Inflation and Income Inequality in an Open-Economy Growth Model with Liquidity Constraints on R&D*

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Abstract

This study presents a framework to understand the relationship between inflation and income inequality in an open-economy Schumpeterian growth model with heterogeneous households, firm-level innovation, and cash-in-advance constraints on R&D investment. We show that the global real interest rate channel can play an important role in determining the relationship between inflation and income inequality. In small economies, which have negligible impact on the global interest rate, income inequality is likely to exacerbate as the inflation rate rises. In contrast, for large economies that significantly affect the global interest rate, inflation and income inequality may display a U-shaped relationship. These theoretical predictions are supported by the quantitative analysis calibrating the model to the US and eurozone economies, as well as our empirical findings using cross-country data.

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1 Introduction

The surge in income inequality in major economies has attracted increasing attention from policy makers, notably among central banking authorities (Bernanke, 2015; Yellen, 2016; Draghi, 2016). This calls for a comprehensive understanding of the redistributional effect of monetary policy and the potential inflation-inequality relationship, especially following the global high inflation after 2022.

Existing empirical studies on the relationship between inflation and inequality typically yield mixed findings. Some find that they are positively correlated, while others suggest a negative relationship at least under certain conditions.[1] Meanwhile, several studies document that the inflation-inequality relationship may be non-linear (Galli and van der Hoeven, 2001; Bulíř, 2001), and vary across countries or over time (Barro, 2000). These findings, combined with the key insight from the seminal work of Kuznets (1955), have underscored the intrinsic nexus between income inequality, economic growth and inflation, and remarkably motivated a burgeoning body of literature that explores the interplay among these three variables using an endogenous growth framework (i.e., García-Peñalosa and Turnovsky, 2006; Jin, 2009; Chu *et al.*, 2019; Zheng *et al.*, 2020).

This paper provides an open-economy endogenous growth model to investigate the inflation-inequality relationship. In a comprehensive survey, Colciago *et al.* (2019) postulate that the mixed empirical findings seem to imply an overall positive relationship between inflation and income inequality, which may turn negative when inflation falls below a certain threshold level. We show that on top of a threshold level of inflation, the correlation between inflation and inequality may also depend on the relationship between a country's economic growth and the real interest rate in the country. In our model, income inequality is likely to exacerbate as the inflation rate rises if an economy has negligible impact on the global interest rate (e.g., due to its small size and/or low economic growth). In contrast, for large economies that significantly affect the global interest rate, inflation and income inequality may display a U-shaped relationship. Our theoretical framework can potentially reconcile the aforementioned empirical discrepancies in the inflation-inequality relationship.

We are particularly interested in investigating the role of the global interest rate channel in shaping the inflation-inequality relationship for two reasons. First, the literature suggests that asset values and bond holdings form critical channels propagating the long-run effect of inflation on inequality (Doepke and Schneider, 2006; Chu *et al.*, 2019). Based on a panel dataset covering 149 countries, Furceri and Loungani (2018) find that capital account liberalization widens the

[1] For instance, Albanesi (2007) presents cross-country evidence of a positive correlation, which is supported by other recent studies such as Ghossoub and Reed (2017). However, Andres and Hernando (1997) shows that even a moderate increase in the inflation rate (as witnessed within OECD countries) has a negative impact on growth rates. In light of a positive correlation between income inequality and economic growth at least in the short to medium term (as documented in Forbes, 2000), this indicates a negative relationship between inflation and income inequality.

income distribution and increases the income share of top earners. These findings jointly point to the need of exploring the inflation-inequality relationship within an open-economy framework that accommodates a global financial market, where the impacts of small and large economies on the global interest rate are notably distinct. Second, an emerging strand of the empirical literature examines the international transmission of monetary policy and the global inflation dynamics (De Paoli, 2009; Cetorelli and Goldberg, 2012; Buch *et al.*, 2019; Mumtaz and Surico, 2009; Byrne *et al.* (2012)).[2] In the growth literature, however, it remains unclear how monetary policy implemented in a country with significant impact in the global financial markets (i.e., the US) can be translated into a determinant of income distribution in other countries.

To fill these gaps, this study develops a two-country open-economy Schumpeterian growth model featuring heterogeneity in households and firms, cash-in advance (CIA) constraints on R&D activities, and a global bond market which transmit the costs of inflation not only between domestic sectors but also across countries.[3] Motivated by the empirical evidence documented in Piketty (2014), we capture income inequality through introducing heterogeneous households in terms of asset holdings. This setting allows income distribution to be endogenously determined. We introduce monetary policy via imposing CIA constraints on R&D firms, which is motivated by the empirical relevance of liquidity constraints to R&D investment (Brown *et al.*, 2012; Lyandres and Palazzo, 2016). In addition, we assume that firms are heterogeneous in terms of their number of product lines (as in Klette and Kortum, 2004). This model specification enables us to investigate whether the inflation-inequality relationship hinges on the effect of monetary policy on firm-size distribution.[4]

We assume that the equity market and the market for financing R&D in each country are autarky. However, a global real bond market exists such that the real interest rate is identical in both countries. Households allocate their endowments to purchase equity shares of monopolistic firms and lend to domestic firms needing to finance their R&D activities. Incumbent and entrant firms in each country hire labor for R&D, with labor costs financed by loans in the form of cash

[2]Representative work of theoretical exposition of global inflation includes Melitz and Ottaviano (2008), Bentolila *et al.* (2008), and Henriksen *et al.* (2013).

[3]Within this strand of literature, previous studies have mainly considered a closed-economy framework, albeit with a few notable exceptions. Chen and Turnovsky (2010), for instance, study the growth-inequality relationship in a small open economy, suggesting that the relationship depends on agents' access to international capital markets. However, their paper does not delve into the effect of monetary policy on inequality. Guo *et al.* (2022) exploit a small-open-economy New Keynesian framework with heterogeneous agents to investigate the trade-off between aggregate stabilization and inequality in consumption under different exchange-rate regimes. Leveraging a North-South monetary model with R&D and international trade, Afonso and Sequeira (2022) scrutinize the effect of inflation on specialization, growth and wage inequality. Our paper, however, takes a different path by investigating the relationship between inflation and income inequality.

[4]We find that the key model implications remain largely the same in a canonical quality-ladder growth model with homogeneous firms. It indicates that firm-size distribution and income distribution both respond to changes in monetary policy. And a significantly right-skewed distribution of firms does not necessarily contribute to a widening income gap if large firms are not endowed with a substantial financing cost advantage. These findings could be pertinent to the discussion on the relationship between rising "superstar firms" and inequality (Song *et al.*, 2019; Haltiwanger *et al.*, 2022).

from domestic households. Successful innovation by a firm replaces the leading-edge technology from its current holder, thereby expanding the number of product lines that the innovating firm operates. In this scenario, the innovation intensity of incumbent firms and the entry rate of new firms in a country jointly determine the aggregate innovation rate. This, in turn, affects the growth rate of the country's technology and total output. In the presence of CIA constraints on R&D investment, domestic inflation elevates the cost of R&D and curtails firms' innovation rates, leading to a negative effect on domestic technology growth.

Given that the global real interest rate is the weighted average of technology growth in both countries, a rise in domestic inflation reduces the global real interest rate, thus diminishing the returns on holding financial assets. We refer to this impact as the *negative growth effect*. Moreover, an increase in domestic inflation affects the country's financial asset holdings in two ways. First, inflation reduces the rate of creative destruction by discouraging innovation activities, leading to an appreciation in the value of existing firms and their equity prices. Second, higher inflation increases the cost of holding money, causing a decrease in the demand for money to finance R&D. This results in a decline in bond holdings. Under the baseline model, where incumbent and entrant firms are subject to CIA constraints with equal strengths, the increase in equity value dominates the decrease in bond holdings, inducing a net increase in the value of financial assets. We label this effect as the *positive valuation effect*.

In the baseline framework, beyond a certain inflation threshold, the positive valuation effect consistently dominates the negative growth effect, fostering a positive correlation between domestic inflation and inequality. When inflation rate is low, however, the negative growth effect can be sufficiently strong such that it surpasses the opposing valuation effect. In this case, the relationship between inflation and inequality exhibits a U-shaped pattern. This is more likely to occur when the home country strongly influences the global real interest rate, such as instances where the home country's technology growth significantly outpaces that of the foreign country. On the contrary, when the home country's impact on the global interest rate is minimal, the positive valuation effect always dominates the negative growth effect, resulting in a monotonically increasing relationship between inflation and inequality.[5]

While domestic inflation can mitigate income inequality under specific conditions, our findings suggest that the effect of domestic monetary policy is likely to be moderate. In our open economy framework, the reduction in income disparity originates from the negative growth effect, which is jointly determined by domestic and foreign technology growth. In addition, we show that the negative growth effect of inflation is less pronounced for incumbent firms than for entrants. Although inflation escalates the cost of innovation, it concurrently augments the size of incumbent firms, thereby stimulating more innovation activities. Our baseline model sug-

[5] For analytical tractability, our baseline model assumes that the CIA constraints are identical for incumbent and entrant firms. We relax this assumption in our numerical analysis and find that the inflation-inequality relationship is contingent on the relative strengths of the CIA constraints faced by these R&D firms. Further details are provided in Appendix B.

gests that these two effects can offset each other, resulting in a zero net impact on the innovation intensity of incumbent firms.[6]

The key implications of our theoretical model also find empirical support in cross-country regressions, using data from 65 high- and upper-middle-income countries. Our empirical study provides novel evidence that the inflation-inequality relationship hinges critically on a country's global influence. Specifically, we find a U-shaped relationship between inflation and inequality among economies with a high degree of global influence. In contrast, the relationship seems to increase monotonically among economies with less global influence. To gauge the economic influence of a country in the sample, we construct an index that jointly takes into account GDP, GDP growth and financial openness. Among high influence economies which display a U-shaped inflation-inequality relationship, we find that the inequality-minimizing inflation rate is around 1.14%, which is close to the numerical simulation of our theoretical model.[7]

The contributions of our study are twofold. First, we demonstrate that the proposed model is able to reconcile the divergent empirical findings in the literature.[8] Our model implies that the relationship between inflation and income inequality in the domestic country can be either positive or U-shaped, depending on its market size and technological growth rate relative to the foreign country. In our model, the effect of monetary policy on income inequality is transmitted through two channels: the relative value of financial assets (equity and bonds) to wage, and the global real interest rate. The proposed mechanism aligns with the empirical analysis of Madsen (2019), emphasizing asset returns as an important source of income inequality. In particular, we show that the global real interest rate is a weighted average of domestic and foreign technology growth rates. This implies that monetary policy independently implemented in each country can affect income distribution in both countries.

In addition, this study contributes to the literature by offering meaningful implications for theory- and evidence-based policy making. We find that, for small economies with limited influence on the global interest rate, the dual goal of boosting long-term economic growth and reducing income inequality can be concurrently achieved if the monetary authority sets the inflation target at the lowest possible level. In essence, the Friedman rule retains its optimality even when considering the objective of minimizing inequality. For large economies that exert significant impact on the global interest rate, a U-shaped inflation-inequality relationship implies the potential tradeoff between growth and income inequality. In this scenario, there is an optimal

[6]In the presence of CIA constraints with unequal strengths, however, the extended model in Appendix B shows that incumbents' innovation intensity in the domestic country is weakly increasing (decreasing) in domestic inflation if incumbent firms are less (more) cash-constrained than entrant firms.

[7]Note that it is lower than the estimate of Galli and van der Hoeven (2001), whose empirical analysis is based on a dataset covering fewer economies.

[8]In this study, we restrict our attention to the long-run relationship between inflation and inequality, rather than the short-run responses of inequality to conventional or unconventional monetary policy shocks. For recent empirical studies on the latter topic, please refer to Furceri and Loungani (2018) and Samarina and Nguyen (2019).

inflation level that minimizes income inequality, albeit at the cost of economic growth.[9]

This study relates to the literature on inflation and innovation in a growth-theoretic framework that features CIA requirements. Marquis and Reffett (1994) firstly analyze the effects of inflation on innovation in the Romer (1990) type variety-expansion growth model.[10] Subsequent studies investigate the effects of inflation on innovation in the Schumpeterian type quality-ladder growth model. Representative studies include Chu and Cozzi (2014) and Huang *et al.* (2017).[11] Recent studies, such as Chu *et al.* (2017) and Arawatari *et al.* (2018), explore this issue by incorporating firm heterogeneity into R&D-based growth models.[12] However, the analysis of the above studies is based on a closed-economy setting. The current study contributes to the literature by introducing an open-economy framework that is able to provide potential policy implications on cross-country interactions between inflation and inequality. One notable exception is Chu *et al.* (2015), who also analyze the long-run effects of inflation on innovation in a two-country quality-ladder model with semi-endogenous growth. Nevertheless, all the aforementioned studies feature a representative household, the assumption of which, by nature, does not provide insights on inequality-related issues. The novel contribution of this study is to incorporate household heterogeneity into a two-country framework with international trade in order to analyze the effects of inflation on inequality in addition to innovation and economic growth in a global economy.

This study speaks to the literature on innovation and inequality in an R&D-based growth model; see, for example, Zweimüller (2000), Foellmi and Zweimüller (2006), Grossman and Helpman (2018), and Aghion *et al.* (2019), in which the innovation-inequality relationship is their main focus. In addition, Chu (2010) and Chu and Cozzi (2018) explore the effects of patent protection on income inequality, whereas the present study differs from their interesting studies by considering the effects of monetary policy instead. This paper is closely related to Chu *et al.* (2019), who explore the effects of inflation on innovation and inequality. Our results complement their work in two aspects. First, the framework of Chu *et al.* (2019) considers the closed economy setting, which rules out the effect of foreign policy changes on domestic economy. Our framework, however, exploits the open-economy framework and suffices to capture the cross-country effects of inflation on income inequality. Second, the cross-country empirical evidence in Chu *et al.* (2019) suggests an inverted-U effect of inflation on income inequality, which is justified analytically by the presence of endogenous entry of heterogeneous firms. In contrast, our empirical analysis shows a U-shaped inflation-inequality relationship among countries with high global influence, and a positive correlation among countries with low global influence, both of which

[9]However, whether central banks should set the inflation target specifically to minimize income inequality falls outside the scope of this paper.

[10]Recently, Gil and Iglésias (2020) study the effects of inflation on innovation in a similar Romer growth model in which R&D is complemented with physical capital accumulation.

[11]Huang *et al.* (2021) and Zheng *et al.* (2021) explore the effects of inflation on innovation in a growth model with both variety expansion and quality improvement.

[12]Specifically, Chu *et al.* (2017) consider endogenous entry of heterogeneous firms in a quality-ladder growth model, whereas Arawatari *et al.* (2018) consider heterogeneous R&D abilities of firms in a variety-expansion growth model.

can be rationalized by the relative magnitude of domestic to foreign technology growth rate.

Finally, this study also contributes to a recent growing literature that unifies innovating firms and aggregate innovation in a general equilibrium framework that allows firms to add or lose their product lines on the basis of innovation and creative destruction forces.[13] The pioneering works of Klette and Kortum (2004) and Lentz and Mortensen (2008) show that many behaviors under this framework are consistent with the applied micro literature (e.g., the pattern of R&D investment and its nexus to firms). Subsequent studies extend this framework to analyze various issues in applied growth theory. For example, Aghion *et al.* (2016) explore the relationship between taxation and economic growth through the lens of corruption and government inefficiency. Acemoglu *et al.* (2016) analyze the nature of a transition to clean technology and the use of carbon taxes. Akcigit and Kerr (2018) analyze how different types of innovation (external versus internal) affect economic growth and the firm size distribution. Acemoglu *et al.* (2018) explore the implications of industrial policies on long-run growth and welfare. Akcigit *et al.* (2021) explore the importance of the distinctions between basic and applied research investment. This paper complements these interesting studies by focusing on monetary policy and income inequality in an open economy.

The rest of this paper proceeds as follows. Section 2 introduces the model setup. Section 3 characterizes the decentralized equilibrium. Section 4 analyzes the cross-country effects of monetary policy. Section 5 performs a quantitative exercise and an empirical analysis. Finally, Section 6 concludes this study.

2 The Baseline Model

We construct an open-economy version of the monetary Schumpeterian growth model featuring both heterogeneous households and heterogeneous firms. Specifically, we extend to a two-country environment the closed-economy framework of Klette and Kortum (2004), in which quality-improving innovations give rise to growth due to the actions of entrants and incumbents, who are heterogeneous in terms of the number of product lines. Moreover, we introduce heterogeneous households in terms of asset endowment as in García-Peñalosa and Turnovsky (2006) and money demand via CIA constraints on R&D investment as in Chu and Cozzi (2014). The nominal interest rate in each country serves as the monetary policy instrument. When spelling out the model, to conserve space, only equations for the home country h are present. The corresponding equations for the foreign country f are analogous.

[13]The model of firm-level innovation, including innovation by both continuing firms and new entrants, enriches the traditional endogenous technological change literature by capturing different measures of innovative performance, such as firm growth, entry, and size distribution. Therefore, this model provides a simple analytical framework that can accommodate both the characteristics of individual firms and the behavior of the aggregate economy.

2.1 Households

There is a unit measure of households in country h, and each household is indexed by $s \in [0,1]$. The infinitely-lived households are identical in terms of time preference. The lifetime utility of household s in country h is given by

$$U^h(s) = \int_0^\infty e^{-\rho t} \ln c_t^h(s) dt, \tag{1}$$

where $c_t^h(s)$ is the consumption of final goods of household s at time t, and the parameter $\rho > 0$ represents the subjective discount rate. The asset-accumulation equation of household s expressed in real terms (i.e., denominated in units of final goods) in country h is given by

$$\dot{a}_t^h(s) + \dot{m}_t^h(s) = r_t a_t^h(s) + w_t^h - \pi_t^h m_t^h(s) + i_t^h b_t^h(s) - c_t^h(s) + \tau_t^h, \tag{2}$$

where $a_t^h(s)$ is the real value of financial assets (in the form of equity shares of monopolistic firms in country h), $m_t^h(s)$ is the real money balance held by household s that can be lent to entrepreneurs, and r_t is the real interest rate in country h. Each household in country h inelastically provides a unit of labor to earn the real wage rate w_t^h. π_t^h, the inflation rate, captures the cost of holding money. The amount of loans is $b_t^h(s)$, whereas i_t^h is the nominal interest rate as well as the return rate paid by entrepreneurs. τ_t^h is the amount of lump-sum transfer that each household receives from the government. It is assumed that the wealth of household s is given by the total value of her financial assets and bond holding (i.e., $a_t^h(s)$ and $b_t^h(s)$). The corresponding CIA constraint facing household s is[14]

$$b_t^h(s) \leq m_t^h(s). \tag{3}$$

We follow Dinopoulos and Segerstrom (2010) to assume that there is a global market. In this case, the real interest rates in the two countries must be equal such that $r_t^h = r_t^f = r_t$. Household s in country h maximizes her lifetime utility in Equation (1) subject to the budget constraint in (2) and the CIA constraint in (3). Solving this standard utility-maximization problem yields the familiar Euler equation

$$\frac{\dot{c}_t^h(s)}{c_t^h(s)} = r_t - \rho. \tag{4}$$

This equation implies that the growth rates of real consumption across households are identical such that $\dot{c}_t^h(s)/c_t^h(s) = \dot{c}_t^h/c_t^h$, where $c_t^h \equiv \int_0^1 c_t^h(s) ds$ is the total consumption of all households. Moreover, the no-arbitrage condition between all assets and money gives rise to the Fisher equa-

[14]In the classical CIA constraint on consumption in the conventional literature, the distribution of consumption across households is identical to that of money holdings because in equilibrium $c_t^h(s) = m_t^h(s)$, regardless of the specific fraction of consumption subject to the CIA constraint. As shown in Ragot (2014), however, both Italian and US data suggest that the distribution of money (M1) is similar to that of financial wealth, and much more unequally distributed than that of consumption expenditure. Therefore, the present study mainly focuses on households' financial motives for money holding, in addition to R&D firms' cash flow sensitivity.

tion $i_t^h = r_t + \pi_t^h$.

