Adame Espinosa, Francisco

Working Paper

Monetary rules, financial stability and welfare in a non-Ricardian framework

Working Papers, No. 2023-14

Provided in Cooperation with:
Bank of Mexico, Mexico City

Suggested Citation: Adame Espinosa, Francisco (2023) : Monetary rules, financial stability and welfare in a non-Ricardian framework, Working Papers, No. 2023-14, Banco de México, Ciudad de México

This Version is available at:
https://hdl.handle.net/10419/297007

Banco de México

Working Papers

N° 2023-14

Monetary Rules, Financial Stability and Welfare in a non-Ricardian Framework

Francisco Adame Espinosa
Banco de México

November 2023

Documento de Investigación
2023-14

Working Paper
2023-14

Monetary Rules, Financial Stability and Welfare in a non-Ricardian Framework*

Francisco Adame Espinosa†
Banco de México

Abstract: This work is based on a new Keynesian theoretical model for an advanced economy, which incorporates overlapping generations to analyze a channel through which fluctuations in household financial wealth influence aggregate demand. The optimal monetary policy, corresponding to that of a central planner maximizing households' welfare, aims to mitigate financial fluctuations while simultaneously reducing variability in inflation and the output gap. The model is calibrated for the United States and reproduces the effect of variations in the price of financial assets on aggregate demand. The results show, first, that in the presence of productivity, financial, and demand shocks, optimal monetary policy significantly improves aggregate welfare by stabilizing financial fluctuations that impact households' wealth. Secondly, in the face of productivity and financial shocks, an augmented monetary rule responding explicitly to fluctuations in the price of financial assets, in addition to inflation and output gaps, can reproduce the welfare achieved under optimal monetary policy. However, this is not the case for demand shocks.
Keywords: Monetary Policy, Monetary Rules, Overlapping Generations
JEL Classification: E21, E44, E52, E58

Resumen: Este trabajo parte de un modelo teórico nuevo Keynesiano para una economía avanzada, que incorpora generaciones traslapadas para analizar un canal por el cual las fluctuaciones en la riqueza financiera de los hogares influyen en la demanda agregada. La política monetaria óptima, que corresponde a la de un planeador central que maximiza el bienestar de los hogares, busca mitigar las fluctuaciones financieras y, simultáneamente, reducir la variabilidad en la inflación y brecha del producto. El modelo se calibra para Estados Unidos y reproduce el efecto de las variaciones en el precio de los activos financieros sobre la demanda agregada. Los resultados muestran, en primer lugar, que en presencia de choques de productividad, financieros y de demanda, la política monetaria óptima mejora significativamente el bienestar agregado al estabilizar las fluctuaciones financieras que impactan la riqueza de los hogares. En segundo lugar, ante choques de productividad y financieros, se encuentra que una regla monetaria ampliada, que responda explícitamente a fluctuaciones en el precio de los activos financieros, en adición a las brechas de inflación y del producto, puede reproducir el bienestar alcanzado bajo la política monetaria óptima. Sin embargo, esto no ocurre ante choques de demanda.
Palabras Clave: Política Monetaria, Reglas Monetarias, Generaciones Traslapadas

*I want to thank Julio Carrillo, Rocío Elizondo-Camejo, Ángelo Gutiérrez-Daza, and Salvatore Nisticò.
† Dirección General de Investigación Económica. Email: francisco.adame@banxico.org.mx.

1 Introduction

The monetary policy literature contains contrasting points of view about how the central bank should react to shocks affecting financial markets. On the one hand, there is the view of Bernanke and Gertler (2001) that an inflation-targeting (IT) framework should not respond to stock price fluctuations. They argue that stabilizing stock prices may cause harm by disturbing output dynamics. On the other hand, Cecchetti et al. (2000) suggest that a central bank should "lean against the wind" and achieve greater macroeconomic stabilization by including asset prices in its loss function. Both approaches focus on the effects that asset price fluctuations could have on the supply side of the real economy, mainly through financial-intermediation channels. However, less attention is paid to the effects that asset prices could have on the demand side.

One channel through which asset price fluctuations could influence aggregate demand is by affecting households' financial wealth, as a drop in stock prices decreases the wealth of households owning stocks. The empirical literature has shown that this channel is particularly significant in developed economies.[1] Based on textual analysis of the Federal Open Market Committee's minutes and transcripts, recent studies find that this channel is of particular interest to the committee.[2] In this paper, we study how this channel can be incorporated in the design of optimal monetary policy for an advanced economy that faces different types of uncertainty (namely, productivity, demand, and financial shocks). To this end, the model is calibrated to reproduce the estimated effect in the United States of changes in financial asset prices on aggregate demand. Also, we study whether, in the presence of this channel, monetary rules can be implemented to reproduce optimal policy allocations.

Using a non-Ricardian framework, we study whether a monetary authority is able to im-

[1] While Chodorow-Reich et al. estimates the importance of the wealth effect for the US, Di Maggio et al. estimates size of this channel for Sweden.

[2] Cieslak and Vissing-Jorgensen (2021) show that policy makers have a tendency to analyze asset prices, as they see them as an important driver of households' financial wealth.

plement a policy that allows it to achieve optimal social welfare outcomes in an advanced economy in which the demand side is sensitive to fluctuations in financial wealth. First, we quantify the reduction of the social welfare loss that results from conducting optimal policy, under commitment and under discretion, instead of an IT regime implementing a monetary policy that reproduces the allocations unaffected by nominal rigidities. We conduct this analysis by considering the existence of different types of shocks that affect financial wealth fluctuations.

Second, we quantify the welfare loss that arises when the central bank implements its policy through a monetary rule that tracks the natural rate, adjusts to inflation and output gap fluctuations, and is augmented to respond to asset prices. We use a rule with these features to characterize the case of a monetary authority transitioning from an IT regime to a regime that incorporates the importance of financial wealth stabilization. We illustrate the ability of this rule to reproduce optimal policies under discretion and under commitment. In the case of productivity and financial shocks, we find that this rule can reproduce the outcomes from an optimal policy under commitment. However, in the case of demand shocks, the monetary rule fails to reproduce the outcomes achieved by the optimal monetary policy.

Drawing on Nisticò (2016), we use a model that introduces the perpetual-youth assumption into the standard New Keynesian model of the business cycle. In this economy, participation in financial markets is segmented. A portion of the population remains inactive in financial markets, relying on their labor income to finance consumption. The remainder of the population consists of active participants who utilize financial assets to smooth their intertemporal consumption. However, in every period, active participants face an exogenous probability of losing their access to financial markets and becoming inactive. Those departing from active participation are replaced by previously inactive agents with zero financial wealth. This turnover in access to financial markets results in surviving active participants becoming heterogeneous in terms of their age and, consequently, in the wealth they have accumulated.

While incumbent market participants with accumulated wealth can use it for consumption, new participants are constrained in their consumption, as they do not have financial wealth. Active participants have access to an insurance contract that enables them to smooth consumption despite the risk of becoming inactive. Consequently, active participants individually optimize their consumption as if they were guaranteed to be present in the subsequent period. Nevertheless, in the future, not all active participants will remain, and newcomers will enter with zero wealth. Therefore the average level of consumption will be lower that it would be if all incumbent participants were to stay. As a result, the interaction of agents with accumulated wealth and those with zero wealth drives a wedge in the aggregate Euler equation. The turnover of market participants leads to a condition in which financial wealth becomes relevant to determine aggregate consumption. Notably, this feature allows us to represent a channel in which fluctuations in asset prices are transmitted to the real economy through aggregate demand in a small-scale New Keynesian model.

In this setup, Nisticò (2016) analytically derives a second-order approximation of the social welfare loss function that incorporates the heterogeneity within and across cohorts that results from differences in accumulated wealth. The result is a welfare loss function that increases with quadratic deviations of inflation, output, and financial wealth from the steady-state equilibrium. In this framework, fluctuations in financial wealth increase consumption dispersion across cohorts, which is undesirable for a benevolent central planner. By modeling the response to cost-push shocks, Nisticò (2016) shows quantitatively that the welfare loss declines significantly when a central bank pursues optimal policies that reduce the volatility in financial wealth.

We extend the results from Nisticò (2016) and incorporate shocks affecting productivity, households' marginal utility and shocks affecting fundamental asset prices—that is, supply, demand and financial shocks, respectively. We compare the welfare loss under an optimal policy against the level found under an IT that ignores the importance of financial wealth to

demand fluctuations. When a productivity shock occurs, implementing an optimal policy under both discretion and commitment results in a welfare loss that amounts to approximately 64% and 55% of the level observed under IT, respectively. In the case of a demand shock, implementing an optimal policy diminishes the welfare loss to nearly 45% under discretion, and close to 41% under commitment, in comparison to the IT. Lastly, in the event of a financial shock that impacts the fundamental valuation of asset prices, the welfare loss amounts to about 65% and 59% of the IT level under discretion and commitment respectively.

Accordingly, we quantity the reduction of the welfare loss when monetary policy is implemented through monetary rules. We consider a simple monetary rule, responding to inflation and the output gap, and an augmented rule that also incorporates a response to asset prices. A rationale for introducing asset prices into the rule is that they are an intermediate target for stabilizing fluctuations in financial wealth. In the model, financial wealth depends on future asset prices and the dividends paid by the corporate sector. For instance, a sudden increase in financial wealth can be dampened by a tightening in the policy rate, which reduces asset price valuations through the discount rate. Also, this rule tracks the fluctuations of the natural rate. This feature is introduced to illustrate the potential welfare improvements that an advanced economy that pursues an IT regime can attain by including financial-wealth considerations.

