# 1 Introduction

An emerging body of empirical studies in economics and finance have shed light on the rise of "superstar firms" and the potential economic consequences of this trend (Autor *et al.*, 2020). Traditional wisdom, known as the Gibrat's law, posits that expected firm growth rates are independent of size, and that the distribution of firm sizes is log normal and stable over time (e.g., Simon and Bonini, 1958; Mansfield, 1962). This view, however, is challenged by subsequent studies, which present convincing evidence that firm distribution not only is significantly right-skewed (e.g., Axtell, 2001; Lotti and Santarelli, 2004), but also exhibits noticeable cross-country differences (e.g., Alfaro *et al.*, 2009; Bento and Restuccia, 2017). These findings have ignited a heated debate on the underlying economic factors and transmission mechanisms shaping the distribution of firm sizes.

The seminal work of Luttmer (2007) provides insightful theoretical explanations to the empirical phenomenon of right-skewed firm distribution, also known as the Zipf's law (Axtell, 2001). It emphasizes the impact of entry, fixed costs, and imitation on firm size distributions. However, the literature lacks comprehensive theoretical studies formally assessing how firm distributions respond to the policy instruments in the government's toolbox. To fill this gap, this study proposes an R&D-based general equilibrium model. We explore the impacts of monetary and fiscal policies on firm size distribution, labor reallocation, economic growth, and social welfare, which can provide important implications on theory-based policy-making.

Inspired by Klette and Kortum (2004), we develop a Schumpeterian growth model with heterogeneous firms in terms of their number of product lines.[1] Extending their framework, we impose a cash-in-advance (CIA) constraint on households' consumption to introduce money into the model economy, where we assume that the supply of money is precisely controlled by the monetary authority. Monetary policy and financing constraints are of particular relevance in our theoretical exposition for a few reasons. On the one hand, existing studies suggest that financial constraints play a critical role in determining firm distributions and dynamics (Cooley and Quadrini, 2001; Desai *et al.*, 2003). Specifically, Cabral and Mata (2003) find that incorporating financial constraints into a simple model can account for the key patterns of the evolution of firm size distributions exhibited among Portuguese manufacturing firms.[2] On the other hand, a fast-growing empirical literature highlights the linkages between monetary policy shocks and firm sizes. For instance, using high-frequency interest rate shocks, Kroen *et al.* (2021) demonstrate that reducing interest rate in an already low interest rate environment favors industry leaders and promotes the creation of superstar firms. In this study, we attempt to explore the transmis-

[1] This framework is known for adequately capturing the key pattern of firm size distributions in the real-world data.

[2] Beck *et al.* (2008) also show that financial development also boosts the growth of small firms. In contrast, Angelini and Generale (2008) suggest that financial constraints seem not the main determinant of the firm size distribution evolution. Their importance is negatively related to the development of the financial system.

sion mechanism of monetary policy, along with its economic consequences, through the lens of endogenous R&D investment decisions.

In our theoretical model, the role of the fiscal authority is multifaceted. First, the government employs labor to produce public goods and services, which are valued by households, and hence, enter their utility function. Second, the fiscal authority is responsible for infrastructure construction. We assume that a higher degree of infrastructure development can boost the productivity of both incumbent and entrant R&D firms, in the spirit of Aghion *et al.* (2016). This assumption is motivated by the empirical evidence in the study of Ma *et al.* (2021), which leverages the high-speed railway construction in China as a quasi-natural experiment and identifies a strong promoting effect of infrastructure development on innovation and entrepreneurship. Additionally, the fiscal authority collects revenue primarily through the levying of corporate income taxes to balance the budget.[3] This process unavoidably introduces distortions. We explicitly specify and emphasize the role of the fiscal authority because there is an ongoing debate about the impact of institutional factors and tax regimes on firm distribution. Exploiting French firm data, Garicano *et al.* (2016) investigate the effect of size-contingent law on firm distribution, productivity and welfare. They find that this regulation benefits particularly small firms with few employees and hurts workers. In a recent study, Gallemore and Maydew (2023) investigate the potentially asymmetric effect of corporate tax on small and large firms. They find no systematic evidence that the tax system benefits large superstar firms. In this study, we demonstrate how taxation and infrastructure development can shape the distribution of firm sizes through affecting incumbent and entrant firms' R&D investment decisions, and explore their growth and welfare implications.

In this study, we find that an increase in the nominal interest rate can enhance the R&D intensity of both incumbent and entrant firms, leading to a higher rate of innovation for these firms. In addition, an increase in the corporate income tax rate can promote R&D investment in incumbent firms through improvements in infrastructure. This increase in infrastructure development results in a higher rate of innovation and an expansion in the sizes of incumbent firms. However, it potentially reduces the R&D intensity and innovation rate of entrant firms. Consequently, a rise in the corporate income tax rate leads to an increased proportion of large firms in the market.

In this study, we calibrate the theoretical model to the US economy. Our quantitative analysis shows that raising the nominal interest rate from the baseline level to 10% would increase the rate of technological progress or economic growth by 0.69 percentage points. However, it would also

[3] In the baseline model, we also assume that the monetary authority transfers its seigniorage revenue to the fiscal authority for the development of infrastructure projects. This assumption is motivated by the findings demonstrating the empirical relevance of seigniorage revenue. Neumann (1992) suggests that the traditional monetary seigniorage in the US is around $14 billion per annum during 1980s. Following the method in Cukierman *et al.* (1989), Andrabi (1997) indicates that seigniorage accounts for a non-negligible fraction of total government revenue, averaging 2.3% in the US and 8.3% in Japan between 1971 and 1982. In the sensitivity analysis, we also consider the conventional model specification (as in Chu and Cozzi, 2014, among others), where seigniorage revenue is not directed to fund infrastructure development but is instead reallocated to households in the form of lump-sum transfers.

lead to an increase in the inflation rate from 2.18% to 4.39%. This phenomenon can be attributed to the fact that a higher nominal interest rate can increase the government's seigniorage revenue, which can be invested in infrastructure development, thereby enhancing the innovation efficiency and market entry rate. As a consequence, the average firm size decreases and the proportion of small firms with fewer than two product lines increases. This results in a more left-skewed distribution of firm sizes and a higher degree of market competition.

In terms of fiscal policies, an increase in the corporate income tax rate exhibits an inverted U-shaped relationship with the market entry rate. Specifically, as the corporate income tax rate rises, the market entry rate grows, leading to a negative effect on the average firm size. However, average firm size rises overall in response to higher tax rate, which is attributed to the large positive effect of rising tax rate on incumbents' innovation rate. We numerically show that an increase in the tax rate leads to a fall in the number of smaller firms and a rise in the share of larger firms, resulting in a right-skewed firm size distribution.

This study makes several contributes to the existing literature. First, this paper presents a comprehensive analysis of the impacts of monetary and fiscal policies on economic growth and social welfare within a framework that takes into account firm heterogeneity. Although numerous studies have examined the growth and welfare effects of policy instruments from various perspectives, few have specifically addressed how these policies shape the distribution of firm sizes. Overlooking the redistributive effect of policy instruments may lead to an inaccurate understanding of their implications for growth and welfare.[4] Second, this study integrates monetary and fiscal policies in a unified framework, enabling the assessment of the optimal policy design that coordinates these policy tools. In addition, our theoretical model disentangles the role of the fiscal authority and evaluates the effectiveness of two fiscal policy instruments. In addition to the conventional tool of adjusting tax rates, we demonstrate that the allocation of government budget between the provision of public goods and infrastructure development can greatly affect technological innovation, growth, and social welfare. Particularly, the welfare effect of government budget allocation depends on households' valuation of public goods and services.

Our paper is closely related to the literature on firm size distribution and superstar firms. Recent studies shed light on the potentially adverse economic outcomes associated with high concentration of economic activity in large and profitable superstar firms. These include an abnormally high return to capital (Rajgopal *et al.*, 2023), a falling share of labor in GDP (Autor *et al.*, 2020), decreases in market competition (Grullon *et al.*, 2019; De Loecker *et al.*, 2020), and an amplified inequality (Haltiwanger *et al.*, 2022; Song *et al.*, 2019). Empirical studies concern whether interest rate adjustments (Kroen *et al.*, 2021) and tax regimes (Gallemore and Maydew, 2023) are the driving forces behind the rise of superstar firms. Our study offers a theoretical exploration

[4] Miyakawa *et al.* (2022) also studies the reallocation effects of monetary policy by incorporating menu cost into an R&D-driven growth model with heterogeneous firms. They find high nominal growth leads to an increase in the market share of innovative firms as menu-cost burdens are heavier for less innovative firms. We complement this novel study by exploring the policy implications of monetary and fiscal policies.

to these important questions. In addition, given the cross-country differences in firm size distributions, Poschke (2018) suggests that these differences should be attributed to variations in the level of development rather than distortions. However, our theoretical analysis proposes an alternative scenario, demonstrating that these differences can be driven by implemented policies.

