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Macroprudential tax on debt

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Abstract

With the aim of testing macroprudential policies' effectiveness, this research models a rich and open economy hit by future news shocks about fundamentals and regime switches in global liquidity. Agents take excessive debt to finance current consumption, making the economy more vulnerable to financial crises. Quantitative findings of the simulation shows that a tax on debt, optimally set by a social planner, increases total welfare and decreases the probability and the magnitude of financial crisis. However, it is shown that if news precision increases too much, a tax on debt may be even deleterious because it reduces economic growth.

Keywords: Macroprudential policy, news shocks, Fisherian debt effect.

1 Introduction

The recent financial crisis raised the debate on how policy makers and economists can reduce the likelihood and magnitude of future crises' aftermath. As a consequence, a branch of the literature on macroeconomic dynamics encourages to hamper the systemic risk in the economy by counter-cyclically adopting macroprudential policies. Some of the most important ones include: loan-to-value (LTV) ratios, tax on the cost of borrowing, capital buffering, liquidity requirements and dynamic provisioning.

This work tries to assess the effectiveness of a macroprudential tax on debt within the dynamics of financial crises. In particular, the model is borrowed from Bianchi, Liu and Mendoza (2015[11]), henceforth BLM. It embraces propagations of shocks through the *Fisherian debt-deflation* amplification power. This theory postulates an economy that oscillates between periods of booms and recessions, according to its degree of leverage. Among other factors, agents tend to borrow in accordance with their expectation about future wealth and with the degree of liquidity in the economy (e.g. level of interest rate). The effect of shocks on the probability and magnitude of a crisis is directly proportional to the debt outstanding in the economy, because fragility of the system becomes wider as leverage increases. As advocated in Durdu et

al. (2013[20]), past research found that rich economies have more debt outstanding than poor economies in equilibrium. Moreover, credit and consumption growth in poor economies (BLM) differ with respect to those in rich economies (Baseline model here). As a result, the interesting challenge I address is to understand how particular macroprudential policy instruments impact the two different environments.

The economy in this model is characterized by three kinds of shocks: tradable income (denoted by y_t^T), noisy news on fundamentals (s_t) and interest rate (q_t , proxy for global liquidity) shocks. These circumstances are considered in accordance to existing studies on financial crises: elements like these are fundamental determinants of credit growth dynamics. Calvo (1996[15]) and Shin (2013[30]) showed the importance of global interest rates and global market status for capital inflows or domestic credit (Beaudry et al., 2014[3]). Moreover, these shocks can be seen as unconventional, since the majority of previous quantitative studies focused, for instance, on standard TFP or exclusively on interest rate shocks (e.g. Mendoza, 2010[10]).

Simply stated, the model describes that once an adverse shock in interest rate hits the economy or whenever good news about future income are not realized, the severity of the financial crisis (sharp cut in consumption and capital flows) on the economy increases. To discourage agents' willingness to over-borrow (pecuniary externality), financial regulators set an optimal¹ macroprudential tax τ_t^* on the cost of borrowing, which increases the cost of bonds in the agent's budget constraint².

Even if at a lesser extent than BLM, this simulation eventually shows that good news provoke higher mass in the right-tail (i.e. high debt levels) of the distribution of bonds' holdings in the economy. My quantitative findings can be summarized into three aspects: firstly, rich economies experience less frequent, but higher in magnitude, crisis events than poor economies do. In particular, the economy modeled in this work yields probabilities of facing a crisis of 1.44% and 1.04% with and without macroprudential intervention, respectively, which is trans-

¹Optimality of the tax comes from equating the social planner's Euler equation of bonds and the decentralized equilibrium with tax.

²In BLM, regulators opt for implementing a tax τ_t on the cost of borrowing as macroprudential policy because it is just the debt that causes the pecuniary externality in the model.

lated into 40 basis points of gain. On the other hand, the BLM economy yields 3.51% and 2.27% with and without the policy, achieving 124 basis points of gain. This may be due to the higher credit ratings and higher debt outstanding of rich than poor economies; secondly, as a consequence of the first result, the optimal macroprudential tax on debt in this setting achieve roughly half the welfare gain achieved in a poor economic setting: 0.066% in this model and 0.12% in BLM; thirdly, as agents receive more precise news on their future income, social planner’s intervention becomes less effective, likely because agents are able to better allocate resources between consumption at $t = 0$ and bonds at $t = 1$.

The structure of the paper proceeds as follows: section 2 concisely revises recent approaches on testing macroprudential policies; in section 3, the main model and shocks’ dynamics are presented; the work proceeds in section 4 with the calibration of parameters and the results quantitatively developed in MATLAB, including a scenario analysis on news precision. To calculate the effects of the policy, the decentralized equilibrium (DE) scenario is compared with the Social planner (SP) equilibrium³. A conclusive section closes the work.

2 On testing Macroprudential policies: existing approaches

The existing literature on modeling set of macroprudential policies is still improving. The main reason behind that is the difficulty in assessing clear interactions between macroeconomics and financial markets dynamics (Adler, 2014[2]). Hence, these models still rely upon different, but essential, assumptions. Macroprudential policies have been defined by the ECB Vice-President Vitor Constâncio as “those maneuvers aiming at preventing and mitigating systemic risk, which includes strengthening the resilience of the financial system and smoothening the financial cycle, in order to preserve the effective provision of financial services to the real economy”.

By following a similar approach to Galati et al. (2014[23]), there are two ways for assessing the effectiveness of macroprudential policies: theoretical and empirical strategies⁴.

³SP equilibrium is the one including the implementation of a macroprudential tax, τ_t^* , on debt

⁴In order to describe different existing approaches of studies on the effectiveness of macroprudential policies, Galati et al. (2014[23]) adds “stylized presentations” to the two categories described here.