Following Dinopoulos and Segerstrom (2010) and Chu *et al.* (2015), this study also makes several simplifying assumptions on asset and money holdings. First, we assume that domestic monopolistic firms engaging in the production of intermediate goods and R&D investment can only be owned by domestic households, which rules out the possibility that domestic households hold foreign financial assets. In addition, it is assumed that domestic households do not hold foreign currency to satisfy the CIA constraint. While domestic and foreign nominal interest rates in the model economy are allowed to differ, the law of one price implies that the difference in nominal interest rates is purely accounted for by domestic and foreign inflation, which is simply reflected in the fluctuations in the nominal exchange rate. The same real interest rate across countries implied by the global real bond market disincentivizes domestic households to hold foreign currency.[15]

2.2 Production Relations

The global market produces a unique final good for consumption in the two countries. Competitive firms produce consumption goods by aggregating two types of gross outputs by country h and f (i.e., Y_t^h and Y_t^f) using a standard Cobb-Douglas aggregator as in Klenow (1996) such that[16]

$$C_t = \frac{\left(Y_t^h\right)^{1-\alpha}\left(Y_t^f\right)^{\alpha}}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}, \tag{5}$$

where $\alpha \in (0,1)$ governs the output shares of country-level inputs and also determines the importance of foreign goods in consumption production. Solving the profit-maximization problem yields the conditional demand functions for Y_t^h and Y_t^f, respectively,

$$Y_t^h = \frac{(1-\alpha)C_t}{p_{y,t}^h},$$

$$Y_t^f = \frac{\alpha C_t}{p_{y,t}^f},$$

where $p_{y,t}^h$ is the price of Y_t^h and $p_{y,t}^f$ is the price of Y_t^f. Both of these prices are expressed in units of the final good. Suppose that the nominal price of the final good in country h is $P_{c,t}^h$, which is denominated in units of currency in country h. Then, the assumption that the final good is freely traded across the two countries ensures the law of one price to hold such that the nominal price of the final good denominated in units of currency in country f is $P_{c,t}^f = \epsilon_t P_{c,t}^h$, where ϵ_t is the

[15]As suggested by Chu *et al.* (2015), domestic households might exploit foreign currency for bond purchases, if the uncovered interest rate parity does not hold. This possibility, however, is typically not considered in the literature.

[16]The use of a Cobb-Douglas aggregator instead of a more general CES aggregator leads to a convenience that allows for Y_t^h and Y_t^f to grow at different rates on the balanced growth path.

nominal exchange rate.

Gross outputs are also produced by competitive firms. In country h, competitive firms produce Y_t^h by aggregating a unit measure of intermediate goods $Z_t^h(j)$ according to the following production function:

$$Y_t^h = \exp\left(\int_0^1 \ln Z_t^h(j)dj\right), \tag{6}$$

where $Z_t^h(j)$ is the quantity produced of intermediate good j. From profit maximization, the conditional demand function of $Z_t^h(j)$ is given by

$$Z_t^h(j) = \frac{p_{y,t}^h Y_t^h}{p_{z,t}^h(j)} = \frac{(1-\alpha)C_t}{p_{z,t}^h(j)},$$

where $p_{z,t}^h(j)$ is the price (denominated in units of final good) of $Z_t^h(j)$. Moreover, the standard price index of Y_t^h is given by $p_{y,t}^h \equiv \exp\left(\int_0^1 \ln p_{z,t}^h(j)dj\right)$.

Intermediate goods in country h are not allowed to be traded, and are produced monopolistically by local innovators who hold the latest patent on product line j, according to the following production technology:

$$Z_t^h(j) = q_t^h(j) l_{z,t}^h(j), \tag{7}$$

where $q_t^h(j)$ is the product-line-specific labor productivity and $l_{z,t}^h(j)$ is the labor employed for production in country h. Then the marginal cost of production in product line j is $w_t^h / q_t^h(j)$. Each innovation improves the productivity of a given product line j from $q_t^h(j)$ to $(1+\lambda^h)q_t^h(j)$, where λ^h 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

$$p_{z,t}^h(j) = (1+\lambda^h)\frac{w_t^h}{q_t^h(j)}.$$

In addition, the profit flow and the wage expenditure in this product line are, respectively, given by

$$\Pi_t^h(j) = \frac{\lambda^h}{1+\lambda^h} p_{y,t}^h Y_t^h = \frac{\lambda^h}{1+\lambda^h}(1-\alpha)C_t, \tag{8}$$

$$w_t^h l_{z,t}^h(j) = \frac{p_{y,t}^h Y_t}{1+\lambda^h} = \frac{(1-\alpha)C_t}{1+\lambda^h}. \tag{9}$$

Equations (8) and (9) indicate that the profit flow and the employment level of production labor for each product line are identical.

2.3 Innovation Technology

At any given time, a firm in country h denoted by $k^h \in [0, K^h]$ is defined by a collection of product lines. In equilibrium, the number of product lines summarizes the state of a firm. Denote by n^h the number of product lines of an incumbent firm in country h. A firm expands in the product space through successful innovations, whereas it exits the market and becomes an outsider for $n^h = 0$. With a probability of $x^h_{k,t}$, 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 $(1 + \lambda^h)$. In this case, the firm becomes the new monopoly producer in line j' and thereby increases the number of its production lines to $n^h + 1$. At the same time, each of its n^h current production lines is subject to the rate τ^h_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 $n^h + 1$ with a probability of $n^h x^h_{k,t}$ and decreases to $n^h - 1$ with a probability of $n^h \tau^h_t$ (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^h) with the number of scientists ($S^h_{k,t}$), according to the following Cobb-Douglas production function:

$$X^h_{k,t} = \left(\frac{S^h_{k,t}}{\varphi^h} \right)^{\gamma^h} (n^h)^{1-\gamma^h},$$

where $X^h_{k,t}$ is the Poisson innovation flow rate, $\gamma^h \in (0, 1)$ is the elasticity of innovation with respect to scientists, and $\varphi^h > 0$ is a scale parameter. This study follows the existing literature, such as Chu and Cozzi (2014) and Huang *et al.* (2022), to incorporate a CIA constraint on R&D investment at time t, such that incumbent firms need to borrow from households to finance their wage payment to scientists. This setting implies an extra layer of financing cost on R&D activities, the magnitude of which is affected by the monetary policy instrument, namely the nominal interest rate i^h_t. Thus, the R&D cost function of a typical firm is given by

$$C^h(x^h_{k,t}, n^h) = w^h_t S^h_{k,t}(1 + \xi^h i^h_t) = \varphi^h n^h w^h_t (x^h_{k,t})^{\frac{1}{\gamma^h}} (1 + \xi^h i^h_t),$$

where $x^h_{k,t} \equiv X^h_{k,t}/n^h$ is defined as the innovation intensity (probability) of the firm, and $\xi^h \in [0, 1]$ is the strength of the CIA constraint on R&D in country h.

2.4 Entry

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

$$x^h_{e,t} = \frac{S^h_{E,t}}{\phi^h}, \tag{10}$$

where $x^h_{e,t}$ is the aggregate entry rate in the economy and $S^h_{E,t}$ is the number of scientists hired for entrant R&D. Equation (10) indicates that the arrival of one unit of successful innovation requires entrant firms to hire ϕ^h_t scientists. Similarly, we assume that entrants also need to borrow money in advance from households to facilitate their wage payment. Taking into account this borrowing cost, the free-entry condition for entry is given by

$$x^h_{e,t} V^h_t(1) = w^h_t S^h_{E,t}(1 + \xi^h i^h_t), \tag{11}$$

which equates the value of a new entry $V^h_t(1)$ to the cost of innovation. For analytical simplicity, the baseline model assumes that the strength of the CIA constraint on entrant R&D is identical to that on incumbent R&D. In Appendix B, we present an extended model in which this assumption is relaxed.[17]

2.5 Monetary Authority

Denote by M^h_t the nominal money supply in country h. Accordingly, the real money balance in country h is given by $m^h_t = M^h_t / P^h_{c,t}$, where $P^h_{c,t}$ is the price of consumption goods denominated in units of currency in country h. Then consider the growth rate of money supply $\dot{M}^h_t / M^h_t$ as a policy instrument that can be controlled by monetary authority in country h. In this case, the inflation rate in country h is determined by $\pi^h_t \equiv \dot{P}^h_{c,t} / P^h_{c,t} = \dot{M}^h_t / M^h_t - \dot{m}^h_t / m^h_t$. Additionally, combining this condition with the Fisher equation (i.e., $i^h_t = \pi^h_t + r_t$) yields the one-to-one relationship between the nominal interest rate and the nominal money supply, such that[18]

$$i^h_t = \dot{M}^h_t / M^h_t + \rho. \tag{12}$$

Given this result, throughout the rest of this study, we will use i^h_t to represent the instrument of monetary policy in country h for simplicity. Finally, monetary authority in country h redistributes to domestic households seigniorage revenues in the form of a lump-sum transfer, namely $\tau^h_t = \dot{M}^h_t / P^h_{c,t} = \left(\dot{M}^h_t / M^h_t\right)\left(M^h_t / P^h_{c,t}\right) = \left(\dot{m}^h_t / m^h_t + \pi^h_t\right) m^h_t = \dot{m}^h_t + \pi^h_t m^h_t$.

3 Monetary Policy and Economic Growth

This section characterizes the steady-state equilibrium of the model and explores the effects of monetary policy on economic growth. To solve the model, we focus on a balanced growth

[17] For a clear analytical solution, the baseline model considers equal strengths of the CIA constraints on incumbent and entrant R&D. As shown in the numerical analysis of Appendix B, allowing the strengths of CIA constraints to differ will bring an additional resource (labor) reallocation effect between incumbents and entrants. Conditional on our calibration, however, the negative relationship between the aggregate technology growth rate and the nominal interest rate, as illustrated below, remains unchanged.

[18] On the balanced growth path, c^h_t and m^h_t grow at the same rate of $r_t - \rho$ according to the Euler equation (4).

path (BGP), where all aggregate variables grow at a constant rate, and the firm size distribution is invariant. Hence, along BGP, time subscript t is dropped when it causes no confusion.

3.1 Stationary Equilibrium

We first analyze the innovation decision of firms. The stock-market value of an n-product firm $V_t^h(n^h)$ at time t satisfies the following Bellman equation:

$$rV_t^h(n^h) - \dot{V}_t^h(n^h) = \max_{x_k^h \geq 0} \left\{ \begin{array}{l} n^h \Pi_t^h - n^h w_t^h \varphi^h x_k^{\frac{1}{\gamma^h}} (1 + \xi^h i^h) \\ + n^h x_k^h [V_t^h(n^h + 1) - V_t^h(n^h)] \\ + n^h \tau^h [V_t^h(n^h - 1) - V_t^h(n^h)] \end{array} \right\},$$

where $\tau^h = x_k^h + x_e^h$ is the aggregate rate of creative destruction. This equation is similar to the ones in Klette and Kortum (2004) and Aghion *et al.* (2014), except the presence of $(1 + \xi^h i^h)$, which captures the additional cost of innovation induced by the CIA constraint. It is easy to verify that the value function takes the form of

$$V_t^h(n^h) = n^h v^h C_t, \tag{13}$$

where $v^h \equiv V^h/n^h$ is the average normalized value of a production unit in country h. Solving the maximization problem yields

$$x_k^h = \left[\frac{\gamma^h v^h}{\varphi^h \omega^h (1 + \xi^h i^h)} \right]^{\frac{\gamma^h}{1-\gamma^h}}, \tag{14}$$

where $\omega^h = w_t^h / C_t$. Substituting (13) into (11), coupled with (10), yields

$$v^h = \phi^h \omega^h (1 + \xi^h i^h). \tag{15}$$

Combining (14) and (15) shows that the (steady-state) equilibrium of an incumbent's innovation intensity is given by

$$x_k^h = \left(\frac{\gamma^h \phi^h}{\varphi^h} \right)^{\frac{\gamma^h}{1-\gamma^h}}, \tag{16}$$

and substituting (13) into the Bellman equation yields the equilibrium entry rate such that

$$x_e^h = \frac{(1-\alpha)\lambda^h}{\phi^h \omega^h (1 + \lambda^h)(1 + \xi^h i^h)} - \gamma^h \left(\frac{\gamma^h \phi^h}{\varphi^h} \right)^{\frac{\gamma^h}{1-\gamma^h}} - \rho, \tag{17}$$

where the Euler equation $g = r - \rho$ has been applied and the steady-state value of ω^h will be given by (22).

To characterize the equilibrium, we first derive the firm size distribution in country h. For any incumbent firm with n^h product lines, it will gain new products at the rate of $n^h x_k^h$ and lose existing products at the rate of $n^h \tau^h = n^h(x_k^h + x_e^h)$. Hence, in expectation each incumbent firm is shrinking at the rate given by

$$\frac{n^h x_k^h - n^h \tau^h}{n^h} = -x_e^h.$$

Denote by μ_{n^h} the mass of firms with n^h leading-edge product lines in country h. Thus, the distribution must satisfy the flow equations that equate the inflows and the outflows such that

$$\begin{aligned}
&\mu_1^h \tau^h = x_e^h \qquad \text{for} \quad \text{entry and exit,} \\
&(x_k^h + \tau^h)\mu_1^h = 2\mu_2^h \tau^h + x_e^h \qquad \text{for} \quad n^h = 1, \\
&(n^h - 1)x_k^h \mu_{n^h - 1} + (n^h + 1)\tau^h \mu_{n^h + 1} = (x_k^h + \tau^h) n^h \mu_{n^h}, \qquad \text{for} \quad n^h > 1.
\end{aligned}$$

Moreover, because there is a unit mass of products and each product is produced by one firm, we have

$$\sum_{n^h=1}^{\infty} n^h \mu_{n^h} = 1. \tag{18}$$

Let S_K^h and S_K^f be the aggregate level of incumbent R&D labor in country h and f, respectively. Thus, we have $S_K^h = \sum_{n^h=1}^{\infty} \mu_{n^h} S_k^h$ and $S_K^f = \sum_{n^f=1}^{\infty} \mu_{n^f} S_k^f$. In addition, denote the aggregate level of production labor, asset holdings, and bond holdings in country h by $L_{Z,t}^h \equiv \int_0^1 l_{z,t}^h(j)dj$, $a_t^h \equiv \int_0^1 a_t^h(s)ds$, and $b_t^h \equiv \int_0^1 b_t^h(s)ds$, respectively. Similarly, denote the counterparts in country f by $L_{Z,t}^f \equiv \int_0^1 l_{z,t}^f(j)dj$, $a_t^f \equiv \int_0^1 a_t^f(s)ds$, and $b_t^f \equiv \int_0^1 b_t^f(s)ds$, respectively. These allow us to define the balanced growth path equilibrium, which is presented in Appendix A.1.

Integrating (9) over j and rearranging the resulting equation yield the aggregate production labor in country h on the BGP such that

$$L_Z^h = \frac{1-\alpha}{(1+\lambda^h)\omega^h}. \tag{19}$$

The number of scientists devoted to entrant R&D in country h is derived by using (10):

$$S_E^h = \phi^h x_e^h, \tag{20}$$

where x_e^h is given by (17). Using $S_k^h = n^h \varphi^h (x_k^h)^{1/\gamma^h}$ and x_k^h in (16) yields

$$S_K^h = \sum_{n^h=1}^{\infty} \mu_{n^h} S_k^h = \varphi^h \left(\frac{\gamma^h \phi^h}{\varphi^h}\right)^{\frac{1}{1-\gamma^h}}. \tag{21}$$

where the second equality applies (18). Substituting (19), (20) and (21) into the labor-market-clearing condition in country h yields

$$\omega^h = \frac{(1-\alpha)(1+\lambda^h+\xi^h i^h)}{(1+\lambda^h)(1+\xi^h i^h)(1+\phi^h \rho)}. \tag{22}$$

Substituting (22) into (17) yields the steady-state value of the entry rate such that

$$x_e^h = \frac{\lambda^h(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)} - \gamma^h\left(\frac{\gamma^h \phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}} - \rho. \tag{23}$$

Accordingly, we obtain the following result.

Lemma 1. *In country h, the entry rate is decreasing in the nominal interest rate; and the incumbent's innovation intensity is independent of it.*

Proof. Use (23) to show that x_e^h is decreasing in i^h and (16) to show that x_k^h is invariant of i^h. □

Intuitively, a higher nominal interest rate i^h raises the cost of entrant R&D and decreases the incentives for new product lines, so the entry rate x_e^h declines. Nevertheless, a change in the nominal interest rate yields two effects on the incumbent's innovation intensity. On the one hand, a higher nominal interest rate raises the R&D cost of incumbents and decreases their incentives for innovation. On the other hand, a higher nominal interest rate reduces the rate of creative destruction caused by potential entry, which leads to a larger firm size for each incumbent and thereby an increase in incumbents' incentives for innovation. Since these two opposing effects offset one another in our theoretical model, x_k^h becomes independent of i^h.

3.2 Inflation and Growth

Substituting (7) into (6) yields the production function of gross output in country h such that

$$\ln Y_t^h = \int_0^1 \ln Z_t^h(j)dj = \ln\left[\frac{1-\alpha}{(1+\lambda^h)\omega^h}\right] + \int_0^1 \ln q_t^h(j)dj, \tag{24}$$

where the second equality applies (9). Define by $Q_t^h \equiv \exp\left(\int_0^1 \ln q_t^h(j)dj\right)$ the aggregate quality index in country h. During a small time interval Δt, the quality index evolves as follows:

$$\begin{aligned}\ln Q_{t+\Delta t}^h &= \int_0^1 \left\{\tau^h \Delta t \ln[(1+\lambda^h)q_t^h(j)] + (1-\tau^h\Delta t)\ln q_t^h(j)\right\} dj + o(\Delta t)\\ &= \tau^h \Delta t \ln(1+\lambda^h) + \ln Q_t^h + o(\Delta t),\end{aligned}$$

which implies that the growth rate of quality index in country h is given by

$$
\begin{aligned}
g^h \equiv \frac{\dot{Q}_t^h}{Q_t^h} = \frac{\dot{Y}_t^h}{Y_t^h} &= (x_e^h + x_k^h)\ln(1+\lambda^h) \\
&= \left[\frac{\lambda^h(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)} + (1-\gamma^h)\left(\frac{\gamma^h\phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}} - \rho\right]\ln(1+\lambda^h).
\end{aligned} \tag{25}
$$

Apparently, the technology growth rate g^h in country h is decreasing in the domestic nominal interest rate i^h, whereas it is independent of the foreign nominal interest rate i^f.