This paper also connects to the literature examining the impact of monetary policy on technological innovation and economic growth. Inspiring by Marquis and Reffett (1994) who introduce a CIA constraint on households' consumption into the framework of Romer (1990) to investigate the growth effect of inflation, subsequent studies have further explored this topic within the canonical Schumpeterian growth model by using different approaches of money demand. For instance, Chu and Lai (2013) incorporate money through the money in utility (MIU) function; Chu and Cozzi (2014), and Hu *et al.* (2021) model money demand via a CIA constraint on firms' R&D activities; and Oikawa and Ueda (2018) use the menu cost approach to construct a cashless economy model. Despite the distinct micro mechanisms that characterize monetary demand, most of these studies find that higher inflation reduces the long-run economic growth rate.[5]

This study adds to the literature investigating the effects of taxation and public investment on entrepreneurship, innovation and economic growth. Recent studies on this topic includes Gentry and Hubbard (2005), Djankov *et al.* (2010), Calderon and Servén (2004), Singhal (2008), Chakraborty and Dabla-Norris (2011), and Aghion *et al.* (2016), among many others. Our model is particularly related to the seminal work of Aghion *et al.* (2016), which examines how corruption affects growth and welfare through distorting the efficiency of tax revenue allocation towards infrastructure. Differing from theirs, our model permits the division of the government budget between productive infrastructure and non-productive public goods in an environment where fiscal and monetary policies are both present. Our study also connects to the debate concerning the efficient size of government. Empirical findings in Facchini and Melki (2013) suggest that the country-specific efficient government size measured by public spending for France was around 30%. In contrast, Arawatari *et al.* (2023) develop an endogenous growth model with heterogeneous entrepreneurial ability, indicating that the impact of government spending on growth comes into play only when its size is either exceptionally large or small. We contribute to the discussion by showing that the growth effect of government spending is tied to how allocations are balanced between productive and non-productive public goods.

The remainder of the paper is organized as follows. Section 2 presents our theoretical framework. Section 3 defines the steady-state equilibrium and analytically evaluates the effects of monetary and fiscal policies. Section 4 reports findings of our quantitative analysis. Finally,

[5]By emphasizing the sectoral heterogeneities, Huang *et al.* (2021), Huang *et al.* (2023), and Zheng *et al.* (2021) find that the relationship between inflation and growth can be non-monotonic. Some other recent studies highlight some other dimensions of heterogeneities. For instance, Chu *et al.* (2017) propose a framework featuring random quality improvement of R&D firms; Arawatari *et al.* (2018) emphasize the heterogeneity of entrepreneurial ability; and Hori (2020) develops a model connecting R&D efficiency to financing constraints. These studies reveal that different ways of modeling technological innovation and heterogeneity characteristics can yield remarkably distinct relationships between monetary policy and economic growth, which in turn affects the evaluation of optimal monetary policy.

Section 5 concludes this paper.

# 2 The model

In this section, we extend the quality-ladder model with heterogeneous innovative firms in Klette and Kortum (2004) by (a) incorporating money demand via a CIA constraint on consumption; (b) introducing fiscal policy, and productive and non-productive government expenditure. The nominal interest rate serves as the monetary policy instrument, and both the corporate income tax rate and distributional rule of government spending are treated as the fiscal policy toolkit. The effects of monetary policy and fiscal policy are examined by considering the implications of altering the rate of nominal interest, corporate income tax rate, and distributional rule of government spending on economic growth and social welfare. Throughout the analysis, we focus on the steady state equilibrium.

## 2.1 Households

There is a unit continuum of identical households, and the lifetime utility function of each member is given by

$$U = \int_0^\infty e^{-\rho t}\{\ln c(t) + \eta \ln G(t) + \theta \ln[1 - L(t)]\}dt, \tag{1}$$

where $c(t)$ is the consumption good for each member and $L(t)$ is the amount of labor supply. The parameter $\rho > 0$ is the discount rate, $\eta > 0$ represents the preference over public goods and services provided by the government, and $\theta > 0$ measures the disutility from supplying labor. The law of motion for assets of each household member (expressed in real terms) is

$$\dot{a}(t) + \dot{m}(t) = r(t)a(t) + w(t)L(t) - \pi(t)m(t) - c(t), \tag{2}$$

where $a(t)$ is the real asset value, $r(t)$ is the real interest rate, and $w_t$ is the real wage rate. $m_t$ is the real money balance that the household member holds in order to facilitate consumption, and $\pi_t$ is the inflation rate that reflects the cost of holding money. The corresponding CIA constraint on consumption is expressed as $\xi c(t) \leq m(t)$, with the parameter $\xi \in [0, 1]$ measuring the fraction of consumption expenditure subject to cash constraint.

The household's optimal problem is to maximize the discounted utility in (1) subject to the budget constraint in (2) and the CIA constraint. Solving the standard dynamic optimization yields the familiar Euler equation $\dot{c}(t)/c(t) = r(t) - \rho$, the optimal condition between consumption and leisure

$$w(t)[1 - L(t)] = \theta c(t)[1 + \xi i(t)], \tag{3}$$

and the no arbitrage condition between holding real money and asset such that $i(t) = r(t) + \pi(t)$, where $i(t)$ is also the nominal interest rate.

### 2.2 Production relations

The economy produces a unique final good $Y(t)$ that is all for consumption. It is produced by using a unit continuum of differentiated intermediate goods $x(j,t)$ such that

$$Y(t) = \exp\left(\int_0^1 \ln x(j,t) dj\right). \tag{4}$$

This equation implies that the demand function of each differentiated intermediate goods is

$$x(j,t) = Y(t) / p_x(j,t), \tag{5}$$

where $p_x(j,t)$ is the price of intermediate goods $j$ relative to the final good.

The differentiated intermediate goods in each industry $j$ are produced by a monopolistic leader, who holds a patent on the latest innovation. This leader's products are replaced by the ones of a new entrant who has a more advanced innovation due to the *Arrow replacement effect*.[6] The current leader's production function is given by

$$x(j,t) = q(j,t) L_x(j,t), \tag{6}$$

where $q(j,t)$ is the product-line-specific labor productivity and $L_x(j,t)$ is the labor employed for production. Then the marginal cost of production in product line $j$ is $w(t)/q(j,t)$. Each innovation improves the productivity of a given product line $j$ from $q(j,t)$ to $(1+\lambda)q(j,t)$, where $\lambda$ is the step size of quality that determines the price markup over the marginal cost. Therefore, the monopolistic price in product line $j$ is given by

$$p_x(j,t) = (1+\lambda)\frac{w(t)}{q(j,t)}.$$

We assume that the government taxes firm operating profits (net of R&D expenditure) at the rate of $\tau \in [0,1]$. Accordingly, the after-tax profit flow in this product line is given by

$$(1-\tau)\Pi(j,t) = \frac{\lambda(1-\tau)Y(t)}{1+\lambda}. \tag{7}$$

The wage expenditure is

$$L_x(j,t) = \left(\frac{1}{1+\lambda}\right)\frac{Y(t)}{w(t)}. \tag{8}$$

[6] We assume that the replaced leader exits the market so that it does not impose a constraint on the markup charged by the new leader.

Equations (7) and (8) indicate that the profit flow and the employment level of production labor for each product line are identical.

## 2.3 Incumbent firms

At any given time, a firm denoted by $k \in [0, K]$ is defined by a collection of product lines. In equilibrium, the number of product lines summarizes the state of a firm. Denote by $n$ the number of product lines of an incumbent firm. A firm expands in the product space through successful innovations, whereas it exits the market and becomes an outsider for $n = 0$. With a probability of $z_k(t)$, a firm is successful in its current R&D investment and innovates over a random product line $j' \in [0, 1]$. Then the productivity in line $j'$ increases by a proportion of $(1 + \lambda)$. In this case, the firm becomes the new monopoly producer in line $j'$ and thereby increases the number of its production lines to $n + 1$. At the same time, each of its $n$ current production lines is subject to the rate $m(t)$ of creative destruction by new entrants and other incumbents. Therefore, in an instant of time, the number of production units of a firm increases to $n + 1$ with a probability of $nx_k(t)$ and decreases to $n - 1$ with a probability of $nm(t)$ (and these probabilities will be defined in the following subsections).

Innovations are undirected across product lines. To innovate, firms combine their existing knowledge stock that they have accumulated over time ($n$) with the number of R&D labor ($S_{k,t}$) and infrastructure in the economy according to the following production function:

$$Z_k(t) = S(t) \left( \frac{L(k, t)}{\varphi} \right)^{\gamma} n^{1-\gamma}, \tag{9}$$

where $Z_k(t)$ is the Poisson innovation flow rate, $\gamma \in (0, 1)$ is the elasticity of innovation with respect to R&D labor, and $S(t)$ is the quality of economy's infrastructure. Thus, the R&D cost function of a typical firm is given by

$$w(t)L_k(t) = \varphi n w(t) \left[ \frac{z_k(t)}{S(t)} \right]^{1/\gamma}.$$

## 2.4 Entry

There is a mass of potential entrants into the intermediate sector, whose R&D production function is given by

$$z_e(t) = \frac{S(t)L_e(t)}{\phi}, \tag{10}$$

where $z_e(t)$ is the aggregate entry rate in the economy and $L_e(t)$ is the number of R&D labor hired for entrant innovation. The free-entry condition for entry is given by

$$z_e(t)V(1, t) = w(t)L_e(t), \tag{11}$$

which equates the value of a new entry $V(1,t)$ to the cost of innovation.

## 2.5 Government

The government plays a dual role in this model, acting as both the monetary and fiscal authorities. As the monetary authority, it formulates and implements monetary policy, while as the fiscal authority, it sets tax rates. The government then utilizes the fiscal revenue generated to employ labor for the provision of public goods and services $G(t)$, and for infrastructure development $S(t)$.

