Global Inflation and the Failure of Exchange Rate Insulation

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Abstract

This paper studies inflation dynamics in a global economy where exchange rates fail to insulate domestic prices. We develop a multi-country New Keynesian framework in which global forces operating through tradable goods markets generate persistent inflation and equilibrium indeterminacy under empirically relevant monetary policy rules. We identify two key drivers: a distributed lag of global slack and a global common trend in tradable prices. Empirically, these forces account for post–Global Financial Crisis inflation puzzles, including missing disinflation, missing reflation, and COVID-19 inflation volatility.

I. Introduction

What determines inflation dynamics in a globally integrated economy where tradable goods prices are not anchored by domestic conditions? Standard open-economy New Keynesian models imply that exchange rate adjustments insulate domestic inflation from global shocks through a "divine cancellation," rendering inflation primarily a function of local conditions.[1] At the other extreme, currency union models eliminate this mechanism, allowing global forces to transmit directly into domestic prices through tradable goods markets.[2] Where does the real world lie between these benchmarks?

A growing body of empirical evidence suggests that exchange rate insulation is limited in practice. For the Galí and Monacelli (2005) mechanism to hold, exchange rates must be closely tied to macroeconomic fundamentals such as output gaps and relative demand conditions. Instead, exchange rate movements are largely driven by financial flows and asset demand, weakening their connection to domestic fundamentals (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000; Devereux and Engel, 2003; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021). Moreover, cross-country inflation dynamics exhibit strong co-movement that cannot be explained by exchange rate adjustments alone (Auer et al., 2019). These findings point to a central role for global forces—particularly those operating through tradable goods markets (Heise, Karahan, and Şahin, 2022)—in shaping domestic inflation.

This paper develops a framework to characterize inflation dynamics in such an environment and shows that global forces can generate persistent inflation and equilibrium indeterminacy when tradable prices are not fully anchored. This takes place through two distinct channels. The first is a distributed lag effect of global slack, reflecting the propagation of global demand conditions through production networks and input linkages. The second is a global common trend in tradable goods prices, capturing slow-moving demand–supply imbalances that are not fully reflected in contemporaneous measures of global slack. Both forces operate independently of domestic conditions and generate persistent inflation dynamics.

A key implication of our framework is that inflation dynamics may exhibit equilibrium indeterminacy under empirically relevant monetary policy rules. In particular, when central banks respond weakly to tradable goods inflation—consistent with the common practice of "looking through" external cost-push shocks—global forces can become weakly anchored, allowing self-reinforcing dynamics to emerge. In

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[1] See Galí and Monacelli (2005) for the canonical results.

[2] Hazell et al. (2022) develops a currency union model to explain regional inflation dynamics in the United States.

this environment, inflation is not uniquely pinned down by fundamentals, and global components can behave as persistent sunspot-like processes. This mechanism provides a structural explanation for the apparent disconnect between inflation and domestic slack observed in recent decades.

We formalize these ideas in a multi-country New Keynesian model with tradable and non-tradable sectors and globally integrated production. The model highlights how global demand, relative prices, and cross-country spillovers jointly determine domestic inflation. We characterize the conditions under which equilibrium is determinate and show that these conditions depend critically on the strength and composition of monetary policy responses. In particular, stabilizing inflation requires sufficiently strong responses to tradable-sector developments, either directly through inflation or indirectly through the output gap.

Guided by the theoretical framework, we develop an empirical global Phillips curve that incorporates the persistent global forces implied by the model. We construct proxies for the distributed lag of global slack and the global trend in tradable prices, and estimate their effects using cross-country data. The results show that these global factors exert a statistically significant and persistent influence on both realized inflation and inflation expectations. Moreover, allowing for these forces substantially improves the empirical performance of the Phillips curve without requiring time-varying slope coefficients or ad hoc structural breaks.

Our framework provides a unified explanation for several well-known inflation puzzles. It accounts for the missing disinflation following the Global Financial Crisis, the missing reflation during the 2010s, and the heightened volatility of inflation during the COVID-19 period. In contrast to conventional explanations that rely on changes in the slope of the Phillips curve, we show that these episodes can be understood as shifts in exposure to persistent global forces. Once these forces are accounted for, the relationship between inflation and domestic slack remains broadly stable.

