral asset. The collateral price is directly affected by the technology shock through the marginal productivity but also by the asset dynamics.

$$F_{k_{1,t+j+1}} = \hat{z}_{t+j+1} - (1-\alpha)\,\hat{k}_{1t+j}$$

The rise in asset prices, coupled with the increase in investments and a reduction in interest rate implies a credit boom

$$\hat{b}_{t+1} = \hat{q}_{t+1} + \hat{k}_{t+1} - \hat{R}_t$$

Thus, constrained agents suffer the direct impact of the technology shock and also the indirect impact through asset prices and interest rate variations.

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

$$R_t = \frac{U_{c_{1,t}}}{\beta_1 E_t U_{c_{1,t+1}}}$$

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.

Now, I study how the impact of the technology shock is affected by different degrees of credit market development. Figure 10 shows how the first impact of a technology shock on individual consumption is related to the degree of access to the credit market. The higher γ the stronger the reaction of consumption. When the degree of access to credit financing is higher agents enter the period with an higher level of indebtedness. Consequently they are more heavily leveraged and thus when a shock occurs less able to smooth its effects. As shown in Figure 5, the higher γ the lower the beginning of the period wealth of constrained agents. In fact, even if the value of their assets and their fraction of total output is higher, the burden of the debt decreases their initial wealth. Higher leveraged agents are less able to smooth the effects of shocks on consumption.

Figure 11 shows instead the intensity of the reaction of investment decisions by constrained agents. The impact of the shock on capital expenditure shows an inverted U relationship with the degree of access to the credit market. On the same graph is ploted 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. As we see, the reactions of investment decisions and downpayment are symmetricaly 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. In fact the amount to buy a unit of capital is given by

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

When a technology shock takes place, the price of capital and the interest rate move in the opposite direction. For instance, a negative technology shock has a negative effect on q_t and a positive impact on R_t. Moreover, as shown in Figure 11 the higher γ the weaker the reaction of q_t to the shock. In economies with higher access to the credit market q_t reduces by less, then also the downpayment required reduces by less. Being more expensive to buy capital, we expect k_{2t} to reduce by more. On the contrary, an higher γ is associated to a weaker reaction of the interest rate to shocks. When R_t increases by less, the increase in the downpayment is reduced, thus, the reaction of k_{2t} is expected to be weaker. Thus, the intensity of capital response depends on which of the two opposite effect prevales. Figure 12.b shows how the reaction of capital varies with γ when the interest rate is constant over the business cycle. Since now the effect on downpayment is weaker the higher γ (it only depends on q_t), the impact of the shock on capital is larger.

How does a technology shock affect total productivity under different credit market regimes?

As already pointed out by Cordoba and Ripoll (2004), the elasticity of total output to technology shocks can be written as[13]:

$$\epsilon_{yz} = \epsilon_{yk_2} \epsilon_{k_2 z} = \frac{F_{k_2} - F_{k_1}}{F_{k_2}} \alpha \frac{y_2}{y} \epsilon_{k_2 z}$$

The first term is the productivity gap between constrained and unconstrained agents, α represent the share of collateral in production while $\frac{y_2}{y}$ is the production share of constrained agents and $\epsilon_{k_2 z}$ is the redistribution of capital. As shown in steady state Figures (5) the fraction of total output produced by constrained agents increases with γ due to the fact that more capital is held by the constrained population. However, for the same reason, the productivity gap decreases with γ. Thus, the second impact on depends on this two opposite forces. Figure 12 shows how the reaction of total output to a technology shock varies with the degree of access to credit financing. The second Figure represents the case of constant interest rate. As we see, regardless the shape of capital reaction to technology shocks, the relationship between γ and the second impact of z_t on y_t has an inverted U shape. That is of course more pronounced when $\epsilon_{k_2 z}$ is not monotonic.

[13] Since 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.

Now, I look at the volatility of output and asset prices delivered by the symulated model. Figure 13 shows the standard deviation of this two variable in economies with different degrees of access to the credit market. Each point represents the asymptotic standard deviation of output or asset prices given a particular value for γ in the range [0,1]. The relation between output volatility and γ shows an inverted U shape. Thus, according to the model, both the first impact and standard deviation have the same kind of non-linear relationship with the degree of access to the credit market. Asset prices volatility declines with γ up to 0.9 to rise intead for higher values of γ.

6 Conclusion

[preliminary]

This paper studies how the provision of credit in connection with collateral assets affects both economic performance and the business cycle volatility. I provide a simple framework for analyzing the role of credit market development in an economy with imperfect credit markets.

I assume that agents face credit constraints, with the constraints being tighter at a lower level of credit market development. This model economy is used to discuss the interaction between aggregate output dynamics, collateral/asset prices and wealth distribution.