2.1 Theoretical methodologies

This category can be divided into two areas: “Banking/finance models” and “Dynamic Stochastic General Equilibrium (DSGE) models”. The former category is based on the state-dependent structure of assets and contracts (Diamond et al.,1983[17], 2001[18]). Asymmetry of information and incentive problems are the basis for possible financial instability in the economy. If on the one hand these models highlight the convoluted cooperation between lenders and borrowers, on the other one, they completely ignore the function of timing and business cycle level and usually entail only partial equilibrium settings (Al-Darwish et al., 2011[1] and Jaffee and Walden, 2011[26]). The latter category, instead, study the need for macroprudential policies resulting from two sources of failures: the financial amplification mechanism of agents’ over-borrowing behavior⁵ or the excessive risk-taking behavior incurred by banks (Kashyap et al., 2014[28]). In this context, DSGE models are useful for simulating different shocks hitting the economy and for analyzing the impact of *ad-hoc* regulatory measures. This category of DSGE models, say *first generation model* (D. Adler, 2014[2]), is constructed upon the financial accelerator system of Bernanke (1999[8]), upon Brunnermeier & Pederson (2009[14]) and upon Graub & Vayanos (2002). It has to be noticed that first-generation models suffer from two important pitfalls: firstly, they assume an economy eventually coming back to its steady-state (because of the log-linearization procedure around the steady-state); secondly, they ignore endogenous shocks. Therefore, rather than log-linearly approximating around the steady-state, solving the full dynamics of the model (allowing outcomes to follow a distribution of events, multiple equilibria) is the basis of the “second generation models”. He & Krishnamurthy (2012, 2013), Brunnermeier & Sannikov (2014) and Benigno (2013[4]) are only some of the most important models included in this category.

This second-generation models are usually established on the "Neo-Fisherian" theory. By embracing the debt-deflation spiral of Irving Fisher theory (1933[21]), when borrowing constraint binds (naturally during crisis), private agents’ and policymakers’ decisions affect the state of

⁵Private agents, in fact, neglect the externalities of their sub-optimal actions and measures such as Loan-to-value ratios, margin requirements on Repos used by shadow banking and liquidity coverage ratios, would avoid fire sales and credit shrinkages and may improve total welfare.

the economy (Bianchi et al., 2010[10], Jeanne et al., 2013[27], Benigno et al., 2013[4]). In this occasion, when eventually state-contingent taxes are adopted by regulators, financial stability may improve substantially. In Bianchi and Mendoza (2010[10]) for instance, policy makers can neutralize the credit externality which these models depend on, by imposing status-contingent average taxes on debt and dividends of about 1% and -0.5%, respectively. This tax is higher during periods when leverage is building up and the economy is becoming vulnerable to a financial crisis. The main idea is that this kind of tax hinders the willingness of private agents in accumulating precautionary savings. The work described in this research is just on the same line of the second generation models of the vast “financial frictions” theory.

2.2 Empirical approaches

Because of shortage of available data (as discussed in Galati et al., 2013[22]) and, as mentioned above, the non-clear establishment in relating the macro economy and financial system, undertaking empirical approaches on macroprudential effectiveness is still arduous.

The most complete datasets used in empirical studies on macroprudential policies contain data at international policy level, size and volatility of cross-border borrowing, data about systemically important banks and official surveys (IMF (2011b)). The most important datasets are constructed by Lo (2009), Borio (2010), Federico et al. (2012a) and Brunnermeier et al. (2014). Once data are collected, empirical approaches still suffer from a typical drawback in econometrics, namely the complicated matter in identifying causal relationship against correlation. Often, these works are based on linear regression analysis, panel data regression (Kuttner et al., 2012[29] and Vandebussche et al., 2015[31]), counterfactual simulations (e.g. Antipa et al., 2010, Catte et al., 2010, or Barrell et al., 2010) or stress testing (Sorge, 2004, and Borio and Drehmann, 2009[12]). Different national and supra national banks, such as the ECB or the Bank of Canada, approach the level of systemic risk in the financial system by adopting macro stress-testing models. They are naturally forward-looking but generally fail to include feedback loops between the macroeconomy and the financial sector.

3 Model

The model is along the same line of the introductory future news about income and shifts in global liquidity proposed in BLM (2015[11]). The social planner optimization problem needs to solve the pecuniary externality caused by excessive borrowing of agents.

3.1 Households

In a small and open economy, a representative household maximizes a classical Constant Relative Risk Aversion (CRRA) intertemporal utility function (or power utility) by choosing to consume an amount c_t^T of tradable and c_t^N of nontradable goods:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c) = E_0 \sum_{t=0}^{\infty} \beta^t \frac{[\omega(c^T)^{-\eta} + (1-\omega)(c^N)^{-\eta}]^{\frac{\gamma-1}{\eta}}}{1-\gamma} \quad (1)$$

where β is the subjective discount factor, bounded between 0 and 1, measure of impatience. The term $\frac{1}{1+\eta}$ is the intertemporal elasticity of substitution (IES) between tradable and nontradable goods, ω represents the share of consumption on tradable goods and $(1-\omega)$ on nontradable ones, with $0 < \omega < 1$. The term γ represents the coefficient for relative risk aversion, identifying precautionary savings, namely the aversion to consumption stream that varies over time and across states of nature. The function $u(c)$, whose curvature allows for risk aversion and intertemporal substitution, is required to be concave and twice continuously differentiable. Ceteris paribus, for high levels of γ , IES become smaller and, thus, intertemporal consumption becomes less substitutable (high γ -individuals want to maintain a smooth inter-temporal consumption profile). By assuming unitary price for tradable goods, i.e. $p_t^T = 1$, agents' maximization problem described above is subject to the following budget constraint:

$$q_t b_{t+1} + c_t + p_t^N c_t^N = b_t + y_t^T + p_t^N y_t^N \quad (2)$$

where $q_t b_{t+1} = \frac{b_{t+1}}{R_t}$ is the total price of b_{t+1} 1-year maturity plain-vanilla bonds. Of course, shifts in the inflation-adjusted interest rate R_t lead to different states of global liquidity, be-

cause for higher levels of R_t , the agent faces a tighter budget constraint (he can consume less in the future). Each period, the representative agent chooses $\{c_t^T, c_t^N, b_{t+1}\}_{t \geq 0}$, given a fixed endowment of bonds, b_t , and nontradables, y_t^N , and given a collection of news on the stochastic Markov chain process for the endowment of tradables, y_{t+k}^T , with $k \geq 1$.