Related Literature. Our work builds on Auer et al. (2019), who examine the cross-border propagation of cost-push shocks. We depart from their partial-equilibrium approach by incorporating price stickiness to study the fundamental drivers of global inflation. Furthermore, rather than modeling the granular details of international supply chains, we exploit a theoretical result—derived in Section II—that the distributed lag structure of global slack is governed by global production function parameters. This result is crucial for developing a rich but parsimonious framework to capture three types of persistent forces that have been conventionally omitted as part of transitory cost-push shocks: (a) delayed global slack effects, (b) a global inflation trend driven by incompletely anchored tradable goods prices, and (c) the time-varying sensitivity of domestic inflation to these global forces.

This paper also contributes to the extensive literature investigating why the standard New Keynesian Phillips curve struggles to explain post-GFC inflation puzzles. We engage directly with the debate over whether the slope of the Phillips curve has flattened (Blanchard, Cerutti, and Summers, 2015; Coibion and Gorodnichenko, 2015; Ball and Mazumder, 2018; McLeay and Tenreyro, 2019; Di Giovanni et al., 2019; Hasenzagl et al., 2022; Hazell et al., 2022). By demonstrating that global factors play a dominant role in shaping the domestic inflation process, we extend the framework of Hazell et al. (2022). Crucially, we introduce a novel empirical approach to identify these new forces by utilizing the inflation data of small open economies. This structural identification cleanly distinguishes our methodology from the standard literature practice of extracting common statistical movements in global inflation (Ciccarelli and Mojon, 2010; Mumtaz and Surico, 2012; Ha et al., 2024).

Finally, the global sunspot mechanism in our framework connects to recent work on global tradable fundamentals, including the tradable goods scarcity emphasized by Fornaro and Romei (2024), and the unanchored expectations of price setters highlighted by Coibion and Gorodnichenko (2015). We show that the sunspot's effect on domestic inflation was particularly acute during the COVID-19 pandemic, when global tradable goods producers operated at or near full capacity. By empirically documenting a pronounced co-movement between this global sunspot and medium- to long-term inflation expectations, our findings underpin a central policy implication: stabilizing domestic inflation dynamics increasingly requires active global coordination.

The rest of the paper is organized as follows. Section II presents the theoretical analysis. Section III develops the empirical framework and presents the main results. Section IV discusses the novel explanation for the three post-GFC empirical puzzles. Section V concludes.

II. Theoretical Analysis

This section derives the structural inflation equation for a world economy operating as a currency union with N small open economies. Labor is immobile across borders, but goods trade occurs without frictions. Each economy is populated by a representative household and a continuum of firms producing tradable and non-tradable goods using globally sourced non-labor inputs.

We establish the general N-country setup, and then for analytical tractability, specialize to a symmetric two-country case. To capture a plausible scenario where domestic central banks adjust interest rates to stabilize domestic inflation while seeing through external cost-push pressures, we allow the global central bank to respond more weakly to tradable goods inflation than to average non-tradable goods inflation. The focus of our theoretical analysis consists of two parts: (a) the key inflation drivers in the structural inflation equation, and (b) the determinacy of equilibrium.

2.1 Household Decision Problem

Households maximize the period utility function that takes a Greenwood-Hercowitz-Huffman (GHH) form to determine optimal labor supply.

$$u\left(C_{i,t}, L_{i,t}^{T}, L_{i,t}^{NT}\right) = C_{i,t} - \chi_i^T \frac{\left(L_{i,t}^{T}\right)^{1+(\varphi^T)^{-1}}}{1+(\varphi^T)^{-1}} - \chi_i^{NT} \frac{\left(L_{i,t}^{NT}\right)^{1+(\varphi^{NT})^{-1}}}{1+(\varphi^{NT})^{-1}},$$

where $L_{i,t}^{T}$ and $L_{i,t}^{NT}$ denote labor supplied to the tradable and non-tradable sectors, $\varphi^m > 0$ is the Frisch elasticity of labor supply in sector $m \in \{T, NT\}$, $\chi_i^m > 0$ scales the disutility of labor.

