The Borrowing Cost Channel of Monetary Transmission

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Abstract

This paper examines the effect of monetary policy on the extensive margin of the production sector when the borrowing cost of the firm differs by its productivity. Consistent with the literature and the empirical findings, (i) monetary policy stimulates the entry of the firms not only through the trade-off between increased demand and increased cost, but also directly through reducing the borrowing cost. However, in the current calibration of the model, (ii) monetary policy might offset the initial increase in output through the demand channel by directly attracting less efficient firms. In contrast, a model without size dependent interest rate exhibits a pronounced output response and moderate inflation sensitivity, lacking the economic stabilization conferred by differentiated borrowing costs. Moreover, a model without size dependent interest rate and firm entry/exit mechanisms displays amplified output and inflation responses, indicative of a standard New Keynesian approach that abstracts from firm dynamics. Inclusion of size dependent borrowing costs and dynamic firm behavior in our model dampens these responses, suggesting a stabilizing effect on the economy and highlighting the transitory nature of policy impacts, which are absent in the standard framework.

Keywords: firm exit, firm entry, monetary policy, variable interest rate, interest rate gap

JEL Codes: E24, E32, E52, E58, L11

"The Federal Reserve System helps foster growth in local and regional communities by connecting small businesses ⋯ These connections amplify our understanding of challenges that small businesses and startups can face, and underscore that creditworthy small businesses and startups need adequate and affordable access to credit in order to form, grow, and succeed."

- Randal K. Quarles, Former Federal Reserve Board Vice Chair for Supervision

1 Introduction

The relationship between monetary policy and economic activity is central to macroeconomic theory, particularly how adjustments in interest rates influence borrowing costs and thereby affect economic decisions across the production sector. This chapter examines the dynamics of monetary transmission through the borrowing cost channel, specifically focusing on its impact on firm entry and exit decisions. By analyzing variations in monetary policy, we explore how these changes alter borrowing conditions and subsequently influence firms' decisions to enter or exit the market. This leads us to the central question of our study: How do monetary policy adjustments affect firms' decisions of entry and exit the market, and what are the broader implications for economic dynamics?

We analyze the borrowing cost channel of monetary transmission using a New Keynesian framework that incorporates Hopenhayn's entry and exit dynamics. Our model provides a structured approach to simulate the impact of size-dependent borrowing costs on firms with different productivity levels. This integration allows for an examination of how adjustments in monetary policy, especially through borrowing costs, influence firm behavior differentially depending on their productivity levels. The layout of the model is specifically designed to capture the variability in firm responses to monetary shocks, which is crucial for understanding the broader economic implications of policy changes. The study reveals that changes in monetary policy (expansionary monetary policy shock) have a differential impact on the production sector. Notably, the average productivity level responds distinctly, showing a marked decline. This suggests that the entry of less productive firms, stimulated by easier borrowing conditions (lower interest rate), may lead to a decrease in overall sector productivity.

Such a decline in average productivity is critical as it reflects the dual nature of monetary policy effects: while potentially boosting economic activity, it may also facilitate the persistence or emergence of less efficient firms, thus possibly resulting in inefficient resource allocation. The analysis underlines that the policy rate affects both aggregate demand—via increased consumption—and aggregate supply—by altering firm costs and productivity thresholds. Specifically, the borrowing cost channel appears to reduce the cutoff for productivity, thereby lowering fixed operational costs and influencing the dynamics of market entry and exit along with average productivity.

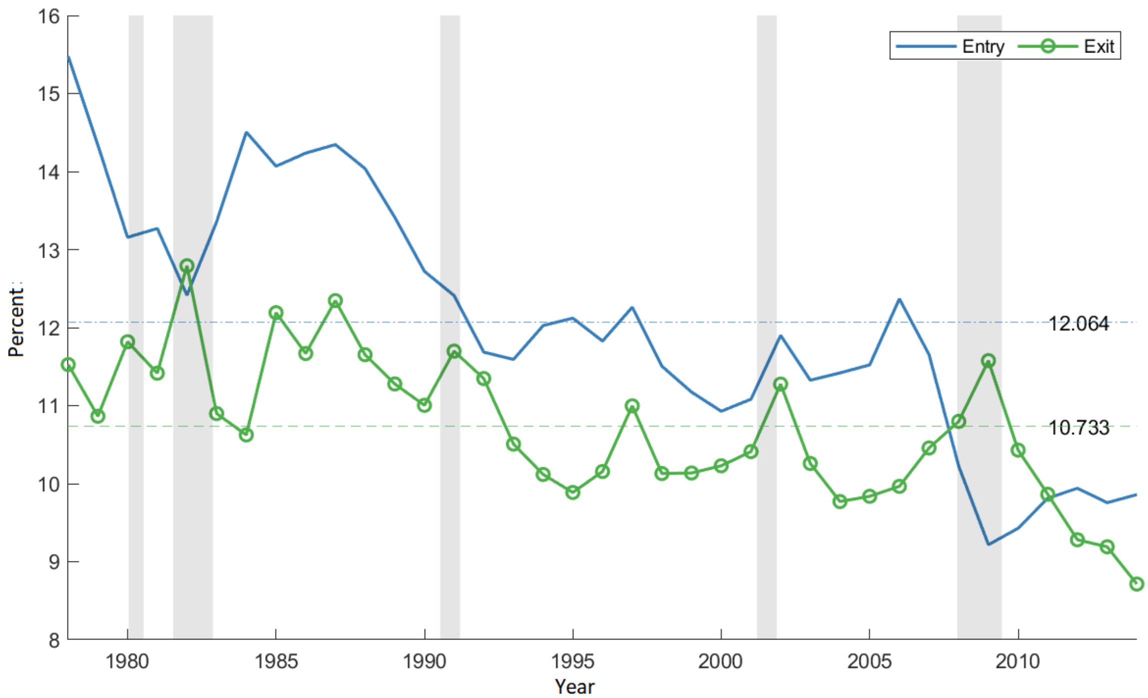

Figure 1. Entry and exit rate in the United States, 1978 to 2014. The shaded area represents the NBER business cycles.

Year Despite the limitations posed by data availability, the empirical analysis provides essential context for understanding the model's predictions. Our review of firm entry and exit patterns in Figure 1 (Business Dynamics Statistics Database) reveals a degree of empirical support for the theoretical predictions, although the data does not explicitly clarify the impact of monetary policy on these dynamics. Initial observations suggest a potential expansionary influence on firm entry, although the clarity of this impact becomes less certain when analyzed using local projection methods Figure 2. We estimated the effect of policy shock on entry and exit using local projections method with the extended Romer and Romer narrative monetary policy shock. [1] While the entry rate responds notably to monetary policy shocks, the exit rate's reaction is comparatively muted, and interestingly, appears to decline over a three-year horizon. The complexity observed in interpreting this data highlights the importance of developing policy strategies to understand how monetary policy shapes the landscape of firm entry and exit.

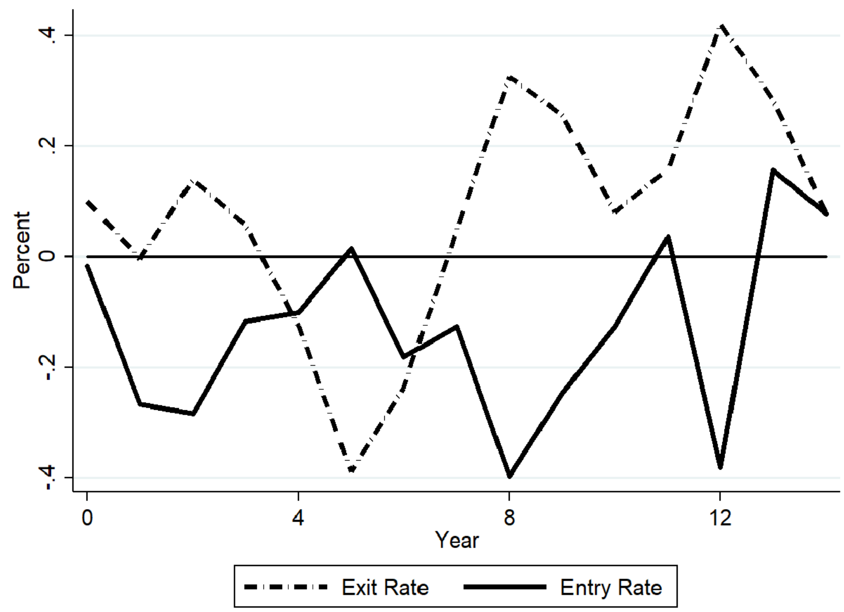

Figure 2. Impulse response of business dynamism with respect to extended Romer and Romer monetary policy shock using local projection.

In the comparative analysis of model impulse responses under different assumptions, our study presents key findings that distinguish our model from standard counterparts in the field. Specifically, the sensitivity of firm entry and exit rates to changes in monetary policy is more pronounced in our model. This distinct response is attributed to the unique integration of borrowing cost dynamics and productivity levels, which are not typically addressed simultaneously in conventional New Keynesian models. Our model illustrates that lower borrowing costs significantly boost the entry of new firms, particularly those at lower productivity levels, while higher costs discourage entry, which may prevent potential over-saturation of less productive entities in the market. This detailed modeling approach enables a more precise understanding of the economic landscape, suggesting that monetary policy can have targeted impacts that differ across sectors and firm sizes. Building on the empirical foundations

[1] Initially proposed by Romer and Romer (2004) and further extended by Miranda-Agrippino and Ricco (2021)

discussed earlier, these insights from the comparative analysis emphasize the need for detailed policy measures. By acknowledging the differential impacts highlighted by our model, policymakers can better address the specific needs of various economic sectors, enhancing overall economic efficiency and stability.

This paper builds upon the existing body of research, offering a novel perspective on the transmission of monetary policy, by incorporating a detailed examination of firm entry and exit dynamics, borrowing costs, and productivity. We enhance the existing body of research by studying the effect of monetary policy on the extensive margin of the production sector, when the borrowing cost of the firm differs by its productivity. Our approach involves developing a model that encapsulates both firm entry and exit (Hopenhayn, 1992) within a general equilibrium framework, as described by Lewis and Poilly (2012), and incorporates the type of credit constraints articulated by Jermann and Quadrini (2012). The model is otherwise standard New Keynesian model with representative household and monetary authority. Within this model, we identify three inter-related monetary policy transmission channels: demand channel, the secondary increase in costs, and the borrowing cost channel.