In addition, it is necessary to specify the credit constraint that restricts the agent's amount of debt to a ceiling, i.e. a fraction κ of his total income. This is typically interpreted as the institutional frictions by which lenders can curb κ from borrower in case of default:

$$q_t b_{t+1} \geq -\kappa(y_t + p_t^N y_t^N) \quad (3)$$

In order to maximize the CRRA lifetime utility described in 1, the representative agent needs to choose the optimal amount of stochastic processes $\{c_t^N, c_t^T, b_{t+1}\}_{t \geq 0}$, subject to his budget constraint 2 and 3. The resulting maximization first order conditions (FOCs) are then specified below:

$$\lambda_t = \frac{\partial u(c)}{\partial c_t^T} \quad (4)$$

From (4) and taking into account the derivative of $c = [\omega(c^T)^{-\eta} + (1 - \omega)(c^N)^{-\eta}]^{\frac{-1}{\eta}}$, we get:

$$\frac{\partial C / \partial C^N}{\partial C / \partial C^T} = p_t^N = \left(\frac{1 - \omega}{\omega} \right) \left(\frac{c_t^T}{c_t^N} \right)^{\eta+1} \quad (5)$$

The resulting Euler equation is:

$$\lambda_t = \frac{\beta}{q_t} E_t[\lambda_{t+1} + \mu_t] \quad (6)$$

while the last optimality condition is:

$$q_t b_{t+1} + \kappa(y_t + p_t^N y_t^N) \geq 0 \quad (= 0 \text{ if } \mu_t > 0) \quad (7)$$

where λ is the Lagrangian multiplier on the budget constraint, (2), and μ is the Lagrangian multiplier on the credit constraint, (3). It is important to notice how shifts (or shocks) in gross real interest rate (i.e. changes in global liquidity), $\frac{1}{q_t}$, influences borrowing capacities

through the right side of the agent's Euler equation (6). It is natural that in a low interest rates circumstance, borrowing is cheap and agents tend to accumulate more debt. Furthermore, news about future income, y_{t+1} , affects either borrowing capacity at $t = 0$ and expectations on future ($t > 0$) borrowing. Intuitively, once agents receive positive news about their future income, their current consumption starts to increase. But, since this future realization is uncertain and not concrete yet, they incautiously decide to excessively borrow anyway. At the same time, good news decreases future borrowing's needs in agents' budget constraint, by increasing future borrowing capacity. In the end, the combination of the two eventually alters the stability of the economy through the financial system, increasing its vulnerability to financial crises.

3.2 Modeling news about future values of tradable income

In this section, the mechanism through which news about future fundamentals values, i.e. future realizations of y^T , is introduced. The approach follows closely Durdu et al. (2013[20]).

The tradable income process is structured as to follow an AR(1) process:

$$\ln(y_t^T) = \rho \ln(y_{t-1}^T) + \epsilon_t$$

with $E(\epsilon) = 0$ and $E(\epsilon^2) = \sigma_\epsilon^2$. Moreover, it is assumed that in each period the agent receives a signal s_t about 1-period ahead tradable income shock. Because of this predictive power, the signal will make the agent changing his revision on forecast for next period tradables income. In particular, the forecast of next period's tradable income shock (y_{t+1}) is made as such to incorporate the signal s_t . In order to develop the stochastic probability process of tradables income realization only, BLM make use of the Bayes' theorem, conditional on some values of current income y_t^T , and news signal, s_t , that agents receive in each period:

$$p(y_{t+1}^T = l | s_t = i, y_t^T = j) = \frac{p(s_t | y_{t+1}^T = l) p(y_{t+1}^T | y_t = j)}{\sum_n p(s_t = i | y_{t+1}^T = n) p(y_{t+1}^T | y_t = j)} \quad (8)$$

For quantitative issues, it is necessary to express the joint Markov process evolution of the

tradable income, y^T , and news signal, s , through the conditional probability $\Pi(\cdot)$:

$$\begin{aligned} \Pi(y_{t+1}, s_{t+1}, y_t, s_t) &\equiv p(s_{t+1} = k, y_{t+1} = l | s_t = i, y_t = j) = \\ &p(y_{t+1} = l | s_t = i, y_t = j) \sum_m [p(y_{t+2} = m | y_{t+1} = l) p(s_{t+1} = k | y_{t+2} = m)] \end{aligned} \quad (9)$$

The function $\Pi(\cdot)$ (equation 9) transforms signals and income levels at t with the same equivalent figures at $t+1$ (expected realization). Once again, it is important that this stochastic process is known by the agent, who decides in its accordance to create rational expectations on their future consumption and borrowing decisions' development⁶. The values for y^T shocks are discretized through the Tauchen and Hussey's method⁷.

Subsequently, it is needed to specify the probability of receiving a public signal given a definite value l for future income. In other words, signal precision is defined as:

$$p(s_t = i | y_{t+1}^T = l) = \begin{cases} \theta & \text{if } i = l \\ \frac{1-\theta}{N-1} & \text{if } i \neq l \end{cases} \quad (10)$$

where s_t identifies the news signal that the agent collects at time t whereas N is the number of states of y_{t+1}^T (with $N = 3$). The term θ is the precision parameter of the signal: for $\theta = 1$, the precision of the signal is certain and agent can thoroughly incorporate the future value y_{t+1} acting in its accordance. For simple tractability of the model, it is assumed that even if $\theta = 1$, the agent still faces uncertainty about y_{t+k} , with $k \geq 2$. In the real world, of course, private agents receive many signals likely occurring at different future periods. Then, for values $\theta = \frac{1}{N}$, $p(s_t = i | y_{t+1}^T)$ becomes a uniform probability function because, regardless the values of y_{t+1}^T , the possible values of the news signal receive all equal probability $\frac{1}{N}$. In this case the agent's borrowing decision is not influenced, because none of the states of nature for y_{t+1}^T is overweighted. Furthermore, it is assumed that news signal is publicly available to both households and regulators. Of particular interest are the cases when signals are very precise

⁶Only the stochastic process for y_t^T is present because it is assumed that y_t^N is taken as given.

⁷The purpose is to find a Markov chain whose sample paths approximate those of the AR(1) described above.

