Optimal macroprudential regulation in a Fisherian model of financial crises

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1. Introduction

Financial crises of the magnitude that caused the ongoing Great Recession are relatively rare but dramatic and socially costly events. As was the case with the 1990s emerging markets crises or the Great Depression of the 1930s, the Great Recession was preceded by prolonged booms in credit, economic activity and asset prices, followed by a sharp, sudden crash. This observation has made policymakers wary of periods of rapid credit expansion and surging asset prices, and has led to the view that financial regulation is in urgent need of revamping to incorporate a macroprudential focus to contain systemic excessive borrowing in the expansionary phase of the credit cycle. Research on the development of the macrofinancial framework that is required to construct quantitative models to inform the design of this new regulation is at an early stage. We report in this paper on some of the key lessons that follow from the research we are conducting to contribute to fill this gap (see Bianchi and Mendoza (2011) for further details).

Research on this topic is at an early stage primarily because macroeconomics has a lot of work to do in producing sound quantitative models that can incorporate realistic mechanisms explaining the dynamics that turn typical business cycles into full-fledged financial crises. In particular, a good model of macroprudential regulation should pass two litmus tests: first, the model should provide a plausible quantitative explanation of the stylised facts that characterise actual financial crises, and of the frequency with which these crises occur; second, the model should provide a framework for relating policy instruments to the actions of economic agents in a way that can capture the effects by which policy actions taken in "good times" alter the features of financial crises in "bad times." These are challenging tasks, because they involve studying the dynamics of complex nonlinear intertemporal models with financial frictions using global methods that can approximate accurately the incentives (or the lack thereof) of market participants to take prudential action in the face of potentially serious financial risks.

We construct our framework starting with a theoretical foundation based on the theory of financial crises postulated by Irving Fisher in his classic 1933 article on the Debt-Deflation Theory of Great Depressions. Following Mendoza (2010), the engine of our model is a borrowing constraint that limits an individual's borrowing ability for consumption smoothing and for working capital financing to a fraction of the market-determined value of the assets the individual can post as collateral. When the constraint binds, agents fire-sale assets, which leads to a spiralling decline in asset prices and borrowing ability that can greatly amplify the effects of the underlying shocks driving business cycles, just as Fisher described in his work.

The key step in extending the model to make it useful for studying macroprudential policy is to recognise that the borrowing constraint introduces a systemic pecuniary externality in credit markets, which arises because of the Fisherian feedback loop between asset prices and collateral constraints. During booms, increases in asset prices relax collateral constraints

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and boost output. As leverage increases, a small shock can trigger fire sales, a collapse in asset prices and a deep recession. During both the boom and crash phases, however, individual agents fail to internalise the implications of their own actions for market-determined asset prices. In particular, by failing to internalise the Fisherian deflation dynamics they might face in bad times, they choose to borrow "too much" in good times.

We analyse the case for macroprudential regulation by considering how a social planner who internalises the feedback loop between leverage, asset prices and collateral constraints can enhance financial stability and make everyone better off. In particular, we answer two key questions: first, what are the effects of macroprudential regulation on the frequency and magnitude of financial crises? Second, what are the features of the policy instruments that are necessary to implement the planner's constrained-efficient allocations?

We answer these questions using a nonlinear dynamic stochastic general equilibrium model of asset prices and business cycles with credit frictions. As in the model of Mendoza (2010), our model provides a unified framework to study business cycles and financial crises since the latter are events that occur with positive probability and are anticipated by agents during regular business cycles. In the model, collateral assets take the form of an asset in fixed aggregate supply (eg land). Private agents take the price of this asset as given, producing the systemic pecuniary externality mentioned above. The social planner faces an identical set of feasible credit positions, but internalises the effects of debt choices on future asset prices and wages.

When the constraint becomes binding, production plans are also affected, because working capital financing is needed in order to pay for a fraction of labour costs, and working capital loans are also subject to the collateral constraint. As a result, when the credit constraint binds output falls, because of a sudden increase in the effective cost of labour. This affects dividend streams and therefore equilibrium asset prices, feeding back again to the real side of the economy and to credit market access.

We calibrate the decentralised competitive equilibrium to US data and ask how the allocations and prices that characterise it compare with those of the social planner. Our findings suggest that there is significant potential to enhance financial stability and improve social welfare with the introduction of macroprudential regulation, but they also highlight the challenges that policymakers face in the design of optimal macroprudential regulation.

