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# Effectiveness of macroprudential policies under borrower heterogeneity

Maria Teresa Punzi
Katrin Rabitsch

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# Effectiveness of macroprudential policies under borrower heterogeneity*

Maria Teresa Punzi†[1] and Katrin Rabitsch[1]

[1]Vienna University of Economics and Business

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**Abstract**

We study the impact of macroprudential policies using a novel model which takes into account households' ability to borrow under different loan-to-value ratios which are tied to their collateral values. Such model generates a larger amplification in real and financial variables, compared to standard models that assume homogeneity in the leveraging and deleveraging process.

Conditional on this model, we consider the implications of macroprudential policies that aim to lean against an excessive credit cycle. In particular, we allow macroprudential authorities to tighten excessive lending to higher leveraged households, whose riskiness had been evaluated too optimistically. We find that a policy that targets only the group of households that most strongly deleveraged after an adverse idiosyncratic housing investment risk shock, is welfare-improving at social and individual levels, relative to a macroprudential policy which targets all households in the economy.

*Keywords:* Endogenous Loan-to-Value ratio, Heterogeneity, Macroprudential Policy
*JEL-Codes:* E23, E32, E44

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†Vienna University of Economics and Business. E-mail: punzimt@gmail.com; punzi@bc.edu.

## 1 Introduction

Before the financial crisis in 2007, there has been a broad consensus among policymakers and academics that monetary policy should primarily focus on price stability; as a result, many central banks have adopted inflation-targeting. However, the occurrence of financial crises and their consequences has led to a widespread idea that strengthening the resilience of the financial system as a whole is a major need. Since then, macroprudential (MaPru) tools have become popular in dealing with financial stability.

One of the main goals of MaPru policies is to mitigate or dampen the procyclicality of the financial system interconnected with the real economy. During periods of upswings, large credit availability leads to a steep rise in asset prices and leverage, consequently the financial system will be exposed to excessive credit growth. Under these conditions, a sudden reversal of the business cycle, an economic downturn, leads financial institutions to charge borrowers higher lending rates with substantial deleveraging, asset collapses and reductions in credit supply. Therefore, an effective MaPru tool is a means or a policy that countercyclically reduces the build-up of financial cycles.

We claim that a MaPru tool, in order to be effective in leaning against excessive credit expansion and asset price booms in the amplification mechanisms linked to leverage, should be based on a theoretical model that adequately replicates such stylized facts. With this aim, we study MaPru policy by employing the banking model version of household borrower heterogeneity of Punzi and Rabitsch (2016), which is able to generate a quantitatively important contractionary effect on credit, mainly driven by a contraction of Borrowers who face higher LTV ratios. Such effect is found to be substantially more severe compared to standard models abstracting from borrower heterogeneity.[1] In particular, Punzi and Rabitsch (2016) find that a tightening of collateral constraint that falls most strongly on the highest leveraged Borrowers, as experienced at the onset of the financial crisis, contributes strongly to a reduction in total lending. Compared to a model version characterized by homogeneous Borrowers, where total lending drops 7%, the baseline model with borrower heterogeneity produces a substantially larger contraction in total lending of 11%. Similar discrepancies arise for other key variables like output and aggregate consumption.

Therefore, we build up on Punzi and Rabitsch (2016)'s model and implement an exercise similar to Quint and Rabanal (2014) by introducing a MaPru tool that affects the fraction of loans that the banking sector can lend to each group of Borrowers. In this exercise, we parameterize the idiosyncratic housing investment risk shock such that the model replicates the pre-crisis volatility in the respective loan-to-value (LTV) ratios. In such setting, we ask the following questions: (i) How should the MaPru tool be designed in order to achieve the maximum social and individual welfare? (ii) Should the MaPru authorities target all Borrowers, or only higher leveraged ones? We

[1] This line of research is also connected to Punzi and Rabitsch (2015), where, under a different setup, we find a larger amplification mechanism originating from corporate debt when heterogeneous investors face different leverage ratios when they collateralize the value of capital.

find that a countercyclical rule that targets only Borrowers with the highest LTV ratio and responds to credit growth (as a percentage of GDP) for that particular group of Borrowers is welfare improving. This MaPru measure is able the avoid the house price collapse when a shock to idiosyncratic housing investment risk hits the economy and decreases the volatility in the mortgage debt-to-GDP ratio.[2]

A significant amount of research has focused on the implementation of MaPru policies with models that aim to describe the interactions between the real economy and the financial sector. Under the class of dynamic stochastic general equilibrium (DSGE) models with financial frictions, several authors have evaluated the impact of MaPru policy through welfare analysis. See Pariès, Sørensen, Rodriguez-Palenzuela, et al. (2011), Kannan, Rabanal, Scott, et al. (2012), Angeloni and Faia (2013), Lambertini, Mendicino, and Punzi (2013), Mendicino and Punzi (2014), Quint and Rabanal (2014), Suh (2011), Bailliu, Meh, and Zhang (2015), Brzoza-Brzezina, Kolasa, and Makarski (2015). The main limitation of these approaches is that borrowing households are typically all considered equal without explicit consideration of heterogeneity in borrowing conditions among them and that the resulting amplification in such setting is typically not quantitatively large enough to replicate the last housing boom-bust cycle.[3] In contrast, we find that heterogeneity is an important aspect in explaining business cycle fluctuations from financial shocks as the behavior of a small group of Borrowers is able to drag down the entire economy. Deng, Quigley, and Order (2000) also emphasize the importance of heterogeneity of borrowers in explaining behavior in the mortgage market, and that borrowers who choose higher loan-to-value (LTV) ratio are more likely to default.

The rest of the article is organized as follows. Section two describes the data on loan-to-value distribution and lays out the main results from a model featuring borrower heterogeneity. Section three proposes MaPru tools and provides results based on welfare analysis. Section four concludes.