While we find that an augmented rule that responds to fluctuations in asset prices can reproduce the outcomes of the optimal policy under discretion for financial and productivity shocks, this rule is less effective when the advanced economy faces demand shocks. Under financial and productivity shocks, the augmented rule allows the monetary authority to reduce the welfare loss to 65% of the level under an IT regime for both shocks. However, under demand shocks, the welfare loss is reduced to 86% of the loss observed under an IT regime. Also, the augmented monetary rule provides even lower welfare benefits as demand shocks become more persistent. These results suggests that in a non-Ricardian New Keynesian framework, simple deviations from the IT regime through an augmented monetary rule can reproduce optimal outcomes in the face of productivity and financial shocks. Notwith-

standing this, this rule can provide marginal welfare benefits when the advanced economy faces demand shocks.

Related literature. Our paper is related to two strands of the literature that use a non-Ricardian New Keynesian framework to analyze the response of monetary policy in the presence of a financial-wealth channel that drives aggregate demand. The first strand characterizes the theoretical conditions for monetary rules to generate a stable rational expectations solution within the model. Airaudo et al. (2015) show that in this framework with simple monetary rules, the rational expectations equilibrium can be undetermined under standard values of the rule. Furthermore, they show that a mild response to stock prices under the simple monetary rule may restore equilibrium determinacy. Similarly to us, Nisticò (2012) uses a monetary rule tracking the natural-rate outcomes; the rule is augmented to introduce a response to deviations of the stock price from its level in the flexible-price allocation. Nisticò (2012) finds that an important condition to preserve the rational expectations equilibrium is that such a rule has to respond aggressively to inflation. We refrain from evaluating the sensitivity of the equilibrium to several structural parameters. The combination of parameters in our model does not introduce an unstable rational expectations equilibrium. In contrast, we focus on the potential of monetary rules responding to asset prices to attain the outcomes of the optimal monetary policy.

Within the same framework, a second strand of the literature studies the conduction of monetary policy and its consequences for macroeconomic stability and welfare. Nisticò (2012) uses an ad hoc loss function that may be understood as representing central bank preferences and studies the effectiveness of different monetary rules augmented to respond to asset prices. This loss function is a weighted average of the variances of inflation, the output gap, and interest rates.[3] Nisticò (2012) uses this loss function to quantify the optimal response to asset prices and show how structural parameters, affecting determinacy, can affect the magnitude of this response. Unlike Nisticò (2012), we use a micro-founded social wel-

[3]The weights for each type of volatility are chosen arbitrarily.

fare loss function that arises from nontrivial aggregation across cohorts. We compute optimal values for the response to asset price fluctuations in a monetary rule that aims to replicate the outcomes under the optimal monetary policy.

Also in this strand of literature is Nisticò (2016). As noted, we extend this work in two directions. First, we introduce supply, demand and financial shocks to quantify an economy's potential welfare improvement if it transitions from a strict IT regime to a regime that attains socially optimal outcomes. The second extension is to evaluate the potential of monetary rules to reproduce optimal policies. A novel finding of ours is that within this framework, monetary rules are effective at reproducing optimal welfare desirable outcomes when the advanced economy faces productivity and financial shocks. However, the effectiveness of such rules is reduced when the advanced economy faces demand shocks.

The paper is also related to the literature on the empirical tendency of negative stock market returns to be followed by monetary policy easing in the US, also called the Fed put.[4] Cieslak and Vissing-Jorgensen (2021) show that negative stock market returns are associated with negative updates of the real-GDP growth forecasts presented in the Fed's monetary policy meetings. They estimate monetary rules to show that negative stock market returns predict changes in the target rate mainly through the rate's effects on GDP growth forecasts. Using textual analysis, they show that Federal Open Market Committee participants update their GDP growth forecasts, as they view stock market returns as an important driver of households' financial wealth and, consequently, consumption. We contribute to this literature by showing the effectiveness of monetary rules augmented to respond to asset prices to attain the efficient outcomes derived from optimal policy.

[4]The term "Fed put" arises from the analogy to a financial put option. An asset holder with a put option has the right to sell their asset at a strike price, which can be higher than the market price at the moment the contract expires. Cieslak and Vissing-Jorgensen (2021) show that after the mid-1990s the Fed decreased its target rate when stock markets prices dropped abruptly. The Fed's actions are analogous to a put option, as asset holders benefit with higher prices than those that arise if the target rate had not been adjusted.

The paper is organized as follows. Section 2 presents the model, and Section 3 presents the optimal problem of the monetary authority. Section 4 presents the quantitative results. First, we explain the parameterization of the model. Second, we quantify the welfare losses under alternative policies. Third, we conduct an impulse-response analysis to explain the mechanisms through which monetary rules can reproduce welfare losses under optimal policies. Finally, we provide a robustness exercise to observe whether the properties of the model hold under different assumptions of the model. Finally, Section 5 concludes.

2 Model

2.1 Supply Side

There are two categories of firms: final goods producers and intermediate goods producers. The latter supply differentiated goods to the former, who then convert these inputs into final goods. Intermediate goods producers operate as imperfect monopolists when selling their products, whereas final goods producers operate within a perfectly competitive market. Additionally, intermediate goods producers issue financial claims linked to their dividends.

Final Goods Producers

Final goods producers operate in a competitive market environment, offering their finished product, denoted as Y_t, to households at an aggregate price level, P_t. They have access to a Constant Elasticity of Substitution (CES) technology given by

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}. \tag{1}$$

This technology combines intermediate goods $Y_t(i)$, which are imperfect substitutes, with their elasticity of substitutions represented by ϵ. The solution of the cost-minimization prob-

lem for these firms establishes the demand for an intermediate good, expressed as

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\epsilon} Y_t. \tag{2}$$

Intermediate Goods Producers

A continuum of intermediate goods producers, denoted by i, offers its differentiated good, $Y_t(i)$, to final goods producers. Each firm i operates with a technology exhibiting constant returns to scale, defined as $Y_t(i) = \exp(a_t)N_t(i)$. Here, labor is represented by $N_t(i)$ and is acquired at the prevailing wage rate W_t. These firms face a productivity shock, a_t, which evolves according to the autoregressive process: $a_t = \rho_a a_{t-1} + \varepsilon_t^a$, with ε_t^a being normally distributed: $N(0, \sigma_a^2)$. Furthermore, each firm benefits from a subsidy, equivalent to $1 - \tau$, on its marginal costs. Given the linear production technology the marginal cost MC_t is the same for all intermediate goods producers and it can be expressed as

$$MC_t = \frac{W_t}{exp(a_t)P_t}. \tag{3}$$

The expression for the linearized marginal cost is

$$mc_t = w_t - p_t - a_t. \tag{4}$$

Intermediate goods producers experience nominal rigidities as described by Calvo (1983). Every period, there is a probability $(1 - \theta)$ that they will adjust their prices to $P_t^\star(i)$. Alternatively, they might retain the prior period's price, $P_{t-1}^\star(i)$, with a probability θ. The firm's pricing decision at time t is a dynamic optimization problem. A firm able to revise its price seeks to determine the optimal price $P_t^\star(i)$ that maximizes its expected future profit stream. In doing so, the firm considers future marginal costs denoted by MC_{t+k}, the demand for their product $Y_{t+k}(i)$, and the probability θ^k that it would not be able to reset its prices $\forall k \geq 0$.

The formal representation of this optimization problem is as follows

$$\max_{P_t^*(i)} \quad \mathbb{E}\sum_{t=0}^{\infty}\theta^k \mathcal{F}_{t,t+k} Y_{t+k}(i)[P_t^*(i) - (1-\tau)\frac{\epsilon}{\epsilon-1}P_{t+k}MC_{t+k}] \tag{5}$$

s.t

$$MC_{t+k} = \frac{W_{t+k}}{exp(a_{t+k})P_{t+k}}$$

$$Y_{t+k}(i) = \left[\frac{P_t^*(i)}{P_{t+k}}\right]^{-\epsilon} Y_{t+k}$$

where $\mathcal{F}_{t,t+k}$ is the stochastic discount factor. The solution to this problem is characterized by the optimal price, which is a weighted sum of future discounted markups over marginal cost

$$P_t^*(i) = \mathbb{E}_t \sum_{k=0}^{\infty} \omega_{t,t+k}(1-\tau)\frac{\epsilon}{\epsilon-1}P_{t+k}MC_{t+k} \tag{6}$$

where $\omega_{t,t+k}$ is the income discount factor for the firm k periods ahead knowing that $\omega_{t,t+k} = \frac{\theta^k \mathcal{F}_{t,t+k} P_{t+k}^{\epsilon}}{\sum_{k=0}^{\infty}\theta^k \mathcal{F}_{t,t+k} P_{t+k}^{\epsilon}}$. By combining the aggregate price with the definition and the optimal price of firms able to reset their prices (6), we obtain the following version of the New Keynesian Phillips curve which represents the dynamics of inflation

$$\pi_t = \kappa mc_t + \beta \mathbb{E}_t \pi_{t+1} \tag{7}$$

where the slope of the Phillips curve is defined by $\kappa = \frac{(1-\theta)(1-\theta\tilde{\beta})}{\theta}$.

Financial Assets

Following Nisticò (2012), we explicitly model a corporate sector that issues financial assets. We deviate from the conventional assumption that profits are uniformly distributed among households. Instead, an intermediate goods firm issues a claim $Z_t(i)$ against its future dividends at market price $Q_t(i)$. The total amount of assets issued by intermediate firms i is normalized to one, meaning $\int_0^1 Z_{t+1}(i)di = 1 \; \forall i \in [0,1]$. Therefore, we define dividends as

the profits from the intermediate goods firms

$$D_t(i) = Y_t(i)\left(1 - (1-\tau)\frac{\epsilon}{\epsilon - 1}MC_t\right) \tag{8}$$

where the corresponding linearized equation is represented by

$$d_t = \frac{2\epsilon - 1}{\epsilon}y_t - \frac{\epsilon}{\epsilon - 1}(n_t + w_t - p_t). \tag{9}$$

Finally, define the total dividends $D_t \equiv \int_0^1 D_t(i)di$ and the stock price index by $Q_t \equiv \int_0^1 Q_t(i)di$.