Building on the foundational models in monetary policy and firm dynamics, our research introduces a sophisticated model that integrates the dynamics of firm entry and exit within a general equilibrium framework. This model not only aligns with the foundational aspects of the New Keynesian framework but also extends the analysis to cover the extensive margin of the production sector, offering a more comprehensive understanding of how monetary policy influences firm behavior. Our paper extends the work of Beaudry et al. (2011), who were among the first to incorporate firm entry in a New Keynesian setting by introducing idiosyncratic productivity shocks upon entry. Beaudry et al. (2011) made an early contribution to studying firm dynamics in a New Keynesian setting by emphasizing firm productivity draws upon entry. They highlight the role of market expectations and investment dynamics in driving business cycles, laying the groundwork for understanding firm dynamics. In our model, we build on this approach by examining how monetary policy, specifically through the borrowing cost channel, influences firm productivity and entry/exit decisions. By integrating size-dependent borrowing costs, our study further explores the effects of monetary policy on firms with varying productivity levels, providing a more detailed analysis of economic cycles influenced by firm entry and exit dynamics.

Further, the model contrasts with Bilbiie et al. (2012) by emphasizing the impact of monetary policy on firm entry and exit rather than merely on product creation and destruction. They extend the earlier work by introducing exogenous exit and demonstrate that the impulse response functions in the extended model better match empirical data. Our analysis provides a detailed examination of how monetary policy through the borrowing cost channel influences firm dynamics, extending the discussion beyond traditional models. By integrating insights from Lewis and Poilly (2012), who incorporate an entry decision process in which only some desired entrants are successful (thereby making entry and exit dynamics more persistent), our model highlights the importance of borrowing costs and firm productivity in shaping the entry and exit dynamics across the economic landscape. Moreover, our analysis significantly advances the dialogue on how monetary policy impacts economic activity by integrating firm-level heterogeneity and differential borrowing costs into the New Keynesian model. This approach not only addresses some limitations observed in previous studies, such as those by Hartwig and Lieberknecht (2020), which feature endogenous exit decisions with flat financing costs in production, making exit more cyclical and persistent, but also provides a more granular analysis of the distributive effects of monetary policy across firms with varying productivity levels. Our paper enhances the understanding of the complex interplay between monetary policy and firm-level responses, highlighting the intricate mechanisms through which monetary policy influences the economic cycle.

The remainder of the paper is organized as follows: Section 2 describes the model, highlighting its structure and the dynamics it captures. Section 3 presents the results, analyzing the effects of monetary policy shocks within the model's framework. Concluding remarks and discussions of the findings' implications for monetary policy and economic theory are provided in Section 4.

2 Model

We construct a dynamic stochastic general equilibrium model with endogenous entry and exit similar to Lewis and Poilly (2012) and Bilbiie et al. (2012). Our model extends the prior literature by incorporating idiosyncratic productivity heterogeneity, similar to Hartwig and Lieberknecht (2020) and introduces a productivity-dependent interest rate.

Within the model, entry is determined in the flavor of Hopenhayn (1992), where firms compare potential profits against the fixed costs associated with entry. Similarly, firms opt to exit when their anticipated profits turn negative. The demand-side structure of the economy adheres to the textbook-standard New Keynesian framework.

2.1 Final Goods Retailer

There is a final goods retailing firm that bundles intermediate goods and sells consumption goods to the households. Bundling technology is given by CES production function:

$$Y_t = \left(\int_{z \in \mathcal{Z}} y_t(z)^{\frac{\theta-1}{\theta}} dz \right)^{\frac{\theta}{\theta-1}}$$

, where $\theta > 1$. The optimization problem retailer faces is to maximize profit by choosing the inputs $y_t(i)$:

$$\max_{\{y_t(i)\}_{z \in \mathcal{Z}}} P_t Y_t - \int_{z \in \mathcal{Z}} p_t(z) y_t(z) dz$$

Retailer's profit maximization implies the following demand schedule for intermediate varieties:

$$y_t(z)^C = \left(\frac{p_t(z)}{P_t} \right)^{-\theta} Y_t \tag{1}$$

Plugging Equation (1) into the CES production yields the aggregate price index:

$$P_t = \left(\int_{z \in \mathcal{Z}} p_t(z)^{1-\theta} dz \right)^{\frac{1}{1-\theta}} \tag{2}$$

2.2 Intermediate Goods Wholesaler

The economy is populated with a continuum of wholesale firms on the interval $[z_m, \infty)$, indexed by $z \in \mathcal{Z}$. Each wholesale firm produces differentiated intermediate good $y_t(z)$ using labor $l_t(z)$ as input. Each firm is endowed with the aggregate productivity A_t and firm-specific technology z. Notice that z is without a time subscript, implying that z remains unchanged along the wholesaler's lifetime. [2] The production function is linear in labor and is given as follows:

$$y_t(z) = A_t z l_t(z) \tag{3}$$

[2] More description of the idiosyncratic productivity z is given at the Entry and Exit section.

The log of aggregate productivity A_t follows $AR(1)$:

$$\ln A_t = \rho_A \ln A_{t-1} + \epsilon_t^A \tag{4}$$

To solve for the optimal price setting and labor demand, let us divide the problem into two parts: cost minimization of choosing optimal input and profit maximization through optimized input.

2.2.1 Labor Demand

First, we solve the intermediate firm's cost minimization problem. Wholesale firms choose the optimal amount of labor to minimize the cost. To finance the cost of production, wholesalers need to raise funds with a loan $b_t(z)$. At the end of the period, $b_t(z)$ is repaid with the gross interest rate $R_t(z)$. Firm's productivity bounds the ability to borrow. This variable interest rate is set up in the spirit of the working capital limited enforcement constraint as in Jermann and Quadrini (2012). The key difference between Jermann and Quadrini (2012) and the model introduced, however, is that the variable interest rate is directly a function of productivity z, rather than an enforcement constraint that can be recovered when default. The observed differences can be partly attributed to the model's simplification, which omits capital to maintain computational tractability. Additionally, the presence of positive profits among intermediate goods firms stems from the inherent characteristics of monopolistic competition.

Specifically, the intermediate firm must borrow funds to cover the fixed operational cost f of effective labor at the gross interest rate $R_t(z)$, which varies with the firm's idiosyncratic productivity z. Therefore, wholesalers cost minimization problem involves minimizing the real total cost by selecting the labor input $l_t(z)$:

$$\min_{l_t(z)} tc_t(z) = \min_{l_t(z)} p_t(z)y_t(z) - w_t l_t(z) - \frac{f}{A_t} R_t(z)$$

, subject to the production technology (3). Cost minimization then implies that:

$$mc_t(z) = \frac{w_t}{A_t z} \tag{5}$$

, conditional on Equation (3) and the idiosyncratic productivity z. Notice that the primary effect of entry and exit is pronounced through the marginal cost, thus showing heterogeneity in the responses of each firm.

2.2.2 Optimal Pricing

Given the optimal input decision, the firms maximize profit by choosing the optimal price subject to the relative demand (1). The real profit of the firm is given by:

$$\pi_t = \frac{p_t(z)}{P_t} y_t(z) - tc_t(z) - pac_t(z) \tag{6}$$

, where unit marginal cost mc_t is given by (5) and price adjustment cost is given according to Rotemberg (1982):

$$pac_t = \frac{\tau}{2} \left(\frac{p_t(z)}{p_{t-1(z)}} - 1 \right) \frac{p_t(z)}{P_t} y_t(z)$$

Solving the dynamic optimal pricing problem will yield:

$$p_t(z) = \mathcal{M}_t(z) mc_t(z) \tag{7}$$

, where the markup $\mathcal{M}_t(z)$ is as follows:

$$\mathcal{M}_t(z) = \frac{\theta}{(\theta - 1)(1 - pac_t) + \tau \left(\frac{\partial pac_t}{\partial p_t} - \mathbb{E}_t \Lambda_t \frac{\partial pac_{t+1}}{\partial p_t} \right)} \tag{8}$$

, where Λ_t is a household's stochastic discount factor. Similar to the marginal cost, markup $\mathcal{M}_t(z)$ is a function of the idiosyncratic productivity z. Further notice that without the presence of a price stickiness τ, Equation (8) can be reduced to:

$$\mathcal{M}_t(z) = \frac{\theta}{\theta - 1}$$

, which is identical to the markup in the canonical RBC model. By solving the optimal pricing problem, we can have a mapping from the idiosyncratic productivity z to the real profit Π, characterized by equations (5), (6), (7), and (8). The results are summarized in the following proposition.

Proposition 1. *Assuming $R_t(z)$ is decreasing in z, the mapping $\pi_t(z) : \mathcal{Z} \to \mathbb{R}$ is increasing in z.*

Proof. Notice that combining equations (5), (6), (7), and (8) yields the following expression for the real profit:

$$\pi_t(z) = \frac{p_t(z)}{P_t} \left(1 - \mathcal{M}_t(z)^{-1} - pac_t(z)\right) y_t(z) - \frac{f}{A_t} R_t(z)$$

Since real price $p_t(z)$ and relative demand $y_t(z)$ is an increasing function of z and inverse of a markup $\mathcal{M}_t(z)^{-1}$ and price adjustment cost $pac_t(z)$ is a decreasing function of z, the first term in the right hand side is a increasing in z. Hence, if $R_t(z)$ is decreasing in z, $\pi_t(z)$ is increasing in z. □

2.2.3 Firm Entry

Starting each period, entering wholesale firm draws idiosyncratic productivity z from the known Pareto distribution z.

$$G(z) = 1 - \left(\frac{z_m}{z}\right)^{\kappa} \tag{9}$$

Notice that z is public information, and therefore every agent in the economy observes z and infers $\pi_t(z)$, with the help of the mapping Equation (6). The rest of modeling largely follows Lewis and Poilly (2012) and Hartwig and Lieberknecht (2020) in the Hopenhayn (1992) fashion.