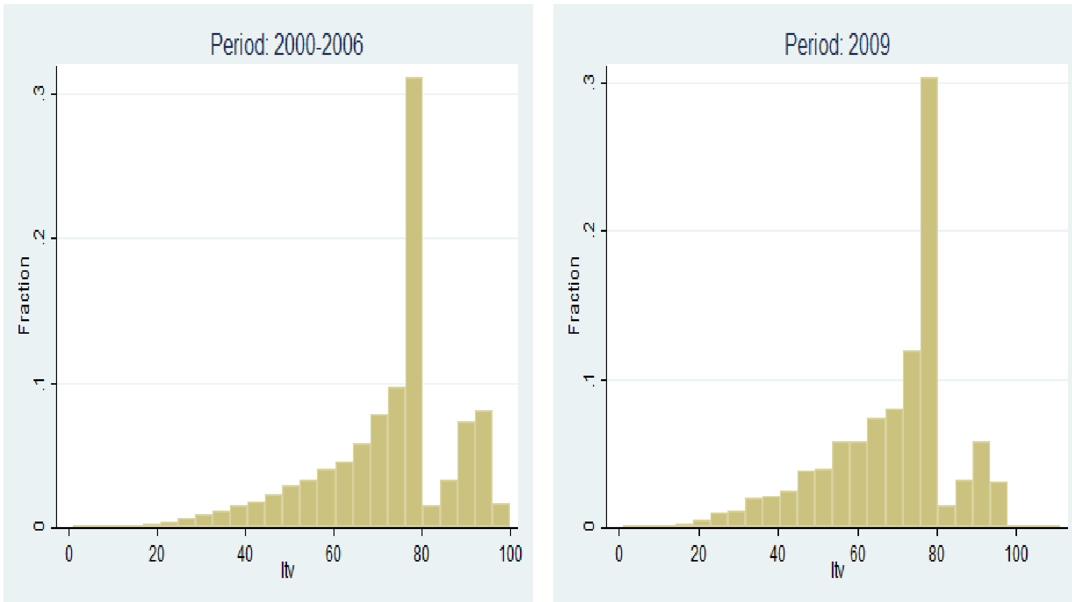
## 2 Model, Data and Amplification

We follow Punzi and Rabitsch (2016) in modeling the housing and mortgage market under the lens of a DSGE model with a banking sector. In particular, Punzi and Rabitsch (2016)'s model features endogenous LTV ratios and mortgage default, and allows for two types of Borrowers who use their housing as collateral in a mortgage contract, called a low-LTV type Borrower if $0 < LTV \leq 80\%$, and high-LTV type if $LTV > 80\%$.

[2] Throughout the paper, the terms "mortgage debt-to-GDP" and "debt-to-GDP" are used interchangeably.

[3] Most of the previous literature in a standard DSGE model has considered only one representative Borrower who choose the average LTV ratio when borrowing against the value of the collateral. (See Iacoviello (2005), Campbell and Hercowitz (2009), Iacoviello and Neri (2010), Gerali, Neri, Sessa, and Signoretti (2010), Mendicino and Punzi (2014), Iacoviello (2015), Justiniano, Primiceri, and Tambalotti (2015)).

**Fig. 1:** Data: Loan-to-Value Ratios.




The motivation of Borrower heterogeneity is found in the characteristics of the loan-to-value ratios distribution extracted from Fannie Mae and Freddie Mac's single family home purchase mortgages. Figure 1 compares the fraction of LTV ratios for holdings of mortgage loans between the period 2000-2006 and 2009.

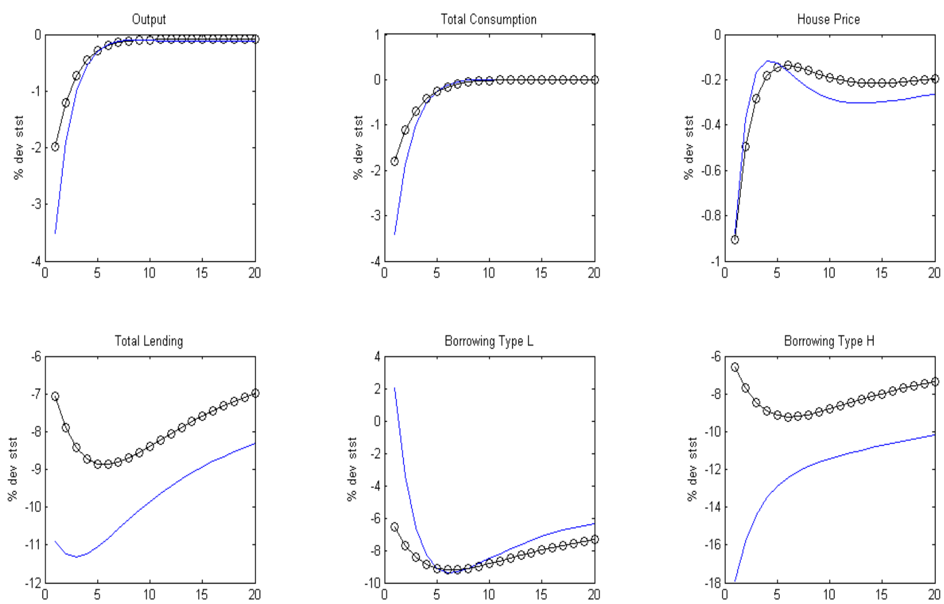
More specifically, as documented in Punzi and Rabitsch (2016), the overall economy-wide average LTV ratio drops from 73% in 2000-2006 to 69% in 2009, while the average LTV ratio for the high-LTV type Borrowers drops from 91% to 85%, and the average LTV ratio for the low-LTV type Borrowers drops from 67% to 64%, over the same sample period. Punzi and Rabitsch (2016) replicate this stylized fact. They assume that an unanticipated increase in the volatility of idiosyncratic housing investment risk hits the economy in such a way that the drop in LTV ratios mimics the pre-crisis and post-crisis periods. Compared to a model abstracting from Borrower heterogeneity, the deleveraging process induced by idiosyncratic housing risk shocks leads to a substantial decrease in real and financial variables, generating a deep recession. See Figure 2.