2.2 Demand Side

The demand side of the economy features a discrete-time stochastic version of the perpetual youth model with overlapping generations as in Yaari (1965) and Blanchard (1985). In each period, a certain share of households, known as active and denoted by ϑ, takes part in financial markets, while the rest, $1-\vartheta$, is inactive and does not have access to such markets. There is a rotation between both types of agents. An active agent becomes inactive with probability γ, and an inactive agent becomes active with probability ρ. We assume that the population size is constant; therefore, we assume $\varrho(1-\vartheta) = \vartheta\gamma$.

For each type of agent, the size of the cohorts is determined by their probability of remaining in their respective group. Agents who start in a specific group and remain for a period of j (k) years are members of the j-year (k-year) cohort. It is also important to note that the size of the cohort tends to decrease over time. In the case of an active agent living for j periods, the size of the cohort is $m(j) = \gamma(1-\gamma)^j$. For an inactive agent living k periods, the size of the cohort is $m(k) = \gamma(1-\gamma)^k$.

Inactive agents. Agents not participating in financial markets behaves as a non-Ricardian consumer as they do not have savings, and their only source of income comes from their labor

supply, —that is, they are hand-to-mouth consumers. The problem of a cohort with age (k) that is not participating (NP) is to choose a sequence of consumption $C_{k,t}^{NP}$ and labor supply decisions $N_{k,t}^{NP}$ to solve

$$\begin{aligned} &\underset{\left\{C_{k,t}^{NP}, N_{k,t}^{NP}\right\}}{max} \mathbb{E}_t \left[\delta log C_{k,t}^{NP} + (1-\delta)(1-N_{k,t}^{NP})\right] \\ &\text{s.t.} \\ &P_t C_{k,t}^{NP} = W_t N_{k,t}^{NP} - T_{k,t}. \end{aligned}$$

where $\beta \in (0,1)$ and $\delta \in (0,1)$ denote the discount factor and the consumption weight in the utility function, respectively. The term $T_{k,t}$ is a lump sum tax specific to the k-year-old agent. The optimality condition of this problem and the budget constraint imposes that labor supply is constant $N_{k,t}^{NP} = \frac{1}{1+\delta}$ and the wage rate determines the level of consumption, that is, $C_{k,t}^{NP} = \frac{W_t}{1+\delta}$.

Active participants. An agent of age j participating in financial markets can choose to save in one-period bonds, denoted as $B_{j,t+1}^{\star}$, or to invest in shares issued by firm i, represented as $Z_{j,t}(i)$. Bonds are discounted at the stochastic factor $\mathcal{F}_{t,t+1}$, and the price per share of firm i is given by $Q_t(i)$. In this economy, the relationship between the policy interest rate r_t and the stochastic discount factor, $\mathcal{F}_{t,t+1}$, is given by the equation

$$1 + r_t = \frac{1}{\mathbb{E}_t\{\mathcal{F}_{t,t+1}\}}. \tag{10}$$

The financial wealth of the j-year-old cohort is the sum of bonds and stocks, expressed as $\Omega_{j,t}^{\star} = B_{j,t+1}^{\star} + \int_0^1 \left(Q_t(i) + D_t(i)\right) di$. Following Blanchard (1985), households have access to a contract that guarantees a return of $\frac{\gamma}{1-\gamma}$ on their financial wealth, provided they continue participating in financial markets. However, in case of becoming inactive, they transfer their financial wealth to a perfectly competitive insurance firm providing the contract. This assumption allows active agents to smooth consumption regardless of the future risk of becoming inactive agents.

Active decisions can be affected by two exogenous shocks. First, households face an exogenous stochastic demand shock shifting their period utility ν_t which follows an autoregressive process $\nu_t = \rho_\nu \nu_{t-1} + \varepsilon_t^\nu$ where $\varepsilon_t^\nu \sim N(0, \sigma_\nu^2)$. Second, stocks' prices are subject to a financial shock, which can deviate prices from their fundamental asset valuation. This shock e_t follows an autoregressive process $e_t = \rho_e e_{t-1} + \varepsilon_t^e$ where $\varepsilon_t^e \sim N(0, \sigma_e^2)$.

We consider a framework with a differentiated lump sum taxation structure impacting old and new participants in distinct manners. Specifically, for old participants belonging to generation j, the lump sum transfer, denoted as $T_{j,t}$, is computed as follows:

$$T_{j,t} = T_t + \Upsilon_j \left[\frac{1}{1-\gamma} - \mathbb{E}\left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \right\} \right], \tag{11}$$

where T_t represents a uniform lump sum tax applicable to all, and the second term captures a cohort-specific tax burden, with Υ_j denoting the tax rate for generation j.

The infinite horizon problem that j-year-old agent participating in the financial market solves is characterized by

$$\underset{\left\{C_{j,t}^P, B_{j,t+1}, Z_{j,t}(i), N_{j,t}^P\right\}_{t=0}^{\infty}}{max} \mathbb{E}_t \sum_{i=t}^{\infty} \beta^t (1-\gamma)^t exp(\nu_t) \left[\delta log C_{j,t}^P + (1-\delta)(1-N_{j,t}^P) \right]$$

s.t.

$$P_t C_{j,t}^P + \mathbb{E}\left\{ \mathcal{F}_{t,t+1} B_{j,t+1}^\star \right\} + P_t \int_0^1 Q_t(i) Z_{j,t+1}(i) = W_t N_{j,t}^P - T_{j,t} + \Omega_{j,t}^\star$$

$$\frac{1}{1-\gamma} \left[B_{j,t}^\star + P_t \int_0^1 (Q_t(i) + D_t(i)) Z_{j,t}(i) \right] \equiv \Omega_{j,t}^*$$

where the term $T_{j,t}$ denotes a lump-sum tax paid by a j-year-old agent. The following first-

order equations characterize the optimality conditions of the j-year-old active agent:

$$N_t: \quad C^P_{j,t} = \frac{\delta}{1-\delta}\frac{W_t}{P_t}(1-N^P_{j,t}) \tag{12}$$

$$B^*_{j,t}: \quad \mathcal{F}_{t,t+1} = \beta\mathbb{E}_t\left\{\frac{P_t}{P_{t+1}}\frac{C^P_{j,t}}{C^P_{j,t+1}}exp(\varepsilon^\nu_t)\right\} \tag{13}$$

$$Z^\star_{j,t}(i): \quad Q_t(i) = \mathbb{E}_t\left\{\mathcal{F}_{t,t+1}\frac{P_{t+1}}{P_t}exp(e_t)\left[Q_{t+1}(i)+D_{t+1}(i)\right]\right\}. \tag{14}$$

In this structure, the consumption of a j-period-old cohort depends on the expected future labor income and current financial wealth. To show this, first, let define the expected discounted flow of after-tax labor income as $h_t = \mathbb{E}_t\sum_{k=0}^{\infty}\mathcal{F}_{t,t+k}(1-\gamma)^k(\frac{W_{t+k}}{P_{t+k}}-T_{t+k})$. Second, we combine the optimality conditions for labor supply, bond savings, and stock holdings, to iterate forward the flow of funds and express the budget constraint of a j-year-old cohort as:

$$\frac{1}{1+\delta}C^P_{j,t} = h_t + \mathbb{E}_t\sum_{k=0}^{\infty}\left\{\mathcal{F}_{t,t+1}(1-\gamma)^k\frac{1}{\delta}P_{t+k}C^P_{t+k}\right\} + \mathbb{E}_t\left\{\mathcal{F}_{t,t+1}\Omega_{j,t+1}\right\}. \tag{15}$$

From the intertemporal marginal rate of substitution , we can derive the following expression for the consumption profile of a j-year-old cohort

$$\mathbf{C}^P_{j,t} = \begin{cases} \frac{\delta}{\Sigma_t}(h_t+\Omega_{j,t}-\Upsilon_{j,t}) & \text{existing cohorts j} < \text{t} \\ \frac{\delta}{\Sigma_t}(h_t+\Upsilon_j) & \text{new cohorts j = t} \end{cases} \tag{16}$$

where we let $\Sigma_t \equiv \mathbb{E}_t\left\{\beta^k(1-\gamma)^k exp(\varepsilon^\nu_{t+k}-\varepsilon^\nu_t)\right\}$ to represent the discounted lifetime sum of shocks affecting the marginal propensity to consume.[5] The previous expression shows how the differences in financial wealth drive consumption heterogeneity across cohorts. In particular, notice that a newly active cohort has a lower level of consumption than older cohorts because their financial wealth is zero.[6]

[5]To derive this expression, we use a non-ponzi condition implies that $\mathbb{E}_t\left\{\mathcal{F}_{t,t+1}\Omega_{j,t+1}\right\} \to 0$ as $t \to \infty$

[6]Notice that at period t the discounted lifetime sum of shocks Σ_t and the discounted lifetime non-financial income h_t does not depend on the cohort profile. Therefore, it is straightforward to argue that the consumption is lower for new cohorts.