I show that an increased access to the credit market implies higher asset prices. Being able to borrow more, the impatient agents increase both their consumption and investment expenditures. This leads to a more efficient allocation of capital between the two groups of agents and consequently increases total production and wealth. For the market to clear the other group of agents should be willing to demand less of the asset in fix supply. Thus, their opportunity cost of holding the asset must increase.

A second contribution of this paper is to analyze the link between credit market development and business cycles. The higher level of liabilities, both in absolute terms and relative to the income, make agents less able to smooth the effects of technology shocks. Economies at an intermediate level of credit market development are more vulnerable to shocks.

Policies directed to credit market development should take into account the impact on business cycle volatility. Based on the first results, policy makers should promote credit market development as a source of improvement in economic performance and welfare. On the other hand, regardless of credit sustainability and financial crises, they should also pay attention to the impact of the credit market characteristic on short-run instability.

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Appendix .1 Equilibrium Conditions

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

$$\frac{U_{c_{1,t}}}{R_t} = \beta_1 E_t U_{c_{1,t+1}} \tag{E.1}$$

$$\frac{U_{c_{2,t}}}{R_t} - \mu_{2,t} = \beta_2 E_t U_{c_{2,t+1}} \tag{E.2}$$

$$q_t - \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} q_{t+1} = \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} F_{k_1,t+1} \tag{E.3}$$

$$q_t - \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} q_{t+1} = \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} F_{k_2,t+1} + \gamma E_t q_{t+1} \frac{\mu_{2t}}{U_{c_{2,t}}} \tag{E.4}$$

4 aggregate conditions

$$n_1 k_{1t} + n_2 k_{2t} = K_{1t} + K_{2t} = 1 \tag{E.5}$$

$$y_t = n_1 y_{1t} + n_2 y_{2t} \tag{E.6}$$

$$n_1 b_{1t} + n_2 b_{2t} = 0 \tag{E.7}$$

1 budget constraint[14]

$$c_{2t} + q_t(k_{2t} - k_{2t-1}) = y_{2t} + \frac{b_{2t}}{R_t} - b_{2t-1} \tag{E.8}$$

1 borrowing constraint

$$b_{2,t} = \gamma E_t \left[q_{t+1} k_{2t} \right] \tag{E.9}$$

the resource constraint

$$y_t = n_1 c_{1t} + n_2 c_{2t} \tag{E.10}$$

the two technologies:

$$y_{1t} = Z_t k_{1t-1}^{\alpha} \qquad y_{2t} = Z_t k_{2t-1}^{\alpha} \tag{E.11}$$

12 equations and 12 unknowns:$\{\mu_{2t}, q_t, R_t, y_t\}$ and $\{c_{it}, k_{it}, b_{it}, y_{it}\}_{t=0}^{\infty}$ for i=1,2.

[14] Using the Walras' Law we can drop at each t one of the two budget constraints.

Appendix .2 Steady State

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

$$\frac{1}{R} = \beta_1 \tag{ss.1}$$

from E.2 the lagrange multiplier:

$$\mu_2 = (\beta_1 - \beta_2)\, u_{c_2} \tag{ss.2}$$

Using E.3 and E.4:

$$q = \frac{\beta_1}{1-\beta_1} F_{k_1} = \frac{\beta_2}{1-\beta_2-\gamma(\beta_1-\beta_2)} F_{k_2} \tag{ss.3}$$

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:

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

In case the two group of agents have different technologies, substituting for K_1 the equation become nonlinear in K_2 and not solvable analytically,thus, a *nonlinear rootfinding problem* arises.

In the *nonlinear rootfinding 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 the $f(x)$ is represented by ss.

In this case I implement a numerical algorithms for solving the system quickly and accurately.

Then using E.3:

$$q = \frac{\beta_1}{1-\beta_1} F_{k_1} \tag{ss.4}$$

where $F_{k_1} = \left(\frac{1-K_2}{n_1}\right)^{\alpha-1}$.

Thus I find the steady state borrowing level:

$$b_2 = \gamma\,[q k_2] = -b_1 \tag{ss.5}$$

and the total production:

$$y = n_1 y_1 + n_2 y_2 \tag{ss.6}$$

where

$$y_1 = k_1^{\alpha} \quad y_2 = k_2^{\alpha} \tag{ss.7}$$

From E.8 I find the consumption of the borrowers

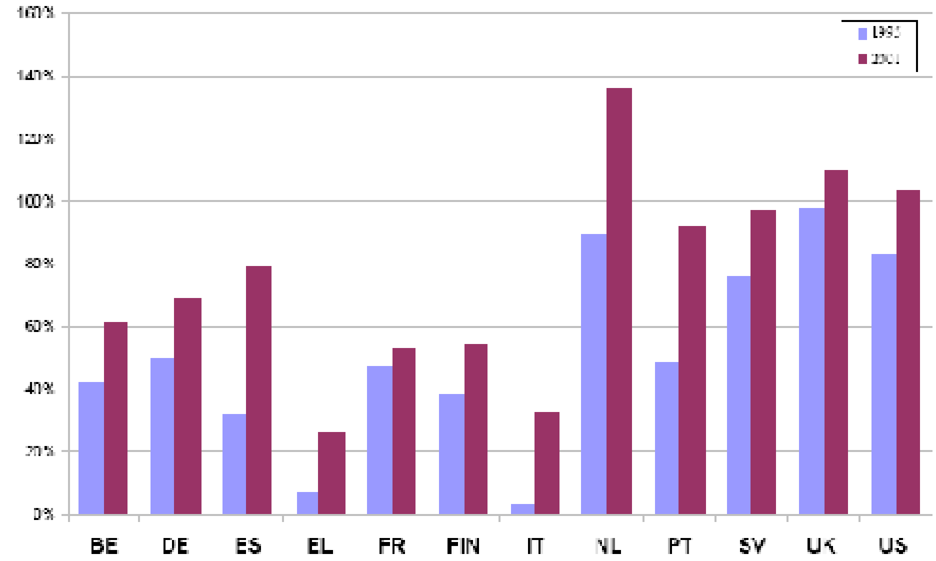
$$c_2 = y_2 - b_2 \left(1 - \frac{1}{R}\right) \tag{ss.8}$$

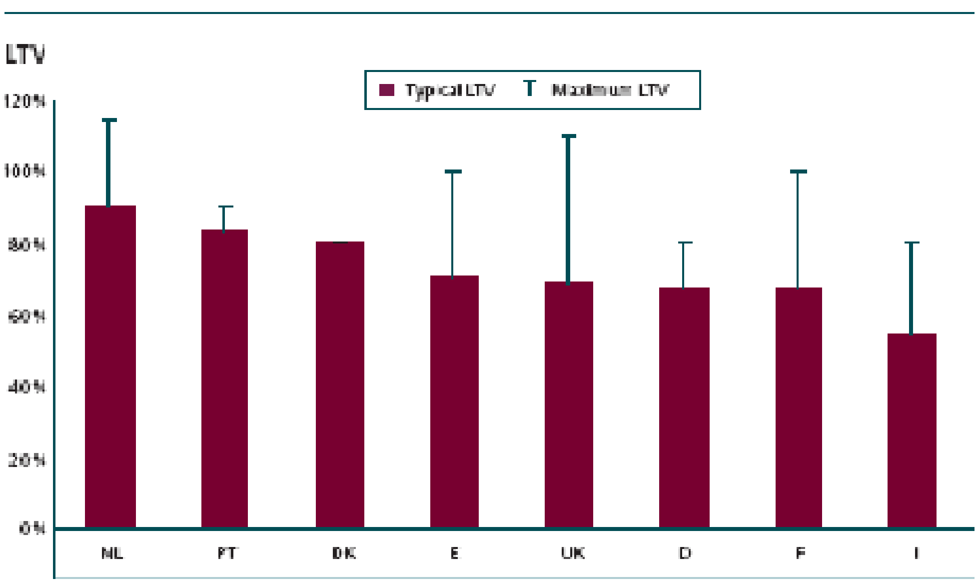
and from the resource constraint the consumption of the group of lenders