## 3 Macroprudential Policy

MaPru policy aims to strengthen the financial system's resilience against adverse shocks in the economy and to actively limit the buildup of financial vulnerability via an ex-ante stabilization process.[4]

[4]Macroprudential policy instruments offer a wide range of financial regulation measures, such as a capital buffer, capital requirement, time-varying liquidity buffer, maximum leverage ratio, debt service to income ratio and loan-to-value ratio.

**Fig. 2:** Idiosyncratic Housing Investment Risk Shock: 'homogeneous borrowers' version (circled black line) versus 'heterogeneous borrowers' version (solid blue line).



In this note, we follow Quint and Rabanal (2014) in implementing MaPru policies. We assume that the banking sector limits the issuance of new mortgage loans in a countercyclical way.

**Table 1:** Bank Balance Sheet

| Assets | Liabilities |
|---|---|
| Loans to Borrower Type 1: $B_{L,t}(\Upsilon_t)^{-\phi}$ | Deposits; $D_t$ |
| Loans to Borrower Type 2: $B_{H,t}(\Upsilon_t)^{-\phi}$ | Bank Capital: $x_t$ |

Table 1 shows the bank's stylized balance sheet, where variable $\Upsilon_t$ is a countercyclical MaPru tool responding to either:

- changes in the mortgage debt-to-GDP ratio;
- changes in the house price; or,
- changes in individual debt positions-to-GDP.

The change is measured in terms of percentage deviations from respective steady-state values. The parameter $\phi$ is the policy coefficient chosen to maximize the effectiveness of the MaPru policy in terms of social welfare. If $\phi = 0$, then no MaPru policy is implemented. If $\phi > 0$, then credit will be extended in a countercyclical way: periods of excessive credit expansion (reduction) would trigger use of the MaPru tool as a tax (subsidy) on loan supply, such as to limit (foster) household leverage.

### 3.1 Welfare Analysis and Pareto Weights

In order to evaluate the effectiveness of the use of MaPru tools, we compare the social welfare values achieved when a time-varying MaPru tool is implemented relative to the case in which the MaPru measure is absent. We obtain second-order accurate welfare approximations and find the optimal policy as the maximal social welfare achieved, using conditional welfare measures. See Benigno and Woodford (2005), Benigno and Woodford (2012), Rotemberg and Woodford (1999), Sutherland et al. (2002) and Schmitt-Grohé and Uribe (2004). Therefore, we optimize social welfare using the second-order approximation of the equilibrium.[5]

The individual welfare of each group of households, $V_{jt}$, is measured by the conditional expectation of discounted lifetime utility as of time $t$

$$V_{jt} \equiv \max E_t \left[ \sum_{t=0}^{\infty} \beta_j^t U(C_{jt}, H_{jt}, L_{jt}) \right] = U(C_{jt}, H_{jt}, L_{jt}) + \beta_j^t E_t V_{jt+1},$$

[5] See Schmitt-Grohé and Uribe (2004) for details of the use of the second-order approximation method.

where $C_j, H_j, L_j$ represent consumption of goods, housing services and hours worked for each group of households, respectively.

A common practice is to use a social welfare function that averages the utility of the population with equal weights. See Aiyagari and McGrattan (1998). However, Mendicino, Pescatori, et al. (2004), Lambertini, Mendicino, and Punzi (2013), Mendicino and Punzi (2014) and Jacob, Smith, and Yao (2014) weight the welfare function by the discount factors of the different types of economic agents.[6] In contrast, we use Pareto weights to aggregate individual welfare in a social welfare function, i.e. a weighted average of the welfare of the Savers and the two type of Borrowers, and calculate the implied Pareto weights under the social welfare function that obtains the maximum social welfare when the MaPru measure is active.:

$$Max_{\{\phi,\zeta\}} SV_t \equiv \left[\omega_j \Sigma_{j=1}^{n} V_{j,t}\right], \tag{3.1}$$

where

$$\omega_j = \frac{C_{j,t}^{\zeta}}{\Sigma_{j=1}^{n} C_{j,t}^{\zeta}}, \tag{3.2}$$

$\omega_j$ are the Pareto weights on household $j$, and the coefficient $\zeta$ is the weight of utilitarian social welfare function. See Chang, Chang, and Kim (2015). For values of $\zeta > 0$, the government assigns relatively larger weights to the Savers (rich households), while for values of ($\zeta < 0$), larger weights are assigned to Borrowers. Notice that the case in which all groups of households obtain equal weights in the social welfare function is nested in this setup as the special case where $\zeta = 0$. It is important to note that the parameter $\zeta$, that governs whether the government favors rich or poor households in the social welfare function, does typically not affect the ranking of optimality of MaPru measures.

We calculate the relative welfare gain between policies, expressed in terms of consumption equivalence, under the assumed log-preferences, as follows:

$$SV_{MaPru} - SV_0 = ln(1-\lambda) + \frac{\bar{\beta}}{1-\bar{\beta}} ln(1-\lambda), \tag{3.3}$$

where $\lambda$ denotes the fraction of life-time consumption that households under the implemented MaPru tool would be willing to sacrifice, leaving them indifferent between having the policy implemented or not, and $\bar{\beta}$ is the social discount factor that is the average of the discount factors of all households.

The so computed welfare gains enable us to rank the different MaPru policies.[7]

[6] They assign the weights $\omega_s = (1-\beta_s)$ and $\omega_b = (1-\beta_b)$ to allow the Borrowers and the Savers to achieve the same level of welfare for any given level of constant consumption streams.

[7] Several authors have studied the interaction of monetary and macroprudential policy. In this paper we focus our attention only on macroprudential policy; the interaction of macroprudential and monetary polices is left for future research.