Agents' turnover has consequences for the aggregate relationship for intertemporal consumption. Active agents can be replaced in the next period by new cohorts with zero wealth. Let define the average consumption for active participants as $C^P_{t+1} \equiv \sum_{j=-\infty}^{t} \gamma(1-\gamma)^j C^P_{j,t}$. The average consumption for an active participant, denoted as $C^P t$, is constituted by the consumption of both older cohorts, $C^O j, t$, and newer cohorts, $C^N_{j,t}$. This relationship can be expressed mathematically as follows

$$C^P_t = \sum_{j=-\infty}^{t-1} \gamma(1-\gamma)^j C^P_{j,t} + \gamma C^P_{t,t}. \tag{17}$$

Therefore the next period, average consumption for active participants C^p_t can be expressed as

$$C^P_{t+1} = (1-\gamma) C^O_{t+1} + \gamma C^N_{t+1} \tag{18}$$

where C^O_{t+1} and C^N_{t+1} represents the future consumption of old and new participants. As argued before, new participants consume less than older cohorts given their lack of wealth. The difference between the consumption of new participants and older cohorts is driven by the aggregate wealth

$$C^O_{t+1} - C^N_{t+1} = \frac{\delta}{\Sigma_t} \Omega. \tag{19}$$

The substitution of active cohorts drives a wedge between the individual and the average rate of intertemporal substitution. In the current period, active cohorts are able to smooth consumption intertemporally, so their individual marginal rate of substitution equals the stochastic discount factor. However, as current active agents are replaced in the future, the stochastic discount factor is not equal to the average marginal rate of substitution. The average marginal

rate of substitution can be represented as

$$\begin{aligned}\mathbb{E}_t\{\mathcal{F}_{t,t+1}\} &= \mathbb{E}_t\left\{\beta\frac{P_tC_t^P}{P_{t+1}C_{t+1}^O}\right\}\\ &= \mathbb{E}_t\left\{\beta\frac{P_tC_t^P}{P_{t+1}\left(C_{t+1}^P+\frac{\gamma\delta}{\Sigma_t\, t}\right)}\right\}.\end{aligned} \tag{20}$$

Previous expression shows how aggregate wealth fluctuations drive a wedge in the average consumption dynamics of the economy. Finally, this expression provides a representation of the IS equation for this economy

$$C_t^P = \frac{\gamma\Sigma_t}{\beta(1-\gamma)}\underbrace{\mathbb{E}_t\left\{\mathcal{F}_{t,t+1}\frac{P_{t+1}}{P_t}\Omega_{t+1}-\Upsilon_t\right\}}_{\text{Financial wealth channel}}+\frac{1}{\beta}\mathbb{E}_t\left\{\mathcal{F}_{t,t+1}\Sigma_{t+1}\frac{P_{t+1}}{P_t}C_{t+1}^P\right\}. \tag{21}$$

2.3 Market clearing conditions.

The aggregate consumption in the economy is derived from the consumption of active participants and non-participants. Aggregate consumption is represented as follows

$$C_t = \vartheta C_t^P + (1-\vartheta)C_t^{NP}. \tag{22}$$

In equilibrium, the market for state-contingent bonds clears, implying that the net supply of these bonds is equal to zero:

$$B_t = 0. \tag{23}$$

Given that this economy is closed, the production of goods and services, represented by Y_t, is consumed domestically. Therefore, the output in the economy is equal to the aggregate consumption:

$$Y_t = C_t. \tag{24}$$

The aggregate labor supply in the economy, denoted as N_t, is determined by the contributions from both active participants N_t^P and non-participants N_t^{NP}. This relationship is formally

expressed as

$$N_t = \vartheta N_t^P + (1-\vartheta) N_t^{NP}. \tag{25}$$

We define the aggregate labor demand as

$$N_t \equiv \int_0^1 N_t(i) di. \tag{26}$$

In turn, the aggregate production is represented by

$$Y_t \Xi_t = \exp(a_t) N_t, \tag{27}$$

where $\Xi_t \equiv \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} di$ represents the price dispersion among intermediate goods producers.

We proceed to represent the equilibrium in a set of linearized equations that represent the dynamics of the economy given the exogenous shocks and the policy rate. First, it is standard to represent the linearized natural output y_t^n as the production that arises in the absence of nominal rigidities–that is, when $\pi_t = 0$. From the definition of the marginal cost and the optimality condition of the labor supply we obtain that $y_t^n = a_t$. In the economy without nominal rigidities, the natural rate of interest that sustains output at its natural level while keeping inflation at zero is defined as follows

$$\begin{aligned} r_t^n = &\left((\rho_a - 1) + 1 - \beta\rho_a 1 - (1-\psi)\beta\rho_a\psi\rho_a\right) a_t \\ &+ \left(\frac{\beta\Theta\psi\psi_\nu\rho_\nu}{1-\beta\rho_\nu(1-\psi)}\rho_\nu(1-\rho_\nu). \right. \end{aligned} \tag{28}$$

Let define the output gap x_t as the deviation of the output from its natural level– that is $x_t \equiv y_t - y_t^n$. By using this definition, the aggregate euler condition and the aggregate definition of consumption, we characterize the dynamics of the output gap as

$$x_t = \mathbb{E}_t x_{t+1} + \frac{\psi}{\Theta}\mathbb{E}_t\omega_{t+1} - \frac{1}{\Theta}(r_t + \mathbb{E}_t\pi_{t+1} - r_t^n) \tag{29}$$

where $\psi \equiv \frac{1-\beta(1-\gamma)}{(1-\gamma)}\frac{1}{1-\beta}\frac{\mu}{1+\mu}$ and $\Theta \equiv 1-\phi\frac{1-\vartheta}{\vartheta}$.[7] Also, from the definition of financial wealth, we can characterize the equation for financial wealth as

$$\omega_t = \beta\mathbb{E}_t\omega_{t+1} + (1-\beta)\frac{\mu-(1+\varphi)}{\mu}x_t - (1-\beta)a_t + (r_t - \mathbb{E}_t\pi_{t+1} - \rho) + e_t. \tag{30}$$

Finally, the definition of the Phillips curve can be represented by

$$\pi_t = \kappa x_t + \beta\mathbb{E}_t\pi_{t+1}. \tag{31}$$

3 Optimal Monetary Policy and Monetary Rules

A benevolent central planner is responsible for solving the optimal monetary policy problem in the economy. For a given exogenous shock, the planner aims to choose aggregate allocations, which maximize the aggregate lifetime utilities of existing and future generations Nisticò (2016) shows that the benevolent central planner solves a two-stage problem. The central planner's first problem is to choose a cross-sectional distribution of consumption and hours that maximizes the aggregate period utility. When all agents are considered equal by a planner, the optimal cross-sectional distribution is to maintain an equal level of consumption for all agents regardless of their longevity. Second, the planner chooses a sequence of aggregate allocations that maximize the lifetime aggregate utility for all the periods.

Nisticò (2016) derives a second-order approximation around the steady state of the aggregate lifetime utility. The approximation derived by Nisticò (2016) considers that the steady state equilibrium reaches the optimal level of aggregate utility. This means that any deviations from the steady state are considered undesirable. The following welfare loss function

[7] In these expressions we used the definition of the inverse of the Frisch elasticity of labor supply is $\phi \equiv \frac{N_{ss}}{1-N_{ss}}$ and N_{ss} is the total labor supply in steady state. The markup is defined by $\mu \equiv \frac{\epsilon}{\epsilon-1}$.

represents this approximation

$$\mathcal{L}_{\pi,x,\omega} = \frac{(1+\varphi)\nu}{2\vartheta}\mathbb{E}_t \left\{ \sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \alpha_\pi \pi_t^2 + \alpha_\omega \omega_t^2 \right) \right\} \tag{32}$$

where $\alpha_\pi = \vartheta \frac{\varepsilon}{\nu\kappa}$ corresponds to the relative weight for inflation and $\alpha_\omega = \frac{\vartheta^2 \psi \mu}{\nu[(1+\phi)(1-\beta)(1+\mu)]}$ is the relative weight for financial stability. This representation shows that welfare loss function $\mathcal{L}_{\pi,x,\omega}$ increases when either the output gap, the inflation rate, or financial wealth deviates from the steady state.

In the subsequent section, we employ the welfare loss function to assess the significance of recognizing the presence of financial wealth influencing the dynamics of aggregate consumption. For this purpose, we set the IT regime as the reference policy framework. Within this framework, a policymaker seeks to stabilize both the inflation rate and the output gap, without giving due consideration to the role of financial wealth. In our analysis, we calculate the welfare loss function within the IT framework and compare it to the welfare loss observed under alternative policy regimes that recognize the significance of financial wealth. Initially, we contrast the IT regime with optimal policies executed under both discretion and commitment. This comparison determines the maximum potential decrease in the welfare loss function, achievable through the optimization efforts of a central planner. Also, we assess the IT regime against a regime where monetary policy is guided by monetary rules that respond to the inflation rate, output gap, and asset prices. The objective of this second comparison is to ascertain whether a similar reduction in welfare loss, comparable to that achieved by the optimal policy, can be attained in a decentralized economy where the central bank uses monetary rules. In the rest of the section, we describe the different policy regimes under which the monetary policy can be implemented.