(for instance, $\theta > 0.90$), because asymmetry of information may arise. In this regard, as Durdu et al. (2013[20]) found, one of the differences between emerging and developed economies is in the degree of precision of news. It is shown (Boz et al., 2011[13], Gelos et al., 2005[24]) that, differently from poor economies, higher income per capita countries are typically characterized by relatively accurate information systems. For this purpose, several cases for θ will be presented in the quantitative section.

3.3 Modeling global shifts in liquidity, R

Global liquidity shocks are considered to allow for exogenous factor hitting the economy. Regimes of this kind can vary from high to low levels of world real interest rate, which is used as a proxy for liquidity. For a matter of simplicity however, the process for interest rate shocks is made standard two-point, transitioning from R^h to R^l . Its properties are:

Transitioning probabilities: $F_{hh} \equiv p(R_{t+1} = R^h | R_t = R^h)$; $F_{ll} \equiv p(R_{t+1} = R^l | R_t = R^l)$

Switching probabilities: $F_{hl} = 1 - F_{hh}$ and $F_{lh} = 1 - F_{ll}$

Long-run regime probabilities: $\Pi^h = \frac{F_{lh}}{F_{lh} + F_{hl}}$ $\Pi^l = \frac{F_{hl}}{F_{lh} + F_{hl}}$

Long-run unconditional mean: $E[R] = \frac{F_{lh}R^h + F_{hl}R^l}{F_{lh} + F_{hl}}$

Unconditional Variance: $\sigma^2(R) = \Pi^h(R^h)^2 + \Pi^l(R^l)^2 - E[R]^2$

1st order autocorrelation: $\rho(R) = F_{ll} - F_{hl} = F_{hh} - F_{lh}$

3.4 Regulator's problem

In the context of shocks hitting the economy, a social planner aims at maximizing either borrowers' and lenders' welfare in the market, by containing the frequency and the pecuniary externalities of the financial crisis. In theoretical terms, the constrained maximization problem for the social planner involves directly choosing the optimal amount of bonds in the economy satisfying his credit constraint. This decision is similar to private agent's, but the regulator internalizes the effect of borrowing on consumption and on the tightness of the credit constraint

(3). The regulator's maximization problem is:

$$V(b, z) = \max_{p^N, c^N, c^T, b'} \left[u \left(\omega (c^T)^{-\eta} + (1 - \omega) (c^N)^{-\eta} \right)^{-\frac{1}{\eta}} + \beta EV(b', z') \right] \quad (11)$$

subject to the following resource constraint (12), nontradable market clearing condition (13), credit constraint (14) and optimal condition for allocation of consumption (15):

$$c^T + qb' = b + y^T \quad (12)$$

$$c^N = y^N \quad (13)$$

$$qb' \geq -\kappa(y^T + p^N y^N) \quad (14)$$

$$p^N = \left(\frac{1 - \omega}{\omega} \right) \left(\frac{c^T}{c^N} \right)^{\eta+1} \quad (15)$$

where the current bond holdings, b , and the actual exogenous shocks, $z = (y, s, q)$, represent state variables. It is possible to show that FOCs that solve the problem above are:

$$\lambda_t = \frac{\partial u(c)}{\partial c^T}(t) + \mu_t \psi_t \quad (16)$$

$$\lambda_t = \frac{\beta}{q_t} E_t[\lambda_{t+1} + \mu_t] \quad (17)$$

where λ_t and μ_t represents the Lagrange multipliers on the resource constraint (12) and the credit constraint (14), respectively, while $\psi \equiv \kappa \left[\frac{1-\omega}{\omega} (1+\eta) \frac{c^T}{y^N} \right]$ represents the effect of c_t^T on the level of borrowing capacity and the relative price of nontradables, which in turn affect y^T (i.e. collateral). Thus, the term $\mu_t \psi_t$ in equation (16) identifies the additional benefit of tradable goods resulting from relaxing the credit constraint.

3.5 Optimal macroprudential tax on debt

The interesting channels through which news about future income and regime shifts in global liquidity affect the economy are:

- “Positive news” at period t about future fundamentals (increase in $E[y_{t+1}]$) lead, on the one hand, to an increase in current consumption, which must be accompanied by an increase in borrowing (because y_{t+1} has not been realized yet) and, on the other hand, to an increase on expectations for future borrowing capacities, which further reduce future financing needs. Eventually, this mechanism may result in high levels of financial vulnerability in the economy.
- Whenever low levels of interest rates characterize the economy, access to borrowing becomes easier and, as a result, agents are willing to take more debt. Higher interest rates may lead to the opposite.

After an unforeseen interest rate increase or⁸ a negative income disturbance shocking the economic system, aggregate consumption shrinks, which in turn leads to a contraction in the credit constraint and in capital flows. In this regard, intervention by the social planner is needed especially for hindering this fueling in vulnerability. In fact, as explained in section 2, those intervening policies aim at reducing the borrowing incentives of agents. They vary from Loan-to-Value (LTV) ratios to taxes on the cost of borrowing, from capital requirements to reserve requirements (Galati et al., 2014[23]). The option of a tax on debt causes the first term in the right-hand of the agent’s budget constraint (2) to become $[\frac{q_t}{(1+\tau_t)}b_{t+1}]$. The optimal level of τ_t^* is set to equate the regulator’s Euler equation of bonds to the decentralized equilibrium level with tax. In the special case of $\mu_t = 0$, the optimal macroprudential tax on debt results in:

$$\tau_t^* = \frac{E_t[\mu_{t+1}\phi_{t+1}]}{E_t[u_T(t+1)]} \quad (18)$$

A tax of zero is implemented when $u(c_t) > \beta REu(c_{t+1})$, while, more generally, whenever $\mu_t > 0$, it can be shown that there exists several taxes level that satisfy the efficient allocation of choices.

⁸In the model it is assumed that y^T shocks are independent with respect to liquidity shocks.

4 Quantitative analysis

4.1 Calibration

The main difference with BLM model is that, instead of calibrating the parameters for a poor economy, the framework of this work is calibrated for a rich economy. Hence, I calibrate the economy for OECD countries with the use of data taken from *OECD Main Economic Indicator* and *World Bank Open Data*, while BLM calibrate the model for Argentina. The resulting parameters are summarized in table 1 and all their calculation methodologies are subsequently explained in details.