Upon observing z, each potential entrant firm finances their sunk cost of entry, f_E, measured in units of effective labor, from households. Subsequently, only a fraction, denoted as, $S_{N,t}$, of these entering firms become operational. Entry success probability is given as follows:

$$S_{N,t}(N_{E,t}, N_{E,t-1}) = 1 - F_N\left(\frac{N_{E,t}}{N_{E,t-1}}\right) \tag{10}$$

, where $F_N(\cdot)$ denotes a failure rate (hazard rate). Following Lewis and Poilly (2012), F_n has a adjustment cost structure:

$$F_N(x) = g_3\left(\exp\left(g_1(x-1)\right) + \frac{g_1}{g_2}\exp\left(-g_2(x-1)\right) - 2\right)$$

, with the steady-state property $F_N(1) = F'_N(1) = 0$. For adjustment cost parameter $F''(1) = g_1 g_3(g_1 + g_2) \equiv \psi$, we restrict ψ to be greater than 0. Following property holds from the assumption:

$$\frac{\partial S_{N,t}}{\partial N_{E,t}} = -F'\frac{1}{N_{E,t-1}}$$
$$\frac{\partial^2 S_{N,t}}{\partial N_{E,t}^2} = F'\frac{N_{E,t}}{N_{E,t-1}^2}$$

, with the steady-state property $\left.\frac{\partial S_{N,t}}{\partial N_{E,t}}\right|_{SS} = \left.\frac{\partial^2 S_{N,t}}{\partial N_{E,t}^2}\right|_{SS} = 0$. Notice that $S_{N,t}(\cdot)$ is a decreasing function of the current entry and increasing function of entry last periods. Hence, as the hazard rate is modeled, incumbents' failure can be interpreted similar to the investment adjustment cost.[3]

2.2.4 Firm Exit

Firm exit follows the framework established by Jermann and Quadrini (2012) and Hartwig and Lieberknecht (2020). First, every period, fixed proportion of firms face an exogenous exit shock δ. Thus, the law of motion for the total number of firms is:

$$N_t = (1-\delta)\left(N_{t-1} + S_{N,t}(N_{E,t}, N_{E,t-1})N_{E,t-1}\right).$$

After the shock, incumbent firms decides to exit the market or not by observing their profit. If profit of a firm foreseen to be positive, the firm stays in the market:

$$\pi_t(z) \geq 0$$

From the Proposition 1, we know that for a reasonable value of z_{min}, there exists a threshold value $\bar{z}$ such that the exit condition holds with the equality:

$$\pi_t(\bar{z}_t) = 0 \tag{11}$$

Equation (11) implicitly defines the value for the cutoff productivity $\bar{z}_t$ and thus endogenously determine the exit. Only the firms with idiosyncratic productivity $\bar{z}_t \geq 0$ will achieve non-negative profits and therefore remain in the market. Also notice, that while z is time-invariant, $\bar{z}_t$ is time-varying. The number of surviving firms is given by the exit combined with the Pareto distribution:

$$N_t^S = (1 - G(\bar{z}))N_t$$

2.2.5 Timing of a Intermediate Firms

The timing of firms' decisions is summarized in Figure 3:

Starting of a period, potential entrants draw idiosyncratic productivity z from a Pareto distribution $G(z)$. Aggregate productivity A_t is also drawn and known to the

[3] The modeling technique allows firm's entry and exit to gradually adjust for the shock. See Appendix of Lewis and Poilly (2012) for further discussion.

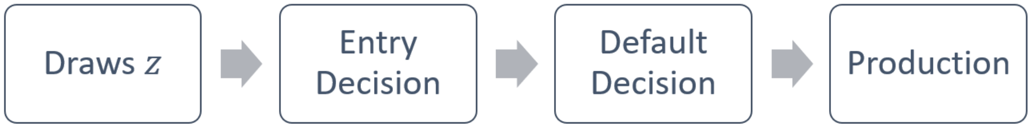

Figure 3. Timing of a intermediate firm's decision.

firms. After learning z, potential entrants decide whether to enter or not. Notice, that z is a public information. Entry decision is subject to their financing ability, which is determined by productivity and the entry (fixed) sunk cost f_E. After they enter into the market, all firms decide whether to exit or not. First, the firms will face an exogenous exit shock, and then they will see the mapping $\pi_t(z)$ to determine whether to exit the market or not. In optimum, only the firms with non-negative profit will operate, and the threshold productivity is implicitly determined by Equation (11). Once the firm decides whether to exit or to stay, they start the production. In each period, firms need to finance their fixed cost f using intraperiod loan. Financing of a fixed operation cost f is subject to their ability to borrow, represented by the individual interest rate $R_t(z)$.

2.3 Household

The household's problem is standard. Infinitely-lived representative household maximizes its expected lifetime utility:

$$\max \mathbb{E}_0 \left(\sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \chi \frac{L_t^{1+\eta^{-1}}}{1+\eta^{-1}} \right) \right)$$

, where C_t is consumption, L_t is a labor supply, η is a Frisch elasticity, subject to the budget constraint:

$$C_t + x_t \nu_t (N_t + H_t) + B_{t+1} = w_t L_t + x_t N_t \nu_t + x_t S_{N,t} \mathbb{E}_z(d_t(z)) + R_{t-1} B_t$$

, where x_t is an equity holding, B_t is a bond holding, ν_t is a value of a share. Notice, that in the model there are two types of financial instruments, bonds and equity. Bonds' price is determined at R_t, and the equity price is determined by the the firm's value, ν_t. Acquisition of both instruments are assumed to be competitive. The first-order conditions associated to the household's maximization problem are as follows:

$$\Lambda_t = \beta(1-\delta)\mathbb{E}_t\left(\frac{C_t}{C_{t-1}}\right) \tag{12}$$

$$1 = \Lambda_t \frac{1}{1-\delta}\mathbb{E}\left(R_t\right) \tag{13}$$

$$1 = \frac{1}{\nu_t}\Lambda_t \mathbb{E}\left(\nu_t + \frac{S_{N,t}}{N_t}\mathbb{E}_z(d_t(z))\right) \tag{14}$$

$$\frac{\chi L_t^{\eta^{-1}}}{w_t} = \frac{1}{C_t} \tag{15}$$

2.4 Monetary Policy

The central bank conducts monetary policy according to Taylor Rule:

$$\ln\frac{R_t}{R_{SS}} = \phi_R \ln\frac{R_{t-1}}{R_{SS}} + (1-\phi_R)\left(\phi_\pi \ln\frac{\pi_t}{\pi} + \phi_y \ln\frac{Y_t}{Y_{t-1}}\right) + \varepsilon_t^M$$

2.5 Aggregation

2.5.1 Pareto Distribution and the Variable Interest Rate

We assumed that the individual productivity z is drawn from the Pareto distribution $G(z)$. The conditional probability distribution of a surviving firm is:

$$G(z|z \geq \bar{z}_t) = \frac{dG(z)}{1-G(\bar{z}_t)} \tag{16}$$

Then, following from Ghironi and Melitz (2005) and Lewis and Poilly (2012), the surviving firms' average productivity $\tilde{z}_t$ is given by:

$$\tilde{z}_t = \left(\int_{\bar{z}}^{\infty} z^{\theta-1} dG(z|z \geq \bar{z}_t)\right)^{\frac{1}{\theta-1}} = \bar{z}_t\left(\frac{\kappa}{\kappa-\theta+1}\right)^{\frac{1}{\theta-1}} \tag{17}$$

According to Proposition 1, $R_t(z)$ decreases in z. For simplicity, we modeled $R_t(z)$ such that in aggregate, $\tilde{R}_t = R_t$:

$$\tilde{R}_t = \mathbb{E}_z[R_t(z)|z \geq \bar{z}] = R_t \tag{18}$$

One possible simple specification is to model $R_t(z)$ in a linear form:

$$R_t(z) = R_t + C\left(\tilde{z}^{\theta-1} - z\right) \tag{19}$$

, where C is a constant. Thus, from the specification it follows:

Proposition 2. *Assuming $R_t(z)$ has a form of Equation (19). Then, $\mathbb{E}_z[R_t(z)|z \geq \bar{z}] = R_t$.*

Proof.

$$\begin{aligned}
\mathbb{E}_z[R_t(z)|z \geq \bar{z}] &= \int_{\bar{z}}^{\infty} R_t(z)dG(z|z \geq \bar{z}_t) = \int_{\bar{z}}^{\infty} \left(R_t + C\left(\tilde{z}\theta - 1 - z\right)\right) dG(z|z \geq \bar{z}_t) \\
&= R_t + C\left(\tilde{z}^{\theta-1} - \int_{\bar{z}}^{\infty} z dG(z|z \geq \bar{z}_t)\right) = R_t + C\left(\tilde{z}^{\theta-1} - \tilde{z}^{\theta-1}\right) \\
&= R_t
\end{aligned}$$

□

2.5.2 Start-up Financing

Notice that household's utility value of $N_{E,t}$ in equilibrium can be given as follows:

$$\nu_t \left(S_{N,t} + \frac{\partial S_{N,t}}{\partial N_{E,t}} N_t\right) + \beta \mathbb{E}_t \left(\frac{C_t}{C_{t+1}} \nu_{t+1} \frac{\partial^2 S_{N,t}}{\partial N_{E,t}^2} N_{E,t+1}\right) \tag{20}$$

Note that the first term of Equation (20) represents the immediate success rate, while the second and third terms refer to the marginally decreased success rate today due to entry and the marginally increased success rate due to entry in the next period, respectively. Therefore, household's overall marginal benefit, in terms of consumption good from investing in the start up firm, is determined by Equation (20). Equating the marginal cost and benefit of investment give us the following free entry condition:

$$\int_{z \in \mathcal{Z}} \frac{w f_E}{Az} dz = \frac{w f_E}{A\tilde{z}} = \nu_t \left(S_{N,t} + \frac{\partial S_{N,t}}{\partial N_{E,t}} N_t\right) + \beta \mathbb{E}_t \left(\frac{C_t}{C_{t+1}} \nu_{t+1} \frac{\partial^2 S_{N,t}}{\partial N_{E,t}^2} N_{E,t+1}\right) \tag{21}$$

Finally, we define the competitive equilibrium in the model.

