

WORKING PAPERS

15 | 2011

**ON THE AMPLIFICATION ROLE OF
COLLATERAL CONSTRAINTS**

Caterina Mendicino

May 2011

The analyses, opinions and findings of these papers represent the views of the authors, they are not necessarily those of the Banco de Portugal or the Eurosystem

Please address correspondence to
Caterina Mendicino
Banco de Portugal, Economics and Research Department
Av. Almirante Reis 71, 1150-012 Lisboa, Portugal;
Tel.: 351 21 313 0063, email: cmendicino@bportugal.pt



Banco de Portugal
EUROSYSTEM

BANCO DE PORTUGAL

Av. Almirante Reis, 71

1150-012 Lisboa

www.bportugal.pt

Edition

Economics and Research Department

Pre-press and Distribution

Administrative Services Department

Documentation, Editing and Museum Division

Editing and Publishing Unit

Printing

Administrative Services Department

Logistics Division

Lisbon, May 2011

Number of copies

150

ISBN 978-989-678-084-5

ISSN 0870-0117 (print)

ISSN 2182-0422 (online)

Legal Deposit no. 3664/83

On the Amplification Role of Collateral Constraints*

Caterina Mendicino[†]

Abstract

How important are collateral constraints for the propagation and amplification of shocks? To address this question, we analyze a stochastic general equilibrium version of the model by Kiyotaki and Moore (JPE, 1997) in which all agents face concave production and utility functions and are generally identical, except for the subjective discount factor. We document that the existence of costly debt enforcement plays an important role in the endogenous amplification generated by the model. Limiting the amount of borrowing up to a reasonable fraction of the value of the collateral asset, makes the amplification generated by collateral constraints sizable and significantly larger than what we observe either in the representative agent version of the model, or in the version of the model where inefficiencies in the liquidation of the collateralized asset are neglected.

JEL: E 20, E 3, E 21.

Key Words: Business cycle, Debt Enforcement Procedures, Endogenous Borrowing Limits.

*An earlier version of this paper circulated as Bank of Canada working paper 2008-23. I have benefited from extensive discussions with Martin Floden, Zvi Hercowitz, Lars Ljungqvist and Nobu Kiyotaki. I am also grateful to Kosuke Aoki, Giancarlo Corsetti, Carlos De Resende, Nikolay Iskrev and John Leahy for useful feedbacks on this project. I thank seminar participants at the 2008 Annual Meeting of the American Economic Association, 2007 meeting of the Society of Computational Economics, 11th meeting Society of Computational Economics and Finance, 2006 Far East Meeting of the Econometric Society, XXX Simposio de Analisis Economico, 2005 meeting Money-Macro Finance group, X Vigo workshop on Dynamic Macroeconomics, Swedish Riksbank, European University Institute, ECB, Bank of Canada and Bank of Portugal for valuable suggestions. This paper is built on the second chapter of my dissertation. All remaining errors are mine.

[†]Banco de Portugal, Research Department and UNICEE Catolica-Lisbon. Email: caterina.mendicino@bportugal.pt; Homepage: <http://sites.google.com/site/caterinamendicino/>

1 Introduction

Standard Real Business Cycle theories succeed in accounting for business cycle observations of aggregate quantities, such as output, investment and consumption, by relying mainly on large and persistent aggregate productivity shocks. Kiyotaki and Moore (1997) and Kiyotaki (1998) show that if debt is fully secured by collateral, even small and temporary productivity shocks can have large and persistent effects on economic activity. Kiyotaki and Moore's theoretical work has been very influential and an increasing number of papers have documented the contribution of collateral constraints to business cycle fluctuations. Collateralized debt is becoming a popular feature of business cycle models.¹ A common assumption in this strand of the business cycle literature is that debt enforcement procedures are costly and lenders limit the agents' ability to borrow to a fraction of the value of their collateral.

Kocherlakota (2000) and Cordoba and Ripoll (2004) demonstrated that collateral constraints *per se* are unable to propagate and amplify exogenous shocks. In particular, Cordoba and Ripoll (2004) document that the endogenous amplification generated by Kiyotaki and Moore (1997) is driven by unorthodox assumptions on agents' preferences – i.e. lenders' linear utility – and technology – i.e. borrowers' linear technology in the collateral asset. As a result, in a modified version of the model in which all agents face the same concave preferences and production technologies, no amplification is found. The authors find that models with collateral constraints require implausible parameters' values in order to generate amplification. Moreover, allowing for the input of production to be elastically supplied decreases the sensitivity of output to productivity shocks.

Papers on the amplification role of collateral constraints have neglected the role of inefficiencies in the liquidation of the collateralized assets. As docu-

¹For instance, on the international transmission of business cycles, see Iacoviello and Minetti (2007); on the role of the housing and collateralized debt in the transmission and amplification of shocks, see Iacoviello (2005) and Iacoviello and Neri (2010); on the macroeconomic implications of mortgage market deregulation, see Campbell and Hercowitz (2005); on the business cycle implications for durables and non-durables see Sterk (2010); on the role of nominal debt in sudden stops, see Mendoza (2006) and Mendoza and Smith (2006); on overborrowing Uribe (2007).

mented by Djankov, Hart, McLiesh and Shleifer (2008) debt enforcement procedures around the world are significantly inefficient. Worldwide an average of 48 percent of an insolvent firm's value is lost in debt enforcement. Thus, limiting the amount lent to a fraction of the value of the asset turns out to be a reasonable assumption.

We aim to reconcile these two strands of the business cycle literature by exploring the role of costly debt enforcement procedures in the amplification of productivity shocks through collateral constraints. To this purpose we allow for costly repossession of the collateralized asset in a stochastic general equilibrium version of the model by Kiyotaki and Moore (1997) modified as in Cordoba and Ripoll (2004). Accordingly, we assume that a fraction of the collateral value is lost in debt enforcement and lenders are not willing to lend the full amount of the collateral value. Moreover, all agents face concave production and utility functions and are generally identical, except for the subjective discount factor.

This paper provides several insightful results. First, even under collateral constraints, when inefficiencies in the liquidation of the collateralized asset are neglected, the misallocation of the factor of production in the economy is negligible. The reason is as follows. Borrowers, limited in their capital holding by the existence of credit constraints, experience higher marginal productivity of capital. Thus, lower degrees of inefficiencies in the credit market, as proxied by higher Loan-to-Value (LTV henceforth) ratio – i.e. the fraction of the collateral asset up to which agents are allowed to borrow – imply less sizable differences between borrowers and lenders in terms of their capital holding and, thus, their marginal productivity. We show that when agents can borrow the full amount of their collateral value, the allocation of capital under collateral constraints is very close to the allocation in the frictionless economy, and credit frictions in the form of collateral constraints do not have sizable implications for aggregate production.

Second, the sensitivity of output to productivity shocks depends on the redistribution of capital between borrowers and lenders and varies in a non-linear way with respect to the LTV ratio. The intuition is as follows. Lower

LTV ratios imply larger difference between borrowers' and lenders' productivity and more sizable gains from a better allocation of resources. Nevertheless, the redistribution of capital to the borrowers is limited by the low LTV ratio itself that restricts the access to external funds. In contrast, high LTV ratios allow for a larger redistribution of capital among agents but are associated to smaller differences in the marginal productivity of capital. Thus, the overall gains from the redistribution are low. At an intermediate level of LTV ratios, collateral constraints amplify the effects of productivity shocks on output and generate sizable endogenous persistence even under standard assumptions on preferences and technology. For reasonable LTV ratios collateral constraints significantly amplify the effects of productivity shocks on output even under standard assumptions on preferences and technology.

Robustness analysis also delivers interesting results. Allowing for capital to be elastically supplied dampens the amplification of shocks only when agents can borrow almost the all amount of the collateral asset. When capital is reproducible, movements in the relative price of capital enter the measurement of aggregate output and directly affect the transmission of shocks to output. Since lower LTV ratios are related to larger differences in productivity between borrowers and lenders, more capital is needed to fill the productivity gap and the sensitivity of the relative price of capital to productivity shocks is larger. Thus, under the assumption of inefficiencies in the liquidation of the collateralized asset, the relative-price effect generates much larger endogenous amplification and persistence of shocks on output than in the benchmark model.

We also find that the role of the LTV ratio for amplification is independent from the other parameters and our results are, thus, robust to alternative calibrations. Moreover, when agents cannot borrow the full amount of the collateral value, the effect of changes in the LTV ratio on the solution of the model are not similar to changes in other parameters. Using the local identification procedures developed by Iskrev (2010.a), we find that in the first-order approximate solution all parameters are locally identifiable and, thus, no multicollinearity in terms of the solution of the model is found between the degree of inefficiencies

in the credit market and the other parameters. Thus, we can conclude that the effect of changing the degree of inefficiency in the debt enforcement procedure is not locally almost the same as changing other parameters.

Last, we relax the common assumption of always-binding constraints and deal with the occasionally-binding constraints using a penalty-function algorithm.² As a result, we document that our results also hold under alternative assumptions regarding the binding nature of the collateral constraint.

The paper is organized as follows. Section 2 presents the benchmark model economy and Section 3 the steady state implications. Section 4 studies the transmission and amplification of productivity shocks. Section 5 conducts robustness. Section 6 draws some conclusions.

2 The Model Economy

We adopt a two-agents close-economy model *à la* Kiyotaki and Moore (1997) modified as in Corboda and Ripoll (2004) to introduce standard assumptions on preferences and technology. The economy is populated by two types of agents who 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 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 one unit of the durable asset can be exchanged for q_t units of the consumption good, and the credit market. The economy is populated by a continuum of heterogeneous agents of unit mass: m_1 *Patient Entrepreneurs* (denoted by 1) and m_2 *Impatient Entrepreneurs* (denoted by 2). Ex-ante heterogeneity on the subjective discount factor – $\beta_2 < \beta_1 < 1$ – is assumed in order to impose the existence of flows of credit in this economy.

Agents of type $i - i = 1, 2$ – maximize their expected lifetime utility as given

²For the use of a "barrier method" to deal with inequality constraints, see among others Den Haan and Oaktan (2009), Den Haan and De Wind (2010), Kim, Kollmann and Kim (2009) Judd (1998), and Preston and Roca (2006).

by

$$\max_{\{c_{it}, k_{it}, b_{it}\}} E_0 \sum_{t=0}^{\infty} (\beta_i)^t U(c_{it})$$

s.t. a budget constraint

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

where y_{it} is the individual production, k_{it} is a durable asset, c_{it} , a consumption good, and b_{it} , the debt level.