First, as the monetary authority, it controls the nominal interest rate $i(t)$, which is kept constant over time ($i(t) = i > 0$). Denote by $M(t)$ the nominal money supply. Then the total seigniorage revenue collected is $\dot{M}(t)/P_Y(t)$. Let $\mu(t)$ denote the growth rate of nominal money supply, which is kept constant on steady state equilibrium. Thus, by log-differentiating the relation $m(t) = M(t)/P_Y(t)$ with respect to time, together with the Fisher equation (i.e., $i = \pi(t) + r(t)$) [7], the total seigniorage revenue can be expressed as $\mu m(t) = (i - \rho)m(t)$. Motivated by the evidence demonstrating the non-negligible magnitude of seigniorage in total government income (Andrabi, 1997), in the baseline model, we assume that the seigniorage revenue is transferred to the fiscal authority to fund the infrastructure development. In the sensitivity analysis presented in Section 4.3.2, we also follow the conventional approach by assuming that seigniorage revenue is reallocated to households through lump-sum transfers.

Second, as the fiscal authority, the government determines the rate of corporate income tax and collects tax revenue. The amount of tax revenue is $\tau\Pi(t) = \tau \int_0^1 \Pi(j,t)dj = \tau\lambda Y(t)/(1+\lambda)$. Therefore, the aggregate amount of the government's income is given by

$$T(t) = \tau\lambda Y(t)/(1+\lambda) + (i-\rho)m(t). \tag{12}$$

The government uses income to provide non-productive public goods or services and to improve the economy's infrastructure (productive). The stock of infrastructure $S(t)$ depreciates at the rate $\delta \in (0,1)$ at every instant. The government hires $L_g(t)$ workers to engage in public goods production with one-to-one technology $G(t) = L_g(t)$, and $L_s(t)$ works to produce units of infrastructure also with one-to-one technology such that $F(t) = L_s(t)$. As a result, the law of motion for the infrastructure can be expressed as

$$\dot{S}(t) = L_s(t) - \delta S(t). \tag{13}$$

The government's balanced budget constraint is expressed as

$$w(t)\left[L_g(t) + L_s(t)\right] = T(t). \tag{14}$$

[7] On the balanced growth path, $c(t)$ and $m(t)$ grow at the same rate of $r(t) - \rho$ according to the Euler equation.

Finally, the government also decides how to allocate the fiscal revenue between infrastructure construction and the provision of final good and services. Let $\alpha \in (0,1)$ denote the share of government spending that is devoted to finance non-productive public goods productions. In this sense, we formally have

$$L_g(t)/L_s(t) = \alpha/(1-\alpha). \tag{15}$$

# 3 Effects of monetary and fiscal policies

In this section, we derive the steady-state equilibrium of the model and investigates the growth and welfare implications of monetary and fiscal policies. Particularly, we restrict attention to a balanced growth path (BGP), where all aggregate variables grow at a constant rate, and firm size distribution is time-invariant. Consequently, time subscript $t$ is omitted along the BGP when it does not lead to any confusion.

To solve for the stationary equilibrium, we first depict the innovation decision of incumbent firms. At any instant of time, the market value of an incumbent firm holding $n$ product lines satisfies the following Bellman equation:

$$rV(n) - \dot{V}(n) = \max_{z_k \geq 0} \begin{Bmatrix} n(1-\tau)\Pi - \varphi n w (z_k/S)^{1/\gamma} \\ + n z_k [V(n+1) - V(n)] \\ + nm[V(n-1) - V(n)] \end{Bmatrix}, \tag{16}$$

where $m = z_k + z_e$ is the aggregate rate of creative destruction in a given product line $j$. Equation (16) suggests that the real return on holding the stocks of an n-product-line firm subtracting the changes in firm's market value can be decomposed into three components, namely, total after-tax profit less the R&D expenditure, the expected increase in firm value when the firm gains additional product lines via successful innovation, and the expected loss in firm value due to creative destruction by other incumbent and entrant firms. Similar to Klette and Kortum (2004), the solution to the value function takes the following form:

$$V(n) = nvY, \tag{17}$$

where $v \equiv V(n)/n$ is defined as the normalized value of a production unit. Combining equations (10), (11), and (17) yields $v = \phi\omega/S$, where $\omega \equiv w/Y$ is the wage rate relative to total output. Solving the incumbent's maximization problem yields the equilibrium innovation rate,

$$z_k = S\left(\frac{\gamma\phi}{\varphi}\right)^{\frac{\gamma}{1-\gamma}}. \tag{18}$$

Plugging Equation (17) into (16), together with the BGP condition $r = \rho + g$, we obtain the equilibrium entry rate given by

$$z_e = \frac{\lambda(1-\tau)S}{\phi\omega(1-\lambda)} - \frac{\varphi S}{\phi}\left(\frac{\gamma\phi}{\varphi}\right)^{\frac{1}{1-\gamma}} - \rho. \tag{19}$$

To derive the equilibrium wage rate and infrastructure development, we need to define the steady-state equilibrium. For an incumbent firm, at any time $t$, the probability that it can increase its number of product lines from $n$ to $(n+1)$ is $nz_k$, whereas the probability that it loses one product line (from $n$ to $(n-1)$) is given by $nm = n(z_k + z_e)$. In expectation, an $n$-product-line firm shrinks at the rate $(nz_k - nm)/n = -z_e$. In steady-state equilibrium, the distribution of firm size stays time-invariant, implying that a series of conditions need to be satisfied. Let $f(n)$ denote the sum of incumbent firms with exactly $n$ product lines. First, recall that firms with only one product line will exit the market if their leading position is taken over by other firms. Hence, in equilibrium, entry rate is equal to exit rate, which suggests

$$mf(1) = z_e. \tag{20}$$

Second, we know that successful innovation (with probability $z_k$) and creative destruction (with probability $m$) jointly reduce the total number of incumbent firms holding exactly one product line. Since the steady-state equilibrium requires that the total number of one-product-line firm remains constant, the change needs to be offset by entrant firms, which gains one product line via successful innovation, and two-product-line incumbent firms, which loses one product line due to creative destruction. Hence, when $n = 1$, we have

$$z_k f(1) + mf(1) = 2f(2)m + z_e. \tag{21}$$

Exploiting the same reasoning process, we generalize the condition of time-invariant firm size distribution for any $n > 1$, which is given by

$$(z_k + m)nf(n) = (n+1)f(n+1)m + (n-1)f(n-1)z_k. \tag{22}$$

In addition, since there is a unit mass of intermediate goods, each produced by one monopolistic leader, it regulates that

$$\sum_{n=1}^{\infty} nf(n) = 1. \tag{23}$$

Let $L_k = \sum_{n=1}^{\infty} f(n)L(k)$ and $L_x \equiv \int_0^1 L_x(j)dj$ denote the aggregate levels of incumbent R&D labor and manufacturing labor, respectively. Given the steady-state firm size distribution, the balanced growth path equilibrium is defined as follows. All steady-state equilibrium values will be denoted by an asterisk $*$.

**Definition 1.** *The balanced growth path equilibrium consists of constant nominal interest rate $i$ and tax rate $\tau$, constant prices $\{w^*, r^*\}$, a constant value of incumbent firms $V(n)$, constant incumbent firm innovation $Z_k^*$ and entrants' innovation $z_e^*$ yielding the destruction rate $m^*$, constant infrastructure level $S^*$ and the allocation $\{c^*(t), Y^*(t), x^*(j,t), a^*(t), m^*(t), L_z^*, L_e^*, L_g^*, L_s^*\}_{t\geq 0}$ with the price sequence $\{P_Y^*(t), p_x^*(j,t)\}$ such that all households maximize utility, all firms maximize profits, the government balances its budget constraint, and all markets clear; specifically, the labor market clearing condition satisfies*

$$L_x^* + L_k^* + L_e^* + L_g^* + L_s^* = L^*; \tag{24}$$

*the asset market clears condition satisfies $a^* \equiv \int_0^1 f(n)V^*(n)$; the final good market clearing condition satisfies $c^*(t) = Y^*(t)$.*

Next we will solve for the balanced growth path equilibrium. From (3), coupled with the final good market clearing condition, we derive the aggregate labor supply given by

$$L^* = 1 - \frac{\theta(1+\xi i)}{\omega^*}. \tag{25}$$

Moreover, along the BGP, infrastructure $S^*$ and government investment $F^*$ are constant. Equation (13) then implies

$$\dot{S}/S = 0 \Leftrightarrow S^* = L_s^*/\delta \tag{26}$$

Additionally, Equations (12), (14), and (15) suggest

$$L_s^* = \frac{(1-\alpha)\left[\xi\left(i-\rho\right) + \tau\lambda/(1+\lambda)\right]}{\omega^*}. \tag{27}$$

By plugging (8), (15), (25), and (27) into the labor market clearing condition (24), we solve for the wage to output ratio such that[8]

$$\omega^* = \frac{(1+\theta)\left(1+\xi i\right) - \xi\rho}{1+\rho\phi\delta/L_s^*} \tag{28}$$

Therefore, using (28) to substitute for $\omega$ in (19) shows

$$z_e^* = \frac{\lambda\left(1-\tau\right)\left(L_s^*/\delta + \rho\phi\right)}{\phi\left(1+\lambda\right)\left[\left(1+\theta\right)\left(1+\xi i\right) - \xi\rho\right]} - \frac{\varphi}{\phi}\left(\frac{L_s^*}{\delta}\right)\left(\frac{\gamma\phi}{\varphi}\right)^{\frac{1}{1-\gamma}} - \rho, \tag{29}$$

where $L_s^*$ is implicitly determined as follows

$$\frac{1}{L_s^*} + \frac{\rho\phi\delta}{(L_s^*)^2} = \frac{(1+\theta)\left(1+\xi i\right) - \xi\rho}{(1-\alpha)\left[\xi\left(i-\rho\right) + \lambda\tau/\left(1+\lambda\right)\right]} \tag{30}$$

[8] More specifically, we use $L_x \equiv \int_0^1 L_x(j)dj$ and (8) to derive the aggregate level of manufacturing labor $L_x^*$, and use $L_k = \sum_{n=1}^{\infty} f(n)L(k)$, (9) and (18) to derive the aggregate level of incumbent R&D labor $L_k^*$.

which is obtained by combing (27) and (28). It is straightforward to show that $\partial L_s/\partial i > 0$, implying that infrastructure construction increases in response to higher nominal interest rate. According to Equation (30), the effect of nominal interest rate on infrastructure construction is twofold. On the one hand, an increase in nominal interest rates motivates consumers to enjoy more leisure time, reducing labor supply, and driving up the real wage rate. Consequently, it lowers the quantity of labor allocated to other sectors, resulting in a decrease in $L_s^*$. On the other hand, according to Equation (12), an increase in the nominal interest rate implies higher seigniorage revenue for the government, leading to higher government income. This rising income can be exploited to boost investment in infrastructure development, thereby enhancing $L_s^*$. Conditional on a constant government income distribution mechanism (i.e., $\alpha$ remains unchanged), the latter effect (promoting investment in infrastructure development) dominates the former (a fall in labor allocation in the government sector), indicating that an increase in the nominal interest rate can raise $L_s^*$. Therefore, Equation (30), combined with (26), suggests that an increase in nominal interest rates can enhance infrastructure development through augmenting government's seigniorage revenue.

