Macro-prudential policies in a DSGE model with financial frictions*

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Abstract

We evaluate the merits of different macro-prudential policies (tools and instruments) in the context of a fully-fledge DSGE model incorporating a distinctive role for the banking sector, for the households sector, and their interlinkages. We focus on three instruments-policies: 1) the LTV ratio, 2) the banks’ leverage ratio, 3) a tax on the banks total assets transferred to the banks’ net worth. Preliminary results show that the LTV policy is very effective in reducing the variability in the credit market and in inflation. Moreover it mitigates substantially the negative impact on the real economy due to a shock in the housing market.

Keywords: Macro-prudential policies, financial frictions, DSGE

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1 Extended Abstract

The aim of the paper is to evaluate the advantages and disadvantages of different macro-prudential policies both in the case when monetary policy is taken as given by the regulator and in the case when there is an interaction between the two. In order to be able to to that, the first step is to build a set up rich enough to explore a large number of policies. This is the reason why we extend a fairly standard New Keynesian DSGE model to incorporate a financial intermediary sector that faces endogenous balance sheet constraints along the lines of Gertler and Karadi (2011). With the important difference that credit are given to households rather than entrepreneurs.

The starting point is the distinction between two types of households as in Iacoviello (2005) The impatient households discount the future more heavily than the patient households, and face a binding borrowing constraint in equilibrium. Unlike the original set up of Iacoviello (2005), in which banks do not play a role and the “credit market” works through the direct interaction between patient and impatient households, we will explicitly model the financial intermediation sector between the two types of households. This extension to the Iacoviello (2005) framework implies that the assumption of a single interest rate, i.e. the risk-free interest rate, will no longer hold. In order to assign a non-trivial role to banks that act as a financial intermediary between patient households - who receive a risk-free interest rate on their deposits - and the impatient households, the interest rate charged to the latter households for their borrowing should differ from the risk free interest rate. This requires the assumption of frictions in the financial intermediation process.

Some recent papers take this latter aspect into account. In fact, Andrés and Arce (2008) and Gerali et al. (2010) assume monopolistic competition in the banking sector. In their framework, patient households deposit savings in banks, receiving the risk free interest rate as remuneration, and banks provide loans to impatient households at a rate that they set to be higher than the one paid on deposits due to their monopoly power.

In the Gertler and Karadi (2011) framework, the assumption of riskless return from deposits is kept unchanged, but a positive difference is assumed between this risk free rate and the rate of return banks earn on their assets. This positive risk premium arises due to the presence of frictions in the intermediation process and limits to the banks’ ability to obtain funds from their depositors by assuming a moral hazard problem between banks and their depositors. This agency problem leads to an endogenous balance sheet (leverage) constraint limiting the ability of banks to acquire assets. Although frictions are introduced between banks and their depositors in the Gertler and Karadi (2011) set-up, the intermediation process between banks and borrowing entrepreneurs is assumed to be frictionless. We therefore deviate from Gertler and Karadi (2011) in two main directions. First, we assume (impatient) households obtaining credit from the financial intermediaries. Second, we subject the intermediation process between impatient households and intermediaries to frictions, in order to model interactions between changes in households’ wealth and banks’ balance sheets.
To summarize, we explicitly model the interaction between the collateral-constrained households and the leverage-constrained banking sector, therefore merging the Iacoviello (2005) framework into Gertler and Karadi (2011).

1.1 Policy Applications

The proposed framework is firstly used to compare different macro-prudential policies. We focus on three particular policies. Along the line of the recent Basel III accords, we consider a policy looking at the banking sector. The general idea is to impose the bank a threshold value for the capital to assets ratio. In our set-up this is equivalent to impose an upper bound to the leverage ratio.

The second policy we consider is based on the assumption the the potential regulator can set the loan-to-value ratio. This is a policy which is adopted in some countries like Honk-Kong and Canada.

Finally we analysis a policy based on the assumption that the regulator is able to impose a tax on the assets of the bank and make a transfer to the bank themselves to integrate their net worth.

Our framework is also useful to analyze the following issues. We will use it to look into the effects of standard monetary policy (i.e. interest rate policy) and unconventional monetary policy (i.e. credit policy) at the zero lower bound. The aim is to quantify the welfare effects of credit policy when interest rate policy becomes ineffective at a binding zero lower bound constraint. Although unconventional monetary policy may not receive a lot of support by critics, it might be one of the few tools monetary policy can use in order to affect the economy in the short run. Therefore, studying the effect of unconventional monetary policy becomes particularly interesting in the presence of zero lower bound. We will contrast our results to those provided in Gertler and Karadi (2011), as the presence of a borrowing household sector will introduce a distinct transmission mechanism and hence can lead to outcomes not necessarily in line with Gertler and Karadi (2011).

