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CREDIT MARKET AND MACROECONOMIC VOLATILITY

by Caterina Mendicino

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In 2007 all ECB publications feature a motif taken from the €20 banknote.

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CONTENTS

Abstract

This paper investigates the role of credit market size as a determinant of business cycle fluctuations. First, using OECD data I document that credit market depth mitigates the impact of variations in productivity to output volatility. Then, I use a business cycle model with borrowing limits *a la* Kiyotaki and Moore (1997) to replicate this empirical regularity. The relative price of capital and the reallocation of capital are the key variables in explaining the relation between credit market size and output volatility. The model matches resonably well the reduction in productivity-driven output volatility implied by the established size of the credit market observed in OECD data.

Keywords: *credit frictions, reallocation of capital, asset prices.*

JEL codes:E21-E22- E44- G20

Non-Technical Summary

Studying the determinants of business cycle fluctuations is crucial for understanding the dynamics of modern economies. The aim of this paper is to examine how the degree of credit market development is related to business cycle fluctuations in industrialized countries. The paper presents some empirical facts and a model economy whose aim is to replicate the relation between credit market size and the volatility of output.

First, OECD data are used to show that a negative and significant relation exists between credit market size – as a proxy for the degree of credit market depth – and the propagation to output of variation in productivity. Credit market size substantially reduces the volatility of output driven by variations in productivity. Second, I present a model economy in which different degrees of credit market development, *ceteris paribus,* affect the sensitivity of output to productivity shocks and thus its volatility over the business cycle. I use a stochastic dynamic general equilibrium model with collateral constraints *a la* Kiyotaki and Moore (1997) in which higher liquidation costs characterizes less developed credit systems. Existing literature dealing with credit markets has shown that credit frictions may be a powerful transmission mechanism that propagates and amplifies shocks. This paper demonstrates that in a model with collateral constraints, movements in the relative price of capital and thus the reallocation of capital, substantially affect the sensitivity of output to shocks. In accordance with the empirical findings, the model asserts that the propagation of variations in productivity to output is greater in economies with tighter credit markets. The reduction in productivity-driven output volatility implied by the model is closely related to the data.

1 Introduction

As a result of macroeconomic, political and legal factors, credit markets significantly differ among OECD countries[1]. At the same time the volatility of the cyclical component of output shows a noticeable degree of variation across countries and time (Figure 1.a). Table 1 reports that credit market size is negatively and significantly correlated with the volatility of output, consumption, investment, investment in residential properties and housing prices[2]. Preliminary analysis on OECD data, indicating that smoother fluctuations are associated with greater sizes of the credit market, provide a reasonable ground to investigate the relation between credit market development and business cycle fluctuations in industrialized countries. The analysis is conducted in three steps. First, OECD data are used to document the relation between the degree of credit market development and macroeconomic fluctuations. Specifically, a greater size of the credit market, as a proxy for credit market depth, reduces the propagation of variations in productivity to output volatility. Second, I develop a two-sector business cycle model that links the degree of credit market development to the sensitivity of output to productivity shocks, and thus its volatility over the business cycle. Last, I compare the predictions of the model with the empirical findings. The model predicts a reduction in productivity-driven output volatility of about 20% that closely corresponds to the data evidence. Despite the stylized nature of the model, it mimics the data reasonably well both qualitatively and quantitatively.

Model. The model is 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 in terms of discount factors, and consequently, impatient agents become borrowers. Credit constraints arise because lenders cannot force borrowers to repay. Thus, physical assets, are used not only as factors of production but also as loan collateral. My setup differs from Kiyotaki and Moore (1997) framework, in that I use more standard assumptions as to preferences and

[1]See e.g. La Porta, Lopes-de Silanes, Shleifer, Vishny (1997) and Djankov, Hart, McLiesh and Shleifer(2006),

[2]See also figures 1.a and 1.b. Correlations are computed for quarterly variables averaged over rolling three-year periods during the 1983-2004 a sample of 20 OECD countries.Volatility is measured as the standard deviation of the log detrended real variables. Hodrick-Prescott filter are used to remove the estimated trend of the series.

technologies[3]. Aggregate uncertainty is introduced into the model, so asset prices are not perfectly predicted by the agents. To be able to investigate the behavior of economies that differ in terms of access to credit financing, I allow for the existence of liquidation costs in modeling the collateral constraint[4].

According to the Schumpeterian view, aggregate shocks generate an inter-firm reallocation of resources, and evidence of this is well established as pertains to job flows. Rampini and Eisfeldt (2005) have recently demonstrated the relevance of physical capital reallocation over the business cycle[5]. In fact, 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, and equipment) is procyclical.

The model presented in this paper generates a negative relationship between the degree of credit market development and output volatility giving a primary role to variations in relative prices and thus the reallocation of capital across firms. When the economy is hit by a positive neutral productivity shock agents increase their capital expenditure, the relative price of capital rises and existing capital is thus reallocated to the production of the capital good. In economies with a greater access to the credit market, the productivity gap between the two groups of agents is smaller. Thus, following a productivity shock, less capital is redistributed to the more productive agents. The sensitivity of asset prices to the shock is reduced and consequently less capital is reallocated to the capital good production. As a result total production reacts by less to the shock. The magnitude of the effect of credit market size on the reduction in the volatility of output induced by variations in productivity is in accordance with the empirical findings.

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[3] Kiyotaki and Moore assume that the agents are risk neutral and apart from using different discount factors, they 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.

[4] As in Aghion et al. (2005) collateral requirements serve as a proxy for the degree of credit market development. Tighter collateral constraints result in a smaller size of the credit market and thus, characterize economies with a less-developed credit market.

[5] See also Maksimovic and Phillips (2001), Andreade, Mitchell, and Stafford (2001), Schoar (2002), Jovanovic and Rousseau (2002). A few papers also 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 (Maksimovic and Phillips (2001)) and that gains derived from reallocation appear larger when productivity differences are greater (Lang, Stulz, and Walkling (1989) and Servaes(1990)).

This results contribute 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. I document that in the model presented here, the magnitude of amplification is related to the degree of credit rationing. The results of Cordoba and Ripoll hold only for economies with the least possible degree of credit rationing allowed by the model.

Layout. The paper proceeds as follows. Section 2 discusses some empirical evidence. Section 3 presents the model, while section 4 discusses the solution method and calibration. Section 5 shows the steady-state implications of different degrees of credit rationing. Section 6 presents the dynamics of the model, and Section7 the relationship between credit market size and business cycle volatility. Section 8 investigates the importance of having two sectors of production in the model by comparing the results in terms of volatility with the one sector model version. Section 9 presents the conclusions of the study.

2 Related Literature and Empirical Facts

Literature. 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. 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. Iacoviello (2005) documents the relevance of housing prices and collateralized debt for the transmission and amplification of shocks. These papers have been very influential and a big strand of the literature has used collateral constraints as an amplification mechanism of shocks. Nevertheless, only few papers have analyzed the role of the degree of credit market development on business cycle fluctuations. 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. Aghion, Angeletos, Banerjee, and Manova (2005) document that the degree of credit market development makes growth less sensitive to commodity price shocks.

Recent papers on the U.S. Great moderation also provide some insights on the relation between financial factors and business cycle fluctuations. Justiniano and Primiceri (2006) report that the decline in the volatility of shocks specific to the equilibrium condition of investment accounts for most of the decline in the macro volatility. Further more they also document evidence of the fact that the reduction in the volatility of the relative price of investment corresponds remarkably well with the timing of the financial deregulation. Campell and Hercowitz (2005) demonstrate that indeed the financial reforms of the mortgage market that took place in the early 1980s., coincided with a decline in the volatility of output, consumption, and hours worked. Similarly, Guerron (2007) shows that the great moderation can be partially attributed to the decreased portfolio adjustment costs resulting by the same process of financial deregulation. Jermann and Quadrini (2005) attribute a primary role to a more flexible use of equity financing in accounting for a substantial reduction in macroeconomic volatility.

This paper is in the same spirit of Aghion et al. (2003) and Aghion et al. (2005), but it focuses on the role of credit market depth in the transmission of variations in productivity to the volatility of output in industrialized countries. In doing so, I do not limit the analysis to the comparison of two different degrees of financial development – i.e. calibrated pre- and post-Great-Moderation – but I explore the theoretical nexus by analysing a full range of levels of development in the domestic credit market including all possible state of development across OECD countries in the last two decades.

Cross-country analysis also suggest a link between credit market development and economic fluctuation. Using large samples of countries, most of which developing countries, Beck et al. (2000), Denizer, Iyigun, and Owen (2002) and Da Silva (2002) demonstrate that well-developed credit markets induce smoother output fluctuations. More recent papers document the effects of bank financing and financial deregulation on the volatility of output growth, risk sharing and efficiency. Among others, Morgan, Rime and Strahan (2006), Larrain (2006) and Acharya, Imbs and Sturgess (2006) using state-level US data suggest a link between financial modernization, industrial production volatility and specialization of investments.

Empirical Evidence. In the following I test the effects of the degree of credit market development on output volatility in OECD countries. In particular I examine the effect of credit market size on the propagation of variation in productivity to output. Following Aghion et al (2005), I measure credit market depth, $Credit_{i,t}$, by the size of the credit market, i.e. the credit extended to the domestic private sector by banks and other financial institutions as a share of GDP.

To test for causality I estimate a panel specification:

$$\sigma^{Y}_{i,t} = \mu_i + \lambda_t + \beta_1 Credit_{i,t} + \beta_2 X^{control}_{i,t} + u_{i,t} \tag{1}$$

where the time index refers to non-overlapping three-year periods, $\sigma^{Y}_{i,t}$ is the standard deviation of the business cycle component of GDP in real terms for country i, μ_i is a country-specific effect, λ_t is a time-specific effect, and $u_{i,t}$ is the variability in output not explained by the regressors. All the variables refer to non-overlapping three-year periods. The dataset includes quarterly time-series data from 1983 to 2004 for 20 OECD economies[6]. 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 and Song (1996), and Ferreira da Silva (2002), I define this as the change in the log of real GDP minus 1-α times the change in the log of employment. To reduce concerns about potentially omitted variables I include country fixed-effects. I also allow for time fixed effects to capture time trends affecting all countries in the sample. However, I also control for other potential determinants of business cycle fluctuations, such as the variability of the short-term interest rate, terms of trade and consumption prices. Since I am interested in the volatility of the cyclical component of GDP, Solow residuals, and interest rates, the HP filter method is used.

Table 2 summarizes the results. As in Aghion et al. (2005) credit market size does not appear to be directly related to output volatility. However, private credit mitigates the impact of variations in productivity to output. Although the fixed-effect specification reduces concern about potentially omitted variables, in column 2 and 3 I introduce into the

[6] All OECD data used are obtained from the OECD database, while the data regarding private credit come from the IFS.

regression a set of control variables for other potential sources of business cycle volatility. A larger credit market does dampen the propagation of Solow residual volatility to output of about 13-18% depending on the control variables introduced in the regression. In table 2, I measure credit market size as a moving average over the three years. However, table 3 show that the result is robust independently of how credit market size is measured. In column 2, I measure credit market size as the beginning of the period value to emphasize how the established credit-to-GDP ratio affects volatility in the following period. I also check the robustness of the relation, using the average over the all period sample, as a measure of credit market development that varies only in the cross-section and not over time (column 3). In all specification the interaction between credit market size and the standard deviation of Solow residuals has a negative and significant sign. Thus, across OECD countries, in the last twenty years, credit market size reduces the volatility of output induced by variations in productivity.