Definition 1. *The competitive equilibrium consists of a sequence of quantities $\{Y_t, C_t, L_t, S_t, H_t, N_t, \tilde{d}_t, \tilde{\mu}_t, \bar{d}_t, \bar{\mu}_t\}$ and prices $\{w_t, R_t, \nu_t, P_t, w_t, \tilde{p}_t, \bar{p}_t\}$ and exogenous variables $\{A_t, R_t\}$ that is characterized by the following:*

1. *Households maximize their utility subject to the budget constraint:*

2. *Each firm maximizes its profit subject to cost minimizing input conditional on variable interest rate and entry and exit decision: pricing, markup, marginal cost is individually satisfied.*

3. *Goods market clears:*

$$Y_t = C_t + S_{N,t}p\tilde{a}c_t + \nu N_{E,t} = d_t N_t + w_t L_t$$

4. *Labor market clears:*

$$L_t = \left(\int_{\mathcal{Z}} l_t(z)^{(\theta_W - 1)/\theta_W} dz \right)^{\theta_W/(\theta_W - 1)}$$

5. *financial market clears.*

3 Results

3.1 Calibration

Parameters	Value	Interpretation and Source
θ	3.8	Elasticity of substitution (Ghironi and Melitz, 2005)
θ_W	21	Elasticity of substitution of Labor Hartwig and Lieberknecht (2020)
f_E	1	Fixed cost of entry (Ghironi and Melitz, 2005)
β	0.99	Time discount (Ghironi and Melitz, 2005)
κ	3.4	Pareto distribution parameter (Ghironi and Melitz, 2005)
z_m	1	Minimum level of technology (normalized)
η	2	Frisch elasticity (Lewis and Poilly, 2012)
χ	12.5	Calibrated to match the steady state
f	0.03	Calibrated to match the steady state
Exit rate	12.06	Business Dynamics Statistics (1978-2014)
Entry rate	10.73	Business Dynamics Statistics (1978-2014)
τ	77	Price Stickiness (Bilbiie et al., 2012)
ϕ_R	0.8	Taylor Rule Parameter (Del Negro et al., 2015)
ϕ_π	1.5	Taylor Rule Parameter (Del Negro et al., 2015)
ϕ_y	0.125	Taylor Rule Parameter (Del Negro et al., 2015)

Table 1. Parameters used to calibration.

Table 1 describes the parameters used in the calibration of the model. Entry rate and exit rate are matched to the Business Dynamics Statistics data in the steady-state. Two parameters χ and f are calculated from the steady-state to match the market clearing condition. [4]

3.2 Benchmark Model

The analysis of the monetary policy transmission mechanism within the context of firm entry and exit provides compelling insights into the interplay between policy

[4]Calculation of steady-state is presented in the Appendix B.

interventions and market dynamics. The model's response to an expansionary monetary policy shock, as depicted in Figure 4, illustrates a complex pattern in responses across various macroeconomic variables, suggesting that the dynamics of average productivity are instrumental in understanding these responses.

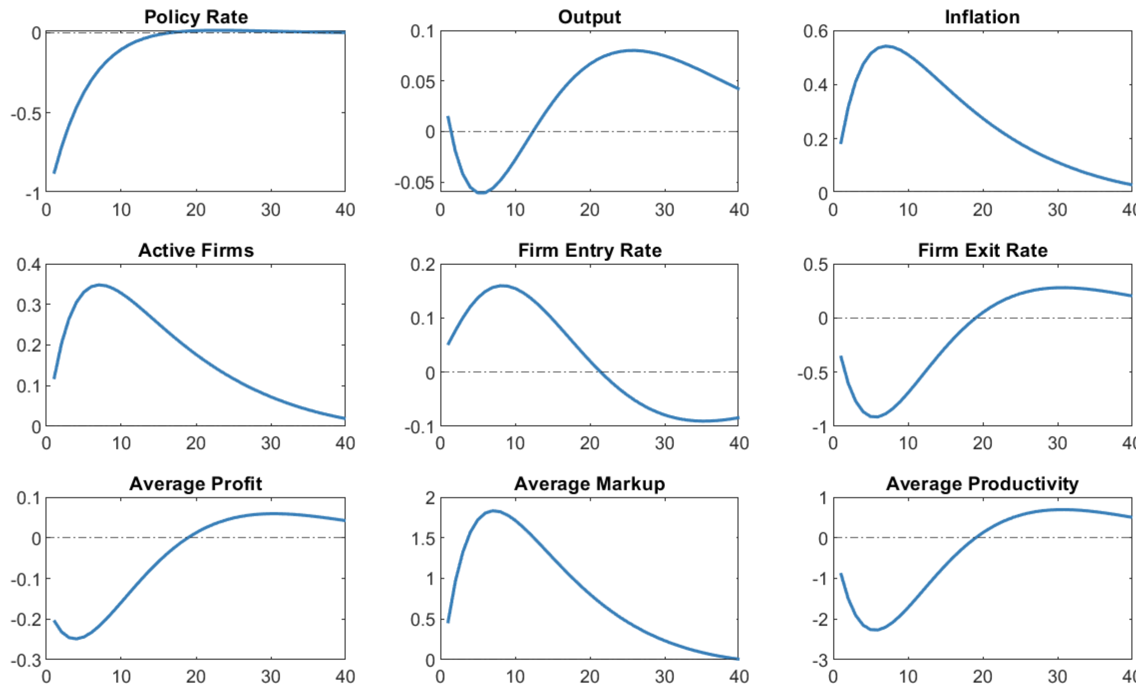

Figure 4. Impulse responses of the macroeconomic variables under expansionary monetary policy.

Number of active firms initially increase, indicating a surge in market participation as borrowing costs diminish. This increase is, however, not persistent and is followed by a decline, which may reflect market capacity constraints or the diminishing stimulatory effects of the policy. The firm entry rate shows a significant peak before declining, indicating the temporary impact of the policy. Interestingly, the firm exit rate inversely mirrors the entry rate's trajectory, suggesting that the policy may have temporarily deterred exits, only for them to resume as the policy's effects wane.

In terms of profitability, the initial decline in average profit following the policy shock suggests that while entry barriers may be lowered, the consequent competition or cost pressures could erode profit margins. This is followed by a recovery, likely as a result of market adjustments and firm exits, which restore equilibrium. The average markup follows a similar pattern, initially spiking as firms possibly capitalize on increased demand before falling back, likely due to competitive pricing strategies or market saturation.

Average productivity exhibits the most notable response, with a sharp decline indicating that the entry of less productive firms may diminish the overall productivity. This is significant, as it indicates that while policy can stimulate economic activity, it may also allow the survival or entry of less efficient firms, potentially leading to inefficient resource allocation.

The model's findings highlight the dual effect of the policy rate on aggregate demand, through increased consumption, and on aggregate supply, by impacting firm costs and productivity thresholds. The cost channel seems to lower the cutoff productivity by reducing fixed operation costs, affecting the market's entry and exit dynamics and average productivity. This provides an essential insight for policymakers aiming to encourage a competitive yet stable economic environment.

$$\begin{aligned}\pi_t(z) &= \frac{p_t(z)}{P_t}\left(1 - \mathcal{M}_t(z)^{-1} - pac_t(z)\right) y_t(z) - \frac{f}{A_t} R_t(z) \\ &= \underbrace{\frac{p_t(z)}{P_t} y_t(z)}_{\text{(1) Increased Demand}} - \underbrace{\frac{p_t(z)}{P_t} pac_t(z) y_t - \mathcal{M}_t(z)^{-1} y_t(z)}_{\text{(3) Increased Cost}} - \underbrace{\frac{f}{A_t} R_t(z)}_{\substack{\text{(2) Decreased} \\ \text{Borrowing Cost}}}\end{aligned}$$

As we explore further the supply side of the transmission mechanism, the borrowing cost emerges as a crucial factor. The model suggests that lower borrowing costs, stemming from a decreased policy rate, directly impact the threshold productivity level, affecting firm behavior in terms of output and inflation. The increased attractiveness of equity investments, following the policy shock, further intensifies this effect, leading to a surge in firm entries. This phenomenon stresses the intricate relationship between financial markets and real economy responses to monetary interventions.

Figure 5 and Figure 6 emphasize on the role of adjustment costs, which not only extend but also amplify the initial decrease in output. The shift from bonds to equities in the short term, leading to increased firm entries, highlights the adjustment costs' role in shaping the market's response and potentially leading to a more dynamic but volatile firm environment.

Despite data constraints, the empirical analysis (Figure 1 and Figure 2) provide context for the model's predictions. The patterns observed in firm entry and exit offer

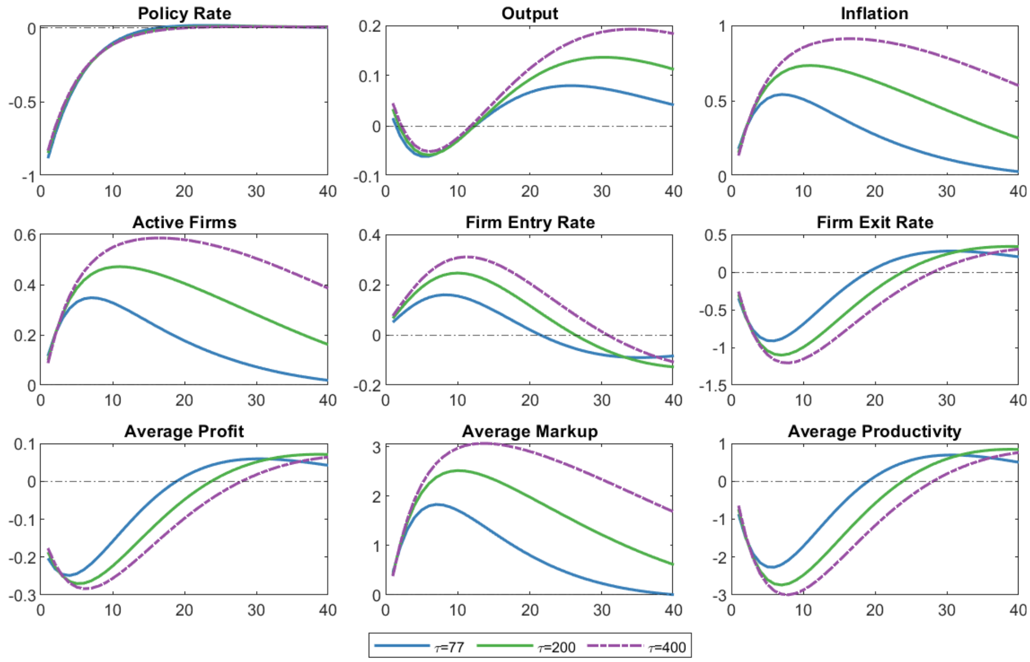

Figure 5. Impulse response of the macroeconomic variables under expansionary monetary policy, benchmark model with different values of τ.