Similarly, we can show that $\partial L_s^*/\partial \tau > 0$. Intuitively, raising the corporate income tax rate can increase government fiscal revenue. Assuming no changes in the government income distribution mechanism, an increase in fiscal revenue indicates a rise in resources allocated to infrastructure development, thereby enhancing both $L_s^*$ and $S^*$. Summarizing the above analytical results yields the following proposition.

**Proposition 1.** *An increase in the nominal interest rate and an increase in the corporate income tax rate both lead to a higher level of infrastructure development.*

Given **Propersition 1**, Equation (18) implies that an increase in the nominal interest rate affects the R&D intensity and innovation rate of incumbent firms merely indirectly through changing the level of infrastructure development. The absence of any direct effect of monetary policy on incumbent firms' innovation activities, however, is not surprising in the framework of Klette and Kortum (2004). First, changes in the nominal interest rate influences the allocation of R&D labor by shifting households' labor supply, thereby affecting the R&D intensity of incumbent firms. In the meantime, changes in the nominal interest rate affect the allocation of R&D labor to entrant firms and the entry rate. Consequently, the likelihood that incumbent firms get replaced by new entrants declines, since it leads to adjustments in the expected firm value. These two opposing effects coincide with each other, neutralizing the direct effect of $i$ on incumbent firms' innovation. However, **Proposition 1** suggests that an increase in $i$ tends to promote infrastructure construction. Therefore, the R&D efficiency and innovation rate of incumbent firms both increase. That is, $\partial z_k^*/\partial i > 0$.

For analogous reasons, changing the corporate income tax rate does not generate any direct impact on incumbents' innovation rate. But **Proposition 1** suggests that the indirect effect of corporate income tax rate can be transmitted through the infrastructure development channel, leading to a positive relationship between $z_k^*$ and $\tau$. Therefore, we have the following proposition:

**Proposition 2.** *An increase in the nominal interest rate and an increase in the corporate income tax rate both raise the innovation rate of incumbent firms.*

Exploring Equation (18), it can be shown that, holding the level of infrastructure $S$ constant, an increase in the nominal interest rate suppresses market entry. The reason is that a higher nominal interest rate incentivizes households to increase their leisure time and reduce labor supply, which raises the labor wage rate. As a consequence, it decreases the amount of labor allocated to entrants' R&D activities, reducing the market entry rate. Similarly, an increase in the corporate income tax rate lowers the after-tax monopoly profits, along with the expected value of innovation, hampering market entry.

From **Proposition 1**, however, we see that there is an additional channel of infrastructure development through which monetary and fiscal policies affect the entry rate indirectly. First, an improvement in infrastructure enhances the R&D efficiency of entrant firms and motivate them to increase R&D investment, which tend to raise the entry rate. Second, based on **Proposition 2**, promoting infrastructure development also boosts the R&D efficiency of incumbent firms, leading to a higher R&D intensity. It results in a shift of labor forces away from entrant firms, reducing the entry rate. Taking the derivative of equation (19) with respect to $L_s^*/\delta$, we see that an increase in the level of infrastructure stimulates the entry rate. Taking into account all these effects, however, the overall impact of monetary and fiscal policies on $z_e^*$ seems ambiguous.

**Proposition 3.** *An increase in the nominal interest rate and an increase in the corporate income tax rate can increase or decrease the entry rate.*

Furthermore, we investigate the effects of monetary and fiscal policies on the economic growth rate. The steady-state final good production can be expressed as $\ln Y = \ln(1/\omega(1+\lambda)) + \int_0^1 \ln q(j)dj$. Define $Q = \exp(\int_0^1 \ln q(j)dj)$ as the aggregate quality index. Within any small time interval $\Delta t$, the change in $Q$ is governed by the following law of motion

$$\begin{aligned} \ln Q(t+\Delta t) &= \int_0^1 \{m\Delta t \ln[(1+\lambda)q(j,t)] + (1-m\Delta t)\ln q(j,t)\}\, dj + o(\Delta t) \\ &= m\Delta t \ln(1+\lambda) + \ln Q(t) + o(\Delta t), \end{aligned}$$

Hence, we derive the technological growth rate, as well as the growth rate of output per capita, as follows:

$$g^* = \left[\frac{\lambda(1-\tau)(L_s^*/\delta + \rho\phi)}{\phi(1+\lambda)(1+\theta)(1+\xi i) - \xi\rho} + (1-\gamma)\left(\frac{L_s^*}{\delta}\right)\left(\frac{\gamma\phi}{\varphi}\right) - \rho\right]\ln(1+\lambda) \tag{31}$$

Given **Propositions 2** and **3**, Equation (31) suggests that raising the nominal interest rate can increase or decrease the technological growth rate. Particularly, when the effect of infrastructure development on R&D efficiency is sufficiently high, increases in the nominal interest rate and/or the corporate income tax rate stimulates the economic growth rate through enhancing the innovation activities of the incumbent firms. Otherwise, a higher nominal interest rate and/or corporate income tax rate can reduce economic growth. Summarizing these analytical results yields the following proposition.

**Proposition 4.** *An increase in the nominal interest rate and an increase in the corporate income tax rate can increase or decrease the economic growth rate.*

Note that impact of monetary and fiscal policies on entry and growth rates depends heavily on the values of the structural parameters. In addition, it is difficult to derive clear analytical solution depicting the response of firm size distribution and social welfare to the policy instruments. Hence, we address these questions in the numerical analysis that follows.

# 4 Quantitative analysis

In this section, we calibrate the model using the US data and provide a quantitative evaluation of the aforementioned propositions. We employ several counterfactual analyses to illustrate the impact of monetary and fiscal policies on the targeted macroeconomic variables. In addition, due to the recursive nature of the solution for the distribution of firm sizes, analytical assessment of the impact of $i$ and $\tau$ on $f(n)$ seems challenging. Hence, we exploit numerical simulations to examine how changes in policy instruments affect the market shares of firms across different size categories.

## 4.1 Calibration

There are nine structural parameters in our model: $\{\rho, \eta, \theta, \xi, \lambda, \gamma, \varphi, \phi, \delta\}$ and three policy parameters $\{i, \tau, \alpha\}$. We set the discount rate $\rho$ to a conventional value of 0.03. For the tax levied on corporate profits, we set $\tau = 24.2\%$ to match the average corporate income tax rate from 1980 to 2017.[9] As for the quality step size of innovation $\lambda$, we calibrate it by matching the price markup documented by Bils and Klenow (2004), i.e., $1 + \lambda = 1.2$. Moreover, the depreciation rate of infrastructure is fixed to $\delta = 15\%$, following Aghion, Akcigit, Cagé and Kerr (2016). Since the value of parameter $\eta$ does not affect equilibrium labor allocations, firm distribution and aggregate economic growth, we set it to 0.1 and consider an sensitivity analysis in the following numerical exercises when examining the social welfare effect.

[9] The data are from the national income and product account (NIPA) tables released by the Bureau of Economic Analysis (BEA). We follow Mertens and Ravn (2013) but differ it by taking into account the role of the state and local governments to compute the average corporate income tax rate given by $\tau = (FCT + SCT)/CP$, where FCT is the federal taxes on corporate income less Federal Reserve banks (Table 3.2: line 8), SCT is the state and local taxes on corporate income (Table 3.3: line 11), and CP is the corporate income tax base, which consists of corporate profits (Table 1.12: line 13) net of Federal Reserve banks profits (Table 6.16 B-C-D: line 11).