3 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 δ. 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:

$$\max_{\{c_{it},k_{it},b_{it}\}} E_t \sum_{t=0}^{\infty} \beta_i^t U(c_{it})$$

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

$$c_{it} + q_t(k_{it} - (1-\delta)\,k_{it-1}) = F_{it} + \frac{b_{it}}{R_t} - b_{it-1} \tag{2}$$

and a *borrowing constraint*

$$b_{it+1} \leq \gamma E_t \left[q_{t+1} k_{it} \right] \tag{3}$$

Real production is given by

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

where y_{it} represents the technology for producing consumption goods and h_{it} is the production for capital goods

$$y_{it} = Z_t \left(k^c_{it-1} \right)^{\alpha^y_i} \qquad h_{it} = Z_t \left(k^h_{it-1} \right)^{\alpha^h_i} \tag{4}$$

with k^j_{it-1} – $j = c, h$ – being the stock of capital used as an input of production in the two sectors. Unlike Kiyotaki and Moore (1997), I assume that agents have access to the same concave production technology[7]. Kiyotaki and Moore 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 ($\alpha^y_1 = \alpha^h_1 = \alpha^y_2 = \alpha^h_2$). Moreover, I also allow for reproducible capital and assume that each agent is able to produce both consumption and investment goods[8]. For simplicity, I will assume that both types of production are identical[9]. 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 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, 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,

[7]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.

[8]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).

[9]The assumption of decreasing returns in the production of invetment goods is equivalent to assume convex adjustment costs for investments.

agents cannot borrow more than a certain amount such that what they have to reimburse in the next period cannot exceed the expected value of next period assets $b_{it} \leq \gamma E_t [q_{t+1} k_{it}]$; where $\gamma < 1$, and $(1-\gamma)$ represents the cost lenders must pay to repossess the asset. 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. In fact, a high γ represents a lower degree of credit rationing and thus a more developed financial sector while a low γ represents an underdeveloped system[10]. As I will show below, the model displays a one to one mapping between γ and the size of the credit market.

3.1 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

$$\max_{k^c_{it-1}} Z_t \left\{ \left(k^c_{it-1}\right)^{\alpha} + q_t \left(k_{it-1} - k^c_{it-1}\right)^{\alpha} \right\}$$

This leads to the first-order condition,

$$\left(k^c_{it-1}\right)^{\alpha-1} = q_t \left(k_{it-1} - k^c_{it-1}\right)^{\alpha-1} \tag{5}$$

The relative price of capital equals the ratio of the marginal productivity of capital in the two sectors. 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:

$$k^c_{it-1} = \theta k_{it-1} \tag{6}$$

where $\theta(q) = \frac{q_t^{\frac{1}{\alpha-1}}}{1+q_t^{\frac{1}{\alpha-1}}}$. Thus, the allocation of existing capital between the two productions depends on the current relative price of capital. The total production of each individual can be expressed as

$$F_{it} = k^{\alpha}_{it-1} Z_t \left[\theta^{\alpha} + q_t (1-\theta)^{\alpha}\right] \tag{7}$$

[10] In an economy in which the legal system is very efficient the commitment problem vanishes and the borrowing constraint is not necessary any more.

Step 2: Utility maximization

Now it is possible to simplify the maximization problem, obtaining

$$\max_{\{c_{it},k_{it},b_{it}\}} E_t \sum_{t=0}^{\infty} \beta_i^t U(c_{it})$$

s.t. the *budget constraint*

$$c_{it} + q_t(k_{it} - (1-\delta) k_{it-1}) = k_{it-1}^{\alpha} [Z_t \theta^{\alpha} + q_t (1-\theta)^{\alpha}] + \frac{b_{it}}{R_t} - b_{it-1}$$

and the *borrowing constraint*

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

The agents' optimal choices are then characterized by

$$\frac{u_{c_{i,t}}}{R_t} \geq \beta_i E_t u_{c_{i,t+1}} \tag{8}$$

and

$$q_t - \beta_i E_t \frac{u_{c_{i,t+1}}}{u_{c_{i,t}}} q_{t+1} (1-\delta) \geq \beta_i E_t \frac{u_{c_{i,t+1}}}{u_{c_{i,t}}} \left(F_{k_{i,t+1}} \right) \tag{9}$$

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, $\left[q_t - \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} q_{t+1} (1-\delta) \right]$, is greater than or equal to the expected discounted marginal product of capital.

In this framework, impatient agents borrow up to the maximum possible amount in a neighborhood of the deterministic steady state. In fact, if we consider the Euler equation for the impatient household in the steady state,

$$\mu_2 = (\beta_1 - \beta_2) U_{c_2} > 0 \tag{10}$$

μ_{2t} 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

$$b_{2,t} = \gamma E_t [q_{t+1} k_{2t}] \tag{11}$$

and

$$k_{2t} = \frac{W_{2,t} - c_{2,t}}{\left[q_t - \gamma E_t \frac{q_{t+1}}{R_t} \right]} \tag{12}$$

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

$$\frac{U_{c_{i,t}}}{R_t} - \mu_{2,t} = \beta_i E_t U_{c_{i,t+1}} \tag{9.a}$$

Moreover, borrowers internalize the effects of their capital stock on their financial constraints. Thus, 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:

$$q_t - \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} q_{t+1} (1-\delta) = \beta_2 E_t \frac{U_{c_{2,t+1}}}{U_{c_{2,t}}} \left(F_{k_{2,t+1}}\right) + \gamma E_t q_{t+1} \frac{\mu_{2,t}}{U_{c_{2,t}}} \tag{10.a}$$

Collateral constraints alter the future revenue from an additional unit of capital for the borrowers. Holding an extra unit of capital relaxes the credit constraint and thus increases their shadow price of capital. Thus, this additional return encourages borrowers to accumulate capital even though they discount the revenues more heavily that lenders. As long as the marginal product of capital differs from its market price, borrowers have an incentive to change capital stock[11]. 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:

$$q_t - \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} q_{t+1} (1-\delta) = \beta_1 E_t \frac{U_{c_{1,t+1}}}{U_{c_{1,t}}} \left(F_{k_{1,t+1}}\right) \tag{10.b}$$

Agents' capital stock evolves according to

$$k_{it} = (1-\delta) k_{it-1} + h_{it} \tag{13}$$

The total stock of capital k_t is given by

$$k_t = k_{1t} + k_{2t} \tag{14}$$

The following conditions also hold

$$y_t = y_{1t} + y_{2t} = c_{1t} + c_{2t} \tag{15}$$

$$b_{1t} = -b_{2t} \tag{16}$$

[11]The price of capital is higher than the frictionless marginal tobin's q for the borrowers.

4 Model Solution

4.1 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[12] is 0.95. I assume the following utility function:

$$U(c_{it}) = \frac{c_{it}^{1-\varphi}}{1-\varphi} \tag{17}$$

and set φ to equal 2.2. The productivity parameter, α is 0.36, as in the tradition of the real business cycle literature[13]. The capital depreciation rate equals 0.03. The baseline choice for the fraction of borrowing-constrained population is set to 50. The parameter representing the degree of credit rationing, γ, is in the [0,1] range. Finally, I calibrate the technology shocks according to standard values in the real business cycle literature[14]. Table 4 summarizes the parameter values.

4.2 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*:

$$x_t = Px_{t-1} + Qz_t$$
$$y_t = Rx_{t-1} + Sz_t$$

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

[12] 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.

[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 $P, Q, R, andS$, 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).[15].

5 Credit Market Size and the Deterministic Steady State

Now, I analyze how the degree of credit rationing, γ, affects the deterministic steady state of the model. Since total output is maximized when the marginal productivity of the two groups is identical, I examine how the allocation of capital between the two groups varies with γ. Using households' optimal choice of capital – equations (10.a) and (10.b) – evaluated at the steady state, it is possible to show that as long as $\gamma < \frac{1}{\beta_1}$,

$$\frac{K_1}{K_2} = \left[\frac{\beta_1}{\beta_2}\frac{1-\beta_2(1-\delta)-\gamma(\beta_1-\beta_2)}{1-\beta_1(1-\delta)}\right]^{\frac{1}{1-\alpha}} > 1 \qquad (18)$$

The steady-state allocation of capital depends on the subjective discount factors, $\beta_1$and β_2, the fraction of the two groups of agents, n, the depreciation rate, δ, and the degree of credit market development, γ. Thus, the allocation under credit constraints reduces the level of capital held by the borrowers. In fact, as long as $\gamma < \frac{1}{\beta_1} = 1.0101$, equation (19) implies a difference in the marginal productivity of the two groups. Figure 2a shows the steady-state productivity gap with respect to γ. 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 γ does reduce the output loss.

Figure 2b shows the deterministic steady-state values of the model's variables with respect to the degree of credit market development, γ. Increased access to the credit market implies credit expansion, b_{ss}, and thus a rise in the level of investment by borrowers, k_{2ss}. With more capital allocated to the most productive group of agents, there is an increase

[15] See Uhlig (1995), *A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily*, for a description of the solution method.

in the production share of constrained agents, and consequently in total production, y_{ss}. Hence, the amount of total capital, K_{ss}, and consumption, C_{ss}, are higher as well[16]. In the steady state, asset price depends on the marginal productivity of capital and increases with γ[17]. The model delivers also a mapping between the ratio of private credit to total output and $\gamma = \frac{b_2}{qk_2}$. Figure 2.c shows that by varying γ between zero and unity, it is possible to reproduce the same private credit-to-GDP as found in the data and thus, directly relate the theoretical results to the empirical findings.

6 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

$$\ln(Z_t) = \rho_Z \ln(Z_{t-1}) + \varepsilon_{Zt}, \ \varepsilon_{Zt} \backsim^{iid} N(0, \sigma_\epsilon) \tag{19}$$

Figure 3.a 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 1.2% in the first period and further more in the second. In what follows I will show that variations in the relative price of capital generated by the redistribution of capital between the two groups of agents, strongly contribute to the amplification of the shock. In fact, variation in q_t determine the reallocation of existing capital between different sectors of production (reallocation of capital in terms of use) and thus generate amplification of the shock already in the period in which the shock hits the economy.

As a response to a neutral technology shock, the model displays co-movement between the consumption and capital good production. However, the production of the capital good

[16] Up to a certain value of γ, borrowers' consumption increases. This is 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 γ 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.

[17] The steady state value of $qss = \frac{\beta_1}{1-\beta_1(1-\delta)} F_{k_1} = \frac{\beta_2}{1-\beta_2(1-\delta)-\gamma\frac{\mu}{Uc_2}} F_{k_2}$ is always less than unity for any value of $\gamma < 1$. Thus, the model can never the equivalent to the standard one-sector real business cycle model with a one-to-one trasformation rate between consumption and capital.

displays evidence of significant amplification, while the production of the consumption good reacts much less markedly (Figure 3.b). As a positive shock hits the economy, borrowers – limited in their capital holding before the occurrence of the shock by the existence of borrowing constraints – increase their demand for productive assets. Thus the user cost of holding capital rises as shown in Figure 3.b. The increase in the relative price of capital implies a more profitable use of the input of production in the capital good sector and thus a reallocation of capital towards this production. This allows for the agents to more easily smooth the effect of the shock through investment. The change of use of the existing productive asset affects the impact of the shock on the two productions. As indicated by θ, capital is reallocated towards the production of investment goods in coincidence of the two major peaks of amplification[18]

$$\hat{\theta} = \frac{\hat{q}_t}{\theta(1-\alpha)}$$

This explains the stronger effect of the shock on the production of the capital good. With asset prices increasing and the production of investment goods strongly reacting to the shock, the response of aggregate real output to a productivity shock is greatly amplified. The rise in borrowers' current investment expenditures propagates the positive effect of the shock to their production over time. Since the marginal productivity of capital is higher for borrowers, this also generates a second period amplification on aggregate production[19].

