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Research Report

Heterogeneity and business cycle fluctuations

FinMaP-Policy Letter, No. 4

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FinMaP-Policy Letter

No. 4



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FINMAP -

FINANCIAL DISTORTIONS AND MACROECONOMIC PERFORMANCE: EXPECTATIONS, CONSTRAINTS AND INTERACTION OF AGENTS

DATE: 06/30/2016

TITLE

HETEROGENEITY AND BUSINESS CYCLE FLUCTUATIONS

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Boom-bust cycles in asset prices and economic activity are a central issue in policy and academic debates. An increasing rate of default on mortgage loans in the U.S. precipitated the financial crisis of 2007. A large stock of debt and high asset prices have been both a cause and a consequence of the crisis because more borrowers had access to bigger loans at lower rates of interest. The prolonged recession and difficult recovery highlight the fact that financial frictions are a key driver of business cycle fluctuations. During normal times imbalances emerge and the financial sector can mitigate financial frictions. Yet, during periods of crisis wealth can be destroyed and the financial sector adds fragility and instability to the whole economy.

The recent financial crisis has highlighted the importance of linking the financial sector and the macroeconomy. Existing macroeconomic models failed to inform policymakers about the factors that led to the financial crisis because they paid little attention to financial variables, both as originators and propagators of shocks to the real economy, and to financial frictions. Recent empirical evidence indicates that ignoring fluctuations in financial variables and their feedbacks on the real economy may induce distortions in the interpretation of business cycles phenomena. Standard New Keynesian Dynamic Stochastic General Equilibrium (DSGE) models have analyzed business fluctuations by incorporating several frictions such as sticky prices, sticky wages, adjustment costs in investment, capital utilization, and various types of shocks. However, most of these models assume that markets are complete and abstract from financial market frictions. This may cause these models to overestimate the contribution of other, more standard sources of business cycle fluctuations and give policymakers an incorrect perception of the channels of the transmission of disturbances. Hence, models taking into account *financial frictions* and *incomplete asset markets* are appealing for explaining phenomena like credit booms and financial crises.

Incorporating financial frictions in macroeconomic models, however, is not new. Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) have been the pioneers of emphasizing the role of the financial sector for understanding the dynamics of the business cycle. Nevertheless, these model extensions are not able to replicate the recent financial crisis in 2007. This strongly suggested that something crucial about the behavior of the macroeconomy is missing. Even if, economic models, and in particular DSGE models, have been improved to explain business cycle fluctuations, they still failed to replicate the huge amplification that has occurred before and during the financial crisis.

As the crisis suggested, the flow of credit is an important variable to be considered by policymakers since credit flows are highly pro-cyclical: fluctuations in credit market follow similar fluctuations in the business cycle. In particular, during recessions, indebtedness decreases significantly and, as a consequence, credit standards indicators tighten up and credit spreads and interest rate differentials decrease.

In the context of incomplete markets, financial frictions are an important source of amplification. For instance, if the economy is hit by a negative productivity shock, then it will experience a drop in employment and investment and the ability of borrowers to demand for credit will decline. This negative outcome is amplified if the drop in investment is coupled with a fall in the market value of assets used as collateral. Therefore, the presence of financial frictions leads to a larger deterioration in investment and employment relative to a decline which would have occurred in absence of financial frictions.

In this framework of financial frictions and incomplete markets, heterogeneity turns out to be crucial.

If all agents are homogeneous, there is no reason to trade claims intertemporally or intratemporally, and we would have an economy with complete markets. However, certain assets cannot be traded. For instance, agents can hold bonds but they cannot hold assets with payoffs contingent on information that becomes available in the future, making markets incomplete and leading to heterogeneity in the allocation of consumption and saving.

More questions for policy makers emerge. What are the drivers of the strong run-up in asset prices before the crisis? What are the key ingredients generating large fluctuations in the business cycle?