3.1 Inflation Targeting Regime

The IT regime considers maintaining allocations at the flexible price equilibrium for every period, that is, fluctuations in inflation ($\pi_t = 0$) and output gap ($x_t = 0$) completely disappear in equilibrium $\forall t \geq 0$. A planner can implement this policy by setting the interest rate at the level of the natural interest rate r^n, which in this framework is represented by

$$\begin{aligned} r_t^n = &\left((\rho_a - 1) + 1 - \beta\rho_a 1 - (1-\psi)\beta\rho_a\psi\rho_a\right) a_t \\ &+ \left(\frac{\beta\Theta\psi\psi_\nu\rho_\nu}{1-\beta\rho_\nu(1-\psi)}\rho_\nu(1-\rho_\nu)\Theta\psi_\nu\right)\nu_t \\ &+ \frac{\psi\rho_e}{1-\beta(1-\psi)\rho_t}e_t. \end{aligned} \tag{33}$$

A planner implementing this regime ignores that financial wealth (ω_t) is subject to fluctuations that affect consumption heterogeneity across active agents in the financial market. In the flexible price equilibrium, financial wealth is affected by the three exogenous shocks in the economy – that is productivity shocks (ϵ_t^a), demand shocks (ϵ_t^ν), and financial shocks (ϵ_t^e). To illustrate this, notice that the financial wealth dynamics under a flexible price equilibrium is represented by

$$\omega_t = \frac{1-\beta\rho^a}{1-(1-\psi)\beta\rho_a}a_t + \frac{1}{1-(1-\psi)\beta\rho_e}e_t - \frac{\beta\Theta\psi_\nu(\rho_\nu - 1)}{1-(1-\psi)\beta\rho_\nu}\nu_t. \tag{34}$$

3.2 Optimal Monetary Policy

Compared to an IT regime, a benevolent central planner recognizes the importance of fluctuations in financial wealth and seeks to minimize the welfare loss function $\mathcal{L}_{\pi,x,\omega}$ given the dynamics of inflation, the output gap, and financial wealth. Given a shock $\xi_t \in \{z_t, \nu_t, e_t\}$,

the problem under optimal policy can be represented as

$$\mathcal{L}_{\pi,x,\omega} = \min_{\{\pi_t,x_t,q_t\}_{t\geq 0}} \left\{ \frac{(1+\varphi)\nu}{2\vartheta} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \alpha_\pi \pi_t^2 + \alpha_\omega \omega_t^2 \right) \right\}$$

s.t.

$$\begin{aligned}
\pi_t &= \kappa x_t + \beta \mathbb{E}_t \pi_{t+1} \\
x_t &= \mathbb{E}_t x_{t+1} + \frac{\psi}{\Theta} \mathbb{E}_t \omega_{t+1} - \frac{1}{\Theta}(r_t + \mathbb{E}_t \pi_{t+1} - r_t^n) \\
\omega_t &= \beta \mathbb{E}_t \omega_{t+1} + (1-\beta)\frac{\mu - (1+\varphi)}{\mu} x_t - (1-\beta) a_t + (r_t - \mathbb{E}_t \pi_{t+1} - \rho) + e_t \\
\xi_t &= \rho_\xi \xi_{t-1} + \varepsilon_t^\xi.
\end{aligned}$$

Optimal monetary policy literature, considers two frameworks to solve this problem, namely, monetary policy under discretion and commitment. The problem of a monetary authority under discretion is to find allocations for output gap (x_t), inflation (π_t), and financial wealth (ω_t), such that given the dynamics of these variables the welfare loss $\mathcal{L}_{\pi,x,\omega}$ is minimized period by period. Therefore, when operating under discretion, optimal allocations satisfy the following intratemporal condition

$$x_t = -\alpha_\pi \kappa \pi_t - \alpha_\omega \eta \omega_t. \tag{35}$$

When determining allocations within a commitment framework, the central planner assesses intertemporal trade-offs and set a trajectory of allocations $\{x_t, \omega_t, \pi_t\}_{t\geq 0}$ that preserves the optimal dynamics over time. This leads to the intertemporal optimality conditions, which, under commitment, are represented by the following equations

$$\begin{aligned}
x_t &= \eta \lambda_{2,t} - \Theta \lambda_{2,t-1} + \kappa \lambda_{t,1} \\
\alpha_\pi \pi_t &= \lambda_{1,t-1} - \lambda_{1,t} \\
\alpha_\omega \omega_t &= (1 - \frac{\psi}{\Theta}) \mathbb{E} \omega_{t+1} - \frac{1}{\Theta}(r_t - \mathbb{E}_{t+1} - r_t^n)
\end{aligned} \tag{36}$$

where $\lambda_{1,t}$ and $\lambda_{2,t}$ are Lagrange multipliers associated with the constraints imposed by inflation dynamics π_t and financial wealth dynamics ω_t.

3.3 Monetary Rules

Finally, we study the potential of an augmented monetary rule to provide an approximation to the optimal policy presented in the previous section. We consider that such monetary rule follows a central bank reaction function of the following form

$$r_t = r_t^n + \phi_t \pi_t + \phi_x x_t + \phi_q q_t. \tag{37}$$

where the parameters ϕ_π, ϕ_x, ϕ_q represent the response of the interest rate to inflation, output gap, and asset prices. The monetary rule follows the fluctuations in the natural rate r_t^n as we investigate the extent to which slight deviations from the policy under the IT regime can provide welfare improvements.[8] This monetary rule possesses a characteristic such that, in scenarios where there are no fluctuations pushing the economy away from flexible-price allocations, it aligns with an equilibrium in which both inflation and the output gap are fully stabilized. Within this model, monetary policy achieves stabilization of financial wealth (ω_t) by influencing asset prices. As such, introducing a response to asset prices (ϕ_q) aims to mitigate the oscillations in financial wealth.

4 Quantitative Results

In this section, we calibrate the theoretical model and evaluate the optimal monetary response in the context of fluctuations due to productivity shocks, demand shocks, and financial shocks. In doing so, we extend the results of Nisticò (2016) regarding the relative importance of demand and financial shocks in optimal welfare policy. To this end, we compute the social welfare loss function under a regime pursuing IT, under an optimal policy under discretion,

[8]For instance, Cúrdia et al. (2015) provides empirical evidence for the US, showing that a New Keynesian model estimated to reproduce US real business cycle stylized facts fits the data better when the monetary response tracks the natural rate instead of a rule that omits it.

Table 1: Benchmark calibration

Definition	Parameter	Source
Discount factor	$\beta = 0.99$	Annual interest rate of 4%
Calvo parameter for nominal rigidity	$\theta = 0.75$	Price adjustment for quarters
Weight for consumption in utility function	$\delta = 3.33$	Elasticity of labor supply equal to $\frac{1}{\delta} = 0.3$
Share of participants in financial markets	$\vartheta = 0.8$	
Turnover rate of financial markets participants	$\xi = 0.17$	Financial wealth effect $\frac{\psi}{\Theta} = 0.15$

Source: The parameter for the turnover rate and and share of financial markets are taken from Nisticò (2016). The rest of the parameters are authors calculations.

and under an optimal policy under commitment. Nisticò (2016) shows that a sizable reduction in welfare loss results from transitioning from IT to optimal policy in the context of productivity shocks. We instead assess whether this quantitative result holds in the context of demand and financial shocks.

4.1 Parameterization

Table 1 presents the benchmark parameter values we use. We follow Nisticò (2016) to calibrate the model. The calibration strategy allows us to consider whether an IT regime is suboptimal in the context of demand and financial shocks. Each period is a quarter, and taking standard values in the literature, the coefficient for the discount factor $\beta = 0.99$, which is consistent with a steady-state real interest rate $r_{ss} = 0.1$, and the nominal price rigidity $\theta = 0.75$. The share of agents participating in financial markets is set to $\vartheta = 0.8$.

The consumption weight, δ, is set to maintain a real wage elasticity of $\varphi \equiv \frac{1}{\delta} = 0.3$. The elasticity of demand for an intermediate input ϵ is set to maintain a markup of 20%—that is, $\frac{\mu}{1-\mu} = 1.2$. The standard deviations for the shocks are consistent with the values in Castelnuovo and Nisticò (2010). Therefore, we set $\sigma_a = 0.01$, $\sigma_\nu = 0.0314$, and $\sigma_e = 0.0059$. As a benchmark case, each shock has no persistence.

As mentioned before, we consider a monetary rule (consistent with equation (37)) in which the central bank responds to deviations of inflation, the output gap, and asset prices from the steady state. The response to macroeconomic variables is set at standard values—

namely, $\phi_\pi = 1.5$ and $\phi_x = 0.125$. In Table 2, we compute the optimal response to an asset price fluctuation (ϕ_q) that minimizes the welfare loss function ($\mathcal{L}_{\pi,x,\omega}$)—that is, $\phi_q \in \arg\min \mathcal{L}_{\pi,x,\omega}$. Each column shows the optimal ϕ_q in the monetary rule for each type of shock with persistence ρ_x.[9] As can be seen, for given values of parameters ϕ_x and ϕ_π, the optimal response to asset price fluctuation is similar regardless of the type of shock. Also, as the persistence of the shock increases, the response to asset prices decreases. In our benchmark results, we maintain the zero-persistence assumption, but later we explain how our results are sensitive or robust to different assumptions about persistence.

Table 2: Parameter ϕ_q that minimizes welfare function.

Persistence of the shock	ϵ^A	ϵ^ν	ϵ^e	Simultaneous
$\rho_x = 0$	0.92573	0.92570	0.92573	0.92570
$\rho_x = 0.20$	0.59380	0.59375	0.59380	0.59375
$\rho_x = 0.40$	0.31298	0.31290	0.31298	0.31289
$\rho_x = 0.60$	0.11160	0.11149	0.11160	0.11149
$\rho_x = 0.8$	0.00900	0.00961	0.00900	0.00961
$\rho_x = 0.99$	-0.00399	-0.00374	-0.00390	-0.00372

Source: Author's calculations. Each column considers the optimal ϕ_q that minimizes the social welfare function for fixed parameters $\phi_x = 0.125$ and $\phi_\pi = 1.5$.

4.2 Quantitative Welfare Losses under Different Policies

Table 3 shows the calculation of the social welfare loss in the context of each type of shock under alternative policy regimes. Each panel shows the welfare loss for each type of shock—that is, productivity, demand, and financial shocks. Additionally, the panel at the bottom shows a measure of the welfare loss in the case in which all shocks interact simultaneously. For a given panel representing the welfare loss in the presence of a particular shock, each column shows the welfare loss in light of the reaction function of each type of policy: IT, discretion, commitment, a simple monetary rule, and an augmented monetary rule.[10] The first three rows in each panel show the standard deviation of the targeted variable (that is,

[9] The last column shows the optimal ϕ_q when all shocks are present simultaneously.