Figure 3b also shows that the rise in asset prices coupled with the increase in borrowers' capital expenditure, implies a credit boom[20]. 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.

Figure 3.c presents the dynamics of the two groups' production in more detail. Since in the first period the agents decide to reallocate their own capital towards the production of capital goods, all agents' productions behave identically. In the second period, given the redistribution of capital towards patient agents, the productions specific to constrained

[18] Variables are in log devation from their steady state values.

[19] In fact, when the capital used by the most productive agents increases — as well as their share of production $(F_{2,t}/F_t)$ – the effect of the shock is amplified even more.

[20]

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

agents are more strongly affected by the shock and display a significant degree of amplification. In contrast, the amplification on lenders' productions is minimal. The reallocation of capital between the two sectors still affects the production behavior of both groups in the second period. However, what generates differences in the impact of the shock is the fact that the capital held by constrained agents increases substantially. Thus, while in the first period the only source of amplification is the reallocation of capital in terms of use, in the second period both sectorial and ownership reallocation take place.

6.1 Credit Market Size and Business Cycle

In what follows, I consider how the sensitivity of output to productivity shocks is affected by γ and consequently the size of the credit market. Figure 4.a, shows the initial impact of productivity shocks – i.e., the intensity of reaction for any given value of γ. As a result, more-developed credit markets display reduced amplification of productivity shocks on output[21]. 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 the relative price of capital and thus the capital reallocation between the two sector. As shown in Figure 4.b (top panel), reducing credit market frictions lowers the sensitivity of asset prices to productivity shocks and consistently reduces the magnitude of capital reallocation. Given that in economies with a lower degree of credit rationing the productivity gap between lenders and borrowers is smaller, less capital is redistributed to the borrowers to fill the gap. Thus, borrowers' demand for capital rises by less reducing the increase in the relative price of capital. So, it becomes less profitable to reallocate capital to the production of investment goods. 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. This effect contributes to the same shock having a weaker impact on total aggregate production. Since the decreased reaction of the capital production sector is greater than the amplification of the shock in the consumption goods production, a larger credit market dampens the propagation of productivity shocks to output.

[21] This finding is in accordance with Calstrom and Fuerst's (1997) results of a stronger impact of neutral technology shocks on output when a lower value or the monitoring cost in the financial contract is assumed.

Cordoba and Ripoll (2004), assuming $\gamma = 1$ in the standard Kiyotaki and Moore setup, show that collateral constraints are unable to generate amplification of productivity shocks. This finding still holds in the model presented here. However, if we allow for different degrees of credit market development the magnitude of the initial amplification impact varies with the credit market size. Thus, the amplification of productivity shocks to output is greater in economies with tighter collateral constraints. Once we allow for γ to be lower than unity, the amplification generated in the model is no longer negligible.

7 Credit market size and output volatility: comparing model predictions with the data

Finally, I examine the relationship between the volatility of the cyclical component of output and the size of the credit market delivered by the model. The aim is to document that the model can reproduce the fact that credit market size reduces the volatility of output induced by variations in productivity by the same magnitude as observed across time and countries. I simulate the model economy for three different values of $\gamma, \{0.2, 0.5, 0.9\}$. The productivity shock follows an AR(1) process, i.e., $\ln(Z_t) = \rho_Z \ln(Z_{t-1}) + \varepsilon_{Zt}, \ \ \varepsilon_{Zt} \backsim^{iid} N(0, \sigma_\epsilon)$. 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 to 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. Table 5 reports the results. The volatility of output implied by γ=0.5 is 3% lower than the volatility obtained with γ=0.2. A more substantial difference occurs when we compare output volatility for higher values of γ. Output is 17% less volatile when γ=0.9 than when γ=0.5. Since γ determines the steady state credit market size of the model, estimations in table 3 column 2, in which I measure credit size as the beginning of the period value, are directly comparable with the results of the model. According to the estimations a well developed credit market reduces the volatility of output due to variations in productivity of about 18%. The size of the credit market in the sample corresponds to values of γ in the theoretical model above 0.5 (see figure 2.c). Thus a reduction of output volatility of about 17% is in accordance with the empirical estimates. Despite its stylized nature, the model is quite successful in matching the data.

For completeness, I simulate the model for 1000 values of γ in the [0,1] range. The number of simulated series for the calculation of moments is 5000 for any given γ. Figure 5 shows that, the standard deviation of total output decreases with the size of the credit market. The model display also a lower volatility of asset prices[22] (see Figure 5, middle panel). The volatility of investment relative to consumption goods decreases with the degree of credit friction as well. The impact of variations in productivity to output volatility is reduced by about 26% for γ between 0.0001 and unity and around 20% for γ between 0.5 and unity. In both the model and the data there is a clear evidence that well developed credit markets induce smoother business cycle fluctuations. The reduction in productivity-driven output volatility implied by the established size of the credit market in the model is of the same magnitude as documented by the empirical findings reported in section 2. Thus, the model mimics the data very closely both qualitatively and quantitatively.

8 One vs Two- Sector Model: Amplification and Volatility

In what follows I show that the two-sector model displays greater amplification and persistence of productivity shocks than the standard Kiyotaki and Moore model. Figure 6.a compares the reaction of total aggregate production in the present model with the response in the one-sector model. In the one-sector version of the model aggregate capital is fixed in supply and only one consumption good is produced. 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 redis-

[22] This result is in accordance with the findings of Justiniano and Primiceri (2005). In fact, 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. Moreover, the decline in the volatility of the relative price of investment was simultaneous with the timing of the "Great Moderation."

tribution 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 Kiyotaki and Moore setup.

Figure 6.b 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[23]:

$$\epsilon_{yz} = \epsilon_{yk_2}\epsilon_{k_2z} = \frac{F_{k_2} - F_{k_1}}{F_{k_2}}\alpha\frac{y_2}{y}\epsilon_{k_2z}$$

The first term is the productivity gap between constrained and unconstrained agents, α is the share of collateral in production, $\frac{y_2}{y}$ is the production share of constrained agents, and ϵ_{k_2z} is the redistribution of capital. In the one-sector model, the fraction of total output produced by constrained agents increases with increasing values of γ because more capital is held by the constrained population. However, for the same reason, the productivity gap decreases with γ. Thus, the second impact of productivity shocks on total output depends on these two opposing forces[24]. As a result, the degree of credit market development affects the reaction of output to productivity shocks differently in the two models. Also in the 1-sector model, the magnitude of the initial amplification impact varies with credit market size. Once we allow for γ to be lower than unity, the amplification generated in the model is no longer negligible[25]. However, the amplification of productivity shocks to output is greater in economies at an intermediate level of credit market development.

Figure 6.c compare the relationship between output volatility and degree of credit market development predicted by the two-sector and one-sector framework. Only the two-sector model displays a negative relation between the implied standard deviation of output and the assumed credit market size at the beginning of the period.

[23] Since 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.

[24] Regardless as to the shape of the capital reaction to technology shocks, the relationship between γ and the second impact of z_t on y_t assumes an inverted U shape; this is, of course, more pronounced when ϵ_{k_2z} is not monotonic.

[25] For further discussion on the amplification role of collateral constraints refer to Mendicino (2006).

9 Concluding Remarks

In this paper I revisit the relationship between the degree of 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. 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. To explain 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. Relying on a business cycle model that takes into account different degrees of credit frictions, I demonstrate that tighter credit markets greatly amplify the propagation to output of variations in productivity. As a result, the reduction in productivity-driven output volatility implied by the model is closely related to the data.

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10 References

1. Acharya, Imbs, and Sturgess, (2006), Finance and the Efficiency of Capital Allocation: Do Bank Branching Regulations Matter?, mimeo.

2. Aghion, P., Abhijit B., and T. Piketty, (1999), Dualism and Macroeconomic Activity, Quarterly Journal of Economics, 114, 1359-1397.

3. Aghion, P., Philippe B. and A. Banerjee, (2003), Financial Development and the Instability of Open Economies, Journal of Monetary Economics, 1077-1106.

4. Aghion, P., G.M. Angeletos, A. Banerjee and K. Manova, (2005), Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment, mimeo.

5. Aiyagari, S.R., (1994), Macroeconomics with Frictions, Federal Reserve Bank of Minnesota Quarterly Review, 18(3).

6. Aizenman, J., (1997), Capital markets integration, volatility and persistence. Journal of Macroeconomics, 19, 217–236.

7. Aizenman, J., and A. Powell, (1997), Volatility and Financial Intermediation. NBER Working Paper 6320.

8. Andrade, G., Mitchell M., and Erik Stafford, (2001), New Evidence and Perspective on Mergers. Journal of Economic Perspectives, 15, 103-120.

9. Arias, A. Hansen G.D. and L.E. Ohanian, (2004), Why Have Business Cycle Fluctuations Become Less Volatile?, mimeo.

10. Aoki, K., Proudman J. and J. Vlieghe, (2001), Houses as Collateral: Has the Link between House Prices and Consumption Changed?, mimeo, Bank of England.

11. Bandiera, O. and Gerard C., (1998), Honoan P.,and F.Schiantarelli, Does Financial Reform Raise or Reduce Savings?, mimeo.

12. Baxter, M., (1996), Are Consumer Durables Important for Business Cycles?, Review of Economics and Statistics, 78, 147-155.

13. Beck, T., Levine, R. and Loayza, N., (1999), Finance and the sources of growth. World Bank Policy Research Working Paper no. 2057.

14. Bekaert, G. Campbell R. H. and C. Lundblad, (2004), Growth Volatility and Financial Liberalization, nber wp. 10560.

15. Bencivenga, V. R. and B. D. Smith, (1993), "Some Consequences of Credit Rationing in an Endogenous Growth Model." Journal of Economic Dynamics and Control, 17, 97-122.

16. Benhabib, J, and A. Rustichini, (1991), Vintage capital, investment and growth, Journal of Economic Theory, 55, 323-339.

17. Benhabib, J., Perli R. and P. Sakellaris, (2005), Persistence of Business Cycles in Multisecors RBC Models, mimeo.

18. Bernanke, B. S., (1984), Permanent Income, Liquidity, and Expenditure on Automobiles: Evidence From Panel Data, Quarterly Journal of Economics, 99 (3), 587-614.

19. Bernanke, B. S. and Mark Gertler, (1989), Agency Costs, Net Worth and Business Fluctuations, American Economic Review, 79, 14-31.

20. Bernanke, B., Gertler, M., Gilchrist, S., (1998), The financial accelerator in a quantitative business cycle framework. NBER Working Paper 6455.