Technology is specific to each producer and only the household that started the production has the skills necessary to complete the process. Nevertheless, agents cannot precommit to produce. This means that if household i decides not to put his effort into production between t and $t + 1$, there would be no output at $t + 1$, but only the asset k_{it} . Agents are free to walk away from the production process and from debt contracts between t and $t + 1$. This results in a default problem that makes lenders willing to protect themselves by collateralizing the borrower's asset. Lenders know that if the borrower chooses not to produce and neglects his debt obligations, they can still get his asset. However, lenders can repossess the borrower's assets only after paying a proportional transaction cost, $[(1 - \gamma)E_t q_{t+1} k_{it}]$. Thus, lending is limited to a fraction, γ , of the value of the asset, such that next period's repayment obligation cannot exceed the expected value of next period assets,

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

The lower γ , the more costly, and, thus, inefficient the debt enforcement procedure. The fraction γ , referred to as the LTV ratio, should not exceed one and is treated as exogenous to the model.

Agents' optimal choices of bonds and capital are characterized by:

$$\frac{U_{c_{i,t}}}{R_t} \geq \beta_i E_t U_{c_{i,t+1}} \quad (2)$$

and

$$q_t - \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} q_{t+1} \geq \beta_i E_t \frac{U_{c_{i,t+1}}}{U_{c_{i,t}}} (F_{k_i,t+1}), \quad (3)$$

where $F_{k_i,t}$ 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, $\left[q_t - \beta_i E_t \frac{U_{c_i,t+1}}{U_{c_i,t}} q_{t+1} \right]$, is greater than or equal to the expected discounted marginal product of capital.

Heterogeneity in the discount factors ensures that in equilibrium patient households lend and impatient households borrow. Thus, for impatient agents, the marginal benefit of borrowing is always bigger than its marginal cost. If $\mu_{2,t} \geq 0$ is the multiplier associated with the borrowing constraint, then the Euler equation becomes:

$$\frac{U_{c_2,t}}{R_t} - \mu_{2,t} = \beta_2 E_t U_{c_2,t+1}. \quad (4)$$

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:

$$q_t - \beta_2 E_t \frac{U_{c_2,t+1}}{U_{c_2,t}} q_{t+1} = \beta_2 E_t \frac{U_{c_2,t+1}}{U_{c_2,t}} (F_{k_2,t+1}) + \gamma E_t q_{t+1} \frac{\mu_{2,t}}{U_{c_2,t}}. \quad (5)$$

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. This additional return encourages borrowers to accumulate capital even though they discount the revenues more heavily than lenders. As long as the marginal product of capital differs from its market price, borrowers have an incentive to change the capital stock.

The lenders' capital decision is instead determined at the point where the opportunity cost of holding capital equals its marginal product:

$$q_t - \beta_1 E_t \frac{U_{c_1,t+1}}{U_{c_1,t}} q_{t+1} = \beta_1 E_t \frac{U_{c_1,t+1}}{U_{c_1,t}} (F_{k_1,t+1}). \quad (6)$$

In the benchmark model the durable asset, k , does not depreciate and has a fixed supply normalized to one.

Both agents produce the commodity good using the same technology:

$$y_{it} = Z_t k_{it-1}^\alpha \quad (7)$$

where Z_t represents a temporary aggregate productivity shock. The shock follows an AR(1) process. Unlike Kiyotaki and Moore (1997), we assume that agents have the same concave production technology. Kiyotaki and Moore (1997) take the two groups of agents to represent two different sectors of the economy. As already highlighted by Corboda and Ripoll (2004) this assumption contributes to exacerbate amplification in the model. Thus, we assume that agents have access to the same concave production technology: $\alpha_1 = \alpha_2 < 1$.

The total stock of capital k_t is given by:

$$k_t = m_1 k_{1t} + m_2 k_{2t}. \quad (8)$$

The following conditions also hold

$$y_t = m_1 y_{1t} + m_2 y_{2t} = m_1 c_{1t} + m_2 c_{2t}, \quad (9)$$

$$m_1 b_{1t} = -m_2 b_{2t}. \quad (10)$$

3 Steady State

3.1 Benchmark Parameter Values

We set the model's parameters to values commonly used in the literature.³ Patient households' discount factor is set equal to 0.99, such that the average annual rate of return is about 4 percent. As a benchmark case, we set the discount factor for impatient agents, β_2 , equals 0.91 and the fraction of borrowers, m , to 50 percent. Given the following utility

$$U(c_{it}) = \frac{c_{it}^{1-\sigma}}{1-\sigma},$$

we set the coefficient of relative risk aversion, σ , equal to 2.2. For the share of capital in production we set $\alpha = 0.4$. The persistence of the aggregate productivity shock is set equal to 0.55. See section 5.2 for robustness to alternative parameters' value.

³See, among others, See among others, Iacoviello and Minetti (2007), Iacoviello (2005), Iacoviello and Neri (2010), Campbell and Hercowitz (2005), Sterk (2010).

For an illustrative purpose, we assume a LTV of 85 percent. Experimental, institutional and macro evidence suggest a calibration for γ below one. Djankov, Hart, McLiesh and Shleifer (2008) find an average of 48 percent of the firm's value is lost in debt enforcement worldwide, around 24 percent among OECD countries and about 14 percent in the US, which correspond to a LTV ratio of 76 and 86 percent, respectively.

Iacoviello (2005) using limited information methods, estimate a business cycle model for the US economy and reports a LTV ratio of 89 percent for the entrepreneurial real estate and 55 percent for the household real estate.⁴ Osborne(2005) report an average LTV ratio in the US mortgage market of 75-80 percent, while Calza et al (2010) document a typical LTV ratio of 80 percent. According to Calza et al (2010) the typical LTV ratios imposed on new loans in the mortgage market vary significantly among OECD countries and range between 50 percent in Italy and up to 90 percent in the Netherlands and the UK. Similar ratios are reported by Osborne (2005).

3.2 Credit Market and Deterministic Steady State

In what follows, we analyze how the deterministic steady state of the model is affected by the equity requirements as proxied by γ . In the deterministic steady state impatient agents are 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 the steady state

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

Since the steady state interest rate is determined by the discount factor of the patient agent:

$$\mu_2 = \left(\frac{1}{R} - \beta_2 \right) u_{c_2} = (\beta_1 - \beta_2) u_{c_2}; \quad (11)$$

⁴Flow of funds data for the US over the last 3 decades give an average ratio of outstanding loans over total assets for the non farm non financial business sector of about 79 percent.

As long as $\beta_2 < \beta_1 < 1$, the lagrange multiplier associated with the borrowing constraint for the impatient household is strictly positive. Thus,

$$b_2 = \gamma [qk_2] \text{ and } k_2 = \frac{W_2 - c_2}{[q - \gamma \frac{q}{R}]},$$

where $W_2 = y_2 + qk_2 - b_2$ is the impatient agent's wealth and $d = [q - \gamma \frac{q}{R}]$ 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. The higher γ the lower the downpayment requirement.

Figure 1 shows the marginal productivity of capital for the two groups of agents as a function of γ in the benchmark model. Using the equations representing the households' optimal choice of capital evaluated at the steady state it is possible to show that as long as $\gamma < \frac{1}{\beta_1}$,

$$\frac{K_1}{K_2} = \left\{ \frac{m_1 \beta_1 [1 - \beta_2 - \gamma(\beta_1 - \beta_2)]}{m_2 \beta_2 [1 - \beta_1]} \right\}^{\frac{1}{1-\alpha}} > 1. \quad (12)$$

Thus, the steady state allocation of capital depends on the subjective discount factors, the population weights for the two groups of agents, and γ . Compared to the frictionless case, the allocation under credit constraints reduces the level of capital held by borrowers and implies a difference in the marginal productivity of capital for the two groups of producers. The higher γ the lower the difference between borrowers' and lenders' marginal productivity and the larger the borrowers' share of total production. Since total output is maximized when the marginal productivity of the two groups is identical, collateral requirements distort total production below the efficient level. However, in the absence of costly liquidation procedures the allocation of capital between the two groups of agents is close to the efficient allocation and the loss in terms of aggregate output is negligible.

4 Productivity Shocks in the Benchmark Model

4.1 Impulse-Responses

Now, we consider the response of the model economy to a productivity shock. We assume that the economy is at the steady state level at time zero and then is hit by an unexpected increase in aggregate productivity of 1 percent. An aggregate shock raises production and thus the earnings of both groups of agents. See Figure 2. As the shock hits the economy, borrowers, initially limited in their capital holdings by borrowing constraints, increase their demand for productive assets. This allows the agents to more easily smooth the effect of the shock. In order for the capital market to clear, lenders have to decrease their demand for capital. The user cost of holding capital increases. Movements in the relative price of capital, altering the value of the collateral asset, affect the ability to borrow. Thus, borrowers' expenditure decisions are affected not only by the direct impact of the shock but also by the larger availability of credit resulting from a rise in the value of their collateral. Due to the higher marginal productivity of capital experienced by the borrowers, the positive effect of an increase in aggregate productivity on total production is propagated over time.

4.2 Amplification and Persistence

Kiyotaki and Moore's theoretical work shows that collateral constraints may generate large amplification of productivity shocks. However, Cordoba and Ripoll (2004) document that the amplification generated by the model is driven by two unorthodox assumptions: the linearity of the borrowers' production technology in the collateral asset and the lenders' linear utility function in consumption. According to their results, when agents face concave preferences and technology no amplification is endogenously generated by collateral constraints under standard parameter values. In what follows we investigate the role of LTV ratios for the amplification of shocks through collateral constraints when borrowers and lenders face the same concave production technology and utility and the parameters are set to values commonly used in the literature. Since in

the benchmark model the first impact of the shock is equal to the shock itself, we look at the second-period effect of the shock. We show that the magnitude of the endogenous amplification delivered by collateral constraints crucially depends on the fraction of the asset used as a collateral in the credit market.