### 3.1.1 Welfare Results

We maximize welfare under different policies, i.e. a time-varying MaPru tool that countercyclically responds to house price inflation, aggregate, or group individual debt-to-GDP growth in order to lean against excess credit growth. We search for the values of $\phi$ such that the coefficient of a countercyclical MaPru tool provides the highest stochastic mean value of the social welfare function. We maximize the objective with respect to $\phi$ over a grid of $[0;1]$ and search for values of $\zeta$ over a grid of values $[-0.5;0.5]$ that justify the maximum social welfare. Each interval point increases by 0.1.[8] The maximization problem under the second order approximation implies that social welfare is maximum conditional on the occurrence of shocks, i.e. both positive and/or negative shocks can occur during the stochastic process. In particular, we consider aggregate technology shocks, housing demand shocks, monetary policy shocks and idiosyncratic housing investment risk shocks. The exogenous processes of housing investment shocks are calibrated in order to replicate the volatility of LTV fluctuations occurred during the pre-crisis period. In this period, the LTV ratios of the Borrower group below and above 80% fluctuated by around 1 and 3 percentage points, respectively.

Tables 2 and 3 report welfare gains/losses achieved when the MaPru authorities target all Borrowers or only the high-LTV type Borrowers, respectively.[9] Each Table reports also volatilities (% change) and Pareto weights under each policy.

**Targeting all borrowers:** Table 2 shows that when the MaPru tool targets all Borrowers, then a measure that countercyclically responds to house price inflation, $\phi_{Qh}$, is optimal as it achieves the highest social welfare. However, this Mapru measure generates a trade-off across households as Borrowers are better off while Savers are worse off. This policy is able to strongly dampen the volatility in house prices, but increases the volatility in output and mortgage loans to GDP. As the Mapru tool helps avoiding large fluctuations in house prices, the impact of adverse shocks is reduced. Indeed, a less pronounced drop in house prices leads to fewer mortgage defaults and less severe drop in Borrowers housing demand. On the other hand, Savers receive less

[8] The choice of the grid considered deserves further comment. In particular, all different policies analyzed are increasing in $\phi$ and $\zeta$. Figure 5 in the Appendix displays a 3-dimensional representation of the social welfare achieved at different levels of $\phi$ and $\zeta$ when the macroprudential tool targets only high-LTV type Borrowers and responds to changes in their individual debt positions-to-GDP. All the other tools produce a similar increasing shape. The figure documents that social welfare increases for higher values of $\phi$, but after $\phi = 1$ the increase flattens out. Crucially, the ranking of the policies that are found optimal is unaffected by further increasing the size of the grid search. Similarly, the policy ranking is also insensitive to changes in $\zeta$.

[9] By 'targeting all Borrower' we mean that the MaPru tool affects the loan supplies to both low-type and high-LTV type Borrowers simultaneously, i.e. $B_{L,t}(\Upsilon_t)^{-\phi}$ and $B_{H,t}(\Upsilon_t)^{-\phi}$. When only high-type LTV borrowers are targeted, the loan supply to low-type LTV borrowers is unaffected from a MaPru policies, i.e. loan supply to low-type Borrowers is given simply by $B_{L,t}$, loan supply to high-type Borrowers is given by $B_{H,t}(\Upsilon_t)^{-\phi}$.

income for lending as the collateral value drops and, as they have less resources to finance consumption in goods and dwellings, their welfare is lower.[10]

If the objective of the policy makers is to achieve the highest social welfare conditional on the fact that all economic agents are better off, then a Mapru tools that countercyclically responds to aggregate debt-to-GDP growth, $\phi_{by}$, is optimal. This policy tool slightly increases the volatility of the Savers' consumption, but efficiently decreases the volatility of all the other variables, in particular dampening the mortgage debt-to-GDP ratio. Since the model generates large fluctuations in total debt-to-GDP, a measure responding to a variation of this variable is effective in reducing the volume of risky mortgage loans issued by the banking sector when a negative housing investment risk shock hits the economy. In absence of this policy, such shock drastically lowers banks' available assets, due to foregone mortgage payments, forces the bank to deleverage and to increase the interest rate charged to Borrowers, which in turns affects bank net worth and creates further contraction of credit and asset prices. The optimal MaPru measure prevents banks from experiencing such large losses as a lower share of defaulting Borrowers enter the mortgage market, thus limiting the increase in default premium and in the probability of foreclosures. Consequently, the deleveraging process will be less severe, with a smaller negative effect on real variables. As a result, the drop on consumption is less pronounced at aggregate and individual levels, relative to a drop occurred in the absence of MaPru policy, thus improving welfare.

**A MaPru measure that countercyclically responds to individual credit growth (i.e., individual debt-to-GDP ratios) for each group of Borrowers, $\phi_{bj}$, is also welfare improving, but achieves a lower social and individual welfare relative to a policy tool responding to the aggregate debt-to-GDP growth. This occurs because the Mapru tool, $\Upsilon_t^{-\phi}$, is quantitatively less effective relative to a tool responding to the overall debt-to-GDP. As a result, the impact on Borrowers' demand of loans and consequently their demand of dwellings is quantitatively less pronounced relative to the previous case, slightly reducing also the impact of the wealth effect on real variables.**

**Targeting only high-LTV type borrowers:** Table 3 presents results for the case when the MaPru policy targets only high-LTV type Borrowers, i.e. the group of Borrowers who face an LTV ratio higher than 80% in steady state. In this case, the optimal policy is to countercyclically respond only to the credit growth (growth of the individual debt-to-GDP ratio) of this group, the high-LTV type, of Borrowers. This is because such a policy directly targets the group for which the borrowing constraint binds most strongly. This policy leads to a very high gain in terms of welfare for both low-LTV and high-LTV type Borrowers, because this tool is most effective in containing the indebtedness for high-LTV type.

