



UDK: 336.7

DOI: 10.2478/jcbtp-2024-0017

Journal of Central Banking Theory and Practice, 2024, 2, pp. 153-185*Received: 16 May 2023; accepted: 09 November 2023****Marcin Pietrzak***** Institute of Economics,
Polish Academy of Sciences,
Warsaw, Poland**E-mail:
mpietrzak@inepan.pl*

Non-Ricardian Borrowers and Mortgage Type: Implications for Monetary Policy Leaning against the Wind

Abstract: Leaning against the wind of credit booms is a monetary policy that is tighter than what is consistent with standard inflation targeting. This way the central bank tries to address excessive household debt. While the merits of such policy have been analysed, I argue that there are two dimensions that have been overlooked but are crucial: (i) ability of borrowers to freely adjust outstanding debt (refinancing) and (ii) dominant mortgage type in the economy (fixed or adjustable rate). I answer the research question using a standard macroeconomic model extended for the presence of borrowers who consume all their disposable income (hand-to-mouth) net of payments on long-term mortgage. I find that the optimal simple policy rule significantly depends on the ability to adjust debt and on mortgage type. Policy prescriptions based on models not accounting for these realistic features may lead to wrong monetary decisions.

Keywords: Financial stability, monetary policy, household debt, non-Ricardian borrowers, DSGE models.

JEL Classification: E32, E40, E52, E58.

1. Introduction

Before the Global Financial Crisis (GFC), a popular view was that central banks should neglect financial vulnerabilities and focus on their price stability mandate. The magnitude of the Great Recession and its consequences for conduct-

ing monetary policy (zero lower bound) led to questioning this view. Therefore, it is crucial to understand whether central banks should pre-emptively address financial vulnerabilities. The monetary policy that addresses such risks is said to be leaning against the wind of financial vulnerabilities (Svensson, 2017). While there are arguments in favour of more targeted policy measures (LTV, capital regulation, etc.) that contain these risks, there is still a need for a better understanding of how monetary policy can help in this dimension (Alpanda and Zubairy, 2017). Different prudential policies are often evaluated through the lens of a New Keynesian (NK) model which provides evaluation criterion – social welfare. When debt is the main financial vulnerability, the Two Agent New Keynesian (TANK) model is often used. In TANK we assume that each period borrowers can frictionlessly adjust debt principal. Only a small fraction adjusts or refinances. Andersen, Campbell, Nielsen and Ramadorai (2020) show that every quarter around 4% of borrowers refinance their mortgage and 50% have never refinanced. Mortgagors behave as if they had high psychological cost of refinancing (Keys, Pope and Pope, 2016).

This paper examines a leaning against the wind (LAW) policy when some borrowers do not refinance their debt, resembling the hand-to-mouth (HTM) concept from Campbell and Mankiw (1989). In this model, non-adjusting borrowers primarily allocate their labour income towards mortgage payments, considering that mortgages have multi-period terms following a 30-year amortization schedule. This friction is integrated into a standard TANK model with long-term debt, drawing inspiration from the limited asset market participation models proposed by Bilbiie (2008, 2019) and the discontinuous market participation model developed by Nisticò (2016).

Extensive research has explored central banks' role in managing financial risks, especially concerning household debt vulnerability (e.g. Ajello, Laubach, Lopez-Salido and Nakata, 2019; Alpanda and Zubairy, 2017; Gelain, Lansing and Natvik, 2018; Gerdrup and Torstensen, 2018; Gourio, Kashyap and Sim, 2018; Nisticò, 2016; Paoli and Paustian, 2017). These studies typically assume short-term debt, but in real world, most debt involves long-term mortgages. Garriga, Šustek and Kydland (2020) and Gelain et al. (2018) emphasize the significance of debt maturity in monetary shock transmission and challenge the conventional wisdom regarding interest rate adjustments during periods of rising debt and consumer prices. This leads us to the question: how should monetary policy adapt when only a small fraction of borrowers can adjust their debt while the majority remain HTM? Incorporating limited asset market participation into standard New Keynesian models has previously reshaped monetary policy approaches (Galí, López-Salido and Vallés, 2004; Bilbiie, 2008, 2019; Nisticò, 2016).

My primary contribution is a novel model designed for examining debt-related policy matters, drawing inspiration from the limited asset market participation literature. In my model, a considerable number of borrowers lack the opportunity to refinance their debt, intensifying the cash-flow impact of monetary shocks. Unlike borrowers with full market access, these non-adjusting borrowers cannot adjust their consumption over time. I use this model to demonstrate that the optimal monetary policy response to debt depends on the type of mortgage—adjustable-rate mortgage (ARM) or fixed-rate mortgage (FRM).

2. Literature review

My research relates to two literature streams. First, it explores the role of monetary policy in averting financial instability and its methods. Advocates of LAW argue it can reduce the magnitude and likelihood of financial crises, but as noted by Svensson (2017), it carries higher costs. Ajello et al. (2019) use a US-calibrated model, showing negligible net benefits of LAW, dependent on how interest rates affect credit growth and its impact on crisis severity. Gerdrup, Hansen, Krogh and Maih (2017) reach a positive net benefit conclusion. Both papers assume credit growth has no impact on output or consumption during normal times, but negative effects during crises. This assumption potentially understates LAW costs in normal times, as noted by Svensson (2017).

A different approach to analysing LAW focuses on household debt, considering its persistent evolution and its implications for monetary policy. Many studies adopt Garriga et al. (2020) framework, integrating long-term debt into a standard TANK DSGE model. They explore the importance of the disposable income channel in monetary policy versus the intertemporal substitution channel. Gelain et al. (2018) apply this framework to assess how central banks should manage the private debt-to-GDP ratio. The authors find that the answer depends on debt persistence. In a one-period debt economy, raising interest rates is conventional wisdom to reduce debt, but for long-term debt, lowering interest rates is more effective. This is also supported by Alpanda and Zubairy (2017) who find that LAW policy is less effective than targeted measures like loan-to-value caps or property taxes. Note that the effectiveness of monetary policy and specifically LAW policy may be determined by other factors: external (Nain and Kamaiah, 2020) or internal (Zuniga and Senbet, 2023). Stein (2013) highlights a key advantage of monetary policy: its ability to permeate all aspects of the financial system, a crucial factor when considering unregulated shadow banking and the potential for regulated banks to shift risks off their balance sheets (Begenau and Landvoigt, 2021).

Second, this study explores monetary policy in the presence of households without asset market access, known as HTM households. Campbell and Mankiw (1989) emphasized their importance in the US. Galí et al. (2004) reveal that HTM households alter interest rate rule properties, especially when their share is significant. Bilbiie (2008) confirms that limited asset market participation changes dynamics in a standard business cycle model. Nisticò (2016) introduces a discontinuous asset-market participation (DAMP) model where households transition between trading and non-trading states. DAMP adds financial stability as an extra policy objective for a welfare-maximizing policymaker.

3. Model

The model represents the limited participation and infrequent refinancing of households in the mortgage market within a standard New Keynesian DSGE framework. It features two types of agents: savers and borrowers, with a focus on household long-term debt. Only a fraction of borrowers adjusts debt.

3.1. Households

Economy is populated by a unit mass of households. There are two types of households: savers and borrowers that differ in the degree of impatience. Fraction $1 - \Psi$ of households are savers and Ψ are borrowers. Each household i -th derives utility from consumption $c_{i,t}$, housing services $h_{i,t}$, and derive disutility from labour $n_{i,t}$. The period utility function of i -th type household is:

$$u(c_{i,t}, h_{i,t}, n_{i,t}) = \frac{c_{i,t}^{1-\sigma}}{1-\sigma} + \rho_{h,t} \log h_{i,t} - \frac{n_{i,t}^{1+\varphi}}{1+\varphi},$$

where $i \in (s, ab, nb)$ stands for savers s , adjusting borrowers ab and non-adjusting borrowers nb , σ measures the inverse of elasticity of intertemporal substitution, $\rho_{h,t}$ is the relative preference for housing services that evolves according to AR(1) process, φ is the inverse of Frisch elasticity. Each type of household faces different constraints. For simplicity, I assume that there is a full insurance within status/family, but limited insurance across statuses/families as in Bilbiie (2019). This means that the solution of i -th type households problem is representative for all the households of the same type.

3.1.1. Borrowers

Borrowers constitute fraction Ψ of households. Borrowers are more impatient than savers $\beta_s > \beta_{ab} = \beta_{nb}$. In contrast to a standard NK model, only some borrowers can adjust their debt level. Fraction $1 - \nu$ of borrowers can adjust their outstanding debt while the remaining fraction ν cannot adjust. Borrowers switch exogenously between their adjusting statuses. I follow Bilbiie (2019) to model how borrowers switch between these statuses. Probability that a borrower will be able to adjust the debt at $t + 1$ given possibility to adjust at t is $\bar{p}$. Probability not to be able to adjust at $t + 1$ given not be able to adjust at t is $\bar{n}$. In a stationary equilibrium the mass of non-adjusting borrowers is

$$\nu = \frac{1 - \bar{p}}{2 - \bar{p} - \bar{n}}. \quad (1)$$

Note that this choice nests standard TANK model when $\bar{p} = 1$ and $\nu = 0$. In line with stylized facts in the previous section I assume that $\bar{p} \ll \bar{n}$, meaning that likelihood of adjusting again is smaller than the likelihood of not being able to adjust again.