Strictly speaking, the second-period elasticity of total output with respect to technology shocks can be written as in Cordoba and Ripoll (2004):

$$\epsilon_{yz} = \epsilon_{yk_2} \epsilon_{k_2z} = \frac{F_{k_2} - F_{k_1}}{F_{k_2}} \alpha \frac{y_2}{y} \epsilon_{k_2z}. \quad (13)$$

The first term is the *productivity gap* between constrained and unconstrained agents, α represents the share of capital in production, while $\frac{y_2}{y}$ is the *production share* of constrained agents, and ϵ_{k_2z} is the elasticity of borrowers' capital with respect to the shock – i.e. the redistribution of capital to impatient agents. As we have already shown in section 3.2, the fraction of total output produced by constrained agents increases with γ since more efficient enforcement procedures induce a better allocation of capital in the economy. However, for the same reason, the productivity gap decreases with γ . These two opposite forces contribute to a non-linear shape of the second-period impact of the shock on total output. Figure 3 plots the second-period variation in output (left panel) and the cumulative response over a 20-quarter period (right panel) w.r.t. the fraction γ of the collateral value up to which agents' can borrow.

The model features negligible amplification in only two parametrization: autarky and fully efficient debt enforcement procedures. These parameterization of the model correspond to the case in which either the production share or the productivity gap are close to zero, respectively. In the absence of a credit market – i.e. $\gamma = 0$ – capital is allocated in a very inefficient way and borrowers' share of total output is close to zero. So, the gains from a better allocation of resources are potentially very big. However, the redistribution of capital induced by the shock itself is limited since impatient agents cannot finance their capital expenditure through the credit market. The amplification of the shocks on total production is, indeed, negligible. Easier access to external funds generates larger redistribution of capital and enhances the endogenous amplification generated

by the model. However, as γ increases the difference in the marginal productivity of capital between lenders and borrowers shrinks. When γ approaches unity the allocation of capital between borrowers and lenders is such that the productivity gap is indeed negligible and the economy is very close to the efficient equilibrium. Thus, as in Cordoba and Ripoll (2004) we find no amplification in this special case.

For intermediate values of γ the model with collateral constraints can generate amplification and persistence of productivity shocks of non-negligible magnitude. The second-period effect and the cumulative effect over a 20-quarter period go hand in hand documenting no trade-off between amplification and persistence of productivity shocks with respect to changes in γ . Moreover, the effect of the shock on output can be much stronger and persistent than the response generated by the representative agent model. In this latter framework, the economy is populated only by patient agents and there are no limits to credit. Over a 20-quarter period the cumulative deviation of output from the steady state can be as large as almost 2 times the variation of output induced in the representative agent version of the model.

The analysis conducted above assumes that borrowers and lenders differ only in terms of their subjective discount factor. Allowing also for heterogeneity also in technologies and preferences, as in Kiyotaki and Moore (1997), generates larger amplification of shocks for any given γ . In particular, Kiyotaki and Moore (1997) assume linearity for the borrowers' production function and for the lenders' utility function. Assuming a linear production function in capital for the borrowers (concave for the lenders) would imply a constant marginal productivity of capital for this group of agents and, thus, a larger productivity gap and more sizable potential gains from the redistribution of capital. Instead, linearity of the lenders' utility function (concavity for the borrowers) would imply a constant real interest rate. If lenders are willing to provide additional funds without any rise in the real interest rate, borrowers' increase in capital expenditure and production is more sizeable. Under these two assumptions on technology and preferences, the elasticity of borrowers' capital to productivity

shocks would be higher. Thus, the amplification of the shock on output would be even more sizable for any given γ .

5 Robustness Analysis

In the following we check for the robustness of the results to alternative model's assumptions, parameters' values and solution method.

5.1 Reproducible Capital

Does allowing for the input of production to be elastically supplied reduce the amplification effect of collateral constraint?

According to Cordoba and Ripoll (2004), if capital is not fixed but rather optimally supplied, the amplification role of collateral constraints is further reduced. Following Cordoba and Ripoll (2004) we now allow for reproducible capital and assume that each agent is able to produce both consumption and investment goods.⁵ Both types of production are identical⁶

$$y_{it} = Z_t (k_{it-1}^c)^{\alpha_y^i}, \quad h_{it} = Z_t (k_{it-1}^h)^{\alpha_h^i}, \quad (14)$$

where y_{it} represents the technology for producing consumption goods and h_{it} is the production for capital goods with $k_{it-1}^j - j = c, h$ - being the stock of capital used as an input of production in the two sectors, respectively. Total individual production is given by

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

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

$$k_{it-1}^c = \theta_t k_{it-1}, \quad (15)$$

⁵In this way we avoid creating a rental market for capital, and make the model directly comparable to those of Kiyotaki and Moore (1997).

⁶The assumption of decreasing returns in the production of investment goods is equivalent to assume convex adjustment costs for investments. Capital is assumed to depreciate at a rate δ equal to 0.025.

where $\theta_t(q) = \frac{q_t^{\frac{1}{\alpha-1}}}{1+q_t^{\frac{1}{\alpha-1}}}$. Thus, the allocation of existing capital between the two productions depends on the current relative price of capital.⁷ The total production of each individual can be expressed as

$$F_{it} = k_{it-1}^\alpha Z_t [\theta_t^\alpha + q_t (1 - \theta_t)^\alpha]. \quad (16)$$

Each agent's capital stock evolves according to

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

Figure 4 compares the output's reaction to the productivity shock for different values of γ . The first- and second-period response of output is displayed. The results show significant first-period amplification. However, the endogenous amplification generated by the model declines with higher LTV ratios. Given that an economy with a high LTV ratio displays a smaller productivity gap between lenders and borrowers, less capital is redistributed to the borrowers. Thus, their demand for capital rises by a smaller margin, which dampens the increase in the relative price of capital. Since in the model with reproducible capital, variations in its relative price enter the measurement of total output, the decline in the sensitivity of the relative price of capital directly affects the sensitivity of total output to productivity shocks.

In the second period both the relative-price effect and the redistribution of capital between groups of producers contribute to amplification. As in the model with capital in fixed supply, the second-period response displays a non-linear shape w.r.t. γ . However, the endogenous amplification generated by the model with elastic capital supply is generally larger than in the benchmark model.

⁷In any given period each agent allocates the existing capital to produce either consumption or investment goods by solving

$$\max_{k_{it-1}^c} Z_t \{ (k_{it-1}^c)^\alpha + q_t (k_{it-1} - k_{it-1}^c)^\alpha \}$$

This leads to the first-order condition,

$$(k_{it-1}^c)^{\alpha-1} = q_t (k_{it-1} - k_{it-1}^c)^{\alpha-1}$$

The relative price of capital equals the ratio of the marginal productivity of capital in the two sectors. Thus, the amount of capital allocated to each type of production equals a fraction of the total capital owned by each agent.

Thus, the result of a reduction in the second-period amplification due to the introduction of elastic capital supply highlighted by Cordoba and Ripoll (2004) holds only for values of γ close to one.

5.2 Parameters' Value

Are our results robust to alternative calibrations? is γ different from the other parameters regarding its effects on the amplification and persistence of productivity shocks?

A few papers highlighted the role of other parameters for amplification. In particular, Pintus (2011), using a version of the model with capital accumulation showed that sizable amplification and persistence can be generated through high, but still empirically plausible, values of relative risk aversion, σ ; Kocherlakota (2000) using a small open economy version of the model highlighted the need of an uncommonly high capital share in production, α , to generate amplification of productivity shocks; Cordoba and Ripoll (2004) concluded that in response to a one-time unexpected shock, sizable amplification can be generated only by assuming implausibly high values of the relative risk aversion, σ , together with uncommonly high capital share in production, α . Previous analysis neglected the role of inefficiencies in the liquidation of the collateral asset and are, thus, based on the assumption that γ equals one.

Results presented above show that for values of γ below unity the model with collateral constraints can generate persistence and amplification of non-negligible magnitude even under standard parameters' values. In this section we investigate how other parameters affect the relationship between γ and amplification and persistence of productivity shocks. Figure 5 documents the sensitivity of the results to alternative parameters' values. We consider parameters' values in the range suggested by the empirical literature.⁸ In accordance with

⁸We choose values for the discount factor, β_2 , in line with previous evidence. In particular, see Lawrance (1991) for estimates of discount factors for poor households in the range (0.95, 0.98); for an empirical distribution of discount factors Carroll and Andrew Samwick (1997) using information on the elasticity of assets with respect to uncertainty find that it ranges in the interval (0.91, 0.99) and Samwick (1998) using wealth holdings documents that mean discount factors of around 0.99 for about 70 percent of the population and below 0.95 for

previous authors, we find that for γ equal one larger amplification is generated by higher values of α , m and σ . Higher values of the risk aversion means that impatient agents are more willingness to smooth the effect of the shocks through borrowing and thus a more persistent effect of the shock. A larger fraction of borrowers, m , means a larger fraction of total capital held by this group of agents. This implies a larger share of output is accrued to borrowers and thus, a more sensitive response of total output to shocks. Regarding m and σ the same result holds for alternative values of γ – i.e. larger amplification and persistence is delivered by higher values of m and σ for any value of γ . In contrast, our findings highlight a non-monotonic relationship between the amplification generated by alternative values of γ and the values of α and β_2 .

Regarding the share of capital in production, we compare the results for $\alpha = 0.4$, which corresponds to the standard definition of capital, with $\alpha = 0.7$, which reflects a broader definition of capital that includes both physical and intangible capital. See, for instance, Angeletos and Calvet (2006). We find that output amplification is not a strictly increasing function of the capital share. The relation between γ and the sensitivity of output to productivity shocks is clearly non-linear with respect to α . A higher α generates larger amplification and persistence of productivity shocks only under high LTV ratios. Thus, Kocherlakota (2000) and Cordoba and Ripoll (2004) results on the need of uncommonly high capital share in production, do not hold for any given value of γ . In fact, standard values for the capital share in production are sufficient to amplify the effect of shocks and generate sizable endogenous persistence in economies with LTV ratios lower than 95 percent.

We are particularly interested is understanding the role of β_2 for amplification. Changes in this parameter have direct effects on the allocation of

about 25 percent of households.

Regarding the fraction of borrowers in the economy, Campbell and Mankiw (1989) estimate around 40 percent of the population to be rule-of-thumb consumers; Jappelli and Pagano (1989) using the 1983 Survey of Consumer Finances estimates 20 percent of the population to be liquidity constrained.