21. Blanchard, O.J. and J. Simon, (2000), The Long and Large Decline in U.S. Output Volatility, Brookings Papers on Economic Activity, 1, 135-147.

22. Boivin, J. and M. Giannoni, (2002), Has Monetary Policy Become Less Powerful?, Columbia Business School, mimeo.

23. Campbell, J. R. and Z. Hercowitz, (2004), The Role of Collateralized Household Debt in Macroeconomic Stabilization, nber wp 11330.

24. Canova, F., (2004), Monetary Policy and the evolution of the US economy: 1948-2002, mimeo.

25. Canova, F. and L. Gambetti, (2004), Structural Changes in the US Economy: Bad Luck or Bad Policy, mimeo.

26. Carroll, C. D. and A. A. Samwick, (1997), The nature of precautionary wealth. Journal of Monetary Economics 40, 41-71.

27. Young, C.E., Ramey,V. A. and R. A. Starr, (1995), Liquidity constraints and intertemporal consumer optimization: Theory and evidence from durable goods," Journal of Money, Credit and Banking 27, 272-287.

28. Clarida, R., Gali J. and M Gertler, (2000), Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory, The Quarterly Journal of Economics, 147-180.

29. Cogley, T. and T.J. Sargent, (2001), Evolving Post-World War II U.S. Inflation Dynamics", NBER Macroeconomic Annual, 16.

30. Cogley, T. and T.J. Sargent, (2003), Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII U.S., New York University, mimeo.

31. Cooley, T. and E. Prescott, Economic Growth and Business Cycles, (1995), in T.Cooley ed., Frontiers of Business Cycle Research (Princeton: Princeton University Press, 1995), 1-38.

32. Cooley, T. F. and V. Quadrini, (1998), Financial markets and firm dynamics. Mimeo, Universitat Pompeu Fabra.

33. Cordoba, J.C and M.Ripoll, (2004), Credit Cycles Redux, forthcoming, International Economic Review.

34. Davis, N. and J. Heathcote, (2005), Housing and the Business Cycle, International Economic review, 751-784.

35. Denizer, C. , Murat Iyigun and A.Owen, (2002), Finance and Macroeconomic Volatility, Contributions to Macroeconomics, Vol. 2: No. 1, Article 7.

36. Driscoll, M., (1991), Deregulation, Credit Rationing, Financial Fragility and Economic Performance, OECD wp 977.

37. Eistfeld, A. and A.A.Rampini, (2005), Capital reallocation and Liquidity, forthcoming, Journal of Monetary Economics.

38. Eistfeld, A. and A.A.Rampini, (2005), New or Used? Investment with Credit Constraints, mimeo.

39. Englund, P., (1996), Loan-to-Value Ratios in Sweden, Scandinavian Housing & Planning Research 13.

40. Fernández-Villaverde, J. and D. Krueger, (2002), Consumption and Saving over the Life-Cycle: How Important are Consumer Durables?, in Proceedings of the North American Summer Meetings of the Econometric Society:Macroeconomic Theory, 2002.

41. Freeman, S. and F. E. Kydland (2000). Monetary aggregates and output,. American Economic Review 90(5), 1125-1145.

42. Gertler, M. (1988), Financial Structure and Aggregate Economic Activity: an Overview, Journal of Money, Credit and Banking, vol.20.

43. Gomme, P., F. Kydland, and P. Rupert, (2001), Home Production Meets Time to Build, Journal of Political Economy 109, 1115-1131.

44. Greenwood, J. and Z. Hercowitz, (1999), The Allocation of Capital and Time over the Business Cycle, Journal of Political Economy 99, 1188-1214.

45. Greenwood, J. , Hercowitz, Z. and P. Krusell, (2000), The Role of Investment-Specific Technological Change in the Business Cycle, European Economic Review 44, 91-115

46. Greenwood, J., R. Rogerson, and R. Wright, (1995), Household Production in Real Business Cycle Theory, in T. Cooley ed., Frontiers of Business Cycle Research (Princeton: Princeton University Press), 157-174.

47. Guerron, P. (2007), Financial Innovation: An Alternative Explanation to the Great Moderation, mimeo.

48. Hanson, M. (2001), Varying Monetary Policy Regimes: a Vector Autoregressive Investigation, Wesleyan University, mimeo.

49. Hodrick, R. J., and E. C. Prescott, (1997), Postwar U.S. Business Cycles: An Empirical Investigation, Journal of Money, Credit and Banking 29, 1-16.

50. Hubbard, R.G., (1997), Capital-Market Imperfections and Investment. NBER Working Paper 5966.

51. Hull L., (2003), Financial Deregulation and Household Indebtedness, DP 2003/01, Reserve Bank of New Zealand.

52. Iacoviello, M., (2005), House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle, American Economic Review, 739-764.

53. Iacoviello, M. and R. Minetti, (2005),International Business Cycles with Domestic and Foreign Lenders , forthcoming Journal of Monetary Economics.

54. Jappelli, T., and M. Pagano (1989), "Aggregate consumption and capital market imperfections: an international comparison", American Economic Review, December, 79, 5, 1088-1105.

55. Jappelli, T., and M. Pagano, (1998), The Determinants of Saving: Lessons from Italy, CSEF working paper.

56. Jovanovic, B., and P. L. Rousseau, (2002), The Q-Theory of Mergers, American Economic Review Papers and Proceedings 91(2), 336-41.

57. Justiniano, A. and G. Primiceri (2006). The time varying volatility of macroeconomic fluctuations.

58. Karras, G., and F. Song, (1996), Sources of business-cycle volatility: an exploratory study on a sample of OECD countries, Journal of Macroeconomics 18, 621–637.

59. Kask, J., (2003), Household Debt and Finacial Stability, Kroon&Economy n 4.

60. King, R, and R. Levine, (1993), Finance and Growth: Schumpeter Might Be Right, Quarterly Journal of Economics 108, 717-737.

61. Kiyotaki, N., (1998), Credit and Business Cycles, The Japanese Economic Review,vol.49, n.1.

62. Kiyotaki, N. and J. Moore, (1997), Credit Cycles, Journal of Political Economy, 211-248.

63. Klein, P., (2000),Using the Generalized Schur Form to Solve a Multi-variate Linear Rational Expectations Model, Journal of Economic Dynamics and Control 24, 1405-1423.

64. Kocherlakota, N.R., (2000), Creating Business Cycles Through Credit Constraints, Federal Reserve Bank of Minneapolis Quartely Review, vol 24, n.3.

65. Larrain, B., (2003), Financial Development, Borrowing Constraints and the Volatility of Industrial Production, mimeo.

66. Larrain, B., (2006), Do Banks Affect the Level and Composition of Industrial Volatility?, Journal of Finance, forthcoming.

67. Levine, R., (1997), Law, Finance, and Economic Growth. University of Virginia, mimeo.

68. Levine, R. (1997), Financial Development and Economic Growth: Views and Agenda, Journal of Economic Literature 35, 688-726.

69. Levine, R., Thorsten B., and A. Demirguc-Kunt, (2001), A New Database on the Structureand Development of the Financial Sector, World Bank Economic Review.

70. Levine, R., Loyaza, N. and T. Beck (2000), Financial Intermediation andGrowth: Causality and Causes, Journal of Monetary Economics 46, 31-77.

71. Long, J. and C. Plosser, (1983), Real Business Cycles, Journal of Political Economy, 91, 39-69.

72. Ma, C.H. and Smith, B. D., (1996), Credit market imperfections and economic development: theory and evidence. Journal of Development Economics, 48, 351-387

73. Maksimovic, V. and G. Phillips, (1998), Asset Efficiency and Reallocation Decisions of Bankrupt Firms, Journal of Finance 53, 1619-1643.

74. McConnell, M. and Perez Quiroz, G., (2000), Output fluctuations in the US: what haschanged since the early 1980s?, American Economic Review, 90, 1464-1476.

75. McKinnon, R., (1973), Money and Capital in Economic Development. Brookings Institution, Washington,DC.

76. Mendicino C. (2006), On the Amplification Role of Collateral Constraints, mimeo.

77. Mercer Oliver Wyman, (2003), Study on the Financial Integration of European Mortgage Markets.

78. Miles D., (1992), Housing Markets, Consumption and Financial Liberalization in the Major Economies, European Economic Review, 36, 1093-1127 .

79. Minsky, H., (1986), Stabilizing an Unstable Economy. Yale University Press, New Haven.

80. Minshkin, F., (2000), Financial Stability and the Macroeconomy, WP 9, Central Bank of Iceland.

81. Morgan,D.P., Rime, B., and P.E. Strhan, (2004), Bank Integration and State Business Cycles, Quarterly Journal of Economics 119, 1555-85.

82. Ortalo-Magné, F. and S. Rady, (2001), Housing Market Dynamics: On the Contribution of Income Shocks and Credit Constraints, CEPR Working Paper 3015.

83. Pagano, M., (1993), Financial markets and growth: an overview. European Economic Review, 37, 613-622

84. Poterba, J., (2000), Stock Market Wealth and Consumption, Journal of Economic Perspectives, 14, Spring, 99-118.

85. Quadrini V. and U. Jerman (2005), Financial Development and Macroeconomic Stability, mimeo.

86. Rajan, R., (1994), Why bank credit policies fluctuate: a theory and some evidence. Quarterly Journal ofEconomics 109, 399–441

87. Ramey, G., and V. Ramey (1995), Cross-Country Evidence on the Link Between-Volatility and Growth, American Economic Review 85, 1138-51.

88. Ramey V.A. and M.D. Shapiro, (1998a), Capital Churning, mimeo.

89. Ramey, V. A., and M. D. Shapiro, (1998b), Costly Capital Reallocation and the Effects of Government Spending, Carnegie-Rochester Conference Series on Public Policy 48, 145-94.

90. Rampini, A. A., (2003), Entrepreneurial Activity, Risk, and the Business Cycle, Working Paper.

91. Sims, C., (2001), Comment to Evolving post WWII US inflation dynamics, NBER Macroeconomic Annual, 16.

92. Sims, C.A. and T. Zha, (2004), Were there Regime Switches in US Monetary Policy,Federal Reserve Bank of Atlanta, working paper 2004 -14.

93. Stock, J., and M. Watson, (1998), Business cycle fluctuations in US macroeconomic time series, NBER Working Paper 6528.

94. Stock, J. and M. Watson, (2003), Understanding Changes in Business Cycle Dynamics, Harvard University, mimeo.

95. Suarez, J., and O. Sussman, (1997), Endogenous cycles in a Stiglitz–Weiss economy, Journal of Economic Theory 76, 47–71.

96. Uhlig, H., (1995), A toolkit for analyzing nonlinear dynamic stochastic models easily, Institute for Empirical Macroeconomics DP 101.

97. Vlieghe G.W., (2003), Imperfect Credit Markets and the Transmission of Macroeconomic Shocks: A Simple Framework, mimeo lse.

98. Watson, M., (1994), Business-cycle durations and postwar stabilization of the US economy, American Economic Review 84, 24–46.

99. Weinberg, J., (1995), Cycles in lending standards, Federal Reserve Bank of Richmond Economic Quarterly 81, 1–18

100. Wited,T., (1992), Debt, Liquidity Constraint, and Corporate Investment: Evidence from Panel Data, Journal of Finance, XLVII, 4.

