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

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Abstract

This study explores the relation 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 find that income inequality may monotonically increase with domestic inflation or display a U-shaped pattern, depending on the influence of a country's technology growth on the global real interest rate. These predictions are supported by our quantitative model calibrated to the US and eurozone economies and empirical results using cross-country data.

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1 Introduction

The redistribution effect of monetary policy through inflation has received increasing attention by monetary economists. For instance, Doepke and Schneider (2006) examine the inflation-induced wealth redistribution among different groups of households in the US, as well as between foreigners and domestic households. Doepke *et al.* (2018) study the effect of an increase in inflation expectation on inequality and aggregate consumption through its effect on house prices. Chu *et al.* (2019) explore the effects of inflation on innovation and income inequality in a quality-ladder growth model.[1]

We contribute to the literature by examining this question in a two-country open-economy framework with endogenous growth. Previous studies in this strand of literature have mainly considered a closed-economy setting.[2] The importance of expanding the literature to a two-country open-economy framework is twofold. First, the relation between inflation and income inequality in an open-economy environment is less studied relative to the international transmission of monetary policy and the global inflation dynamics, which are widely investigated in the literature.[3] Second, a tractable two-country open-economy setting would allow us to investigate the relation conditional upon country-level asymmetries (i.e., country size, relative technological growth and so forth). In particular, the literature suggests that asset values and bond holding form critical channels propagating the long-run effect of inflation on income inequality (see Chu *et al.* 2019). Since the determination of the real interest rate in closed and open economies is substantially different, it is unclear if the relation between inflation and inequality found in closed and small open economies also holds in large open economies. This study fills these gaps in the literature and documents novel results that potentially help to unveil the nexus of previous contradicting empirical findings about the relation between inflation and inequality.

We develop a two-country version of the Schumpeterian growth model in which innovation and inequality are affected by inflation in both countries. Following Klette and Kortum (2004), our model features firm-level innovation in terms of the number of product lines and a cash-in-advance (CIA) constraint on research and development (R&D) investment in each country.[4] Our

[1] See Albanesi (2007), Auclert (2019) and Zheng *et al.* (2020) for examples of other studies on this topic. The redistribution effect of monetary policy can also be transmitted through other channels such as labor income (e.g., Dolado *et al.* (2021)).

[2] Chen and Turnovsky (2010) study the growth-and-inequality relation in a small open economy and find that the relation depends on agents' access to international capital markets. However, their paper does not study the effect of inflation and monetary policy on inequality. Guo *et al.* (2020) 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. Using a North-South monetary model with R&D and international trade, Afonso and Sequeira (2022) examine the effect of inflation on specialization, growth and wage inequality, while our paper focuses on the relation between inflation and total income inequality.

[3] For recent studies of the international transmission of monetary policy, see De Paoli (2009), Cetorelli and Goldberg (2012), Buch *et al.* (2019) and others. For empirical assessment of the global inflation dynamics, see Mumtaz and Surico (2009), Byrne *et al.* (2012) and so forth. Representative work of theoretical exposition of global inflation includes Melitz and Ottaviano (2008), Bentolila *et al.* (2008), and Henriksen *et al.* (2013).

[4] Our main theoretical results are robust to the canonical quality-ladder growth model of aggregate technological

choice of endogenous growth model is inspired by an important insight from the seminal work of Kuznets (1955) that inequality is intimately correlated with economic growth. Recent literature of endogenous economic growth demonstrates that R&D is the modern engine of growth in industrialized economies, following the pioneering work by Romer (1990). Therefore, it is critical to understand the impact of inflation on inequality through its effect on R&D activities and economic growth in a model of endogenous growth. The CIA constraint in our model is motivated by empirical studies that highlight the importance of liquidity constraints to R&D investment activities.[5] This CIA constraint on R&D, combined with an open-economy setting that permits international trade and financial markets, provides a rich framework under which inflation has impacts on R&D investment, economic growth, and income inequality in both countries, since the costs of inflation are transmitted between sectors not only within a country, but also internationally.

Previous empirical studies on the inflation-inequality relation yield mixed findings, although a consensus is that at least above some threshold, income inequality increases with inflation.[6] Albanesi (2007) documents cross-country evidence that inflation and income inequality are positively correlated and proposes an explanation based on political economy. A similar empirical finding is reported in Ghossoub and Reed (2017), who explore the effect of financial development on income inequality. However, Galli and van der Hoeven (2001) find a U-shaped relation in a panel of 15 OECD countries. A nonlinear relation is also documented in Bulíř (2001): inflation can significantly increase income inequality when the inflation level is very high, but not for a low level of inflation. Our model provides a framework to reconcile these contradictory findings in the literature. Our two-country model predicts that the relation between a country's income inequality and inflation depends on foreign country's technology growth, which is a determinant of the global real interest rate. We provide quantitative results from a calibrated model and cross-country empirical results to support our model predictions.

Motivated by the empirical evidence documented in Piketty (2014), this study captures income inequality through introducing heterogeneous households in terms of asset holdings, which allows income distribution to be endogenously determined. 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 the same in both countries, which equals the weighted average of domestic and foreign technology growth. Households allocate their endowments to buy equity shares of monopolistic firms and lend to finance firms' R&D activities in the home country. To lend, households have to first hold money in the spirit of cash in advance.

change. However, the setting of multi-product-line firms in this paper allows us to investigate the inflation-inequality relation in the presence of firm heterogeneity. For instance, it allows distinct strength of liquidity constraints faced by incumbent and entrant firms, which is found an additional factor of shaping the relation between inflation and income inequality.

[5] See, for example, Brown *et al.* (2012) and Lyandres and Palazzo (2016) for empirical evidence on the liquidity requirements of R&D investment.

[6] See Colciago *et al.* (2019) for a survey.

Households supply labor inelastically to earn wage incomes. Given this model setup, a country's income inequality is determined by two factors: the value of financial assets (equity and bonds) relative to wage in the country and the global real interest rate. The proposed mechanism is consistent with the empirical analysis of Madsen (2017), which shows that asset returns are an important source of income inequality.

Inflation affects asset values and the global interest rate through its effect on firms' innovation activities. Incumbent firms and new entrants in each country hire labor to perform R&D (i.e., incumbent R&D and entry R&D) for innovation and the labor costs are financed by loans from domestic households. Successful innovation by a firm replaces the leading-edge technology from its current holder, adding to the number of product lines that the innovating firm is operating. In this case, incumbents' innovation intensity and the entry rate of new firms in a country jointly determine the aggregate rate of innovation, and in turn the growth rate of the country's technology and total output. In the presence of CIA constraints on R&D investment for incumbent firms and new entrants, domestic inflation raises the cost of R&D investment and reduces 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, an increase in domestic inflation decreases the global real interest rate, reducing the returns of holding financial assets. We label this effect as the *negative growth effect*. In addition, an increase in domestic inflation affects the country's financial asset holdings in a twofold fashion. First, an increase in inflation decreases the rate of creative destruction by discouraging innovation activities, so the value of existing firms and their equity prices appreciate. Second, higher inflation increases the cost of holding money, so the demand for money to finance R&D decreases due to the CIA constraint, leading to a decline in bond holdings. Under the baseline model where incumbent and entrant firms are subject to CIA constraints of equal strengths, the increase in equity value dominates the decrease in bond holding, inducing a net increase in the value of financial assets. We label this effect as the *positive valuation effect*.

Under the baseline framework, after a threshold inflation, the positive valuation effect always dominates the negative growth effect, inducing a positive correlation between domestic inflation and inequality. However, if the negative growth effect is strong enough, the negative growth effect could dominate the positive valuation effect when inflation is low. Then the inflation-inequality relationship displays a U shape; this case is likely to occur when the home country plays a large role in determining the global real interest rate (e.g., home country's technology growth is high relative to foreign). However, when the home country has only a minor impact on the global interest rate, the positive valuation effect always dominates the negative growth effect, leading to a monotonically increasing relation between inflation and inequality.[7]

[7] For analytical tractability, our baseline model assumes that the CIA constraints are the same for incumbent and entrant firms. We relax this assumption in our numerical studies and find that the inflation-inequality relation is also contingent upon the relative strengths of the CIA constraints faced by the two types of R&D firms. See Appendix B for more details.