We choose values for the relative risk aversion in line with previous studies and in the range of the estimated distribution by Chiappori and Paiella (2008).

capital between agents. See equation (12). Figure 6 shows that, similarly to γ , higher values of β_2 reduce the productivity gap and increase the output share of borrowers. However, γ and β_2 are very different in terms of their effects on amplification. As shown in figure 7, for reasonable values of β_2 the effect on the productivity gap always dominates and as β_2 gets close to β_1 the endogenous amplification generated by collateral constraints is reduced.⁹ Nevertheless, we find a non-monotonic relation between β_2 and γ in terms of amplification. In particular, higher values of β_2 dampen amplification and persistence for high values of γ while, amplifying the effects of the shock for lower values of γ .¹⁰

Summarizing, the results presented above document that models with collateral constraint require uncommon assumptions about technology and utility in order to generate amplification only for a particular assumptions regarding γ , i.e. γ equal unity.

We find worth highlighting that results presented in this section document an independent role of γ in generating amplification. In particular, independently of other parameters' values, the model features a non-linear relationship between the value of γ and the amplification and persistence generated by productivity shocks. Negligible amplification is always only found for values of γ either close to zero or close to one. Moreover, for intermediate values of γ the endogenous amplification and persistence generated by the collateral constraint is always larger than in the representative-agent version of the same model.

5.2.1 Local Identification Analysis

Is the effect of changing γ locally almost the same as changing other parameters?

In previous sections we studied the effects of different parameters on the response of output to shocks. The sensitivity of output to shocks is only one of the several aspects of the model. This section report a more comprehensive analysis on the effect of different parameters for the solution of the model. We investigate if the effect on the structural characteristic of the model obtained

⁹If β_2 equals β_1 the model collapses into the representative-agent version of the model.

¹⁰Cordoba and Ripoll (2004), already document that higher values of β_2 exacerbate amplification, as long as, β_2 is not too close to β_1 .

by changing γ can also be obtained by changing other parameters. Due to the difficulty in deriving explicitly the relationship between the parameters of the model regarding the model's dynamics, we use the local identification methodology developed by Iskrev (2010.a).¹¹

First, we test for local identification of the model's parameters $\boldsymbol{\theta} = \{\gamma, \beta_2, \sigma, \alpha, m, \rho_z\}$ in terms of the model's solution. A parameter θ_i is (locally) weakly identified if either (1) the matrix $\Gamma(\boldsymbol{\theta})$ that collects the reduced-form parameters of the solution of the model is insensitive to changes in θ_i or (2) if the effects on $\Gamma(\boldsymbol{\theta})$ of changing θ_i can be offset by changing other parameters.¹² Using these criteria, we find that all parameters are identified in a neighborhood of the benchmark parameters' values.

The second condition is particular interesting since it allows us to understand if the effect of changing γ is locally *almost* the same as changing other parameters. We compute the correlation between the column of the Jacobian w.r.t. γ and each of the other parameters – i.e. $\left| \text{corr} \left(\frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \gamma}, \frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \theta_{-i}} \right) \right|$ – for any different value of γ . Correlation among parameters in terms of the solution of the model is a common feature of dynamic general equilibrium models.¹³ As stressed by Iskrev (2010.b) the strength of identification varies across different regions in the parameter space. However, no multicollinearity is found in the model.

The pair-wise correlations in terms of the model's solution depend on where we evaluate the partial derivatives and it is generally higher for γ equal to one. See Figures 8 and 9. The correlation between $\frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \gamma}$ and $\frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \beta_2}$ is particularly high when γ is close to unity. Figure 8 shows that the highest correlation between the two parameters can be found for $\gamma = 0.98$. This means that, for γ

¹¹Most of the literature on identification in DSGE models is concerned with the fact that some parameters can be unidentifiable due to the lack empirical relevance. Iskrev (2010.a and 2010.b) distinguish between the statistical and the economic modelling aspects of identification. We focus on the tools provided by the author to examine how the identification of parameters is influenced by structural characteristics of the model.

¹²The analysis consists of evaluating the ranks of Jacobian matrices. The Jacobian matrix $\frac{\partial \Gamma(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}}$ must have full column rank in order for the parameters to be identifiable. See Iskrev (2010.a) for a description of the methodology.

¹³See Iskrev (2010.a) and Iskrev (2010.b). The latter paper also provides an application to Smets and Wouters (2007) model see section 4.3.

close to unity, small changes in β_2 have very similar effects on the solution of the model to changes in γ . However, we find that the correlation between the effects of the parameters on the model's solution significantly varies with γ and for values of γ below unity the linkage between parameters strongly declines. A lower correlation means that it is less likely to reproduce the same effect of γ on the solution of the mode by changing other parameters.

5.3 Solution Method

Are the results robust to less stringent assumptions regarding the collateral constraint?

As shown in section 3.2 the borrowing constraint is always binding in the deterministic steady state. It is a common procedure in the business cycle literature to solve models with limits to borrowing *à la* Kiyotaki and Moore (1997) assuming that the constraint is also always binding in a neighborhood of the steady state.¹⁴ In contrast, we allow for the constraint to be occasionally-binding outside the steady state by solving the model using a "barrier method" as in Kim, Kollmann and Kim (2010).¹⁵ Thus, we replace the inequality constraint with a differentiable penalty function that enters the utility function of the agents,

$$U(c_{it}) = \frac{c_{it}^{1-\sigma}}{1-\sigma} - P(k_{it}, b_{it}).$$

In order to be able to use perturbation methods, we choose an exponential penalty function as in Den Haan and De Wind (2009)

$$P(k_{it}, b_{it}) = \frac{\kappa_1}{\kappa_0} e^{[-\kappa_0(\gamma_t E_t[q_{t+1} k_{it}] - b_{it})]}.$$

The function is decreasing in the difference between b_{it} and the endogenous limit, $\gamma_t E_t[q_{t+1} k_{it}]$. In practise, we solve an equivalent version of the model in which higher borrowing is feasible but it is too costly to exceed the limit. The derivative of the Penalty function with respect to b_{it} replaces the shadow price

¹⁴See among others, Iacoviello and Minetti (2007), Iacoviello (2005), Iacoviello and Neri (2010), Campbell and Hercowitz (2005), Sterk (2010).

¹⁵See also Den Haan and Oaktan (2009), Den Haan and De Wind (2010), Judd (1998), and Preston and Roca (2007).

of the borrowing constraint. Thus, for $\kappa_1 = \mu_2 = \left(\frac{1}{R} - \beta_2\right) u_{c_2} > 0$, the two versions of the model have the same deterministic steady state. However, differently from an always binding constraint, the penalty function approach doesn't prevent impatient agents to borrow less than the debt limit in a neighborhood of the steady state. Still, the penalty term, κ_0 , discourages the agents from violating the constraint, such that large values of κ_0 ensure that the indebtedness does not exceed the limit. In the benchmark solution, κ_0 equals 100. The agents' optimal choices of borrowing and capital, together with the equilibrium conditions, represent a non-linear dynamic stochastic system of equations. To capture the non-linearity induced by the asymmetric penalty function, we solve for the recursive law of motion relying on a second order approximation.¹⁶

Figure 10 display the response of total output after a productivity shock implied by the two solution methods. The difference between the two impulse-responses is not sizable. As a result, the first period impact and the 20-quarter cumulative effects are very similar. See Figure 11. Thus, for intermediate values of γ the model with collateral constraint generate sizable amplification and persistence even under less strict assumptions regarding the binding nature of the constraint.

6 Conclusions

This paper improves upon previous literature by documenting the contribution of inefficiency in the debt enforcement procedure to the amplification of business cycle fluctuations which other authors have not considered. We argue that the magnitude of amplification crucially depends on the fraction of the asset used as a collateral in the credit market.

In accordance with previous papers that call into question the relevance of collateralized debt as a transmission mechanism, we find that when ineffi-

¹⁶Den Haan and De Wind (2009) solve the model by Deaton (1991) with a penalty function approach and show that, differently from higher order perturbation solutions, the policy function of the second-order approximate solution is close to the accurate solution and that despite being a bit more convex it preserves its shape. Further issues related to the use of approximate solutions for generating simulated data are not of a concern for the purpose of this paper.

ciency in the debt enforcement process are not taken into account – i.e. $\gamma=1$ – collateral constraints predict negligible amplification of productivity shocks to output. Nevertheless, when realistic Loan-to-Value ratios are assumed, the role of collateral constraints in terms of the amplification of productivity shocks is significantly enhanced, even under standard assumptions on the utility function and production process. Thus, results presented by previous literature are not robust to different assumptions on the degree of inefficiency in the credit market.

7 References

- Angeletos, G.M., and L.M. Calvet, 2006. Idiosyncratic Production Risk, Growth and the Business Cycle, *Journal of Monetary Economics*, vol. 53.
- Calstrom and Fuerst, 1997. Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis. *American Economic Review*, vol. 87.
- Calza, A., Monacelli, T., and L. Stracca, 2010. Housing Finance and Monetary Policy, forthcoming *Journal of the European Economic Association*.
- Campbell, J. R. and Z. Hercowitz, 2004. The Role of Collateralized Household Debt in Macroeconomic Stabilization, NBER w.p 11330.
- Campbell, J. Y. and N. G. Mankiw, 1989. Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence, in Oliver J. Blanchard and Stanley Fischer, eds., NBER macroeconomics annual. Vol. 4. Cambridge, MA: MIT Press, pp. 185–216.
- Carlstrom, C.T, Fuerst, T., 2007. Asset Prices, Nominal Rigidities, and Monetary Policy, *Review of Economic Dynamics*, vol. 10.
- Carroll, C. D. and A. A. Samwick, 1997. The Nature of Precautionary Wealth, *Journal of Monetary Economics*, vol. 40.
- Chiappori, P.A. and Paiella, M., 2008. Relative Risk aversion is Constant: Evidence from Panel Data. Discussion paper 5-2008, University of Naples, Parthenope.
- Cordoba, J.C. and M. Ripoll, 2004. Credit Cycle Redux, *International Economic Review*, vol. 45.
- Deaton, A., 1991. Saving and Liquidity Constraints, *Econometrica*, vol. 59.
- Den Haan, W.J., Oaktan, T.,S., 2009. Solving Dynamic Models with Heterogeneous Agents and Aggregate Uncertainty with Dynare or Dynare++, mimeo.
- Den Haan, W.J., and J. De Wind, 2010. Nonlinear and Stable Perturbation-based Approximations, mimeo.
- Djankov, S., Hart O., McLiesh C. and A. Shleifer, (2008), Debt Enforcement Around the World, *Journal of Political Economy*, vol. 116.
- Greenwood, J., G. W. Huffman, and Z. Hercowitz, 1988. Investment, Capacity Utilization, and the Real Business Cycle, *American Economic Review*, vol. 78.
- Hendricks, L., 2007. How Important Is Discount Rate Heterogeneity for Wealth Inequality?, *Journal of Economic Dynamics and Control*, vol. 31.
- Judd, K.L., 1998. Numerical Methods in Economics. The MIT Press, Cambridge, Massachusetts.
- Iacoviello, M., 2005. House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle, *American Economic Review*, vol. 95.
- Iacoviello, M. and R. Minetti, 2006. International Business Cycles with Domestic and Foreign Lenders, *Journal of Monetary Economics*, vol. 53.
- Iacoviello, M. and S. Neri, 2010. Housing Market Spillovers: Evidence from an Estimated DSGE Model, *AEJ Macro*, vol. 2.
- Iskrev, N., 2010.a. Local Identification in DSGE Models. *Journal of Monetary Economics*, vol. 57.
- Iskrev, N., 2010.b. Evaluating the Strength of Identification in DSGE Models. An A Priori Approach, Bank of Portugal w.p. 32-2010.
- Jappelli, T., and M. Pagano, 1989. Consumption and Capital Market Imperfections: An International Comparison. *American Economic Review*, vol. 79.
- Lawrance, E. C., 1991. Poverty and the Rate of Time Preference: Evidence from Panel Data, *Journal of Political Economy*, vol. 99.