In a next step, we will analyze the effects of external capital requirements, which allows for studying the role of capital regulatory aspects of macro prudential policy. In particular, we will examine the consequences of possible interactions between monetary and macro prudential (capital requirements) policy, with or without the presence of a binding constraint on the zero lower bound. We will do this by computing the cooperative and non-cooperative solutions and compare our findings with those of Angelini et al. (2011). Based on the results, we will be able to quantify the welfare costs and/or benefits of alternative policy strategies and cooperation schemes under different scenarios (e.g. crisis vs. non-crisis scenarios). This will provide us with a framework in which we will be able to make policy recommendations under alternative assumptions regarding the state of the economy.
2 The Model

2.1 Households

There are two types of households. On the one hand there are patient households able to smooth their consumption intertemporally. They deposits their savings into the banking sector receiving the risk free interest rate as a remuneration. On the other hand there are impatient households who need to borrow from the banking sector to be able to consume. The amount they can borrow is limited by the value of the collateral they use, namely their house.

Households share some common features. They both get utility from housing services, hence they both express a positive demand for houses. Their consumption is subject to internal habit formation. They offer labor in a competitive labor markets.

The first order conditions for the patient households are

\[ \frac{\partial\tilde{pa}t}{\partial t} W_{pa}^t = \chi (L_{pa}^t) \]  
(1)

\[ E_{t,\beta^{pa}L_{pa}^t R_{t+1}^t = 1} \]  
(2)

\[ Q_{h}^t \tilde{pa}t = \frac{j}{H_{pa}^t} + \beta^{pa} Q_{h}^t \tilde{pa}t R_{t+1}^t \]  
(3)

where \( \tilde{pa}t \) is the marginal utility of consumption

\[ \tilde{pa}t = (C_{t}^{pa} - h^{pa} C_{t-1}^{pa})^{-1} - h^{pa} \beta^{pa} E_{t} (C_{t+1}^{pa} - h^{pa} C_{t}^{pa})^{-1} \]

and

\[ A_{t,t+1}^{pa} = \frac{\tilde{pa}t^{t+1}}{\tilde{pa}t} \]

Equation 1 is the condition for the supply of labour. Equation 2 is the Euler equation determining the consumption path over time. Equation 3 is used to determine the demand for houses.

Impatient households are collateral constrained and they face the following extra constraint on the amount they can borrow

\[ B_{im}^t = m Q_{t+1}^{h} e^{h} H_{im}^{t} \]

where \( m \) is the LTV ratio. Impatient households pay \( R_{t}^{h} \) on their loans because the credit market is not perfect due to the fact that banks might experience limits in their ability to obtain funds from the patient households and \( e_{t}^{h} \) is a shock to the quality of houses.

The f.o.c.s are the following

\[ \tilde{im}^t W_{im}^t = \chi (L_{im}^t) \]  

with

\[ \phi_t^{im} = (C_t^{im} - h^{im}C_{t-1}^{im})^{-1} - h^{im}\beta^{im}E_t \left( C_{t+1}^{im} - h^{im}C_t^{im} \right)^{-1} \]

\[ \Lambda_{t,t+1}^{im} = \frac{\phi_{t+1}^{im}}{\phi_t^{im}} \]

Equation 4 expresses the condition for the impatient households' demand for houses and it is the result of the combination with expression for the Lagrange multiplier of the borrowing constraint.

2.2 Bankers

Bankers are modeled as in Gertler and Karadi (2011). We assume that they provide loans to impatient households only, rather than to entrepreneurs as in the original setup. They fund assets using both their net worth \( N_t \) and deposits collected from the patient households \( D_t \).

The banker's balance sheet is then given by

\[ B_t^{im} = N_t + D_{t+1} \]  

(5)

Given that the banker pays the risk-free interest rate on deposits and receives \( R_t^h \) on loans, the net worth evolves as follows

\[ N_{t+1} = R_{t+1}^h B_t^{im} - R_{t+1} D_{t+1} \]

and using equation 5 we can re-write it as

\[ N_{t+1} = (R_{t+1}^h - R_{t+1}) B_t^{im} + R_t N_t \]

Assuming that the discount factor of the banker between \( t \) and \( t+i \) is \( \beta^{pa,i} \Lambda_{t,t+i}^{pa} \), the banker will operate in period \( i \) only if the following inequality will hold

\[ E_t \beta^{pa,i} \Lambda_{t,t+1+i}^{pa} (R_{t+1+i}^h - R_{t+1+i}) \geq 0, \quad i \geq 0 \]

If capital markets are perfect this equation will always hold as an equality. With imperfect capital markets, however, the premium may be positive due to limits on the intermediary's ability to obtain funds. Hence, with imperfect capital markets there is an incentive for bankers to expand their assets indefinitely by collecting more deposits from the patient households.