Although domestic inflation can narrow income inequality under certain conditions in our model, we find that the effect may only be moderate, especially in an open economy. The inequality improvement is from the negative growth effect, which reduces the real interest rate. However, the effect is dampened in an open economy because the global real interest rate is determined by both domestic and foreign technology growth in this case. In addition, we show that the negative growth effect of inflation is smaller for incumbent firms than new entrants. Although inflation increases the cost of innovation, it also increases the size of incumbent firms, which encourages more innovation activities. Our baseline model suggests that these two effects can even cancel out, leaving no effect of inflation on incumbent firms' innovation intensity.[8]

Our model's theoretical predictions are supported by the quantitative analysis when we calibrate the model to match the economies in the US and eurozone countries. The numerical results show that domestic income inequality is monotonically increasing (decreasing) in domestic (foreign) inflation when the growth rate in the two economies is similar. However, the model displays a U-shaped pattern for the inflation-inequality relation in the home country, if we increase home technology growth relative to foreign, and reduce the share of imported goods in domestic consumption. This finding suggests that the U-shaped relation between domestic inflation and income inequality is more likely to arise in large open economies that play important roles in determining the global interest rate.

We also find empirical support to our model prediction in cross-country regressions, using the data of 65 high and upper middle income countries. Our empirical study provides novel evidence that the inflation-inequality relation hinges critically upon a country's global influence, which is largely consistent with the predictions of our theoretical model. To be specific, we find a U-shaped relation between inflation and inequality among countries of high global influence, whereas the inflation-inequality relation among low influence countries seems monotonically increasing. To gauge the economic influence of a studied country in our sample, we construct an index via jointly taking into account GDP, GDP growth and financial openness. Among high influence economies which display U-shaped relation between inflation and income inequality, it is found that the inequality-minimizing inflation rate is around 1.14%, which is close to the numerical estimate of our theoretical model, even though it is noticeably lower than the estimate of Galli and van der Hoeven (2001), whose empirical analysis is based on a data set covering fewer economies.

Our findings deliver important policy implications. For small economies that have only minor influence on the global interest rate, the goal of enhancing long-run economic growth and alleviating income inequality can be simultaneously achieved if monetary authority sets the inflation target at the minimum possible level. In other words, the Friedman rule remains optimal

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

even when the inequality-minimization objective is taken into account. For large economies that exhibit huge impact on the global interest rate, a U-shaped relation may exist between inflation and income inequality. In this case, there is an inflation level that minimizes income inequality by sacrificing some economic growth. However, it is out of the scope of this paper to determine if the central banks should set the inflation target to minimize income inequality.

1.1 Literature Review

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.[9] 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).[10] 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.[11] 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 is also related 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 relation is their main focus. In addition, **?** 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

[9]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.

[10]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.

[11]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.

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 relation among countries with high global influence, and a positive relation among countries with low global influence, both of which 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.[12] 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 relation 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 a CIA constraint on R&D investment as in Chu and Cozzi (2014). The

[12] 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.

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.

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[13]

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

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

[13]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.

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

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.[14]

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[15]

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

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,

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

[14] 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.

[15] 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.

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

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 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 $x_{k,t}^h$, 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_t^h 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 $n^h x_{k,t}^h$ and decreases to $n^h - 1$ with a probability of $n^h \tau_t^h$ (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 ($S_{k,t}^h$), according to the following Cobb-Douglas production function:

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

where $X_{k,t}^h$ 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_t^h. Thus, the R&D cost function of a typical firm is given by

$$C^h(x_{k,t}^h, n^h) = w_t^h S_{k,t}^h (1+\xi^h i_t^h) = \varphi^h n^h w_t^h (x_{k,t}^h)^{\frac{1}{\gamma^h}} (1+\xi^h i_t^h),$$

where $x_{k,t}^h \equiv X_{k,t}^h / n^h$ 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

$$x_{e,t}^h = \frac{S_{E,t}^h}{\phi^h}, \tag{10}$$

where $x_{e,t}^h$ is the aggregate entry rate in the economy and $S_{E,t}^h$ 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_t^h 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

$$x_{e,t}^h V_t^h(1) = w_t^h S_{E,t}^h (1 + \xi^h i_t^h), \tag{11}$$

which equates the value of a new entry $V_t^h(1)$ 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.[16]

2.5 Monetary Authority

Denote by M_t^h the nominal money supply in country h. Accordingly, the real money balance in country h is given by $m_t^h = M_t^h / P_{c,t}^h$, where $P_{c,t}^h$ is the price of consumption goods denominated in units of currency in country h. Then consider the growth rate of money supply $\dot{M}_t^h / M_t^h$ 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 $\pi_t^h \equiv \dot{P}_{c,t}^h / P_{c,t}^h = \dot{M}_t^h / M_t^h - \dot{m}_t^h / m_t^h$. Additionally, combining this condition with the Fisher equation (i.e., $i_t^h = \pi_t^h + r_t$) yields the one-to-one relation between the nominal interest rate and the nominal money supply, such that[17]

$$i_t^h = \dot{M}_t^h / M_t^h + \rho. \tag{12}$$

Given this result, throughout the rest of this study, we will use i_t^h 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 $\tau_t^h = \dot{M}_t^h / P_{c,t}^h = \left(\dot{M}_t^h / M_t^h\right)\left(M_t^h / P_{c,t}^h\right) = \left(\dot{m}_t^h / m_t^h + \pi_t^h\right) m_t^h = \dot{m}_t^h + \pi_t^h m_t^h$.

[16] 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 relation between the aggregate technology growth rate and the nominal interest rate, as illustrated below, remains unchanged.

[17] On the balanced growth path, c_t^h and m_t^h grow at the same rate of $r_t - \rho$ according to the Euler equation (4).

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 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).[18]

[18] 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.

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

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

where $\chi_1 = \rho > 0$ is implied by (30), combined with the fact that $\{a^h_t, b^h_t, c^h_t, w^h_t, \tau^h_t\}$ all grow at the same steady-state rate of g along the BGP. Since $\theta^h_{d,t}(s)$ is a state variable and the coefficient on $\theta^h_{d,t}(s)$ is positive, the only solution for the one-dimensional differential equation that describes the potential evolution of $\theta^h_{d,t}(s)$ is $\dot{\theta}^h_{d,t}(s) = 0$ for all $t > 0$ along the BGP. This can be achieved, as shown in Appendix A.2, by having the consumption share $\theta^h_{c,t}(s)$ equal to its steady-state value $\theta^h_{c,0}(s)$. 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 $\theta^h_{d,t}(s) = \theta^h_{d,0}(s)$ 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 $I^h_t(s) = rd^h_t(s) + w^h_t$. Aggregating over s yields the total income earned by households in country h such that $I^h_t = rd^h_t + w^h_t$. Combining both equations yields the income share of household s:

$$\theta^h_{I,t}(s) \equiv \frac{I^h_t(s)}{I^h_t} = \frac{\theta^h_{d,t}(s) rd^h_t + w^h_t}{rd^h_t + w^h_t}, \tag{32}$$

where the second equality applies $d^h_t(s) = \theta^h_{d,t}(s) d^h_t$ from Lemma 2. The distribution function of income share $\theta^h_{I,t}(s)$ has a mean of one and the following standard deviation:[19]

$$\sigma^h_{I,t} = \sqrt{\int_0^1 [\theta^h_{I,t}(s) - 1]^2 ds} = \frac{rd^h_t / w^h_t}{1 + rd^h_t / w^h_t} \sqrt{\int_0^1 [\theta^h_{d,t}(s) - 1]^2 ds} = \frac{rd^h_t / w^h_t}{1 + rd^h_t / w^h_t} \sigma^h_d. \tag{33}$$

Given that the value of σ^h_d is stationary, equation (33) implies that the degree of income inequality is an increasing function of rd^h_t / w^h_t, 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 $d^h_t = a^h_t + b^h_t$. From the asset-market-

[19] It is useful to note that the Gini coefficient of income is also given by $\sigma^h_{I,t} = \frac{rd^h_t / w^h_t}{1 + rd^h_t / w^h_t} \sigma^h_d$, when σ^h_d is defined as the Gini coefficient of wealth. The derivation is available upon request.