In our experiments, the probability of a financial crash is reduced from 3% in the decentralised equilibrium to less than 1% in the constrained-efficient equilibrium. Asset prices drop about 25% in a typical crisis in the decentralised equilibrium, compared with 5% in the constrained-efficient equilibrium. Output drops about 50% more in the decentralised equilibrium, because the fall in asset prices reduces access to working capital financing. The social planner can induce the decentralised economy to replicate exactly the constrained-efficient allocations by imposing taxes on debt and dividends of about 1% and –0.5% on average, respectively. While in our model this is possible, we also recognise that attaining the same level of optimality with actual macroprudential regulation is a daunting task. Our model is highly stylised, featuring a representative agent with a single borrowing constraint, one source of exogenous shocks, and with perfectly informed agents and regulators. Further work needs to develop richer models to relax these unrealistic assumptions.

2. Model

The model features a representative firm-household that takes production, employment and borrowing decisions to maximise expected lifetime utility given by

$$E_0\left[\sum_{t=0}^{\infty} \beta^t u(c_t - G(n_t))\right]$$

where c_t represents consumption and n_t represents labour supply. Each household can combine land and labour services purchased from other households to produce final goods using a production technology such that $y = \varepsilon_t F(k_t, h_t)$ where k_t represents individual land holdings, h_t represents labour demand and ε_t is a productivity shock that follows a Markov process.

The budget constraint faced by the representative firm-household is:

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R_t} = q_t k_t + b_t + w_t n_t + \varepsilon_t F(k_t, h_t) - w_t h_t \tag{1}$$

where b_{t+1} denotes holdings of one-period, non-state-contingent discount bonds at the beginning of date t, q_t is the market price of land, R_t is the real interest rate, and w_t is the wage rate.

Following Mendoza (2010), private agents face a collateral constraint that limits total debt, including both intertemporal debt and atemporal working capital loans, not to exceed a fraction κ of the market value of asset holdings (ie κ imposes a ceiling on the leverage ratio):

$$-\frac{b_{t+1}}{R_t} + \theta w_t h_t \leq \kappa q_t k_{t+1} \quad . \tag{2}$$

The interest rate is assumed to be exogenous. This is equivalent to assuming that the economy is a price-taker in world credit markets. This assumption is adopted for simplicity, but is also in line with the evidence indicating that in the era of financial globalisation even the US risk-free rate has been significantly influenced by outside factors, such as the surge in reserves in emerging economies and the persistent collapse of investment rates in Southeast Asia after 1998.

Asset prices and wages are determined in the model's general equilibrium. On the side of wages, when the collateral constraint does not bind, wages are simply determined by the market-clearing condition $G'(h_t) = w_t = \varepsilon_t F_2(K, h_t)$. When the collateral constraint becomes binding, demand for labour decreases since the effective cost of hiring increases and this reduces equilibrium wages and employment. On the side of land prices, the demand for land is driven by the effects of technology shocks on future returns for land and on the stochastic discount factor adjusted to consider the shadow value of land as collateral for debt. A binding collateral constraint triggers a fire sale of land and a substantial drop in asset prices as households rush to reduce their land holdings to repay their debt. This further tightens the collateral constraint generating extra rounds of drops in labour and land demand, which feed again into asset prices.

We study the efficiency of the competitive equilibrium by considering a benevolent social planner who maximises the agents' utility subject to the resource constraint, the collateral constraint and the same menu of credit possibilities of the competitive equilibrium. In particular, we consider a social planner that is constrained to have the same "borrowing ability" (the same market-determined value of collateral assets $\kappa q(b_t, \varepsilon_t)\overline{K}$ at every given state as agents in the decentralised equilibrium), but with the key difference that the planner internalises the effects of its borrowing decisions on the market prices of assets and labour.

The Euler equation for bonds in this planner's problem is

$$u'(t) = \beta R_t \left[E_t u'(t+1) + \mu_{t+1} \Psi_{t+1} \right] + \mu_t \qquad \Psi_{t+1} \equiv \kappa \overline{K} \frac{\partial q_{t+1}}{\partial b_{t+1}} - \theta \frac{\partial w_{t+1}}{\partial b_{t+1}}. \tag{3}$$

The comparable Euler equation for the decentralised equilibrium is given by $u'(t) = \beta R_t E_t u'(t+1) + \mu_t$. Notice that there is an extra term in the Euler equation for the constrained planner's problem. This extra term $\mu_{t+1}\Psi_{t+1}$ represents the additional marginal benefit of savings considered by the social planner at date *t,* because the planner takes into account how an extra unit of bond holdings alters the tightness of the credit constraint through its effects on the prices of land and labour at *t+1*.