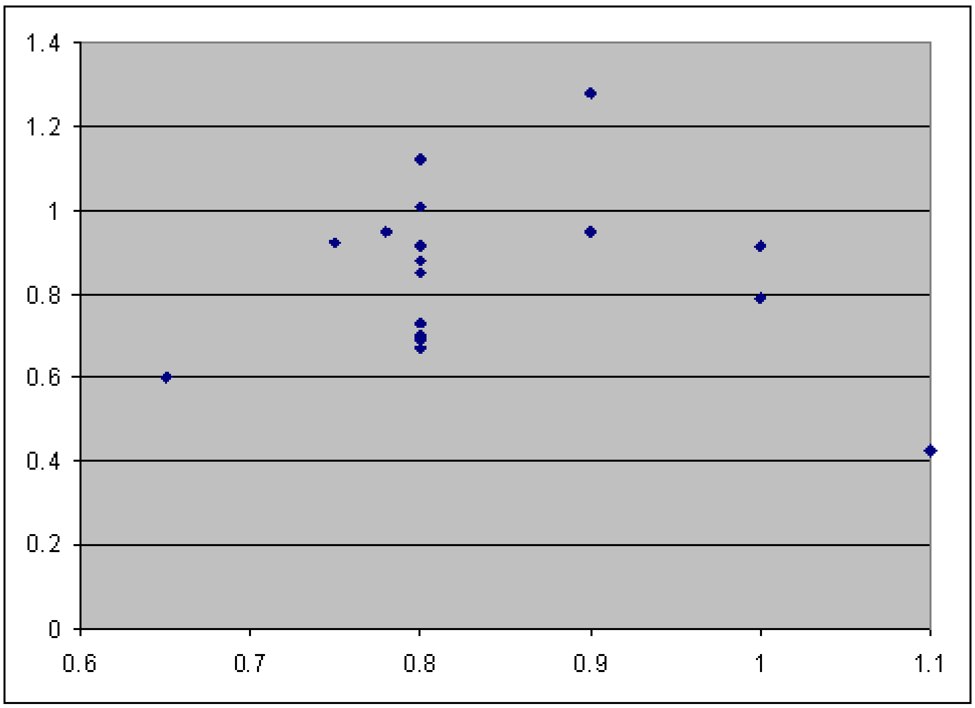
$$n_1 c_1 = y - n_2 c_2 \tag{ss.9}$$

Appendix .3

Chart 1. Household indebtedness (lending to households / households disposable income)