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 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.[20] 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

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

growth rate (and real interest rate) is jointly determined by g^h and g^f. We find that the relation 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 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 relation between the inflation rate and the nominal interest rate is supported by the empirical evidence in **?** and **?**. 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.[21]

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 relation 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

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

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 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.[22] Accordingly, the relation 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 relation 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.[23] 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 relation 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.

[22]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 relation between domestic inflation and domestic income inequality becomes U-shaped; the domestic country is actually equivalent to a closed economy.

[23]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.

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.* (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.

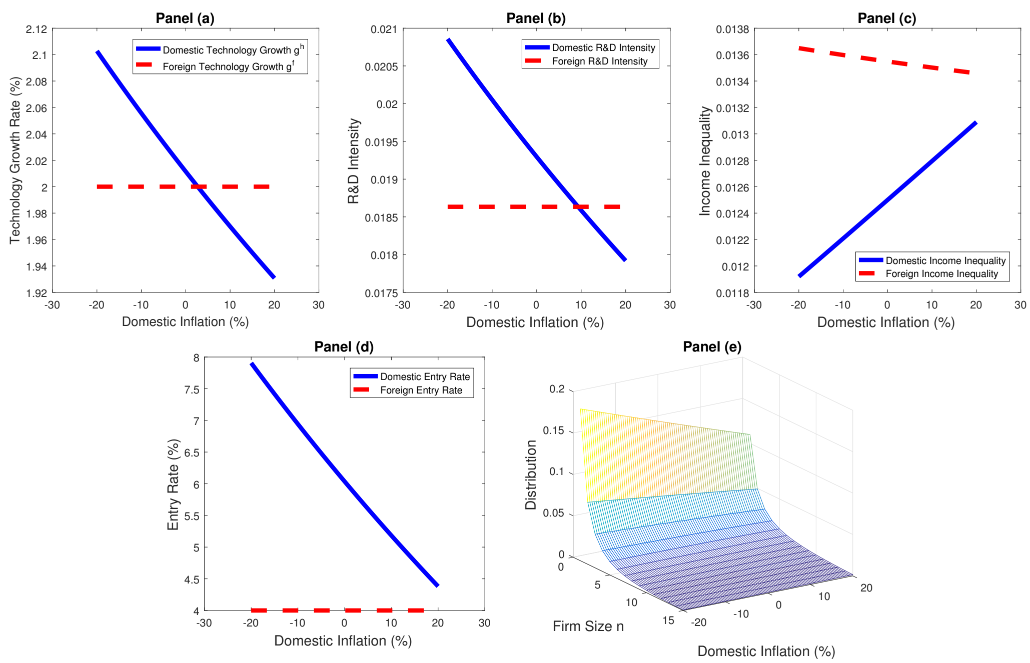

Figure 1: Effects of Domestic Inflation.

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 relation between inflation and income inequality in the domestic country. Further numerical exploration of Proposition 2 is discussed in the next subsection.

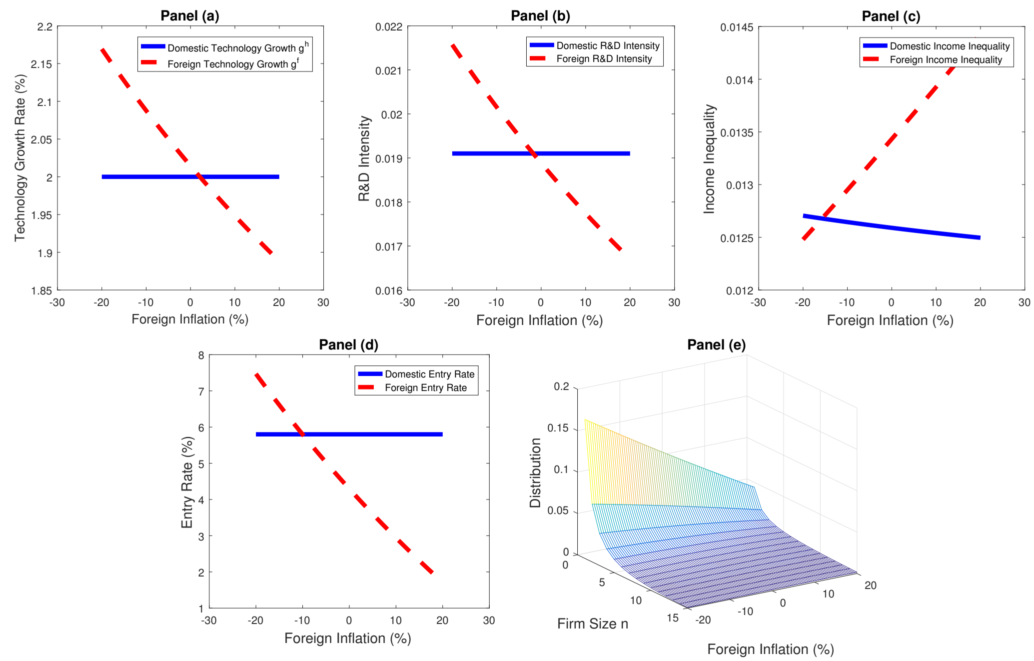

Figure 2: Effects of Foreign Inflation.

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 relation 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.

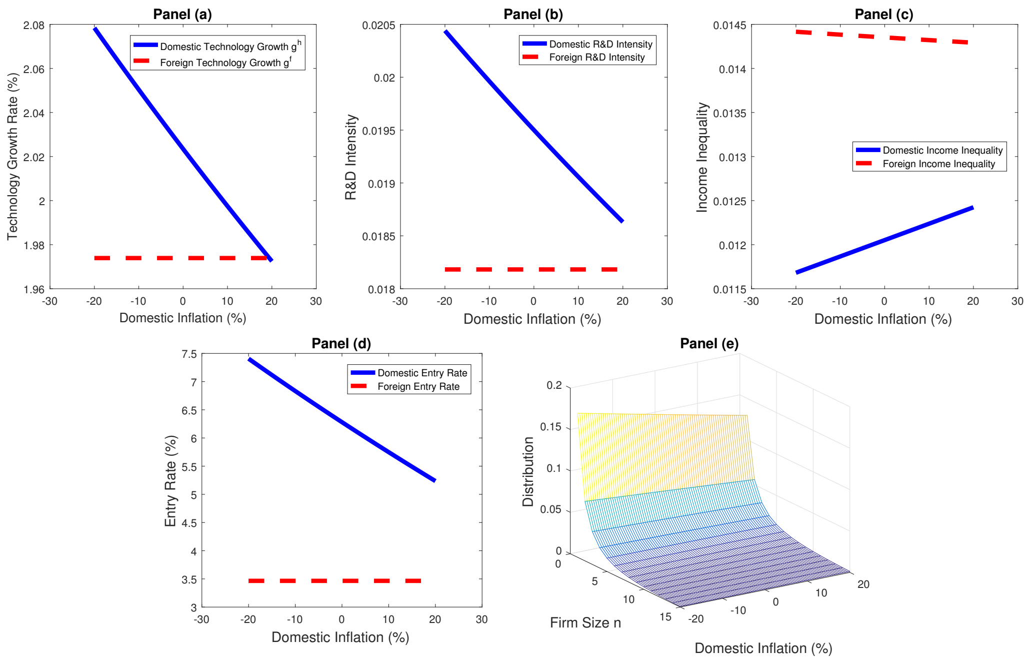

Figure 3: Effects of Domestic Inflation ($\xi^h = 0.2, \xi^f = 0.8$).