At the beginning of the period, borrowers have predetermined stock of real debt and housing. Aggregate shocks are revealed. All borrowers choose consumption and labour supply and adjusting borrowers choose new level of real debt subject to collateral constraint. When making those choices borrowers do not know realizations of idiosyncratic shocks – their adjusting status next period. At the end of the period borrowers learn they status next period. They get equally split fraction of housing and outstanding real debt and move to the new status. Let $\tilde{b}_{i,t}$ be the beginning of the period stock of real debt and $b_{i,t}$ end of period stock of real debt. Same notation follows for housing stock that is we have $\tilde{h}_{i,t}$ and $h_{i,t}$, where $i \in (ab, nb)$. Aggregate intertemporal law of motion for real debt is given by:

$$(1 - \nu)\tilde{b}_{ab,t} = (1 - \nu)\bar{p}b_{ab,t-1} + \nu(1 - \bar{n})b_{nb,t-1}, \quad (2)$$

$$\nu\tilde{b}_{nb,t} = (1 - \nu)(1 - \bar{p})b_{ab,t-1} + \nu\bar{n}b_{nb,t-1}. \quad (3)$$

Equation (2) states that the aggregate beginning of the period real debt of adjusting borrowers next period is the sum of (i) end of period real debt stock of adjusting borrowers that keep adjusting next period (hence we have $(1 - \nu)\bar{p}$) and (ii) end of period real debt stock of non-adjusting borrowers that will adjust next period (hence we have $\nu(1 - \bar{n})$). Equation (3) states that the aggregate beginning of the period real debt of non-adjusting borrowers next period is the sum of (i) end of period real debt stock of adjusting borrowers that will not be able to ad-

just next period (hence we have $(1 - \nu)(1 - \bar{p})$) and (ii) end of period real debt stock of non-adjusting borrowers that will keep not to adjust next period (hence we have $\nu\bar{n}$). The same reasoning follows for housing stock, hence we have:

$$(1 - \nu)\tilde{h}_{ab,t} = (1 - \nu)\bar{p}h_{ab,t-1} + \nu(1 - \bar{n})h_{nb,t-1} \quad (4)$$

$$\nu\tilde{h}_{nb,t} = (1 - \nu)(1 - \bar{p})h_{ab,t-1} + \nu\bar{n}h_{nb,t-1} \quad (5)$$

Adjusting borrowers. Adjusting borrowers are impatient households that can adjust the outstanding real debt by either taking on more real debt or prepaying the real debt. Each adjusting borrower maximizes lifetime utility by choosing consumption $c_{ab,t}$, real debt level $b_{ab,t}$, housing $h_{ab,t}$, and labour supply $n_{ab,t}$. When making these choices, adjusting borrower faces uncertainty whether they have access to the real debt market next period. Therefore, adjusting borrower's decision problem is the maximization of the value function given by:

$$W^{ab}(\tilde{b}_{ab,t}, \tilde{h}_{ab,t}) = \max_{c_{ab,t}, n_{ab,t}, b_{ab,t}, h_{ab,t}} \left(\frac{c_{ab,t}^{1-\sigma}}{1-\sigma} + \rho_{h,t} \log h_{ab,t} - \frac{n_{ab,t}^{1+\varphi}}{1+\varphi} \right) + \beta_{ab} \mathbb{E}_t \left[W^{ab}(\tilde{b}_{ab,t+1}, \tilde{h}_{ab,t+1}) + \frac{\nu}{1-\nu} W^{nb}(\tilde{b}_{nb,t+1}, \tilde{h}_{nb,t+1}) \right] \quad (6)$$

subject to intratemporal outstanding real debt law of motion (2), intratemporal housing stock law of motion (4), budget constraint:

$$c_{ab,t} + \frac{i_{t-1} + \delta}{\pi_t} \tilde{b}_{ab,t} + q_t(h_{ab,t} - (1 - \delta_h)\tilde{h}_{ab,t}) = w_{ab,t}n_{ab,t} + \left(b_{ab,t} - \frac{1-\delta}{\pi_t} \tilde{b}_{ab,t} \right) + \tau_{ab,t} \quad (7)$$

and borrowing constraint on new lending

$$NL_t \equiv b_{ab,t} - \frac{1-\delta}{\pi_t} \tilde{b}_{ab,t} = m_t q_t (h_{ab,t} - (1 - \delta_h)\tilde{h}_{ab,t}), \quad (8)$$

which for simplicity binds all the time. Mortgage nominal interest rate is i_{t-1} , debt amortization rate is δ and housing depreciation rate is δ_h . Hence left hand side of the budget constraint (7) states that adjusting borrowers consume, service debt (mortgage payments) and trade housing at the real price q_t . These expenditures are equal to labour income, new borrowing and (possibly non-zero) transfers to be defined later. Note that the new borrowing is the difference between the end of period real debt level $b_{ab,t}$ and unamortized fraction of the beginning of the period real debt $\frac{1-\delta}{\pi_t} \tilde{b}_{ab,t}$. Borrowing constraint (8) states that the new borrowing is collateralized by the value of housing purchased scaled by loan to value

ratio m_t that evolves according to AR(1) process. The first order conditions for $c_{ab,t}$, $h_{ab,t}$, $n_{ab,t}$ and $b_{ab,t}$ are

$$c_{ab,t}^{-\sigma} = \lambda_{ab,t}, \quad (9)$$

$$n_{ab,t}^{\varphi} = w_{ab,t} \lambda_{ab,t}, \quad (10)$$

$$q_t \lambda_{ab,t} = \frac{\rho_h}{h_{ab,t}} + m_t q_t \mu_{ab,t} + (1 - \delta_h) \beta_{ab} \mathbb{E}_t q_{t+1} [\bar{p}(\lambda_{ab,t+1} - m_{t+1} \mu_{ab,t+1})], \quad (11)$$

$$\lambda_{ab,t} - \mu_{ab,t} = \beta_{ab} \mathbb{E}_t \left[\bar{p} \left(\lambda_{ab,t+1} \frac{1+i_t}{\pi_{t+1}} - \mu_{ab,t+1} \frac{1-\delta}{\pi_{t+1}} \right) + (1 - \bar{p}) \lambda_{nb,t+1} \frac{i_t + \delta}{\pi_{t+1}} \right], \quad (12)$$

where $\lambda_{ab,t}$ is the Lagrangian multiplier on budget constraint and $\mu_{ab,t}$ is the Lagrangian multiplier on the borrowing constraint. Marginal utility of consumption (9) and labour supply (10) are standard. However other two first order conditions differ from what is used in the literature. Housing demand (11) shows that when deciding about the housing stock, adjusting borrowers take into account the fact that next period they have a small probability $\bar{p}$ of being able to trade housing. In fact, when their status changes to non-adjusting, they cannot change housing as well. The same applies to demand for debt (12). When choosing debt stock today, adjusting borrower knows that next period they will be able to adjust with probability $\bar{p}$ and will be constrained with probability $(1 - \bar{p})$. In the latter case, adjusting borrower accounts for the debt servicing cost $\frac{i_t + \delta}{\pi_{t+1}}$ – real interest rate plus debt amortization. Note that when debt is one period $\delta = 1$ and borrowers can always access the debt market ($\bar{p} = 1$) this formula simplifies to a standard first order condition.

Non-adjusting borrowers. Non-adjusting borrowers are households who neither adjust the outstanding debt stock nor trade in housing in the current period. However, they can switch to adjusting status with probability $(1 - \bar{n})$. Each non-adjusting borrower maximizes lifetime utility by choosing consumption $c_{nb,t}$, and labour supply $n_{nb,t}$. When making these choices, non-adjusting borrower faces uncertainty whether she has access to the debt market next period. Therefore, adjusting borrower's decision problem is the maximization of the value function given by:

$$\begin{aligned} W^{nb}(\tilde{b}_{nb,t}, \tilde{h}_{nb,t}) = & \max_{c_{nb,t}, n_{nb,t}} \left(\frac{c_{nb,t}^{1-\sigma}}{1-\sigma} + \rho_{h,t} \log h_{nb,t} - \frac{n_{nb,t}^{1+\varphi}}{1+\varphi} \right) \\ & + \beta_{ab} \mathbb{E}_t \left[\frac{1-\nu}{\nu} W^{ab}(\tilde{b}_{ab,t+1}, \tilde{h}_{ab,t+1}) + W^{nb}(\tilde{b}_{nb,t+1}, \tilde{h}_{nb,t+1}) \right] \end{aligned} \quad (13)$$

subject to intratemporal outstanding real debt law of motion (3), intratemporal housing stock law of motion (5), and budget constraint:

$$c_{nb,t} + \frac{i_{t-1} + \delta}{\pi_t} \tilde{b}_{nb,t} = w_{nb,t} n_{nb,t} + \tau_{nb,t}, \quad (14)$$

which shows that, apart from consumption, non-adjusting borrowers make mortgage payments according to the mortgage nominal interest rate is i_{t-1} and debt amortization rate is δ . Expenditures are financed via labour income $w_{nb,t} n_{nb,t}$ and (possibly non-zero) transfers $\tau_{nb,t}$. Given debt amortization rate δ , end of the period real debt $b_{nb,t}$ is given by:

$$b_{nb,t} = \frac{1-\delta}{\pi_t} \tilde{b}_{nb,t}. \quad (15)$$

Analogously, end of the period housing stock $h_{nb,t}$ is given by:

$$h_{nb,t} = (1 - \delta_h) \tilde{h}_{nb,t}. \quad (16)$$

The first order conditions for $c_{nb,t}$ and $n_{nb,t}$ are

$$\begin{aligned} c_{nb,t}^{-\sigma} &= \lambda_{nb,t} \\ n_{nb,t}^{\varphi} &= w_{nb,t} \lambda_{nb,t} \end{aligned}$$

while real debt stock $b_{nb,t}$ and housing stock $h_{nb,t}$ evolve according to (15) and (16).