Following the same logic, one can also derive the analogous equations for $\{Y_t^f, Q_t^f\}$ and the growth rate of quality index in country f such that

$$
\begin{aligned}
g^f \equiv \frac{\dot{Q}_t^f}{Q_t^f} = \frac{\dot{Y}_t^f}{Y_t^f} &= (x_e^f + x_k^f)\ln(1+\lambda^f) \\
&= \left[\frac{\lambda^f(1+\phi^f\rho)}{\phi^f(1+\lambda^f+\xi^f i^f)} + (1-\gamma^f)\left(\frac{\gamma^f\phi^f}{\varphi^f}\right)^{\frac{\gamma^f}{1-\gamma^f}} - \rho\right]\ln(1+\lambda^f),
\end{aligned} \tag{26}
$$

which is decreasing in the country f's nominal interest rate i^f and independent of the country h's nominal interest rate i^h.

Given (25) and (26), differentiating the log of (5) with respect to time yields the steady-state growth rate of output such that $g \equiv (1-\alpha)g^h + \alpha g^f$. Then differentiating g with respect to i^h and i^f, respectively, yields

$$
\frac{\partial g}{\partial i^h} = (1-\alpha)\underbrace{\frac{\partial g^h}{\partial i^h}}_{<0} + \alpha\underbrace{\frac{\partial g^f}{\partial i^h}}_{=0}; \qquad \frac{\partial g}{\partial i^f} = (1-\alpha)\underbrace{\frac{\partial g^h}{\partial i^f}}_{=0} + \alpha\underbrace{\frac{\partial g^f}{\partial i^f}}_{<0}. \tag{27}
$$

The above results are summarized in the following proposition.

Proposition 1. *The growth rate of domestic (foreign) technology is decreasing in the domestic (foreign) nominal interest rate but independent of the foreign (domestic) nominal interest rate. The economic growth rate in a country is decreasing in both the domestic and foreign nominal interest rates.*

Proof. Proven in the text. □

4 Monetary Policy and Inequality

In this section, we explore how domestic and foreign monetary policies affect income inequality in the domestic country. First, we show in Section 4.1 that the wealth distribution is stationary along the BGP. Thereafter, we explore the cross-country effects of monetary policy on income distribution in Section 4.2.

4.1 Wealth Distribution

Suppose that at time 0 along the BGP, the consumption share of household s in country h is $\theta^h_{c,0}(s) \equiv c^h_0(s)/c^h_0$, and the general distribution function for the consumption share features a mean of one and a standard deviation of $\sigma^h_c > 0$. According to the Euler equation (4), the motion of households' consumption share in country h is time-invariant such that

$$\frac{\dot{\theta}^h_{c,t}(s)}{\theta^h_{c,t}(s)} = \frac{\dot{c}^h_t(s)}{c^h_t(s)} - \frac{\dot{c}^h_t}{c^h_t} = 0. \tag{28}$$

Therefore, the consumption share of household s in country h is identical for all $t > 0$, namely, $\theta^h_{c,t}(s) = \theta^h_{c,0}(s)$. However, $\theta^h_{c,0}(s)$ is an endogenous variable that can be affected by economic policies and is a function of the wealth share of household s. To see this, we characterize the distribution of household s' wealth share. Since household s at any time along the BGP exhausts all the cash holding such that $b^h_t(s) = m^h_t(s)$, her asset-accumulation function in (2) can be rewritten as

$$\dot{a}^h_t(s) + \dot{b}^h_t(s) = r_t[a^h_t(s) + b^h_t(s)] + w^h_t + \tau^h_t - c^h_t(s), \tag{29}$$

where the Fisher equation $i^h_t = r_t + \pi^h_t$ is applied. Aggregating (29) for all s yields

$$\dot{a}^h_t + \dot{b}^h_t = r_t(a^h_t + b^h_t) + w^h_t + \tau^h_t - c^h_t. \tag{30}$$

Define by $d^h_t(s) \equiv a^h_t(s) + b^h_t(s)$ household s' wealth at time t, which consists of financial assets and bond holdings. Moreover, let $\theta^h_{d,0}(s) \equiv d^h_0(s)/d^h_0$ be the share of wealth of household s in country h at time 0 along the BGP. The general distribution function for households' wealth share features a mean of one and a standard deviation of $\sigma^h_d > 0$. It is useful to note that the definition of $d^h_t(s)$ relates the distribution of money to financial wealth, and the deviation of money distribution is identical to that of financial wealth distribution. This feature is in line with the stylized fact documented by Ragot (2014).[19]

Using (29) and (30) to derive the motion of household s' wealth share $\theta^h_{d,t}(s) \equiv d^h_t(s)/d_t(s)$ in country h for all t yields

$$\dot{\theta}^h_{d,t}(s) = \underbrace{\frac{c^h_t - w^h_t - \tau^h_t}{d^h_t}}_{\chi_1 = \rho} \theta^h_{d,t}(s) - \frac{c^h_t \theta^h_{c,0}(s) - w^h_t - \tau^h_t}{d^h_t}, \tag{31}$$

[19] Ragot (2014) uses the US data to show that the Gini coefficient in 2004 is around 0.8 for the distribution of net wealth, which is nearly identical to that of money.

where $\chi_1 = \rho > 0$ is implied by (30), combined with the fact that $\{a_t^h, b_t^h, c_t^h, w_t^h, \tau_t^h\}$ all grow at the same steady-state rate of g along the BGP. Since $\theta_{d,t}^h(s)$ is a state variable and the coefficient on $\theta_{d,t}^h(s)$ is positive, the only solution for the one-dimensional differential equation that describes the potential evolution of $\theta_{d,t}^h(s)$ is $\dot{\theta}_{d,t}^h(s) = 0$ for all $t > 0$ along the BGP. This can be achieved, as shown in Appendix A.2, by having the consumption share $\theta_{c,t}^h(s)$ equal to its steady-state value $\theta_{c,0}^h(s)$. The following proposition summarizes the result.

Lemma 2. *Holding constant the nominal interest rates i^h and i^f, the wealth share of household s is stationary over time such that $\theta_{d,t}^h(s) = \theta_{d,0}^h(s)$ for all $t > 0$ along the BGP.*

Proof. See Appendix A.2. □

4.2 Income Distribution

From (29), the before-transfer income earned by household s in country h is $I_t^h(s) = rd_t^h(s) + w_t^h$. Aggregating over s yields the total income earned by households in country h such that $I_t^h = rd_t^h + w_t^h$. Combining both equations yields the income share of household s:

$$\theta_{I,t}^h(s) \equiv \frac{I_t^h(s)}{I_t^h} = \frac{\theta_{d,t}^h(s) rd_t^h + w_t^h}{rd_t^h + w_t^h}, \tag{32}$$

where the second equality applies $d_t^h(s) = \theta_{d,t}^h(s) d_t^h$ from Lemma 2. The distribution function of income share $\theta_{I,t}^h(s)$ has a mean of one and the following standard deviation:[20]

$$\sigma_{I,t}^h = \sqrt{\int_0^1 [\theta_{I,t}^h(s) - 1]^2 ds} = \frac{rd_t^h / w_t^h}{1 + rd_t^h / w_t^h} \sqrt{\int_0^1 [\theta_{d,t}^h(s) - 1]^2 ds} = \frac{rd_t^h / w_t^h}{1 + rd_t^h / w_t^h} \sigma_d^h. \tag{33}$$

Given that the value of σ_d^h is stationary, equation (33) implies that the degree of income inequality is an increasing function of rd_t^h / w_t^h, because an unequal distribution of wealth is the source of income inequality in this model.

Recall that the total wealth in country h is given by $d_t^h = a_t^h + b_t^h$. From the asset-market-clearing condition, we obtain the asset-wage ratio given by

$$\frac{a_t^h}{w_t^h} = \frac{\sum_{n=1}^{\infty} \mu_n^h V_t^h(n)}{w_t^h} = \frac{v^h}{\omega^h} = \phi^h (1 + \xi^h i^h), \tag{34}$$

where the second and last equalities apply (18) and (15). Obviously, a_t^h / w_t^h is increasing in the domestic nominal interest rate i^h and independent of the foreign nominal interest rate i^f. In

[20] It is useful to note that the Gini coefficient of income is also given by $\sigma_{I,t}^h = \frac{rd_t^h / w_t^h}{1 + rd_t^h / w_t^h} \sigma_d^h$, when σ_d^h is defined as the Gini coefficient of wealth. The derivation is available upon request.

addition, substituting (21) and (20) into b_t^h/w_t^h yields the bond-wage ratio:

$$\frac{b_t^h}{w_t^h} = \frac{\xi^h \lambda^h (1+\phi^h \rho)}{1+\lambda^h+\xi^h i^h} - \xi^h \phi^h \rho, \tag{35}$$

which is increasing in the domestic nominal interest rate i^h and independent of the foreign nominal interest rate i^f. Thus, we can derive the ratio of total interest income to wage income:

$$\frac{rd_t^h}{w_t^h} = \frac{r(a_t^h+b_t^h)}{w_t^h} = (\rho+g)\left\{\phi^h(1+\xi^h i^h) + \frac{\xi^h \lambda^h (1+\phi^h \rho)}{1+\lambda^h+\xi^h i^h} - \xi^h \phi^h \rho\right\}. \tag{36}$$

Differentiating (36) with respect to i^f shows that a rise in the foreign nominal interest rate decreases the ratio of total interest income to wage income rd_t^h/w_t^h via the growth-retarding effect (according to Proposition 1), provided that it does not affect d_t^h/w_t^h in country h. Thus, using equation (33), we see that a higher i^f reduces income inequality in country h.

In contrast, the effect of the domestic nominal interest rate i^h on the ratio of total interest income to wage income rd_t^h/w_t^h is transmitted through two channels, namely the asset-wage ratio d_t^h/w_t^h channel and the economic growth rate g (or equivalently the real interest rate r) channel. In particular, the former channel accommodates two opposing effects. First, a higher i^h raises the expected firm value per product line (v^h) in the R&D sector, because a larger firm value must be accompanied by the rise in R&D cost, according to the free entry assumption.[21] As a result, a_t^h/w_t^h rises, which tends to increase d_t^h/w_t^h. Second, a higher i^h triggers increased cost of financing wage payment, and hence, weakens R&D firms' money demand. As a consequence, b_t^h/w_t^h decreases, which tends to reduce d_t^h/w_t^h. Without any analytical ambiguity, however, the increase in a_t^h/w_t^h induced by higher nominal interest rate always dominates the decline in b_t^h/w_t^h, resulting in the *positive valuation effect* on d_t^h/w_t^h.

For the economic growth rate channel, Proposition 1 indicates that increased i^h reduces the domestic economic growth rate g and the real interest rate r. Consequently, rd_t^h/w_t^h decreases and the distribution of income tends to be narrowed. We label it the *negative growth effect*, which corresponds to the interest rate effect in Chu and Cozzi (2018), but in the meantime differs noticeably in terms of the transmission mechanism. In our study, the effect of i^h on domestic income inequality is contingent on foreign technology growth rate, since domestic economic growth rate (and real interest rate) is jointly determined by g^h and g^f. We find that the relationship between domestic nominal interest rate and domestic income inequality becomes U-shaped when foreign technology growth rate g^f is sufficiently low. In that case, the negative growth effect through r tends to dominate the positive valuation effect through d_t^h/w_t^h for low initial levels of domestic nominal interest rate i^h, whereas the positive effect through d_t^h/w_t^h could dominate the negative growth effect through r for higher levels of i^h. Hence, there exists a positive threshold rate of

[21]It corresponds to the asset-value effect in Chu and Cozzi (2018).

domestic nominal interest such that domestic income inequality can be minimized. The intuition of this interesting result is that, in the presence of a low foreign technology growth rate g^f, the contribution to country h's economic growth rate mainly comes from domestic technology growth rate g^h. When initial nominal interest rate i^h is low, its effect on narrowing the income distribution gets strengthened.

To the contrary, if foreign technology growth rate g^f is relatively high, then conditional on a rise in i^h, the positive valuation effect through d_t^h/w_t^h always dominates the negative growth effect through r, amplifying the degree of income inequality. In this case, the degree of income inequality is monotonically increasing in domestic nominal interest rate. Summarizing the aforementioned results, we obtain the following proposition.

Proposition 2. *For a sufficiently low (high) foreign technology growth rate, the effect of domestic nominal interest rate on domestic income inequality is U-shaped (monotonically increasing). Moreover, domestic income inequality is monotonically decreasing in foreign nominal interest rate.*

Proof. See Appendix A.3. □

It is worth noting that the model-implied qualitative effects of the nominal interest rate on economic growth and income inequality also apply to the effects of inflation. Similar arguments in the context of monetary Schumpeterian growth model can be found in Chu and Cozzi (2014) and Chu *et al.* (2017). Combining the Fisher equation and the Euler equation, the inflation rate is given by $\pi = i - r = i - g(i) - \rho$. Therefore, it is straightforward to show that $\partial\pi/\partial i = 1 - \partial g(i)/\partial i > 0$ if $\partial g(i)/\partial i < 1$. The positive long-run relationship between the inflation rate and the nominal interest rate is supported by the empirical evidence in Mishkin (1992) and Booth and Ciner (2001). Moreover, in the quantitative analysis to be discussed in the next section, our calibration ensures that steady-state inflation is increasing in the nominal interest rate.[22]

In addition, Proposition 2 implies that the effect of domestic inflation on domestic income inequality is closely related to the size of a country (i.e., the value of α). Specifically, for small open economies (SOEs), namely under a large α, their inflation rates are positively correlated with income inequality. In contrast, for large open economies (LOEs), namely under a small α, the relationship between inflation and income inequality displays a U shape. Intuitively, recall that domestic inflation is jointly determined by the global real interest rate r (i.e., the negative growth effect) and the (relative) value of financial assets d_t^h/w_t^h (i.e., the positive evaluation effect). In this setting, the ratio d_t^h/w_t^h is only affected by home factors and it always increases with domestic inflation. However, the global real interest rate r can be affected by both home and foreign inflation, since r is a weighted average of domestic and foreign technology growth (i.e., $r = g + \rho = (1-\alpha)g^h + \alpha g^f + \rho$). Given the weight of each country, r will be dominated by the country whose technology growth rate is higher. If the domestic country is an LOE, r will

[22]To simplify our numerical and empirical analyses, we explore the model implications using the inflation rate, instead of the nominal interest rate.

mainly reflect the domestic country's technology growth; this is more likely to occur when the foreign country exhibits a low growth rate of technology.[23] Accordingly, the relationship between domestic inflation and domestic income inequality is determined by the interplay of the two opposing effects between the real interest rate r and the ratio d_t^h/w_t^h. In contrast, if the domestic country is an SOE, it (and its monetary policy) barely has an impact on r, since SOEs have no influence on the global interest rate by assumption. Therefore, r will mainly reflect the foreign country's technology growth; this is more likely to occur when the foreign country exhibits a high growth rate of technology. Accordingly, the relationship between domestic inflation and domestic income inequality is increasing, as greatly determined by the ratio d_t^h/w_t^h. In Section 5, both the numerical and the empirical analyses will show that a country's size is important for how domestic inflation affects domestic income inequality.[24] In addition, Appendix B presents the extended model where the identical strengths of CIA constraints are relaxed, and numerically explores the model implications on growth and income inequality, which are shown to be largely consistent with those under the baseline framework.

5 Quantitative Analysis

This section presents the quantitative analysis where we calibrate the baseline model to the US and eurozone data. Without loss of generality, we assume that the US is the domestic country, whereas the eurozone is the foreign country. In particular, we numerically evaluate the relationship between inflation rates and five targeted macroeconomic variables, namely technology growth rates, R&D intensity, income inequality, entry rates, and the firm size distribution, conditional on a benchmark of parameter values, along with several alternatives for sensitivity check and policy experiments.

5.1 Calibration

Our calibration on the set of structural parameters $\{\rho, \alpha, \lambda^h, \lambda^f, \phi^h, \phi^f, \varphi^h, \varphi^f, \xi^h, \xi^f, \gamma^h, \gamma^f\}$ closely follows the literature. We set the discount rate ρ to a standard value of 0.05. The parameters λ^h and λ^f for the step size of quality improvement in the domestic and foreign countries are both chosen to be 0.05, which is consistent with the range of estimates from Akcigit and Kerr (2018). Following Chu *et al.* (2015), we calibrate the two parameters regulating the strength of CIA constraints, namely ξ^h and ξ^f, to 0.33 and 0.56, respectively, and the parameter regulating the importance of foreign output to domestic consumption α to 0.42. Following Aghion *et al.*

[23]To see this, consider an extreme case of the foreign country having zero technology growth. In this case, r is completely determined by domestic technology growth and the relationship between domestic inflation and domestic income inequality becomes U-shaped; the domestic country is actually equivalent to a closed economy.

[24]In Subsection 5.4, we construct an index to measure a country's global influence, and approximate SOEs and LOEs by low influence economies (LIEs) and high influence economies (HIEs), respectively.

(2016), we calibrate γ^h and γ^f to 0.5, and set the entry rate x_e^h in the US to 0.058. As for the entry rate of eurozone countries, we follow Lentz and Mortensen (2008), who exploit the data on Denmark to estimate the firm entry rate, to set x_e^f to 0.04. In addition, the growth rates of the US and eurozone economies are set to 2%, and inflation rates are calibrated to 2.7% and 2.1%, respectively. Matching the calibrated long-run economic growth rates and firm entry rates, conditional upon the aforementioned parameter values, suffices to pin down the productivity parameters ϕ^h, ϕ^f, φ^h and φ^f. Consequently, the implied US and eurozone innovation rates, τ^h and τ^f, are around 0.41, which is close to the estimate in the literature (i.e. Acemoglu and Akcigit 2012), highlighting that the time length of new arrival of innovation is approximately 3 years. Table 1 summarizes the values of parameters and targeted moments.