Table 1: Correlation with Credit Market Size

Countries 20, Period 1983-2004

	$\sigma(y)$	$\sigma(c)$	$\sigma(I)$	$\sigma(Ih)$	$\sigma(q)$
credit	-0.2992**	-0.2089**	-0.2498**	-0.2575**	-0.1052*

σ(y),σ(c),σ(I), σ(ih), standard deviation of respectively detrended log real output, consumption, investment andinvestment in residential properties. σ(q) standard deviation of detrended log housing prices, *credit* stands for credit to the private sector as a share of gdp, is the ratio during the same period. Three years avagages Data on 20 OECD countries. Source: OECD. 1 and 5 per cent significant coefficients respectively one and two stars.

Table 2: Credit and Output Volatility. Fixed Effects

credit*solow	*-0.137519*	*-0.132813*	**-0.179567**
	(0.079350)	(0.077951)	(0.110335)
σ(solow)	**0.626929**	**0.630919**	**0.702902**
	(0.144504)	(0.143700)	(0.175903)
credit	0.229395	0.293451	0.287628
	(0.369062)	(0.408291)	(0.460433)
R^2	0.570027	0.589365	0.583302
Countries	20	20	20
obs	140	140	140
Period	1983-04	1983-04	1983-04

Dependent Variable, σ(y), standard deviation of detrended log real output.
Credit is the credit market size averaged over the 3 year period.
Col 2. controls: volatility of interest rate, terms of trade, cpi
Col 3. controls: property rights, volatility of interest rate, terms of trade, cpi
Panel regressions based on 3-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

Table 3: Credit and Output Volatility. Fixed Effects

credit*solow	**-0.179567**	**-0.182865**	**-0.302671**
	(0.110335)	(0.049198)	(0.085678)
σ(solow)	**0.702902**	**0.686364**	**1.020229**
	(0.175903)	(0.166009)	(0.205955)
credit	0.287628	0.293451	
	(0.502297)	(0.426280)	
R^2	0.583302	0.595468	0.586303
Countries	20	20	20
obs	140	140	140
Period	1983-04	1983-04	1983-04

Dependent Variable, σ(y), standard deviation of detrended log real output.
Col. 1: Credit is the credit market size averaged over the 3 year period.
Col. 2: Credit is the credit market size at the beginning of the period
Col. 3: Credit is the credit market size averaged over the all period
Controls: property rights, volatility of interest rate, terms of trade, cpi. Panel based on 3-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.

Table 4: Parameter Values

preferences		**shock process**	
discount rate	$\beta_1 = 0.99$	autocorrelation	$\rho_z = 0/0.95$
	$\beta_2 = 0.95$	variance	
	$\varphi = 2.2$		
technology			
	$\alpha = 0.36$	**borrowing limit**	$\gamma \in [0, 1]$
depreciation rate	$\delta = 0.03$	**population**	$n = 0.5$

Table 5: Volatility Simulated Series

	$\sigma(y)$	$\frac{\sigma(I)}{\sigma(C)}$	$\sigma(q)$
0.2	1.3462	2.1377	1.4915
0.5	1.3096	1.7570	1.3398
0.9	1.1155	1.2514	1.0374

Output Volatility and Credit Market Size

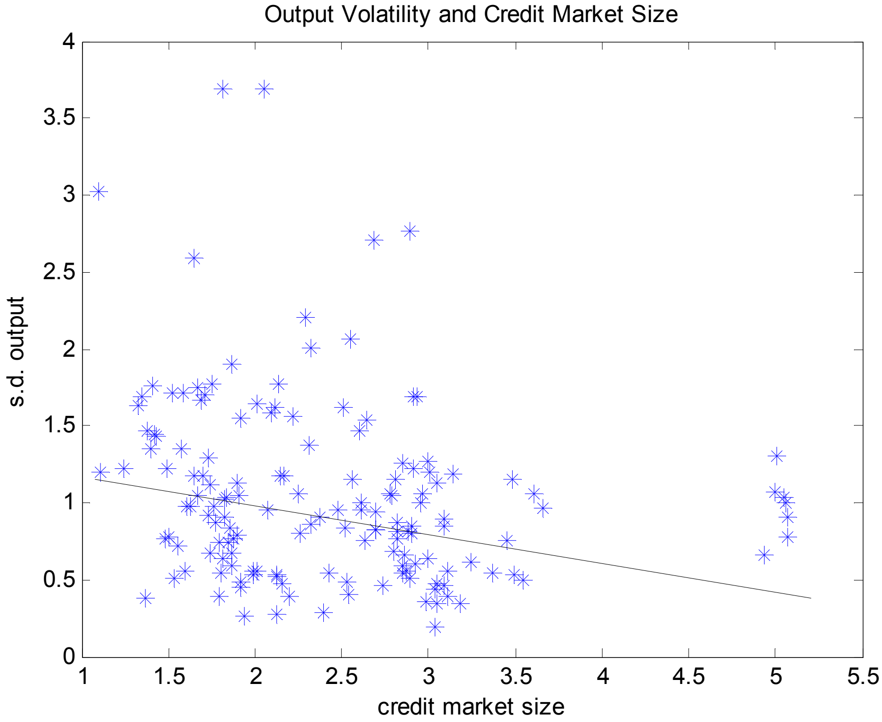


Figure 1a plots the measure of credit market development against the measure of business cycle volatility. Output's standard deviations as well as the average of private credit as a share of Gdp are calculated on quarterly data for 3 non-overlapping year

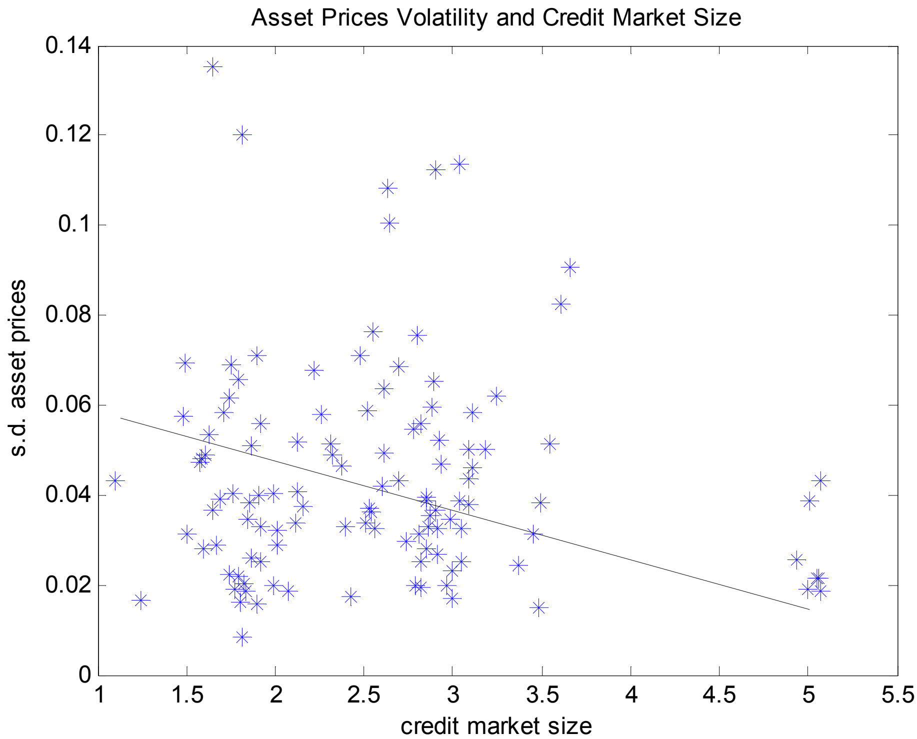


Figure 1b plots the measure of credit market development against the measure of business cycle volatility. Asset Prices ' standard deviations as well as the average of private credit as a share of Gdp are on quarterly data for 3 non-overlapping year

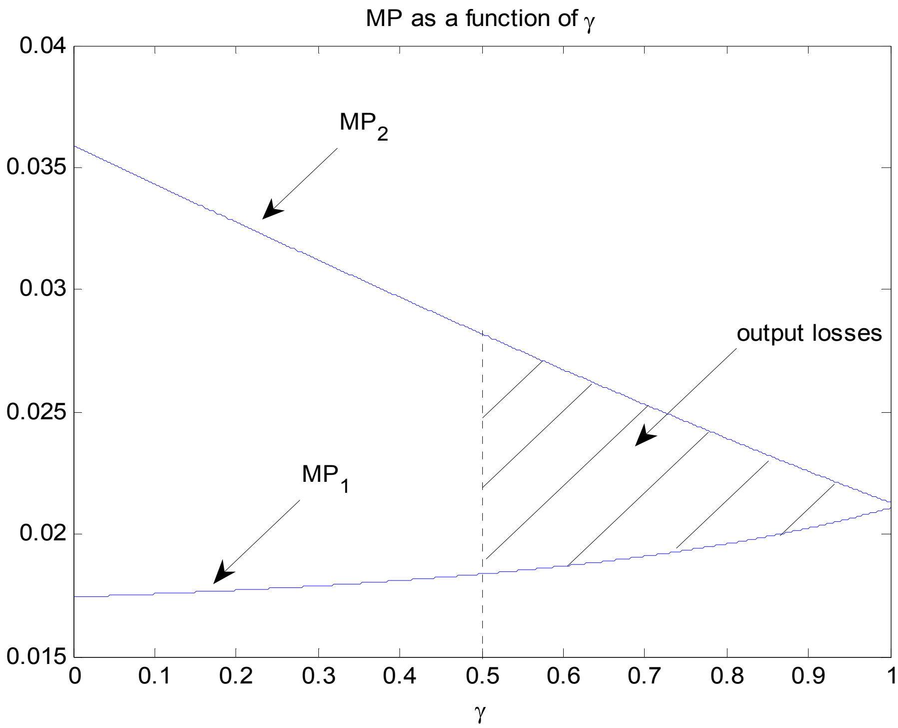
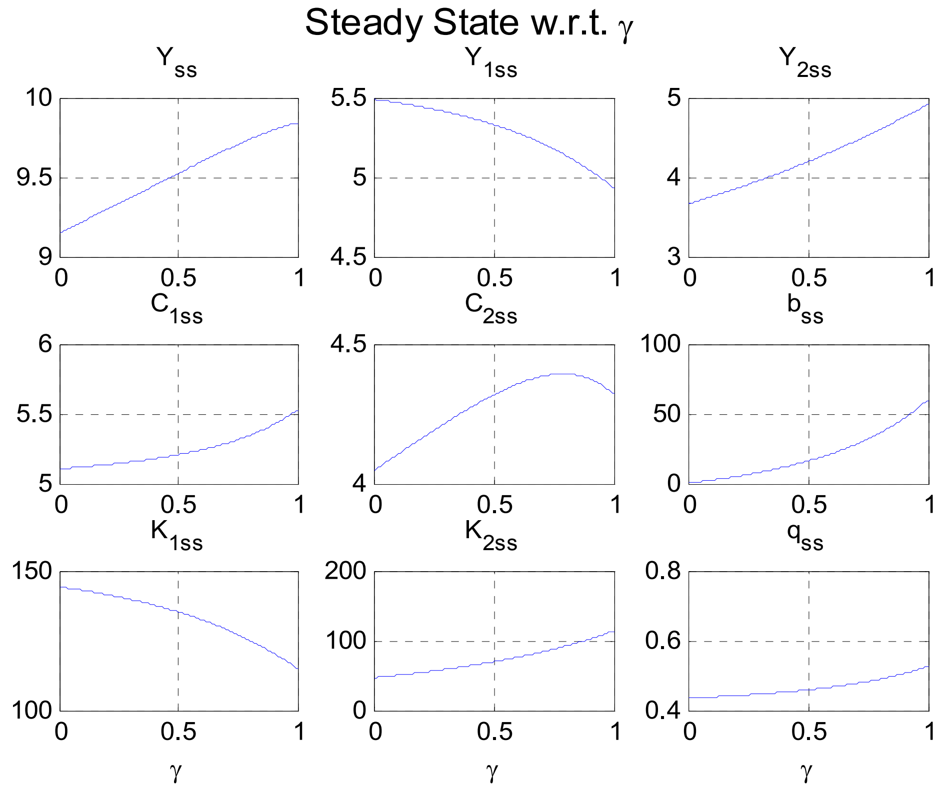


Figure 2.a shows how the steady state productivity gap in total production between the two groups of agents varies with respect to γ.