3.1.2. Savers

Savers constitute fraction $1 - \Psi$ of households. Savers are more patient than borrowers and, therefore, they lend to borrowers. Savers derive utility from consumption $c_{s,t}$, housing $h_{s,t}$ and get disutility from labour supply $n_{s,t}$. Savers maximize lifetime utility given by

$$W^s(b_{s,t}, h_{s,t}) = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta_s^t \left(\frac{c_{s,t}^{1-\sigma}}{1-\sigma} + \rho_{h,t} \log h_{s,t} - \frac{n_{s,t}^{1+\varphi}}{1+\varphi} \right) \right\}, \quad (17)$$

subject to budget constraint

$$\begin{aligned} c_{s,t} + \left(b_{s,t} - \frac{1-\delta}{\pi_t} b_{s,t-1} \right) + q_t \left(h_{s,t} - (1 - \delta_h) h_{s,t-1} \right) = \\ w_{s,t} n_{s,t} + \frac{i_{t-1} + \delta}{\pi_t} b_{s,t-1} + \tau_{s,t}, \end{aligned} \quad (18)$$

where $b_{s,t}$ is the level of assets/deposits, consequently $(b_{s,t} - \frac{1-\delta}{\pi_t} b_{s,t-1})$ is a new lending, $(h_{s,t} - (1 - \delta_h)h_{s,t-1})$ is stock of housing traded, $w_{s,t}n_{s,t}$ is labour income, $\frac{i_{t-1}+\delta}{\pi_t} b_{s,t-1}$ mortgage receipts and $\tau_{s,t}$ is real net transfer. Savers choices are the solution of the maximization problem (17) subject to (18) and are given by the following first order conditions for $c_{s,t}$, $n_{s,t}$, $b_{s,t}$ and $h_{s,t}$.

$$c_{s,t}^{-\sigma} = \lambda_{s,t},$$

$$n_{s,t}^{\varphi} = w_{s,t} \lambda_{s,t},$$

$$\lambda_{s,t} = \beta_s \frac{1+i_t}{\pi_{t+1}} \lambda_{s,t+1},$$

$$\lambda_{s,t} q_t = \frac{\rho_h}{h_{s,t}} + (1 - \delta_h) \beta_s \mathbb{E}_t \lambda_{s,t} q_{t+1}.$$

Transfers. Before moving on to supply side of the model economy, I need to specify what the transfers are $\tau_{ab,t}$, $\tau_{nb,t}$, $\tau_{s,t}$ that each agent receives as can be seen in respective budget constraints (7), (14) and (18). I follow Debortoli and Galí (2017) and assume that these transfers are fraction of dividends paid out by firms. Transfers per capita are the same for borrowers whether they can adjust debt or not. Therefore, transfers are given by

$$\tau_{ab,t} = \tau_{nb,t} = (1 - \tau) \text{div}_t, \quad (19)$$

$$\tau_{s,t} = \left(1 + \frac{\tau\Psi}{1 - \Psi}\right) \text{div}_t, \quad (20)$$

where div_t are real dividends from firms that are held by savers, and τ controls the degree of redistribution. For $\tau = 0$ we have full redistribution as per capita transfers for all agents are the same. On the other hand, when $\tau = 1$ all dividends from firms are paid to savers. Debortoli and Galí (2017) refer to $\tau = 0$ as uniform rule and to $\tau = 1$ as a wealth-based rule of profits redistribution.

3.2. Firms

Firms are owned by savers. There are two types of firms: (i) retailers who are perfectly competitive firms with flexible prices and (ii) intermediate goods producers who use labour to produce intermediate goods that are sold to retailers. Intermediate goods producers are monopolistically competitive and are subject to price stickiness. Profits arising from intermediate goods producers are redistributed according to redistribution rules (19) and (20).

3.2.1. Retailers

A representative retailer combines intermediate goods according to a technology with constant elasticity of substitution:

$$Y_t = \left[\int_0^1 y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where $j \in [0,1]$ is j -th intermediate good used to produce final output and $\varepsilon > 1$ is the constant elasticity of substitution between intermediate goods. Standard cost minimization problem yields demand function for intermediate good j

$$y_t(j) = \left(\frac{p_t(j)}{p_t} \right)^{-\varepsilon} Y_t, \quad (21)$$

where the aggregate price index for intermediate goods is given by

$$p_t = \left[\int_0^1 p_t(j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}. \quad (22)$$

3.2.2. Intermediate good producers

Intermediate goods producers problem is two-step. First, they choose labour inputs by minimizing the labour costs subject to production function. Second, they chose optimal pricing knowing that they are likely not to be able to reset the price next period. Intermediate good producers use labour only according to the production function

$$y_t(j) = A_t n_t(j), \quad (23)$$

where A_t is AR(1) productivity level and $n_t(j)$ is a firm's j aggregate labour input which is a weighted geometric average of each type of households with weights given by population shares

$$n_t(j) = \left(n_{s,t}(j) \right)^{1-\Psi} \left(n_{ab,t}(j) \right)^{\Psi(1-\nu)} \left(n_{nb,t}(j) \right)^{\Psi\nu}. \quad (24)$$

Intermediate production function (23) together with aggregate labour input equation (24) generate constant income shares for each agent (Benigno, Eggertsson and Romei, 2020). The producer of variety j solves cost minimization problem that yields the marginal cost of production $\chi_t(j)$ (which is the Lagrange multiplier associated with the constraint (23))

$$\min_{n_{s,t}(j), n_{ab,t}(j), n_{nb,t}(j)} \{w_{s,t}n_{s,t}(j) + w_{ab,t}n_{ab,t}(j) + w_{nb,t}n_{nb,t}(j)\}$$

subject to $y_t(j) \leq A n_t(j)$.

Solving for $n_{s,t}(j)$, $n_{ab,t}(j)$, $n_{nb,t}(j)$ and aggregating over firms gives labour demand conditions

$$w_{s,t}n_{s,t} = w_{ab,t}n_{ab,t} = w_{nb,t}n_{nb,t} = \chi_t \Delta_t Y_t, \quad (25)$$

where Δ_t is the price dispersion defined as $\Delta_t = \int_0^1 \left[\frac{p_t(j)}{p_t} \right]^{-\varepsilon} dj$. Real marginal cost is given by

$$\chi_t = \frac{W_t}{A_t(1-\Psi)^{1-\Psi}(\Psi(1-\nu))^{\Psi(1-\nu)}(\Psi\nu)^{\Psi(\nu)}},$$

where $W_t = (w_{s,t})^{1-\Psi} (w_{ab,t})^{\Psi(1-\nu)} (w_{nb,t})^{\Psi(\nu)}$ is the aggregate wage index. We can also aggregate (23) over firms to relate aggregate intermediate goods production as a product of dispersion and total output

$$(1-\Psi)^{1-\Psi}(\Psi(1-\nu))^{\Psi(1-\nu)}(\Psi\nu)^{\Psi(\nu)} A_t N_t = \Delta_t Y_t, \quad (26)$$

where $N_t = (n_{s,t})^{1-\Psi} (n_{ab,t})^{\Psi(1-\nu)} (n_{nb,t})^{\Psi(\nu)}$. After deriving marginal cost we can move to solving for the optimal price.

Intermediate producers cannot freely adjust prices. I follow Calvo (1983) and assume that j -th firm has an ability to reset the price each period with probability $1 - \psi$. This implies that $1 - \psi$ firms resets their prices, while remaining fraction ψ does not change their prices. When deciding about the optimal price, firms take demand for their goods (21) as given. The producer of j -th variety solves the optimal price $p_t^*(j)$ resetting problem by maximizing expected discounted profits given by

$$\max_{p_t^*(j)} \mathbb{E}_t \sum_{k=0}^{\infty} \left\{ \psi^k \beta^k \frac{\lambda_{s,t+k}}{\lambda_{s,t}} \left[(1 + \tau^f) \frac{p_t^*(j)}{p_{t+k}} - \chi_{t+k} \right] y_{t+k}(j) - T_{F,t}(j) \right\},$$

where ψ is the fraction of firms that does not adjust the prices and τ^f is a subsidy, financed by a lump-sum tax $T_{F,t}(j)$, to make steady state production efficient. First order condition is standard and given by

$$p_t^*(j) = \frac{\varepsilon}{(\varepsilon-1)(1+\tau^f)} \frac{\mathbb{E}_t \sum_{s=0}^{\infty} \psi^s \beta^s \Lambda_{1,t+s} [\chi_{t+s} (p_{t+s})^\varepsilon] Y_{t+s}}{\mathbb{E}_t \sum_{s=0}^{\infty} \psi^s \beta^s \Lambda_{1,t+s} [(p_{t+s})^{\varepsilon-1}] Y_{t+s}}. \quad (27)$$

Note that all producers will choose the same price, hence I drop the j subscript $\forall_j p_t^*(j) = p_t^*$. Using aggregate price level (22) we have

$$\Pi_t^{1-\varepsilon} = \psi + (1 - \psi)(\Pi_t^*)^{1-\varepsilon}. \quad (28)$$

What follows is that the price dispersion evolves according to

$$\Delta_t = (1 - \psi)\Pi_t^\varepsilon(\Pi_t^*)^{-\varepsilon} + \psi\Pi_t^\varepsilon\Delta_{t-1} \quad (29)$$

Real profits are given by¹

$$\text{div}_t = (1 - \chi_t\Delta_t)Y_t \quad (30)$$

3.3. Monetary policy and taxes

Monetary policy is conducted according to the extended Taylor rule

$$1 + i_t = (1 + i_{t-1})^{\phi_i} \left((1 + \bar{i}) \left(\frac{\Pi_t}{\Pi} \right)^{1+\phi_\Pi} \left(\frac{Y_t}{Y} \right)^{\phi_Y} \left(\frac{x_t}{\bar{x}} \right)^{\phi_x} \right)^{1-\phi_i} \xi_{i,t}, \quad (31)$$

where ϕ 's are the weights assigned to relevant variables, $\bar{i}$ is the steady state nominal interest rate level, x_t is a variable of macroprudential interest, and $\xi_{i,t}$ is monetary shock governed by AR(1) process. Specifically, I consider two most advocated measures: (i) aggregate debt level to output $\frac{B_t}{Y_t}$ and new lending NL_t as defined in (8), that is $x_t \in \left[\frac{B_t}{Y_t}, NL_t \right]$. These variables have been previously analysed by Gelain et al. (2018). The remaining part is the government budget. Government collects lump-sum taxes from firms $T_{F,t}$ and redistributes them back to firms according to

$$\tau^f Y_t = T_{F,t}, \quad (32)$$

which implies that the budget is by definition balanced. Government is also in charge of redistribution of dividends (19) and (20).