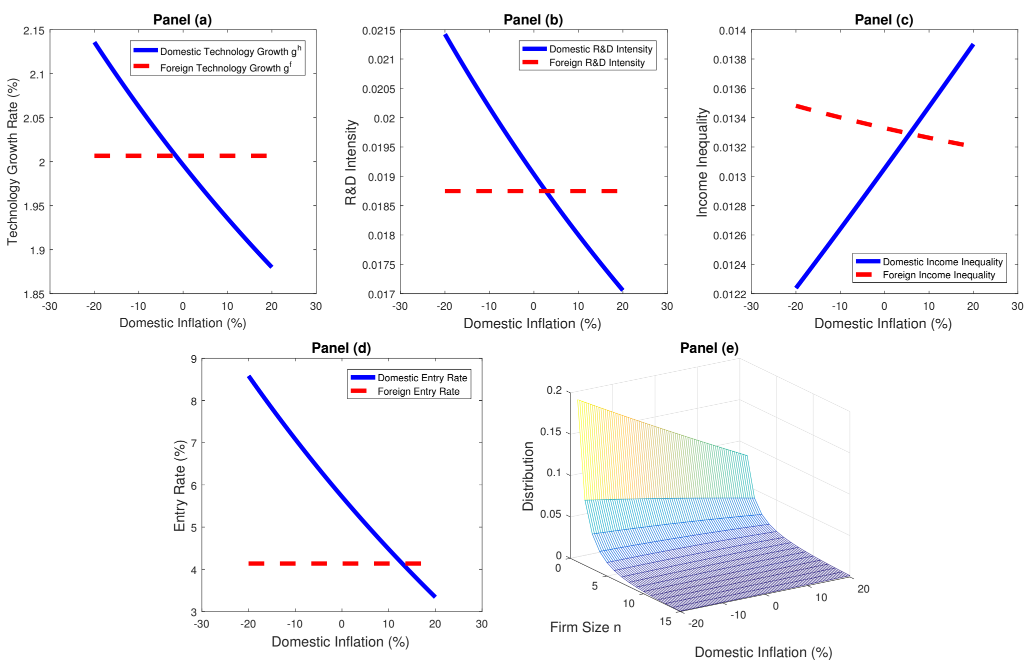

Figure 4: Effects of Domestic Inflation ($\xi^h = \xi^f = 0.5$).

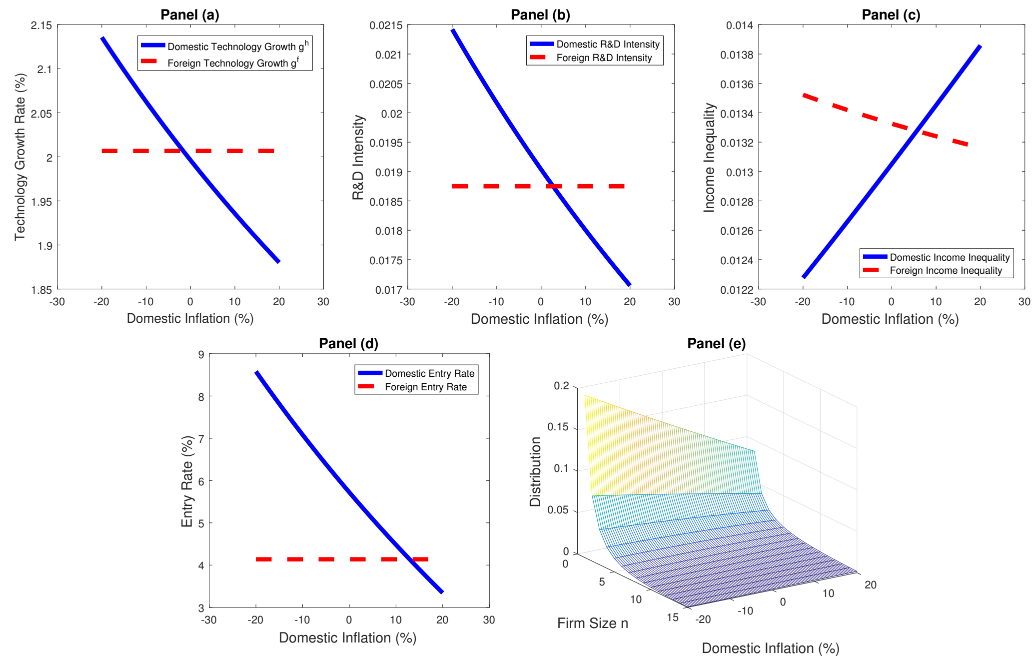

Figure 5: Effects of Domestic Inflation ($\alpha = 0.25; \xi^h = \xi^f = 0.5$).

In Section 4, Proposition 2 suggests that a U-shaped relation 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 addition, 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 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 relation 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.

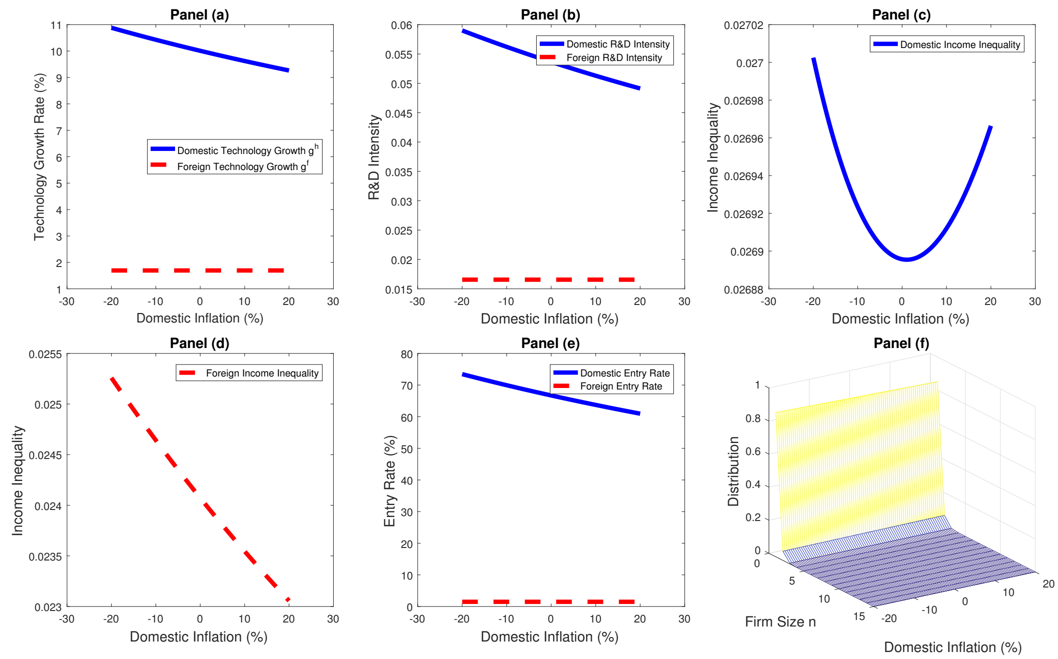

Figure 6: Effects of Domestic Inflation (U-shaped Calibration).

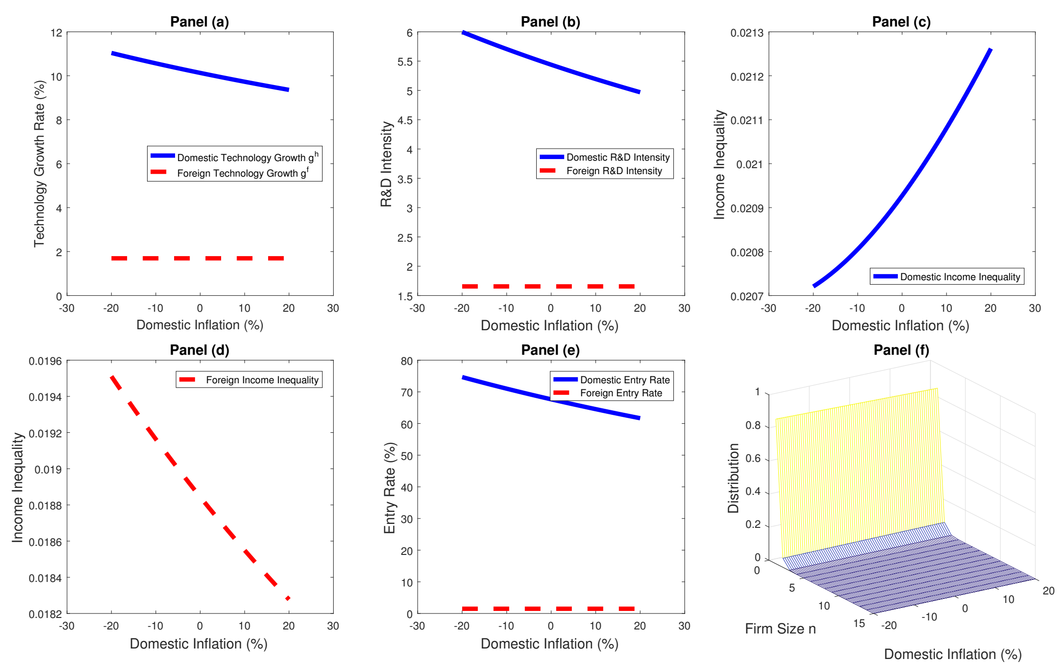

Figure 7: Effects of Domestic Inflation (U-shaped Calibration, $\alpha = 0.6$).