In order to put a limit on the expansion of the bankers' assets, Gertler and Karadi (2011) assume the existing of a moral hazard/costly enforcement problem between bankers and their depositors. In the beginning of the period
the banker can choose to divert the fraction $\lambda$ of available funds from the project and instead transfer them back to the household. The cost to the banker is that the depositors can force the intermediary into bankruptcy and recover the remaining fraction $1 - \lambda$ of assets. However, it is too costly for the depositors to recover the fraction $\lambda$ of funds that the banker diverted.

In this set up the following incentive constraint must be satisfied

$$V_t \geq \lambda B_t^{im}$$

where $V_t$ is the banker’s expected terminal wealth. The left side is what the banker would lose by diverting a fraction of assets. The right side is the gain from doing so.

It can be shown that the banker’s expected terminal wealth can be written as

$$V_t = l_t B_t^{im} + \eta_t N_t$$

with

$$l_t = E_t \{ (1 - \theta) \beta^{pa} \Lambda_{t,t+1}^{pa} (R_t^{h} - R_{t+1}) + \beta^{pa} \Lambda_{t,t+1}^{pa} \theta x_{t,t+1} l_{t+1} \}$$

$$\eta_t = E_t \{ (1 - \theta) + \beta^{pa} \Lambda_{t,t+1}^{pa} \theta z_{t,t+1} \eta_{t+1} \}$$

where $x_{t,t+1}$ is the gross growth rate in assets between $t$ and $t + 1$, $z_{t,t+1}$ the gross growth rate of net worth, and $\theta$ is the probability for a banker to be banker also the next period.

Combining 6 with 7 it is possible to derive the following equation

$$B_t^{im} = \frac{\eta_t}{\lambda - l_t} N_t = \phi_t^{h} N_t$$

where $\phi_t^{h}$ is the ratio of privately intermediated assets to equity. Holding constant $N_t$, expanding $B_t^{im}$ raises the bankers’ incentive to divert funds. Equation 8 limits the intermediaries leverage ratio to the point where the banker’s incentive to cheat is exactly balanced by the cost. In this respect the agency problem leads to an endogenous capital constraint on the intermediary’s ability to acquire assets.

### 2.3 Intermediate goods producers

Entrepreneurs are standard. They produce wholesale goods according to the following production function

$$Y_t = A_t (U_t \varepsilon_t^K K_t)^{\alpha} L_t^{1-\alpha}$$

where $U_t$ is the degree of capital utilization and $\varepsilon_t^K$ is a shock to the quality of capital as in Gertler and Karadi (2011).
The f.o.c.s for the demand for labour and capital are

\[ pm_t \alpha \frac{Y_t}{U_t} = b U_t \epsilon_t K_t \]

\[ \sigma pm_t (1 - \alpha) \frac{Y_t}{L_{pa}^t} = W_t^{pa} \]

\[ (1 - \sigma) pm_t (1 - \alpha) \frac{Y_t}{L_{im}^t} = W_t^{im} \]

The return on capital is determined as follows

\[ R_k^t = \left[ \frac{pm_{t+1} \alpha \frac{Y_{t+1}}{\epsilon_{t+1} K_{t+1}^h} + (Q_{t+1} - \delta (U_{t+1})))}{Q_t} \right] \epsilon_{t+1}^h \]

### 2.4 Capital producers

As in CEE capital producers face investment adjustment costs. Hence the evolution of investments is given by the following equation

\[ Q_t = 1 + f(.) + \frac{I_t + I}{I_{t-1} + I} f'(.) - E_t \Lambda_{t,t+1}^{pa} \left( \frac{I_{t+1} + I}{I_t + I} \right)^2 f'(.) \]

where \( f(1) = f'(1) = 0 \) and \( f''(1) > 0 \). Capital stock evolve as follows

\[ K_{t+1} = (1 - \delta (U_t)) K_t + I_t \]

### 2.5 Final goods producers

They produce final goods and they provide the demand for the intermediate goods. They are subject to price rigidities and hence they determine the evolution of inflation over time which is described by the New Keynesian Phillips curve.