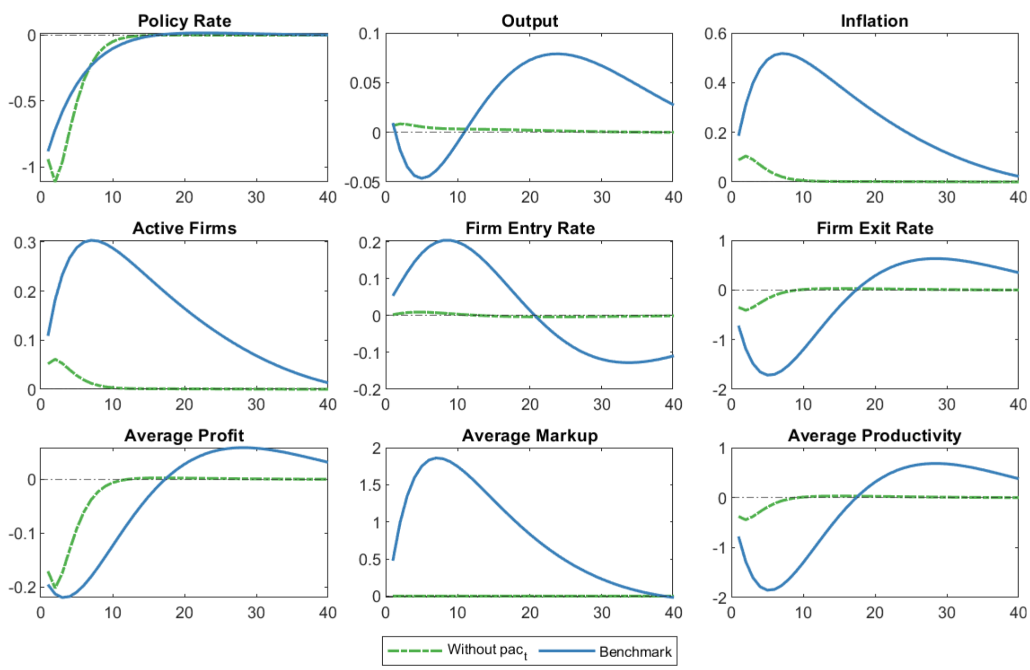

Figure 6. Impulse response of the macroeconomic variables under expansionary monetary policy, benchmark model and the model without price adjustment cost.

a degree of empirical support and highlight further areas for investigation. While the impact of monetary policy on firm dynamics is not explicitly clear from the data, there is an indication of an effect on firm entry rates, consistent with the theoretical model.

The empirical findings present a complex scenario. An initial examination suggests a possible expansionary impact on firm entry, but the clarity of this effect is less certain when employing local projection techniques. While the entry rate appears to be responsive to monetary policy shocks, the exit rate does not show a significant response and seems to decline over a three-year period. This divergence in responses between entry and exit rates raises critical questions about the channels through which monetary policy operates and highlights the necessity for a novel approach to policy formulation that encompasses the complex responses of economic agents to a policy change.

In summary, the model's analysis, in line with empirical observations, suggests that monetary policy affects firm entry and exit dynamics in a complex manner. The interplay between adjustment costs, demand, and supply effects illustrates the sophisticated nature of policy transmission mechanisms. Future research should further clarify these dynamics and explore the implications of policy interventions on the market structure and productivity.

3.3 Comparative Analysis of Model Impulse Responses Under Different Assumptions

This section presents a comparative analysis of the impulse responses generated by the benchmark model under different assumptions in response to an expansionary monetary policy. The objective is to systematically compare how different modeling approaches — particularly the introduction of differential borrowing costs through the lens of size dependent policy rate — affect the behavior of key macroeconomic indicators following a policy shock. Through this comparison, we aim to identify critical differences in the predicted outcomes of these models, providing insights into the underlying mechanisms that drive responses to monetary policy.

This analysis contrasts the model detailed in our study, which incorporates size dependent interest rates, against a model that omits this feature, as well as against a more simplified model excluding both firm entry/exit dynamics and size dependent interest rates.

In the model without size dependent policy rate, the impulse responses to an

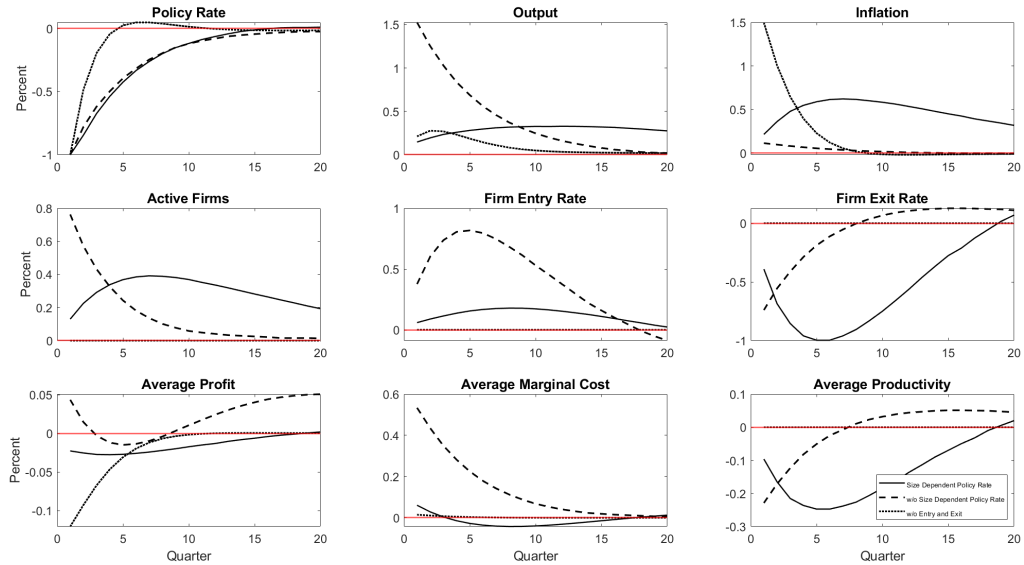

Figure 7. Impulse responses of the macroeconomic variables under expansionary monetary policy, benchmark model, benchmark model without variable policy rate, and benchmark model without entry/exit and variable policy rate.

expansionary monetary policy shock mirrors the outcomes observed by Hartwig and Lieberknecht (2020): output surges by 1.5 percent, and inflation rises by 0.1 percentage points. These results, while reflective of an idealized view of monetary policy effectiveness, departs from empirical benchmarks by not fully capturing the intricate dynamics between monetary policy and the diverse responses at the firm level. The alignment of the results with Hartwig and Lieberknecht (2020) under a simplified framework underscores the significant role that size-dependent interest rates play in bridging the gap between theoretical models and the empirical realities of monetary policy's impact on the economy.

In the model without size dependent policy rate, the impulse responses to an expansionary monetary policy shock shows that the presence of sticky wages results in a scenario where firms experience a lag in adjusting wages, thereby achieving enhanced sales and profitability. This is reflected in the impulse responses presented in Figure 7, which show a significant increase in profits, thereby elevating firm valuations and motivating firm entry, thereby indicating a procyclical trend in the number of active firms. Conversely, average productivity diminishes, attributed to the engagement of lower-productivity firms in production, a direct consequence of the reduced profit threshold and increased firm valuation.

In the model featuring size dependent borrowing costs, the impulse responses to a similar expansionary monetary policy exhibit a distinctively subtle reaction . This differentiation primarily arises from the model's unique premise that the nominal interest rate varies according to each firm's productivity level. This departure from traditional models directly affects firms' borrowing costs, thereby altering the thresholds for firm entry and exit. The reduction in the policy rate induce an increase in active firms, attributed to the diminished barriers to entry resulting from reduced borrowing costs. While this initial increase parallels the observations in the model excluding a size dependent policy rate, the patterns of firm entry and exit in the present model display more propagated responses to a policy rate change.

Furthermore, the model predicts an initial drop in average productivity, mirroring trends in the model without size dependent policy rate, but arising from fundamentally different causes. Here, the decline in productivity is precipitated by the entrance of a wider array of firms, facilitated by the variable interest rates. In contrast to the model lacking a size dependent policy rate, where productivity changes are linked solely to wage adjustments, the observed decrease in productivity in this context is also a direct result of the monetary policy's effect on the borrowing environment.

In the standard framework (benchmark model without entry/exit and variable policy rate), the response of output to a monetary policy shock is notably more pronounced, with an impact roughly double that observed in our benchmark model. This amplified reaction is indicative of the model's simplified structure, where the homogeneous influence of policy does not contend with the complexities of firm heterogeneity. It is the absence of entry and exit dynamics that leads to this overstatement, failing to capture the market's endogenous self-regulatory behavior that naturally tempers such fluctuations.

Inflation, similarly, responds with a pronounced sensitivity in the standard model, tripling the response seen in the benchmark. This discrepancy arises from the lack of a variable interest rate mechanism, which, in our model, introduces a tiered system of firm financing that dampens the transmission of policy into prices. Without this feature, the standard model exhibits an inflation response that lacks moderation through the differential costs of borrowing, which in reality, buffer the economy against such sharp increases in the price level.

4 Conclusion

This paper develops a small New Keynesian model incorporating Hopenhayn's entry and exit framework to examine the impact of monetary policy on the extensive margin of the production sector, particularly when firms' borrowing costs vary according to their productivity levels. Through three distinct mechanisms — the demand channel, increased costs, and the borrowing cost channel — monetary policy encourages firm entry not only by altering the trade-off between equity and bond investments but also by directly lowering borrowing expenses. Moreover, the model's current calibration reveals that the presence of an alternative financial instrument hinders the output's expansionary response, an effect that is further magnified by cost channels.

The main limitation of this study is twofold. First, the absence of publicly available data restricts a comprehensive empirical analysis. Despite the authors' best efforts, data on quarterly or monthly firm entry and exit rates were unavailable. Second, the model does not explore optimal monetary policy. Instead, it introduces the potential for an alternative policy that is more favorable to small businesses by reducing interest rate variability among different firms, as suggested in Appendix C. Preliminary findings indicate that by attenuating the direct demand channel, the initial decrease in output is mitigated, allowing the economy to support an increase in firms and employment at lower costs. The application of this policy and welfare analysis under the proposed framework remains a topic for future research.