Note that, since $\partial q_{t+1} / \partial b_{t+1} > 0$ and $\partial w_{t+1} / \partial b_{t+1} > 0$, Ψ_{t+1} is the difference of two opposing effects and hence its sign is in principle ambiguous. The term $\partial q_{t+1} / \partial b_{t+1} > 0$ is strictly positive, because an increase in net worth increases demand for land and land is in fixed supply. The term $\partial w_{t+1} / \partial b_{t+1} \geq 0$ is positive, because the effective cost of hiring labour increases when the collateral constraint binds, reducing labour demand and pushing wages down. We found, however, that the value of Ψ_{t+1} is positive in all our quantitative experiments with baseline parameter values and variations around them, and this is because $\partial q_{t+1} / \partial b_{t+1}$ is large and positive when the credit constraint binds due the effects of the Fisherian debt-deflation mechanism.

The above expression for the planner's Euler equation for bonds also shows some of the key ingredients of the macroprudential policies necessary to correct the externality. One crucial element is to introduce a wedge in the Euler equation for bonds to reduce the incentive to overleverage. We show in Bianchi and Mendoza (2011) how to implement this wedge with a tax on debt (see Bianchi (2010) for the use of capital requirements and loan-to-value (LTV) ratios as equivalent policy measures).

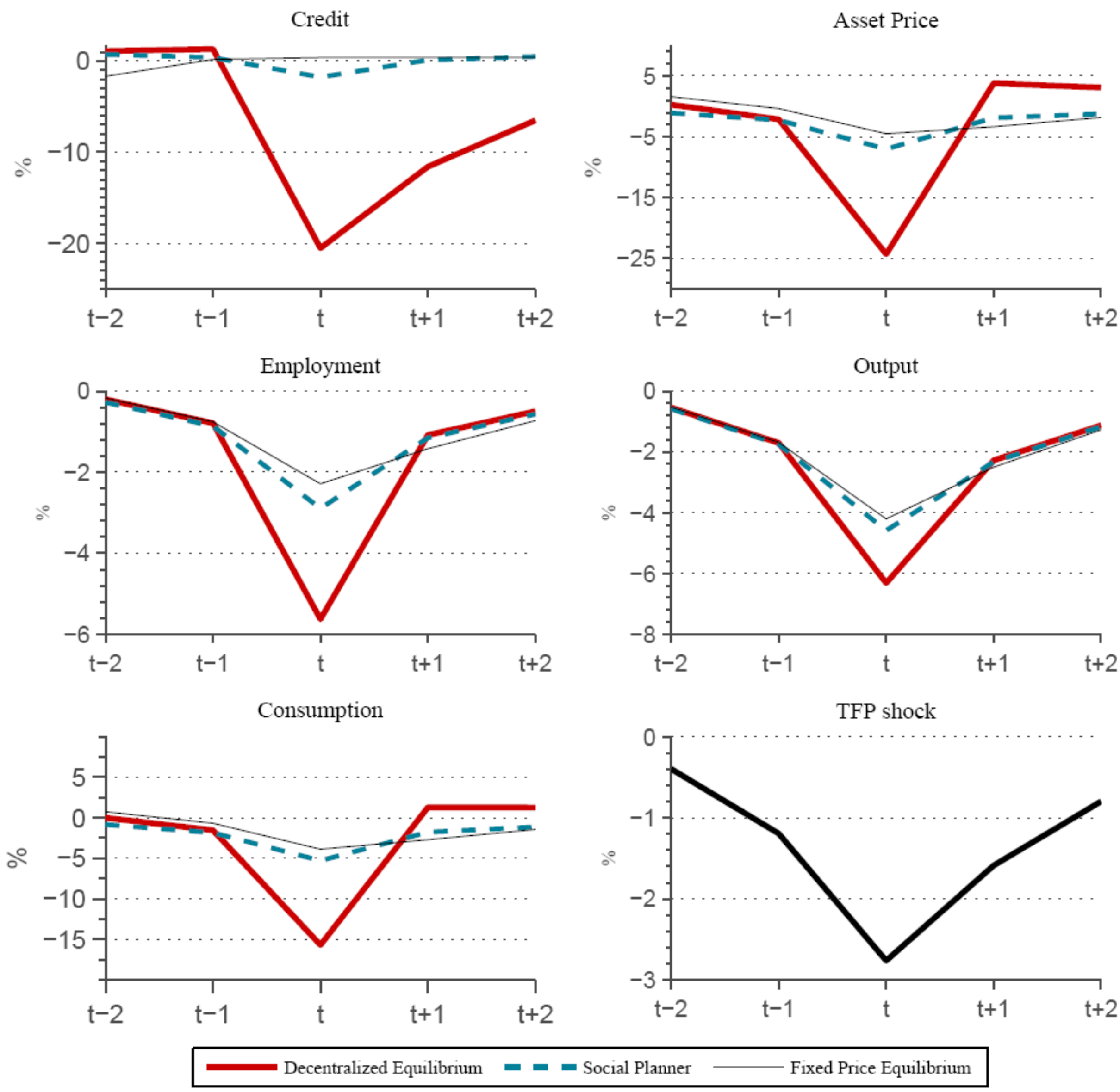
3. Quantitative analysis

The calibration and the solution method are described in detail in Bianchi and Mendoza (2011). To demonstrate the impact of macroprudential regulation, we construct an event analysis of financial crises with simulated data obtained by performing long stochastic time-series simulations of the competitive and constrained-efficient economies, as well as a fixed-price economy that corresponds to a competitive equilibrium in which the credit constraint becomes $-b_{t+1} / R + \theta w_t h_t \leq \kappa \overline{q}\ k_{t+1}$ where $\overline{q}$ is the average price (that is, effectively this economy has a credit constraint but no Fisherian deflation). A financial crisis episode is defined as a period in which the credit constraint binds and this causes a decrease in credit that exceeds one standard deviation of the first-difference of credit.

The first important result of the event analysis is that the incidence of financial crises is significantly higher in the competitive equilibrium. We calibrated κ so that the competitive economy experiences financial crises with a long-run probability of 3.0%. But financial crises occur in the constrained-efficient economy only with 0.9% probability in the long run. Thus, the credit externality increases the frequency of financial crises by a factor of 3.33.

The second important result is that financial crises are more severe in the competitive equilibrium. This is illustrated in the event analysis plots shown in Figure 1. The event windows are for total credit, consumption, labour, output, TFP and land prices, all expressed as deviations from long-run averages. These event dynamics are shown for the decentralised, constrained-efficient, and fixed-price economies. The event analysis is constructed so that it captures a median crisis in the decentralised equilibrium and such that the path for the constrained-efficient and fixed-price economies is simulated using the same initial conditions and the same exogenous shocks as in the crisis in the decentralised equilibrium.

Figure 1



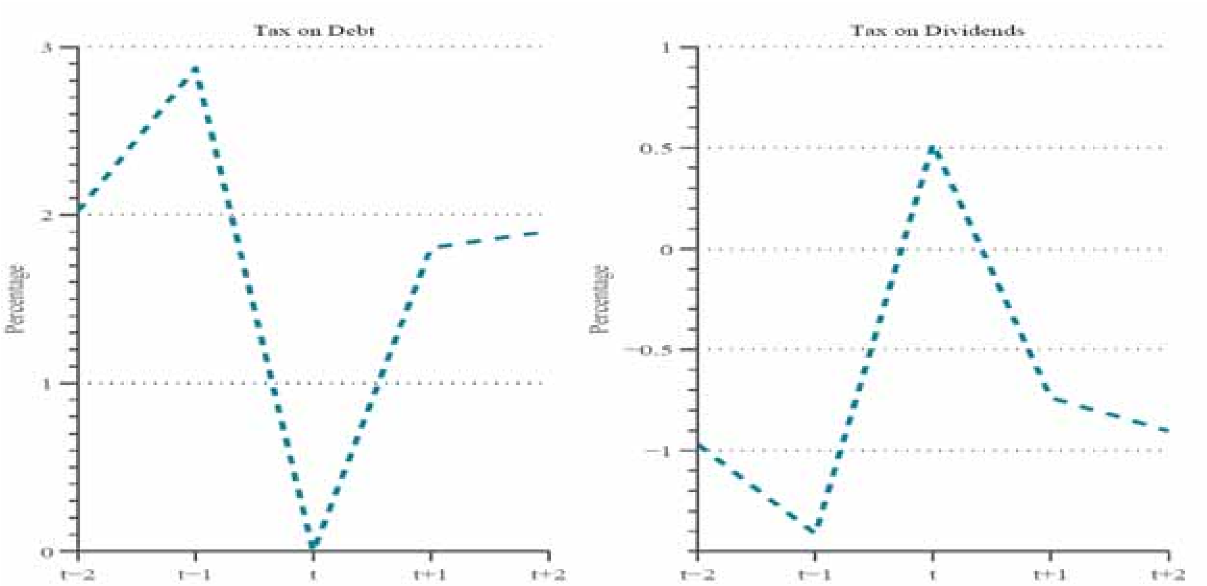
The features of financial crises at date *t* in the competitive economy are in line with the results in Mendoza (2010): the debt-deflation mechanism produces financial crises characterised by sharp declines in credit, consumption, asset prices and output. In this sense, our model aims to comply with the first litmus test we posed in the Introduction.