We point to the importance of heterogeneity in the economic agents' distribution to replicate the extra amplification driven by asset prices in explaining large business cycle fluctuations. Heterogeneous borrowing agents are added to an otherwise conventional macroeconomic DSGE model with financial frictions. For this purpose, borrowers are modeled as being heterogeneous in their ability to borrow from collateral, calibrated to better match empirical stylized facts, where either firm leverage ratios or households' loan-to-value ratios vary significantly over their respective distributions. Thus a saving agent in the model has a portfolio choice of where to optimally allocate her savings, whether to provide loans to highly leveraged agents or agents that fund their (productive or housing) investments mostly from their own resources.

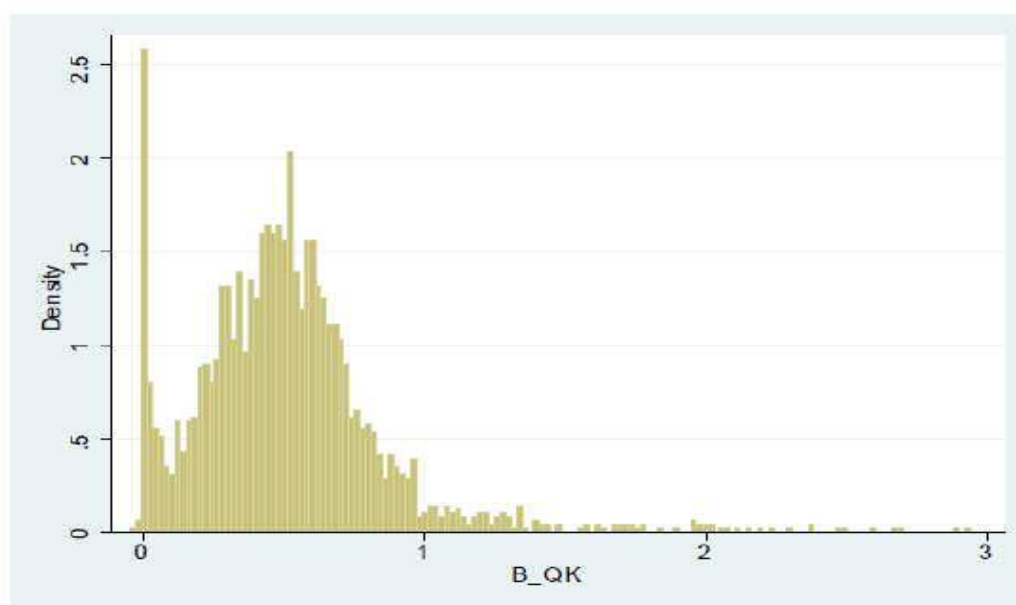
This topic belongs to a big portion of our developments in Workpackage 4 for the FinMap project.

In order to address the questions above, one of our papers in Workpackage 4 focuses on **investors' heterogeneity**. See our Deliverable D4.2, FinMap Working Paper 24 “Investor Borrowing Heterogeneity in a Kiyotaki-Moore Style Macro Model”.

We have extensively worked on a macroeconomic model with financial frictions to account for heterogeneity in investors' ability to borrow from collateral. The literature leading this field, both the seminal contributions of Kiyotaki and Moore (1997) and Bernanke et al. (1999), retains a high degree of aggregation: there typically exists a *representative* financially-constrained agent, and existing models are typically calibrated to match an economy-wide average of leverage ratios.

In the data, observed leverage ratios (assets to net worth) of US non-financial firms are, on average, at around 1.5–2 (see, e.g. CGFS, 2009), with wide cross-sectional variation. Leverage ratios of financial intermediators are substantially higher. We take up a framework *à la* Kiyotaki and Moore (1997) but instead of a representative investor we introduce different investor types that each can manage different types of capital, which are collateralizable to different degrees. We calibrate the model to match observed leverage ratios of the quintiles of the distribution of leverage ratios for US non-financial firms, using the dataset of Rauh and Sufi (2010). See Figure 1.