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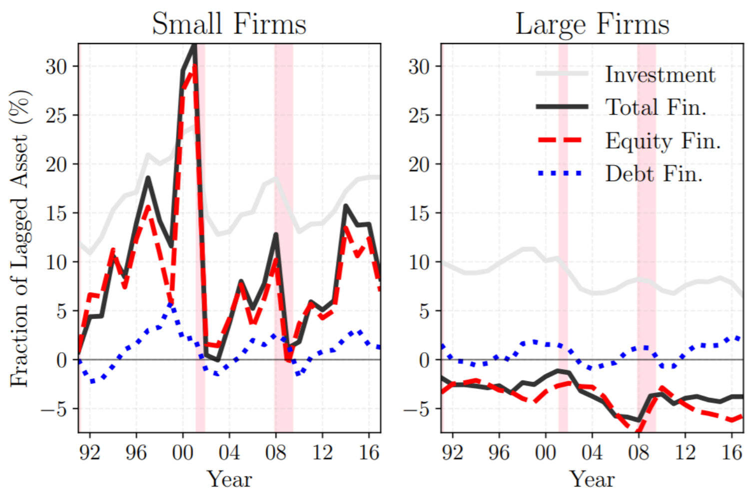
Appendix

A Financing Option by Size



A1. Channel of financing by firm size (Guo, 2020)

B Calculation of the Steady-State

We will solve the model for zero-inflation steady state. Normalizing technology, labor endowment, and exogenous entry cost, we have:

$$A_{SS} = 1 \tag{22}$$
$$L_{SS} = 1 \tag{23}$$
$$f_E = 1 \tag{24}$$
$$\pi = 1 \tag{25}$$
$$\pi^C = 1 \tag{26}$$

Household's bond Euler equation and definition of stochastic discount factor implies that:

$$\beta R_{SS} = \pi_{SS} \tag{27}$$
$$\Lambda_{SS} = \beta(1-\delta) \tag{28}$$

Firm's optimization with Equation (25) implies:[5]

$$\tilde{\mu}_{SS} = \frac{\theta}{\theta - 1} \tag{29}$$
$$\tilde{\pi}_{SS} = (1 - \tilde{\mu}_{SS}^{-1})\frac{C_{SS}}{S_{SS}} - f w_{SS} R_{SS}^{\vartheta} \tag{30}$$
$$\tilde{\rho}_{SS} = \tilde{\mu}_{SS}\tilde{mc}_{SS} = S_{SS}^{\frac{1}{\theta-1}} \tag{31}$$
$$\tilde{mc}_{SS} = \frac{w_{SS}}{\tilde{z}_{SS}} \tag{32}$$
$$\tilde{y}_{SS} = \frac{Y_{SS}^{C}}{\tilde{\rho}_{SS} S_{SS}} \tag{33}$$
$$\bar{\mu}_{SS} = \frac{\theta}{\theta - 1} \tag{34}$$
$$\bar{\pi}_{SS} = (1 - \tilde{\mu}_{SS}^{-1})\bar{\rho}_{SS}\bar{y}_{SS} - f w_{SS} R_{SS}^{\vartheta} = 0 \tag{35}$$
$$\bar{\rho}_{SS} = \bar{\mu}_{SS}\bar{mc}_{SS} \tag{36}$$
$$\bar{mc}_{SS} = \frac{w_{SS}}{\bar{z}_{SS}} \tag{37}$$
$$\bar{y}_{SS} = \tilde{y}_{SS}\left(\frac{\bar{z}_{SS}}{\tilde{z}_{SS}}\right)^{\theta} \tag{38}$$

[5] On average and for the threshold firm

Firm's entry condition together with the definition of steady state ($\frac{H_t}{H_{t-1}} = \frac{H_{SS}}{H_{SS}} = 1$) implies:

$$\Psi_{SS} = 1 - F\left(\frac{H_{SS}}{H_{SS}}\right) = 1 \tag{39}$$

$$\Psi_{1,SS} = 0 \tag{40}$$

$$\Psi_{2,SS} = 0 \tag{41}$$

$$w_{SS} = \nu_{SS}(\Psi_{SS} + \Psi_{1,SS}H_{SS}) + \beta\nu_{SS}\Psi_{2,SS}H_{SS} = \nu_{SS} \tag{42}$$

Furthermore, based on the firm's entry and exit dynamics and given the steady-state exit rate, ζ_{SS}, we are able to determine the steady-state threshold level. This allows us to compute both the number of surviving firms and the total number of firms at the steady-state, using Equation (39).

$$\bar{z}_{SS} = \frac{z_m}{(1 - \zeta_{SS})^{1/\kappa}} \tag{43}$$

$$\tilde{z}_{SS} = \left(\frac{\kappa}{\kappa - (\theta - 1)}\right)^{\frac{1}{\theta-1}} \bar{z}_{SS} \tag{44}$$

$$N_{SS} = \frac{1 - \delta}{\delta} H_{SS} \tag{45}$$

$$S_{SS} = (1 - \zeta_{SS})N_{SS} \tag{46}$$

From the household's Euler equation for equity, we can get an expression relating ν, S/N and $\tilde{d}$ in the steady state:

$$(1 - \Lambda_{SS})\nu_{SS} = \Lambda_{SS}\frac{S_{SS}}{N_{SS}}\tilde{d} \tag{47}$$

Lastly, market clearing implies:

$$Y_{SS} = C_{SS} + \nu_{SS}H_{SS} = w_{SS}L_{SS} + \tilde{d}_{SS}S_{SS} \tag{48}$$

$$Y^C_{SS} = C_{SS} \tag{49}$$

$$I_{SS} = \nu_{SS}H_{SS} \tag{50}$$

$$\pi_{SS} = \bar{d}_{SS}S_{SS} \tag{51}$$

We can further rewrite Equation (48) by substituting in the results and rearranging as follows:

$$
\begin{aligned}
& C_{SS} + \nu_{SS} H_{SS} = w_{SS} + \tilde{d}_{SS} S_{SS} \\
\Rightarrow & \frac{\tilde{\mu}_{SS}^{-1}\tilde{d}_{SS} + f\nu_{SS}R_{SS}^{\vartheta}}{1-\tilde{\mu}_{SS}^{-1}} S_{SS} = (1-H_{SS})w_{SS} && \Leftarrow \text{Plugging in Equation (42)} \\
\Rightarrow & \frac{\tilde{\mu}_{SS}^{-1}\tilde{d}_{SS} + f w_{SS}R_{SS}^{\vartheta}}{1-\tilde{\mu}_{SS}^{-1}} S_{SS} = (1-H_{SS})w_{SS} && \Leftarrow \text{Plugging in Equation (30)} \\
& \frac{\tilde{\mu}_{SS}^{-1}\Theta + 1}{1-\tilde{\mu}_{SS}^{-1}} f w_{SS} R_{SS}^{\vartheta} S_{SS} = (1-H_{SS})w_{SS} && \Leftarrow \text{Plugging in } \frac{\tilde{d}_{SS}}{w_{SS}} \\
& \frac{\tilde{\mu}_{SS}^{-1}\Theta + 1}{1-\tilde{\mu}_{SS}^{-1}} f R_{SS}^{\vartheta} S_{SS} = 1 - \frac{\delta}{1-\delta} N_{SS} && \Leftarrow \text{Plugging in Equation (45)} \\
& \frac{\tilde{\mu}_{SS}^{-1}\Theta + 1}{1-\tilde{\mu}_{SS}^{-1}} f R_{SS}^{\vartheta} \frac{1-\beta(1-\delta)}{\beta(1-\delta)} \frac{1}{\Theta f R_{SS}^{\vartheta}} N_{SS} = 1 - \frac{\delta}{1-\delta} N_{SS} && \Leftarrow \text{Plugging in } \frac{S_{SS}}{N_{SS}}
\end{aligned}
$$

Arranging the terms to get a closed-form solution for N_{SS}:[6] [7]

$$
N_t = \left(\frac{\tilde{\mu}_{SS}^{-1} + \Theta^{-1}}{1-\tilde{\mu}_{SS}^{-1}} \frac{1-\beta(1-\delta)}{\beta(1-\delta)} + \frac{\delta}{1-\delta} \right)^{-1} \tag{52}
$$

[6] Note that in the third line, $\frac{\tilde{d}_{SS}}{w_{SS}}$ is calculated as follows. First, note that using from Equation (31) to Equation (33), Equation (37) and Equation (38), $\bar{\rho}_{SS}\bar{y}_{SS}$ can be re-written as follows:

$$
\bar{\rho}_{SS}\bar{y}_{SS} = \frac{\bar{\rho}_{SS}}{\tilde{\rho}_{SS}} \left(\frac{\bar{z}_{SS}}{\tilde{z}_{SS}}\right)^{\theta} \frac{Y_{SS}^C}{S_{SS}} = \frac{\bar{\mu}_{SS}\tilde{m}c_{SS}}{\tilde{\mu}_{SS}\tilde{m}c_{SS}} \left(\frac{\bar{z}_{SS}}{\tilde{z}_{SS}}\right)^{\theta} \frac{Y_{SS}^C}{S_{SS}} = \left(\frac{\kappa}{\kappa-(\theta-1)}\right)^{-1} \frac{Y_{SS}^C}{S_{SS}}
$$

Plugging the result in Equation (35), while noting the equivalence of Equation (30) and Equation (34) in the steady state will yield:

$$
\begin{aligned}
& f w_{SS} R_{SS}^{\vartheta} = (1-\tilde{\mu}_{SS}^{-1}) \left(\frac{\kappa}{\kappa-(\theta-1)}\right)^{-1} \frac{Y_{SS}^C}{S_{SS}} \\
\Rightarrow & (1-\tilde{\mu}_{SS}^{-1}) \frac{Y_{SS}^C}{S_{SS}} = \frac{\kappa}{\kappa-(\theta-1)} f w_{SS} R_{SS}^{\vartheta}
\end{aligned}
$$

Then, using Equation (49), we can rewrite Equation (30):

$$
\begin{aligned}
& \tilde{d}_{SS} + f w_{SS} R_{SS}^{\vartheta} = (1-\tilde{\mu}_{SS}^{-1}) \frac{Y_{SS}^C}{S_{SS}} \\
& \qquad = \frac{\kappa}{\kappa-(\theta-1)} f w_{SS} R_{SS}^{\vartheta} \\
\Rightarrow & \tilde{d}_{SS} = f R_{SS}^{\vartheta} \left(\frac{\theta-1}{\kappa-(\theta-1)}\right) w_{SS} \equiv \Theta f R_{SS}^{\vartheta} w_{SS}
\end{aligned}
$$