1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.6
0.7
0.8
0.9
1
1.1

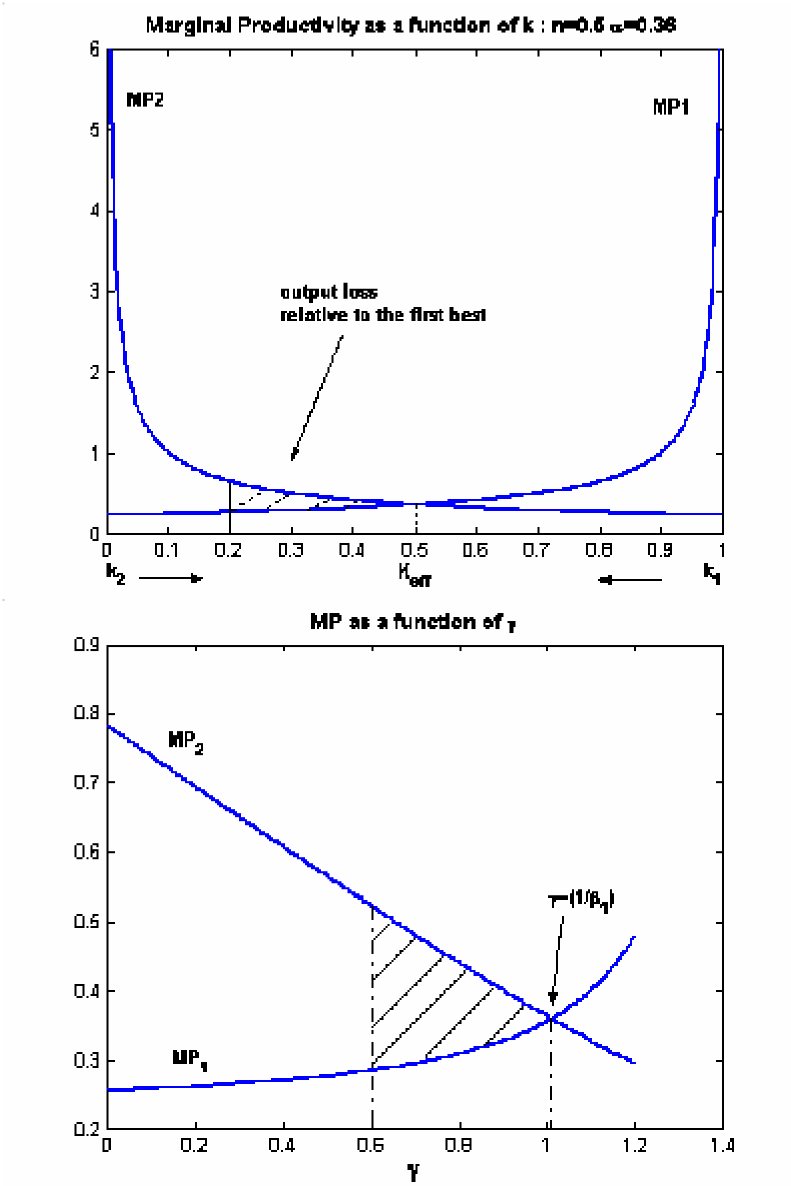


Figure 1: Steady State and MP