In the presence of a U-shaped relation, 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 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.[24] 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.

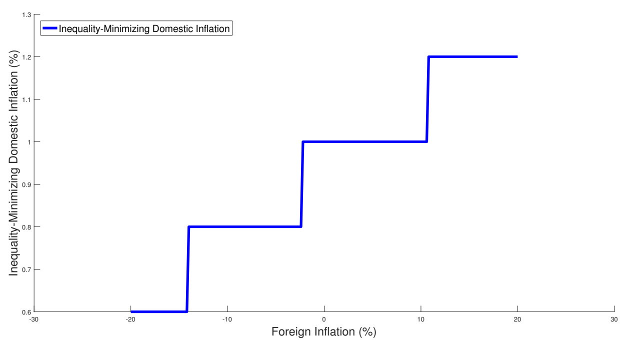

Figure 8: Inequality-Minimizing Level of Domestic Inflation in Response to Foreign Inflation

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

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

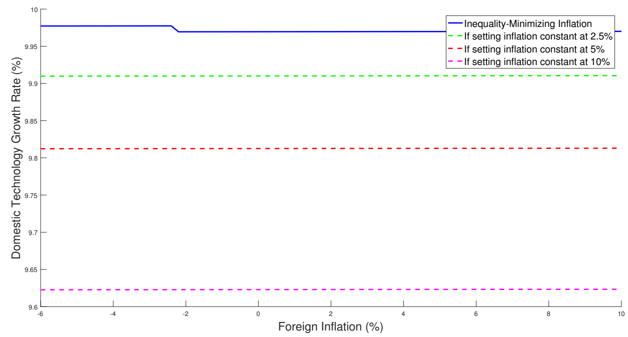

Figure 9: Inequality-Minimizing Level of Domestic Inflation: Economic Growth

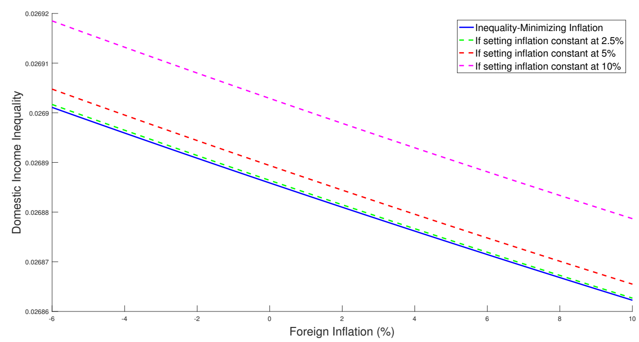

Figure 10: Inequality-Minimizing Level of Domestic Inflation: Income Inequality

even more unequal. However, Galli and van der Hoeven (2001) provide empirical evidence that the relation 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 relation 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 relation 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.[25]

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.[26] 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.[27] 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

[25]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.

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

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

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 to eliminate countries with only one complete observation, since one observation in an arbitrary year seems unable to accurately capture the long-run relation 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.

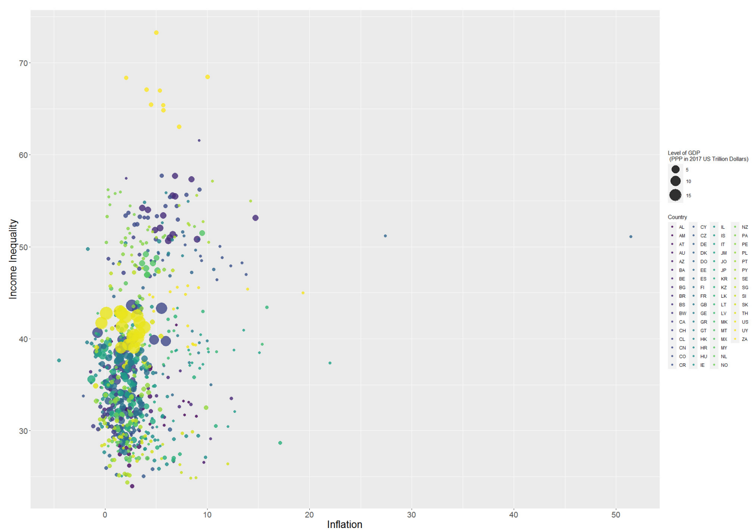

Figure 11: Scatter Plot of Observations for All Countries (Panel Data)

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 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 relation 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.

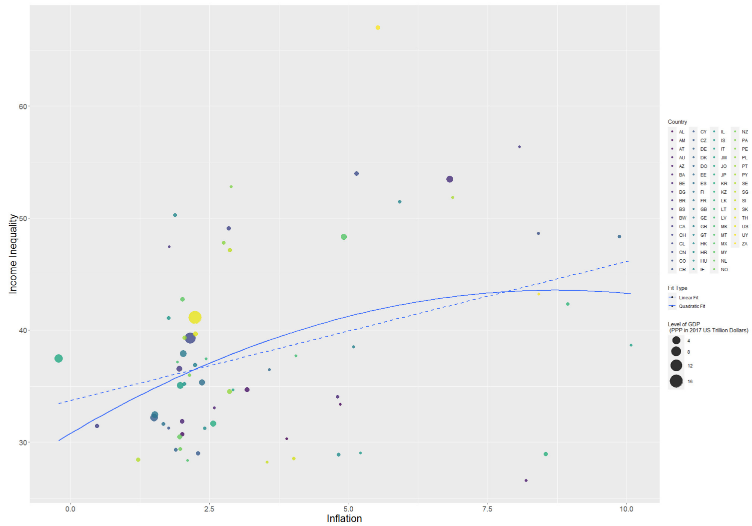

Figure 12: Scatter Plot of Observations for All Countries (Cross-sectional Data)