3.4. Equilibrium

An equilibrium in this economy is given by the set of stochastic processes for prices and quantities that solve households and producers optimization problems subject to relevant constraints and such that all markets clear. The model econo-

¹ I assume that the subsidy τ^f is financed by lump-sum taxes levied on firms $T_{F,t}$. Hence government budget constraint is balanced (32). This implies that the formula for real profits can abstract from the subsidy and tax.

my description closes with monetary policy rule. Regarding market clearing we need debt market to clear

$$B_t \equiv (1 - \Psi)b_{s,t} = \Psi \left((1 - \nu)b_{ab,t} + \nu b_{nb,t} \right), \quad (33)$$

housing market clearing condition is

$$H_t = (1 - \Psi)h_{s,t} + \Psi \left((1 - \nu)h_{ab,t} + \nu h_{nb,t} \right), \quad (34)$$

labour market clears by definition. Finally, the aggregate output Y_t can be either consumed or used for residential investment

$$Y_t = C_t + q_t I H_t, \quad (35)$$

where $C_t = (1 - \Psi)c_{s,t} + \Psi \left((1 - \nu)c_{ab,t} + \nu c_{nb,t} \right)$, and residential investment is given by $I H_t = H_t - H_{t-1}$. Real house price q_t measures the rate of transformation between consumption and investment and is defined as

$$q_t = \exp \left(\xi (I H_t - \overline{I H}) \right) \quad (36)$$

where $\overline{I H}$ is the steady state level of residential investment and ξ measures the curvature of the production possibility frontier that controls the rate of transformation q_t between consumption and residential investment (Garriga et al., 2020). Therefore, more curvature means higher sensitivity ξ , which implies that when a shock hits, more of the aggregate adjustment goes through change in house price rather than the residential investment. The model equilibrium conditions are log-linearized around deterministic steady state and the system of equations is solved using perturbation methods. 1st approximation is used to compute the impulse response functions (IRFs) presented in section 3.6 while 2nd approximation is used in section 4.

3.5. Calibration

The parameter values are shown in Table 1 organized in three categories related to households, debt and firms. Most parameters are set independently even before solving for deterministic steady state of the model. The goal is to benchmark the results against the models used in the literature. Starting with households related parameters, I set savers discount factor β_s to 0.993 which implies steady state value of nominal interest equal to 2.9%. Then I set borrowers discount factor β_b to 0.97. While this value does not have material impact on the dynamics of the variables, the low value of this parameter guarantees that borrowers are

impatient enough to make the borrowing constraint (8) bind in the steady state. Similar values are used in Iacoviello and Neri (2010) and Gelain et al. (2018). Housing preference weight ρ_h governs the relative preference of shelter services over consumption. Note that I use the same preference weight ρ_h to all households irrespective of their type. Setting ρ_h to the value of 0.083 together with housing depreciation δ_h of 0.01 implies that new housing investment accounts for 7.6% of output in the steady state. According to the National Income and Product Accounts (NIPA), in the first three quarters of 2021, residential investment accounted for 4.7% of US GDP. Note, however, that the output in the model is not a direct counterpart of GDP. Since output is used for consumption and new housing, I relate these to variables to personal consumption expenditures (67.8%) and residential investment (4.7%) only. Hence the implied share of new housing in output is 6.5%. The chosen value for housing preference ρ_h is also close to 0.1 in Iacoviello (2005). I keep the values of intertemporal elasticity of substitution σ and elasticity of labour supply φ at their usual level of 1. Finally, I assume that there is no redistribution of dividends in the model and set τ to 1, so savers receive all profits that firms generate outside of steady state.

Table 1 Key parameters

Parameter	Name	Value	Source/Target
Households			
β_s	Savers discount factor	0.993	Iacoviello and Neri (2010)
β_b	Borrowers discount factor	0.970	Iacoviello and Neri (2010)
ρ_h	Housing preference	0.083	New housing to output at 7.6%
σ	Intertemporal elasticity of substitution	1.000	Iacoviello (2005)
φ	Elasticity of labour supply	1.000	Iacoviello (2005)
$\bar{p}$	Fraction keeping adjusting	0.100	Andersen et al. (2020)
$\bar{n}$	Fraction keeping non-adjusting	0.800	Andersen et al. (2020)
Ψ	Fraction of borrowers	0.600	Gelain et al. (2018)
τ	Savers share in profits	1.000	Debortoli and Galí (2017)
δ_h	Housing depreciation	0.010	Iacoviello and Neri (2010)
Debt			
$\bar{m}$	Steady-state LTV	0.720	Debt to output ratio at 83%
δ	Debt amortization	0.019	Gelain et al. (2018)
Firms			
ε	Elasticity of substitution	6.000	Iacoviello and Neri (2010)
ψ	Fraction of firms participating prices	0.750	Iacoviello and Neri (2010)
ξ	Curvature of PPF	3.200	Garriga et al. (2020)

Important category of households-related parameters pertains to population shares. The share of borrowers in the model is set to the conventional value of 0.6 as in Garriga et al. (2020) and Gelain et al. (2018). Recently, Tzamourani (2021) showed that this percentage is around 40% in the European Union data (Household Finance and Consumption Survey). However in this model I do not account for renting hence the 40% value may underestimate the share of borrowers when renters are not in the model economy. Last two household parameters govern the likelihood of switching between statuses – from adjusting to non-adjusting ($1 - \bar{p}$) and from non-adjusting to adjusting ($1 - \bar{n}\bar{p}$). The two parameters $\bar{p}$ and $\bar{n}$ imply the stationary share of non-adjusting borrowers as given by (1). These parameters are not standard and pose a challenge. I follow empirical literature on mortgage refinancing, especially Andersen et al. (2020) who using high-quality administrative data show that 50% of mortgagors do not refinance, while each quarter around 4% of them refinance. Note that their sample covers time period when interest rates trended downwards so quarterly refinancing rate may be overestimated. These numbers cannot pin down the parameters in the model as we are not given value of $\bar{n}$. Given that households failure to refinance is well-documented (Andersen et al., 2020; Keys et al., 2016) it is safe to assume that $\bar{n}$ is large. How large exactly? Setting $\bar{p}$ to 0.1 and $\bar{n}$ to 0.8 results in the stationary fraction on non-adjusting borrowers of 0.81. Given that borrowers constitute only 60% of the population, we have 40% of households are savers, 11% of households are borrowers who adjust their mortgage and remaining 49% of borrowers are non-adjusting. As seen in the previous section, the parameters governing the transition between statuses are important for intertemporal choices of adjusting borrowers. Specifically $\bar{p}$ enters housing demand equation (11) and debt demand condition (12).

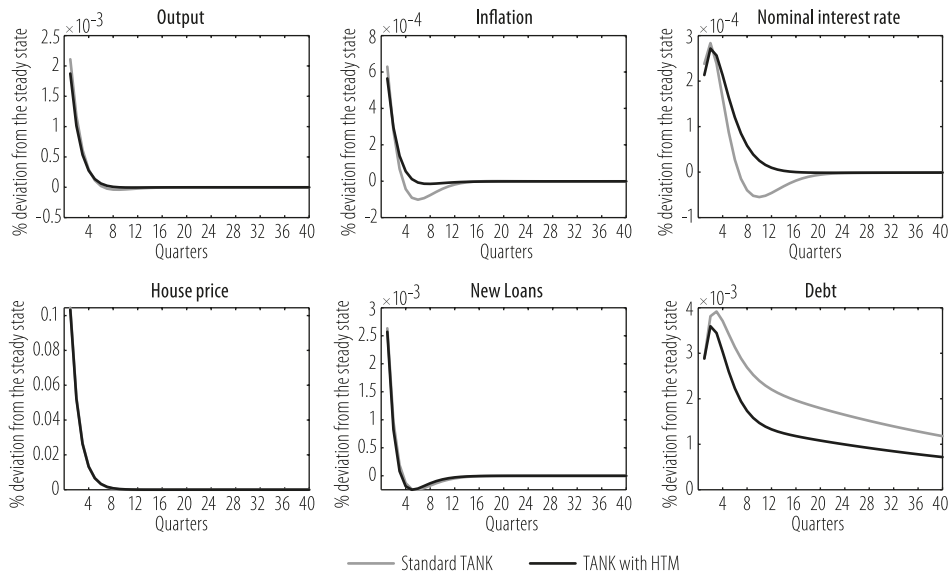
Second set of parameters is related to long-term debt. I choose the value of debt amortization δ equal to 0.019 to reflect the repayment of a standard 30-year mortgage contract with adjustable-rate mortgage (Garriga et al., 2020; Gelain et al., 2018). In contrast to Garriga et al. (2020), I refrain from allowing debt amortization to be time-varying as it does not change the model dynamics much relative to the case when it is held constant – see figure 2 in Gelain et al. (2018). The chosen value of debt amortization implies that each quarter borrowers have to pay 1.9% on the principal value of their mortgage plus the nominal interest rate set by the central bank in the previous period. I set the value of loan to value ratio $\bar{m}$ to 0.72 in order to hit the target debt to output ratio at 83% which is close to 30-year average value of household debt to GDP ratio in the US according BIS data (Credit to the non-financial sector statistics data). Third category of parameters is related to supply side of the economy and these are also set to their usual values – familiar from textbook versions of Representative Agent New Keynes-

ian model. The only new parameter is ξ which measures the sensitivity of house price to residential investment. Note that according to (35) the final output can be used for consumption or for residential investment. The rate of transformation between consumption good and residential investment is described by q_t , which is also the relative, real price of the outcome of residential investment – new housing. Curvature parameter ξ controls the rate at which these two uses of final output are transformed. In the steady state I impose the normalization that the rate of transformation is one, as anticipated in equation (36).

3.6. Model properties with a standard policy rule

The first step is to see how the model economy behaves when hit by each shock I consider in this chapter that is fundamental to housing and debt markets – housing preference shock $\xi_{\rho,t}$, loan to value shock $\xi_{m,t}$, and monetary shock $\xi_{i,t}$ and compare how key variables evolve in a model economy with non-adjusting borrowers and without them. In Figure 1, we see the response to households suddenly valuing shelter services more. This shift boosts output, inflation, and house prices. Borrowers with market access can now borrow more, as the collateral constraint no longer applies. Those who can adjust their debt levels choose to borrow more. Most variables evolve similarly in both models, but the standard TANK model shows a stronger response in output and inflation because all borrowers can increase consumption. In contrast, among non-adjusting borrowers, only a fraction can raise consumption with rising housing wealth.