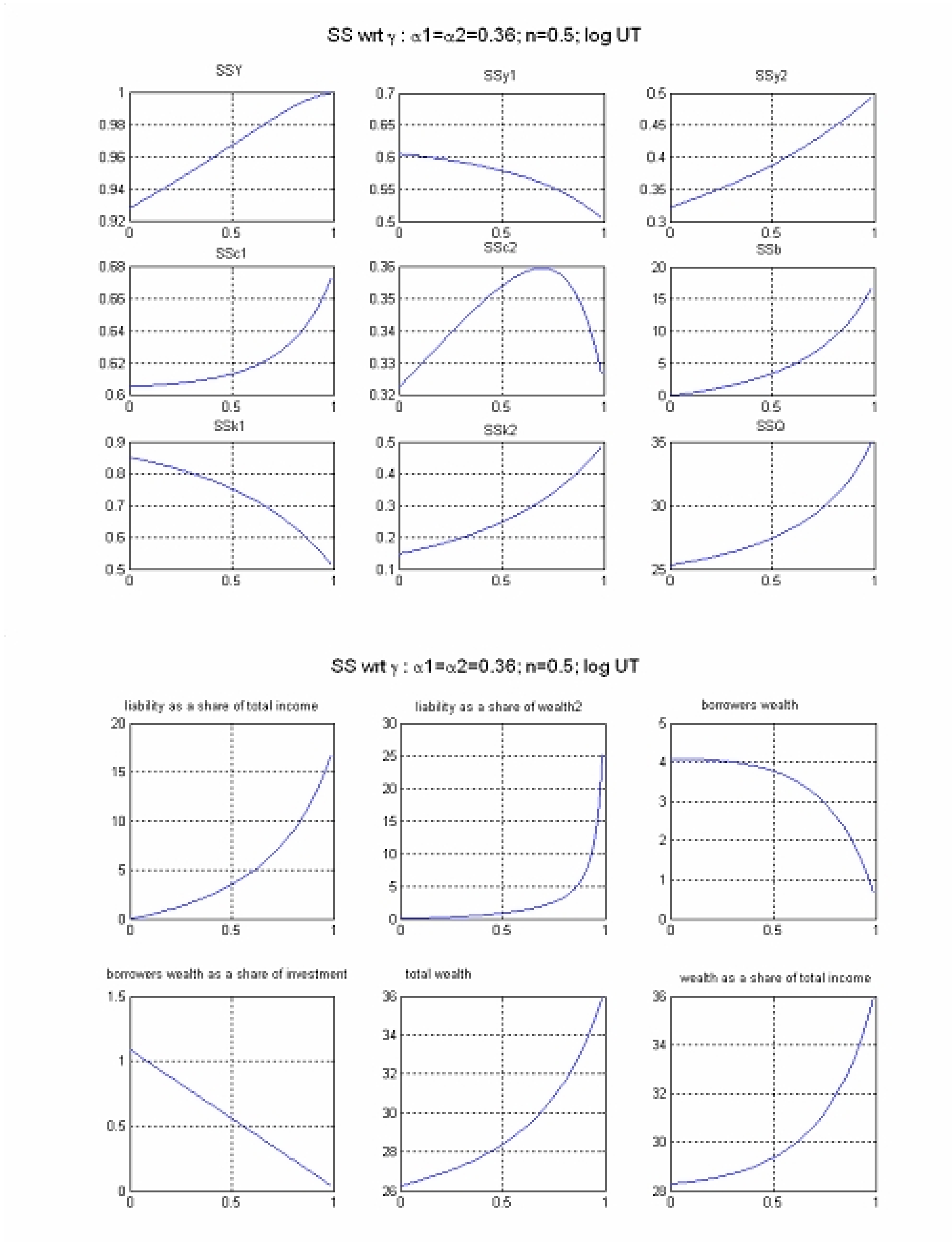


Figure 2: Steady State and LTV ratio

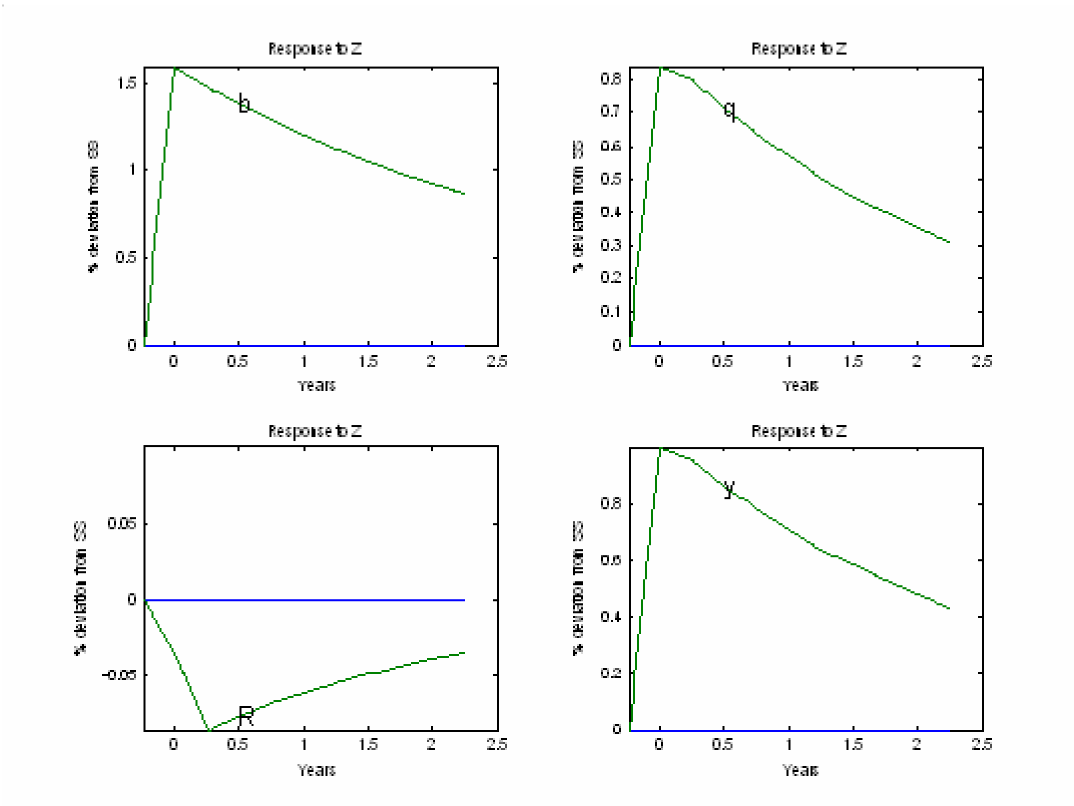


Figure 3: positive temporary technology shock