- Kim, S., Kollmann, R., and J. Kim, 2009. Solving the Incomplete Markets Model with Aggregate Uncertainty using Perturbation Methods, *Journal of Economic Dynamics and Control*, vol. 34, 50-58.
- Kiyotaki, N., 1998. Credit and Business Cycles, *The Japanese Economic Review*, vol. 49.
- Kiyotaki, N. and J. Moore, 1997. Credit Cycles, *Journal of Political Economy*, vol. 105.
- Kocherlakota, N.R., 2000. Creating Business Cycles Through Credit Constraints, Federal Reserve Bank of Minneapolis Quarterly Review, vol 24.
- Mendoza, E., 2006. Lessons from the Debt Deflation Theory of Sudden Stops, *American Economic Review Papers & Proceedings*, vol. 96.
- Mendoza, E., and K. A. Smith, 2006. Quantitative Implications of a Debt-Deflation Theory of Sudden Stops and Asset Prices, *Journal of International Economics*, vol. 70.
- Osborne, J., 2005. Housing in the Euro Area. Twelve Markets, One Money, International Finance Discussion Papers 740, Central Bank of Ireland.
- Pintus, P.A., 2011. Collateral Constraints and the Amplification-Persistence Trade-Off. *Economics Letters*, vol. 110.
- Preston, B., and M. Roca, 2006. Incomplete Markets, Heterogeneity and Macroeconomic Dynamics, mimeo.
- Samwick, A., 1998. Discount Rate Heterogeneity and Social Security Reform, *Journal of Development Economics*, vol. 57.
- Smets, F. and R. Wouters, 2003. An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association*, vol.1.
- Sterk, V., 2010. Credit frictions and the comovement between durable and non-durable consumption. *Journal of Monetary Economics*, vol. 57.
- Uribe, M., 2006. On Overborrowing, *American Economic Review Papers and Proceedings*, vol. 96.
- Warner, J. T., and S. Pleeter, 2001. The Personal Discount Rate: Evidence from Military Downsizing Programs, *American Economic Review*, vol. 91.

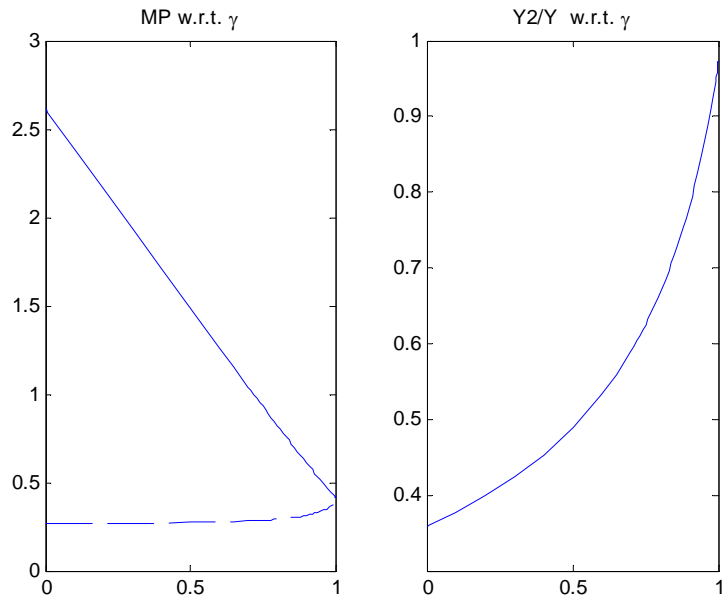


Figure 1 Benchmark Model. Steady state productivity gap between the two groups of agents (solid line borrowers, dashed line lenders) and borrowers' share of total production as a function of γ .

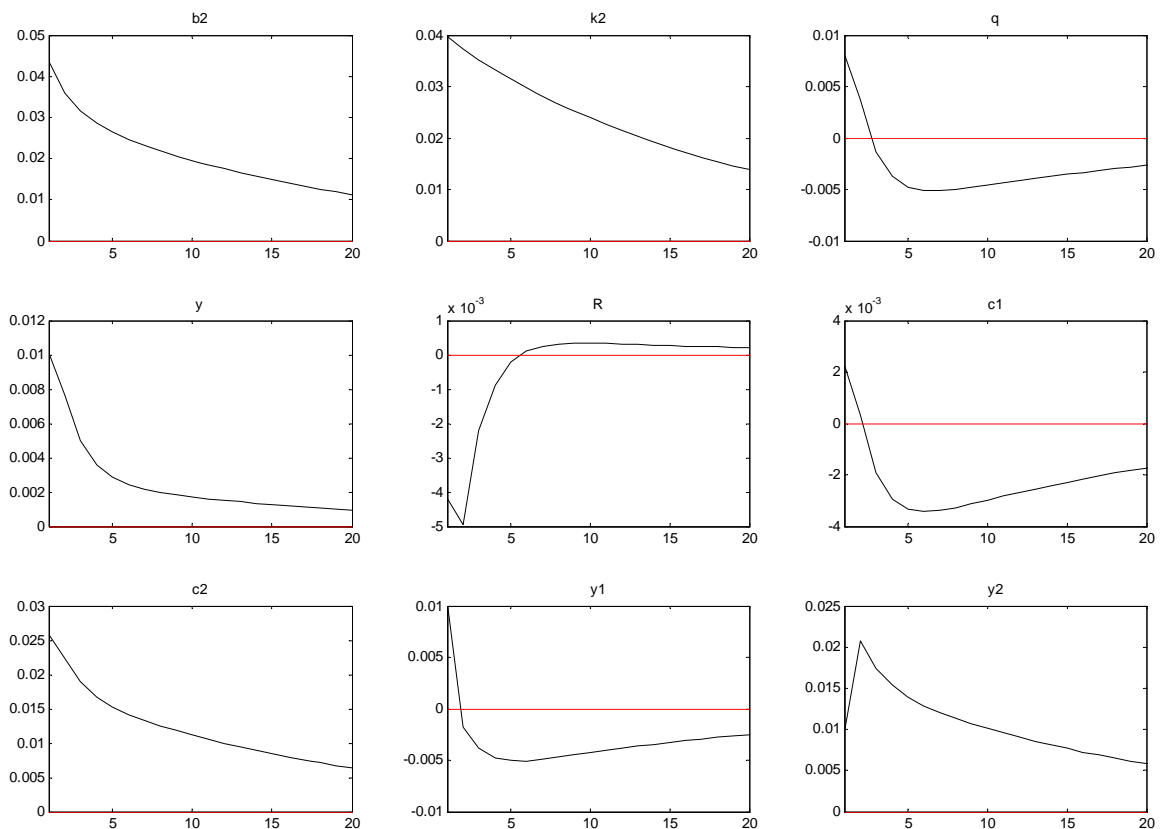


Figure 2. Benchmark Model. Responses of the model economy to a one-period 1% increase in aggregate productivity; $\gamma=0.85$. The vertical axes measure deviations from the steady state, while on the horizontal axes are years.

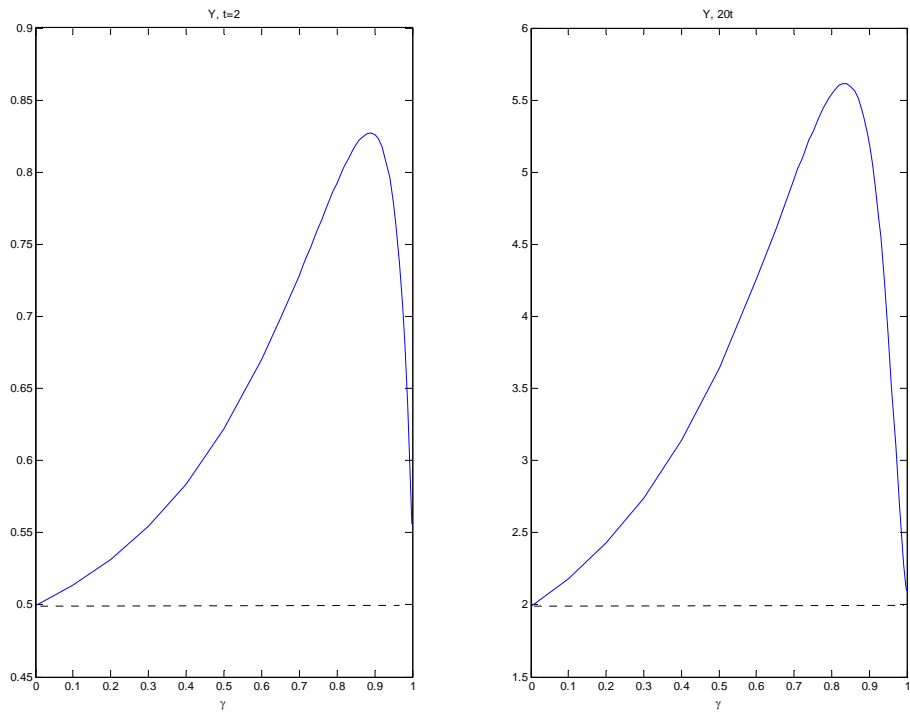


Figure 3. Benchmark Model. Sensitivity of Output to a productivity shock for any given γ ; second-period (left panel) and cumulative response over a 20 quarters period (right panel). Dotted-line representative agent model.