We next jointly calibrate the remaining seven parameters $\{\theta, \xi, \gamma, \phi, \varphi, i, \alpha\}$ by matching seven model-implied moments in the steady state to empirical data. Following Akcigit and Kerr (2018), we minimize the distance between the sample moments and the model-implied counterparts according to the following criterion:

$$\min \sum_{\kappa=1}^{7} \frac{|model(\kappa) - data(\kappa)|}{|model(\kappa)|/2 + |data(\kappa)|/2},$$

where we index each moment by $\kappa$. The seven moments we target are as follows: (1) we set the labor employment to $1/3$ in line with the conventional literature; (2) The average growth rate of real GDP per capita in the US is around 2% and the corresponding expression is (31); (3) Following Aghion, Akcigit, Cagé and Kerr (2016), the corporate tax revenue share of GDP over $1982-2007$ is 3.4%. The corresponding expression is $\tau\Pi/(c + wL_k + wL_e + wL_s + wL_g)$ in our model; (4) According to the estimation results in Garcia-Macia, Hsieh and Klenow (2019) that uses the US census LBD data, the employment share of entrants per year is 3.4% during the period of $2003-2013$; (5) The long-run average US R&D investment to GDP ratio was around 2.6% per annum, which corresponds to the ratio of $(wL_k + wL_e)/(c + wL_k + wL_e + wL_s + wL_g)$; (6) Lanjouw (1998) finds that the obsolescence rate of a patented innovation is in the range of $7-12\%$. We take an intermediate value of 10% as a proxy for the aggregate innovation arrival rate; (7) The average inflation rate in the US from 2000 to 2020 is around 2.1%. Exploiting this procedure, we report the calibrated values and the model-implied moments in Table 1.[10]

## 4.2 Benchmark simulation

### 4.2.1 Monetary policy

Based on the calibrated parameters above, Figure 1 depicts the impact of changes in the nominal interest rate on the production sector and economic growth. In this practice, the corporate income tax rate and the distribution mechanism of government income are kept at their baseline levels. The results in Figure 1 indicate that an increase in the nominal interest rate (or growth rate of nominal money supply) can effectively stimulate technological innovation and enhance the economic growth rate. Specifically, raising the nominal interest rate from the baseline level ($i = 7.1\%$) to $i = 10\%$ would result in a 0.69% rise in the rate of technological progress and economic growth, despite that the equilibrium inflation rate increases from the benchmark 2.18% to 4.39%.[11] This positive effect on economic growth can be attributed to the increases in both the incumbent R&D intensity ($z_k^*$) and the entry rate of innovative firms ($z_e^*$). The increase in the

[10] The small discrepancies arise because parameter values must fall in a certain range to be economically meaningful. For example, none of the parameters can be negative, and the CIA-constraint, incumbent R&D elasticity, and government spending distribution rule parameters must be in the $[0, 1]$ interval.

[11] In our calibrated economy, firm entry quits if the nominal interest rate is lower than 4.46%. We thus report numerical results within the range of $i \in [0.045, 0.3]$.

Table 1: Calibration

| Panel A. Parameter values | | | |
|---|---|---|---|
| Pre-determined Parameters | | Calibrated Parameters | |
| Parameters | Value | Parameters | Value |
| Subjective discount rate ($\rho$) | 0.03 | CIA constraint on consumption ($\xi$) | 0.868 |
| Corporate income tax rate ($\tau$) | 0.242 | Leisure preference ($\theta$) | 1.745 |
| Quality step size ($\lambda$) | 0.2 | Incumbent R&D elasticity ($\gamma$) | 0.001 |
| Public goods preference ($\eta$) | 0.1 | Entrant R&D productivity ($\phi$) | 0.108 |
| Infrastructure depreciation rate ($\delta$) | 15% | Nominal interest rate ($i$) | 0.071 |
| | | Incumbent R&D productivity ($\varphi$) | 0.598 |
| | | Government spending rule ($\alpha$) | 0.470 |

| Panel B. Model Fit | | | | | |
|---|---|---|---|---|---|
| Moment | Data | Model | Moment | Data | Model |
| Labor employment | 0.333 | 0.337 | Per capita economic growth rate | 2.0% | 1.92% |
| Corporate tax revenue share | 3.4% | 3.64% | Entrant labor share | 3.4% | 3.37% |
| Creative destruction rate | 10% | 10.5% | R&D to GDP ratio | 2.6% | 2.89% |
| Inflation rate | 2.18% | 2.18% | | | |

nominal interest rate can also lead to higher government revenue from seigniorage tax/inflation tax, conditional on a fixed government fiscal revenue distribution mechanism. Consequently, the better provision of infrastructure level enhances the incumbent R&D and entry R&D efficiency, thereby driving innovating firms to increase investment to eventually promote the economic growth.

In addition, the average firm size decline in response to more entrant firms entering the market. In the intermediate goods sector, the total number of firms $F^*$ can be expressed as

$$F^* = \sum_{n=1}^{\infty} f(n) = \hat{z}_e^* \ln(1 + 1/\hat{z}_e^*),$$

where $\hat{z}_e^* \equiv z_e^*/z_k^*$ is the relative entry rate. Since the sum of all product lines is normalized to one, $1/F^*$ measures the average firm size. As shown in Figure 1, when the nominal interest rate increases, $1/F^*$ falls sharply, but the marginal effect becomes smaller as $i$ continues to rise. We find that the rise in entrant firms implies that the distribution of firm sizes concentrates more heavily at the left tail, and that market competition becomes more intense. The "true" distribution function of firm sizes satisfies $\hat{f}(n) = f(n)/F^* = [1/(1+\hat{z}_e^*)]^n \,/\, [n \ln(1+1/\hat{z}_e^*)]$. Comparing the firm size distribution when $i$ takes the value of 15%, 10% and 5%, we find that higher nominal interest rate is associated with a larger market share of firms with no more than four product lines, but a smaller share of firms with more than four product lines. More interestingly, we observe that higher nominal interest rate (i.e., $i = 15\%$) is associated with a smaller market share of large firms with a substantial number of product lines (i.e., $n = 8$). Hence, our model also predicts that raising the nominal interest rate favors sufficiently small and medium firms.

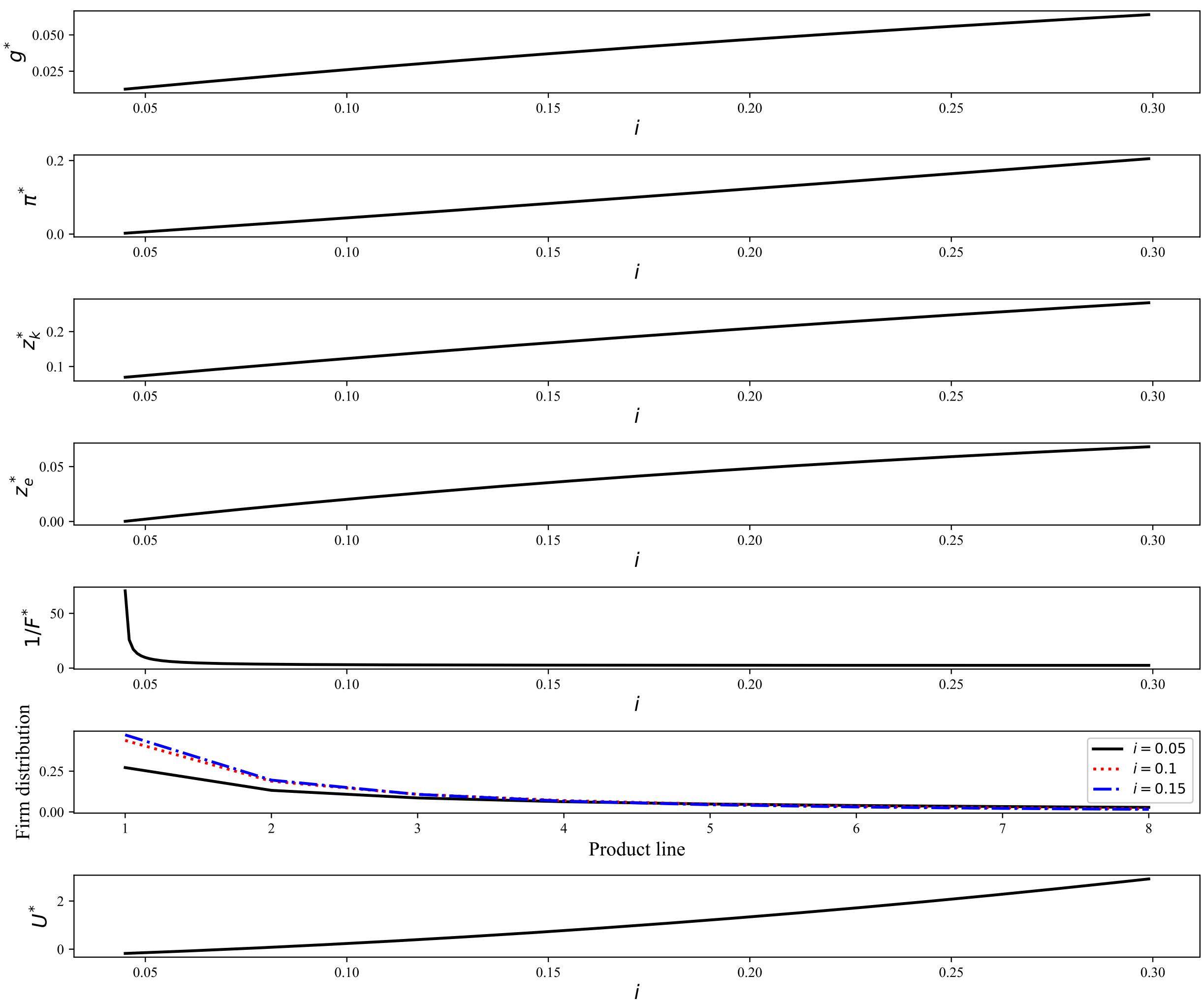


Figure 1: Effects of changes in nominal interest rates.