[10] While a simple rule considers a specification as in equation (37) but only responds to inflation and the output gap (that is, $\phi_q = 0$), an augmented rule considers a functional form like equation (37).

inflation, output gap, and financial wealth), and the last row shows the welfare loss.

Panel A in Table 3 shows the welfare loss when the economy is only subject to productivity shocks. Columns 1 to 3 show that implementing an optimal monetary policy, either under discretion or commitment, instead of pursuing IT, reduces welfare losses significantly. Notice that the magnitudes differ to those shown in the published paper for two reasons. First, we use a different magnitude for the shock and, second, we consider a social welfare function derived in the corrigendum associated to the published version. Optimal monetary policy under discretion reduces the welfare loss by up to 65% of the loss under IT; under commitment the reduction is up to 59.1%. I extend Nisticò (2016) to observe whether a policy rule that deviates from the natural rate can reduce the welfare loss. Column 4 shows that a simple rule barely increases the welfare loss compared to the IT case. Column 5 shows that an augmented monetary rule that reacts to asset prices reduces the welfare loss to a point close to an optimal policy under discretion. Notice that that this rule attains a reduction of the welfare loss in the same way as optimal policies: by decreasing significantly the financial-wealth volatility associated with consumption dispersion but allowing for a marginal increase in the volatility of inflation and the output gap.

In Panel B in Table 3, we extend the analysis of Nisticò (2016) by studying the welfare loss in the context of only preference shocks (that is, demand shocks). Consistently with a productivity shock, the flexible-price allocation shows much higher welfare losses compared with the losses under an optimal policy under commitment and discretion.

The welfare loss of monetary policy under discretion (commitment) is 45% (41%) of the loss observed under IT. Still, the reduction in the welfare loss is lower when the monetary policy is implemented by monetary rules. A simple (augmented) rule results in a welfare loss up to 71% (86%) of the loss under IT. Not only do monetary rules yield welfare reductions far from that obtained under optimal policy, but they introduce a trade-off, as they are effective at moderating the volatility of financial wealth but exacerbate the volatility of macroeconomic

variables (that is, inflation and the output gap). To illustrate this, consider the ratio of the volatility of inflation under an augmented rule and under commitment: almost 2.5. In turn, the relative volatility of the output gap under the augmented rule vis-a-vis the rule under commitment is 1.86. And under the augmented rule the volatility of financial wealth is lower than the volatility under a rule under commitment; the ratio is 0.35. Even a simple monetary rule produces better welfare outcomes than an augmented rule.

Panel C in Table 3 extends the analysis of Nisticò (2016) by reproducing the previous welfare analysis considering the impact of an exogenous financial shock that alters the fundamental valuation of asset prices. As in previous cases, there are important welfare improvements from pursuing the optimal policy that stabilizes the financial wealth channel. Upon comparing columns 1 and 2, we observe that the relative loss under discretion is 62% of the loss under flexible-price allocation. And the loss under commitment is 59% of the loss observed under IT. While a simple rule yields almost the same loss as under IT, an augmented monetary rule yields a welfare loss close to that of the optimal policy under discretion.

Last, Panel D in Table 3 shows the welfare losses when all the shocks interact simultaneously. This panel shows that an augmented monetary rule can bring welfare benefits compared with a framework that pursues the flexible-price allocation. In relative terms, an augmented rule introduces lower losses than those under IT. The policies under commitment and discretion generate losses up to 64% and 58% of the losses under IT. The augmented rule is limited in its ability to lower losses compared with optimal policies. From the analysis above, given the relative size of the shocks, this is because a demand shock exacerbates inflation and the output gap under the augmented rule.

Table 3: Welfare loss for different shocks.

Panel A: Productivity Shock

	IT	Discretion	Commitment	Simple Rule	Augmented Rule
(σ_π) Std. Inflation	0	0.04991	0.04114	0.00001	0.04757
(σ_x) Std. Output gap	0	0.44746	0.49647	0.00012	0.42647
(σ_ω) Std. Financial Wealth	1.0023	0.61687	0.55882	1.0023	0.63494
Welfare Loss	**0.00959**	**0.00617**	**0.00537**	**0.00959**	**0.00625**

Panel B: Demand Shock

	IT	Discretion	Commitment	Simple Rule	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.02200	0.01816	0.04078	0.04591
(σ_x) Std. Output gap	0.00000	0.19726	0.21906	0.36554	0.41157
(σ_ω) Std. Financial Wealth	0.52973	0.27194	0.24617	0.12699	0.08734
Welfare Loss	**0.00268**	**0.00122**	**0.00110**	**0.00192**	**0.00231**

Panel C: Financial Shock

	IT	Discretion	Commitment	Simple Rule	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.02936	0.02421	0.00001	0.02827
(σ_x) Std. Output gap	0.00000	0.26323	0.29211	0.00012	0.25339
(σ_ω) Std. Financial Wealth	0.58963	0.36289	0.32870	0.58964	0.37136
Welfare Loss	**0.00332**	**0.00217**	**0.00196**	**0.00332**	**0.00216**

Panel D: Simultaneous shocks

	IT	Discretion	Commitment	Simple Rule	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.06196	0.05105	0.05728	0.05989
(σ_x) Std. Output gap	0.00000	0.55542	0.61609	0.51349	0.53688
(σ_ω) Std. Financial Wealth	1.27777	0.76570	0.69380	1.46001	0.90207
Welfare Loss	**0.01559**	**0.00966**	**0.00874**	**0.02383**	**0.01157**

Source: Author's calculations. This table shows the welfare loss for different regimes: flexible price allocations, optimal policy under discretion, and optimal policy under commitment. The values presented in the table were scaled by the factor 10^3.

4.3 Impulse-Response Analysis

In the previous section, we showed the potential of an augmented monetary rule to produce welfare losses close to the optimal welfare outcomes when the economy faces productivity and financial shocks. Also, we found that in the presence of demand shocks, the welfare improvement is moderate. In this section, we study the impulse response functions (IRFs) for each type of shock and explain how a monetary rule augmented to respond to asset prices can explain previous results. As we will see, the ability of the monetary rule to mimic the response of optimal policy depends on its ability to adjust the response to asset prices as an intermediate target to reduce the effect of financial wealth.

Figure 1 shows the IRFs of several variables under alternative approaches to monetary policy: IT, discretion, commitment, and an augmented monetary rule. The solid line shows the response of the economy under commitment allocations, the dotted line allocations under discretion, the circled line the outcomes under IT, and the red line the response under an augmented monetary rule.

Panel A in Figure 1 shows the IRFs for a productivity shock of one standard deviation. In the response, under the IT regime the nominal interest rate decreases more than under either an optimal policy or the augmented rule. Under IT, an increase in productivity implies a decrease in the natural rate to set inflation and the output gap at their zero-steady state values. However, also under IT, financial wealth increases as dividends and asset prices rise. While dividends rise mainly because of the productivity shock, asset prices rise because of the decrease in the nominal interest rate. As a consequence, financial wealth translates into consumption dispersion across cohorts.[11]

Unlike under the IT regime, in the response, we observe that alternative optimal policies

[11]Under zero persistence, the active cohorts have more wealth than agents not participating in financial markets. When the persistence parameter increases, wealth across financially active cohorts also rises, as the shocks are persistent and some households will not be active in the period.

and the monetary rule allow for negative inflation and output gap, which interact with a moderate increase in financial wealth. Under these policies, the adjustment of the interest rate is moderate. Optimal policies prescribe a smaller decrease in the policy rate to dampen the increase in financial wealth. As a consequence, the restrictive policy reduces the output gap; as consequence, we observe a decrease in inflation.

The augmented monetary rule recommends an adjustment to the interest rate close to the rate under the optimal policy under discretion. In particular, the close adjustment in the policy rate under both type of policies introduces a smaller increase in asset prices than under the IT regime. The smaller increase in asset prices is the main factor driving down financial wealth. As a result, optimal policies and the augmented monetary rule allow for almost the same response in all the endogenous variables. Not surprisingly, this explains the findings in Panel A in Table 3.

Simultaneously, the increase in the marginal cost of producing an intermediate good creates downward pressure on inflation. In the case of an economy under IT, the monetary policy prescribes a downward adjustment in the natural rate of interest in order to stabilize output at the level consistent with the zero-inflation target. However, under discretion and commitment, the adjustment in the interest rate is lower because the monetary policy tries to counteract the effect of the rise in dividends on financial wealth. The policy-rate adjustment under optimal policy is consistent with responses to inflation and the output gap that deviate from the steady state.

Panel B in Figure 1 shows the IRFs to a positive shock of one standard deviation to a household's marginal utility—that is, a demand shock. All the alternative policies prescribe a tightening of monetary policy in response to this shock. Because under flexible prices consumption dispersion is unimportant, the monetary policy under IT is less restrictive than under optimal policies. Even with a less restrictive policy under IT, asset prices decrease more than under optimal policies. This result is due to the dynamics of dividends, which fall

with a positive output gap—that is, $d_t = \left[\frac{\mu-(1+\varphi)}{\mu}\right] x_t + a_t$.

In this context, the monetary rule is less responsive than optimal rules. In fact, the smaller increase in the policy rate allows asset prices to barely adjust. As a consequence, financial wealth shows a small adjustment. However, the smaller increase in the policy rate is unable to reduce the inflationary pressures that arise from the increase in households' expenditures.