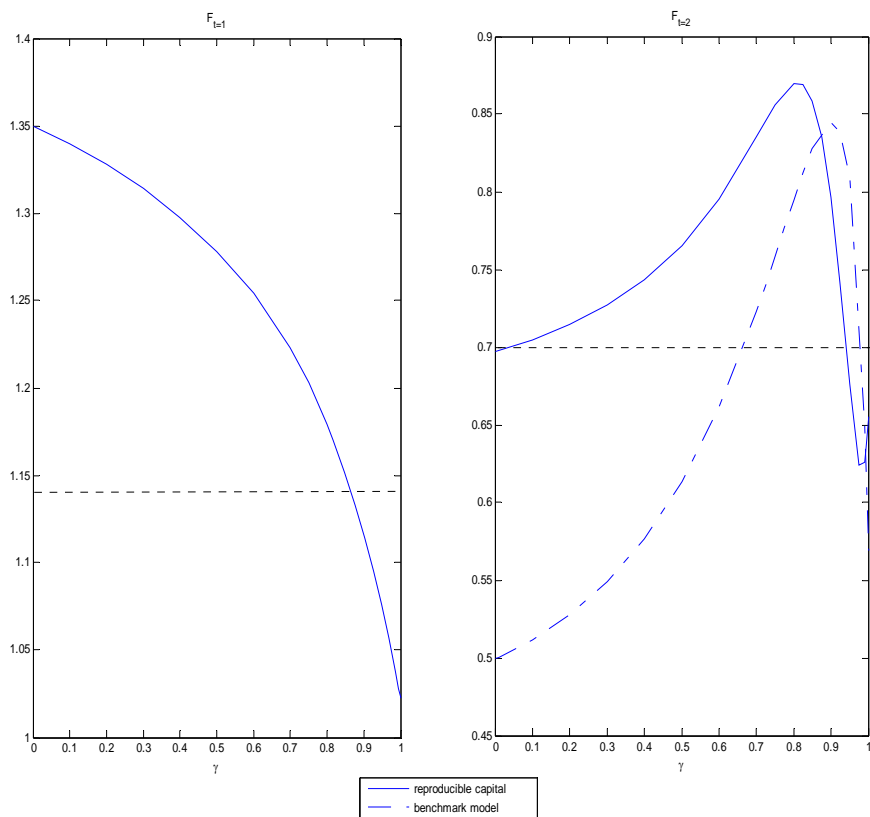


Figure 4. Reproducible Capital Model. Sensitivity of Output to a productivity shock for any given γ ; first-period (left panel), second-period response (right panel). Dotted-line representative agent model; dashed-line benchmark model.

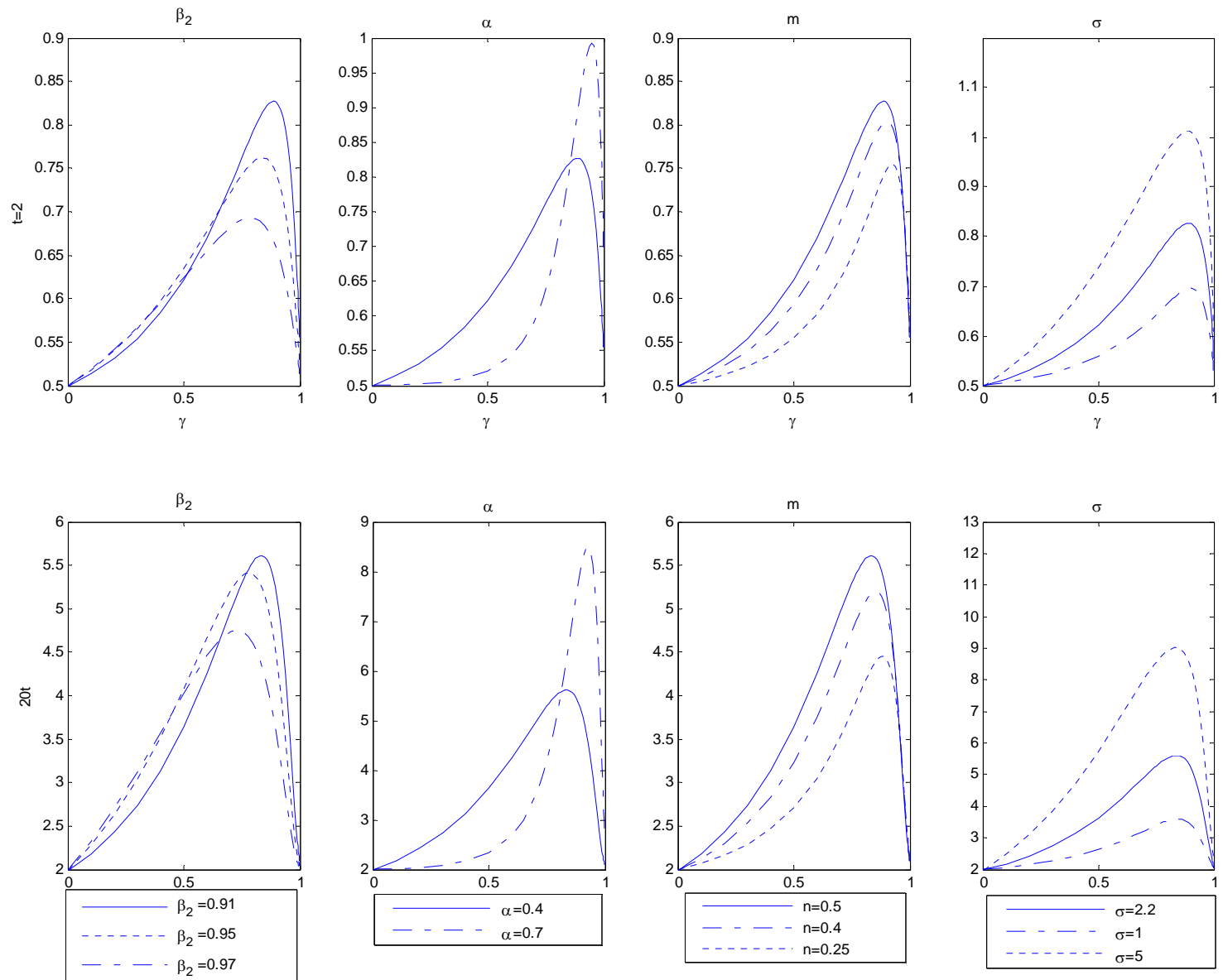


Figure 5. Benchmark Model. Sensitivity of Output to a productivity shock for any given γ ; second-period (left panel) and cumulative response over a 20 quarters period (right panel) for alternative parameters' value.

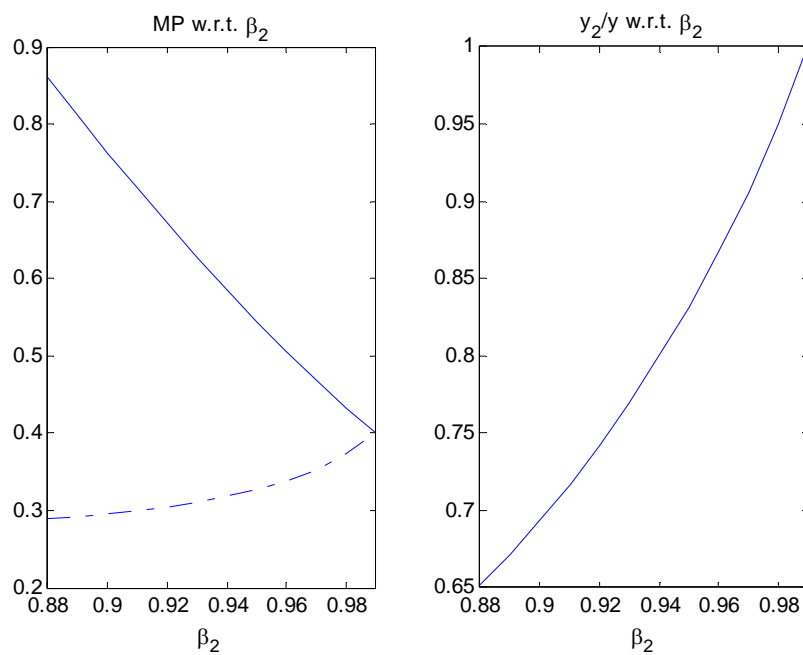


Figure 6 Benchmark Model. Steady state productivity gap between the two groups of agents (solid line borrowers, dashed line lenders) and borrowers' share of total production as a function of β_2 .

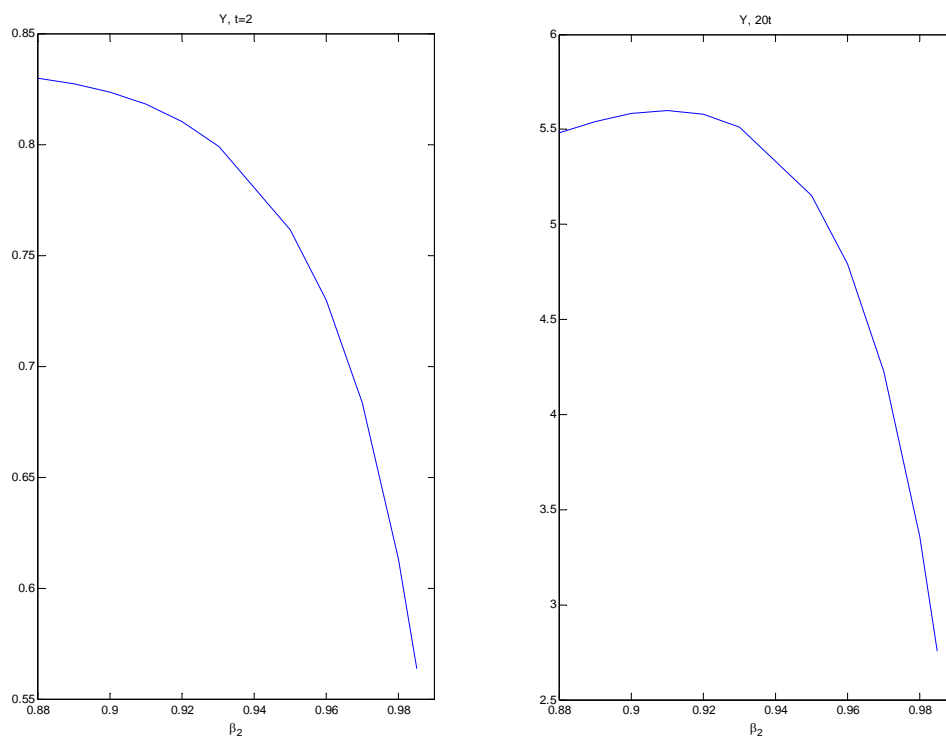


Figure 7. Benchmark Model. Sensitivity of Output to a productivity shock for any given β_2 ; second-period (left panel) and cumulative response over a 20 quarters period (right panel).