Parameters	β	γ	ω	η	κ	θ	y^N	N_{yT}	$E[y^T]$	ρ_y^T	σ_y^T	R^h	R^l	F_{hh}	F_{ll}
Values	0.91	2	0.35	0.45	0.32	0.67	1	3	1	0.866	0.033	1.0232	0.9865	0.6013	0.3391

Table 1: Estimated parameters to calibrate the baseline model

For a matter of comparison with BLM (2015), the parameter θ is initially set at $2/3$, which corresponds to the midpoint between two extreme events, i.e. $\frac{1}{N} = 0.33$ and 1 .

To estimate the value for ω instead, the dichotomy between tradable and nontradable goods must be taken into account (Duarte et al., 2008[19]). However, by following their definition⁹, it has been calculated $\omega = 0.35$, consistently with the literature¹⁰.

The next essential parameter to estimate is the elasticity of substitution between tradable and nontradable goods, i.e. $\frac{1}{1+\eta}$. Although Bianchi (2011) reported this measure ranging from 0.40 to 0.83 (in the end, BLM (2015) conservatively opt for 0.83), existing studies do not focus on developed countries and exclude data series covering the recent financial crisis. Thus, by means of dataset from *OECD Main Economic Indicator* and *World Bank Open Data* on 27 developed countries¹¹, two approaches to estimate the elasticity of substitution between

⁹According to the OECD, services include transport (both freight and passengers), travel, communications services (postal, telephone, satellite, etc.), construction services, insurance and financial services, computer and information services, royalties and license fees, other business services (merchandising, operational leasing, technical and professional services, etc.), cultural and recreational services, and government services not included in the list above.

¹⁰e.g. in BLM (2015) $\omega = 0.32$, in Stockman and Teaser (1995) and in Dotsey and Duarte (2008), $\omega = 0.44$

¹¹The 27 considered countries are: AUS, AUT, BEL, CAN, CZE, DNK, FIN, FRA, DEU, GRC, HUN, IRL, ITA, LUX, NLD, NZL, NOR, POL, SVK, ESP, SWE, CHE, GBR, USA, SVN, LVA and EST.

tradable and nontradable goods are followed in this research: Lorenzo, Aboal and Osimani (2004) and Stockman and Tesar (1995). The former starts the estimation from (4) and takes into account the derivatives of the CES aggregate $c = [\omega(c^T)^{-\eta} + (1 - \omega)(c^N)^{-\eta}]^{-\frac{1}{\eta}}$:

$$\frac{\partial C/\partial C^N}{\partial C/\partial C^T} = p_t^N = \left(\frac{1 - \omega}{\omega}\right) \left(\frac{c_t^T}{c_t^N}\right)^{\eta+1} \quad (19)$$

Then,

$$\frac{c^N}{c^T} = \left[\frac{\omega}{1 - \omega} p_t^N \right]^{\frac{-1}{1+\eta}}$$

After taking logarithms to both sides, the elasticity of substitution between tradable and nontradable goods can be easily estimated through the following OLS regression, for each country over time:

$$\ln(C_t^T/C_t^N) = \ln\alpha_0 - \alpha_1 \ln(RER) \quad (20)$$

where $\alpha_0 \equiv \left(\frac{\omega}{1-\omega}\right)^{\frac{1}{1+\eta}}$, $\alpha_1 \equiv \frac{1}{1+\eta}$ and $RER \equiv \frac{p_t^T}{p_t^N}$. Estimated coefficients for $\alpha_1 \equiv \frac{1}{1+\eta}$ were weighted by means of the size of the country (i.e. GDP per capita). Eventually, the weighted average elasticity of substitution measure for OECD countries results to be 0.6167, corresponding to a value for η of 0.6215.

The latter approach is in turn based on Kravis and Robert E.Lipsey (1987) method and considers the seven largest industrial countries using data from OECD datasets (their estimated value for $1/(1+\eta)$ is 0.44). By means of the same dataset, the approach to estimate η is based on regressing nontradable goods consumption share on the price index for nontradable goods share and, to control for the income effect, on GDP per capita. Of course, the most striking figure to estimate is the relative price of nontradables with respect to tradables, P^N/P^T . But, by following M.Goldstein and L.H.Officer (1979[25]), it may be proxied by CPI/WPI¹². After weighting for each country's GDP per capita, the second estimate for the coefficient η is 0.2826, resulting into a measure for the elasticity of substitution of 0.7797. In summary, the resulting estimated values for η are therefore 0.6215 and 0.2826, which in turn lead to estimated values

¹²Consumer Price Index and Wholesale Price Index

for the elasticity of substitution between tradable and nontradable goods in rich economies of 0.6167 and 0.7797, respectively, in line with the literature¹³. To calibrate the model in this research, an average between the two estimates has been opted for the elasticity of substitution: $IES = \frac{\frac{1}{1+\eta_1} + \frac{1}{1+\eta_2}}{2} = 0.69$. Moreover, by means of the same dataset, I estimate values for the standard deviation and the autocorrelation coefficient of tradable goods: $\sigma_{y^T} = 0.033$ and $\rho_{y^T} = 0.866$. Subsequently, the value for γ is set at 2, as usual in the literature, and for κ at 0.32, consistently with Bianchi (2011) and to generate a probability of crisis of 3%.

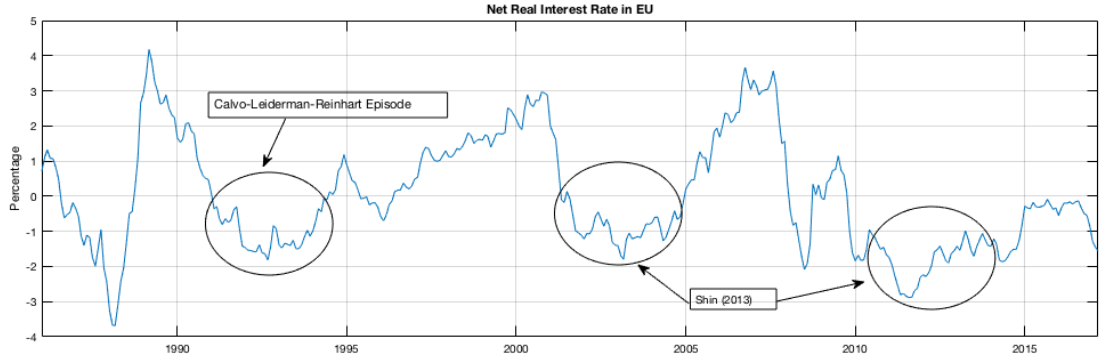


Figure 1: European levels of liquidity, i.e. Net Real interest rate, over the sample period 1986-2017.