The five macro variables illustrated in the event windows show similar dynamics across the three economies in the two years before the financial crisis. When the crisis hits, however, the collapses observed in the competitive equilibrium are much larger. Credit falls about 20 percentage points more, and two years after the crisis the credit stock of the competitive equilibrium remains 10 percentage points below that of the social planner. Consumption, asset prices, and output also fall much more sharply in the competitive equilibrium than in the planner's equilibrium. The declines in consumption and asset prices are particularly larger

(–16% against –5% for consumption and –24% against –7% for land prices). The asset price collapse also plays an important role in explaining the more pronounced decline in credit in the competitive equilibrium, because it reflects the outcome of the Fisherian deflation mechanism. Output falls by 2 percentage points more, and labour falls almost 3 percentage points more, because of the higher shadow cost of hiring labour due to the effect of the tighter binding credit constraint on access to working capital.

The dynamics of the debt and dividend taxes around crisis events are shown in Figure 2. The debt tax is high relative to its average, at about 2.7%, at $t-2$ and $t-1$, and this reflects the macroprudential nature of these taxes: their goal is to reduce borrowing so as to mitigate the magnitude of the financial crisis if bad shocks occur. At date t the debt tax falls to zero, and it rises again at t+1 and t+2 to about 2%. The latter occurs because, being this close to the crisis, the economy still remains financially fragile (ie there is still a non-zero probability of agents becoming credit-constrained next period).[2] By showing these results illustrating the prudential incentives of the taxes that decentralise the planner's allocations, our model also aims to comply with the second litmus test we mentioned earlier.

Figure 2



4. Conclusion

The traditional approach to financial regulation requires the solvency of each and every financial institution to be monitored. This microprudential approach has been recently questioned in light of the recent period of high turbulence in financial markets worldwide. In particular, discussions on international financial reform advocate the need of a macroprudential approach. This approach considers how decisions of individual market participants affect the whole financial sector and how developments in the financial sector can affect the real economy and feed back again into the financial sector. We have described

[2] The tax on dividends follows a similar pattern. Dividends are subsidised at a similar rate before and after financial crisis events, but they are actually taxed when crises occur. The reason is that the social planner needs to support the same pricing function of the competitive equilibrium that would arise without policy intervention.

some recent results that evaluate the macroeconomic and welfare effects of this approach in a Fisherian model of financial crises.

Our findings suggest that there are potentially large benefits from adopting a macroprudential approach. In fact, in our simulations, the frequency of a financial crash can be reduced about threefold and the severity of these episodes is substantially reduced. It is important to note, however, that introducing macroprudential regulation does not eliminate the credit cycles in the economy nor does it eliminate the probability of a financial crisis. This is consistent with the idea that the purpose of macroprudential regulation is not to achieve financial stability per se, but to incorporate in the regulatory framework those systemic effects that individual institutions ignore in their private calculations of risk.

We have focused on the time dimension of macroprudential policy (see Borio (2010)). It would be interesting to consider a richer heterogeneity that would allow us to study how policy instruments should be targeted on different types of institutions and on different forms of risk-taking. In the cross-sectional dimension, the choice on how to correlate risks would be a key determinant of aggregate exposure and it is an important aspect that we leave for future research.

At the same time, we would like to point out that actual implementation of macroprudential policies in financial markets remains a challenging task. For example, we have shown that restoring constrained-efficiency requires a tax on debt that increases with the probability of a financial crisis. Implementing this policy requires real-time monitoring of the build-up of systemic risk in order to appropriately adjust the policy instruments and with a sufficient lead to actually have an effect before the crash occurs. Further work on implementation of macroprudential policy is a critical avenue for future research.

References

Bianchi, J (2010): “Overborrowing and systemic externalities in the business cycle”, *American Economic Review*, forthcoming.

Bianchi J and E Mendoza (2011): “Overborrowing, financial crises and macro-prudential policy”, *IMF Working Paper*, WP/11/24.

Borio, C (2010): “Implementing a macroprudential framework: blending boldness and realism”, paper presented at the HKIMR-BIS conference, Hong Kong, July.

Mendoza, E (2010): “Sudden stops, financial crises, and leverage”, *American Economic Review*, vol 100(5), pp 1941–66.