Figure 1: Distribution of Leverage Ratio (i.e. Debt-to-Assets ratio)



Given such stylized fact, we consider in our setup 5 investors and calibrate each leverage ratio to match the 90, 70, 50, 30, and 10-th percentiles of the distribution of debt ratios (measured as total

debt to total assets at book value) of US non-financial firms, using the dataset of Rauh and Sufi (2010). This dataset contains 2453 public US non-financial firms, for the period of 1996–2006. Each investor’s size is calibrated to the share of the total sales (as a proxy for value-added) of firms in a specific quintile in total sales of all firms. The weights reflect the fact that firms in the quintiles with high debt ratios are typically smaller, because small firms rely more on external finance. The leverage ratios (assets-to-net worth) are reported in Table 1.

Table 1: Quintile Values of Leverage Distribution

Leverage measure	10%	30%	50%	70%	90%
$k = \frac{B}{QK}$	0.102	0.339	0.479	0.606	0.845
$\varphi = \frac{QK}{N}$	1.11	1.51	1.91	2.54	6.44

$k = \frac{B}{QK}$ is the debt-to-assets ratio and $\varphi = \frac{QK}{N}$ is the assets-to-net worth ratio.

The saving household now has a portfolio choice of which group to extend its loans to.

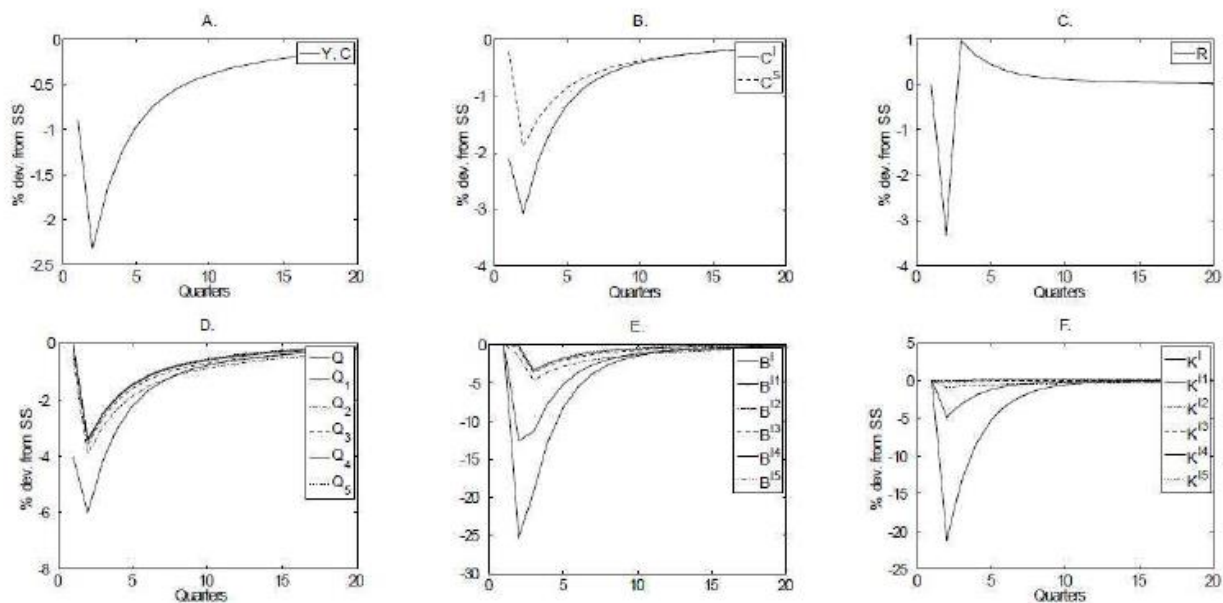
As shown in Figure 2, a model with heterogeneous investors produces a more pronounced financial amplification of shocks compared to a model version where the parameters of collateral constraints are calibrated to the economy-wide average (the case of homogeneous investors). This is because investors with the highest leverage are the drivers of asset prices, not the economy-wide average.

Asset price drops in response to negative productivity shocks are therefore stronger in the heterogeneous investors' model, tightening financial constraints of all investors, and leading to additional amplification.