In figure 1, it is possible to see the monthly evolution of real LIBOR for the period I/1986-I/2017. By identifying the global liquidity phase of Calvo et al. (1996[15]) in the first half of the last decade of twentieth century and other two of Shin (2013[30]) in the first half of the first and second decade of the twenty-first century, average R^h and R^l are estimated to be 1.0232 and 0.9865, respectively. For the estimation of F^{hh} and F^{ll} instead, since the last phase of global liquidity occurred as a consequence of the unconventional policies aimed at restoring the majority of developed economies from the recent financial crisis, I ignored the first years after the financial crisis (second phase of Shin, 2013[30]). During the other two liquidity phases (the one of Calvo and the first of Shin), the perpetuation of R^h and R^l resulted to be moderate, leading to annual frequency for the two regimes of $F^{hh} = 0.6013$ and $F^{ll} = 0.3391$.

¹³e.g. Mendoza (1995), i.e. 0.74

4.2 Results

The model is backward solved with Matlab using the recursive-substitution method for the model's optimality conditions. After finding the decentralized equilibrium (DE) and the optimal tax solution set by the social planner (SP), the model simulates 201,000 periods, where the first 1,000 serve for training purposes.

The effects of the optimal macroprudential tax set by the social planner on both the economy modeled in this work (*baseline* column) and the BLM economy (*BLM* column), which lead to moments of the financial crisis, are shown in table 2. The model defines the financial crisis such as all the periods in which the current account (CA/Y) value varies more than two standard deviation from what the DE predicts. Welfare gain instead is calculated as to fill the difference in consumption that equates the decentralized equilibrium (DE) and the social planner (SP) equilibrium welfare.

Moments	Baseline		BLM	
	DE	SP	DE	SP
Long-term moments				
$E[NFA/Y]\%$	-31.00	-30.97	-29.62	-29.31
$\sigma_{CA/Y}\%$	2.73	2.02	3.18	1.75
Welfare Gain %	n/a	0.0658	n/a	0.12
Prob of crisis %	1.44	1.04	3.51	2.27
Financial crisis moments				
$\Delta C\%$	-13.76	-11.24	-14.39	-9.41
$\Delta RER\%$	-43.35	-34.47	-45.55	-27.62
$\Delta CA/Y\%$	14.05	10.79	13.47	7.06
Ω^C	18.10	14.37	4.63	3.25
Ω^{RER}	22.30	17.12	5.61	3.69
$\Omega^{CA/Y}\%$	13.95	10.74	13.37	7.38
$E[\tau]$ pre-crisis %	n/a	1.037	n/a	4.65
Switch from R_l to R_h				
$\Delta C\%$	-13.38	-10.94	-15.49	-10.18
$\Delta RER\%$	-41.95	-33.40	-49.93	-30.25
$\Delta CA/Y\%$	13.03	9.88	14.65	7.7
$E[\tau]$ pre-crisis %	n/a	1.034	n/a	5.11

Table 2: Comparison between moments of the two models, baseline (rich) and BLM (poor) economy, across DE and SP equilibrium.

The most important feature macroprudential regulation must aim for is controlling the credit allocations in “good states” because of their negative externalities flowing into future “bad states”. The economic intuition behind macroprudential policies operation is just hampering the fueling of systemic risk, generally approximated by the amount of leverage in the economy, likely in booming periods. In fact, when the economy is expanding (booming of credit, beginning of investments, etc.) it is difficult to on-going identify precisely the period when its peak is reached. Therefore, it is better to inhibit either the vulnerability (probability) and the consequences (magnitude) of the crisis by just monitoring some macro-signals. This preventive power is reflected in the decline in the magnitude ($\Delta C\%$, $\Delta RER\%$ and $\Delta CA/Y\%$) and probability (from 1.44% to 1.04%, a reduction of only 40 basis points) of crisis in developed economies, in line with Bianchi et al. (2011 and 2015). These figures, however, are much more contained in the baseline than in the BLM economy. Probability of crisis under the SP equilibrium is decreased in BLM by 124 basis points, whereas in the *Baseline* model by only 40 basis points. The analytical reason is that optimal taxes of the former (1.037% and 1.034%) are lower than the ones in the latter (4.65% and 5.11%). Moreover, from an economic standpoint, these findings are supported by previous studies (Uribe and Yue (2006), Neumeyer and Perri (2005), Reinhart et al. (2003)) which showed that crises are more likely to occur in poor economies, because they are characterized by higher interest rate spreads and can only sustain lower debt-output ratios than rich economies. Furthermore, low income-per-capita countries experience countercyclical trade balances and sovereign interest rate spreads more frequently than high income-per-capita countries, which worsen the condition of borrowing in bad times. As a result, although still positive and preventive, the effect of the optimal macroprudential tax on debt on crisis dynamics is curbed in rich economies. Moreover, with the adoption of the macroprudential tax, the long-term average of the net foreign asset position-to-GDP ($E[NFA/Y]$) ratio decreases proportionally less than the volatility of the current account-to-output ratio ($\sigma_{CA/Y}$) does. For a matter of comparison, either poor and rich economies are characterized by about the same mean of debt ratios with and without the tax, while the BLM economy experiences stronger decline in variability of capital flows (from 3.18% to 1.75%), in line with Bianchi et al. (2011[9],

2015[11]). Interestingly to notice is the NFA-GDP ratio: in equilibrium, it is slightly higher in rich economies (-31 in DE and -30.97 in SP) than in poor economies (-29.62 in DE and -29.31 in SP). Welfare gain in BLM (0.12%) doubles the one in this model (0.0658%), fact that strengthens the same thesis. Another difference between the dynamics of the financial crisis in the baseline model and the BLM model is shown in the bottom part of table 2, where the effects of changes in liquidity regimes are presented: while the BLM economy experiences a more intense crisis event in this case than in the previous case (compared to the BLM economy, ΔC , ΔRER and $\Delta CA/Y$ are sharper here than in crisis caused by news on fundamentals), the effects in the rich economy are the opposite (ΔC , ΔRER and $\Delta CA/Y$ are more contained). In practice, it seems that the adoption of different macroprudential policies in different scenarios is advised depending on the characteristics of the economy (e.g. emerging vs. developed economies).