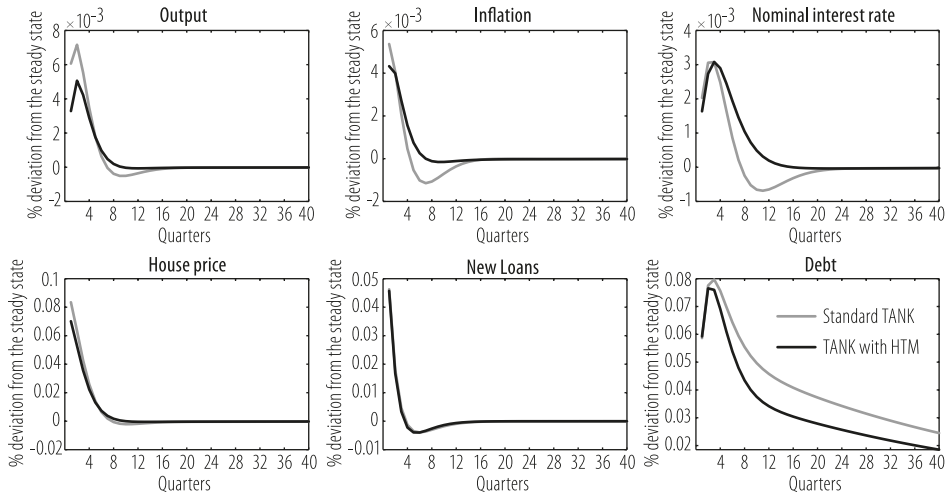
The key difference lies in inflation and debt paths. In the standard TANK, inflation initially rises slightly more, prompting the need for higher interest rates. However, due to the inertial Taylor rule, the response is sluggish. Notably, debt evolution differs between models despite similar new loan patterns. This highlights the significant impact of inflation on debt dynamics. In models with long-term debt, it is inflation, not new loans, that primarily shapes real debt trends. As seen in Figure 1, slightly lower inflation in the standard TANK results in a more persistent and lower debt response. In TANK with HTM borrowers, mid-term higher inflation (4 to 12 quarters) reduces real debt over the entire horizon, effectively shrinking its value.

Figure 1: Impulse response to housing preference shock

Note: Figure presents impulse response of variables due to one standard deviation housing preference shock.

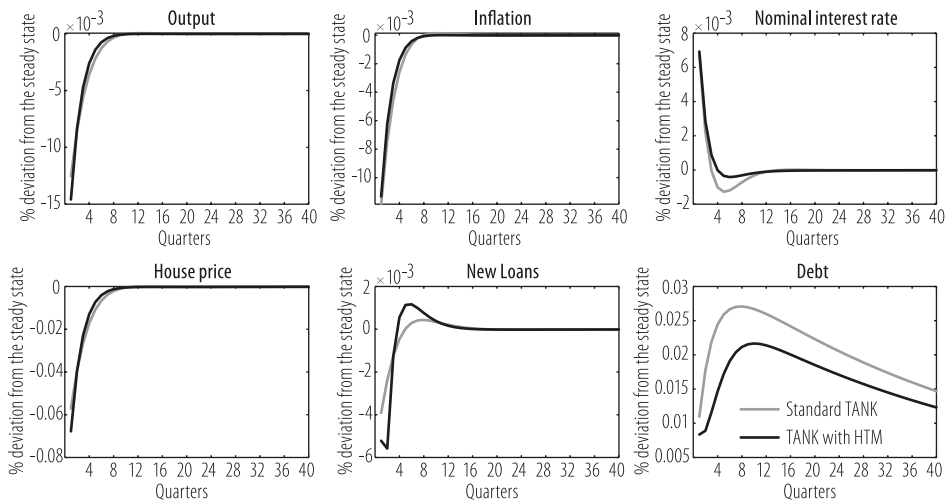
Source: Author

In Figure 2, we see how key variables respond to an unexpected increase in the loan-to-value ratio in both economies. In the standard TANK, output and inflation rise more, benefiting all borrowers who can increase consumption. However, non-adjusting borrowers do not benefit from the relaxed borrowing constraint as they cannot borrow immediately when the shock hits. The initial surge in output and inflation weakens as nominal interest rates rise. In the standard TANK, where all borrowers have access to the debt market, house prices increase more compared to scenarios with non-adjusting borrowers. Like the housing preference shock, lower mid-term inflation leads to higher debt growth. Additionally, new loans initially increase but quickly return to the steady state, while debt levels rise gradually. This aligns with findings from Drehmann, Juselius and Korinek (2018), indicating that new loans have lower autocorrelation than the debt stock, with the peak in new lending preceding the peak in real debt. This property holds in the long-term debt model, regardless of the existence of HTM borrowers.

Figure 2: Impulse response to loan to value shock

Note: Figure presents impulse response due to unexpected one standard deviation loan to value shock.

Source: Author

Figure 3: Impulse response to monetary policy shock

Note: Figure presents impulse response of variables due to one standard deviation monetary policy shock.

Source: Author

Figure 3 reveals the response to an unexpected monetary policy shock. In this scenario, TANK with HTM borrowers shows stronger output and inflation responses due to their higher debt service costs. HTM borrowers cannot adjust their debt, unlike adjusting borrowers who do so more aggressively in this setting, anticipating potential loss of access to debt market in the next period. TANK with HTM borrowers also experiences a more pronounced housing price reaction because of reduced new loan demand. While new loans initially decrease, real debt increases more in the standard TANK due to lower inflation and a smaller new loan decline.

4. Results

In this section, I present the results of the primary exercise: optimizing straightforward linear rules, known for their simplicity and ease of communication to policymakers and the public. However, these rules have limitations. They are linear and may not hold their optimality status when derived from a welfare loss function. Despite these limitations, this paper proceeds with the analysis of optimal simple rules, as suggested by Schmitt-Grohé and Uribe (2007). Before welfare implications, I first discuss the equilibrium determinacy under different monetary policy rules.

4.1. Reacting to debt and equilibrium determinacy

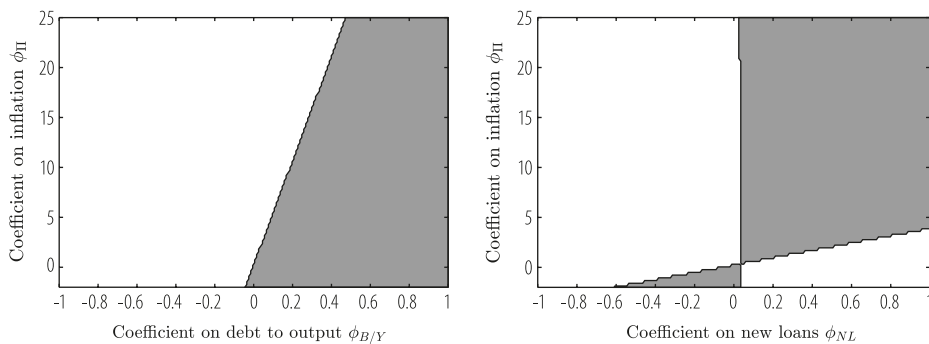
In this section, I document how equilibrium determinacy depends on the values of coefficients in the monetary policy rule (31). Apart from coefficient on inflation $(1 + \phi_\pi)$, I analyse the determinacy when monetary policy systematically reacts to the level of debt to GDP $\phi_{B/Y}$ and to the flow of real new loans ϕ_{NL} . Gelain et al. (2018) show that when debt is one-period then, whenever monetary policy reacts to debt, it can become more passive in reaction to inflation to guarantee a unique equilibrium. However, when debt is multi-period/long-term, then monetary policy must be more active as the response to debt gets stronger.

Note that in this section I refer to a model with long-term debt and in which all borrowers can adjust their debt as a standard TANK model.² In case of standard TANK, probability of keeping access to debt market is $\bar{p} = 1$, and probability of non-adjusting next period conditional on not adjusting in the current period is

² For the comparison of a simple TANK model with long-term debt to a model with one-period debt reader can see Gelain et al. (2018).

$\overline{np} = 1$. Consequently, stationary fraction of non-adjusting borrowers is a free parameter so it is set to $\nu = 0$ as in standard TANK all borrowers can adjust. In this case, calibration of the model follows table 3.5. With regard to TANK with non-adjusting borrowers I find new values for key parameters related to housing and debt to make steady states of both models the same. These values are: housing preference $\rho_h = 0.18$, share of borrowers $\Psi = 0.57$ and steady state loan to value at $\overline{m} = 0.83$.

Figure 4: Determinacy of equilibrium in a standard TANK model



Note: White area: combination of parameters in Taylor rule (31), such that model has a unique equilibrium.

Source: Author

Figure 4 shows the determinacy region when debt is amortized gradually – similarly to Gelain et al. (2018) and Garriga et al. (2020). Left panel shows the case when monetary policy reacts to debt to output. When debt to output is ignored, that is $\phi_{B/Y} = 0$, the value of the coefficient on inflation ($1 + \phi_\pi$) in the Taylor rule is in line with conventional wisdom – it exceeds one and it guarantees uniqueness of equilibrium. Once the monetary policy systematically reacts to debt to output, the response to inflation must be stronger.³ The right panel of figure 4 shows the determinacy of equilibrium when monetary policy reacts to the flow of debt – new loans. In this case, if monetary policy reacts positively to new loans, the reaction to inflation can be weak and passive. When monetary policy reacts negatively to new loans, it must react more strongly to inflation. Comparing both panels of figure 4 shows that the choice of a variable as a policy target has important consequences for the determinacy in a standard model. To the best of my knowledge, new loans were not considered as a policy variable, while

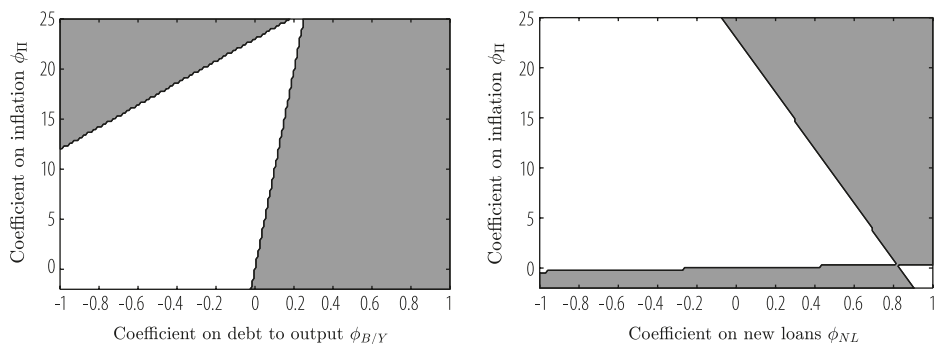
³ This is the same as figure 3 in Gelain et al. (2018).

credit-to-GDP has been advocated by BIS in the context of monetary policy and standalone macroprudential policy.⁴ Are these results robust to incorporating discontinuous debt market participation feature into the standard model?