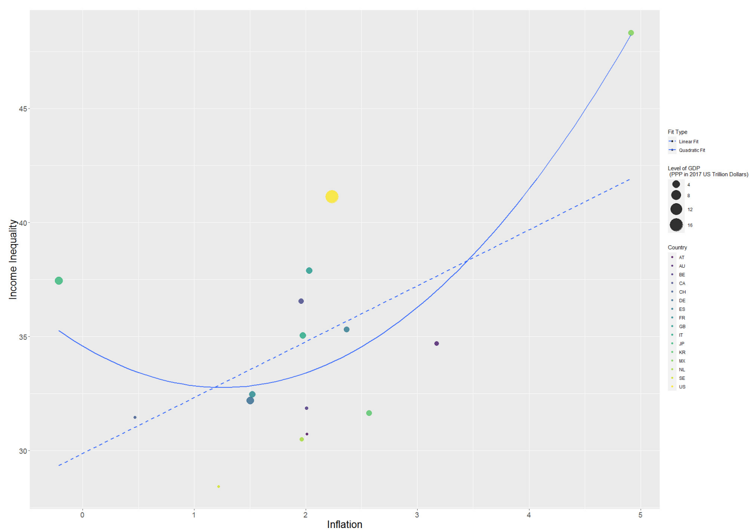

Figure 13: Inflation and Income Inequality in HIEs

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,

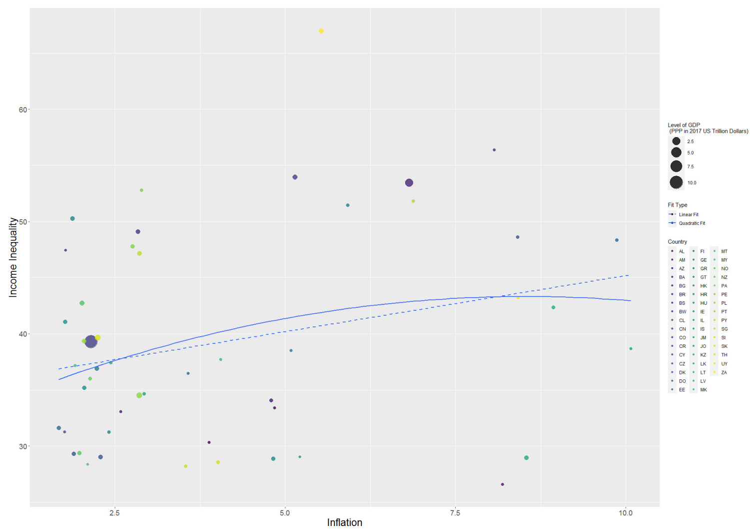

Figure 14: Inflation and Income Inequality in LIEs

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,[28] 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.[29] 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.

[28]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.

[29]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.

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, this model takes into consideration heterogeneous asset holdings of households and CIA constraints on R&D investment; the former is the source of income inequality whereas the latter introduces monetary policy. The model enables us to explore the cross-country effects of inflation on innovation, economic growth, and income inequality, respectively.

We find that higher domestic inflation decreases domestic aggregate technology primarily through a lower entry rate of new firms and does not have an impact on foreign aggregate 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 the channels of the negative growth (via the global interest rate) and the positive valuation (via the value of financial assets). We show that the interplay of these two channels causes ambiguity on the relation between domestic inflation and domestic income inequality, which depends on the growth rate of foreign technology. Specifically, if the growth rate of foreign technology is

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.

sufficiently low (high), higher domestic inflation yields a U-shaped (positive) effect on domestic income inequality. By the feature of small open economies, a large-sized (small-sized) country normally exhibits a low (high) growth rate of foreign technology. Therefore, the above result implies that the impact of domestic inflation on domestic income inequality would be also contingent 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 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 attained 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,

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.

and therefore, monetary authority needs to take into account such a possible growth-inequality tradeoff.

As for future research in this literature, one direction is to reexamine the cross-country effects of inflation on income inequality by introducing additional layers of heterogeneity on firms' type, such as external innovation versus internal innovation as in Akcigit and Kerr (2018), and high-type firms versus low-type firms in terms of their innovative capacity as in Acemoglu *et al.* (2018). Another direction is to pursue the model implications for other policy regimes. It may be a fruitful extension to consider the implementation of trade and fiscal policies, given that the dimensions by which these policy instruments affect resource allocation can be different. Therefore, the effects of these two policy regimes on income inequality may not be identical to those of monetary policy.[30] The third direction is to explore more empirical evidence on the

[30] Nevertheless, when fiscal policy, such as research subsidies to incumbents and entrants, are present in the current

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.

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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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Appendix A Proofs of Propositions (Not intended for publication)

A.1 Definition of Balanced Growth Path Equilibrium

Definition 1. *The balanced growth path equilibrium consists of a sequence of prices* $\{P^h_{c,t}, P^f_{c,t}, p^h_{y,t}, p^f_{y,t}, p^h_{z,t}, p^f_{z,t}, w^h_t, r_t, i^h_t, i^f_t, V^h_t(n), V^f_t(n), \epsilon_t\}_{t=0}^{\infty}$ *and a sequence of allocations* $\{C_t, c^h_t, c^f_t, m^h_t, m^f_t, b^h_t, b^f_t, Y^h_t, Y^f_t, Z^h_t(j), Z^f_t(j), L^h_{Z,t}, S^h_{K,t}, S^h_{E,t}, L^f_{Z,t}, S^f_{K,t}, S^f_{E,t}\}_{t=0}^{\infty}$ *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* $C_t = c^h_t + c^f_t$*; (ii) the labor market in country* h *and* f *clear such that* $L^h_{Z,t} + S^h_{K,t} + S^h_{E,t} = 1$ *and* $L^f_{Z,t} + S^f_{K,t} + S^f_{E,t} = 1$*; (iii) the asset markets in country* h *and* f *clear such that* $\sum_{n^h=1}^{\infty} \mu_{n^h} V^h_t(n^h) = a^h_t$ *and* $\sum_{n^f=1}^{\infty} \mu_{n^f} V^f_t(n^f) = a^f_t$*; (iv) the bond markets in country* h *and* f *clear such that* $b^h_t = \xi^h w^h_t (S^h_{K,t} + S^h_{E,t})$ *and* $b^f_t = \xi^f w^f_t (S^f_{K,t} + S^f_{E,t})$*.*

A.2 Proof of Lemma 2

Along the BGP, $\{a^h_t, b^h_t, c^h_t, w^h_t, \tau^h_t\}$ all grow at the same steady-state rate of g. Thus, d^h_t also grows at the rate of g. Using (30), we have

$$\frac{c^h_t - w^h_t - \tau^h_t}{d^h_t} = r - \frac{\dot{d}^h_t}{d^h_t} = \rho > 0. \tag{A.1}$$

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

$$\theta^h_{c,0}(s) = 1 - \frac{\rho[1 - \theta^h_{d,0}(s)]}{c^h_t / d^h_t}. \tag{A.2}$$

A.3 Proof of Proposition 2

Differentiating (36) with respect to i^f yields

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

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

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

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

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 $\lambda^h < 1$,[31] 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[32]

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

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

[31] 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 $\lambda^h \in [0.05, 0.2] < 1$.

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

(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 (Not intended for publication)

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

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

and

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

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 relation between domestic inflation and domestic incumbent innovation rate becomes negative.

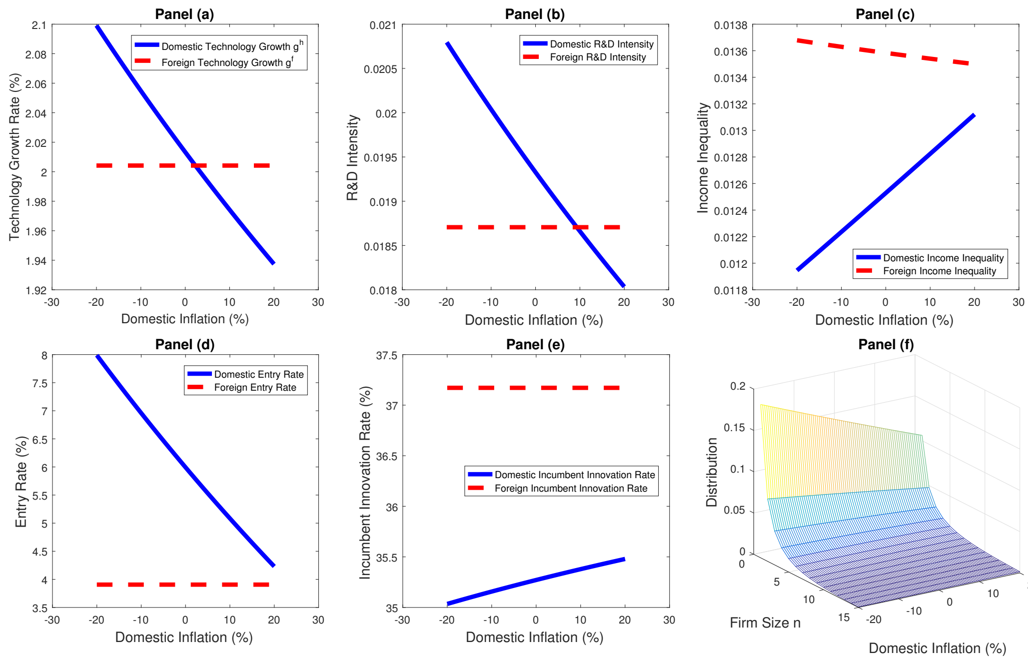

Figure 15: Effects of Domestic Inflation: Benchmark Calibration; $s^{CIA} = 10\%$.