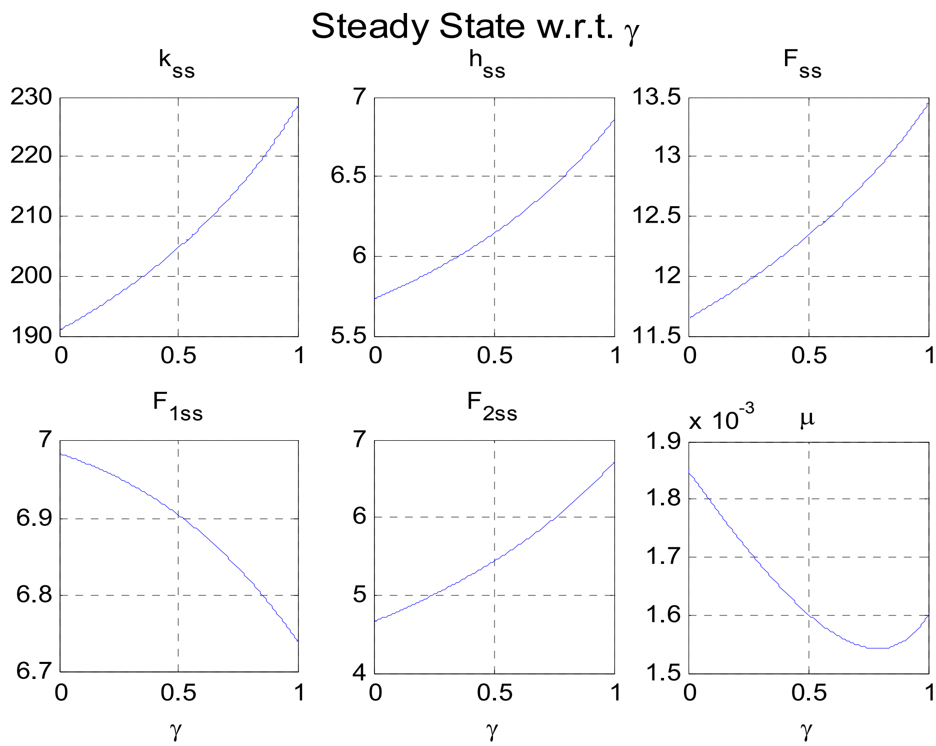


Figure 2.b shows how the steady state values of the model's variables change with respect to the degree of credit market development γ.

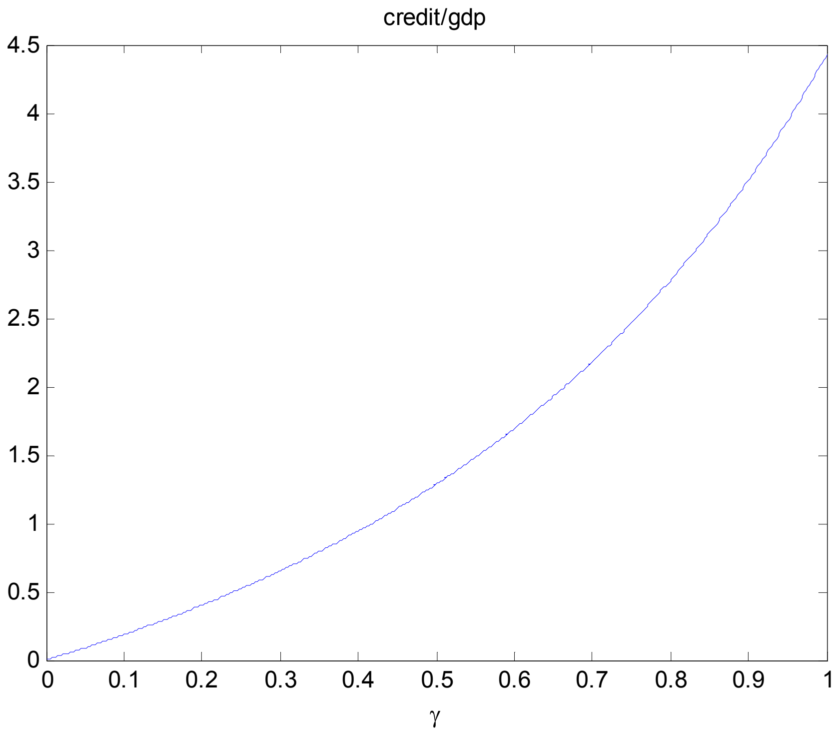


Figure 2.c shows how the steady state values of the size of the credit market change with respect to the degree of credit market development γ.

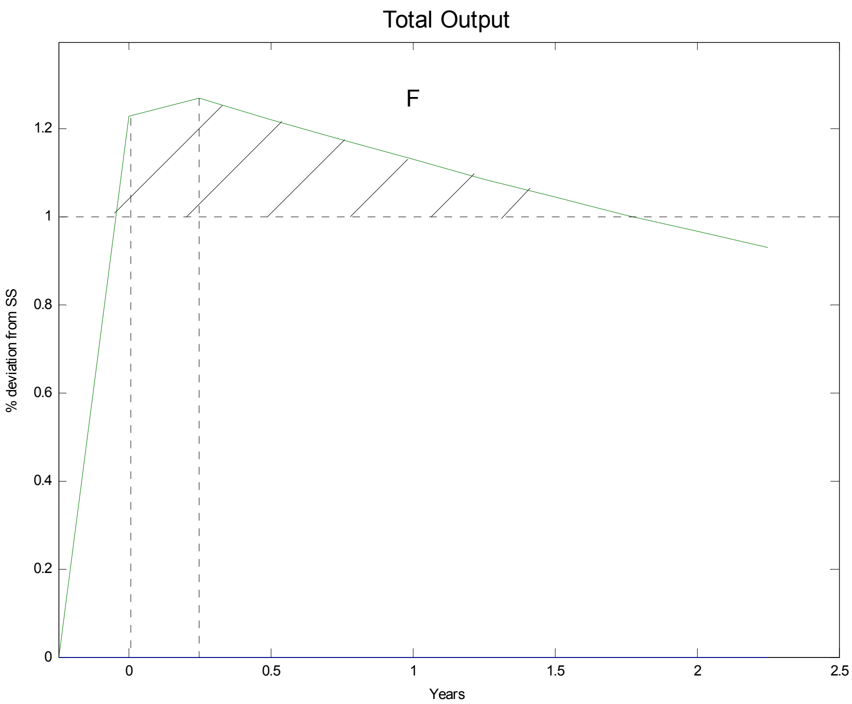


Figure 3.a shows the response of total aggregate output to a 1% increase in productivity.

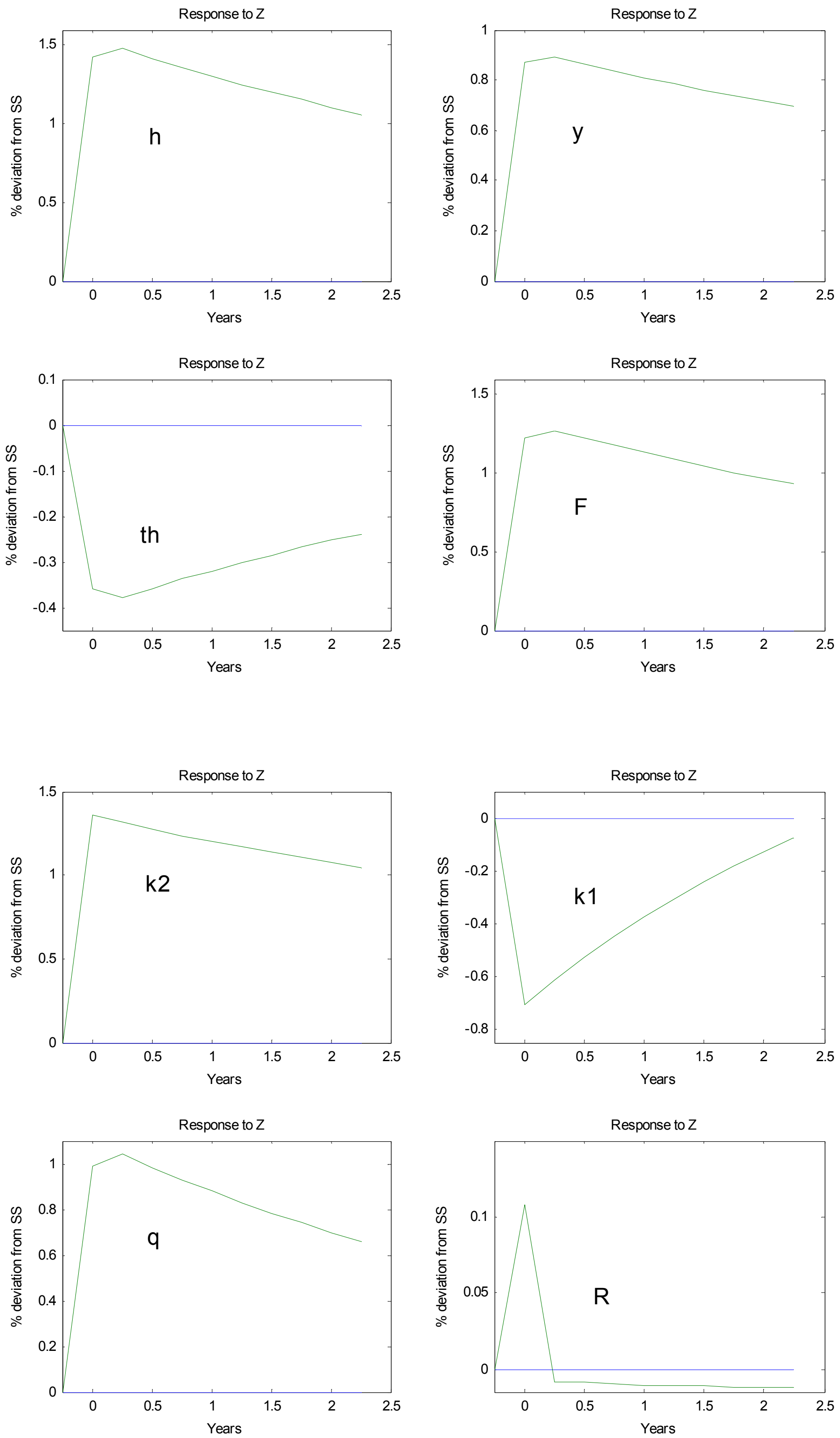


Figure 3.b shows the responses to a 1% increase in productivity.