This is because investor 1, the most levered investor, has to sharply decrease her borrowing and, as a result, her holdings of the fixed asset, by 15.61% and 12.95% respectively. The asset price corresponding to investor 1’s fixed assets drops by almost 3.05% at peak—because of the high leverage ratio this constitutes a much more pronounced asset price drop than in the ‘homogeneous investors’ version. Because asset prices of different types of capital are tightly linked to each other via savers’ intertemporal optimality conditions, they also experience pronounced declines. The (CES-based) aggregate asset price index falls by 2.20% at peak, compared to the more moderate drop of 2.01% in the homogeneous investors’ model. The stronger asset prices declines, in turn, lead to a more substantial tightening of financial constraints also for the other, less levered, investors. This translates into an additional financial amplification compared to the model version where investors are identical, even though on average leverage constraints are not more severe: output in the economy drops, at peak, by 1.33% in the model version with investors who are heterogeneous in their ability

to borrow, compared to just 1.19% in the model with homogeneous investors. This constitutes an additional 11.74% amplification of the heterogeneous over the homogeneous investors' model.

Figure 2: Impulse responses to a 1% productivity decrease, model with heterogeneous investors.

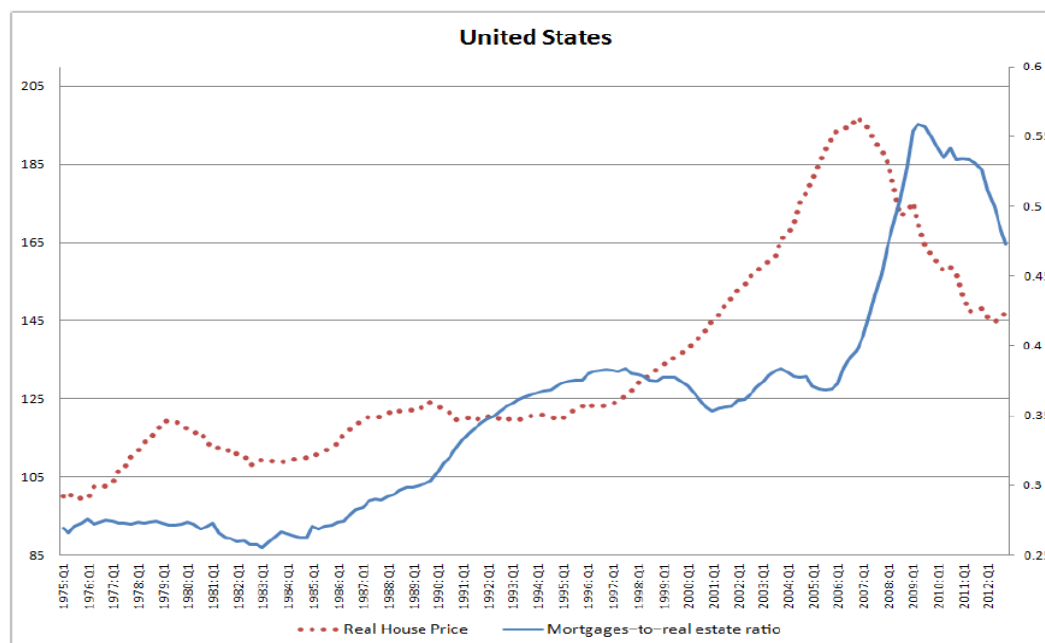


Another paper of our Wokpackage 4 focuses on **households' heterogeneity**: “Borrower heterogeneity within risky mortgage-lending market”.

This paper pays special attention to the housing market, since the latest financial crisis in 2007 has its origins in the housing market, and the turmoil in this specific sector can easily spread over to the rest of the economy. We find that borrowers' heterogeneity matters a lots.

Concerning the household sector and house prices, Figure 3 reports the evolution of house prices and of the ratio between mortgages and the value of real estate. The strong run-up in home values that started at the beginning of 2000 was followed by a similar increase in household indebtedness, so that the mortgage-to-real estate ratio has been roughly stable until 2006. When the housing market crashed, borrowers gave up on their repayment of outstanding mortgages, because the collateralized real estate value fell to lower values with respect to the repayment amount. Thus the ratio spikes after the start of financial crisis.