We differentiate labor applied to tradable and non-tradable sectors to capture sectoral skill difference (Şahin, Song, Topa, and Violante (2014)), such that demand-supply imbalance in tradable sectors may influence the costs of producing tradable goods differently from those of producing non-tradable goods.

The aggregate consumption index $C_{i,t}$ is a nested Constant Elasticity of Substitution (CES) aggregator of tradable and non-tradable goods:

$$C_{i,t} = \left(\sum_{n=1}^{N} \zeta_n^T \left(\left(\int_{z \in I_n^T} \left(Y_{i,n,z,t}^{T}\right)^{\frac{\eta_n^T - 1}{\eta_n^T}} dz \right)^{\frac{\eta_n^T}{\eta_n^T - 1}} \right)^{\frac{\eta-1}{\eta}} + \zeta^{NT} \left(\left(\int_{z \in I_i^{NT}} \left(Y_{i,z,t}^{NT}\right)^{\frac{\eta_i^{NT} - 1}{\eta_i^{NT}}} dz \right)^{\frac{\eta_i^{NT}}{\eta_i^{NT} - 1}} \right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}},$$

where ζ_n^T and ζ^{NT} are the distribution weights, $\eta > 0$ is the elasticity of substitution between tradable and non-tradable goods (and across tradable goods from different countries), and η_n^T and $\eta_i^{NT} > 1$ are the elasticities of substitution between varieties within their respective sectors.

Households supply labor competitively and face the following budget constraint:

$$\sum_{n=1}^{N} \int_{z \in I_n^T} P_{n,z,t}^{T} Y_{i,n,z,t}^{T}\, dz + \int_{z \in I_i^{NT}} P_{i,z,t}^{NT} Y_{i,z,t}^{NT} dz + B_t \leq w_{i,t}^{T} L_{i,t}^{T} + w_{i,t}^{NT} L_{i,t}^{NT} + (1 + r_{t-1}) B_{t-1} + \pi_{i,t} + T_{i,t}.$$

Where $P_{i,z,t}^{m}$ denotes the price of intermediate goods, B_t is the nominal bond purchased, and r_{t-1} is the return to the bond purchased in the previous period, $\pi_{i,t}$ is the profit of firms owned by the household, and $T_{i,t}$ captures the government tax policies that passively ensures that the long-term budget constraint is satisfied.

To solve the household problem, we first define the following price indexes:

- Sectoral prices: $P_{i,t}^{m} = \left(\int_{z \in I_i^m} \left(P_{i,z,t}^{m}\right)^{1-\eta_i^T} dz \right)^{\frac{1}{1-\eta_i^T}}$,

- Global tradable price: $P_t^T = \left(\sum_{n=1}^{N}(\zeta_n^T)^{\eta}\left(P_{n,t}^T\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}$,
- Aggregate consumer price index (CPI): $P_{i,t} = \left((P_t^T)^{1-\eta} + (\zeta^{NT})^{\eta}\left(P_{i,t}^{NT}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}$.

We can further derive demand for goods and labor supply as follows:

- Demand of country i for a specific tradable good z from country n: $Y_{i,n,z,t}^T = (\zeta_n^T)^{\eta}\left(\frac{P_{n,z,t}^T}{P_{n,t}^T}\right)^{-\eta_n^T}\left(\frac{P_{n,t}^T}{P_t^T}\right)^{-\eta}\left(\frac{P_t^T}{P_{i,t}}\right)^{-\eta} C_{i,t}$,
- Demand for a specific non-tradable good z in country i: $Y_{i,z,t}^{NT} = (\zeta^{NT})^{\eta}\left(\frac{P_{i,z,t}^{NT}}{P_{i,t}^{NT}}\right)^{-\eta_i^{NT}}\left(\frac{P_{i,t}^{NT}}{P_{i,t}}\right)^{-\eta} C_{i,t}$,
- Labor supply: $\left(L_{i,t}^m\right)^{\frac{1}{\varphi^m}} = \left(\frac{1}{\chi_i^m}\right)\left(\frac{w_{i,t}^m}{P_{i,t}}\right)$, for $m \in \{T, NT\}$.