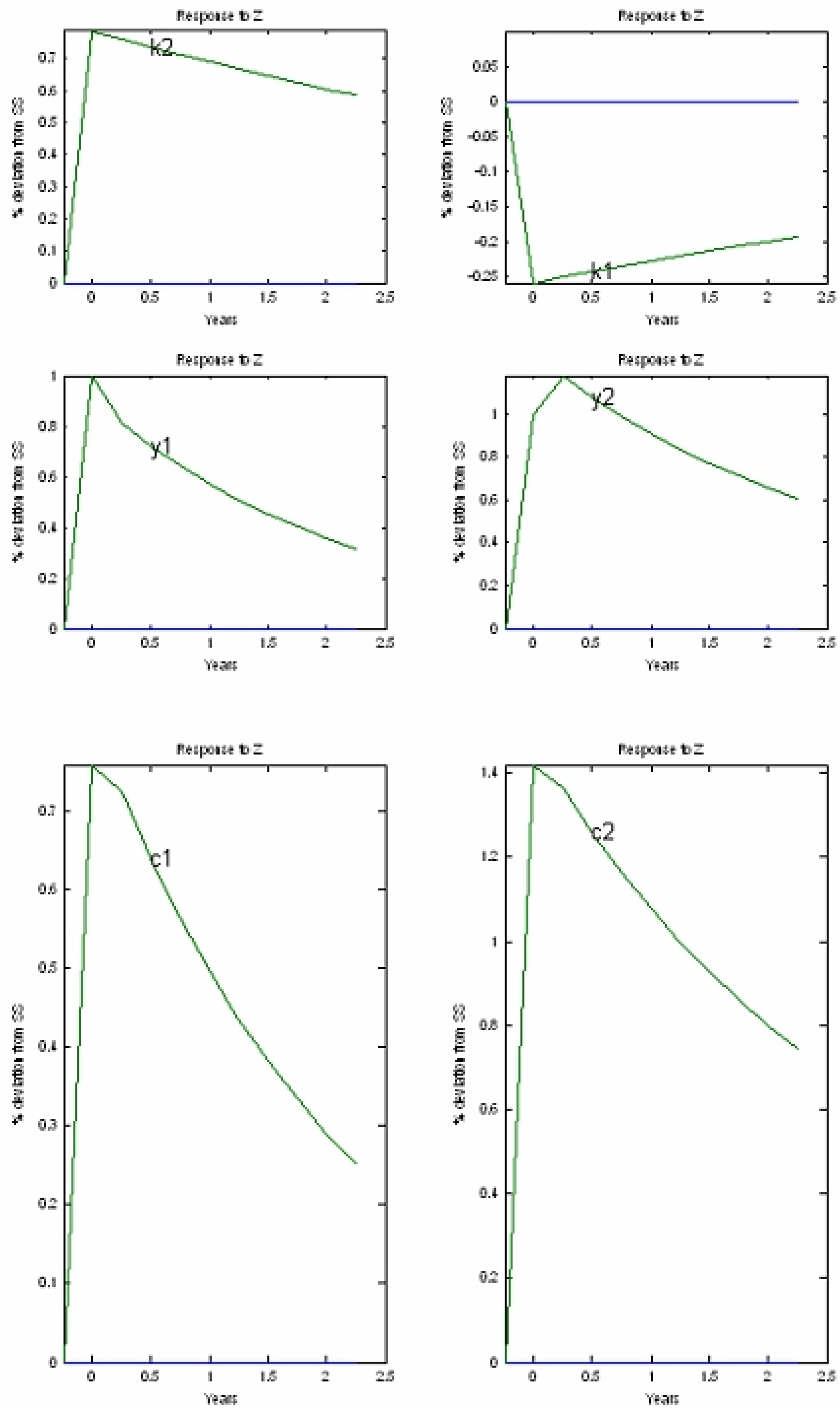


Figure 4: positive temporary technology shock

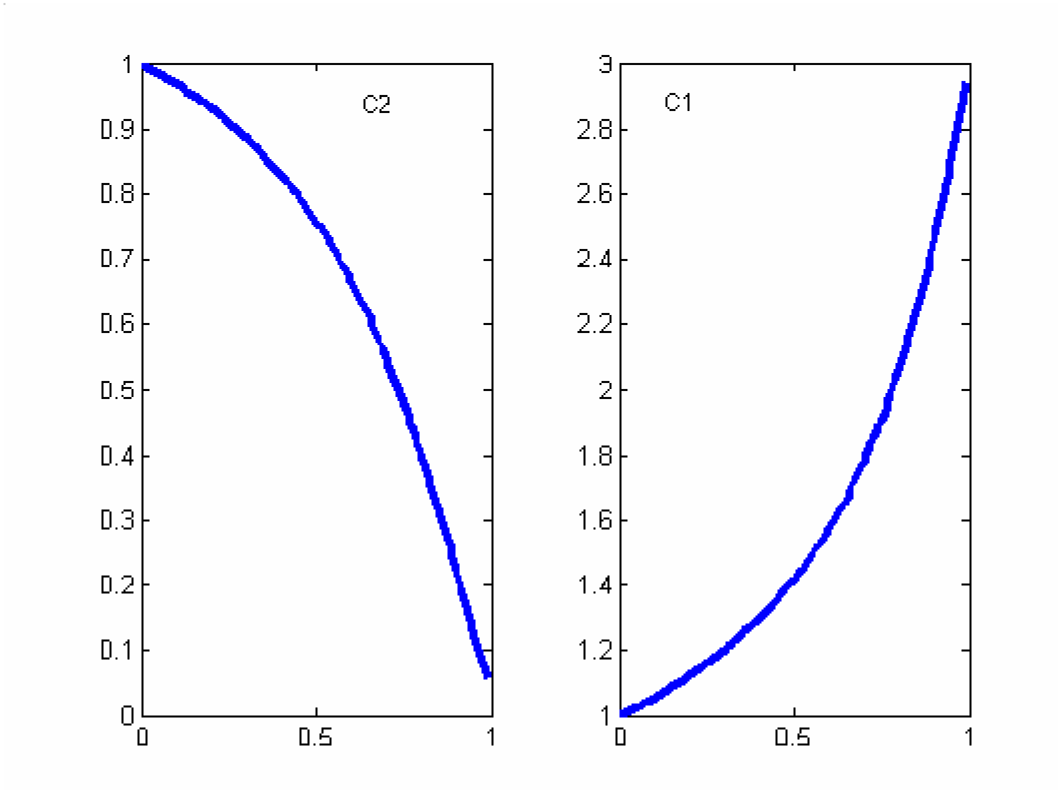


Figure 5: first impact and LTV ratio