The countercyclical tool boosts more lending to low-LTV type as banks wish to keep their overall assets on the balance sheet unaffected. This leads to a high housing

[10] As shown in Punzi and Rabitsch (2016), the lending repayment is a function of the collateral value, i.e. $B_{bj,t}R_t = [F_t(\bar{\omega}_{t+1}) - \mu G_t(\bar{\omega}_{t+1})]E_t(Q_{h,t+1}(1-\delta_H)H_{bj,t}\pi_{t+1})$ .

**Table 2:** Welfare: **Target All Borrowers**

| MaPru Tool | $\phi_{Q_h} = 1.0$ | $\phi_{by} = 1.0$ | $\phi_{byj} = 1.0$ |
|---|---|---|---|
| Social Welfare Benchmark Level | -136.02 | -136.02 | -136.02 |
| Social Welfare Level | -133.90 | -133.92 | -133.95 |
| Social Welfare Gain $\lambda(\%)$ | 3.23 | 3.20 | 3.17 |
| | | | |
| Saver's Welfare Gain $\lambda(\%)$ | -0.08 | 0.11 | 0.11 |
| Borrower Type L's Welfare Gain $\lambda(\%)$ | 0.88 | 0.68 | 0.62 |
| Borrower Type H's Welfare Gain $\lambda(\%)$ | 1.18 | 0.81 | 0.73 |
| Pareto Weights ($\zeta$) | 0.50 | 0.50 | 0.50 |
| Saver ($\omega_s$) | 0.40 | 0.40 | 0.40 |
| Borrower Type L ($\omega_{bL}$) | 0.22 | 0.22 | 0.22 |
| Borrower Type H ($\omega_{bH}$) | 0.38 | 0.38 | 0.38 |
| Volatility (% change) | | | |
| Saver's Cons. | -9.83 | 1.31 | 1.16 |
| Borrower Type L's Cons. | -10.59 | -10.80 | -10.25 |
| Borrower Type H's Cons. | -6.10 | -10.19 | -9.78 |
| Output | 0.95 | -5.59 | -6.10 |
| House Price | -57.48 | -6.23 | -6.31 |
| Mortgage Loans to GDP | 57.72 | -91.49 | -81.56 |

Note: $\phi_{Qh}$, $\phi_{by}$ and $\phi_{byj}$ stand for a MaPru tool responding to house price inflation, total debt-to GDP growth and debt-to-GDP growth for each LTV type Borower, respectively.

demand and high house prices, relative to a similar policy that targets all Borrowers in the economy. Without a house price collapse, the impact of idiosyncratic risk shocks on real and financial variables is less severe, and therefore Borrowers achieve higher consumption levels and higher welfare compared to a MaPru policy that targets all Borrowers. However, this policy is able to dampen the volatility in output, house prices and mortgage debt-to-GDP less relative to the case in which all Borrowers are targeted. On the other hand, the drop in the volatility of Borrowers' consumption is higher relative to Table 2, allowing Borrowers to gain more in terms of welfare.

In all cases, more weight in the social welfare is assigned to the Savers and to the high-LTV type Borrowers, and less is assigned to lower leveraged households.[11] The results are similar to Chang, Chang, and Kim (2015) who find that in the case of U.S. tax reform, the social welfare function assigns a larger weighting to the rich, probably

[11]Since the weights are based on consumption shares, they do not change for different policies, but only for the scenario (all household types or only the high-LTV type) considered. Consumption shares change for different values of $\phi$ and $\zeta$, however the change is minimal for small change of $\zeta$, leaving the value of weights $\omega_j$ almost unchanged. Changes in the weights appears only at the sixth decimal point.

**Table 3:** Welfare: **Target only High-LTV Type Borrowers**

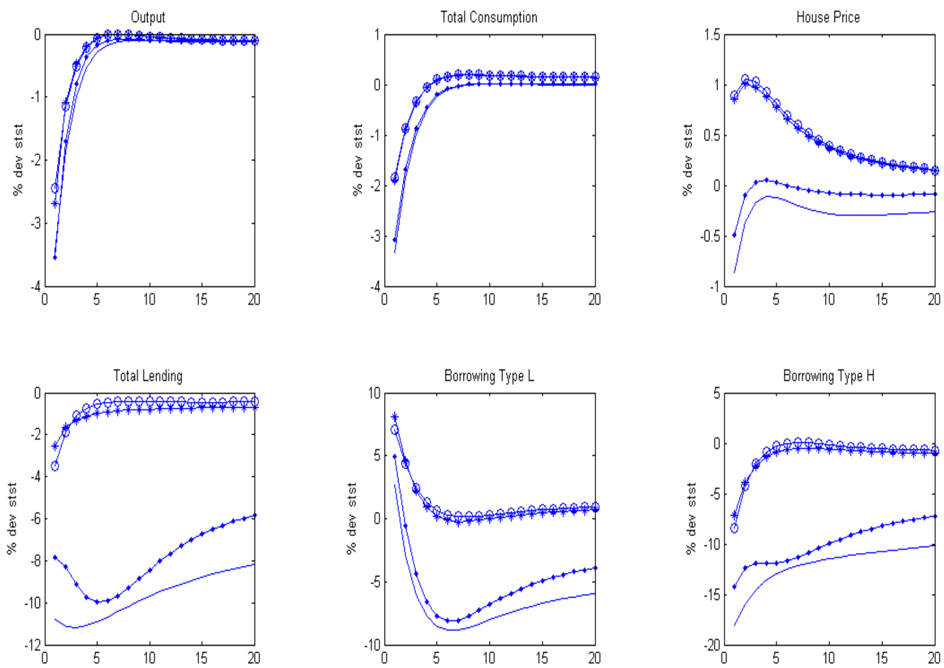
| MaPru Tool | $\phi_{Q_h} = 1.0$ | $\phi_{by} = 1.0$ | $\phi_{byj} = 1.0$ |
|---|---|---|---|
| Social Welfare Benchmark Level | -136.02 | -136.02 | -136.02 |
| Social Welfare Level | -133.99 | -133.93 | -133.89 |
| Social Welfare Gain $\lambda(\%)$ | 3.10 | 3.19 | 3.25 |
| | | | |
| Saver's Welfare Gain $\lambda(\%)$ | -0.05 | 0.11 | 0.11 |
| Borrower Type L's Welfare Gain $\lambda(\%)$ | 0.63 | 0.65 | 0.77 |
| Borrower Type H's Welfare Gain $\lambda(\%)$ | 0.84 | 0.77 | 0.91 |
| Pareto Weights ($\zeta$) | 0.50 | 0.50 | 0.50 |
| Saver ($\omega_s$) | 0.40 | 0.40 | 0.40 |
| Borrower Type L ($\omega_{bL}$) | 0.22 | 0.22 | 0.22 |
| Borrower Type H ($\omega_{bH}$) | 0.38 | 0.38 | 0.38 |
| Volatility (% change) | | | |
| Saver's Cons. | -7.98 | 1.25 | 1.89 |
| Borrower Type L's Cons. | -9.21 | -10.57 | -11.09 |
| Borrower Type H's Cons. | -5.59 | -10.03 | -10.16 |
| Output | -1.80 | -5.85 | -1.15 |
| House Price | -46.83 | -6.18 | -2.20 |
| Mortgage Loans to GDP | 33.54 | -86.31 | -67.16 |