Determinacy area in extended TANK model is presented in the left panel of figure 5. There is almost no change in the determinacy region when monetary policy responds to debt to output, and some borrowers are HTM. The only change is that the slope is steeper now and there is an upper bound of determinacy region in the north-west part of the figure. However, this upper bound binds only when the coefficient on inflation ($1 + \phi_{\pi}$) gets greater than 12 which seems implausible in the real-world setting.

The right panel of Figure 5 reveals that adjusting policy in response to new loans alters the constraints on maintaining determinacy. As the response to new loans strengthens, the required inflation coefficient becomes smaller, resembling results akin to one-period debt, termed "conventional wisdom" by Gelain et al. (2018). A stronger response to financial vulnerabilities allows for a weaker response to inflation. In some cases, with a sufficiently strong reaction to new loans, monetary policy can become passive. This contrasts with the standard TANK model with long-term debt, where a positive reaction to new loans implies that monetary policy can be passive (as shown in the right panel of Figure 4). Is this result surprising? New loans represent the credit flow, like rolling over one-period bond

Figure 5: Determinacy of equilibrium in extended TANK model with HTM



Note: White area: the combination of parameters in Taylor rule (31), such that model has a unique equilibrium.

Source: Author

⁴ Deviation of credit-to-GDP from its trend has been advocated as the main variable for the purpose of Countercyclical Capital Buffer levied on commercial banks Borio (2014).

debt each period. To understand this intuitively, suppose expected inflation increases for some reason. This would lead to higher current inflation through the Phillips curve. Simultaneously, higher inflation expectations stimulate the economy through increased consumption and housing demand, resulting in more new borrowing. Given the positive correlation between current inflation and new loans, a Taylor rule that responds positively to either variable has similar economic implications.

Relating to Galí et al. (2004), who examined monetary policy rules in a standard New Keynesian model with HTM consumers and no assets, they found that as the proportion of HTM households increases, the Taylor principle becomes too weak. In this case, monetary policy must react more than proportionately to inflation. Why? Consider an unexpected improvement in economic activity. This creates increased aggregate demand, lower markups, and higher real wages. The last, in turn, spurs additional aggregate demand, driving up inflation. In a standard model, the Taylor principle dictates that the real interest rate should be high enough to dampen this economic boost. However, when there is a high share of HTM households, the Taylor principle needs to be reinforced. This is because only Ricardian households make intertemporal consumption choices and are directly affected by higher real interest rates. In contrast, HTM households remain unaffected by monetary tightening, keeping their consumption elevated until real wages return to the steady state.

4.2 Leaning against or with the wind or ignore it?

After establishing the determinacy under debt-incorporating monetary policy rules, this section tackles the central research question: should monetary policy react to credit conditions, and if so, how? Specifically, it explores the conditions under which a monetary policy rule should consider debt-to-output or new loans and determines the optimal weights for these factors to achieve social optimality. To address this question, I adopt the approach suggested by Schmitt-Grohé and Uribe (2007), aiming to maximize expected social welfare by choosing coefficients in the monetary policy rule. This approach is clear and interpretable, but it is limited to simple, linear policy rules that depend on predetermined endogenous variables. Additionally, it requires deciding which endogenous variables to include in the policy rule in advance. A possible future research direction involves developing a quadratic welfare loss function to compute the optimal policy rule by minimizing this function, offering a more comprehensive analysis. Define W_t as a life-time social welfare which is the average of life-time welfare of each type of household in the economy weighted by the population shares, that is:

$$W_t = \mathbb{E}_t\{(1 - \Psi)W^s(b_{s,t}, h_{s,t}) + \Psi(1 - \nu)W^{ab}(\tilde{b}_{ab,t}, \tilde{h}_{ab,t}) + \Psi\nu W^{nb}(\tilde{b}_{nb,t}, \tilde{h}_{nb,t})\}, \quad (37)$$

where each term is defined in (17), (6) and (13) respectively. I use expectations operator $\mathbb{E}_t$ since all the value functions are defined recursively. Next, I simulate the model assuming all stochastic shocks follow AR(1) processes. Model is simulated using a second-order approximation for 10,000 periods and first 1,000 observations are dropped. Denote social welfare under baseline policy as $W_t^{baseline}$ and under LAW policy as W_t^{LAW} . This means that $W_t^{baseline}$ is the value given by (37) when coefficient ϕ_x on variable of macroprudential interest in (31) is zero. Accordingly W_t^{LAW} is computed by (37) when the coefficient ϕ_x is non-zero, that is when monetary policy reacts to debt to GDP or to new loans. Using social welfare function to compare different policy regimes has one shortcoming – it is not intuitive to compare values of social welfare. To make the results more interpretable, I compute steady state consumption gain due to LAW policy relative to baseline policy. Define Λ as a steady state consumption gain that equates W_t^{LAW} with baseline counterpart $W_t^{baseline}$. In other words, Λ measures how much policymaker needs to change steady state consumption under baseline scenario in order to make agents indifferent between both policy regimes.⁵ Using Λ as a metric to compare policy regimes gives the intuitive insights about the merits of these regimes in terms of consumption gain. Following Gourio et al. (2018) I assume that the coefficients on the standard variables in the monetary rule (31) are not optimized but set to the values that resemble the actual decision rules of central banks and are often used in the literature. Therefore, parameters collected in $(\phi_i, \phi_\pi, \phi_Y)$ are set to their conventional values: persistence of nominal interest rate ϕ_i is fixed to 0.73, coefficient on inflation ϕ_π is set to 0.27 and coefficient on output ϕ_Y is set to 0. These values come from Iacoviello (2005) and are frequently used in the literature that analyses housing market through the lens of New Keynesian DSGE models.

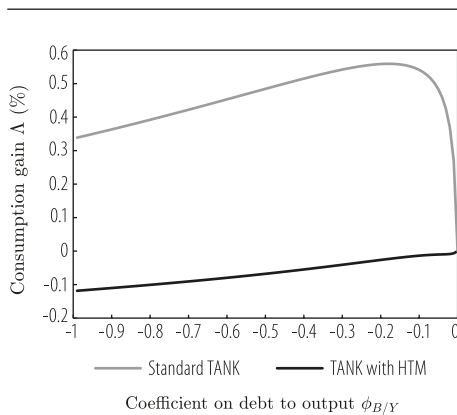
In the first exercise I check whether it is welfare-enhancing when monetary policy reacts to debt to output ratio. Figure 6 shows the change in social welfare defined as in (37), measured in consumption gain Λ , due to systemic reaction to this ratio. Red line shows the gain in standard TANK model, while the blue one shows an economy with HTM borrowers. Using standard TANK we can conclude that small extent of LAW policy in monetary policy rule is welfare enhancing. Systemic reaction to debt to output increases welfare relative to no reaction for any value of $\phi_{B/Y}$ less than zero. As shown in section 4.1 the model does not have a unique equilibrium for positive values of $\phi_{B/Y}$ so only the negative reaction to this ratio can be analysed. Note that the consumption gain is non-linear func-

⁵ See section 3.2 in Schmitt-Grohé and Uribe (2007).

tion of debt to output. Once monetary policy rule takes into account this ratio the benefits increase sharply. The biggest net benefits of LAW policy are achieved quickly for the value $\phi_{B/Y} = -0.18$. Once this value is exceeded, the gains from LAW policy slowly decrease.

Hence, based on standard TANK model in which borrowers can always refinance their mortgage, one can conclude that some degree of LAW policy is optimal. When debt to output deviates positively from steady state level, interest rate should be decreased if central bank aims at curbing excessive indebtedness. This way, central bank boosts economic activity and hence inflation. Higher inflation helps in bringing real debt down more than it negatively affects output. Lower interest rate means that new loans increase, hence surprisingly this kind of policy leads to a credit boom when looking at the flow of debt. But since new loans are a small fraction of outstanding debt, expansionary monetary policy deflates the real debt burden.

Figure 6: Reacting to debt to output – steady state consumption gains relative to baseline



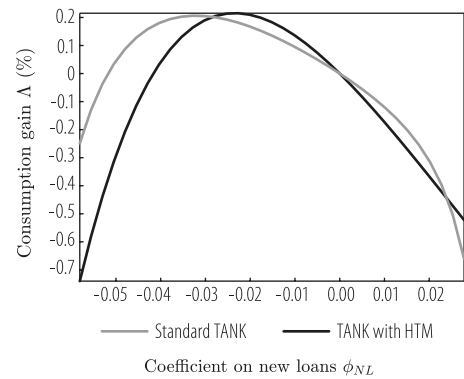
Note: Social welfare is evaluated relative to the baseline case in which monetary policy operates in pure inflation targeting regime. The difference between social welfare values in these two different scenarios is measured using steady state consumption gain that would make households indifferent.