[7] Similarly, the fifth line is derived below. Plugging the expression of $\bar{d}_{SS}$ in the previous footnote

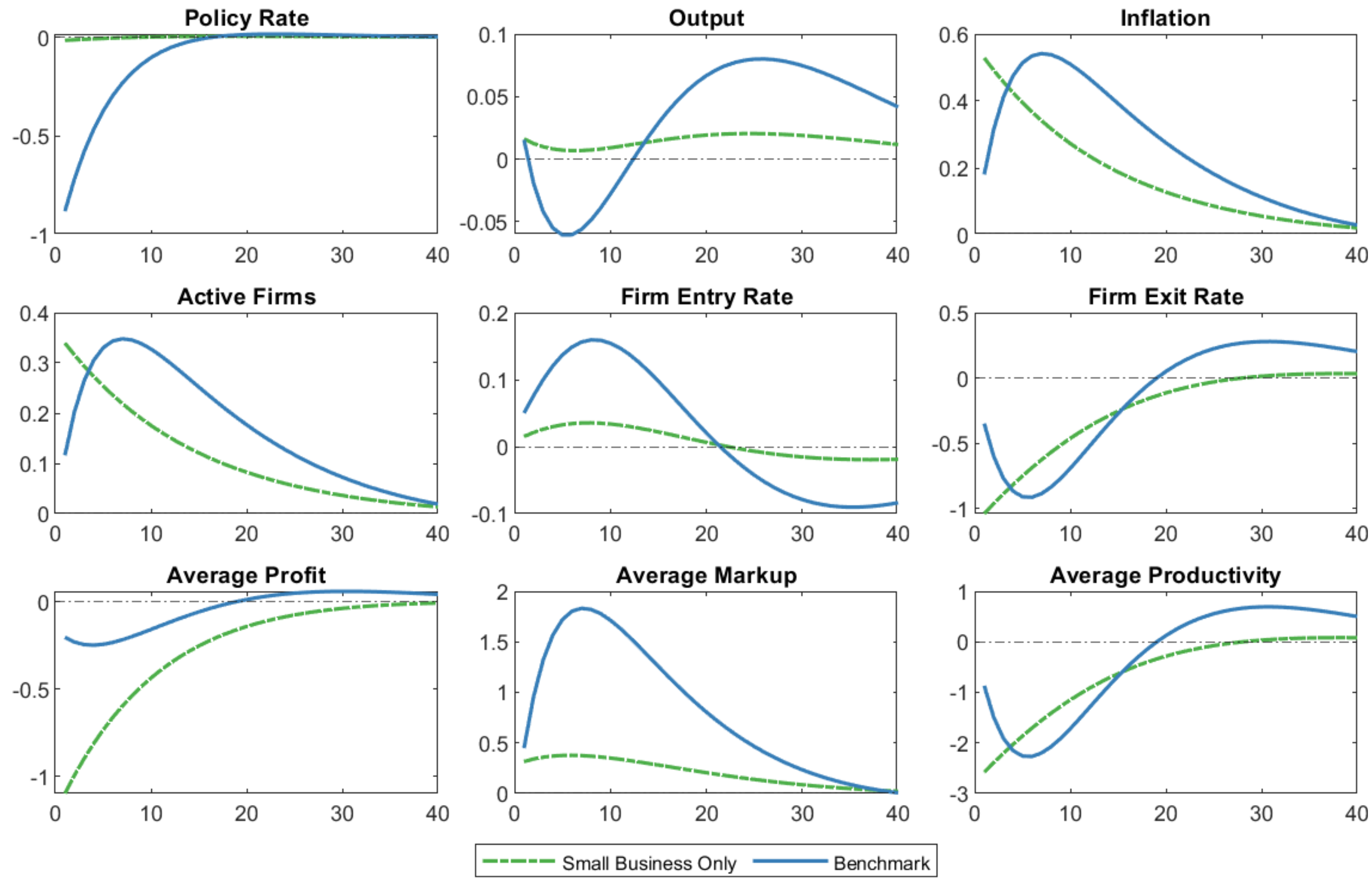
Lastly, the parameters χ and the fixed cost f is numerically calculated in a way that it satisfies the accounting equation.

---

into Equation (47) yields:

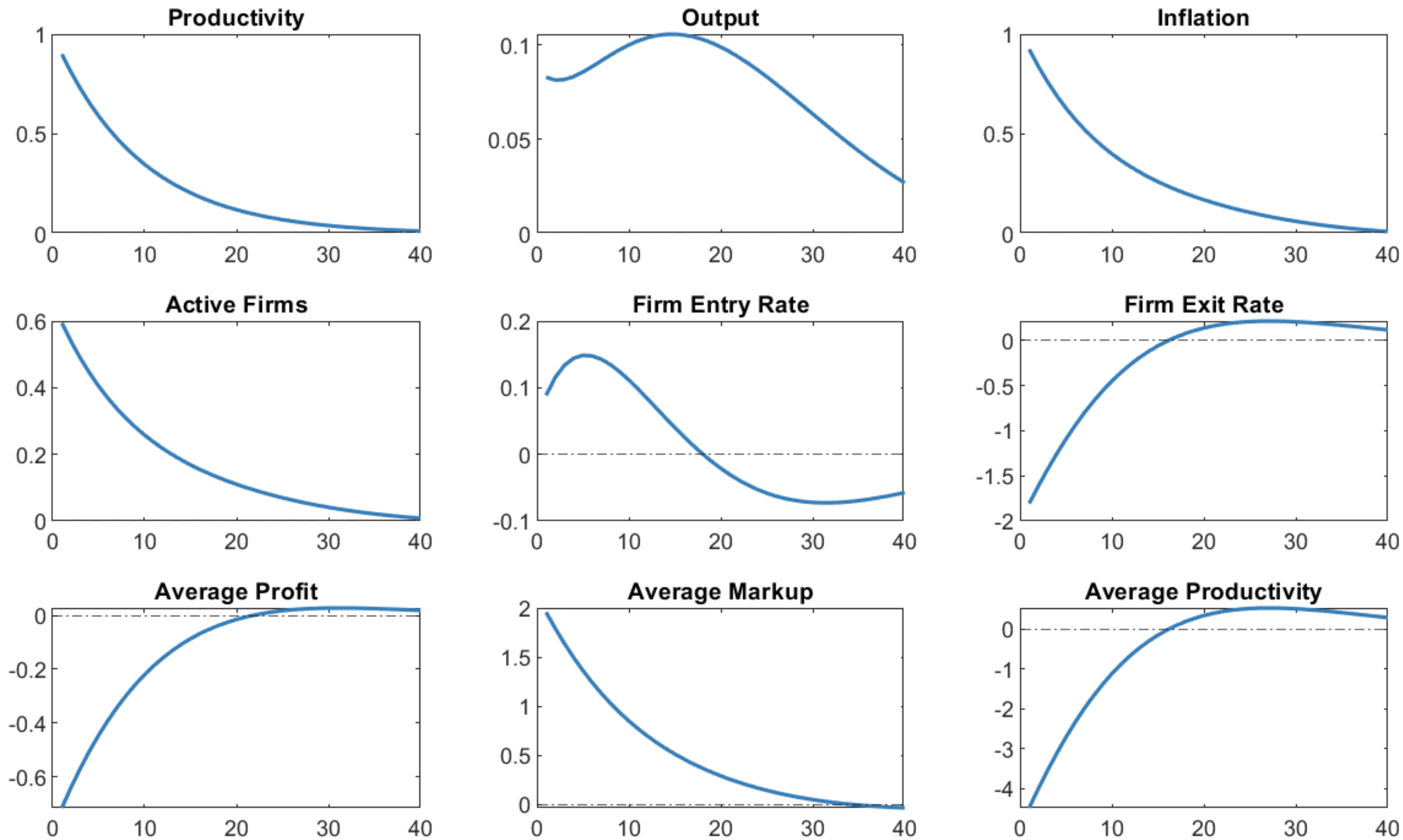
$$
\begin{aligned}
1 &= \beta(1-\delta)\left(1 + \frac{S_{SS}}{N_{SS}} \Theta f R_{SS}^{\vartheta}\right) \\
\Rightarrow \frac{S_{SS}}{N_{SS}} &= \frac{1-\beta(1-\delta)}{\beta(1-\delta)} \frac{1}{\Theta f R_{SS}^{\vartheta}}
\end{aligned}
$$