### 2.6 Housing production

As for investments in capital goods, the residential investments are subject to adjustments costs. Hence the price of houses is determined by the following equation

\[ Q_t^h = 1 + f(.) + \frac{I_{t+1} + I^h}{I_{t-1} + I^h} f'(.) - E_t \Lambda_{t,t+1}^{pa} \left( \frac{I_{t+1} + I^h}{I_t + I^h} \right)^2 f'(.) \]

Net investments are given by

\[ I_{nt}^h = I_t^h - \delta H_t \]

and the house stock is
$$H_{t+1} = \delta^h H_t + I_{nt}^h$$

### 2.7 Policies

Given the richness of our model we can focus on different macro prudential policies. Specifically, they will be introduced in the model in the form of policy rules. We propose here a rule centered on the banks leverage ratio, a rule considering the LTV ratio, and a rule setting a tax on the banks’ total assets.

According to the past proposal of Basil II, but also along the lines of the more recent Basel III Accord, a natural candidate for the regulator to be chosen as an instrument is the leverage ratio. In fact, a minimum capital requirement (relative to the assets) for banks is seen as a solution to safeguard depositors and other stakeholders from the tendency of the banks to excessively increase their leverage.

The model needs to be modified appropriately. In fact, setting a floor for the Net worth to assets ratio means putting a ceiling to the leverage ratio (being the latter the inverse of the former). The leverage ratio is already endogenously determined in our model, but if the regulator sets it the banks should simply adjust their behaviour to the current regulation. In terms of equations the leverage will be set according to the following rule

$$h_t = h + !_p p_t + u_t$$

where $$h$$ is the steady state value of leverage, $$p_t$$ is a macroeconomic variable which the regulator looks at in order to decide how to set $$h_t$$, and $$!_p$$ is a parameter regulating the intensity of the regulator intervention. It can be either positive or negative on the basis of the necessity for the regulator to implement a pro or counter cyclical policy.

Once the regulator set the leverage, bankers will act on the only variable which they really can decide on, namely the fraction $$\lambda$$ of available funds that they can divert. As a consequence the value of that parameter be adjusted to the leverage set by the regulator on the basis of steady state considerations. More realistically, given that $$h_t$$ is time varying, we can assume that $$\lambda$$ is also time varying. As a consequence, it will be dynamically determined by the following equation

$$\lambda_t = \eta_t + \frac{\phi^h_t I_t}{\phi^h_t}$$

The second policy is based on the LTV ratio. This is a policy that is straightforward to implement in our set up. In fact, the only new assumption we need for this policy is to make the LTV ratio $$m$$ time varying. The second step is to define a rule for that variable

$$m_t = m + \omega_m p_t + u^m_t$$
Following Christensen and Meh (2011) we assume that $p_t$ is the log-deviation of the amount borrowed $B_t^{im}$.

Finally the tax policy. As in Gertler et al. (2011) a tax on the banks’ total assets is introduced to finance a transfer to the the same bank, which eventually has to be kept as a reserve. This policy has the advantage that the transfer increase the net worth and hence reduce the leverage. It has the same spirit of a minimum capital requirement policy.

The balance sheet of the bank (equation 5) becomes

$$(1 + \tau) B_t^{im} = (1 + \tau) N_t + D_{t+1}$$

where $\tau$ is the tax rate. In equilibrium the tax is set to make the subsidy revenue neutral, so that the net impact on bank revenues is zero. Hence the net worth evolves as before

$$N_{t+1} = R^h_{t+1} B_t^{im} - R_{t+1} D_{t+1}$$

Substituting the balance sheet and re-arranging we have

$$N_{t+1} = \left[ R^h_{t+1} - (1 + \tau) R_{t+1} \right] B_t^{im} + (1 + \tau) R_t N_t$$

As a consequence we can re-write $l_t$ and $\eta_t$ as follows

$$l_t = E_t \left\{ (1 - \theta) \beta^{pa} \Lambda^{pa}_{t,t+1} \left[ R^h_{t+1} - (1 + \tau) R_{t+1} \right] + \beta^{pa} \Lambda^{pa}_{t,t+1} \theta x_{t,t+1} l_{t+1} \right\}$$

$$\eta_t = E_t \left\{ (1 - \theta) + (1 + \tau) \beta^{pa} \Lambda^{pa}_{t,t+1} \theta z_{t,t+1} \eta_{t+1} \right\}$$

All the other equations remain unchanged.