Panel C shows the IRF after a positive shock to the valuation of financial assets—that is, a financial shock. In this case, the exogenous shock increases directly the asset price, which directly affects financial-wealth valuation. In the IT regime, a shock affects the natural rate when it is persistent; therefore, in our benchmark calibration the effect is null. While monetary policy is neutral under IT, optimal policies prescribe tightening the interest rate. In this framework, optimal policies are intended to reduce asset price valuations in order to offset the rise in financial wealth. The side effect is to reduce current output, as households find it optimal to postpone consumption, which is consistent with a fall in inflation.

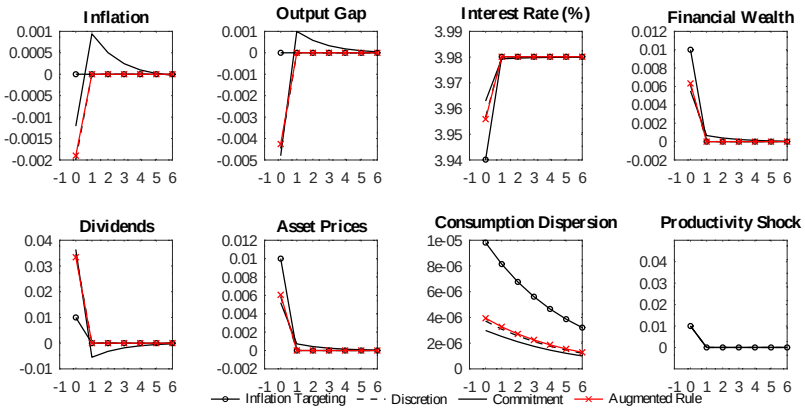
As in the case of a productivity shock, an augmented monetary rule reproduce the outcomes under an optimal policy with discretion. In this case, the monetary authority can offset directly the shock to asset prices through policy tightening. However, this policy increases the volatility of inflation and the output gap. The last column of Table 3 shows this result.

4.4 Sensitivity Analysis

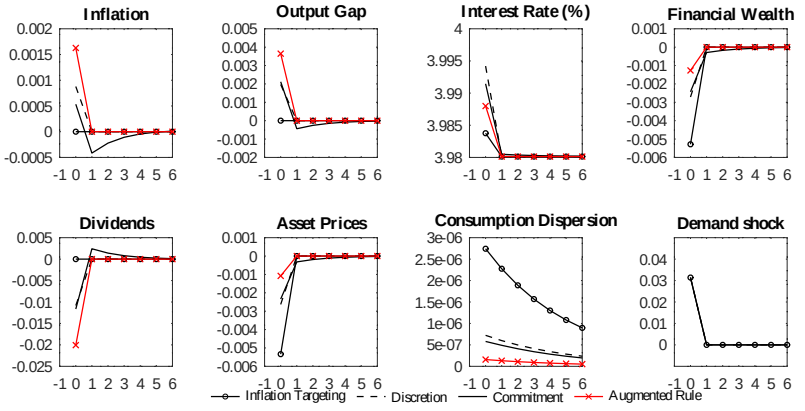
In this section we check the robustness of the previous results in three dimensions. First, as in Cúrdia and Woodford (2010), we explore whether the persistence of the shocks affects the relative welfare-loss reduction due to a monetary rule. Second, instead of using the IT regime to compare the welfare reductions, we consider the reference case to be a flexible inflation-targeting (FIT) regime. This regime minimizes welfare loss by considering only the discounted sum of the quadratic deviations of inflation and the output gap from the steady

Figure 1: Impulse response functions for a productivity, demand, and asset price shock.

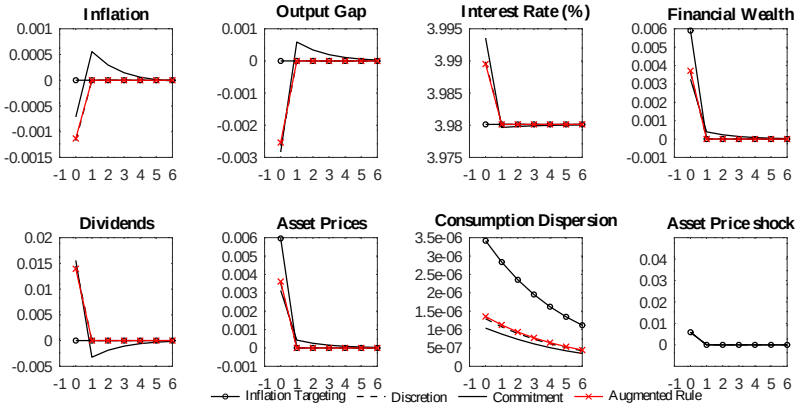
Panel A: Productivity shock ε^A



Panel B: Demand shock ε^ν



Panel C: Financial shock ε^e



Source: Author's calculations. The figure shows the impulse response for inflation, output gap, interest rate, financial wealth, and consumption dispersion. Each plots shows the response of such variables for different policy regimes: inflation targeting, optimal policy under discretion, and optimal policy under commitment. The size of the shock corresponds to one standard-deviation estimated in Castelnuovo and Nisticò (2010).

state of zero—that is, in the welfare-loss equation (32), $\alpha_q = 0$. Finally, we analyze whether the marginal reduction in welfare loss achieved through the monetary rule can be attributed to the fact that stabilizing stock price fluctuations proves to be an imperfect strategy for maintaining financial wealth stability in response to demand shocks. To this aim, we utilize an approximation of the social welfare loss function where financial wealth exclusively reacts to asset prices. We evaluate whether, in this scenario, the monetary rule can diminish the welfare loss function to a level comparable with that achieved under an optimal policy.

Sensitivity to Shocks' Persistence

In the previous section, we parameterized a benchmark version of the model in which shock persistence is null. In Table 2 we observe a reduction in the optimal response to asset price dynamics when the persistence of the shock increases—that is, if $\rho_x \to 1$, then $\phi_q \to \bar{z}$, where $\bar{z} < 0$. In this section, we explore whether the lesser responsiveness of the monetary rule to asset prices affects the rule's ability to improve welfare outcomes. In particular, for productivity and financial shocks, we study whether the decrease in losses is robust even when shocks are persistent. Also, in the face of demand shocks, we study whether the marginal benefits of an augmented monetary rule are still positive.

Table 4 shows a measure of the welfare loss from an augmented rule relative to the loss when pursuing the flexible-price allocation. Therefore, as this relative value is above 1, it implies that the loss under an augmented rule is higher than that under the flexible-price allocation. The first column in Table 4 shows the relative welfare loss when the economy faces only productivity shocks, a_t. It shows that even for high values ($\rho_a = 0.60$), introducing an augmented rule produces welfare benefits.

The second column in Table 4 shows the relative welfare loss when the economy is subject only to demand shocks, ν_t. Not surprisingly, at very low levels of persistence (ρ_ν), an augmented monetary rule produces higher welfare losses than in the flexible-price case. This result suggests that in the face of demand shocks, using an augmented monetary rule to re-

spond to asset prices can be inefficient. Finally, the third column in Table 4 shows that in the presence of a highly persistent financial shock e_t, the augmented rule still provides positive welfare benefits.

Table 4: Welfare under augmented monetary rule relative to welfare under flexible prices.

Persistence of the shock	ϵ^A	ϵ^ν	ϵ^e
$\rho_x = 0$	0.65398	0.86863	0.65479
$\rho_x = 0.20$	0.72821	1.07298	0.72898
$\rho_x = 0.40$	0.83445	1.41865	0.83509
$\rho_x = 0.60$	0.97475	2.08788	0.97511
$\rho_x = 0.8$	1.13080	11.61748	1.13084
$\rho_x = 0.99$	1.37840	10.59969	1.37842

Source: Author's calculations. For a given shock persistence ρ_x, each row considers the ratio of the welfare following an augmented rule with respect to the welfare when the economy follows flexible prices. Each column consider the only shock that is turned on in the simulation.

Sensitivity to IT as Benchmark Regime

In this part we conduct a similar analysis as in Table 3, but instead of comparing the results to those under a strict IT regime, we consider a FIT regime as in Svensson (1999). A FIT regime minimizes a loss function like that in equation (32) but with $\alpha_\omega = 0$. The aim is to quantify the welfare reduction that an augmented monetary rule can bring if we consider a less restrictive policy regime than IT.

Table 5 shows the quantitative welfare losses for (i) optimal policy with commitment under FIT, (ii) optimal policies (that is, discretion and commitment) for the optimal social welfare problem, and (iii) the augmented rule. Panels A and C, corresponding to welfare losses in the presence of productivity and financial shocks, respectively, show that a policy under commitment under FIT is similar to the policy under strict IT. Therefore, as in the IT regime, for the productivity shock and financial shock we observe that the monetary rule causes a sizable reduction in welfare loss with respect to FIT.

Table 5: Welfare loss for different shocks.

Panel A: Productivity Shock

	Commitment FIT	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.04991	0.04114	0.04757
(σ_x) Std. Output gap	0.00000	0.44746	0.49647	0.42647
(σ_ω) Std. Financial Wealth	1.00230	0.61687	0.55882	0.63494
Welfare Loss	**0.00959**	**0.00627**	**0.00567**	**0.00625**

Panel B: Demand Shock

	Commitment FIT	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.02200	0.01816	0.04591
(σ_x) Std. Output gap	0.00000	0.19726	0.21906	0.41157
(σ_ω) Std. Financial Wealth	0.44185	0.27194	0.24617	0.08734
Welfare Loss	**0.00186**	**0.00122**	**0.00110**	**0.00231**

Panel C: Financial Shock

	Commitment FIT	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.02936	0.02421	0.02827
(σ_x) Std. Output gap	0.00000	0.26323	0.29211	0.25339
(σ_ω) Std. Financial Wealth	0.58963	0.36289	0.32870	0.37136
Welfare Loss	**0.00332**	**0.00217**	**0.00196**	**0.00216**

Panel D: Simultaneous shocks

	Commitment FIT	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.00000	0.06196	0.05105	0.07187
(σ_x) Std. Output gap	0.00000	0.55542	0.61609	0.64425
(σ_ω) Std. Financial Wealth	1.24413	0.76570	0.69380	0.74125
Welfare Loss	**0.01478**	**0.00966**	**0.00874**	**0.01072**

Source: Author's calculations. This table shows the welfare loss for different regimes: flexible price allocations, optimal policy under discretion, and optimal policy under commitment. The values presented in the table were scaled by the factor 10^3.