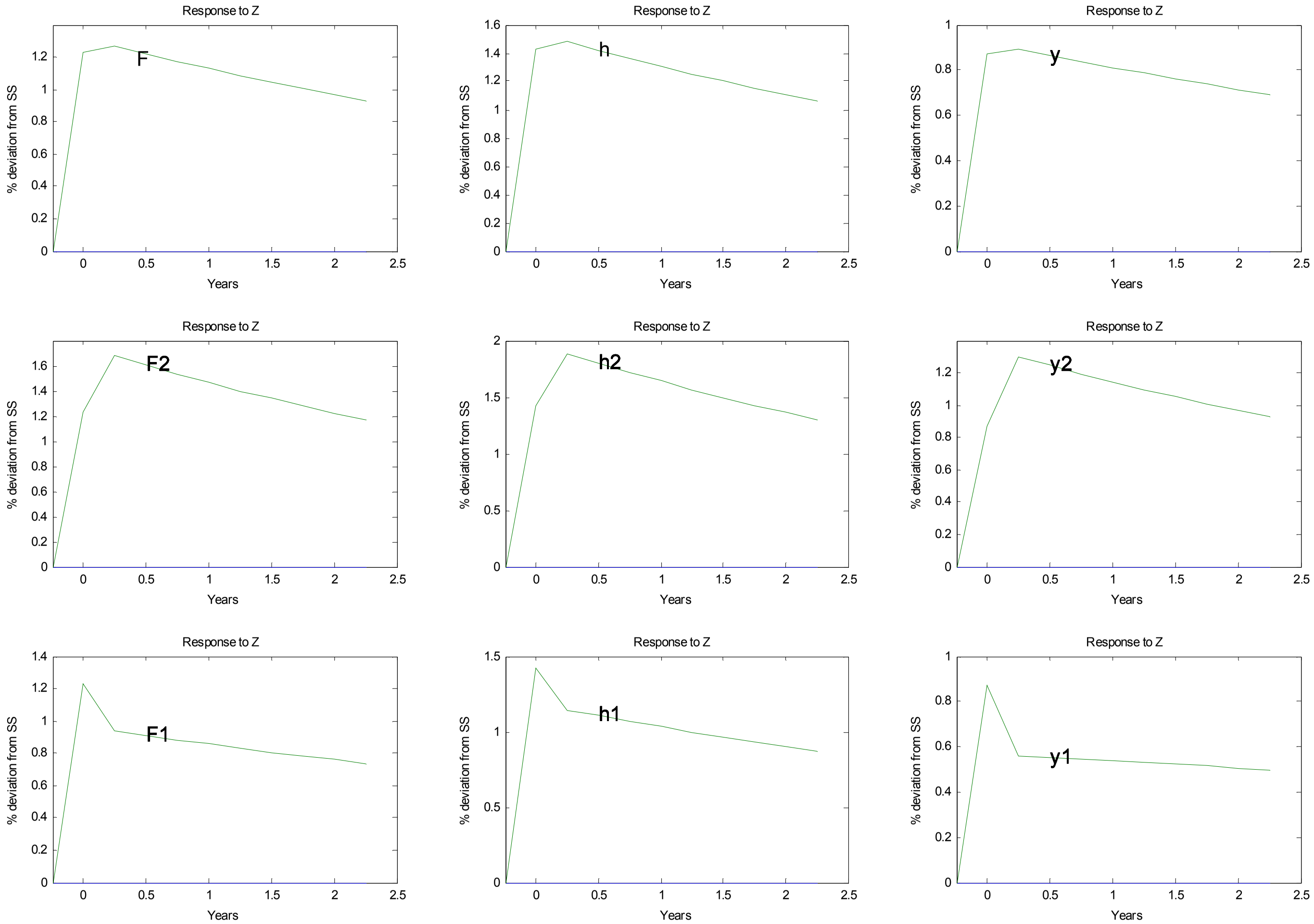


Figure 3.c: responses of the model economy to an unexpected 1% increase in aggregate productivity. The units on the vertical axes are percentage deviations from the steady state, while on the horizontal axes are years.

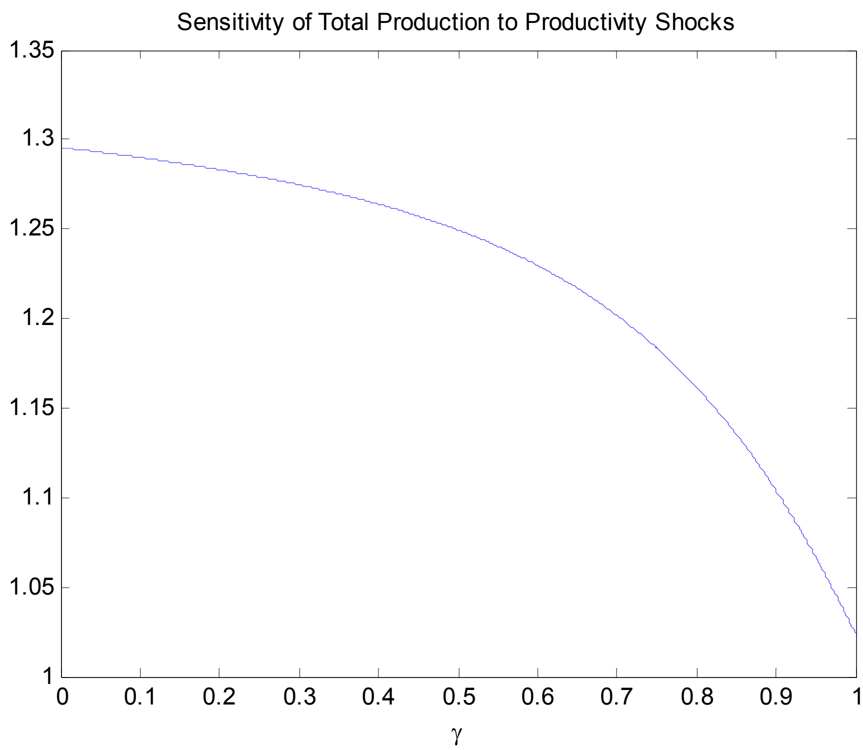


Figure 4.a: first impact of the shock on production -- i.e. the intensity of reaction for any given γ

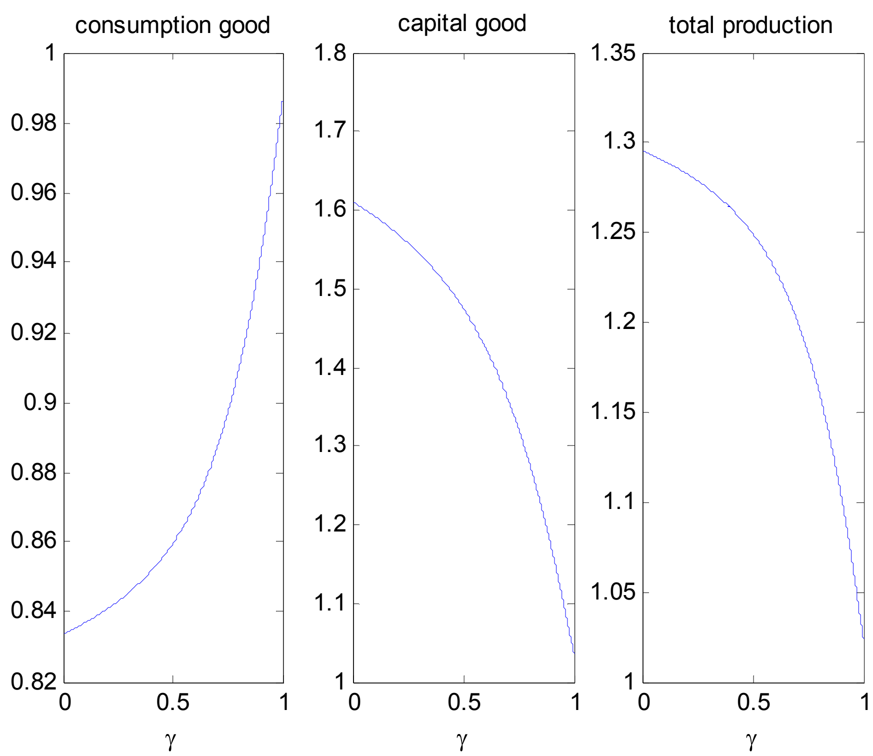


Figure 4.b: first impact of the shock on production -- i.e. the intensity of reaction for any given γ

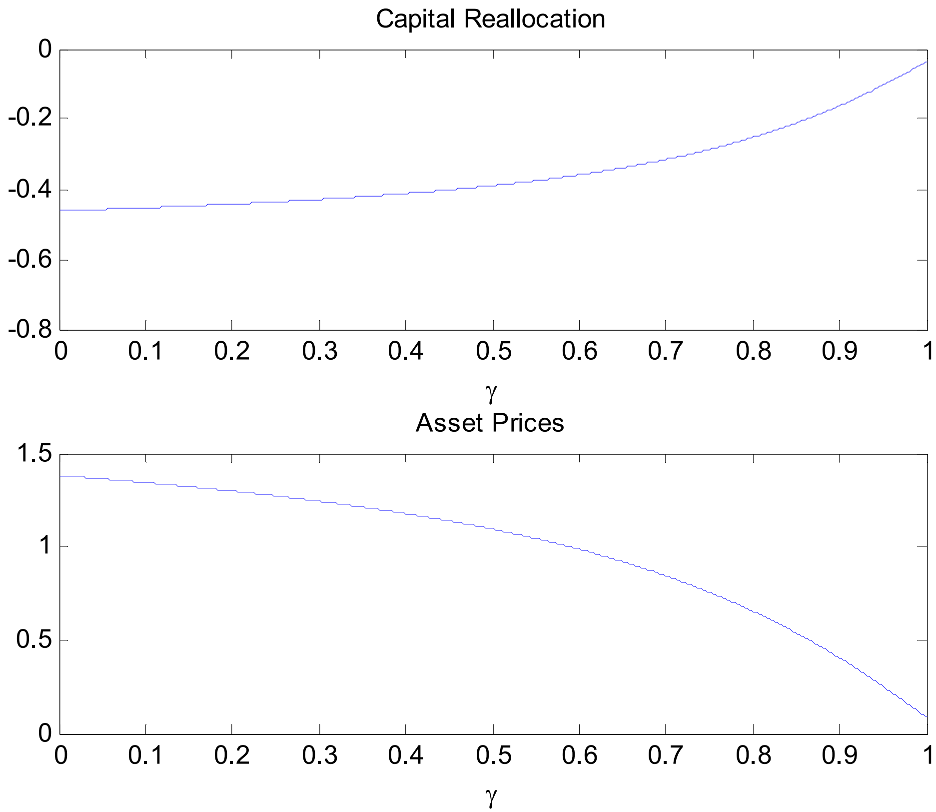


Figure 4.c: first impact of the shock capital reallocation and asset prices.