To numerically analyze the effect of monetary policy on social welfare, we first derive households' utility in the steady-state equilibrium, which is given by

$$U = \frac{\ln Y(0) + \eta \ln L_g + \theta \ln(1 - L)}{\rho} + \frac{g}{\rho^2}, \tag{32}$$

where $\ln Y(0) = \ln L_x = -\ln \omega - \ln(1 + \lambda)$ and the initial aggregate quality index is set to 1. Equation (32) suggests that the effect of monetary policy on social welfare can be transmitted through contemporaneous consumption of output ($Y(0)$), provision of public goods and services ($\ln G = \ln L_g$), leisure ($\ln(1 - L)$), and the technological growth rate ($g$). As shown in Figure 1, there is a positive relationship between the nominal interest rate and social welfare, indicating that the welfare gains from higher growth rate of consumption, more public goods and leisure dominate the welfare loss from lower current consumption.

#### 4.2.2 Fiscal policies

In this numerical experiment, we hold the nominal interest rate constant and explore the impact of two fiscal policy instruments, namely, the corporate income tax rate and allocation of government fiscal revenue. The numerical results in Figure 2 illustrate that an increase in the corporate income tax rate can raise the economic growth rate by stimulating technological innovation. Specifically, a higher corporate income tax rate can improve infrastructure development, leading to higher innovation efficiency and increased R&D investment among incumbent and entrant firms. However, the higher tax rate can also reduce the monopolistic profits and dampen firms' innovation incentives, resulting in a decline in the market entry rate. Further analysis of Figure 2 reveals an inverted U-shaped relationship between the corporate income tax rate and the market entry rate. When the tax rate is low, increasing $\tau$ can generate additional fiscal revenue for infrastructure development and effectively promote innovation efficiency of new entrant firms, which dominates the retarding effect on firm innovation. As a result, the marginal increase in the tax rate boosts firm entry. As the tax rate continues to rise, however, the diminishing monopolistic profits generate a sufficiently strong and negative effect on innovation, which can potentially outweigh the innovation-promoting effect of infrastructure construction. Consequently, the market entry rate decreases. According to our numerical results, the entry rate is maximized at $\tau = 37.7\%$. When the corporate income tax rate reaches $\tau = 0.709$, the market entry rate falls to zero, indicating that no firms have the incentives to enter the market.

In addition, the inverted U-shaped effect of the corporate income tax rate on the market entry rate does not necessarily imply a significant U-shaped effect on the average firm size. Theoretically, an increase in the corporate income tax rate leads to a rise in the number of entrant firms, resulting in a decline in $1/F^*$. Subsequently, the marginal impact of further tax rate increases on the average firm size gradually diminishes, reaching a critical threshold. Simultaneously, when the tax rate experiences moderate increases, the fraction of small firms increases while the proportion of large firms decreases, leading to a more concentrated firm distribution. According to our numerical simulation, however, the effect of $\tau$ on entry rate is relatively small and dominated by its sizable positive effect on incumbents' innovation rate.

In terms of firm sizes, we find that tax rate increases reduce the number of small firms and increase the number of large firms. Comparing the equilibrium outcomes at various income tax rates (i.e.,$\tau = 0.25, 0.45$, and 0.55), we find that the fraction of firms with one product line when $\tau = 0.45$ is consistently lower than its counterpart when $\tau = 0.25$ and 0.55. In contrast, giant incumbent firms with a large number of product lines are benefited from sustained increases in the corporate income tax rate. In terms of households' utility, Figure 2 illustrates that the overall level of social welfare responds positively to higher corporate income tax rates, owing to the increases in the economic growth rate and provision of public goods and services.

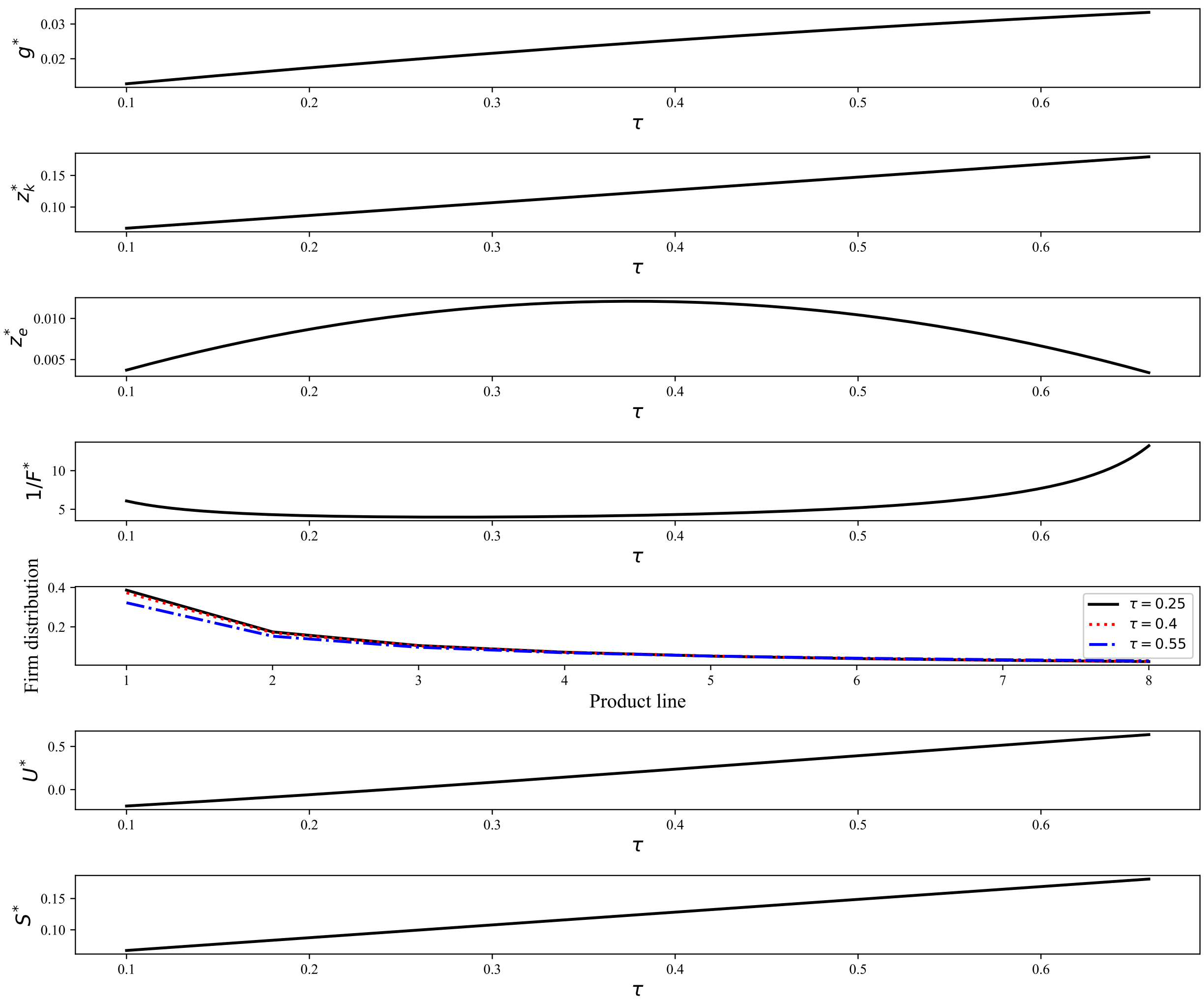


Figure 2: Effects of changes in corporate income tax rates.

In Figure 3, we present the numerical results of adjusting the allocation of government budget. First, Figure 3 reveals that allocating more fiscal revenue to non-productive public goods and services (i.e., raising $\alpha$), instead of improving infrastructure development, has a negative effect on technological innovation and economic growth. When $\alpha$ increases, the retarding impact of corporate income tax on firm innovation dominates the positive effect of improved infrastructure. Hence, the distortionary corporate income tax reduces the efficiency of resource allocation and hinders economic growth. Notably, the market entry rate declines as $\alpha$ increases, and thereby the average firm size gradually expands. The fraction of small firms with fewer than two product lines decreases, while the market share of large firms rises systematically.

Under the baseline calibration, assuming lower consumer preferences for public goods and