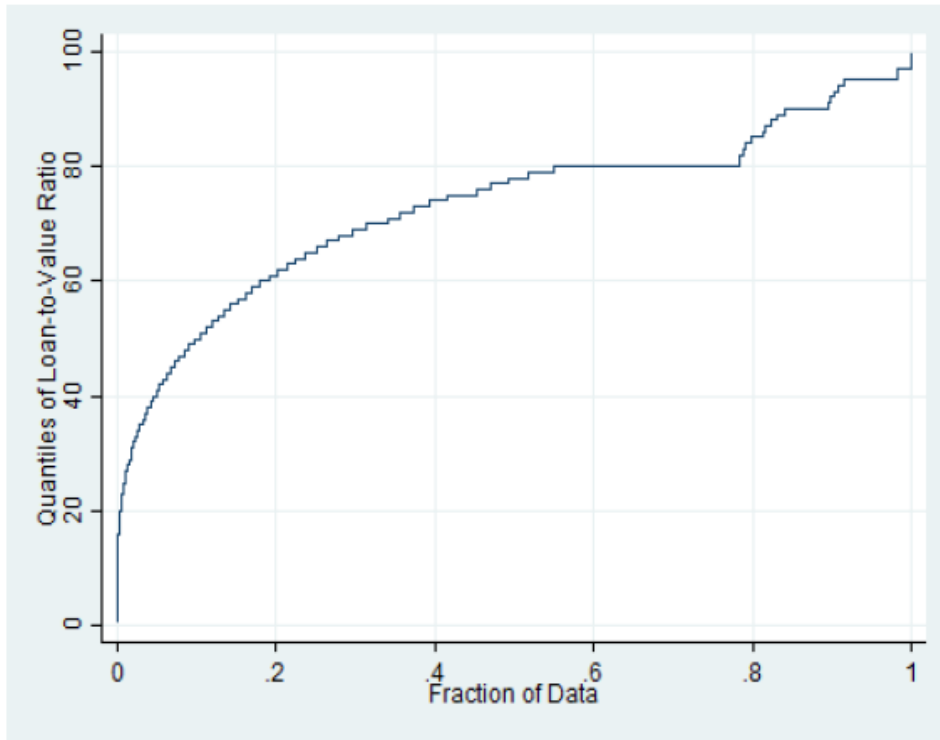
Figure 3: Real house price (left side) and mortgage-to-real estate ratio (right side) for the U.S



We study the distribution of loan-to-values (LTV) ratios to highlight the importance of highly indebted households. A re-evaluation of the riskiness of high-type LTV households leads to a wave of defaults when house prices drop and the mortgage repayment is higher than the current value of the collateral, i.e. the house which has been used to pledge against borrowing. The previous literature has typically modelled the LTV as a constant value, equal to the mean value of the distribution. However, Figure 4 reveals deep heterogeneity in the distribution, and a small portion of households have been applying for mortgages with a LTV almost equal to 100% of the value of the house. This high-LTV borrower is more likely to default, relative to low-LTV type borrowers. In the latter case, borrowers already pay a larger down-payment in anticipation of the mortgage loan; therefore their willingness to default is very low, otherwise the bank will seize the house after they already paid a big portion of the value.

We consider two types of borrowers. We specify them using a distribution of LTV ratios from 12 million home purchases of single-family loans issued during the period of 2000-2006 hold by Fannie Mae and Freddie Mac in the United States. The distribution reveals that households have applied for mortgages with an average LTV value equal to 74%, meaning that on average households anticipated about 26% of the value of the house in the form of down-payment. See Figure 4.