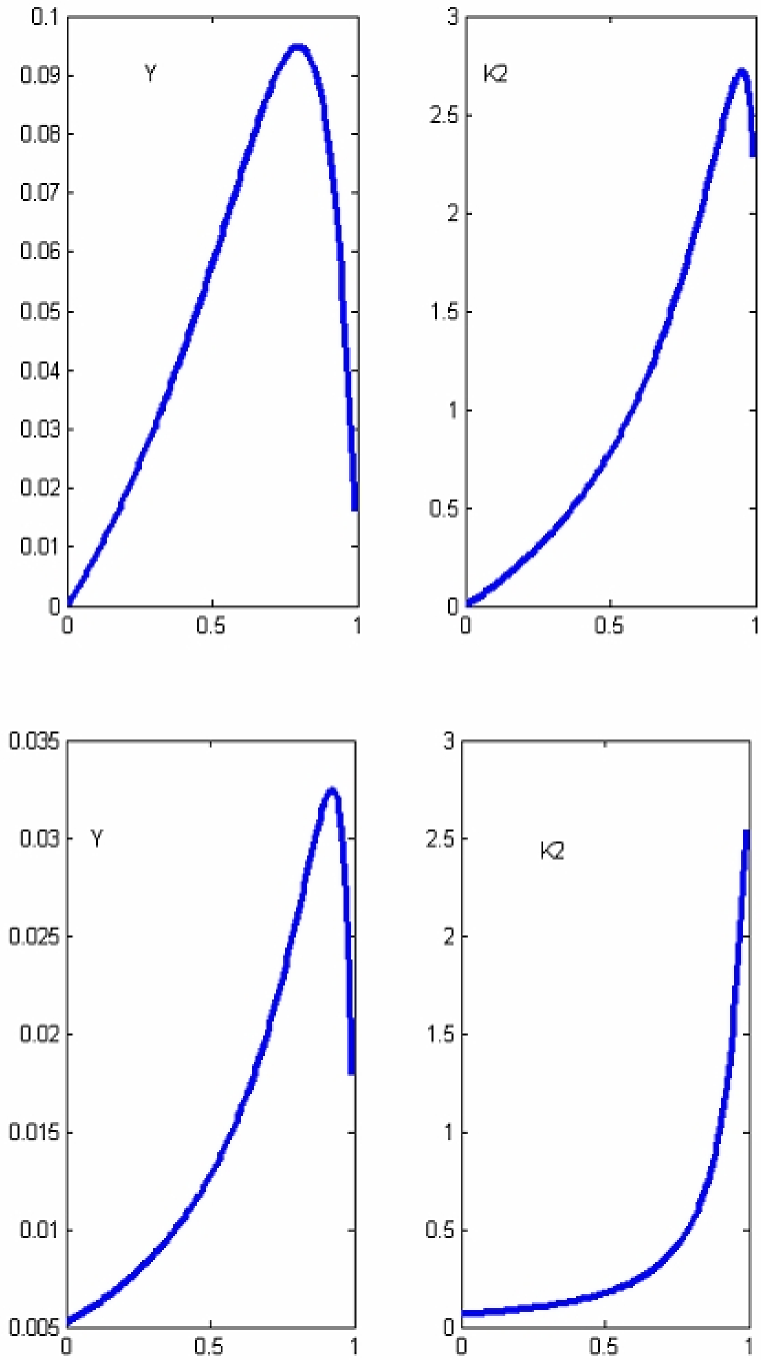


Figure 6: first impact and LTV ratio

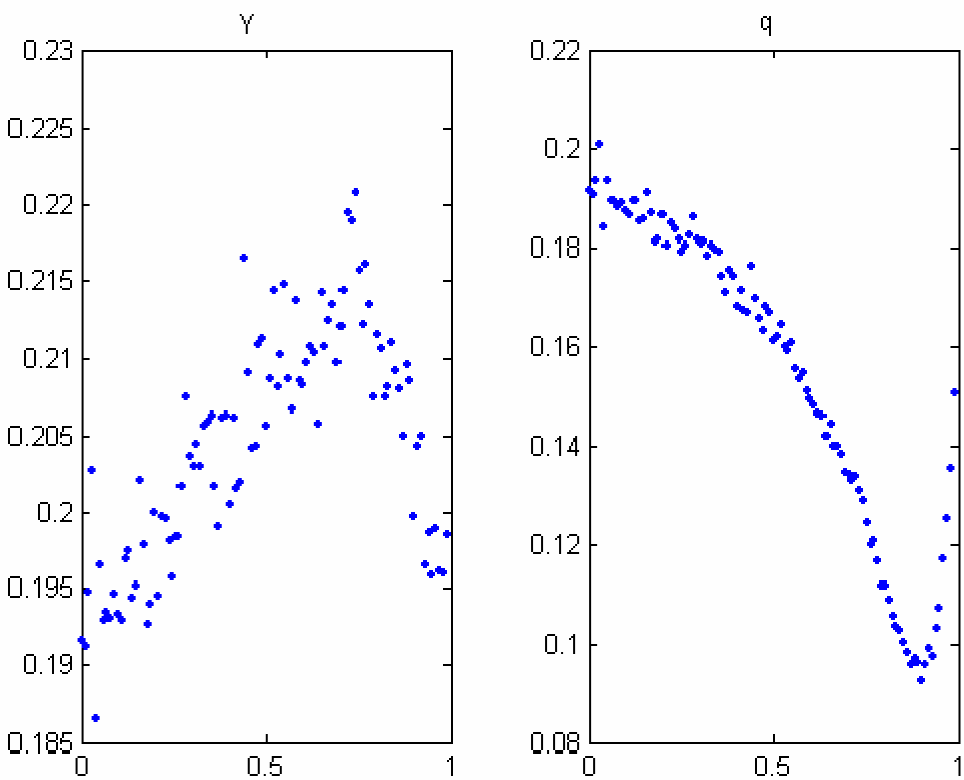


Figure 7: Volatility and LTV ratio