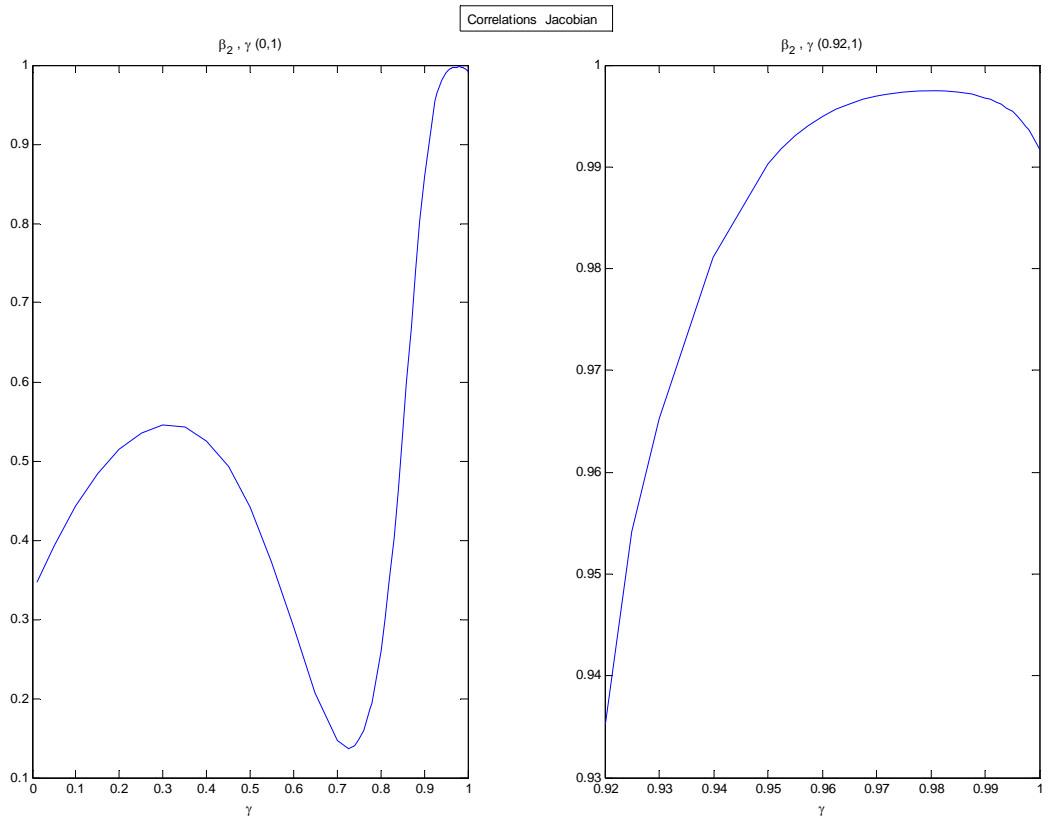


Figure 8. Correlation between the column of the Jacobian w.r.t. γ and β_2 for any given γ .

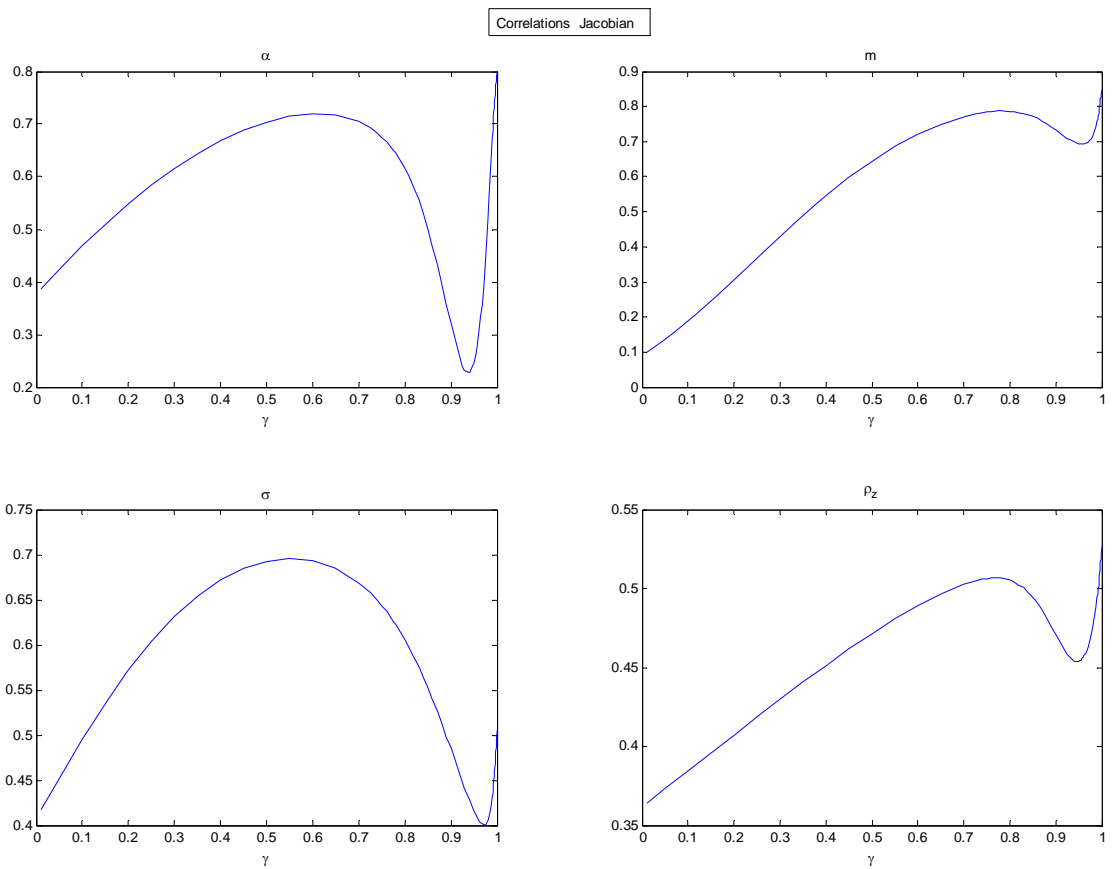


Figure 9. Correlation between the column of the Jacobian w.r.t. γ and each of the other parameters for any given γ .

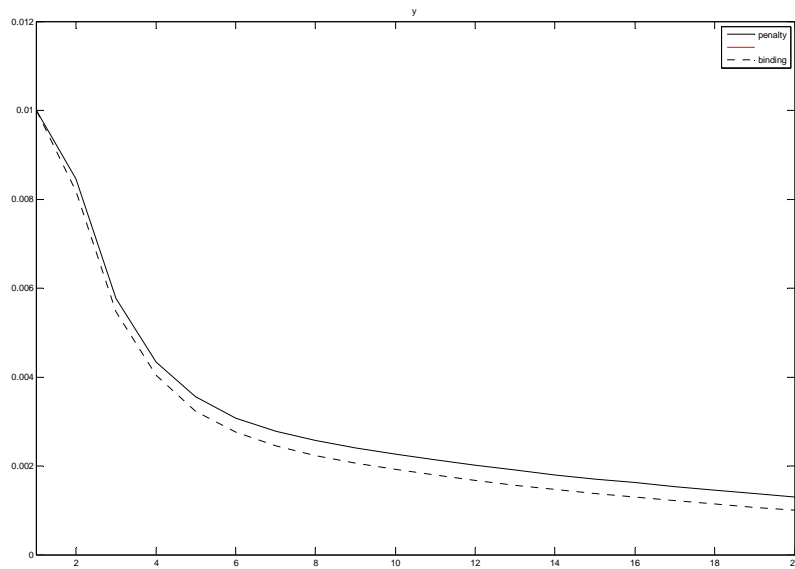


Figure 10. Benchmark Model. Responses of total output to a one-period 1% increase in aggregate productivity; $\gamma=0.85$. The vertical axes measure deviations from the steady state, while on the horizontal axes are years. Penalty function vs always binding constraint.

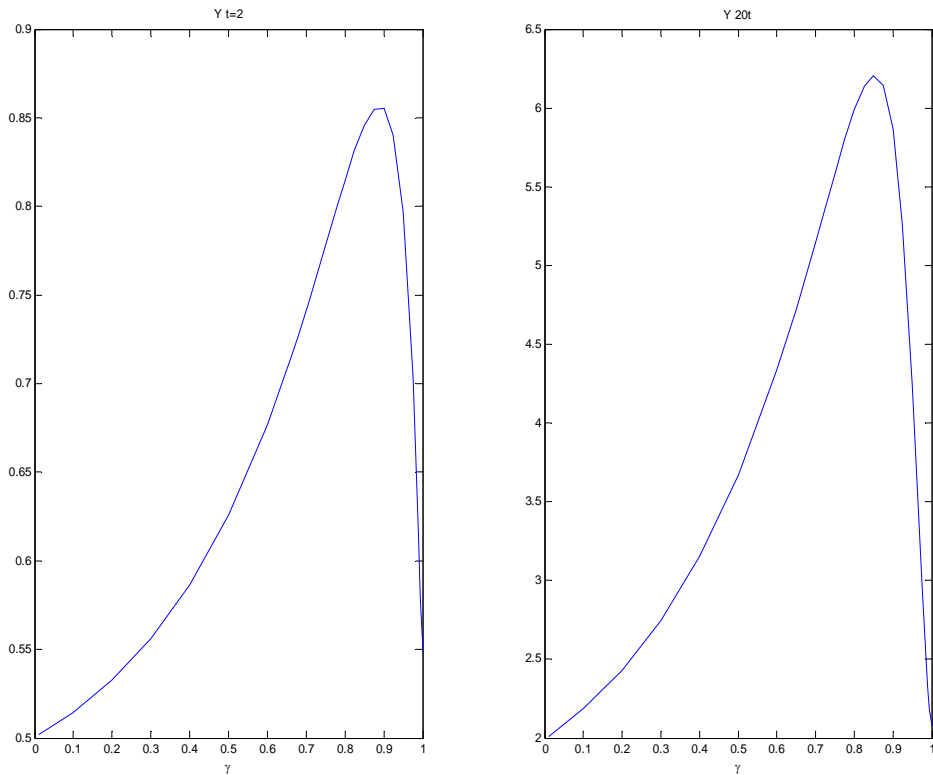


Figure 11. Benchmark Model. Sensitivity of Output to a productivity shock for any given γ ; second-period (left panel) and cumulative response over a 20 quarters period (right panel). Penalty Function.