Figure 4: Quantile Distribution of Loan-to-Value (LTV) ratio



Then we split our sample in two subgroups and we calculate the average of each group. Table 2 shows that about 80% of the sample size has an average LTV ratio equal to 67%, while about 20% of the sample shows an average LTV ratio equal to 91%. Clearly the first group is less willing to default since it already has anticipated about 37% of the value of the collateralized house. In contrast, high-type borrowers are more likely to default, since they have made a small amount of money in advance.

Table 2: LTV ratio Distribution

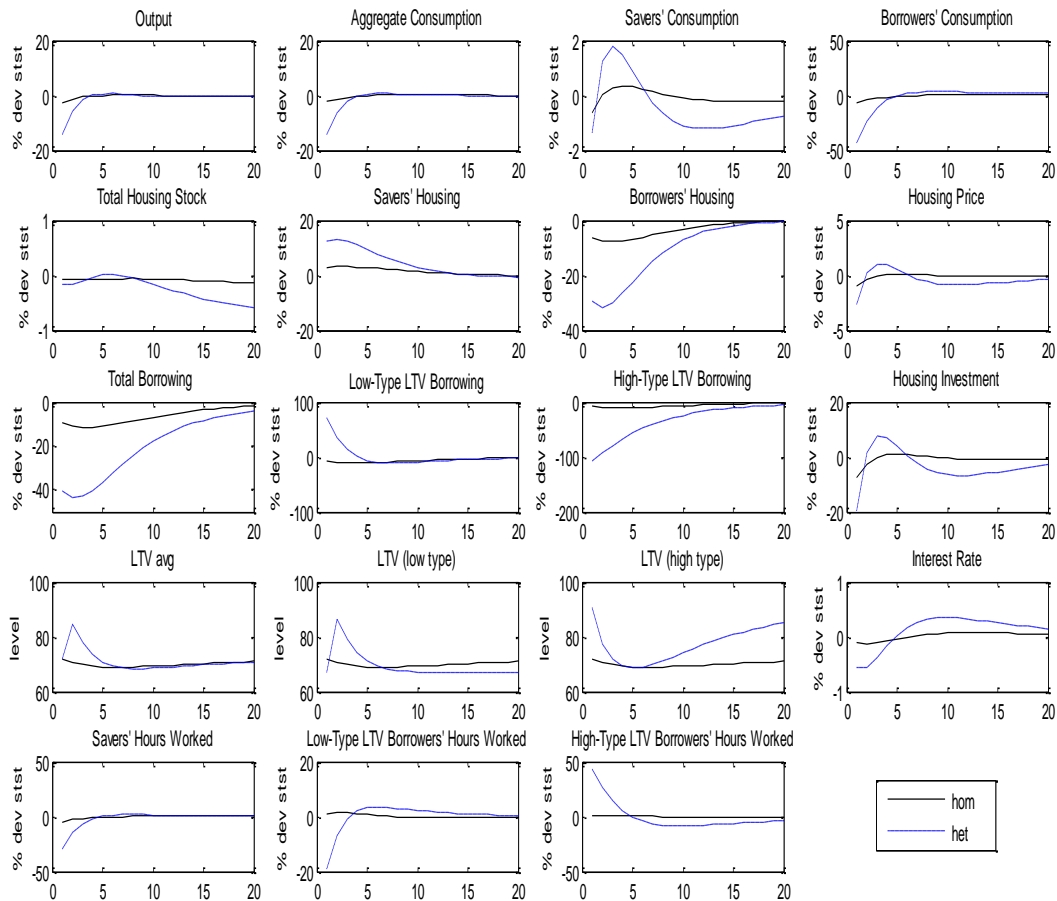
Loan-to-Value (LTV) ratio	Mean Value	Share of Borrowers
All LTVs	74%	100%
$0 < LTV \leq 80$	67%	80%
$80 < LTV < 100$	91%	20%

In our model, we then construct an anticipated shock to riskiness of borrowers that mimics the drop in LTV ratios observed at the onset of the crisis. In the model version with a representative household-borrower this implies a drop in the (economy-wide average) LTV ratio of 72% to 68%. In the model version with heterogeneous household borrowers, a low-LTV type and a high-LTV type, we model the bulk of the contraction in credit as falling on the high-LTV type, whose LTV drops from 91% to 68% after 5 quarters. Despite the same drop in the average, economy-wide, LTV ratio, the latter

model version documents the substantially amplified drop in house price, indebtedness, consumption in durable and non-durable goods, leading to a deep recession. See Figure 5.