In the case of Panel B in Table 5, concerning demand shocks, we observe a result that strengthens the finding regarding FIT. Column 1 shows that pursuing a FIT regime reduces the welfare loss considerably relative to an IT regime (column 1 in Panel B in Table 3). As a consequence, we observe that in the face of demand shocks, pursuing an augmented rule is suboptimal relative to commitment under FIT. In this case a simple rule can be a better option to approximate a reduction in social welfare loss. Thus, this exercise supports our previous result that, in the face of demand shocks, a rule responding to asset prices can produce a very limited, or even null, reduction in welfare loss.

Sensitivity to Asset Prices as a Target in the Loss Function

In the previous section, we found that an augmented rule responding to asset prices is effective in approximating the optimal policy outcomes in the face of productivity shocks and financial shocks. However, under a demand shock, such a rule underperforms, in terms of its ability to reduce the welfare loss, relative to a simple monetary rule. While this result could be a property of the parsimonious representation of the rule, it could instead be that stabilizing stock price fluctuations in the face of demand shocks moves the allocations away from the optimal outcomes.

We explore whether approximating the social welfare loss only through asset prices can bring suboptimal outcomes. Using the above definition of financial wealth (that is, $\omega_t = \beta q_t + (1-\beta)d_t$), this exercise consists in computing an approximation of the social welfare loss when considering only the response to asset prices and avoiding the terms associated with dividends.

In this way, the welfare loss that a central bank tries to minimize is a suboptimal approximation of the true welfare loss. By quantifying the approximated welfare loss and comparing it to the true welfare loss, we try to discern whether the limited welfare-loss reduction of the monetary rule is because stabilizing stock price fluctuations is an imperfect target in the face

of demand shocks. Therefore, the loss function we consider is the following:

$$\mathcal{L}_{\pi,x,q} = \frac{(1+\varphi)\nu}{2\vartheta}\mathbb{E}_t \left\{ \sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \alpha_\pi \pi_t^2 + \alpha_\omega \beta^2 q_t^2 \right) \right\}. \tag{38}$$

This function is an approximation of the true social welfare function because $\mathcal{L}_{\pi,x,\omega} = \mathcal{L}_{\pi,x,q} + 2\beta(1-\beta)q_t d_t + (1-\beta)^2 d_t^2$. Hence, we explore whether, by pursuing optimal policy over $\mathcal{L}_{\pi,x,q}$ the central bank can attain outcomes as in $\mathcal{L}_{\pi,x,\omega}$.

For each panel representing a shock, the first two columns of Table 6 show the optimal social welfare loss $\mathcal{L}_{\pi,x,\omega}$ when the authority follows optimal policies (that is, discretion and commitment) that minimize the loss associated with asset price fluctuations $\mathcal{L}_{\pi,x,q}$. By comparing the first (second) and third (fourth) columns for all the shocks, we observe that even when the authority is minimizing an incorrect loss function, it comes very close to the optimal outcomes. This property holds even for the demand shock. This result suggests that aiming to stabilize fluctuations in q with the augmented rule is not necessarily incorrect.

Table 6: Welfare loss for different shocks.

Panel A: Productivity Shock

	Discretion q_t	Commitment q_t	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.05062	0.04149	0.04991	0.04114	0.04757
(σ_x) Std. Output gap	0.45378	0.49756	0.44746	0.49647	0.42647
(σ_ω) Std. Financial Wealth	0.61142	0.55723	0.61687	0.55882	0.63494
Welfare Loss	**0.00628**	**0.00568**	**0.00627**	**0.00567**	**0.00625**

Panel B: Demand Shock

	Discretion q_t	Commitment q_t	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.02254	0.01849	0.02200	0.01816	0.04591
(σ_x) Std. Output gap	0.20204	0.22173	0.19726	0.21906	0.41157
(σ_ω) Std. Financial Wealth	0.26782	0.24356	0.27194	0.24617	0.08734
Welfare Loss	**0.00122**	**0.00110**	**0.00122**	**0.00110**	**0.00231**

Panel C: Financial Shock

	Discretion q_t	Commitment q_t	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.03008	0.02466	0.02936	0.02421	0.02827
(σ_x) Std. Output gap	0.26962	0.29568	0.26323	0.29211	0.25339
(σ_ω) Std. Financial Wealth	0.35739	0.32520	0.36289	0.32870	0.37136
Welfare Loss	**0.00218**	**0.00197**	**0.00217**	**0.00196**	**0.00216**

Panel D: Simultaneous shocks

	Discretion q_t	Commitment q_t	Discretion	Commitment	Augmented Rule
(σ_π) Std. Inflation	0.06305	0.05167	0.06196	0.05105	0.07187
(σ_x) Std. Output gap	0.56524	0.61962	0.55542	0.61609	0.64425
(σ_ω) Std. Financial Wealth	0.75725	0.68993	0.76570	0.69380	0.74125
Welfare Loss	**0.00969**	**0.00875**	**0.00966**	**0.00874**	**0.01072**

Source: Author's calculations. This table shows the welfare loss for different regimes: flexible price allocations, optimal policy under discretion, and optimal policy under commitment. The values presented in the table were scaled by the factor 10^3.

5 Conclusion

In this article, we studied the potential of monetary rules to attain optimal policy outcomes in a non-Ricardian New Keynesian model. This model includes a macro financial channel observed in advanced economies, where the value of financial assets affects households' wealth and, consequently, aggregate demand. The model is calibrated to replicate the impact of fluctuations in financial asset prices on the aggregate demand as seen in the United States. In this model, increases in financial-wealth volatility count as a source of welfare loss. We incorporate shocks to firms' productivity, households' marginal utility (that is, demand shocks) and shocks affecting asset prices (that is, financial shocks). We quantified the reduction in the welfare loss that a central bank can achieve if it transitions from an inflation targeting regime to one that pursues an optimal policy. Consistent with Nisticò's (2016) finding for cost-push shocks, we found that these reductions are sizable for productivity, demand and financial shocks.

Also, we studied whether monetary rules can attain the optimal outcomes in an economy that tracks the natural rate of interest implied from the inflation targeting regime. Again, the purpose was to show the welfare benefits that a central bank pursuing an inflation targeting regime can attain by responding to macroeconomic and financial variables. We found that simple rules responding to inflation and the output gap do not attain better outcomes than the flexible-price allocation. However, in the face of productivity and financial shocks, introducing a response to asset prices allows the central bank to reproduce the outcomes of pursuing optimal policy. However, under demand shocks, the reduction in welfare loss is minor.

Finally, our conclusions are specific to the model calibrated for the United States. We used a model that abstracts from capital-accumulation, financial-intermediation, and open-economy considerations. These are key elements that could produce different results. Also, our results cannot necessarily be extended to other countries, as different macro financial linkages can play more important roles than the one studied here.

References

Marco Airaudo, Salvatore Nisticò, and Luis-felipe Zanna. Learning, monetary policy, and asset prices. *Journal of Money, Credit and Banking*, 47(7):1273–1307, 2015.

Ben S Bernanke and Mark Gertler. Should central banks respond to movements in asset prices? *american economic review*, 91(2):253–257, 2001.

J Blanchard, Olivier. Debt, deficits, and finite horizons. *Journal of Political Economy*, 93(2): 223–247, 1985.

Guillermo A Calvo. Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3):383–398, 1983.

Efrem Castelnuovo and Salvatore Nisticò. Stock market conditions and monetary policy in a dsge model for the us. *Journal of Economic Dynamics and Control*, 34(9):1700–1731, 2010.

Stephen G Cecchetti, Hans Genberg, John Lipsky, and Sushil Wadhwani. *Asset prices and central bank policy*. Centre for Economic Policy Research, 2000.

Gabriel Chodorow-Reich, Plamen T Nenov, and Alp Simsek. Stock market wealth and the real economy: A local labor market approach.

Anna Cieslak and Annette Vissing-Jorgensen. The economics of the fed put. *The Review of Financial Studies*, 34(9):4045–4089, 2021.

Vasco Cúrdia and Michael Woodford. Credit spreads and monetary policy. *Journal of Money, credit and Banking*, 42:3–35, 2010.

Vasco Cúrdia, Andrea Ferrero, Ging Cee Ng, and Andrea Tambalotti. Has us monetary policy tracked the efficient interest rate? *Journal of Monetary Economics*, 70:72–83, 2015.

Marco Di Maggio, Amir Kermani, and Kaveh Majlesi. Stock market returns and consumption.

Salvatore Nisticò. Monetary policy and stock-price dynamics in a dsge framework. *Journal of Macroeconomics*, 34(1):126–146, 2012.

Salvatore Nisticò. Optimal monetary policy and financial stability in a non-ricardian economy. *Journal of the European Economic Association*, 14(5):1225–1252, 2016.

Lars EO Svensson. Inflation targeting: some extensions. *Scandinavian journal of Economics*, 101(3):337–361, 1999.

Menahem E Yaari. Uncertain lifetime, life insurance, and the theory of consumer. *The Review of Economic Studies*, 32(2):137–150, 1965.