WORKING PAPERS

2010

- 1/10 MEASURING COMOVEMENT IN THE TIME-FREQUENCY SPACE
— *António Rua*
- 2/10 EXPORTS, IMPORTS AND WAGES: EVIDENCE FROM MATCHED FIRM-WORKER-PRODUCT PANELS
— *Pedro S. Martins, Luca David Opromolla*
- 3/10 NONSTATIONARY EXTREMES AND THE US BUSINESS CYCLE
— *Miguel de Carvalho, K. Feridun Turkman, António Rua*
- 4/10 EXPECTATIONS-DRIVEN CYCLES IN THE HOUSING MARKET
— *Luisa Lambertini, Caterina Mendicino, Maria Teresa Punzi*
- 5/10 COUNTERFACTUAL ANALYSIS OF BANK MERGERS
— *Pedro P. Barros, Diana Bonfim, Moshe Kim, Nuno C. Martins*
- 6/10 THE EAGLE. A MODEL FOR POLICY ANALYSIS OF MACROECONOMIC INTERDEPENDENCE IN THE EURO AREA
— *S. Gomes, P. Jacquinot, M. Pisani*
- 7/10 A WAVELET APPROACH FOR FACTOR-AUGMENTED FORECASTING
— *António Rua*
- 8/10 EXTREMAL DEPENDENCE IN INTERNATIONAL OUTPUT GROWTH: TALES FROM THE TAILS
— *Miguel de Carvalho, António Rua*
- 9/10 TRACKING THE US BUSINESS CYCLE WITH A SINGULAR SPECTRUM ANALYSIS
— *Miguel de Carvalho, Paulo C. Rodrigues, António Rua*
- 10/10 A MULTIPLE CRITERIA FRAMEWORK TO EVALUATE BANK BRANCH POTENTIAL ATTRACTIVENESS
— *Fernando A. F. Ferreira, Ronald W. Spahr, Sérgio P. Santos, Paulo M. M. Rodrigues*
- 11/10 THE EFFECTS OF ADDITIVE OUTLIERS AND MEASUREMENT ERRORS WHEN TESTING FOR STRUCTURAL BREAKS IN VARIANCE
— *Paulo M. M. Rodrigues, Antonio Rubia*
- 12/10 CALENDAR EFFECTS IN DAILY ATM WITHDRAWALS
— *Paulo Soares Esteves, Paulo M. M. Rodrigues*
- 13/10 MARGINAL DISTRIBUTIONS OF RANDOM VECTORS GENERATED BY AFFINE TRANSFORMATIONS OF INDEPENDENT TWO-PIECE NORMAL VARIABLES
— *Maximiano Pinheiro*
- 14/10 MONETARY POLICY EFFECTS: EVIDENCE FROM THE PORTUGUESE FLOW OF FUNDS
— *Isabel Marques Gameiro, João Sousa*
- 15/10 SHORT AND LONG INTEREST RATE TARGETS
— *Bernardino Adão, Isabel Correia, Pedro Teles*
- 16/10 FISCAL STIMULUS IN A SMALL EURO AREA ECONOMY
— *Vanda Almeida, Gabriela Castro, Ricardo Mourinho Félix, José Francisco Maria*
- 17/10 FISCAL INSTITUTIONS AND PUBLIC SPENDING VOLATILITY IN EUROPE
— *Bruno Albuquerque*

- 18/10 GLOBAL POLICY AT THE ZERO LOWER BOUND IN A LARGE-SCALE DSGE MODEL
— *S. Gomes, P. Jacquinot, R. Mestre, J. Sousa*
- 19/10 LABOR IMMOBILITY AND THE TRANSMISSION MECHANISM OF MONETARY POLICY IN A MONETARY UNION
— *Bernardino Adão, Isabel Correia*
- 20/10 TAXATION AND GLOBALIZATION
— *Isabel Correia*
- 21/10 TIME-VARYING FISCAL POLICY IN THE U.S.
— *Manuel Coutinho Pereira, Artur Silva Lopes*
- 22/10 DETERMINANTS OF SOVEREIGN BOND YIELD SPREADS IN THE EURO AREA IN THE CONTEXT OF THE ECONOMIC AND FINANCIAL CRISIS
— *Luciana Barbosa, Sónia Costa*
- 23/10 FISCAL STIMULUS AND EXIT STRATEGIES IN A SMALL EURO AREA ECONOMY
— *Vanda Almeida, Gabriela Castro, Ricardo Mourinho Félix, José Francisco Maria*
- 24/10 FORECASTING INFLATION (AND THE BUSINESS CYCLE?) WITH MONETARY AGGREGATES
— *João Valle e Azevedo, Ana Pereira*
- 25/10 THE SOURCES OF WAGE VARIATION: AN ANALYSIS USING MATCHED EMPLOYER-EMPLOYEE DATA
— *Sónia Torres, Pedro Portugal, John T. Addison, Paulo Guimarães*
- 26/10 THE RESERVATION WAGE UNEMPLOYMENT DURATION NEXUS
— *John T. Addison, José A. F. Machado, Pedro Portugal*
- 27/10 BORROWING PATTERNS, BANKRUPTCY AND VOLUNTARY LIQUIDATION
— *José Mata, António Antunes, Pedro Portugal*
- 28/10 THE INSTABILITY OF JOINT VENTURES: LEARNING FROM OTHERS OR LEARNING TO WORK WITH OTHERS
— *José Mata, Pedro Portugal*
- 29/10 THE HIDDEN SIDE OF TEMPORARY EMPLOYMENT: FIXED-TERM CONTRACTS AS A SCREENING DEVICE
— *Pedro Portugal, José Varejão*
- 30/10 TESTING FOR PERSISTENCE CHANGE IN FRACTIONALLY INTEGRATED MODELS: AN APPLICATION TO WORLD INFLATION RATES
— *Luis F. Martins, Paulo M. M. Rodrigues*
- 31/10 EMPLOYMENT AND WAGES OF IMMIGRANTS IN PORTUGAL
— *Sónia Cabral, Cláudia Duarte*
- 32/10 EVALUATING THE STRENGTH OF IDENTIFICATION IN DSGE MODELS. AN A PRIORI APPROACH
— *Nikolay Iskrev*
- 33/10 JOBLESSNESS
— *José A. F. Machado, Pedro Portugal, Pedro S. Raposo*
- 2011**
- 1/11 WHAT HAPPENS AFTER DEFAULT? STYLIZED FACTS ON ACCESS TO CREDIT
— *Diana Bonfim, Daniel A. Dias, Christine Richmond*
- 2/11 IS THE WORLD SPINNING FASTER? ASSESSING THE DYNAMICS OF EXPORT SPECIALIZATION
— *João Amador*

- 3/11 UNCONVENTIONAL FISCAL POLICY AT THE ZERO BOUND
— *Isabel Correia, Emmanuel Farhi, Juan Pablo Nicolini, Pedro Teles*
- 4/11 MANAGERS' MOBILITY, TRADE STATUS, AND WAGES
— *Giordano Mion, Luca David Opromolla*
- 5/11 FISCAL CONSOLIDATION IN A SMALL EURO AREA ECONOMY
— *Vanda Almeida, Gabriela Castro, Ricardo Mourinho Félix, José Francisco Maria*
- 6/11 CHOOSING BETWEEN TIME AND STATE DEPENDENCE: MICRO EVIDENCE ON FIRMS' PRICE-REVIEWING STRATEGIES
— *Daniel A. Dias, Carlos Robalo Marques, Fernando Martins*
- 7/11 WHY ARE SOME PRICES STICKIER THAN OTHERS? FIRM-DATA EVIDENCE ON PRICE ADJUSTMENT LAGS
— *Daniel A. Dias, Carlos Robalo Marques, Fernando Martins, J. M. C. Santos Silva*
- 8/11 LEANING AGAINST BOOM-BUST CYCLES IN CREDIT AND HOUSING PRICES
— *Luisa Lambertini, Caterina Mendicino, Maria Teresa Punzi*
- 9/11 PRICE AND WAGE SETTING IN PORTUGAL LEARNING BY ASKING
— *Fernando Martins*
- 10/11 ENERGY CONTENT IN MANUFACTURING EXPORTS: A CROSS-COUNTRY ANALYSIS
— *João Amador*
- 11/11 ASSESSING MONETARY POLICY IN THE EURO AREA: A FACTOR-AUGMENTED VAR APPROACH
— *Rita Soares*
- 12/11 DETERMINANTS OF THE EONIA SPREAD AND THE FINANCIAL CRISIS
— *Carla Soares, Paulo M. M. Rodrigues*
- 13/11 STRUCTURAL REFORMS AND MACROECONOMIC PERFORMANCE IN THE EURO AREA COUNTRIES: A MODEL-BASED ASSESSMENT
— *S. Gomes, P. Jacquinot, M. Mohr, M. Pisani*
- 14/11 RATIONAL VS. PROFESSIONAL FORECASTS
— *João Valle e Azevedo, João Tovar Jalles*
- 15/11 ON THE AMPLIFICATION ROLE OF COLLATERAL CONSTRAINTS
— *Caterina Mendicino*