Table 1: Parameter values in baseline calibration

Targeted moments					
g^h	g^f	π^h	π^f	x_e^h	x_e^f
2.0%	2.0%	2.7%	2.1%	5.8%	4.0%
Exogenously determined parameters					
ρ	α	ξ^h	ξ^f	λ^h	λ^f
0.05	0.42	0.33	0.56	0.05	0.05
Internally calibrated parameters					
	ϕ^h	ϕ^f	φ^h	φ^f	
	0.1641	0.1665	0.2331	0.2551	

5.2 Effects of Inflation: Benchmark

In the quantitative practice, first, we use the parameter values reported in Table 1 as a benchmark, and explore the effects of domestic inflation on the five targeted variables in both domestic and foreign countries. Fixing the foreign inflation rate at 2.1%, we allow the domestic inflation rate to vary between -20% and 20%. Panels (a) and (b) of Figure 1 suggest that the domestic technology growth rate is decreasing in domestic inflation, partly because higher domestic inflation reduces domestic R&D intensity, and hence, generates a sizable growth-regarding effect. Consistent with the model prediction, however, R&D intensity and the technology growth rate in the foreign country are unaffected by domestic inflation. As for the coefficient rd_t/w_t governing the dispersion of households' income, Figure 1 – Panel (c) suggests that domestic income inequality is monotonically increasing in domestic inflation. It is found that income inequality rises by 1.59% (from 0.0126 to 0.0128) when the inflation rate increases from 2% to 9%. To the contrary, higher domestic inflation unambiguously mitigates foreign income inequality. Therefore, evidence under the benchmark scenario indicates that the maximum domestic technology growth rate and the minimum domestic income inequality can be achieved simultaneously when the central bank sets the long-run domestic inflation target at the lowest possible value.

As shown in Figure 1 – Panel (d), a second source of growth-retarding effect originates from a lower entry rate induced by higher inflation. Given that the innovation rate by incumbents is constant, higher inflation reduces the aggregate innovation rate, leading to slower technological progress. In addition, Figure 1 – Panel (e) shows the asymmetric effect of inflation on incumbent firms with different number of product lines. In particular, we find that higher inflation reduces the shares of firms whose number of product lines is below 6, whereas its impact on the shares of large firms with more product lines is weakly positive.

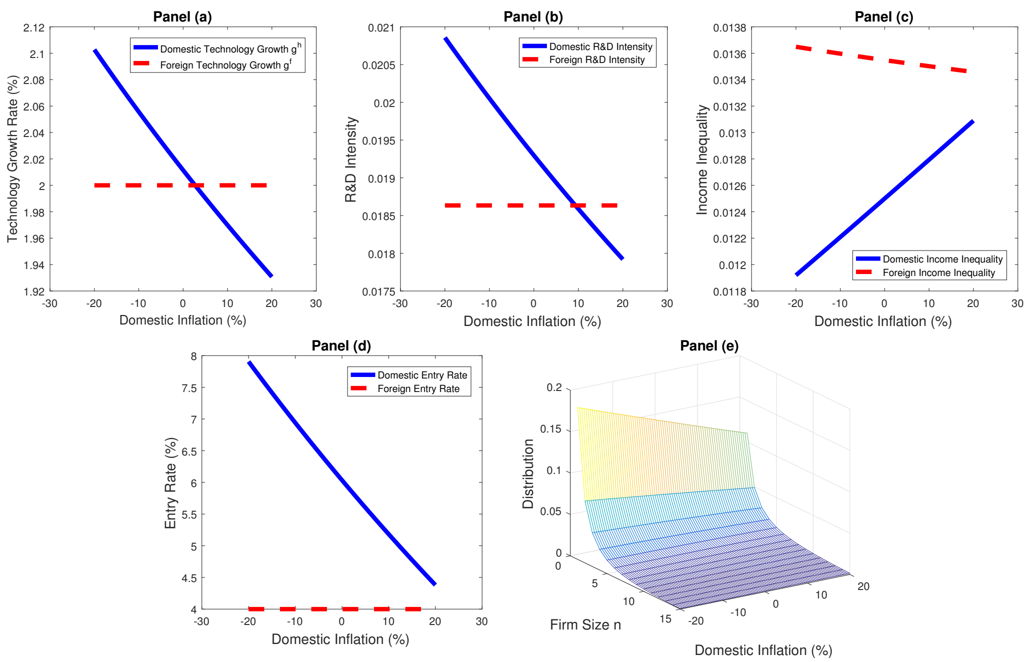

Figure 1: Effects of Domestic Inflation.

Figure 2 reports the effects of foreign inflation, whose value in consideration also ranges from -20% to 20%. Once we view the foreign country as the domestic country, the interpretation of the qualitative pattern of Figure 2 remains similar to that of Figure 1, which is attributed to the fact that the calibrated parameters capturing the US and eurozone economies are largely symmetric. However, it is worth noting that, under the benchmark scenario where the difference between domestic and foreign technological growth rates is not sufficiently large, the model does not generate a U-shaped relationship between inflation and income inequality in the domestic country. Further numerical exploration of Proposition 2 is discussed in the next subsection.

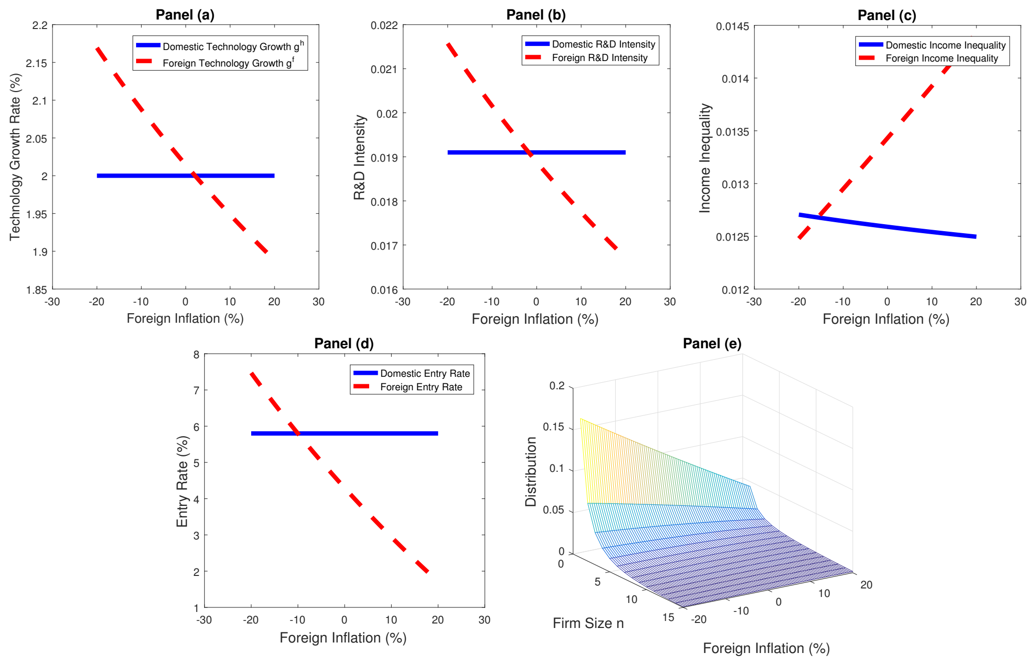

Figure 2: Effects of Foreign Inflation.

5.3 Sensitivity Analysis and Policy Experiment

To perform sensitivity analysis, we restrict our attention to the effects of domestic inflation, and consider alternative values of the structural parameters $\{\xi^h, \xi^f, \alpha, \phi^h, \phi^f\}$. First, when we enlarge the difference between ξ^h and ξ^f by setting $\xi^h = 0.2$ and $\xi^f = 0.8$, the qualitative pattern of the main model implications stays unchanged. As shown in Figure 3 – Panel (c), the relationship between domestic inflation and domestic income inequality is still positive, even though domestic income inequality is now consistently and substantially lower than foreign income inequality. In addition, in the presence of a relatively slack CIA constraint, domestic inflation yields a smaller quantitative impact on firm size distribution than the benchmark. Once we tighten the CIA constraint faced by domestic firms by setting $\xi^h = \xi^f = 0.5$, as reported in Figure 4, the effect of inflation on the number of firms with fewer product lines becomes sizable, and domestic income inequality is no longer systematically lower than foreign income inequality. It is found that domestic income inequality exceeds its foreign counterpart when domestic inflation rate is above 7%. As shown in Figure 5, the model implications are also robust to the calibration where the importance of eurozone output in the US economy, α, is reduced to 0.25.

In Section 4, Proposition 2 suggests that a U-shaped relationship between inflation and income inequality in the home country occurs when foreign technology growth rate is sufficiently low. To further explore the model implication, we consider the following set of parameters. Keeping $\alpha = 0.25$ and $\xi^h = \xi^f = 0.5$, we increase the step size of domestic quality improvement λ^h to 0.138, while reducing the step size of foreign innovation by 0.005 (from 0.05 to 0.045). In ad-

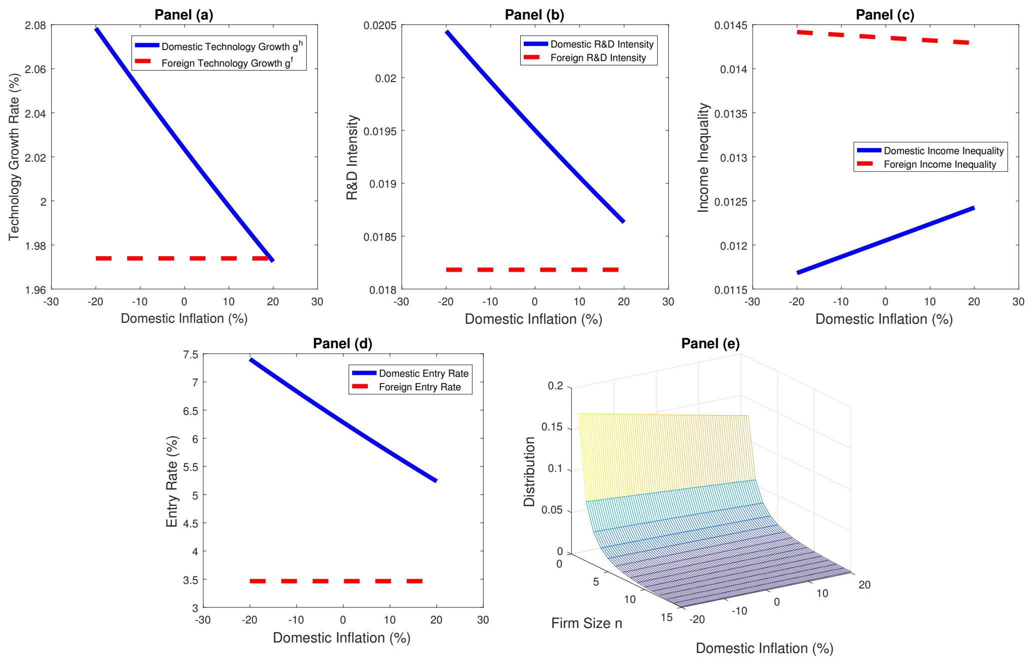

Figure 3: Effects of Domestic Inflation ($\xi^h = 0.2, \xi^f = 0.8$).

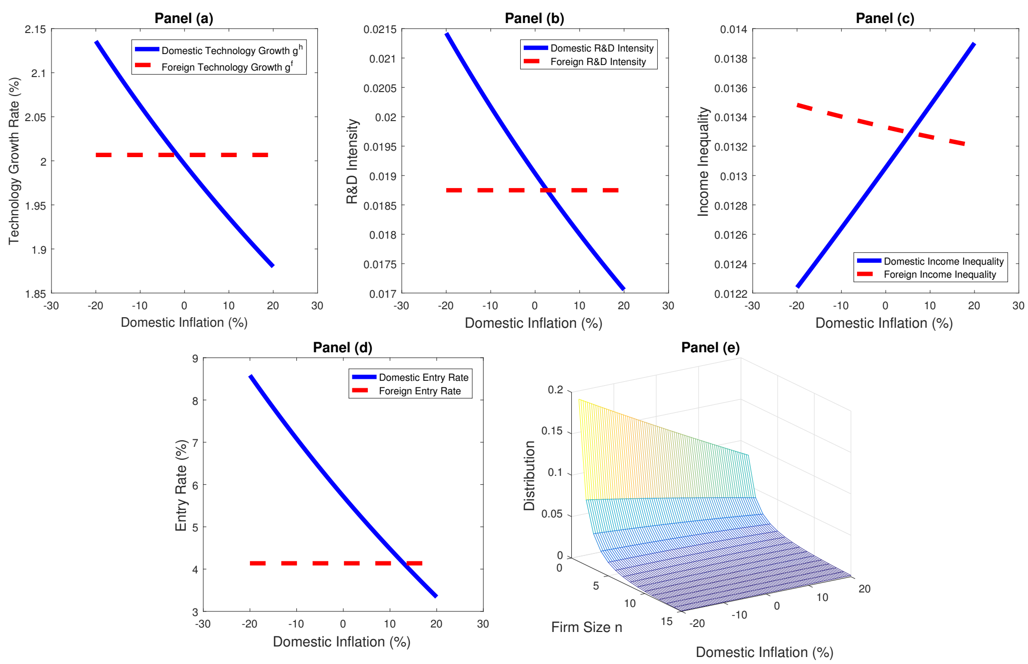

Figure 4: Effects of Domestic Inflation ($\xi^h = \xi^f = 0.5$).

dition, we set the productivity parameters $\phi^h = 0.085$ and $\varphi^h = 0.7$. Our intention is to generate a sizable gap between domestic and foreign technology growth rate, and in the meantime, ensure a positive foreign firm entry rate. Under this set of calibrated parameters, which is referred

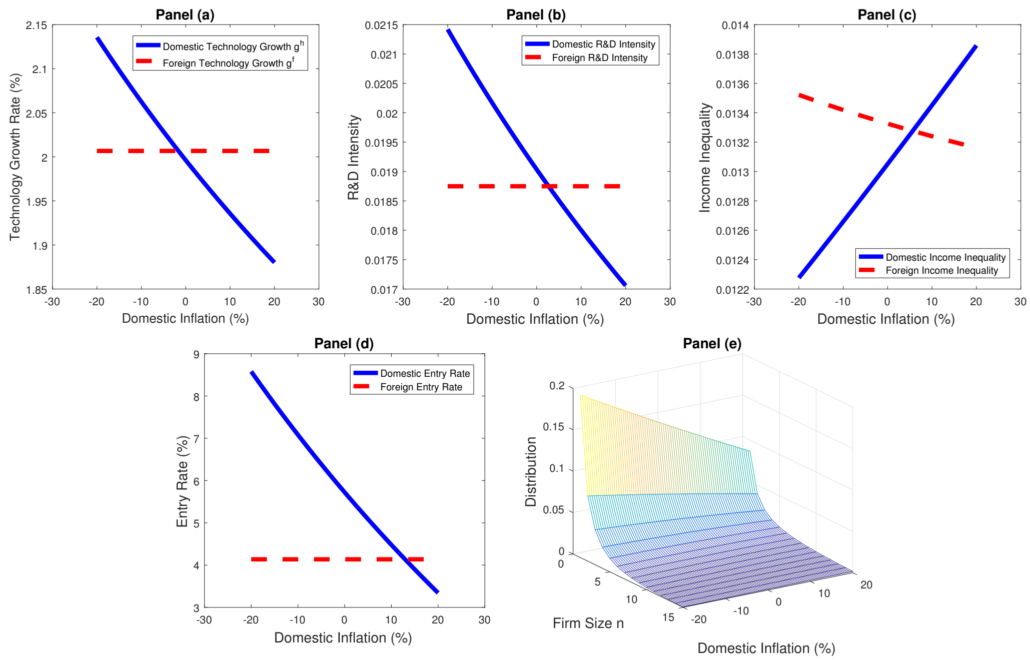

Figure 5: Effects of Domestic Inflation ($\alpha = 0.25; \xi^h = \xi^f = 0.5$).

to as the U-shaped calibration hereafter, Figure 6 shows that the effect of domestic inflation on domestic income inequality becomes U-shaped, whereas foreign income inequality is still monotonically decreasing in domestic inflation. It is found that the inequality-minimizing inflation rate is around 1%. Under the U-shaped calibration, domestic country exhibits remarkably higher values of R&D intensity, entry rate and productivity growth than those in the foreign country. Domestic firm distribution, however, seems largely unaffected by inflation rate.

In an alternative practice, we maintain the U-shaped calibration, but increase α to 0.6. It is worth noting that a large α indicates that the domestic country is a small open economy in nature, as implied by Proposition 2. As shown in Figure 7 – Panel (c), the U-shaped relationship between inflation and income inequality disappears if domestic country becomes small and heavily dependent on foreign final goods. This model implication is consistent with the empirical evidence to be presented in the next subsection.

In the presence of a U-shaped relationship, it is natural to ask what the inequality-minimizing inflation would be given any level of foreign inflation. We address this question and plot in Figure 8 the best responses of domestic inflation when foreign inflation rate varies from -20% to 20%, conditional on the U-shaped calibration. Notice that the best responses of foreign inflation to domestic inflation are trivial, since the foreign country, which is small and exhibits relatively low technological growth rate, can always minimize its income inequality by setting inflation rate at the lowest possible value. Figure 8 suggests that the central bank should gradually raise domestic inflation in response to increased foreign inflation if the objective of monetary policy is

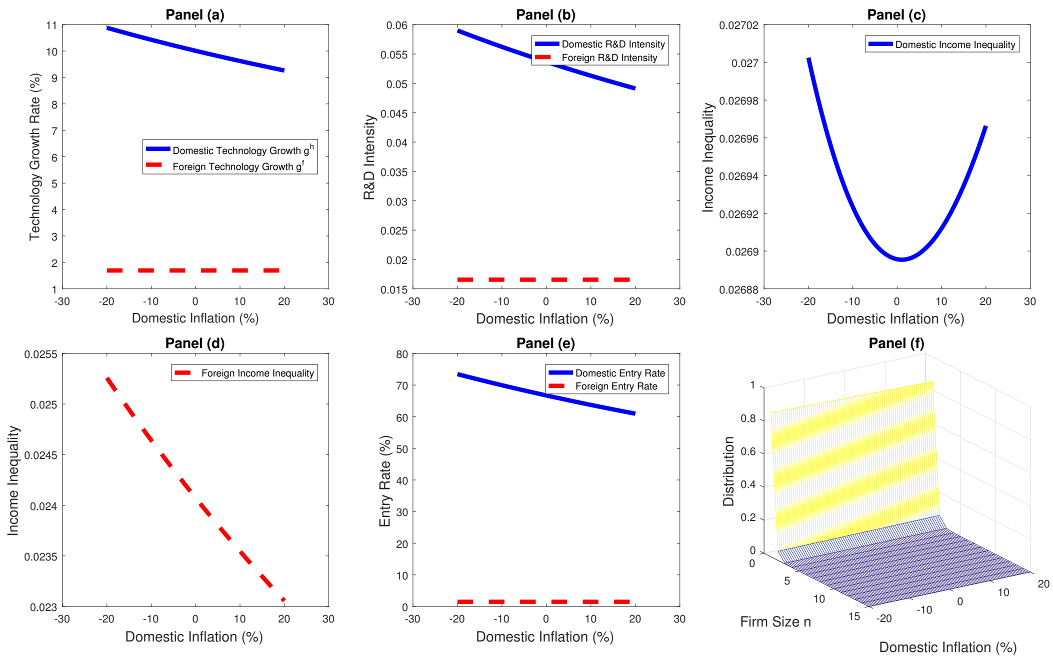

Figure 6: Effects of Domestic Inflation (U-shaped Calibration).