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

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

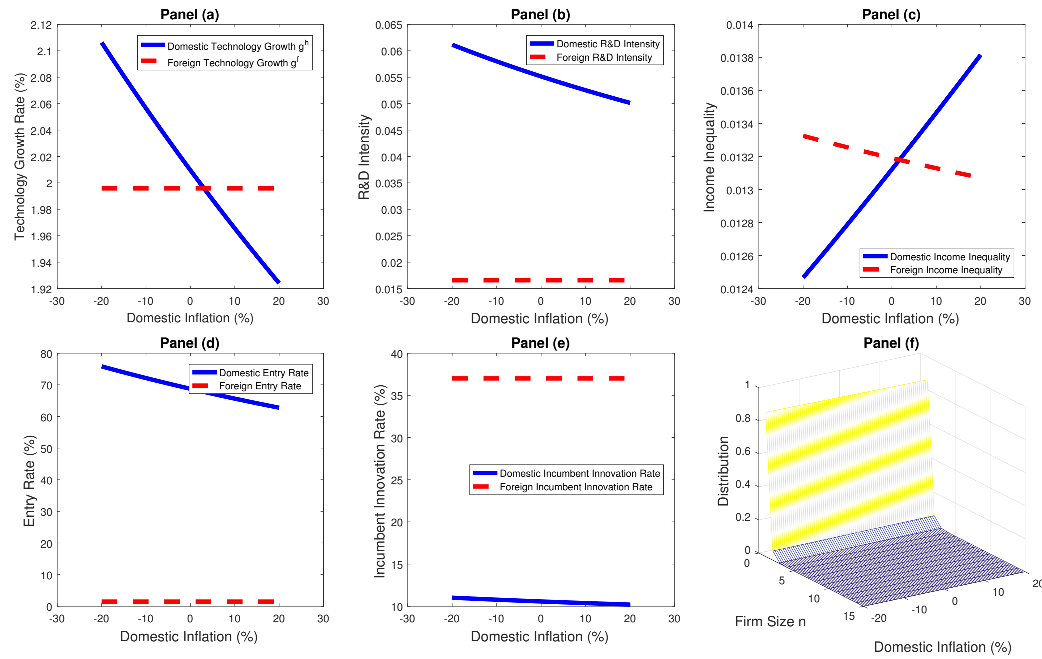

Figure 16: Effects of Domestic Inflation: Benchmark Calibration; $s^{CIA} = -10\%$.

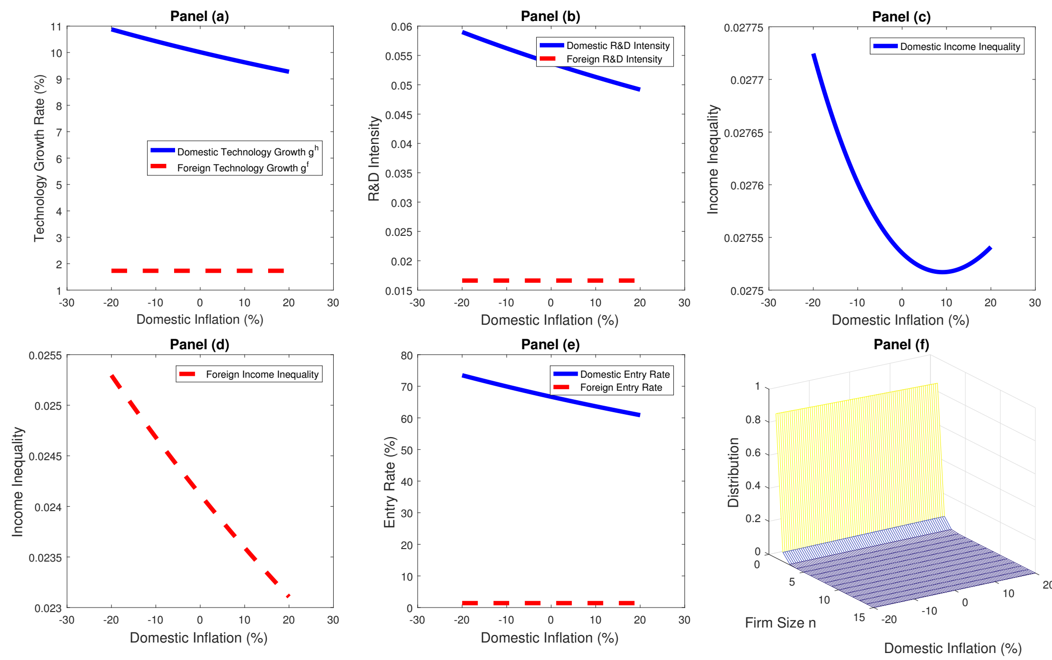

Figure 17: Effects of Domestic Inflation: U-Shaped Calibration; $s^{CIA} = -10\%$.

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.

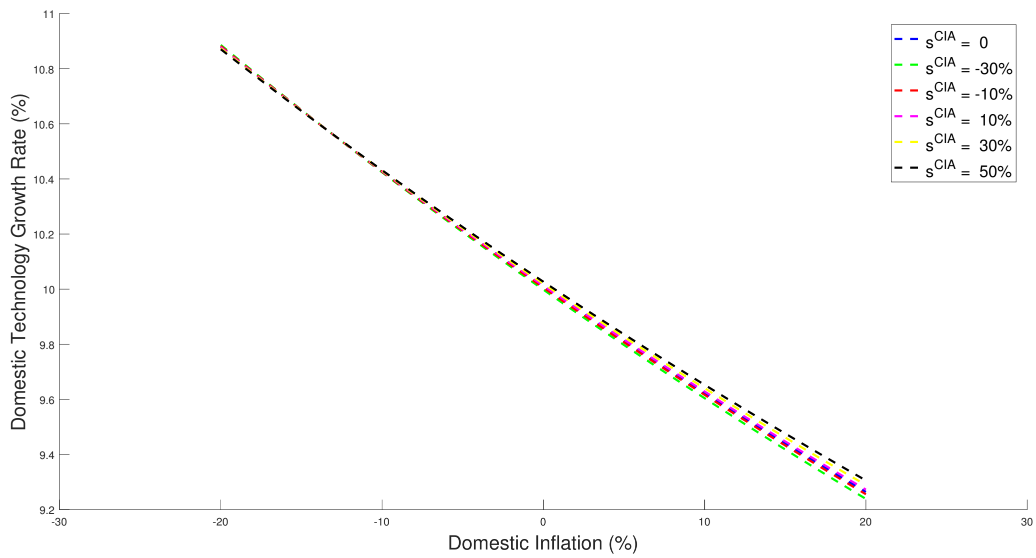

Figure 18: Effect of Domestic Inflation on Growth: U-Shaped Calibration

Second, Figure 19 suggests that the relation 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 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

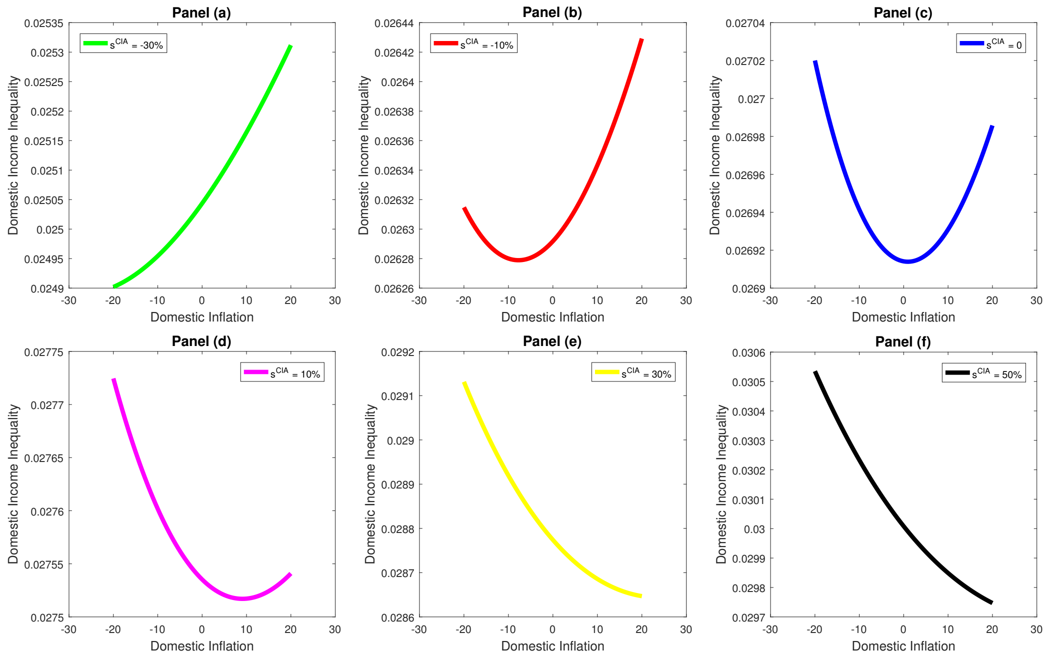

Figure 19: Effect of Domestic Inflation on Income Inequality: U-Shaped Calibration

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.