Note: $\phi_{Qh}$, $\phi_{by}$ and $\phi_{byH}$ stand for a MaPru tool responding to house price inflation, total debt-to GDP growth and debt-to-GDP growth for the high-LTV type Borrower, respectively.

because the Government receives more from Savers. We note again, that, for the grid values considered, the optimal policy ranking is unaffected by the choice of $\zeta$.

Figures 3 and 4 report some counterfactual experiments showing what impulse responses would have been in the crisis experiment of Punzi and Rabitsch (2016), i.e. after the occurance of an adverse mortgage risk shock, if the policy makers would have implemented certain MaPru measures. The shock replicates the pre- and post- crisis average LTV ratio for the high-LTV type Borrowers, which drops from 91% to 85%, and for the low-LTV type Borrowers which drops from 67% to 64%. In both cases, when the MaPru tools target all Borrowers or only high-LTV type Borrowers, the dramatic drop in real and financial variables is reduced relative to a zero policy. The impulse responses to a mortgage risk shock for a MaPru measure responding to changes in the mortgage-to-GDP or credit growth (to GDP) for each individual group are very similar if the MaPru measure targets all Borrowers. However, when punishing only highly leveraged households, the reduced drop in real and financial variables is much more evident when the Mapru tool responds to credit growth (to GDP) for that particular group. Indeed, when the economy suffers from an adverse risk shock and a MaPru tool responding to aggregate debt-to-GDP growth is implemented, the borrowing level for the high-LTV type, i.e. an important part of the bank's assets, drops by 9% (percentage deviations

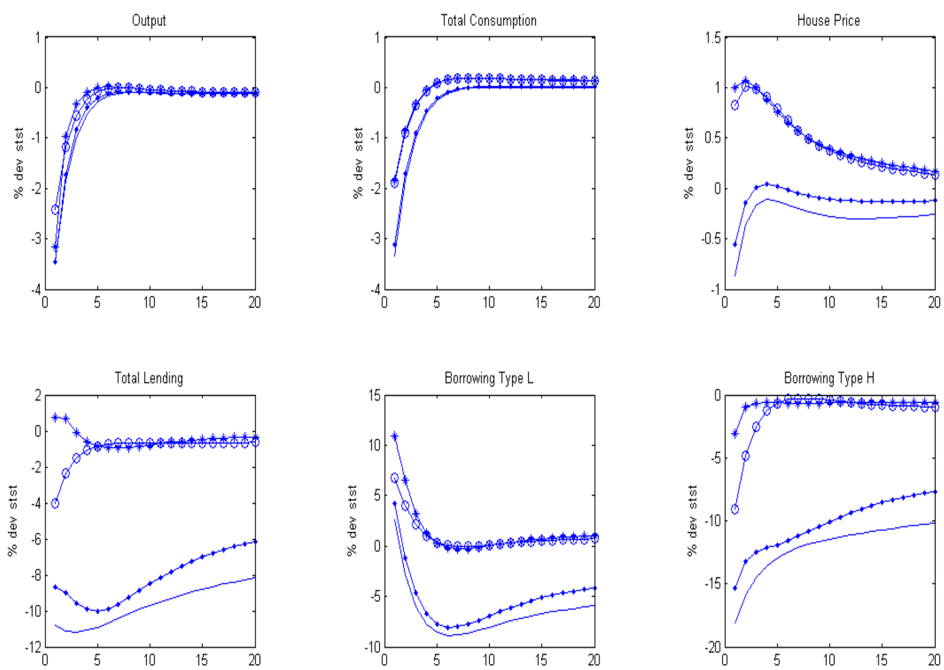
**Fig. 3:** Responses to Mortgage Risk Shock for different MaPru rules responding to: benchmark (solid line); changes in house prices (dotted line); changes in aggregate debt-to-GDP (circled line); changes in individual debt-to-GDP of each group (starred line).




from steady state) and for the low-LTV type, borrowing level increases by 7%, relative to a drop of 8% and an hike of 8% in the case of a MaPru tool responding to individual debt-to-GDP of each group. Compared to a zero policy, the losses banks experience under such MaPru policies are contained, and the drop in resources available to finance consumption in goods and housing is cushioned, most favorably so under the MaPru tool responding to the change in borrowing of high-LTV type Borrowers. In addition, house prices do not fall after the adverse shock, making the negative impact on real variable less severe. Alternatively, a MaPru tool that responds to house price inflation still leads to a negative response of house prices. Such decrease in assets prices still causes a large amount of mortgage defaults with a consequential drop in output and consumption similar to the case in which no MaPru policy is implemented.