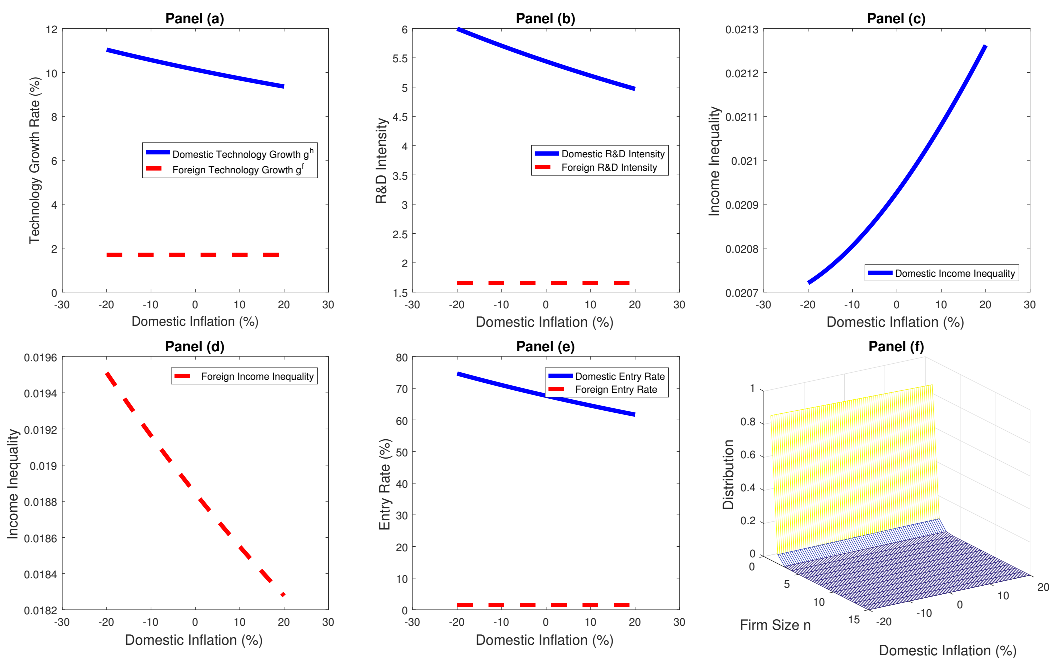

Figure 7: Effects of Domestic Inflation (U-shaped Calibration, $\alpha = 0.6$).

to minimize domestic income inequality.

In Figures 9 and 10, we report the corresponding economic growth rates and income inequality coefficients under the inequality-minimizing inflation, in comparison to three alternative scenarios where inflation rates are set constant at 2.5%, 5% and 10%, respectively.[25] It is observed that relatively high inflation (i.e. 10%) raises income inequality and simultaneously leads to the lowest economic growth rate, which seems the least favorable. When inflation is set constant at 2.5%, the resulting income inequality is higher than the minimized income inequality, but the difference is not substantial. This observation is partly attributed to the fact that inequality-minimizing inflation, given that foreign inflation varies between -6% and 10%, is around 1%, and within its close neighborhood, the effect of lower or higher domestic inflation on income inequality is not quantitatively sizable. As suggested in Figure 9, however, higher domestic inflation would induce a relatively large growth-retarding effect. Therefore, low inflation seems more desirable if both economic growth and income inequality enter the central bank's objective function.

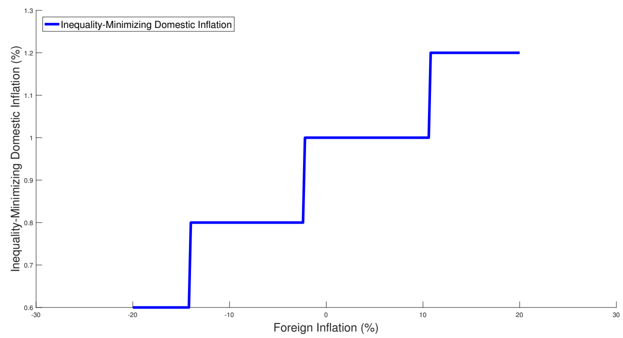

Figure 8: Inequality-Minimizing Level of Domestic Inflation in Response to Foreign Inflation

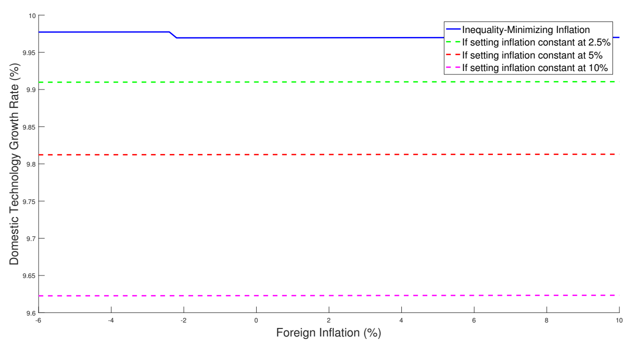

Figure 9: Inequality-Minimizing Level of Domestic Inflation: Economic Growth

[25]The horizontal axis is restricted between -6% and 10% of foreign inflation.

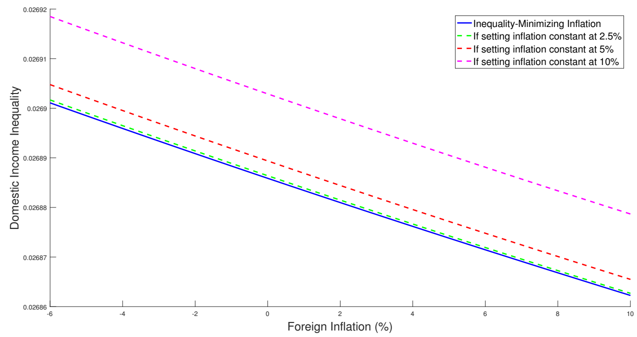

Figure 10: Inequality-Minimizing Level of Domestic Inflation: Income Inequality

5.4 Empirical Evidence

Although some existing literature clearly documents a positive effect of inflation on income inequality (see Albanesi 2007, Ghossoub and Reed 2017, and Afonso and Sequeira 2022), their empirical relation still seems ambiguous. In general, a positive inflation-inequality relation implies that expansionary monetary policy would unavoidably lead to income distribution that is even more unequal. However, Galli and van der Hoeven (2001) provide empirical evidence that the relationship between inflation and income inequality is U-shaped, which implies that higher inflation could possibly mitigate income inequality if the initial inflation rate is sufficiently moderate; and raising inflation enlarges the income gap between the rich and the poor once the inflation rate is greater than certain threshold value. Exploiting data on the US and other 15 OECD countries, Galli and van der Hoeven (2001) find that the inequality-minimizing inflation rate is around 8%. In a sharp contrast to this result, based on a panel data set covering exclusively high income countries, Chu *et al.* (2019) find a hump-shaped relationship between inflation and income inequality, indicating the existence of an otherwise inequality-maximizing inflation rate that is estimated to be around 12%.

While not aiming to fully resolve the empirical discrepancy, this study provides some novel stylized fact that the relationship between inflation and income inequality might depend on the potential influence of a country to the world economy. In particular, it is found that the inflation-inequality relation among high influence economies (HIEs) is U-shaped, whereas the relation among low influence economies (LIEs) seems to be monotonically increasing.

To measure the global influence of an economy, this paper constructs a simple index, which takes the following steps. First, we compute the correlation between a country's GDP growth rate and the GDP growth rate in the US. Second, we calculate the ratio of a country's GDP to the US GDP as a measure of country size. In addition, we collect data on the Chinn-Ito index to capture a country's financial openness. Finally, the index is created by taking the product of the correlation coefficient, the GDP ratio and the degree of financial openness. Index values and ranking are reported in Table C.1.

Based on the index values, we categorize the investigated countries into two groups, namely HIEs and LIEs, and estimate the following static cross-country regression for each group independently:

$$INE_{i,j} = \theta_{1,j}\pi_{i,j} + \theta_{2,j}\pi_{i,j}^2 + H_{INE}X_{i,j} + \varepsilon_{i,j} \tag{37}$$

where INE represents income inequality, π denotes inflation; H_{INE} is the coefficient matrix on a vector of control variables, X, which incorporates unemployment rates and measures of economic freedom and degree of openness; and i and j are country and group indices, respectively. In (37), squared-inflation is included to examine the nonlinear effect of inflation on inequality, and the unemployment rate is exploited to gauge the domestic labor market conditions, which, in theory, could directly affect income distribution. In addition, similar to the estimation strategy in Albanesi (2007) and Ashraf and Galor (2013), all variables in (37) are long-run averages of all available observations in a country (or region) over the entire sample period. We choose not to exploit the results of panel regressions as the primary demonstration of the stylized fact, even though they are, as reported in Appendix C.2, largely consistent with the findings based on the static cross-sectional regressions.[26]

Constrained by the availability and completeness of observations on investigated variables, our empirical practice collects yearly data on 65 high income and upper middle income economies, ranging from 2000 to 2015.[27] In this paper, Gini coefficient published by the World Income Inequality Database (WIID May 2020) is adopted as the measure of income inequality. Economic freedom and financial openness are measured by the Fraser Index and the Chinn-Ito Index, respectively.[28] Data on GDP, inflation, unemployment rate, and trade openness are collected from the World Bank Open Data.

Notice that WIID reports Gini coefficient for around 110 high income and upper middle income economies. Unfortunately, some economies are eliminated from our data set precisely due to unavailability and/or incompleteness of data on investigated variables. Constructing the index that measures a country's global influence requires observations on GDP and Chinn-Ito index, which instantly reduces the number of countries in our data set to 96. Removal of countries with zero or only one complete observation over the studied window from 2000 to 2015 yields a data set consisting of 70 economies. A complete observation is defined as an observation containing no missing value on any of the five variables in the regression (namely Gini coefficient, inflation, unemployment rate, economic freedom and trade openness) of a given year. In fact, most of the missing values in a country happen to the Gini coefficient. We choose

[26]It is found that the significance level of the coefficient estimates using panel regressions is slightly sensitive to model specifications. And exploring the sources causing the sensitivity would further digress away from the primary focus of this study.

[27]It is worth noting that our data set contains a larger number of countries than most of the existing studies.

[28]See Aizenman *et al.* (2010) for the description on the Chinn-Ito Index

to eliminate countries with only one complete observation, since one observation in an arbitrary year seems unable to accurately capture the long-run relationship between inflation and income inequality. In addition, after further eliminating 5 countries (around 7% in our data set) with the highest long-run inflation rate (which exceeds 11% per annum), 65 economies are naturally left in the finalized data set. Figures 11 to 14 visualize the data.

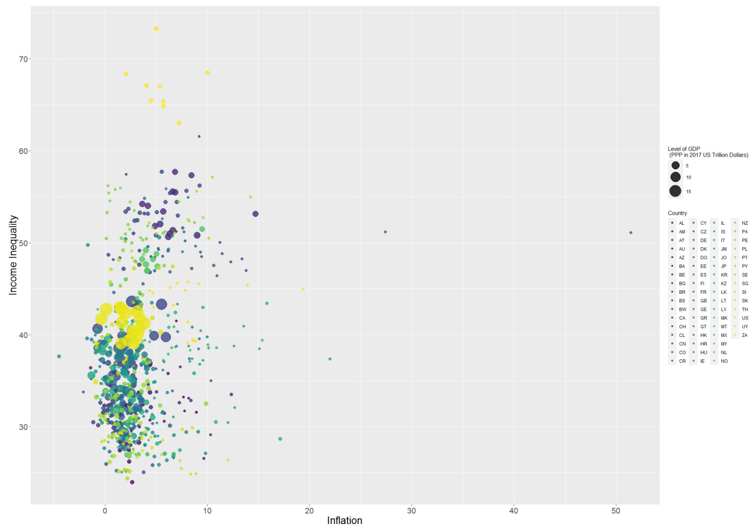

Figure 11: Scatter Plot of Observations for All Countries (Panel Data)

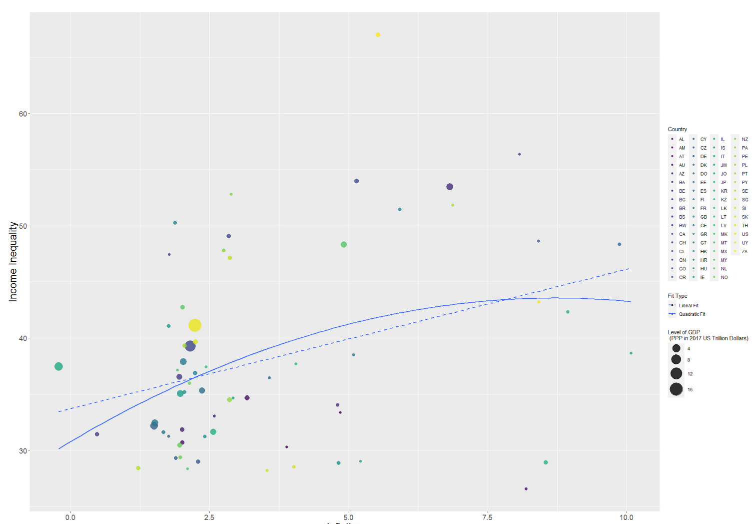

Figure 12: Scatter Plot of Observations for All Countries (Cross-sectional Data)

In the baseline regression, the group of HIEs incorporates the 16 economies ranked top in the list (from US to Australia) over the 2000-2015 window. Consequently, the rest of the economies on the ranking list fall into the LIEs category. Tables 2 and 3 report the coefficient estimates for

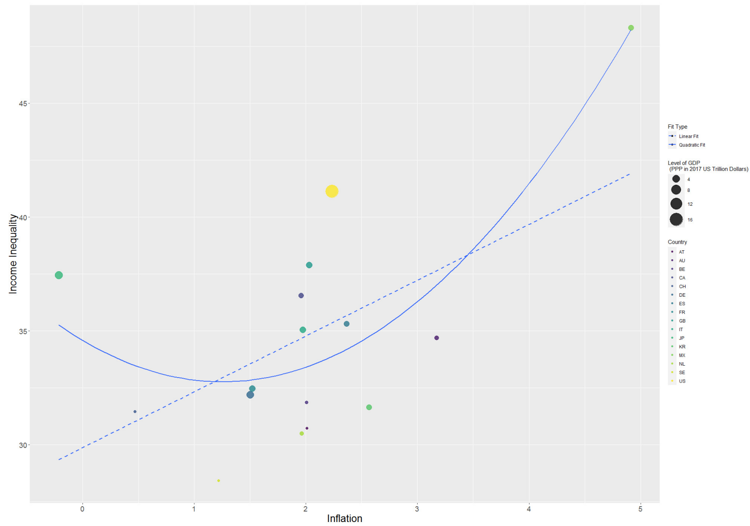

Figure 13: Inflation and Income Inequality in HIEs

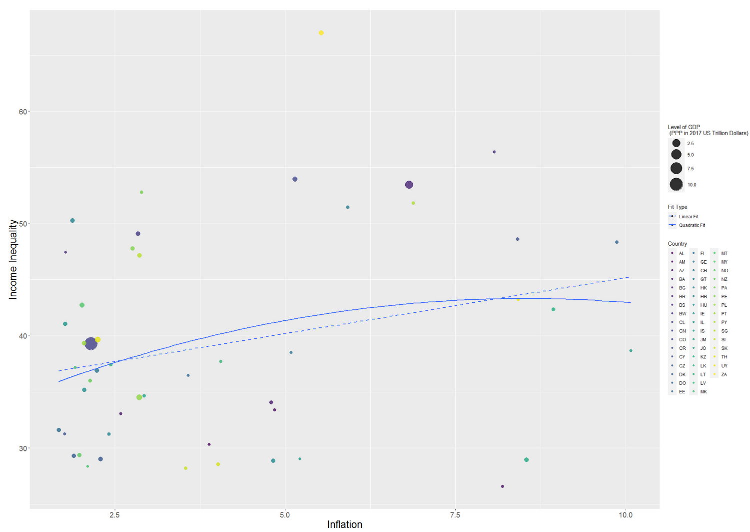

Figure 14: Inflation and Income Inequality in LIEs

HIEs and LIEs, respectively. As shown under Columns (1) and (3) in Table 2, when inflation and squared-inflation are both present, our cross-country regression yields an estimate of coefficient on inflation that is negative and statistically significant at 10% level, and an estimate of coefficient on squared-inflation that is strongly positive at 1% level, despite exclusion of the control variables. Combined with the evidence that estimation excluding squared-inflation leads to a positive but insignificant estimate of coefficient on inflation, it implies that omitting squared-inflation seems unable to adequately capture the empirical relationship between inflation and income inequality among HIEs, which is likely to be U-shaped. According to our baseline estimation, the inequality-minimizing inflation rate is around 1.14%, which is in line with our numerical estimate in the previous subsection.

In an alternative practice, we further narrow down the list of HIEs to 12 countries by removing the 4 bottom countries (namely Sweden, Switzerland, Austria and Australia) ranked in the HIEs list from the baseline regression. As shown under Columns (4) to (6) in Table 2, the empirical evidence for HIEs under the alternative specification remains consistent with that of the baseline estimation, and the U-shaped inflation-inequality relation is observed to be even stronger. Even though the magnitude of estimated coefficients on inflation measures are slightly higher, the model-implied inequality-minimizing inflation rate is still around 1%.

For LIEs, as shown in Table 3, it is found that incorporating squared-inflation into regression is likely to incorrectly capture the inflation-inequality relation. Across all model specifications, none of the estimation yields a statistically significant estimate of coefficient on squared-inflation. In particular, under the index-based measurement of global influence, the coefficient estimate of inflation becomes insignificant once squared-inflation is incorporated. When only the linear effect of inflation on income inequality is permitted, all model specifications imply a positive inflation-inequality relation, which is in line with Albanesi (2007). According to our estimation results, a one-percent increase in inflation raises the Gini coefficient by around 1.04 to 1.27 among LIEs.

Concerning that our index-based measurement of global influence may not adequately capture a country's potential impact on the world economy,[29] as a robustness check, we define HIEs as the 6 largest economies in our full sample, and estimate a series of panel regressions accordingly. With a larger number of observations, we further add government expenditure to GDP ratio and physical capital growth rate to the control vector. Model specifications are provided in Appendix C.2. Under Columns (1) and (3) in Table 4, it is shown that the inflation-inequality relation remains U-shaped, even though the inequality-minimizing inflation rate is higher than that under the index-based estimation.[30] In addition, among LIEs, it is observed that inflation has a weakly positive effect on income inequality, which is also consistent with our finding using the index-based approach.

6 Conclusion

In this study, we build an open-economy microfounded model of firm-level innovation and quality-ladder growth. Incumbents and entrants engage in different types of R&D activities for innovation to expand their production capacity in terms of the number of product lines. In addition, our model considers heterogeneous asset holdings among households and cash-in-advance (CIA) constraints on R&D investment. The former acts as the source of income inequality, while

[29]For example, due to low correlation with the US GDP growth rate and lacking financial openness, China, the second largest economy in the world, is not categorized as an HIE using the index-based measurement.