Monetary policy is described by the following Taylor rule

$$R_t = \rho R_{t-1} + (1 - \rho_R) \left[ R + \kappa_\pi \pi_t + \kappa_y \left( \log Y_t - \log Y_t^{pot} \right) \right] + \varepsilon_t^R$$

2.8 Aggregation

The aggregate resource constraint

$$Y_t = C_t + I_t + I_t^h + G_t$$

Aggregate consumption and houses are aggregated as follows

$$C_t = \sigma C_t^{pa} + (1 - \sigma) C_t^{im}$$

$$H_t = \sigma \varepsilon_t^h H_t^{pa} + (1 - \sigma) \varepsilon_t^h H_t^{im}$$

Labour is aggregated as a Cobb-Douglas function

$$L_t = (L_t^{pa})^\sigma (L_t^{im})^{1-\sigma}$$
3 Analysis

3.1 The model dynamics

In figure 1-4 we report the model dynamics using the impulse response function. We start with the monetary policy shock. An increase in the interest rate has the usual effect of putting the economy into a recession. Investments decrease first, bringing down the demand of capital and its price. Output falls as a consequence. The demand for labour drops and households consume less. Also their demand for housing service decrease, leading to a fall in the residential investments and in the price of houses. Impatient households have less collateral to offer and they ask for less mortgages. This has a direct impact on the bank balance sheet. As the assets decrease banks experience a process of deleveraging. This explains the negative response of leverage on impact. Nevertheless, the fact that banks offer less mortgages has an effects on their revenues. This is the reason why also their net worth drops, explaining also the change in the sign of the leverage after some quarters.

A negative technology shock is shown in figure 2. The causes of the recession are now coming from the supply side of the economy, but the propagation mechanism implies similar responses to the monetary policy shock. The recession explains the decrease in all the real variables and of the associated prices. The banking sector still experiences a contraction of the assets associated to a deleveraging. The net worth now increases substantially on impact and for some quarters because the central bank cuts the interest rate to face the recession, allowing the bank to remunerate deposits much less, with an increase in their revenues.

Finally the quality of houses shock in figure 4. The shock originates in the housing sector with a sudden drop in the value of houses. The ability of the impatient households to obtain credit is drastically reduced. They need to reduce their consumption and their houses demand. This has the effect of creating a recession for two negative effects of consumption and residential investments on output. In the banking sector banks suffer a cut in the mortgages and an even larger decrease in the net worth. This explains the increase in the banks’ leverage.

3.2 The loan-to-value policy

In this section we describe the effects of introducing a regulation in the credit market. The regulator has the power to set the LTV ratio. We have already anticipated the functional form of a the rule that it uses to set its instrument. Given that its main aim should be to counteract the imbalances in the credit market, as emerging from a large increase in the indebtness of households, it make sense to consider a counter cyclical policy. In fact we calibrate the parameter regulating the intensity of the policy $\omega_m$ to $-5$. In this exercise the regulator takes monetary policy as given.

The effects of such a policy are reported in figures 5-7. Considering first
the monetary policy shock we highlight that the counter-cyclical LTV policy is very effective in limiting the drop in the mortgage debt. This has the effect of mitigating partially the effects of the recession, due to the fact that the accessibility of households to credit is not reduced as much as it would be without the regulation. Hence their consumption is less negatively affected and their demand for houses as well. This directly reflects on the response of output that results less accentuated.

The same is true for the technology shock in figure 6. But with the difference that the better condition in credit market favoured by the LTV policy so no transmit to the real and nominal economy. In fact basically all the other variables seem unaffected by the regulation.

Finally and not surprisingly, the regulation has a big impact when a shock originated in the housing sector hits the economy (figure 7). Output would have dropped 3 times more without the regulation, while consumption about twice more. It is worth stressing that also fluctuations in inflation and house prices are smaller than otherwise.

We can conclude that regardless the shock considered, the LTV regulation has always the merit of reducing the volatility in the credit market. The effects on the real economy are less homogenous. In general they are not very accentuated, except in the case of the quality of houses shocks. In the latter case also the variability of inflation and house price is substantially reduced.

4 References


Christensen, I., Meh, C., and Moran, K. (2010), Bank leverage regulation and macroeconomic dynamics.


5 Figures

Figure 1: Monetary policy shock
Figure 2: Technology shock
Figure 3: Quality of capital shock
Figure 4: Quality of houses shock
Figure 5: Monetary policy shock
Figure 6: Technology shock
Figure 7: Quality of houses shock