Source: Author

Figure 6 shows that the optimal policy in the standard TANK model no longer holds when some borrowers cannot refinance their mortgages each period. In this case, a monetary policy reacting to debt-to-output becomes suboptimal for social welfare. Why opt to ignore this policy? Firstly, in the extended model, monetary policy wields greater influence, resulting in amplified responses in key variables like output and inflation to the same-sized monetary shocks. Thus, reacting to debt introduces more volatility compared to ignoring it. Secondly, while monetary shocks pack a punch, the impact of loan-to-value and housing preference shocks is weaker. Borrowers able to adjust their debt anticipate future constraints, tempering their response to these shocks, as evident in the IRFs of key variables in Section 3.6. This blend of potent monetary shock effects and muted responses to other shocks reduces the appeal of macroprudential policy.

Figure 7 shows the results of a similar exercise, but now monetary policy targets new loans. Consumption gain is smaller compared to debt to output targeting. The positive gain takes place only in the very narrow interval of ϕ_{NL} which makes this result sensitive to calibration and other changes in model economy. The main conclusion here, mirroring Ajello et al. (2019), is that the optimal response to new loans should be minimal, typically less than 10 basis points. Interestingly, whether non-adjusting households are included or not does not significantly alter the optimal policy. Both findings, illustrated in Figure 7, stress the importance of lowering the interest rate when new loans increase relative to the steady state. This adjustment is necessary because rising new loans lead to higher borrower indebtedness. When borrowers transition to non-adjusting status, they allocate a larger portion of their income to service debt. To prevent excessive indebtedness, the optimal policy aligns with the trend in new loans. This optimal policy remarkably results in a welfare gain of approximately 0.2% in steady-state consumption. It is essential to note that even though the presence of non-adjusting borrowers made reacting to debt-to-output suboptimal, addressing the flow of debt through new loans still generates positive gains.

Figure 7: Reacting to new loans – steady state consumption gains relative to baseline

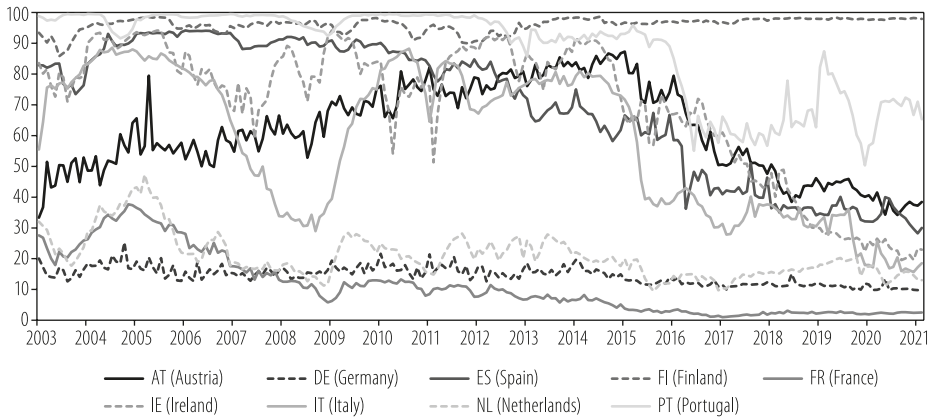


Note: Figure presents social welfare when monetary policy systematically reacts to new loans. Social welfare is evaluated relative to the baseline in which monetary policy operates in pure inflation targeting.

Source: Author

4.3. Mortgage product type and leaning against the wind

In this section, I explore how the choice of mortgage product affects merits of LAW policy. Figure 8 displays the ARM fraction in total mortgages for selected euro area countries, revealing distinct variations. Calza, Monacelli and Stracca (2013) find stronger transmission of monetary shocks to consumption when ARM is prevalent. Kinnerud (2021) and Guren, Krishnamurthy and Mcquade (2021) highlight distinctions between ARM and FRM.

Figure 8: Share of adjustable-rate mortgages

Note: Share of adjustable-rate mortgages in the selected euro area countries in the total value of mortgages in each country.

Data source: ECB (<https://data.ecb.europa.eu/>)

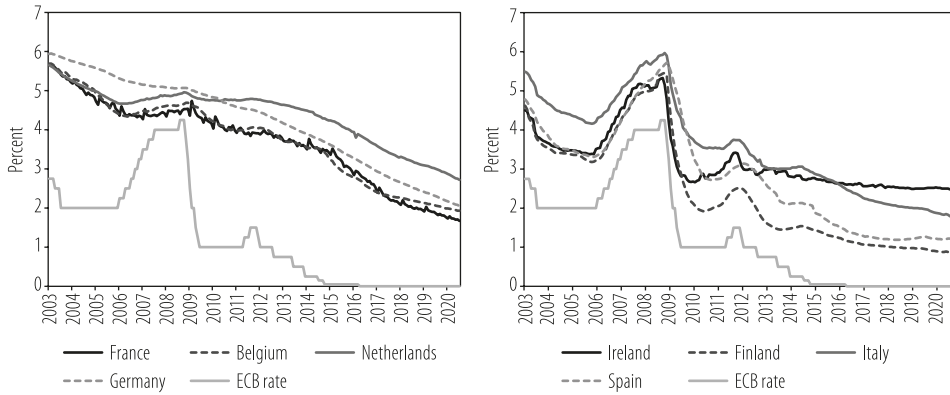
Now I turn back to model description in section 3. Note that so far I used central bank nominal interest rate i_t as an interest rate that applied to mortgages. While this holds in case of ARM, it does not longer holds for FRM. Let r_t be a nominal interest rate on stock of debt. That is r_t denotes the average rate that borrowers are charged on their outstanding mortgages. The evolution of r_t is described by:

$$r_t = \begin{cases} (1 - \phi_t)r_{t-1} + \phi_t i_t, & \text{if FRM} \\ i_t, & \text{if ARM} \end{cases} \quad (38)$$

where ϕ_t denotes the fraction of new loans in debt outstanding $\phi_t = \frac{NL_t}{B_t}$. Equation (38) postulates that in only-FRM economy the average interest rate paid on stock of debt is the weighted average of previous average interest rate on stock r_{t-1} and a new interest rate on flow i_t , where the weights depend on fraction of new loans to total stock of debt. Given that usually new lending is small fraction of total debt (often less than 5%), the average interest rate on stock is slow-evolving variable with considerable inertia. In FRM economy, when monetary policy is tightened, the higher cost of borrowing slowly translates into higher debt service costs for borrowers as the new interest rate applies only to new loans in the current and next periods – it does not apply to the past borrowing. On the other hand, in ARM economy, when monetary policy is tightened the increase in average interest rate on stock of debt mimics central bank policy rate. Figure 9 shows the evolution or a real-world counterpart of r_t in a subset of euro area economies.

The pass-through of the ECB interest rate is weak and slow in FRM dominated countries while it is strong and fast for countries where ARM are more popular.

Figure 9: Average mortgage rate on outstanding mortgages in FRM vs ARM dominated economies



Note: Left panel shows the average interest rate on outstanding mortgages in FRM dominated countries while the right panel shows this interest rate for ARM dominated economies.

Data source: ECB (<https://data.ecb.europa.eu/>)

Apart from the evolution of interest rate on stock of debt the model in the previous section changes whenever i_t enters an equation. In ARM economy central bank interest rate i_t and mortgage rate r_t are the same, but in FRM economy r_t is the rate that enters equation describing households problems. In particular adjusting borrowers budget constraint (7) changes to

$$c_{ab,t} + \frac{r_{t-1} + \delta}{\pi_t} \tilde{b}_{ab,t} + q_t (h_{ab,t} - (1 - \delta_h) \tilde{h}_{ab,t}) = w_{ab,t} n_{ab,t} + (b_{ab,t} - \frac{1-\delta}{\pi_t} \tilde{b}_{ab,t}) + \tau_{ab,t}, \quad (39)$$

non-adjusting borrowers budget constraint (14) changes to

$$c_{nb,t} + \frac{r_{t-1} + \delta}{\pi_t} \tilde{b}_{nb,t} = w_{nb,t} n_{nb,t} + \tau_{nb,t}, \quad (40)$$

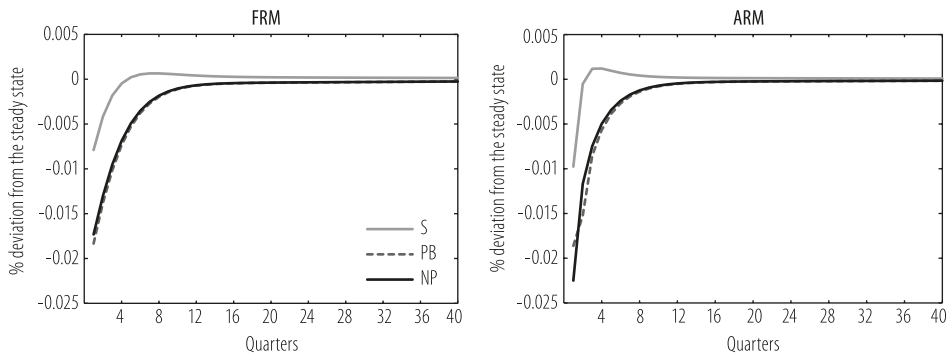
and savers budget constraint (18) changes to

$$c_{s,t} + \left(b_{s,t} - \frac{1-\delta}{\pi_t} b_{s,t-1} \right) + q_t (h_{s,t} - (1 - \delta_h) h_{s,t-1}) = w_{s,t} n_{s,t} + \frac{r_{t-1} + \delta}{\pi_t} b_{s,t-1} + \tau_{s,t}. \quad (41)$$

This means that first order conditions change accordingly as now households that choose consumption intertemporally take slow-evolving r_t into account. Note that the distinction between FRM and ARM will only matter for the dynamic properties of the model and transmission of monetary shocks, while it does not have any importance on deterministic steady state (note that in the steady state equation (38) implies $r = i$ for both ARM and FRM). To what extent dynamic properties of the model change?

Figure 10 displays impulse responses of household consumption following a 50 basis point central bank interest rate increase. In an FRM economy (left panel), both borrower types experience similar small increases in mortgage payments, resulting in comparable reductions in consumption. Even savers reduce consumption due to the intertemporal substitution effect outweighing increased mortgage receipts. Conversely, in an ARM economy (right panel), consumption decreases more noticeably. The higher nominal interest rate directly raises mortgage payments, shrinking disposable income for both borrower types and impacting their consumption. However, adjusting borrowers can compensate for the income drop by (i) accessing the debt market and (ii) selling their housing, with the latter being more significant as it counterbalances the income reduction.