[30]For HIEs, we find that excluding the year-fixed effect yields coefficient estimates in a similar magnitude to those reported in Table 4, but strongly reduces the significance level. These results, not incorporated in the paper, are available upon request.

Table 2: Effect of Inflation on Income Inequality – High Influence Economies.

	Index-Based					
	Baseline			Alternative		
	(1)	(2)	(3)	(4)	(5)	(6)
π	-2.90*	2.01	-2.75*	-3.28**	2.77**	-3.07*
	(1.57)	(1.16)	(1.32)	(1.15)	(1.10)	(1.45)
π^2	1.15***		1.21***	1.17***		1.45***
	(0.26)		(0.25)	(0.21)		(0.36)
Unemployment		-0.31	0.18		-0.34	0.17
		(0.26)	(0.18)		(0.26)	(0.23)
Openness		-0.08***	-0.05*		-0.09**	-0.04
		(0.03)	(0.02)		(0.03)	(0.02)
Economic Freedom		-1.21	2.51		0.20	6.27**
		(3.03)	(2.63)		(2.09)	(2.09)
Specification				Remove AU, AT, SE and CH from Baseline		
Observations	16	16	16	12	12	12
R^2	0.53	0.49	0.67	0.56	0.62	0.89

Notes: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$. Robust standard errors are reported in parentheses. Constant terms are omitted.

the latter introduces a role for monetary policy.

We find that higher domestic inflation impedes domestic aggregate technology growth primarily through reducing the entry rate of new firms. However, it does not have any impact on the growth of foreign technology. Given that economic growth in a country is driven by the growth rates of domestic and foreign technology, domestic economic growth is decreasing in both domestic inflation and foreign inflation. Moreover, domestic inflation affects domestic income inequality through two channels: the negative growth channel (via the global interest rate) and the positive valuation channel (via the value of financial assets). We show that the interplay of these two channels causes ambiguity on the relationship between domestic inflation and domestic income inequality. Specifically, if the growth rate of foreign technology is sufficiently low (high), higher domestic inflation yields a U-shaped (positive) effect on domestic income inequality. We demonstrate that the impact of domestic inflation on domestic income inequality also depends on the country size. Nevertheless, higher foreign inflation leads to a negative effect on domestic income inequality by only operating through the negative growth channel.

We calibrate the model parameters using data on the US and eurozone countries, and numerically evaluate the cross-country effects of inflation on entry of new entrants, firm size distribution, economic growth, and income inequality. The quantitative results are consistent with the predictions of our theoretical model across various sets of parametrization. In particular, the

Table 3: Effect of Inflation on Income Inequality – Low Influence Economies.

	Index-Based					
	Baseline			Alternative		
	(1)	(2)	(3)	(4)	(5)	(6)
π	2.68	1.04***	2.60	3.29	1.15**	3.12
	(2.95)	(0.51)	(2.87)	(2.35)	(0.49)	(2.29)
π^2	-0.16		-0.14	-0.20		-0.19
	(0.26)		(0.26)	(0.21)		(0.21)
Unemployment		0.09	0.07		0.12	0.09
		(0.26)	(0.26)		(0.26)	(0.25)
Openness		-0.01	-0.01		0.01	0.01
		(0.03)	(0.03)		(0.02)	(0.02)
Economic Freedom		0.84	0.85		-0.03	0.15
		(2.63)	(2.65)		(2.35)	(2.36)
Specification				Add AU, AT, SE and CH to Baseline		
Observations	49	49	49	53	53	53
R^2	0.08	0.08	0.08	0.11	0.11	0.12

Notes: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$. Robust standard errors are reported in parentheses. Constant terms are omitted.

benchmark parametrization shows that domestic inflation is negatively correlated with domestic economic growth and positively correlated with domestic income inequality, indicating that the target of "high growth and low degree of inequality" could be potentially achieved by implementing appropriate monetary policy. Furthermore, the empirical analysis in this study provides empirical evidence that the correlation between domestic inflation and domestic income inequality is U-shaped (positive) if the country possesses high (low) global influence. It further leads to the policy implication that, in high influence economies, monetary policy aiming to promote long-run economic growth seems incompatible with the goal of minimizing income inequality, and therefore, monetary authority needs to take into account the possible growth-inequality tradeoff.

Future research in this field could take several directions. One potential avenue is to reexamine the cross-country effects of inflation on income inequality, incorporating additional layers of firm heterogeneity. This could involve differentiating between external and internal innovation, as suggested by Akcigit and Kerr (2018), and distinguishing between high-capacity and low-capacity firms in terms of innovation, as proposed by Acemoglu *et al.* (2018). Another direction involves exploring the model implications for other policy regimes. Considering the implementation of trade and fiscal policies could be a valuable extension, given that the impacts of these

Table 4: Effect of Inflation on Income Inequality – GDP-based Measure

	Robustness: GDP-Based					
	HIEs			LIEs		
	(1)	(2)	(3)	(4)	(5)	(6)
π	-0.77**	-0.49**	-1.22***	-0.03	0.05*	0.03
	(0.35)	(0.23)	(0.33)	(0.04)	(0.03)	(0.07)
π^2	0.14***		0.16***	0.01		0.01
	(0.02)		(0.05)	(0.01)		(0.01)
Unemployment		-0.10	-0.11		0.18***	0.18***
		(0.11)	(0.10)		(0.05)	(0.05)
Openness		-0.07*	-0.08**		0.02***	0.02***
		(0.04)	(0.03)		(0.01)	(0.01)
Gov. Spending to GDP Ratio		-0.98***	-0.96***		0.01	0.01
		(0.35)	(0.29)		(0.12)	(0.12)
Capital Growth Rate		0.03	0.04		0.02	0.02
		(0.03)	(0.03)		(0.01)	(0.01)
Economic Freedom		1.19	1.32		-0.62	-0.63
		(2.40)	(2.13)		(0.79)	(0.79)
Specification	6 Largest Economies US, CN, JP, DE, FR and GB			The Rest of the Economies in the Sample		
Control	No	Yes	Yes	No	Yes	Yes
Country-Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year-Fixed Effect	Yes	Yes	Yes	No	No	No
Observations	85	79	79	788	683	683
R^2	0.04	0.32	0.37	0.01	0.08	0.08

Notes: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$. Robust standard errors clustered by country are reported in parentheses.

policy regimes on income inequality may not mirror those of monetary policy.[31] The third direction is to explore more empirical evidence on the determinants of CIA constraints, which potentially differ in magnitude across different types of innovation, as theoretically analyzed by Zheng *et al.* (2021) and Huang *et al.* (2022). We leave these interesting extensions for future research.

[31]Nevertheless, when fiscal policy, such as research subsidies to incumbents and entrants, are present in the current model with non-distortionary taxes, increasing research subsidies and decreasing inflation would generate the same effects on the economy (e.g., economic growth and income inequality) by reallocating labor from R&D to production. In other words, as compared to the current analysis, research subsidies that are financed by distortionary taxes could create different impacts on the economy.

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Online Appendix

Inflation and Income Inequality in an Open-Economy Growth Model with Liquidity Constraints on R&D

(Not Intended for Publication)

Appendix A Proofs of Propositions

A.1 Definition of Balanced Growth Path Equilibrium

Definition 1. *The balanced growth path equilibrium consists of a sequence of prices* $\{P_{c,t}^h, P_{c,t}^f, p_{y,t}^h, p_{y,t}^f, p_{z,t}^h, p_{z,t}^f, w_t^h, r_t, i_t^h, i_t^f, V_t^h(n), V_t^f(n), \epsilon_t\}_{t=0}^{\infty}$ *and a sequence of allocations* $\{C_t, c_t^h, c_t^f, m_t^h, m_t^f, b_t^h, b_t^f, Y_t^h, Y_t^f, Z_t^h(j), Z_t^f(j), L_{Z,t}^h, S_{K,t}^h, S_{E,t}^h, L_{Z,t}^f, S_{K,t}^f, S_{E,t}^f\}_{t=0}^{\infty}$ *such that all households maximize utility, all firms maximize profits, and all markets clear. That is, (i) the global final-good market clears such that* $C_t = c_t^h + c_t^f$*; (ii) the labor market in country* h *and* f *clear such that* $L_{Z,t}^h + S_{K,t}^h + S_{E,t}^h = 1$ *and* $L_{Z,t}^f + S_{K,t}^f + S_{E,t}^f = 1$*; (iii) the asset markets in country* h *and* f *clear such that* $\sum_{n^h=1}^{\infty} \mu_{n^h} V_t^h(n^h) = a_t^h$ *and* $\sum_{n^f=1}^{\infty} \mu_{n^f} V_t^f(n^f) = a_t^f$*; (iv) the bond markets in country* h *and* f *clear such that* $b_t^h = \xi^h w_t^h (S_{K,t}^h + S_{E,t}^h)$ *and* $b_t^f = \xi^f w_t^f (S_{K,t}^f + S_{E,t}^f)$.

A.2 Proof of Lemma 2

Along the BGP, $\{a_t^h, b_t^h, c_t^h, w_t^h, \tau_t^h\}$ all grow at the same steady-state rate of g. Thus, d_t^h also grows at the rate of g. Using (30), we have

$$\frac{c_t^h - w_t^h - \tau_t^h}{d_t^h} = r - \frac{\dot{d}_t^h}{d_t^h} = \rho > 0. \tag{A.1}$$

Therefore, the coefficient on $\theta_{d,t}^h(s)$ in (31) is always positive. This implies that for any given i^h and i^f, $\dot{\theta}_{dt}^h(s) = 0$ for all $t > 0$ is the only solution of (31) consistent with long-run stability. Moreover, imposing $\dot{\theta}_{dt}^h(s) = 0$ on (31) yields the steady-state value of $\theta_{c,t}^h(s)$ given by

$$\theta_{c,0}^h(s) = 1 - \frac{\rho[1 - \theta_{d,0}^h(s)]}{c_t^h / d_t^h}. \tag{A.2}$$

A.3 Proof of Proposition 2

Differentiating (36) with respect to i^f yields

$$\frac{\partial(rd^h/w_t^h)}{\partial i^f} = \left[\phi^h(1+\xi^h i^h) + \frac{\xi^h \lambda^h (1+\phi^h \rho)}{1+\lambda^h+\xi^h i^h} - \xi^h \rho\right] \frac{\partial g}{\partial i^f} < 0, \tag{A.3}$$

so the effect of i^f on domestic income inequality is monotonically decreasing.

Additionally, using (25) and (26) to rewrite (36) as

$$\frac{rd_t^h}{w_t^h} = \left[\Phi + \ln(1+\lambda^h)\frac{\lambda^h(1-\alpha)(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)}\right] \times \left[\phi^h(1+\xi^h i^h) + \frac{\xi^h\lambda^h(1+\phi^h\rho)}{1+\lambda^h+\xi^h i^h} - \xi^h\rho\right], \tag{A.4}$$

where

$$\Phi = \rho + \alpha g^f + (1-\alpha)\ln(1+\lambda^h)\left[(1-\gamma^h)\left(\frac{\gamma^h\phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}} - \rho\right] > 0$$

is independent of i^h. Differentiating (A.4) with respect to i^h yields

$$\begin{aligned}
&\frac{\partial(rd_t^h/w_t^h)}{\partial i^h} \gtrless 0 \\
\Leftrightarrow & -\frac{\lambda^h\xi^h(1-\alpha)(1+\phi^h\rho)\ln(1+\lambda^h)}{\phi^h(1+\lambda^h+\xi^h i^h)^2}\left[\phi^h(1+\xi^h i^h) + \frac{\xi^h\lambda^h(1+\phi^h\rho)}{1+\lambda^h+\xi^h i^h} - \xi^h\rho\right] \\
& + \left[\Phi + \ln(1+\lambda^h)\frac{\lambda^h(1-\alpha)(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)}\right] \times \left[\phi^h\xi^h - \frac{\xi^h\lambda^h(1+\phi^h\rho)\xi^h}{(1+\lambda^h+\xi^h i^h)^2}\right] \gtrless 0 \\
\Leftrightarrow & -\frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)]\xi^h(1+\xi^h i^h)}{(1+\lambda^h+\xi^h i^h)^2} - \frac{\ln(1+\lambda^h)\left[\lambda^h(1-\alpha)(1+\phi^h\rho)\right](\xi^h)^2\lambda^h(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)^2} \\
& + \frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)](\xi^h)^2\rho}{(1+\lambda^h+\xi^h i^h)^2} + \Phi\left[\phi^h\xi^h - \frac{\xi^h\lambda^h(1+\phi^h\rho)\xi^h}{(1+\lambda^h+\xi^h i^h)^2}\right] \\
& + \frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)\xi^h]}{1+\lambda^h+\xi^h i^h} - \frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)]\xi^h\lambda^h(1+\phi^h\rho)\xi^h}{\phi^h(1+\lambda^h+\xi^h i^h)^3} \gtrless 0 \\
\Leftrightarrow & -\frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)]\xi^h}{(1+\lambda^h+\xi^h i^h)^2}\left[(1+\xi^h i^h) - \xi^h\rho - (1+\lambda^h+\xi^h i^h)\right] + \Phi\left[\phi^h\xi^h - \frac{\xi^h\lambda^h(1+\phi^h\rho)\xi^h}{(1+\lambda^h+\xi^h i^h)^2}\right] \\
& - \frac{2\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)](\xi^h)^2\lambda^h(1+\phi^h\rho)}{\phi^h(1+\lambda^h+\xi^h i^h)^3} \gtrless 0 \\
\Leftrightarrow & \underbrace{\frac{\ln(1+\lambda^h)[\lambda^h(1-\alpha)(1+\phi^h\rho)]\xi^h}{\phi^h(1+\lambda^h+\xi^h i^h)^3}}_{\Gamma_1}\underbrace{\left[\phi^h(\lambda^h+\xi^h\rho)(1+\lambda^h+\xi^h i^h) - 2\xi^h\lambda^h(1+\phi^h\rho)\right]}_{\Gamma_2} \\
& + \Phi\xi^h\underbrace{\left[\phi^h - \frac{\lambda^h(1+\phi^h\rho)\xi^h}{(1+\lambda^h+\xi^h i^h)^2}\right]}_{\Gamma_3} \gtrless 0.
\end{aligned} \tag{A.5}$$

Given Γ_1 is positive for all i^h, the sign of $\partial(rd_t^h/w_t^h)/(\partial i^h)$ depends on the signs of Γ_2 and Γ_3. It is straightforward to see that both Γ_2 and Γ_3 are increasing in i^h, and they are positive if the following conditions are satisfied:

$$1+\lambda^h+\xi^h i^h \geq \frac{2\xi^h\lambda^h(1+\phi^h\rho)}{\phi^h(\lambda^h+\xi^h\rho)}, \quad \text{and} \quad 1+\lambda^h+\xi^h i^h \geq \sqrt{\frac{\lambda^h\xi^h(1+\phi^h\rho)}{\phi^h}}. \tag{A.6}$$

Recall that there exists an upper bound $\hat{i}^h$ that ensures a nonnegative entry rate in country h such that

$$\begin{aligned} x_e^h \geq 0 \Leftrightarrow & \frac{\lambda^h(1/\varphi^h+\rho)}{1+\lambda^h+\xi^h i^h} - \gamma^h\left(\frac{\gamma^h\phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}} - \rho \geq 0 \\ \Leftrightarrow & 1+\lambda^h+\xi^h\hat{i}^h \leq \frac{\lambda^h(1/\varphi^h+\rho)}{\gamma^h\left(\frac{\gamma^h\phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}}+\rho}. \end{aligned} \tag{A.7}$$

Suppose that

$$\frac{\lambda^h(1/\varphi^h+\rho)}{\gamma^h\left(\frac{\gamma^h\phi^h}{\varphi^h}\right)^{\frac{\gamma^h}{1-\gamma^h}}+\rho} \geq \max\left\{\frac{2\xi^h\lambda^h(1+\phi^h\rho)}{\phi^h(\lambda^h+\xi^h\rho)}, \sqrt{\frac{\lambda^h\xi^h(1+\phi^h\rho)}{\phi^h}}\right\}, \tag{A.8}$$

which can be supported under a sufficiently small γ^h. In this case, there must exist a value $\bar{i}^h < \hat{i}^h$ ensuring that both Γ_2 and Γ_3 are positive. It then follows that $[\partial(rd_t^h/w_t^h)/(\partial i^h)]_{i^h=\bar{i}^h}$ is also positive.

Next, we examine the value of $\partial(rd_t^h/w_t^h)/\partial i^h$ at $i^h=0$. We find that for a sufficiently small discount rate ρ, $\Gamma_2|_{i^h=0}<0$ and $\Gamma_3|_{i^h=0}>0$ hold such that

$$\begin{aligned} \Gamma_2|_{i^h=0}<0 \Leftrightarrow & \phi^h(\lambda^h+\xi^h\rho)(1+\lambda^h)-2\xi^h\lambda^h(1+\phi^h\rho)<0 \\ \Leftrightarrow & \rho < \frac{\lambda^h[2\xi^h-\phi^h(1+\lambda^h)]}{\xi^h\phi^h(1-\lambda^h)}, \end{aligned} \tag{A.9}$$

for a general value of $\lambda^h<1$,[32] and

$$\begin{aligned} \Gamma_3|_{i^h=0}>0 \Leftrightarrow & \phi^h(1+\lambda^h)^2 > \lambda^h\xi^h(1+\phi^h\rho) \\ \Leftrightarrow & \rho < \frac{\phi^h(1+\lambda^h)^2-\lambda^h\xi^h}{\lambda^h\xi^h\phi^h}. \end{aligned} \tag{A.10}$$

Conditions in (A.9) and (A.10) can be further summarized as[33]

$$\rho < \min\left\{\frac{\lambda^h[2\xi^h-\phi^h(1+\lambda^h)]}{\xi^h\phi^h(1-\lambda^h)}, \frac{\phi^h(1+\lambda^h)^2-\lambda^h\xi^h}{\lambda^h\xi^h\phi^h}\right\}. \tag{A.11}$$

[32]The literature generally documents that the quality step size of innovation lies in the range of $[1.05, 1.2]$. In our model, it means that $1+\lambda^h \in [1.05, 1.2]$ or equivalently $\lambda^h \in [0.05, 0.2] < 1$.

[33]Parameters are required to ensure a positive ρ.

Given (A.11), we find that for a sufficiently large value of the foreign technology growth rate g^f (i.e., a sufficiently large Φ), $\partial(rd_t^h/w_t^h)/\partial i^h$ at $i^h = 0$ can be positive. As i^h rises, the absolute value of $\Gamma_1\Gamma_2$ becomes smaller, whereas $\Phi\xi^h\Gamma_3$ becomes larger and dominates the product of $\Gamma_1\Gamma_2$. This result implies that $\partial(rd_t^h/w_t^h)/\partial i^h$ and country h's income inequality is a monotonically increasing function of i^h. In contrast, for a sufficiently small value of the foreign technology growth rate g^f (i.e., a sufficiently small Φ), we obtain $[\partial(rd_t^h/w_t^h)/\partial i^h]|_{i^h=0} < 0$. Therefore, $\partial(rd_t^h/w_t^h)/\partial i^h$ and country h's income inequality first decreases in i^h and eventually increases in i^h.