Figure 5: Impulse Responses to 1% unanticipated shock to risky mortgage.

Model with homogeneous household borrowers (solid line); Model with heterogeneous household borrowers (dashed line)



POLICY IMPLICATIONS AND RECOMMENDATIONS

The two papers developed under Workpackage 4 deliver several policy implications and recommendations.

Both papers have demonstrated the importance of agents' heterogeneity and the consideration of the group of highly indebted agents in amplifying the business cycle. More specifically, heterogeneity implies higher response to credit flows and asset price when the economy is hit by exogenous shocks. In addition, heterogeneity increases volatility in both real and financial fundamentals and

such volatility increases during period of crisis and, in particular, when shocks to borrowers' riskiness hit the economy. This has important implications to policy makers in charge of smoothing out the business cycle by minimizing the magnitude of variations in economic growth over the course of the business cycle.

In this context, policy makers should think on their policy tools in terms of monetary policy and macroprudential policy. We highlight two main points.

First, should policy makers respond to asset price fluctuations? In particular, should monetary policy avoid the growth of possibly developing asset price bubbles to minimize damage to the economy when these bubbles burst? Former Chairman of the Federal Reserve Board, Alan Greenspan strongly argued that monetary policy should not try to lean against asset price bubbles, but rather should just clean up after they burst. Previous theoretical models have found that responding to asset prices does not yield any significant gains in terms of output and inflation stabilization. However, previous models were not able to generate the large drop in financial and real variables that we obtain in a model that accounts for borrowers' heterogeneity. Given such large amplifications, academics and policy makers should reconsider the question of asset price targeting since the macroeconomic consequences of assets price fluctuations have proved to be long lasting and severe. More generally, monetary policy should react to asset price bubbles by looking at the effects of such bubbles on employment and inflation, then adjusting policy as required to achieve maximum sustainable employment and price stability.

Second, in designing macroprudential policy, should policy makers focus on the overall agents in the economy or restrict the new rules implied by Basel III only to high risky borrowers?

This question, for the lack of a consideration of borrowers' heterogeneity, could not be addressed in the previous vintage financial friction models.

The Basel Committee on the Global Financial System identifies the loan-to-value (LTV) ratio as one of the macroprudential tools that may act as an automatic stabilizer if adjusted in a countercyclical manner around a pre-established cap.¹ Several country authorities have introduced limits to LTV ratios for mortgages in order to mitigate the risks that can be generated by strong run-up in credit and asset prices. However, previous works have showed ambiguous results in terms of the effectiveness of such macroprudential policy. In general, previous works have showed that there exists a trade-off in terms of welfare achieved by the agent who borrows and the agent who lends. The drawback is that it limits credit also for financially sound agents when times are good, relative to a world where such counter-cyclical rules are absent. Can there be welfare gains achieved if a

¹ See Basel Committee on the Global Financial System (2010).

policy maker focuses on applying counter-cyclical rules only to high-LTV type borrowers? Our model framework allows answering these questions.

We recommend that the policy makers should restrict regulations only to high-type LTV borrowers, which is the riskier one, without applying the same tool to all agents in the economy. In this last case, credit growth will decrease, with negative consequences for economic growth, particularly during recovery.

RESEARCH PARAMETERS

In terms of methodology, we have developed a quantitative dynamic stochastic general equilibrium (DSGE) framework with financial frictions and incomplete asset markets. Previous similar models consider two types of agents, a Saver and a Borrower, motivating the existence of credit flows and the financial accelerator mechanism, where Borrower raises secured credit facilities against asset values to fuel consumption. We improve the previous literature by considering the important role of households' heterogeneity. Our models are carefully calibrated in order to match the distributions of loans of investors or households.