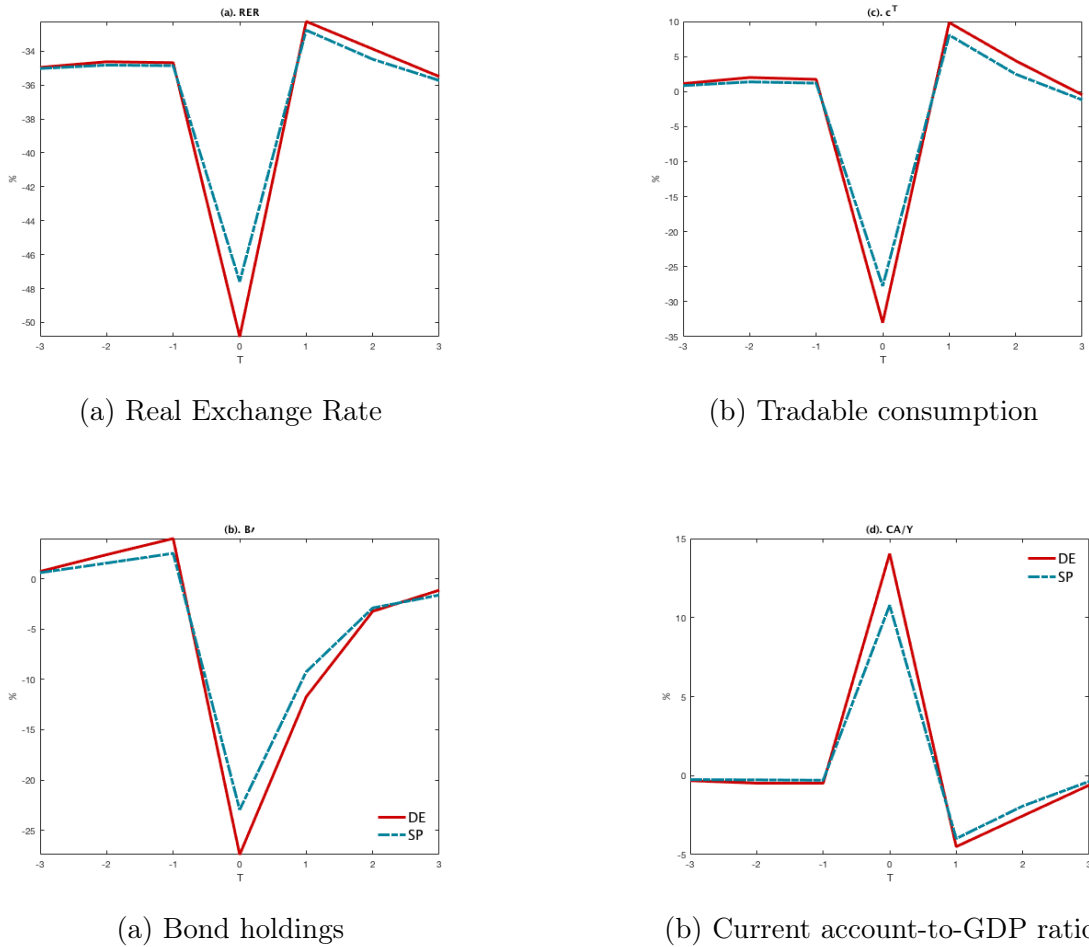


Figure 3: Plots of the main macro variables' dynamics, around crisis, in the DE and SP setting.

Macro variables' dynamics around the crisis event (deviations from the average) across seven periods ($t=7$) are shown in figures 2a, 2b, 3a and 3b. From their analysis, it is even more evident the little positive contribution of the macroprudential tax on debt in reducing the magnitude of drops in consumption, real exchange rate and current account-GDP ratio in the modeled economy. Lastly, values of financial amplification terms (Ω_i , with $i=C, RER$ and CA/Y) are substantially high in the Baseline model¹⁴. This suggests that in rich economies, the effects of shocks on the main variables are larger in financial crises than in non-crisis events. This is confirmed also by the modeled Fisherian mechanism of Mendoza et al. (2010[10]).

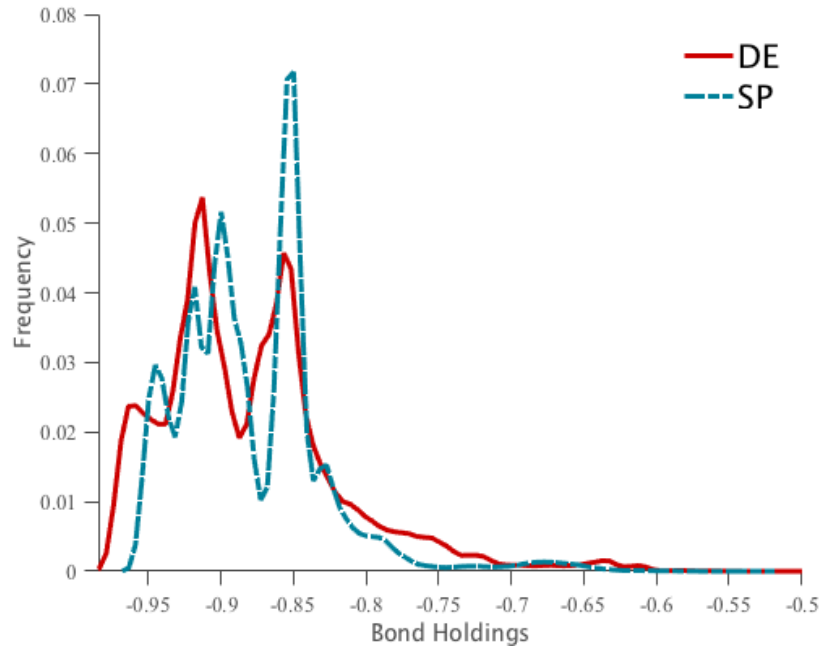


Figure 4: Distribution of bond holdings.