Appendix B An Extension with Distinct CIA Constraints

B.1 Theoretical Model

In this subsection, we extend the model to a more generalized version with unequal CIA constraints on incumbents' R&D and entrants' R&D. Accordingly, in country h, the R&D cost function of a typical incumbent innovating firm becomes

$$C^h(x_k^h, n^h) = \varphi^h n^h w_t^h (x_k^h)^{\frac{1}{\gamma^h}} (1 + \xi_k^h i^h),$$

where ξ_k^h is the strength on the incumbent's CIA constraint. Moreover, the free-entry condition in (11) becomes

$$x_e^h V_t^h(1) = w_t^h S_e^h (1 + \xi_e^h i^h), \tag{B.1}$$

where ξ_e^h is the strength on the entrants' CIA constraint.

Following the same logic in the benchmark model, we solve this extended model and derive the steady-state equilibrium variables as follows. The consumption-adjusted wage rate in (22) becomes

$$\omega^h = \frac{(1-\alpha)(1+\lambda^h+\xi_k^h i^h)}{(1+\lambda^h)(1+\xi_k^h i^h)} \left\{ 1 + \phi^h \rho + \frac{\gamma^h \phi^h (\xi_k^h - \xi_e^h) i^h}{1+\xi_k^h i^h} \left[\frac{\gamma^h \phi^h (1+\xi_e^h i^h)}{\varphi^h (1+\xi_k^h i^h)} \right]^{\frac{\gamma^h}{1-\gamma^h}} \right\}^{-1}. \tag{B.2}$$

Consequently, the steady-state equilibrium of an incumbent's innovation intensity in (16) becomes

$$x_k^h = \left[\frac{\gamma^h \phi^h (1+\xi_e^h i^h)}{\varphi^h (1+\xi_k^h i^h)} \right]^{\frac{\gamma^h}{1-\gamma^h}}, \tag{B.3}$$

and the steady-state equilibrium entry rate in (23) becomes

$$x_e^h = \frac{\lambda^h}{\phi^h(1+\lambda^h+\xi_k^h i^h)} \left\{ 1+\phi^h\rho + \frac{\gamma^h\phi^h(\xi_k^h-\xi_e^h)i^h}{1+\xi_k^h i^h}\left[\frac{\gamma^h\phi^h(1+\xi_e^h i^h)}{\varphi^h(1+\xi_k^h i^h)}\right]^{\frac{\gamma^h}{1-\gamma^h}}\right\} - \gamma^h \left[\frac{\gamma^h\phi^h(1+\xi_e^h i^h)}{\varphi^h(1+\xi_k^h i^h)}\right]^{\frac{\gamma^h}{1-\gamma^h}} - \rho. \tag{B.4}$$

In contrast to the baseline model where x_k^h is independent of the nominal interest rate i^h and x_e^h is strictly decreasing in i^h, equations (B.3) and (B.4) imply that both x_k^h and x_e^h depend on the level of i^h. In particular, in addition to the negative effect of a higher i^h on innovation intensities due to higher R&D costs, the unequal CIA constraints on R&D between incumbents and entrants create a new labor-reallocation effect: a higher i^h shifts the labor employment from a more constrained R&D sector to a less constrained one. Due to this extra labor-reallocation effect, when the less constrained R&D sector happens to be more productive, the negative effect of a higher i^h on the aggregate innovation intensity (i.e., $x_k^h + x_e^h$) becomes weaker. Nevertheless, if this labor-reallocation effect is marginal, then the inflation-innovation relation (and also the inflation-growth relation) in this extended model does not differ too much from the counterpart in the baseline model.

Furthermore, it is straightforward to derive the growth rates of quality index in country h and f given by

$$\begin{aligned} g^h &= (x_k^h + x_e^h)\ln(1+\lambda^h) \\ &= \left\{ \begin{array}{l} \dfrac{\lambda^h}{\phi^h(1+\lambda^h+\xi_k^h i^h)}\left(1+\phi^h\rho + \dfrac{\gamma^h\phi^h(\xi_k^h-\xi_e^h)i^h}{1+\xi_k^h i^h}\left[\dfrac{\gamma^h\phi^h(1+\xi_e^h i^h)}{\varphi^h(1+\xi_k^h i^h)}\right]^{\frac{\gamma^h}{1-\gamma^h}}\right) \\ \qquad\qquad\qquad +(1-\gamma^h)\left[\dfrac{\gamma^h\phi^h(1+\xi_e^h i^h)}{\varphi^h(1+\xi_k^h i^h)}\right]^{\frac{\gamma^h}{1-\gamma^h}} - \rho \end{array} \right\} \ln(1+\lambda^h) \end{aligned} \tag{B.5}$$

and

$$\begin{aligned} g^f &= (x_k^f + x_e^f)\ln(1+\lambda^f) \\ &= \left\{ \begin{array}{l} \dfrac{\lambda^f}{\phi^f(1+\lambda^f+\xi_k^f i^f)}\left(1+\phi^f\rho + \dfrac{\gamma^f\phi^f(\xi_k^f-\xi_e^f)i^f}{1+\xi_k^h i^f}\left[\dfrac{\gamma^f\phi^f(1+\xi_e^f i^f)}{\varphi^f(1+\xi_k^f i^f)}\right]^{\frac{\gamma^f}{1-\gamma^f}}\right) \\ \qquad\qquad\qquad +(1-\gamma^f)\left[\dfrac{\gamma^f\phi^f(1+\xi_e^f i^f)}{\varphi^f(1+\xi_k^f i^f)}\right]^{\frac{\gamma^f}{1-\gamma^f}} - \rho \end{array} \right\} \ln(1+\lambda^f), \end{aligned} \tag{B.6}$$

respectively. Thus, the impact of the nominal interest rate i^h on the domestic (foreign) growth rate g^h (g^f) now is determined by the CIA constraints on both incumbents' R&D and entrants' R&D in its own country, i.e., ξ_k^h and ξ_e^h (ξ_k^f and ξ_e^f).

Similar to the baseline model, the overall effect of the nominal interest rate i^h on the domestic degree of income inequality in this extended model can still be decomposed into the effects on the real interest rate r, the asset-wage ratio a_t^h/w_t^h, and the bond-wage ratio b_t^h/w_t^h, respectively. Specifically, the interest-rate effect operates through $r = g + \rho = (1-\alpha)g^h + \alpha g^f + \rho$, where g^h and g^f are given by (B.5) and (B.6), respectively. The asset-wage ratio in (34) remains unchanged, and the bond-wage ratio becomes

$$\frac{b_t^h}{w_t^h} = \frac{\xi_k^h w_t^h S_K^h + \xi_e^h w_t^h S_E^h}{w_t^h} = \xi_k^h \varphi^h \left[\frac{\gamma^h \varphi^h (1+\xi_e^h i^h)}{\varphi^h (1+\xi_k^h i^h)} \right]^{\frac{1}{1-\gamma^h}} + \xi_e^h \phi^h x_e^h \tag{B.7}$$

where x_e^h is given by (B.4). Equation (B.7) shows that the bond-wage ratio depends on the relative CIA strength between incumbents and entrants.

Importantly, if the aforementioned labor-reallocation effect is marginal (which is the case in the numerical analysis), the interest-rate effect in this extended model does not differ much from the counterpart in the baseline model. In this case, the bond-wage ratio plays a dominant role in the inflation-inequality relation. The intuition is as follows. Suppose that the incumbents' constraint ξ_k^h in the domestic country is constant. Then an increase in the entrants' constraint ξ_e^h not only raises the relative constraint between incumbents and entrants, but also raises the overall constraint of the model. This will increase the bond-wage ratio b_t^h/w_t^h because entrants need to issue more bonds to finance R&D. Moreover, when the inflation rate (or the nominal interest rate) increases, both the bond issuance and wage will decrease. However, in this extended model, the bond issuance decreases more than in the baseline model, because entrants now become more constrained. In contrast, the wage decreases less than in the baseline model, because incumbents can absorb some of the decrease in the labor demand by entrants due to the labor reallocation in R&D. As a result, the bond-wage ratio b_t^h/w_t^h decreases more in this case than in the baseline model. The decrease in the bond-wage ratio can help to reduce income inequality, so the inequality-minimizing inflation rate would rise.

Due to the complexity of the theoretical analysis in this extension, we perform a quantitative analysis in the next subsection to examine the cross-country effects of the nominal interest rates on the targeted macroeconomic variables that are considered in the main text.

B.2 Numerical Analysis for the Extended Model

This subsection numerically explores the extended model where the strengths of the CIA constraints faced by incumbent and entrant firms are distinct. Due to the lack of empirical evidence on their relative strengths, for simplicity, we specify that

$$\xi_e^h = (1 + s^{CIA})\xi_k^h,$$

$$\xi_e^f = (1 + s^{CIA})\xi_k^f,$$

where s^{CIA} measures the percentage points by which the strength of the CIA constraint on entrants are higher (lower) than that of the incumbent firms if s^{CIA} is positive (negative). Note that the extended model reduces to its baseline counterpart once we set $s^{CIA} = 0$.

Holding other calibrated parameters identical to those in Section 5, we start our analysis by setting s^{CIA} to 10%. As shown in Figure 15, the qualitative and quantitative effects of domestic inflation on major economic variables remain largely the same as those under the benchmark calibration. One noticeable exception lies in the effect of inflation on domestic incumbent innovation rate. Different from the baseline model where domestic incumbent innovation rate is unaffected by domestic inflation, Panel (e) of Figure 15 suggests that a higher inflation rate increases domestic incumbent innovation rate if the CIA constraint on entrants is tighter than that on incumbents. Additionally, as shown in Panel (e) of Figure 16, once we consider the case where incumbents are more cash-constrained than entrants by setting s^{CIA} to -10%, the relationship between domestic inflation and domestic incumbent innovation rate becomes negative.

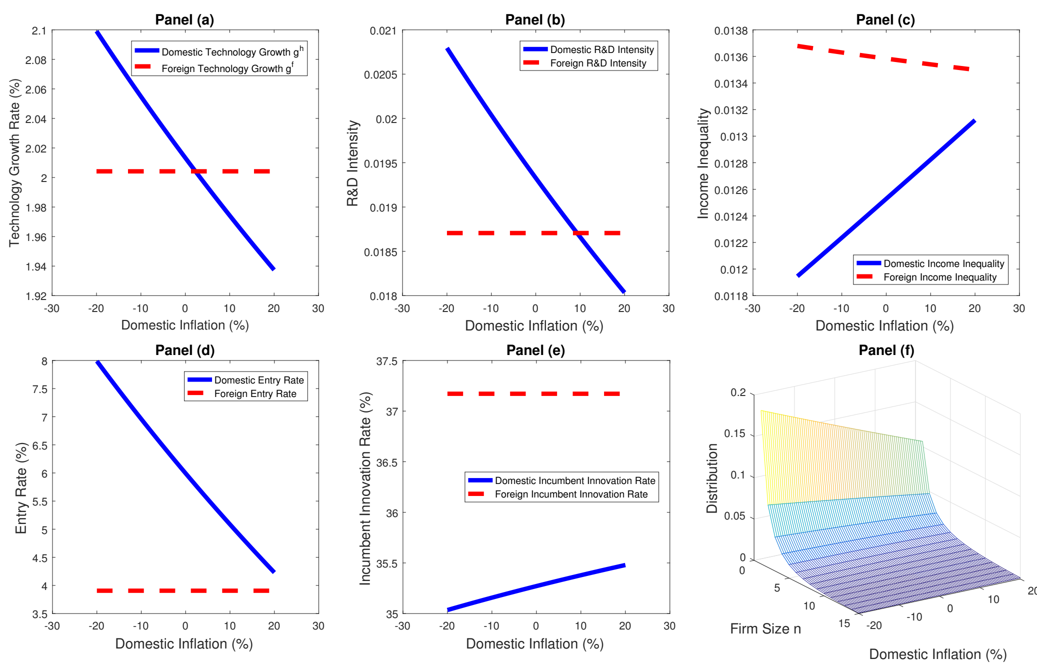

Figure 15: Effects of Domestic Inflation: Benchmark Calibration; $s^{CIA} = 10\%$.

Figure 17 presents the effects of inflation under the U-shaped calibration when s^{CIA} is set to 10%. It is observed that the effect of inflation on growth is quantitatively similar to that in the

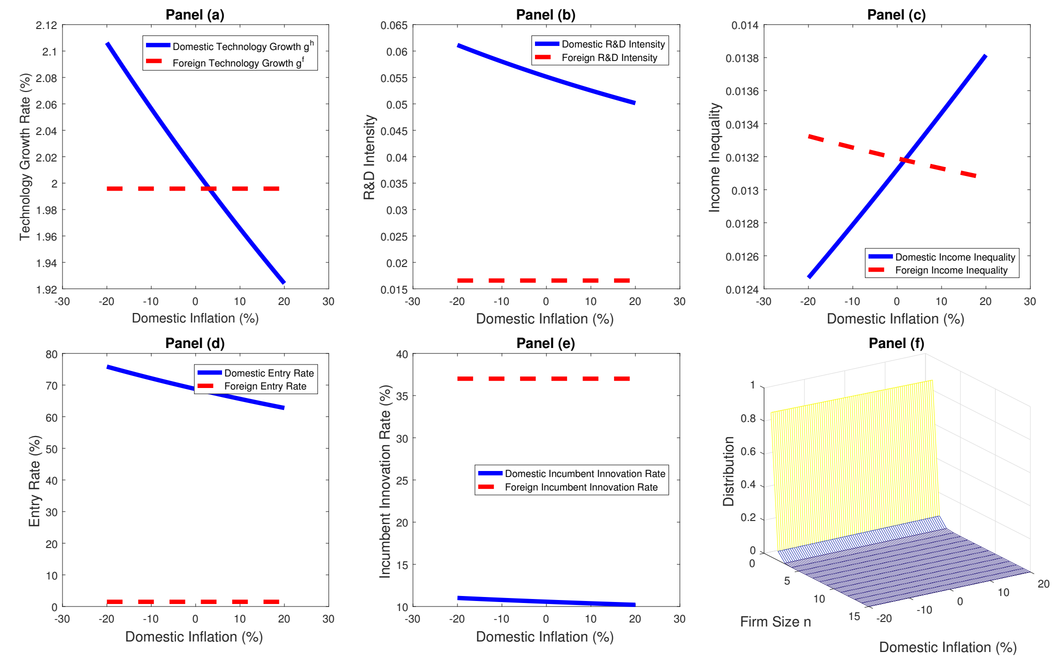

Figure 16: Effects of Domestic Inflation: Benchmark Calibration; $s^{CIA} = -10\%$.

baseline model, and the inflation-inequality relationship remains U-shaped. However, Panel (c) indicates that the inequality-minimizing inflation rate in the domestic country rises to 9%.

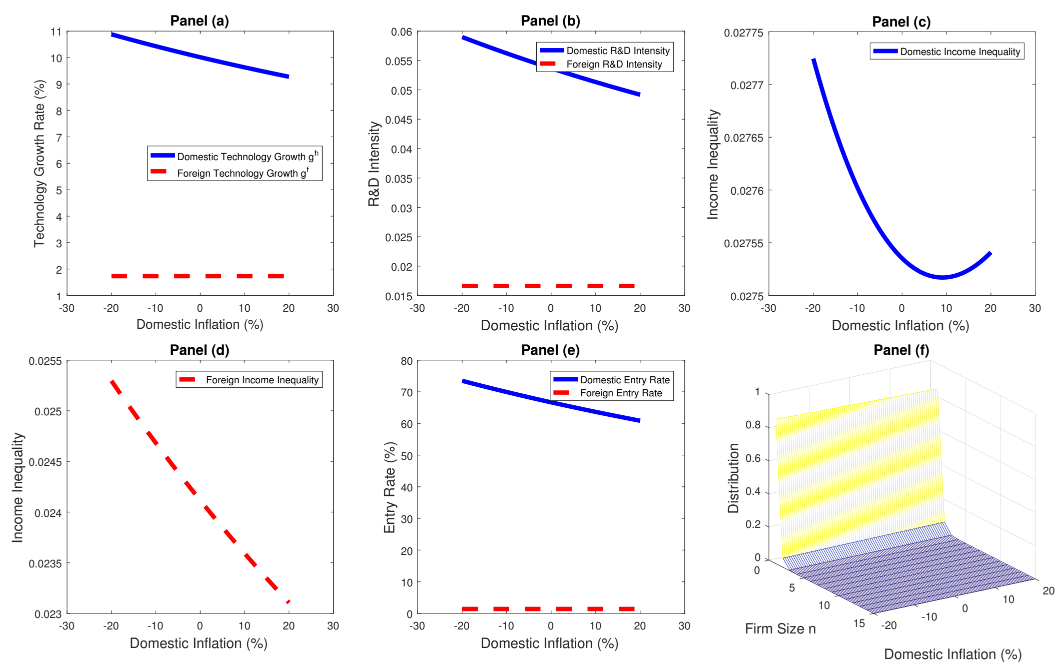

Figure 17: Effects of Domestic Inflation: U-Shaped Calibration; $s^{CIA} = -10\%$.

To further disentangle the effect of unequal CIA constraints on the model-implied economic growth rate and income inequality along the BGP, we exploit the U-shaped calibration and consider 6 candidate values of s^{CIA}. Primary findings are reported from Figure 18 to Figure 20. First, Figure 18 shows that changing the value of s^{CIA} does not remarkably alter the retarding effect of inflation on economic growth. However, it is seen that a higher value of s^{CIA} yields a persistently higher technology growth rate when the inflation rate exceeds a certain threshold level (i.e. -10%). Similar to the discussion in Huang *et al.* (2022) , in the presence of distinct CIA constraints, this property is attributed to the labor reallocation effect where R&D labor is shifted from tightly cash-constrained sector to relatively loosely cash-constrained sector and hence tends to be (weakly) growth-enhancing.