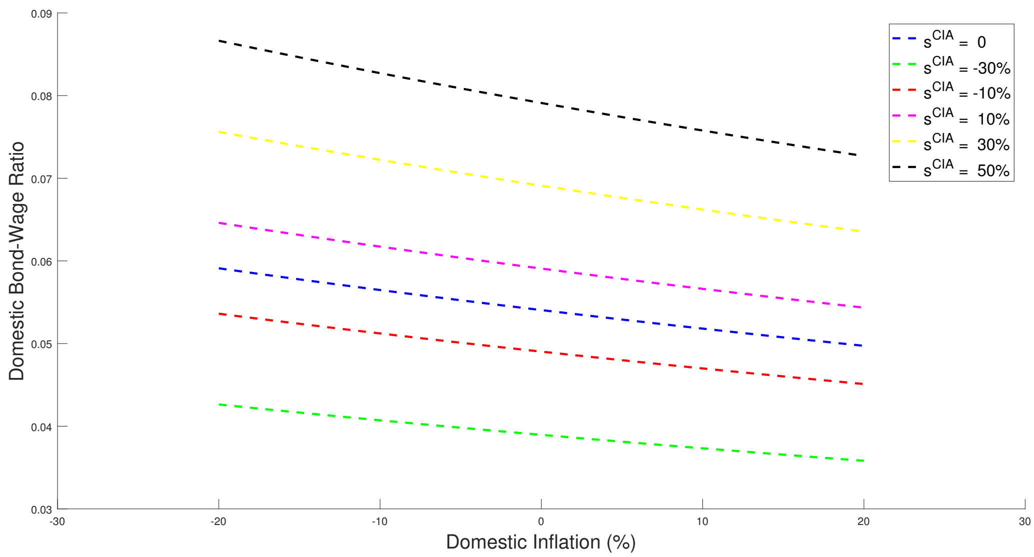

Figure 20: Effect of Domestic Inflation on Bond-Wage Ratio: U-Shaped Calibration

Appendix C Data Description (Not intended for publication)

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=6gyBWA0C_Www1SIRMhFksM6SkdeTWmTaCTAiDzs8NS0&m=08NCmRQFbGaFN9QHKT0S0GTa9lBqaZUy_fIrF5W9gO0&s=yq0KMv4lvFMdEb2PCUA4le5pJm5lNcROnTYpXbZXQ4A&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
24	Hungary	0.7694	0.0148	0.9260	0.0105

Table C.1 (continued)

Rank	Country	Corr with US GDP Growth Rate	GDP Relative to US	Financial Openness	Index
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.

Table C.4: **Descriptive Statistics**

This table reports descriptive statistics for sample firms for the period 2000-2014. Variables are defined in Appendix A. Panel A presents summary statistics for Chinese firm variables, Chinese peer average variables, U.S. peer average variables and macro factors. Peer is defined as Chinese firms in the same 4-digit CISC code and US firms in the matching 4-digit GICS code. For firm size, this table and subsequent tests use the log of millions of units of currency. Panel B presents industry distribution and Panel C shows year distribution of our sample.

Panel A: Summary Statistics

Variables	Obs	Mean	P25	Median	P75	Std
Chinese firm-level characteristics						
Investment	12981	0.065	0.016	0.042	0.088	0.077
Tobin's Q	12981	2.146	1.240	1.687	2.475	1.513
Cash flow	12981	0.059	0.034	0.057	0.089	0.067
Total assets (log)	12981	21.528	20.757	21.390	22.144	1.138
US Peer investment						
U.S. peer averages	12981	0.061	0.038	0.051	0.077	0.033
US Peer Tobin's Q	12981	2.067	1.685	1.981	2.244	0.615
US Peer cash flow	12981	0.000	-0.006	0.018	0.042	0.088
US Peer total assets	12981	6.246	5.977	6.355	6.584	0.673
China peer averages						
China Peer investment	12981	0.069	0.050	0.066	0.086	0.022
China Peer Tobin's Q	12981	2.150	1.598	1.886	2.631	0.761
China Peer cash flow	12981	0.060	0.049	0.058	0.070	0.018
China Peer total assets	12981	21.520	21.207	21.479	21.907	0.479

Panel B: Industry Distribution

	GICS lv1	Obs.		GICS lv2	Obs.		GICS lv3	Obs.
10	Energy	511	1010	Energy	511	101010	Energy Equipment & Services	46
						101020	Oil, Gas & Consumable Fuels	304
15	Materials	2807	1510	Energy	2807	151010	Chemicals	879
						151020	Construction Materials II	281
						151030	Containers & Packaging	34
						151040	Metals & Mining	304
						151050	Paper & Forest Products	304
20	Industrials	3474	2010	Capital Goods	2645	201010	Aerospace & Defense	149
						201020	Building Products III	281
						201030	Construction & Engineering III	277
						201040	Electrical Equipment	436
						201050	Industrial Conglomerates III	106
						201060	Machinery	790
						201070	Trading Companies & Distributors III	225
			2020	Commercial & Professional Services	266	202010	Commercial Services & Supplies	99
						202020	Professional Services	4
			2030	Transportation	563	203010	Air Freight & Logistics III	2
						203020	Airlines III	49
						203030	Marine III	58
						203040	Road & Rail III	64
						203050	Transportation Infrastructure	295
25	Consumer Discretionary	2841	2510	Automobiles and Components	628	251010	Auto Components	340
						251020	Automobiles	197
						201030	Construction & Engineering III	277
			2520	Consumer Durables and Apparel	961	252010	Household Durables	229
						252020	Leisure Equipment & Products	51
						252030	Textiles, Apparel & Luxury Goods	308
			2530	Consumer Services	285	253010	Hotels, Restaurants & Leisure	187
			2540	Media	238	254010	Media III	221
			2550	Retailing	729	255010	Distributors III	26
						255030	Multiline Retail	355
						255040	Specialty Retail	88
30	Consumer Staples	1275	3010	Food and Staples Retailing	229	301010	Food & Staples Retailing III	58
			3020	Food, Beverage and Tobacco	985	302010	Beverages	319
			3030	Household and Personal Products	61	303010	Household Products III	23
						303020	Personal Products III	12
35	Health Care	800	3510	Health Care Equipment and Services	51	351010	Health Care Equipment & Supplies	29
						351020	Health Care Providers & Services	16
			3520	Pharmaceuticals, Biotechnology and Life Sciences	749	352010	Biotechnology III	121
						352020	Pharmaceuticals III	580
45	Information Technology	1262	4510	Software and Services	345	451010	Internet Software & Services III	26
						451020	IT Services	125
						451030	Software	107
			4520	Technology Hardware and Equipment	771	452020	Computers & Peripherals	84
			4530	Semiconductors and Semiconductor Equipment	146	452030	Electronic Equipment, Instruments & Components	371
						453010	Semiconductors & Semiconductor Equipment III	86
50	Telecommunication Service	11	5010	Telecommunication Services	11	501010	Diversified Telecommunication Services	2
Total		12981			12981			9641