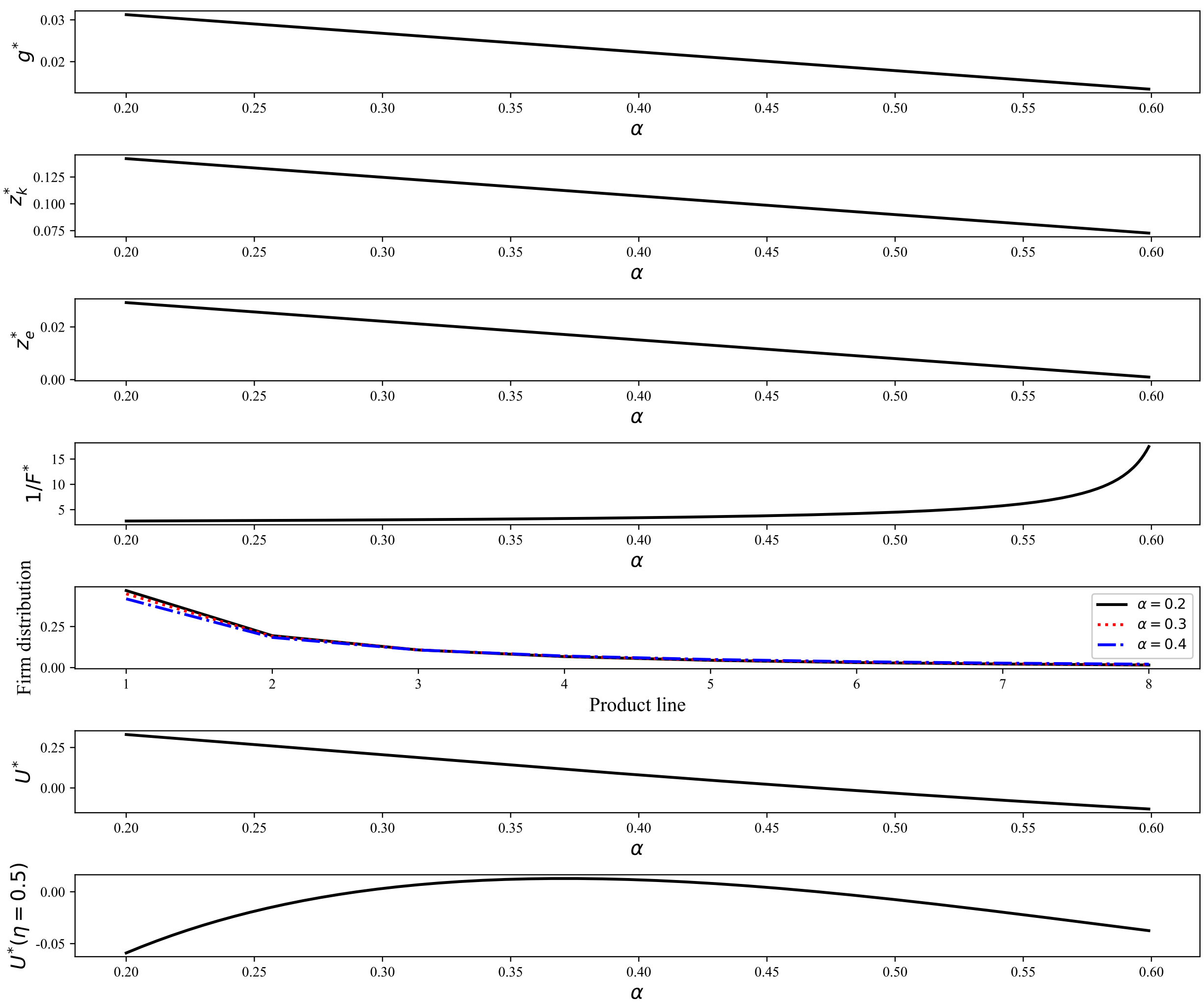


Figure 3: Effects of a change in government spending distributional rule.

services (i.e., a smaller $\eta$), increasing the allocation of fiscal resources to non-productive public goods can hardly improve social welfare. In fact, it leads to a decline in the social welfare due to weakened productive activities, diminished technological innovation, and reduced economic growth. In the last subplot of Figure 3, we raise consumer preferences for public goods and services by increasing $\eta$ from 0.1 to 0.5. In this case, the positive welfare-effect of public good provision dominates the negative effect induced by lower innovation efficiency. Therefore, allocating more fiscal revenue to the production of non-productive public goods can lead to improved social welfare when the preference for public goods and services becomes sufficiently strong.

## 4.3 Sensitivity analysis

In this subsection, we conduct a sensitivity analysis to illustrate the impacts of the infrastructure channel and the seigniorage revenue channel on targeted macroeconomic variables.

### 4.3.1 The role of infrastructure

We assume that the amount of government revenue allocated to infrastructure construction remains constant, irrespective of changes in nominal interest rates and corporate income tax rates. Under these conditions, Figure 4 shows that the R&D intensity of incumbent firms becomes independent of the nominal interest rate, while higher nominal interest tends to reduce the entry rate. Intuitively, the increase in R&D cost negatively impacts the innovation incentives of incumbents, while a lower entry rate, which indicates a reduced risk of replacement by new entrants, positively affects the innovation incentives. These opposing effects cancel each other out, leaving the R&D decisions of incumbents unaffected by the nominal interest rate. However, Proposition 3 suggests that without the effects of improved infrastructure development, entrants are discouraged by a rising nominal interest rate. As a result, the relatively entry rate $\hat{z}_e$ declines, leading to an increase in average firm size and a decrease in the equilibrium economic growth rate. Furthermore, in contrast to the benchmark case, the social welfare is now decreasing in the nominal interest rate, indicating that the Friedman rule becomes socially optimal in this scenario.

Similarly, when the government stops funding infrastructure construction, the quality of infrastructure becomes independent of changes in the corporate income tax rate, as shown in Figure 5.[12] In this case, the R&D decisions of the incumbents remain unaffected by policy shifts, leaving only the entrants being negatively affected by a higher corporate income tax rate. As a consequence, the relative entry rate declines, causing the firm number to decrease and average firm size to rise. Furthermore, both the equilibrium economic growth rate and social welfare are decreasing in a rise in the corporate income tax rate.

### 4.3.2 The role of seigniorage revenue

In this sensitivity analysis, we shut down the seigniorage revenue channel by assuming that the central bank reallocates seigniorage proceeds directly to households via lump-sum transfers, rather than transferring these funds to the government for the provision of public goods and infrastructure. Under this assumption, Figure 6 illustrates the impact of nominal interest rate on the investigated macroeconomic variables.[13] Our findings indicate that both the innovation rate of existing firms and the market entry rate are negatively correlated with the nominal interest

[12] We find that the entry rate decreases to zero when the corporate income rate rises to around 0.43 in this experiment. Therefore, we do not report the firm distribution result in the equilibrium of $\tau = 55\%$ as in the benchmark case.

[13] All benchmark parameters are held constant with the exception of $\alpha$, which is adjusted to 0.05 to ensure a positive entry rate.

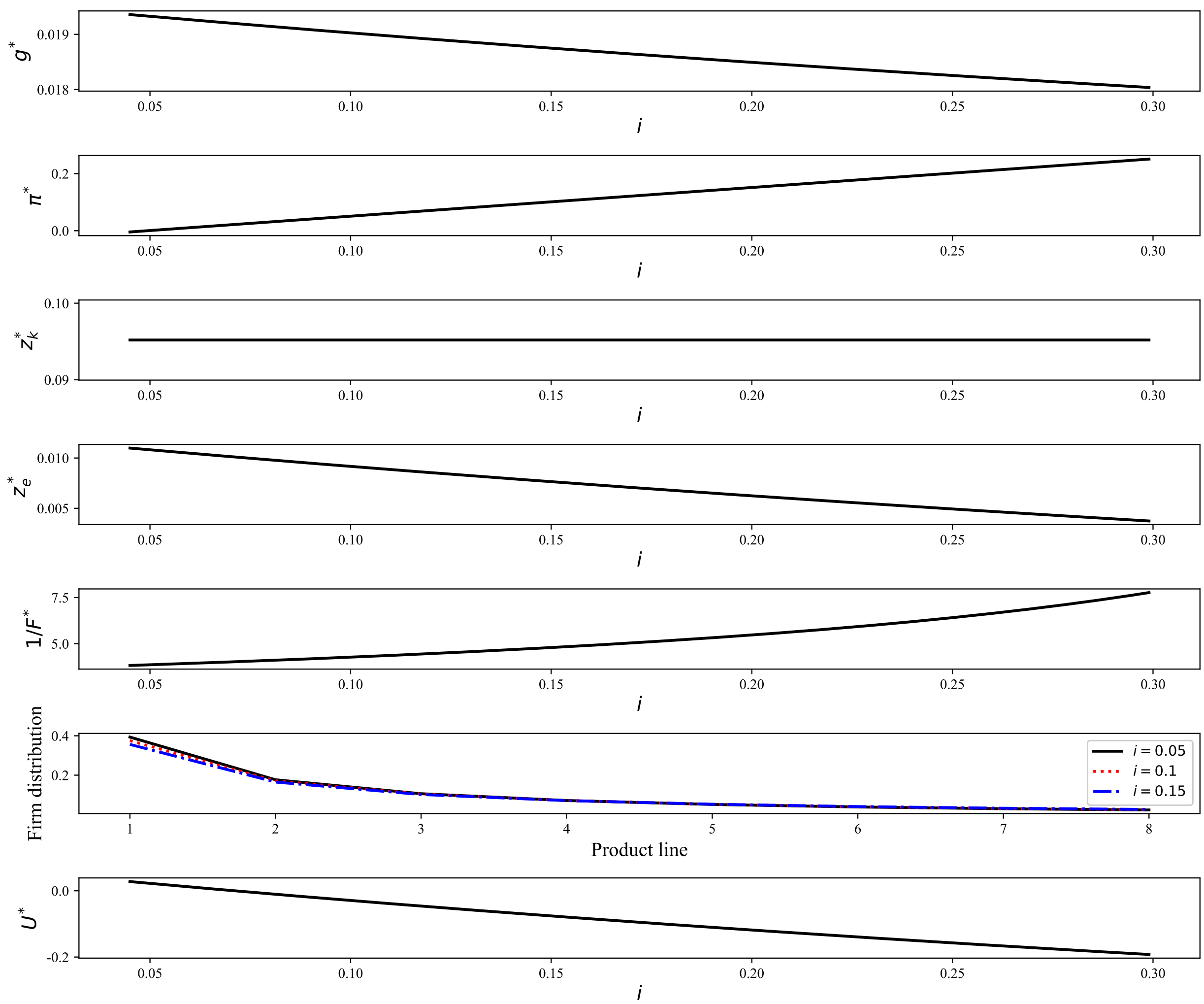


Figure 4: Effects of changes in nominal interest rates.

rate. This further implies that a higher nominal interest rate reduces the overall economic growth rate. The intuition behind this relationship is that, absent the contribution of seigniorage to the enhancement of infrastructure, a higher nominal interest rate imposes unambiguously adverse impacts on innovation. Specifically, a higher real wage rate, stemming from a CIA constraint on consumption, immediately reduces the allocation of labor to entry-level R&D. Meanwhile, the increased real wage rate depresses $L_s$ and infrastructure, which in turn exerts a negative effect on the innovation of incumbent and entrant firms. This inverse relationship between the nominal interest rate and the economic growth rate echoes the findings in previous studies, such as Chu and Cozzi (2014) and Hu *et al.* (2021).