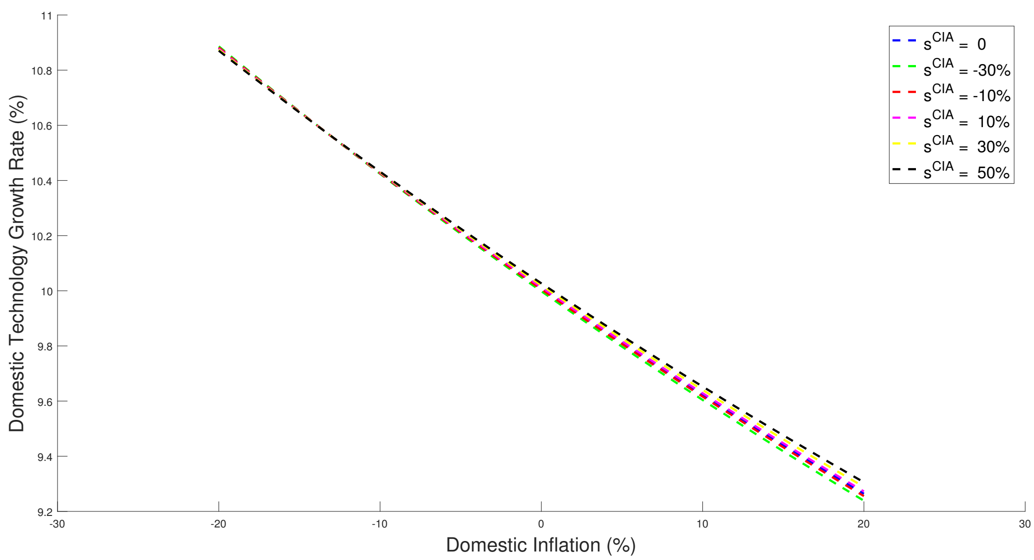

Figure 18: Effect of Domestic Inflation on Growth: U-Shaped Calibration

Second, Figure 19 suggests that the relationship between domestic inflation and domestic income inequality is contingent upon the relative strengths of the CIA constraints on incumbent and entrant firms. In general, when entrant firms are substantially less cash-constrained than incumbent firms (i.e. $s^{CIA} = -30\%$), the inflation-inequality relation within the investigated inflation interval is monotonically increasing. The inflation-inequality relation becomes U-shaped when the value of s^{CIA} is gradually increased, and the inequality-minimizing inflation also rises as s^{CIA} becomes larger. However, when the strength of CIA constraint on entrant firms is sufficiently stronger than that on incumbent firms (i.e. $s^{CIA} = 30\%$), domestic income inequality starts to be monotonically decreasing in domestic inflation.

To understand the underlying channels through which s^{CIA} shapes the curvature of the inflation-inequality relation, recall that, under our theoretical framework, income distribution

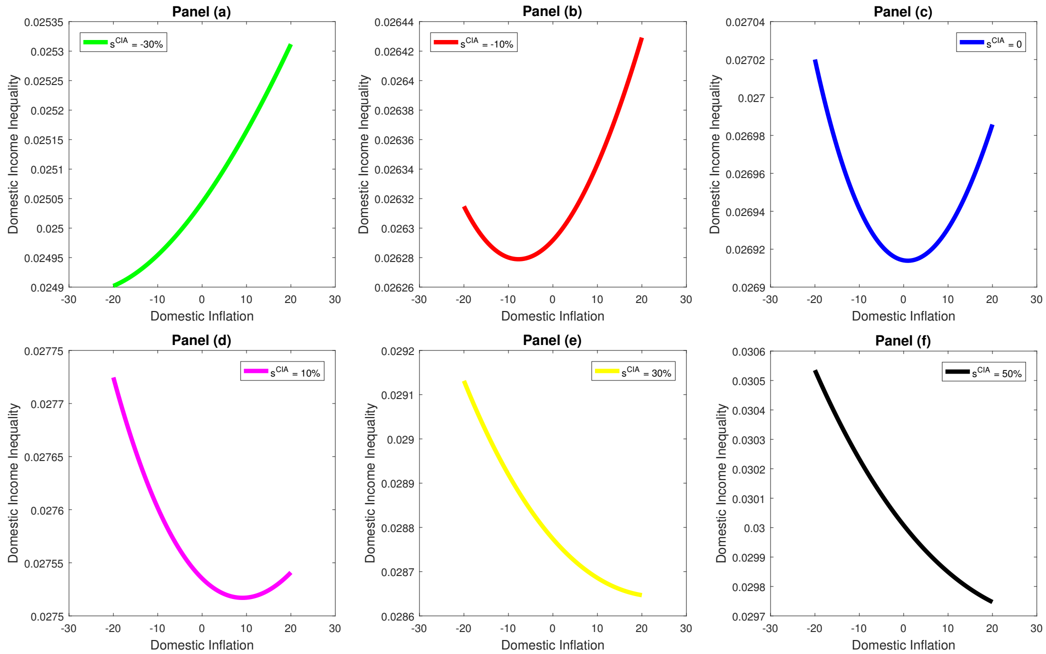

Figure 19: Effect of Domestic Inflation on Income Inequality: U-Shaped Calibration

is jointly determined by the real interest rate, the asset-wage ratio and the bond-wage ratio. Figure 18 shows that distinct CIA constraints on entrants and incumbents do not imply remarkably different inflation-growth relation along the BGP, indicating that altering the value of s^{CIA} can hardly generate a substantially different real interest rate effect. In addition, according to equation (34), the asset-wage ratio is totally independent of s^{CIA}. Therefore, the effect of unequal CIA constraints needs to be transmitted through the bond-wage ratio channel. As confirmed in Figure 20, varying the value of s^{CIA} leads to a quantitatively sizable difference in the bond-wage ratio along the BGP, and therefore, yields a noticeable difference in the curvature of the inflation-inequality relation within the investigated interval.

Finally, it is worth mentioning that further allowing for cross-country asymmetry in distinct strengths of the CIA constraints (for example, letting s^{CIA} in domestic and foreign countries take different values or opposite signs) does not enrich the model implications on growth and income inequality. The numerical results associated with this additional practice are not reported in this extension but will be available upon request.

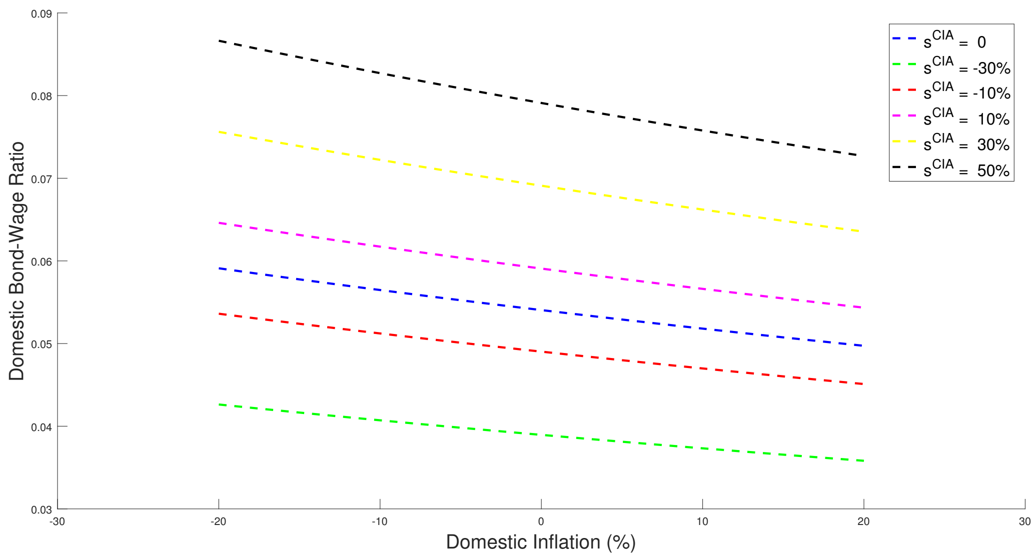

Figure 20: Effect of Domestic Inflation on Bond-Wage Ratio: U-Shaped Calibration

Appendix C Data Description

C.1 Data Construction

Yearly data on the investigated variables for all available high income and upper middle income economies is described as follows:

(1) GDP PPP: GDP (Level) Purchasing Power Parity (constant 2017 International dollar), downloaded from the World Bank Database; Series "NY.GDP.PCAP.PP.KD".

(2) Import Share in GDP: Import values as a percentage of GDP, downloaded from the World Bank Database; Series "NE.IMP.GNFS.ZS".

(3) Export Share in GDP: Export values as a percentage of GDP, downloaded from the World Bank Database; Series "NE.EXP.GNFS.ZS".

(4) Inflation: Annual percentage change in Consumer Prices, downloaded from the World Bank Database; Series "FP.CPI.TOTL.ZG".

(5) Unemployment: ILO estimate of the unemployment rate, downloaded from the World Bank Database; Series "SL.EMP.TOTL.SP.ZS".

(6) Financial Openness: Chinn-Ito Index, published by Aizenman, Chinn and Ito in the Trilemma Indexes (https://urldefense.proofpoint.com/v2/url?u=http-3A__web.pdx.edu_&d=DwIGAg&c=KXXihdR8fRNGFkKiMQzstu-8MbOxd1NuZkcSBymGmgo&r=6gyBWAoC_Www1SIRMhFksM6SkdeTWmTaCTAiDzs8NSo&m=o8NCmRQFbGaFN9QHKToSoGTa9lBqaZUy_fIrF5W9gOo&s=yqoKMv4lvFMdEb2PCUA4le5pJm5lNcROnTYpXbZXQ4A&e=~ito/trilemma_indexes.htm).

(7) Gini Coefficient: Downloaded from the World Income Inequality Database (WIID May 2020).

(8) Government Spending to GDP Ratio: General government final consumption expenditure as a percentage of GDP, downloaded from the World Bank Database; Series "NE.CON.GOVT.ZS".

(9) Capital Stock: Capital stock at current Purchasing Power Parities (2011 US dollars), downloaded from Penn World Table 9.1

Given the above series, the growth rate of GDP is computed as the annual percentage change in GDP per capita, and the degree of economic freedom is defined as the sum of import and export shares in GDP. For the conventional measure of income inequality, WIID occasionally reports multiple observations on the Gini coefficient for a particular country within a year, which are either collected from different sources or computed according to different criteria. Whenever it happens, our strategy of constructing the Gini coefficient series is to take the average of all available observations for country i in year t. For capital growth rate, it is computed as the annual percentage change in capital stock.

Table C.1: Ranking Based no Index Value - High Income and Upper Middle Income Economies

Rank	Country	Corr with US GDP Growth Rate	GDP Relative to US	Financial Openness	Index
-	United States	1.0000	1.0000	-	-
1	Japan	0.8731	0.2907	1.0000	0.2538
2	Germany	0.6242	0.2315	1.0000	0.1445
3	United Kingdom	0.8849	0.1590	1.0000	0.1407
4	France	0.8019	0.1643	1.0000	0.1318
5	Italy	0.7221	0.1542	1.0000	0.1113
6	Mexico	0.8367	0.1215	0.6683	0.0679
7	Canada	0.7462	0.0882	1.0000	0.0658
8	Spain	0.6263	0.1008	1.0000	0.0632
9	Netherlands	0.6155	0.0512	1.0000	0.0315
10	Korea, Rep.	0.5414	0.0938	0.5292	0.0269
11	Belgium	0.8225	0.0306	0.9775	0.0246
12	Sweden	0.8310	0.0265	1.0000	0.0220
13	Switzerland	0.6649	0.0293	1.0000	0.0195
14	Austria	0.7147	0.0258	1.0000	0.0184
15	Australia	0.3726	0.0571	0.7372	0.0157
16	Hong Kong SAR, China	0.7834	0.0200	1.0000	0.0157
17	Denmark	0.9069	0.0172	1.0000	0.0156
18	Norway	0.8120	0.0175	1.0000	0.0142
19	Czech Republic	0.7282	0.0199	0.9448	0.0137
20	Singapore	0.6230	0.0210	1.0000	0.0131
21	Brazil	0.2013	0.1593	0.4069	0.0131
22	Chile	0.7242	0.0198	0.7977	0.0115
23	Finland	0.7475	0.0145	1.0000	0.0108

Table C.1 (continued)

Rank	Country	Corr with US GDP Growth Rate	GDP Relative to US	Financial Openness	Index
24	Hungary	0.7694	0.0148	0.9260	0.0105
25	Portugal	0.5224	0.0198	1.0000	0.0104
26	Malaysia	0.8226	0.0325	0.3713	0.0099
27	Thailand	0.6076	0.0535	0.2908	0.0095
28	Ireland	0.5807	0.0146	1.0000	0.0085
29	Greece	0.3633	0.0218	0.9528	0.0076
30	Israel	0.4865	0.0150	0.9362	0.0068
31	China	0.0665	0.6024	0.1650	0.0066
32	New Zealand	0.6858	0.0095	1.0000	0.0065
33	Poland	0.2607	0.0503	0.4284	0.0056
34	Colombia	0.4343	0.0305	0.3713	0.0049
35	South Africa	0.6583	0.0361	0.1650	0.0039
36	Bulgaria	0.5471	0.0071	0.7094	0.0028
37	Guatemala	0.4697	0.0060	0.9823	0.0028
38	Lithuania	0.6942	0.0044	0.8911	0.0028
39	Croatia	0.6281	0.0061	0.6466	0.0025
40	Peru	0.1535	0.0157	1.0000	0.0024
41	Slovak Republic	0.5217	0.0076	0.5639	0.0022
42	Latvia	0.7351	0.0027	0.9887	0.0020
43	Slovenia	0.6198	0.0039	0.7935	0.0019
44	Estonia	0.8483	0.0021	1.0000	0.0018
45	Dominican Republic	0.3911	0.0067	0.6459	0.0017
46	Costa Rica	0.5125	0.0041	0.7877	0.0016
47	Kazakhstan	0.4611	0.0181	0.1650	0.0014
48	Sri Lanka	0.3280	0.0102	0.3950	0.0013
49	Armenia	0.6441	0.0015	1.0000	0.0010
50	Jamaica	0.6518	0.0016	0.8686	0.0009
51	Georgia	0.5434	0.0020	0.7347	0.0008
52	Bosnia and Herzegovina	0.5461	0.0023	0.6470	0.0008
53	Panama	0.1732	0.0043	1.0000	0.0007
54	Botswana	0.4031	0.0016	0.9269	0.0006
55	Cyprus	0.3758	0.0017	0.7117	0.0005
56	Azerbaijan	0.1574	0.0057	0.3267	0.0003
57	Malta	0.5017	0.0008	0.7380	0.0003
58	North Macedonia	0.4373	0.0015	0.4127	0.0003
59	Iceland	0.6418	0.0009	0.4324	0.0002
60	Paraguay	0.0775	0.0036	0.6358	0.0002
61	Albania	0.0450	0.0017	0.3536	0.0000
62	Bahamas	0.6698	0.0008	0.0000	0.0000
63	Jordan	-0.0031	0.0042	0.9962	0.0000
64	Uruguay	-0.0661	0.0032	1.0000	-0.0002

C.2 Panel Regressions

For country i in group j (HIEs or LIEs), we run the following panel regression:

$$INE_{it,j} = \theta_{1,j}\pi_{it,j} + \theta_{2,j}\pi_{it,j}^2 + H_{INE,j}X_{it,j} + \delta_i + \lambda_t + \varepsilon_{it,j},$$

where t denotes the time index; and δ and λ refer to the country- and year-fixed effects, respectively. Due to remarkable increase in the number of observations, we further add the ratio of government expenditure to GDP and the growth rate of physical capital to the control vector. Estimation results under the GDP-based approach are reported in Table 4 in Section 5.4, and those under the index-based approach are shown in Tables C.2 and C.3 in this section.

In general, the empirical findings based on panel regressions are consistent with those using OLS. It is observed that inflation-inequality relation is U-shaped among HIEs, whereas the relation is weakly positive among LIEs. However, the inequality-minimizing inflation rate under the panel regressions is found to be between 3% to 5%.

Given the potential distinction between country groups of HIEs and LIEs, their regression specifications are slightly different. For GDP-based approach, the regressions for HIEs incorporate the year-fixed effect, since we find that excluding the year-fixed effect yields coefficient estimates of similar magnitude, but substantially reduces the significance level of squared-inflation. For index-based approach, it is found that incorporating economic freedom into the control vector tends to reduce the significance level of inflation measures. Therefore, economic freedom is removed from the control vector when we estimate the panel regressions for HIEs under the index-based approach. However, estimation under the index-based approach is largely robust to the incorporation of year-fixed effect. Empirical results not reported in the paper are available upon request.

Table C.2: Effect of Inflation on Income Inequality – Panel Regressions – HIEs

	Index-Based							
	Baseline				Alternative			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π	-1.02***	-0.16	-0.76***	-0.47	-1.03***	-0.15	-0.80***	-0.92***
	(0.28)	(0.16)	(0.27)	(0.37)	(0.28)	(0.19)	(0.18)	(0.30)
π^2	0.13***		0.13***	0.08***	0.12***		0.12***	0.12***
	(0.03)		(0.03)	(0.03)	(0.02)		(0.02)	(0.03)
Unemployment		0.22***	0.21***	0.20***		0.20**	0.19**	0.16*
		(0.08)	(0.08)	(0.07)		(0.10)	(0.09)	(0.08)
Openness		0.04**	0.04*	0.01		0.03	0.02	0.01
		(0.02)	(0.02)	(0.02)		(0.02)	(0.02)	(0.03)
Gov. Spending to GDP Ratio		0.24	0.29	-0.18		0.23	0.28	-0.23
		(0.21)	(0.20)	(0.18)		(0.23)	(0.24)	(0.24)
Capital Growth Rate		0.07***	0.07***	0.02		0.04**	0.04***	-0.02
		(0.02)	(0.02)	(0.03)		(0.02)	(0.02)	0.02
Specification					Remove AU, AT, SE and CH from Baseline			
Control	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country-Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Fixed Effect	No	No	No	Yes	No	No	No	Yes
Observations	224	224	224	224	169	169	169	169
R^2	0.09	0.18	0.22	0.06	0.11	0.17	0.24	0.14

Notes: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$. Robust standard errors clustered by country are reported in parentheses.

Table C.3: Effect of Inflation on Income Inequality – Panel Regressions – LIEs

	Index-Based							
	Baseline				Alternative			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π	-0.01	0.07**	0.07	0.03	-0.02	0.07**	0.05	0.03
	(0.04)	(0.03)	(0.07)	(0.04)	(0.04)	(0.03)	(0.07)	(0.04)
π^2	0.01		0.01		0.01		0.01	
	(0.01)		(0.01)		(0.01)		(0.01)	
Unemployment		0.18***	0.18***	0.19***		0.17***	0.17***	0.20***
		(0.05)	(0.05)	(0.05)		(0.05)	(0.06)	(0.06)
Openness		0.02**	0.02**	0.03***		0.02**	0.02**	0.03***
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Gov. Spending to GDP Ratio		-0.13	-0.13	-0.02		-0.09	-0.09	-0.02
		(0.13)	(0.13)	(0.13)		(0.13)	(0.13)	(0.12)
Capital Growth Rate		-0.01	-0.01	-0.02		0.01	0.01	-0.01
		(0.02)	(0.02)	(0.02)		(0.02)	(0.02)	(0.2)
Economic Freedom		-0.01	-0.01	0.71		-0.27	-0.29	0.17
		(0.75)	(0.75)	(0.62)		(0.78)	(0.79)	(0.75)
Specification					Add AU, AT, SE and CH to Baseline			
Control	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country-Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Fixed Effect	No	No	No	Yes	No	No	No	Yes
Observations	649	553	553	553	704	604	604	604
R^2	0.01	0.07	0.07	0.10	0.01	0.07	0.07	0.08

Notes: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$. Robust standard errors clustered by country are reported in parentheses.