MaPru tools affect the other types of shocks only on the aggregate and individual borrowing levels, leaving other variables largely unaffected. See Figure 7 in the Appendix.

**Fig. 4:** Responses to Mortgage Risk Shock when targeting only High-LTV type for different MaPru rules: benchmark (solid line); changes in house prices (dotted line); changes in aggregate debt-to-GDP (circled line); changes in individual debt-to-GDP of each group (starred line).



## 4 Conclusion

Conditional on Punzi and Rabitsch (2016)'s model, we consider the implications of macroprudential policies with the aim to lean against the excess in household debt by constraining the ability of the banking system to extend credit to leveraged households. We find that a macroprudential tool that countercyclically limits the supply of credit relative to the debt-to-GDP growth is welfare improving for all agents in the economy. However, if macroprudential authorities target only higher leveraged borrowers, then a rule that countercyclically responds only to the credit growth of this particular group (in particular, to the individual debt to GDP ratio) improves welfare even more, even if it can lead to higher volatility in housing prices, and contains the decrease in the volatility of the mortgage debt-to-GDP. The intuition for this finding is that the borrowing constraint for the high-LTV type Borrower binds strongest, therefore targeting this group with macroprudential policy leads to the greatest welfare gains. We thus conclude that it can be advisable for policymakers to consider the LTV ratio distribution and tailor their policy towards highly leveraged agents in an economy.

## References


Aiyagari, S. R., and E. R. McGrattan (1998): "The optimum quantity of debt," *Journal of Monetary Economics*, 42(3), 447–469.

Angeloni, I., and E. Faia (2013): "Capital regulation and monetary policy with fragile banks," *Journal of Monetary Economics*, 60(3), 311–324.

Bailliu, J., C. Meh, and Y. Zhang (2015): "Macroprudential rules and monetary policy when financial frictions matter," *Economic Modelling*, 50, 148–161.

Benigno, P., and M. Woodford (2005): "Inflation stabilization and welfare: The case of a distorted steady state," *Journal of the European Economic Association*, 3(6), 1185–1236.

——— (2012): "Linear-quadratic approximation of optimal policy problems," *Journal of Economic Theory*, 147(1), 1–42.

Brzoza-Brzezina, M., M. Kolasa, and K. Makarski (2015): "Macroprudential policy and imbalances in the euro area," *Journal of International Money and Finance*, 51, 137–154.

Campbell, J. R., and Z. Hercowitz (2009): "Welfare implications of the transition to high household debt," *Journal of Monetary Economics*, 56(1), 1–16.

Chang, B. H., Y. Chang, and S.-B. Kim (2015): "Pareto Weights in Practice: Income Inequality and Optimal Tax," Discussion paper, Working Paper.

Deng, Y., J. M. Quigley, and R. Order (2000): "Mortgage terminations, heterogeneity and the exercise of mortgage options," *Econometrica*, 68(2), 275–307.

Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010): "Credit and Banking in a DSGE Model of the Euro Area," *Journal of Money, Credit and Banking*, 42(s1), 107–141.

Iacoviello, M. (2005): "House prices, borrowing constraints, and monetary policy in the business cycle," *The American economic review*, 95(3), 739–764.

——— (2015): "Financial business cycles," *Review of Economic Dynamics*, 18(1), 140–163.

Iacoviello, M., and S. Neri (2010): "Housing market spillovers: evidence from an estimated DSGE model," *American Economic Journal: Macroeconomics*, 2(2), 125–164.

Jacob, P., C. Smith, and F. Yao (2014): "Monetary policy in the presence of an occasionally binding borrowing constraint," .

Justiniano, A., G. E. Primiceri, and A. Tambalotti (2015): "Household leveraging and deleveraging," *Review of Economic Dynamics*, 18(1), 3–20.

Kannan, P., P. Rabanal, A. Scott, et al. (2012): "Monetary and macroprudential policy rules in a model with house price booms," *B.E. Journal of Macroeconomics, Contributions*, 12(1), Article 16.

Lambertini, L., C. Mendicino, and M. T. Punzi (2013): "Leaning against boom–bust cycles in credit and housing prices," *Journal of Economic Dynamics and Control*, 37(8), 1500–1522.

Mendicino, C., A. Pescatori, et al. (2004): *Credit Frictions, Housing Prices and*

*Optimal Monetary Policy Rules*. Università degli studi Roma Tre.

Mendicino, C., and M. T. Punzi (2014): "House prices, capital inflows and macroprudential policy," *Journal of Banking & Finance*, 49, 337–355.

Pariès, M. D., C. K. Sørensen, D. Rodriguez-Palenzuela, et al. (2011): "Macroeconomic propagation under different regulatory regimes: Evidence from an estimated dsge model for the euro area," *International Journal of Central Banking*, 7(4), 49–113.

Punzi, M. T., and K. Rabitsch (2015): "Investor borrowing heterogeneity in a Kiyotaki–Moore style macro model," *Economics Letters*, 130, 75–79.

——— (2016): "Borrower heterogeneity within a risky mortgage-lending market," Discussion paper, FinMap Working Paper.

Quint, D., and P. Rabanal (2014): "Monetary and macroprudential policy in an estimated DSGE model of the euro area," *International Journal of Central Banking*, 10(2), 169–236.

Rotemberg, J. J., and M. Woodford (1999): "Interest rate rules in an estimated sticky price model," in *Monetary policy rules*, pp. 57–126. University of Chicago Press.

Schmitt-Grohé, S., and M. Uribe (2004): "Solving dynamic general equilibrium models using a second-order approximation to the policy function," *Journal of economic dynamics and control*, 28(4), 755–775.

Suh, H. (2011): "Evaluating Macroprudential Policy with Financial Friction DSGE Model," Discussion paper, Citeseer.

Sutherland, A., et al. (2002): *A simple second-order solution method for dynamic general equilibrium models*, vol. 3554. Centre for Economic Policy Research.