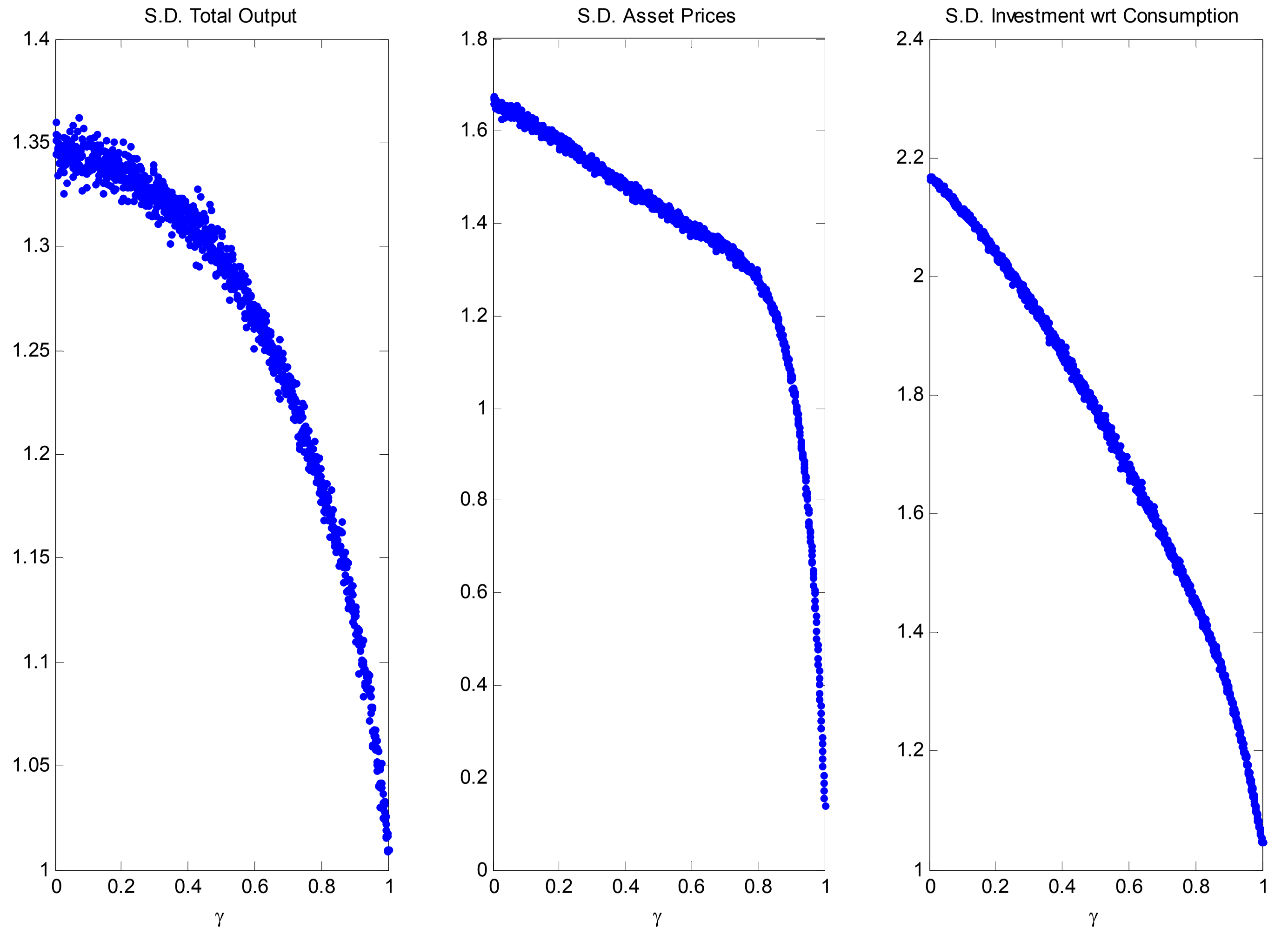
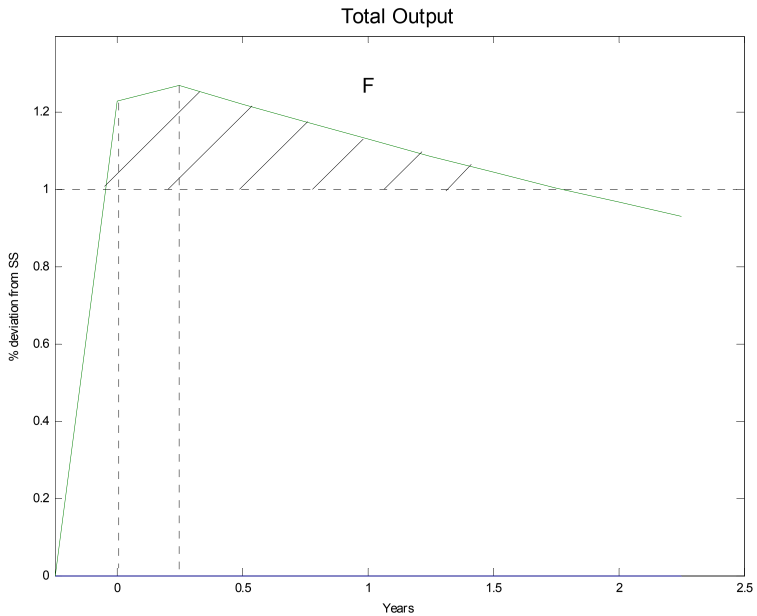


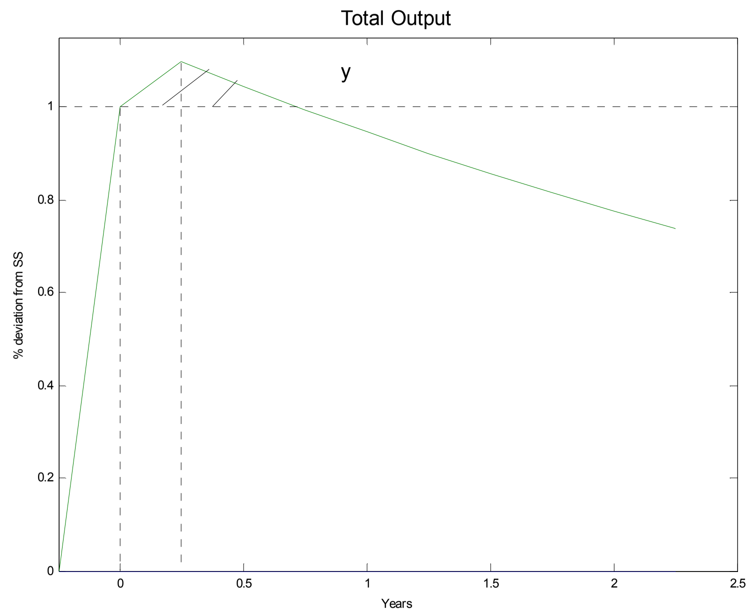
Figure 5: standard deviations given a particular value for γ.

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 6.a shows the response of total aggregate output to a 1% increase in productivity in the two-sector and one-sector model

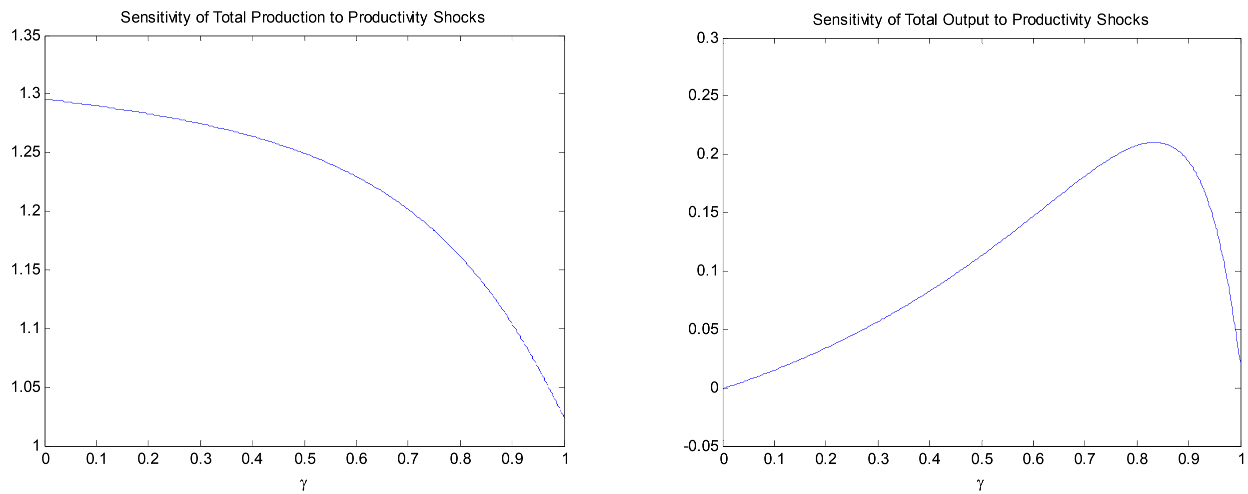


Figure 6.b: first impact of the shock on production -- i.e. the intensity of reaction for any given γ

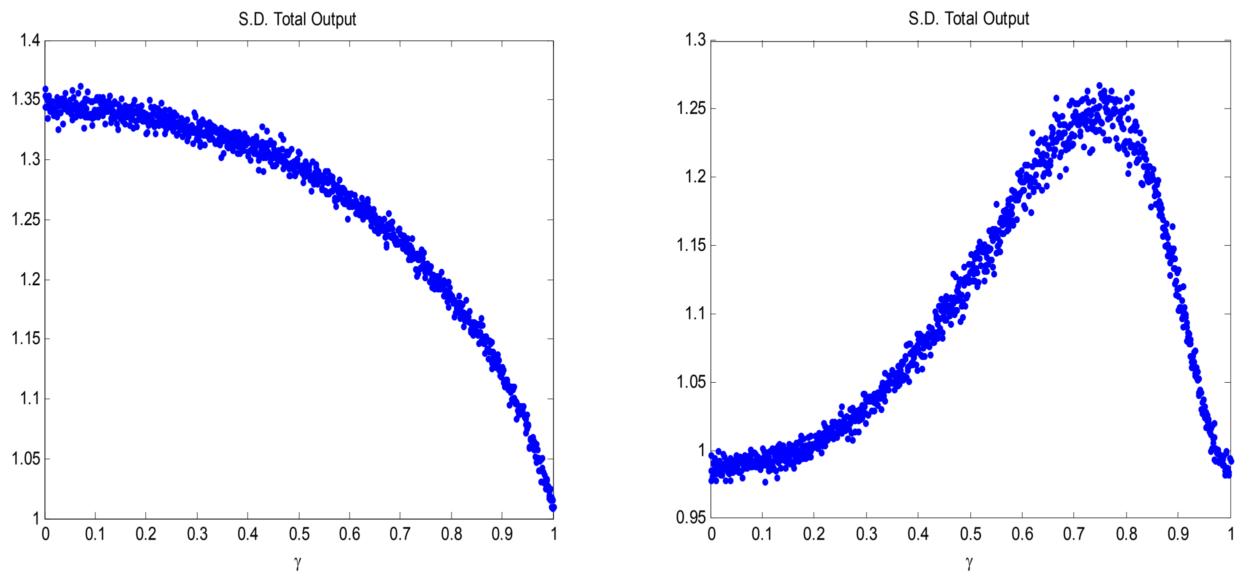


Figure 6.c : each point represents the standard deviations given a particular value for γ

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