C Additional Impulse Responses



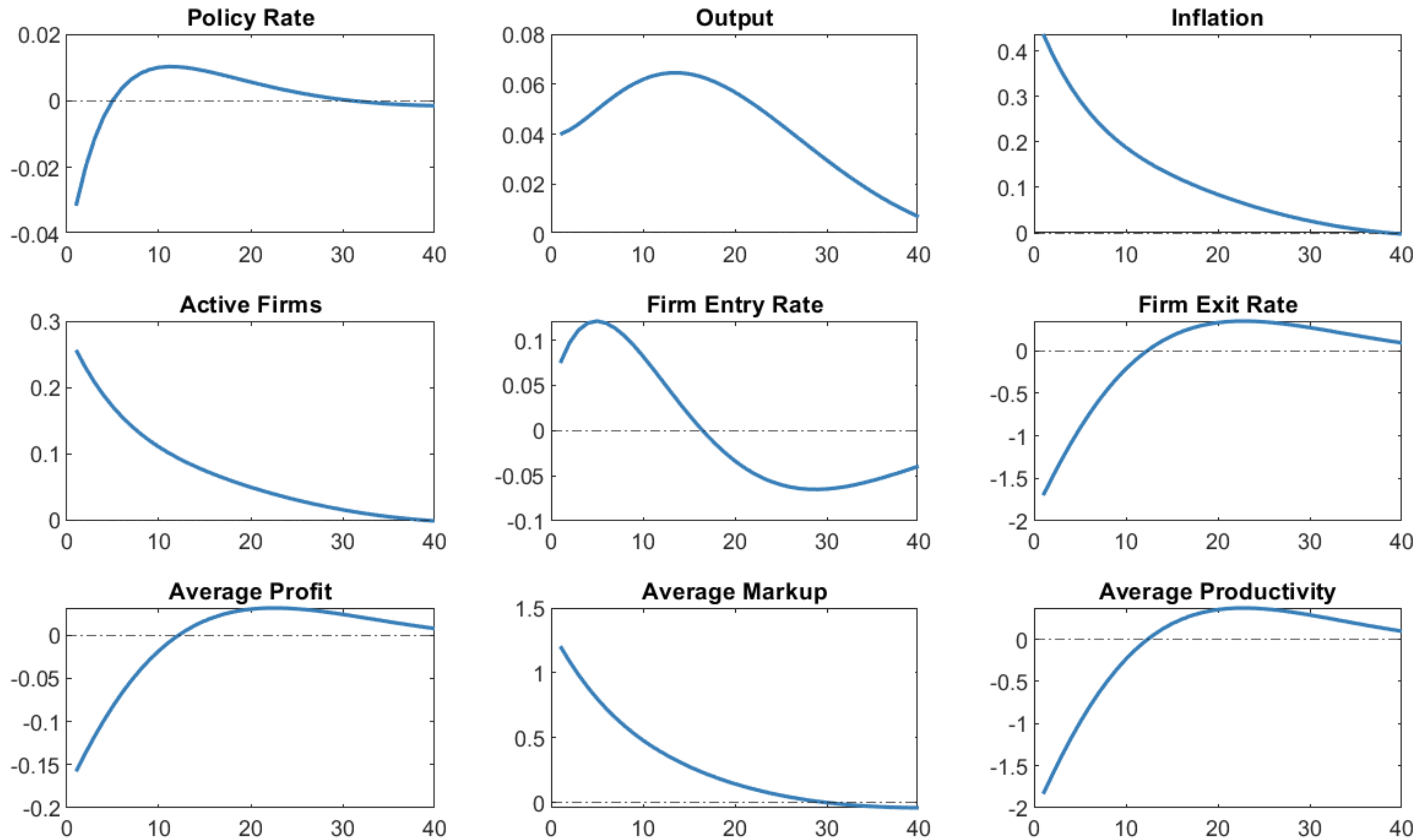
A2. Impulse response of the macroeconomic variables under expansionary monetary policy and the hypothetical small business friendly policy.

C.1 Technological Shock



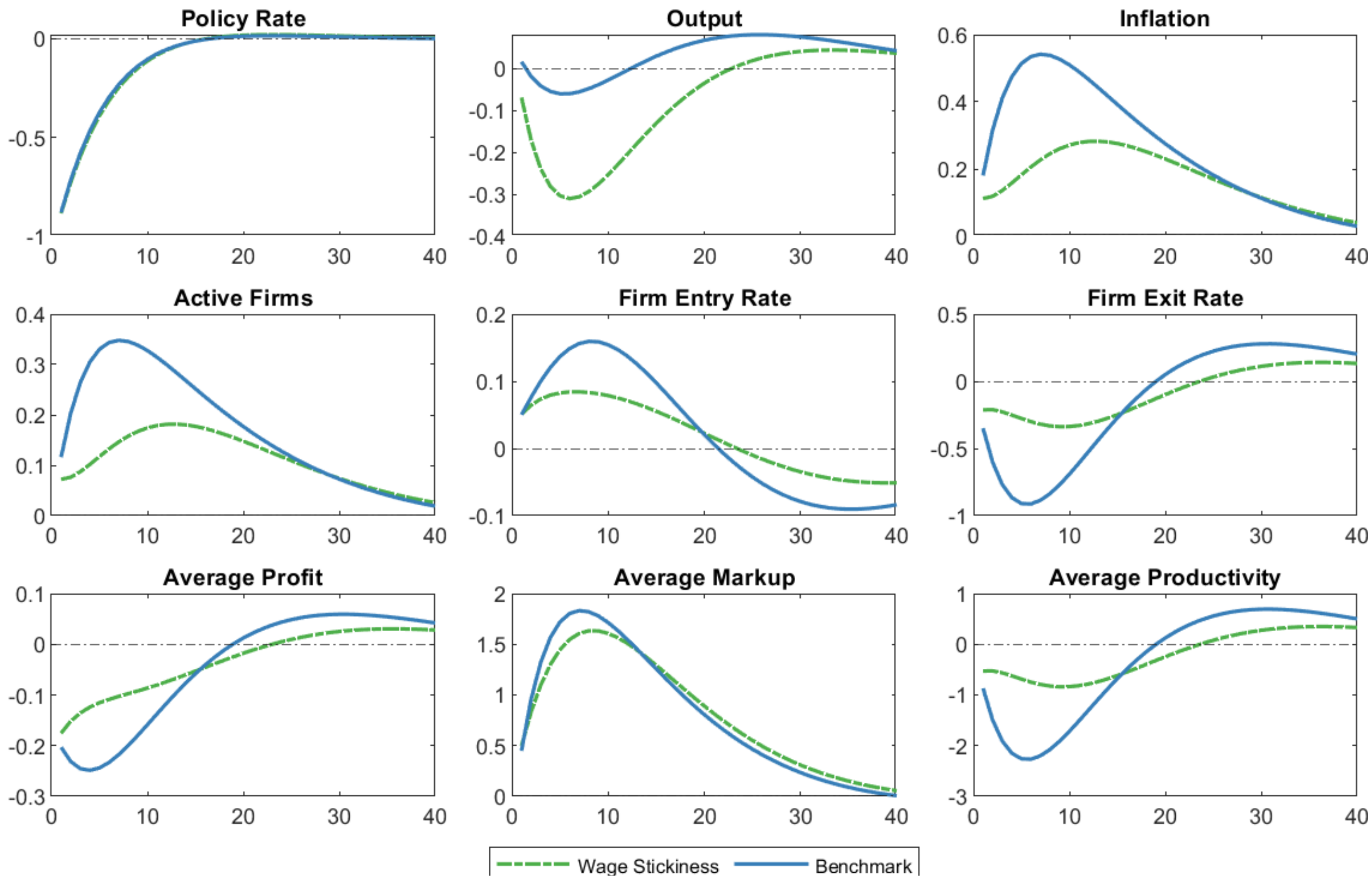
A3. Impulse response of the macroeconomic variables in response to 1% increase in the aggregate production technology.

C.2 Demand Shifting Shock



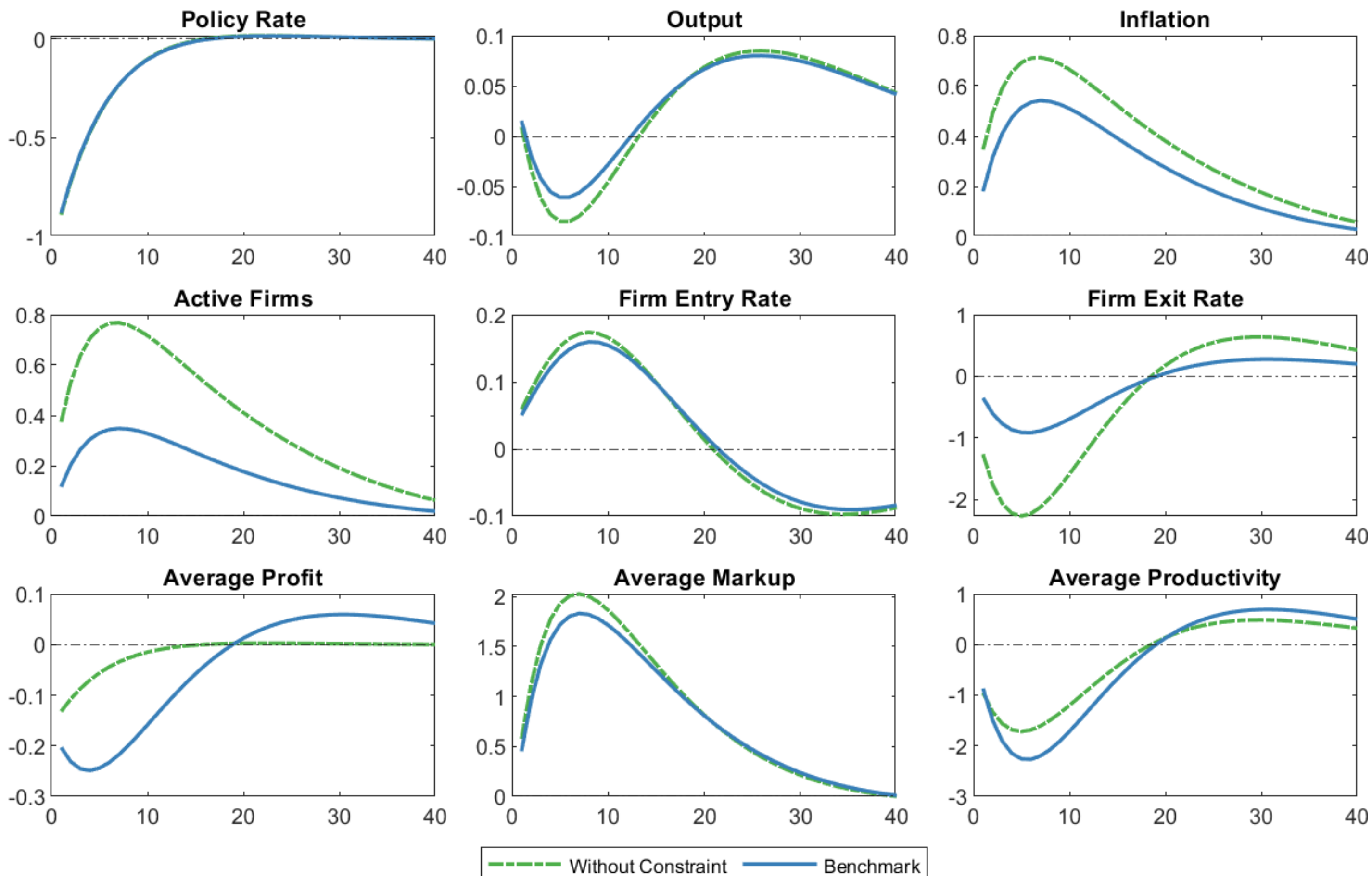
A4. Impulse response of the macroeconomic variables in response to 1% increase in the demand.

C.2.1 Extension: With Wage Adjustment Cost



A5. Impulse response of the macroeconomic variables under expansionary monetary policy, benchmark model and the model with wage stickiness.

C.3 Extension: Without the Variable Interest Rate



A6. Impulse response of the macroeconomic variables under expansionary monetary policy, benchmark model and the model without variable interest rate.