# APPENDIX

**Fig. 5:** Social welfare with respect to reaction parameter ($\phi$) and the social weights ($\zeta$). The macroprudential measure targets only high-LTV type Borrowers and the tool responds to the credit growth (this group's debt to GDP) of this group.

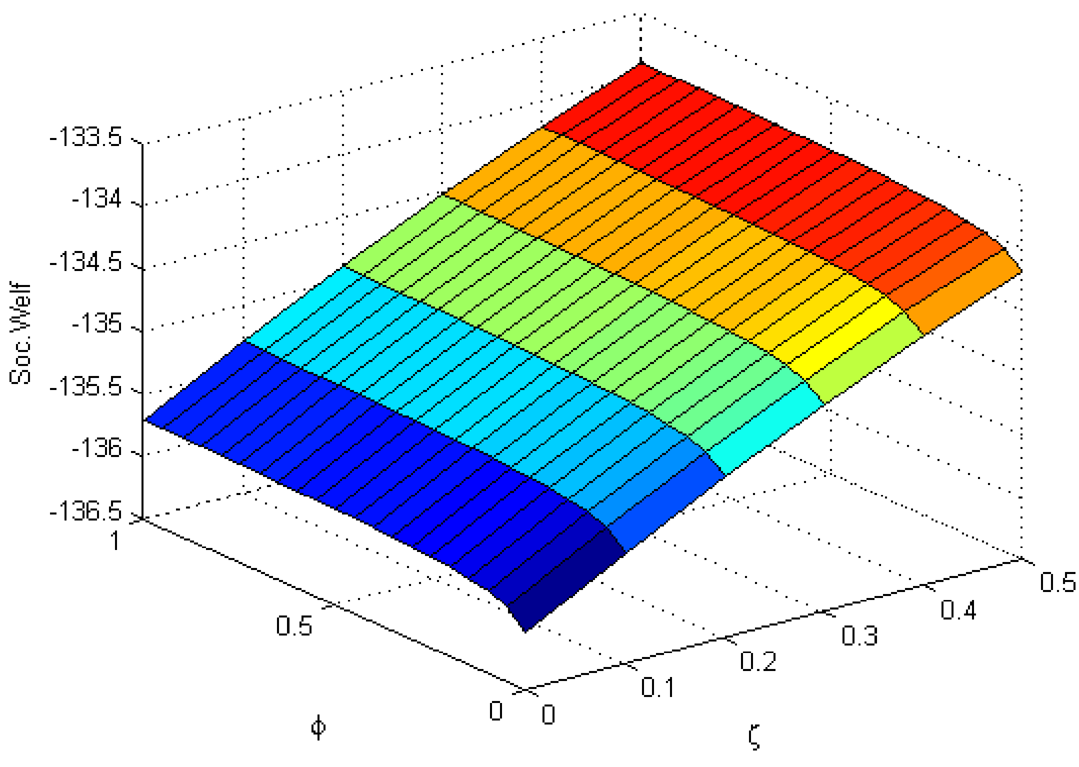


**Fig. 6:** Social welfare with respect only to reaction parameter ($\phi$) ($\zeta = 0.5$). The macroprudential measure targets only high-LTV type Borrowers and the tool responds to the credit growth (this group's debt to GDP) of this group.

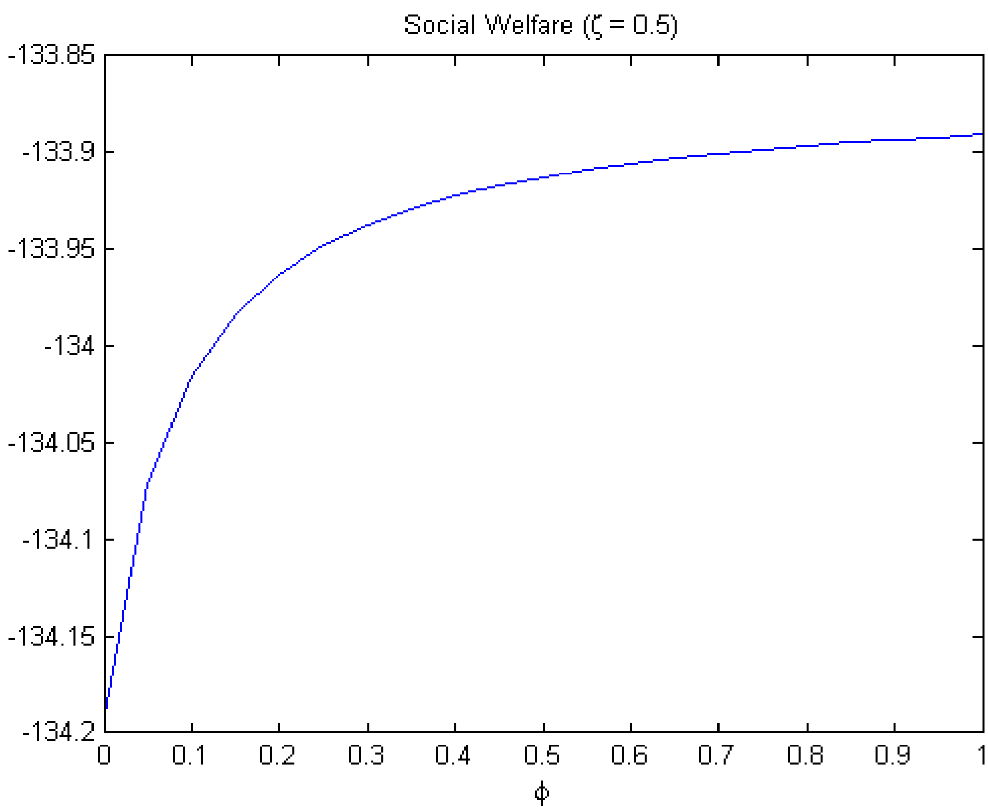


**Fig. 7:** Responses to different Shocks for a MaPru rule responding to "Borrowing growth of high-LTV type" when targeting only High-LTV type.