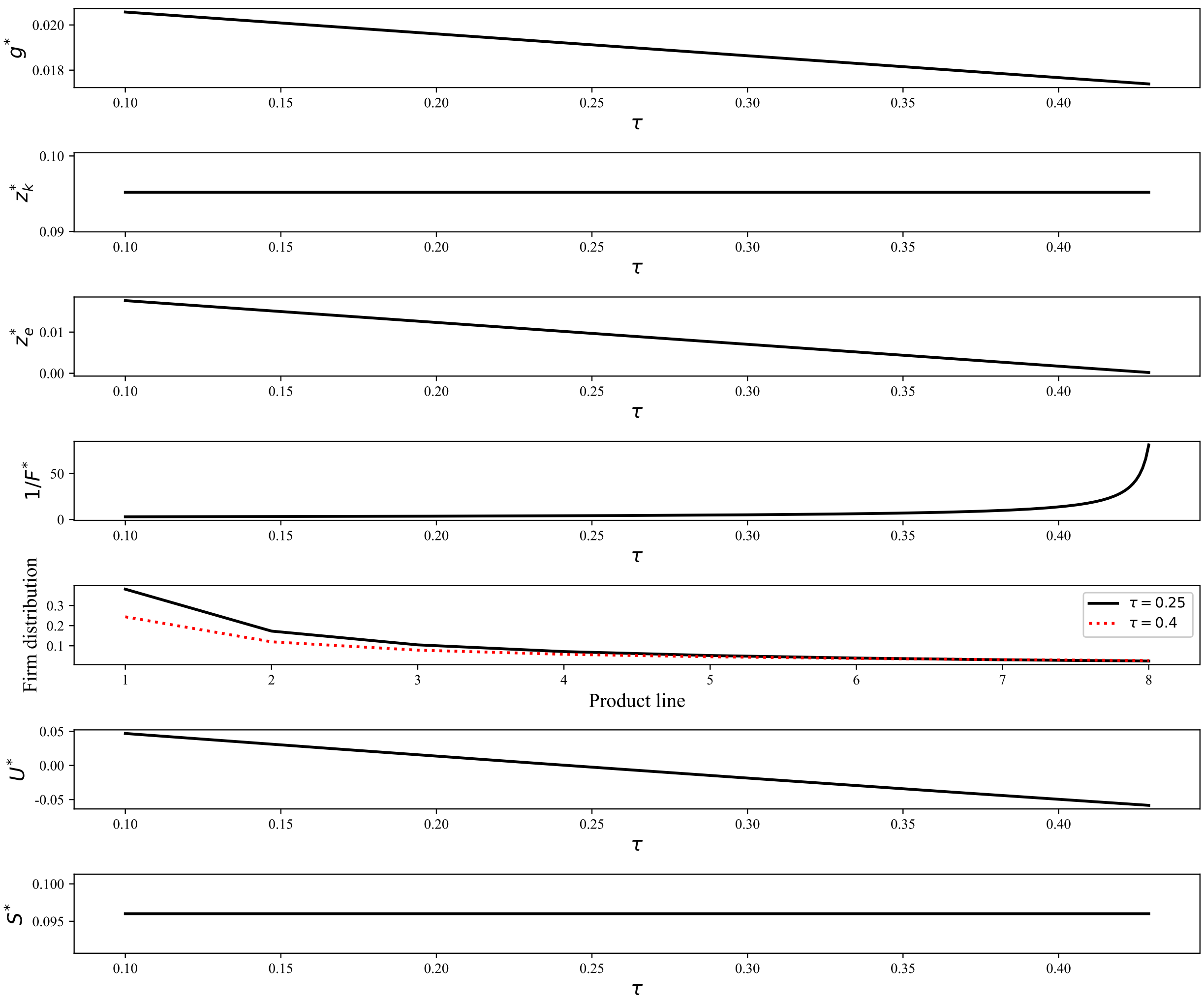


Figure 5: Effects of changes in corporate income tax rates.

## 5 Conclusion

This study examines the effects of monetary and fiscal policies on technological innovation, firm distribution, economic growth, and social welfare in an integrated endogenous growth framework that accommodates heterogeneous firms. The findings demonstrate that higher nominal interest rate can stimulate technological innovation and economic growth by incentivizing innovation activities of incumbent and entrant firms. In the presence of a rising nominal interest rate, the number of firms increases, average firm size declines, and firm distribution becomes more heavily concentrated at the left tail, which jointly imply a more competitive market environment.

Moreover, the study reveals an inverted U-shaped relationship between corporate income tax

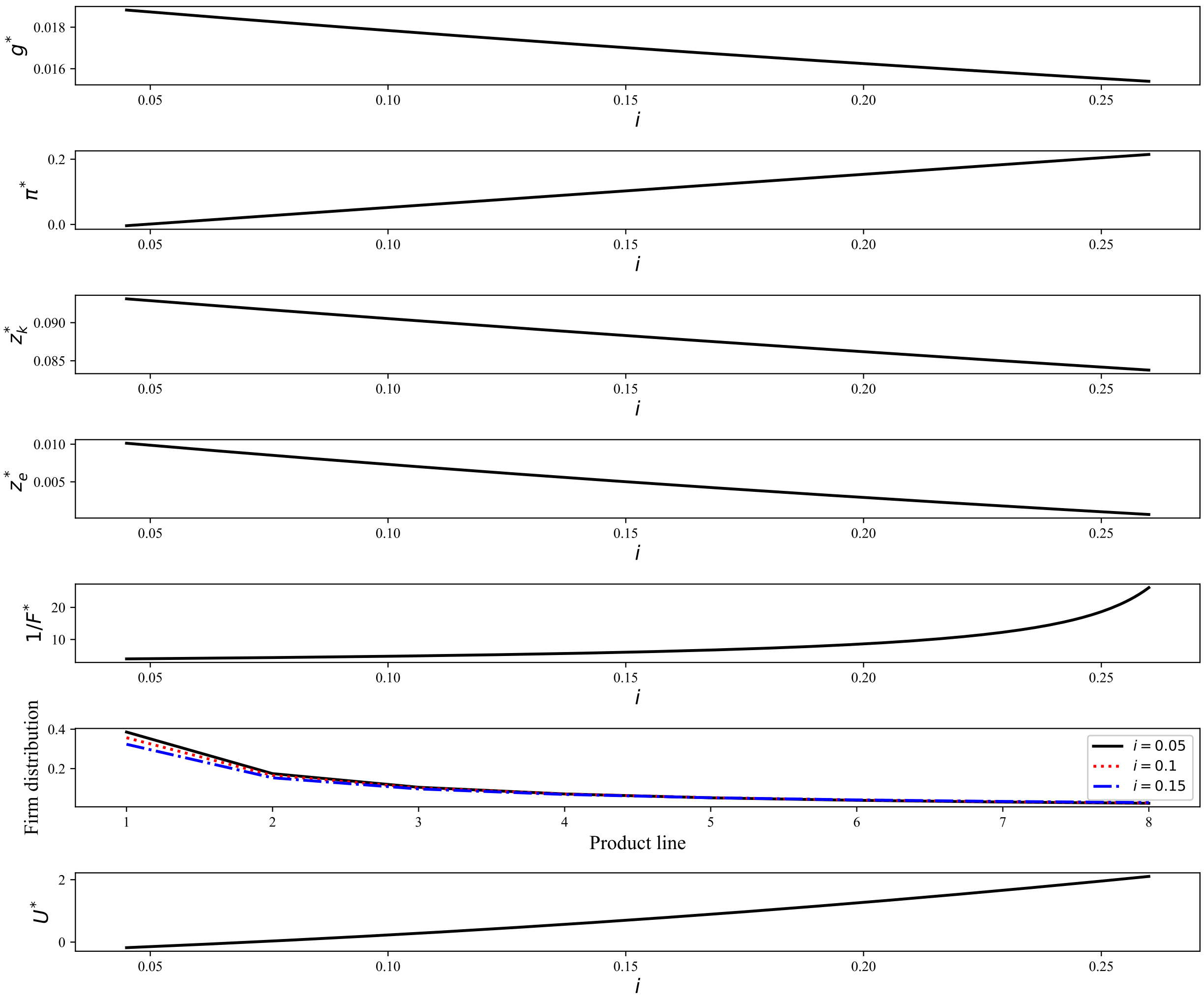


Figure 6: Effects of changes in nominal interest rates.

rate and market entry rate. When corporate income tax rate is initially low, raising it tends to encourage firm entry, resulting in a larger number of firms and a remarkable decline in average firm size. However, the marginal impact of the corporate income tax on average firm size diminishes as corporate income tax continues to rise. Average firm size tends to grow since sufficiently heavy tax burden surpasses the profitability of small innovation firms, which favors giant incumbent firms. When tax rate hikes are moderate, there is a rise in the fraction of small firms and a decline in the market share of large firms. However, continuing increases in the tax rate will ultimately reduce the number of small firms, which benefits large firms and helps them gain more market share.

The analytical and simulation results of this paper provide meaningful implications for policy makers. Overall, this study suggests that properly combining the instruments in the government's toolbox can stimulate economic growth and social welfare. Specifically, allocating a sufficient share of government revenue to investments that can potentially boost productivity (such as infrastructure development) is of critical importance. In addition, combining the expansionary fiscal policy with a moderate inflation rate and corporate income tax rate helps to foster accelerated technological innovation and economic growth.

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