Although similar to the case of the poor economy (BLM), the benefits of the intervention of the social planner on the overborrowing tendency of the economy in DE are less accentuated in a rich economy framework (Baseline). This is reflected in figure 2: as expected, the bond holdings' distribution under the SP is shifted to the right. Hence, agents' overborrowing behavior is corrected. To conclude, the macroprudential tax on debt is more effective in poor economies

¹⁴All kinds of Ω work as financial amplification parameters that identify the ratio between average effects of each variable in financial crisis over the same variable's impact in normal times.

than in rich ones since the latter achieves roughly double the welfare gain (0.12% vs. 0.0658%) and cuts the probability of crisis three times less (124 vs. 40 basis points) than the former.

4.3 Scenario Analysis on news precision

In order to better understand what policy makers can do for limiting the pecuniary externalities caused by financial crises, it is interesting to look at the evolution of financial crisis moments as the precision of news, θ , varies. Firstly, by increasing the degree of news precision, the attention seems to shift on economies with more reliable information distribution system (Boz et al. 2011 [13], Gelos and Wei (2005)[24]). Intuitively, as the precision of news becomes higher, agents are able to better deal with the allocation of debt to finance current consumption and, as a result, the probability of crisis is lower. This intuition is replicated into facts: the output of the scenario analysis on θ , the news' precision parameter, is shown in the figure below:

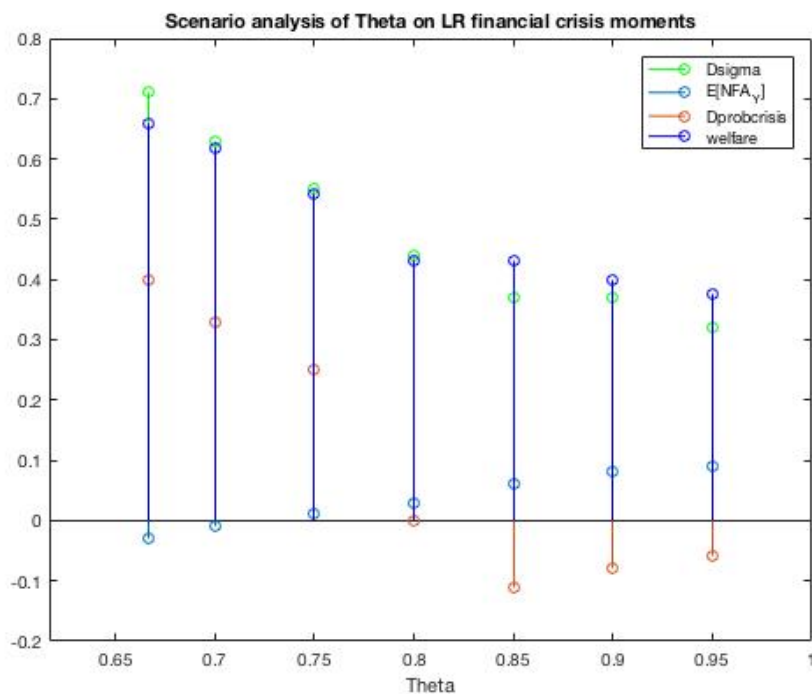


Figure 5: Effects of news precision on four macro variables: $\Delta\sigma(CA/Y)\%$, $\Delta E[NFA/Y]$, $\Delta P(Crisis)\%$ and Welfare % (differences are calculated as $\Delta X = X_{DE} - X_{SP}$).

For example, the variable *Dsigma*, which identifies the difference between $\sigma_{CA/Y}$ in DE and

in SP, decreases as θ increases. This means that, with the macroprudential tax on debt, the variability of current account of the economy improves less as agents receive more precise news about their future income. Furthermore, welfare gains decrease and the magnitude of the crisis' effects, i.e. $E[NFA/Y]\%$, slowly increases. However, the behavior of drops in probability of crisis' figure is not monotonous: for $\theta < 0.85$, it shows a decreasing trend, suggesting that macroprudential policy loses efficiency in richer economies (at $\theta = 0.85$, SP intervention is even deleterious). After this threshold however, the gap between probability of crisis in DE and SP started to increase steadily, meaning that macroprudential tax on debt does properly its job, namely decreasing the likelihood to experience a financial crisis.

The large majority of these results suggest that a macroprudential tax on debt negatively affects an economy in which agents can (almost) perfectly anticipate income shocks by relying on roughly precise news. This is in line with Benigno et al. (2013[4, 5]), who criticized the fact that macroprudential policies reduce growth (negative welfare), especially in rich economies. In these special situations indeed, it may be advised to adopt and coordinate macroprudential policies with either monetary and fiscal policies.

5 Conclusion

Financial crisis dynamics are difficult to inhibit and are different depending on particular country's characteristics. There is no universal way for policy makers to prevent such events. By comparing the beneficiary effects of a macroprudential tax on debt in this model's setting (calibration made with OECD data) with a poor economy's (BLM uses Argentinian data), it is shown that the effectiveness of the social planner intervention is higher in the latter than in the former. In particular, welfare gains in rich economies are halved, drop in probability of crisis goes from 124 basis points to 40 basis points and since the crisis is less likely, macroprudential tax on debt is slightly higher than 1% only (whereas on BLM is around 5%). Then, as a result of news precision analysis, my findings show that a macroprudential tax on debt may become even deleterious as the precision of news on future income received by agents increases. Char-

acterized by different levels of liquidity, tradable income development and allocation between tradable and nontradable goods among others, agents in rich economies can rely on better information flow systems. This is the main reason why financial crises caused by fundamental news shocks are less likely to occur in developed than in poor economies (BLM). This is in accordance with previous researches, which showed that poor economies are characterized by higher interest rate spreads and they can only sustain lower debt-output ratios than rich economies. In the end, we can conclude that debt outstanding in the economy is a crucial driver for financial crises. Research on optimal implementation of macroprudential policies is still far from ideal and needs further improvement.

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