Figure 10: Consumption change due to temporary monetary shock



Note: Impulse response function of consumption due to 50 basis point temporary unexpected monetary shock. Percentage deviation from deterministic steady state. S – saver, PB – participating/adjusting borrower, NP – non-participating/non-adjusting borrower.

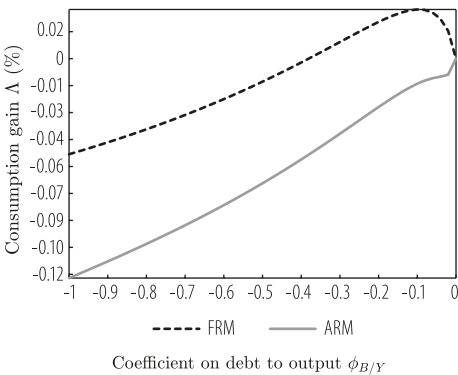
Source: Author

Figure 10 indicates that mortgage product type impacts monetary policy transmission in the modified TANK model, even during temporary shocks. This con-

trasts with Garriga et al. (2020) argument that the debt channel primarily matters for permanent shocks. I proceed to assess the merits of LAW policy in both mortgage economies and investigate whether its degree depends on the mortgage product. Figure 11 presents the welfare gain. In FRM case, the average mortgage rate on stock of debt r_t reacts slowly to changes in central bank interest rate i_t . This means that borrowers do not suffer from excessive volatility of mortgage payments as under ARM. While there is a small gain from targeting debt to output ratio in FRM economy, this gain is too small to have any policy implications.

Figure 12 displays the gains in social welfare when the central bank targets new loans. These gains are notably smaller under FRM. The optimal reaction to new loans remains the same as under ARM. It means that the central bank should lean with the wind of new loans regardless of the mortgage type.

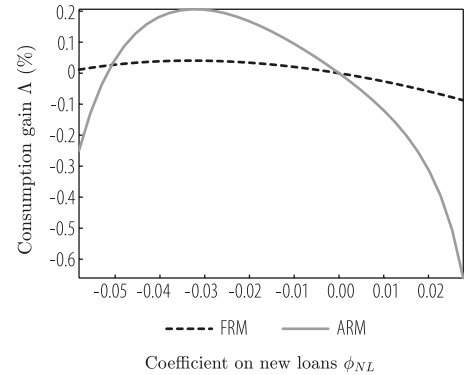
Figure 11: Reacting to debt to output – steady state consumption gains relative to baseline



Note: Figure presents social welfare when monetary policy systematically reacts to debt to output ratio. Social welfare is evaluated relative to the baseline in which monetary policy operates in pure inflation targeting.

Source: Author

Figure 12: Reacting to new loans – steady state consumption gains relative to baseline



Note: Figure presents social welfare when monetary policy systematically reacts to new loans. Social welfare is evaluated relative to the baseline in which monetary policy operates in pure inflation targeting.

Source: Author

5. Conclusions

This study assesses the benefits of central banks reacting to household debt and new loans. I use a TANK model where only a fraction of borrowers can adjust their debt each period. Borrowers who cannot access debt markets rely on disposable income, unaffected by intertemporal substitution in consumption. Interest rates still matter due to mortgage payments and general equilibrium effects. The model features long-term debt and discontinuous access to debt markets. Comparing different monetary policy rules, I find that including households with limited access to debt reduces the advantages of reacting to debt-to-output ratios, making it suboptimal. Neglecting debt altogether becomes a better option. Conversely, reacting to new loans consistently improves social welfare, regardless of the presence of limited-access borrowers. However, these gains are limited under FRM. Keep in mind that this model lacks estimation and does not consider country-specific housing and debt market variations. Thus, the findings are indicative rather than definitive. An essential extension is incorporating financial intermediation to address potential risks related to lowering interest rates.

References

1. Ajello, A., Laubach, T., Lopez-Salido, D., and Nakata, T. (2019). Financial Stability and Optimal Interest Rate Policy. *International Journal of Central Banking*, 15(1):279–326. Publisher: International Journal of Central Banking.
2. Alpanda, S. and Zubairy, S. (2017). Addressing household indebtedness: Monetary, fiscal or macroprudential policy? *European Economic Review*, 92:47–73.
3. Andersen, S., Campbell, J. Y., Nielsen, K. M., and Ramadorai, T. (2020). Sources of Inaction in Household Finance: Evidence from the Danish Mortgage Market. *American Economic Review*, 110(10):3184–3230.
4. Begenau, J. and Landvoigt, T. (2021). Financial regulation in a quantitative model of the modern banking system. *National Bureau of Economic Research*, (28501).
5. Benigno, P., Eggertsson, G. B., and Romei, F. (2020). Dynamic Debt Deleveraging and Optimal Monetary Policy. *American Economic Journal: Macroeconomics*, 12(2):310–350.
6. Bilbiie, F. (2019). Monetary Policy and Heterogeneity: An Analytical Framework. Technical report, Society for Economic Dynamics.
7. Bilbiie, F. O. (2008). Limited asset markets participation, monetary policy and (inverted) aggregate demand logic. *Journal of Economic Theory*, 140(1):162–196.
8. Borio, C. (2014). Macroprudential frameworks:(too) great expectations? *Macroprudentialism. VoxEU eBook*, CEPR, London, pages 29–45.
9. Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12(3):383–398.
10. Calza, A., Monacelli, T., and Stracca, L. (2013). Housing finance and monetary policy. *Journal of the European Economic Association*, 11(suppl_1):101–122. ISBN: 1542-4766 Publisher: Oxford University Press.
11. Campbell, J. Y. and Mankiw, N. G. (1989). Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence. *NBER Macroeconomics Annual*, 4:185–216.
12. Debortoli, D. and Galí, J. (2017). Monetary policy with heterogeneous agents: Insights from TANK models. *Economics Working Papers* 1686, Department of Economics and Business, Universitat Pompeu Fabra.
13. Drehmann, M., Juselius, M., and Korinek, A. (2018). Going with the flows: new borrowing, debt service and the transmission of credit booms. *National Bureau of Economic Research*, (24549).

14. Galí, J., López-Salido, J. D., and Vallés, J. (2004). Rule-of-Thumb Consumers and the Design of Interest Rate Rules. *Journal of Money, Credit and Banking*, pages 739–763. Publisher: JSTOR.
15. Ganić, M. (2023). Can Credit Related Macroprudential Instruments Be Effective in Reducing the Correlation Between Economic and Credit Growth? Cross-Country Evidence. *Journal of Central Banking Theory and Practice*, 12(2), 165–183.
16. Garriga, C., Šustek, R., and Kydland, F. E. (2020). Monk: Mortgages in a New Keynesian model. *Journal of Economic Dynamics and Control*, page 104059. ISBN: 0165-1889 Publisher: Elsevier.
17. Gelain, P., Lansing, K. J., and Natvik, G. J. (2018). Leaning against the credit cycle. *Journal of the European Economic Association*, 16(5):1350–1393. ISBN: 1542-4766 Publisher: Oxford University Press.
18. Gerdrup, K. R., Hansen, F., Krogh, T., and Maih, J. (2017). Leaning Against the Wind When Credit Bites Back. *International Journal of Central Banking*.
19. Gerdrup, K. R. and Torstensen, K. N. (2018). The Effect of Higher Interest Rates on Household Disposable Income and Consumption—a Static Analysis of the Cash Flow Channel. Technical report, Staff Memo. ISBN: 8283790374.
20. Gourio, F., Kashyap, A. K., and Sim, J. W. (2018). The tradeoffs in leaning against the wind. *IMF Economic Review*, 66(1):70–115. ISBN: 2041-4161 Publisher: Springer.
21. Guren, A. M., Krishnamurthy, A., and Mcquade, T. J. (2021). Mortgage Design in an Equilibrium Model of the Housing Market. *The Journal of Finance*, 76(1):113–168.
22. Iacoviello, M. (2005). House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle. *American Economic Review*, 95(3):739–764.
23. Iacoviello, M. and Neri, S. (2010). Housing Market Spillovers: Evidence from an Estimated DSGE Model. *American Economic Journal: Macroeconomics*, 2(2):125–164.
24. Keys, B. J., Pope, D. G., and Pope, J. C. (2016). Failure to refinance. *Journal of Financial Economics*, 122(3):482–499.
25. Kinnerud, K. (2021). The effects of monetary policy through housing and mortgage choices on aggregate demand. Technical report, Working Paper.
26. Nain, Z., and Kamaiah, B. (2020). Uncertainty and effectiveness of monetary policy: a Bayesian Markov switching-VAR analysis. *Journal of Central Banking Theory and Practice*, 9(s1), 237–265.
27. Nisticò, S. (2016). Optimal Monetary Policy in a Non-Ricardian Economy. *Journal of the European Economic Association*, 14(5):1225–1252.
28. Paoli, B. D. and Paustian, M. (2017). Coordinating Monetary and Macroprudential Policies. *Journal of Money, Credit and Banking*, 49(2-3):319–349.

29. Schmitt-Grohé, S. and Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics*, 54(6):1702–1725.
30. Stein, J. C. (2013). Overheating in credit markets: origins, measurement, and policy responses. In Speech given to the symposium on Restoring Household Financial Stability After the Great Recession, Federal Reserve Bank of St. Louis, St. Louis, Missouri, February, volume 7.
31. Svensson, L. E. (2017). Cost-benefit analysis of leaning against the wind. *Journal of Monetary Economics*, 90:193–213.
32. Tzamourani, P. (2021). The interest rate exposure of euro area households. *European Economic Review*, 132:103643.
33. Zuniga, M. C., and Senbet, D. (2023). Does the Effectiveness of Monetary Policy Depend on the Choice of Policy Instrument? Empirical Evidence from South Korea. *Journal of Central Banking Theory and Practice*, 12(2), 239-265.