Let shares $s_{i,z}^T$, $s_{i,z}^{NT}$, and s_n^T denote steady-state expenditure weights implied by the CES aggregators, and let $\tilde{x}_t \equiv \ln\left(\frac{X_t}{\bar{X}}\right)$ denotes the log-deviation of variable X_t from its steady state value $\bar{X}$. We obtain the following relationships for the prices: $\tilde{p}_{i,t}^m = \int s_{i,z}^m \tilde{p}_{i,z,t}^m dz$, $\tilde{p}_t^T = \sum_{n=1}^{N} s_n^T \tilde{p}_{n,t}^T$, $\tilde{p}_{i,t} = \left(1 - s_{i,NT}\right)\tilde{p}_t^T + s_{i,NT}\tilde{p}_{i,t}^{NT}$, where the steady-state CPI weight on non-tradables is

$$s_{i,NT} \equiv \frac{(\zeta^{NT})^{\eta}\left(\bar{P}_i^{NT}\right)^{1-\eta}}{(\bar{P}^T)^{1-\eta} + (\zeta^{NT})^{\eta}\left(\bar{P}_i^{NT}\right)^{1-\eta}}.$$

Let $X_t \equiv C_{i,t} - \frac{\chi_i^T\left(L_{i,t}^T\right)^{1+\left(\varphi^T\right)^{-1}}}{1+(\varphi^T)^{-1}} - \frac{\chi_i^{NT}\left(L_{i,t}^{NT}\right)^{1+\left(\varphi^{NT}\right)^{-1}}}{1+(\varphi^{NT})^{-1}}$, with the coefficients defined by steady-state ratios:

$$s_{x,1} \equiv \frac{\bar{C}_i}{\bar{X}}, \quad s_{x,2} \equiv \frac{\left(\chi_i^T\left(\bar{L}_i^T\right)^{1+\left(\varphi^T\right)^{-1}}\right)}{\bar{X}}, \quad s_{x,3} \equiv \frac{\left(\chi_i^{NT}\left(\bar{L}_i^{NT}\right)^{1+\left(\varphi^{NT}\right)^{-1}}\right)}{\bar{X}}.$$

We apply log-linearization to demand for goods, labor supply, to obtain:

- Goods demand:

$$\tilde{y}_{i,n,z,t}^T = \tilde{c}_{i,t} - \eta_n^T\left(\tilde{p}_{n,z,t}^T - \tilde{p}_{n,t}^T\right) - \eta\left(\tilde{p}_{n,t}^T - \tilde{p}_{i,t}\right),$$

$$\tilde{y}_{i,z,t}^{NT} = \tilde{c}_{i,t} - \eta_i^{NT}\left(\tilde{p}_{i,z,t}^{NT} - \tilde{p}_{i,t}^{NT}\right) - \eta\left(\tilde{p}_{i,t}^{NT} - \tilde{p}_{i,t}\right);$$

- Labor supply:

$$\tilde{w}_{i,t}^m - \tilde{p}_{i,t} = \left(\frac{1}{\varphi^m}\right)\tilde{l}_{i,t}^m, \text{ for } m \in \{T, NT\};$$

2.2 Firm Decision Problem

Let $Y_{i,z,t}^{m}$ denote the output of firm z residing in economy i and operating in sector $m \in \{T, NT\}$. It is produced using $L_{i,z,t}^{m}$ units of sector-specific labor, and intermediate tradable goods sourced from different economies, denoted by $\left\{Y_{i,z,n,z',t}^{F,T}\right\}$. Let $A_{i,z,t}^{m}$ denote the productivity level and $\{\alpha, \zeta_n^T, \eta_n^T, \eta\}$ be the production function parameters that determine the labor share, the dependency on economy n for intermediate goods supply, the elasticity of substitution between tradable intermediate goods within economy n, and the elasticity of substitution among (aggregate) tradable goods produced by different economies. Let I_n^T represent the set of tradable goods produced by economy n. We have the following production function:

$$Y_{i,z,t}^{m} = A_{i,z,t}^{m}\left(L_{i,z,t}^{m}\right)^{\alpha}(M_{i,z,t}^{m})^{1-\alpha},$$

where the intermediate goods inputs $M_{i,z,t}^{m}$ is an aggregate of tradable goods produced across all countries:

$$M_{i,z,t}^{m} = \left[\sum_{n=1}^{N} \zeta_n^T \left(\int_{z' \in I_n^T} \left(Y_{i,z,n,z',t}^{F,T}\right)^{\frac{\eta_n^T - 1}{\eta_n^T}} dz'\right)^{\frac{\eta_n^T}{\eta_n^T - 1}\frac{\eta - 1}{\eta}}\right]^{\frac{\eta}{\eta - 1}}.$$

There are no trade costs such that tradable goods prices are the same across the currency union.

Firms face sticky prices. Every period, a $1 - \theta$ fraction of firms residing in economy i receive an exogenous signal that allows them to adjust prices flexibly, and the rest of the firms keep their prices unchanged.

A firm $z \in I_i^m$ minimizes its total nominal cost for any given level of output $Y_{i,z,t}^{m}$. The firm chooses its optimal mix of labor $L_{i,z,t}^{m}$ and intermediate tradable inputs $Y_{i,z,n,z',t}^{F,T}$ subject to input prices.

Because the firm's intermediate goods aggregator perfectly mirrors the household's CES aggregator for tradable consumption, the minimum cost of a unit of the intermediate tradable bundle is simply the global tradable price index, P_t^T. Therefore, the firm's cost minimization problem simplifies to choosing labor and the intermediate bundle to minimize $w_{i,t}^{m} L_{i,z,t}^{m} + P_t^T M_{i,z,t}^{m}$, subject to the Cobb-Douglas production technology $Y_{i,z,t}^{m} = A_{i,z,t}^{m}\left(L_{i,z,t}^{m}\right)^{\alpha}\left(M_{i,z,t}^{m}\right)^{1-\alpha}$, where $M_{i,z,t}^{m}$ is the CES composite of intermediate tradable goods.

The nominal unit production cost, denoted by $\psi_{i,z,t}^{m}$, and the optimal factor input choices $L_{i,z,t}^{m}$ and $M_{i,z,t}^{m}$ satisfy the following first-order conditions for a given level of output $Y_{i,z,t}^{m}$:

$$\psi_{i,z,t}^{m} = \frac{1}{A_{i,z,t}^{m}}\left(\frac{w_{i,t}^{m}}{\alpha}\right)^{\alpha}\left(\frac{P_t^T}{1-\alpha}\right)^{1-\alpha},$$

$$L_{i,z,t}^{m} = \frac{\alpha\psi_{i,z,t}^{m} Y_{i,z,t}^{m}}{w_{i,t}^{m}},$$

$$M_{i,z,t}^{m} = \frac{(1-\alpha)\psi_{i,z,t}^{m} Y_{i,z,t}^{m}}{P_t^T}.$$

The optimal output choice of $Y_{i,z,t}^{m}$ is then determined by the firm's dynamic pricing problem, where it chooses $P_{i,z,t}^{m,*}$ to maximize the net present value of its expected future profit $\pi_{i,z,t+j}^{m}$, with $\mu_{i,t,t+j}$ capturing the stochastic discount rate of its shareholders (the households):

$$\max_{P_{i,z,t}^{m,*}} E_t \sum_{j=0}^{\infty} (\theta)^j \{\mu_{i,t,t+j}\pi_{i,z,t+j}^{m}(P_{i,z,t}^{m,*})\},$$

where

$$\pi_{i,z,t+j}^{m} = P_{i,z,t}^{m,*} Y_{i,z,t+j}^{m}\left(P_{i,z,t}^{m,*}\right) - \psi_{i,z,t+j}^{m} Y_{i,z,t+j}^{m}\left(P_{i,z,t}^{m,*}\right).$$

$Y_{i,z,t+j}^{m}\left(P_{i,z,t}^{m,*}\right)$ denotes firm output as a function of the optimal price $P_{i,z,t}^{m,*}$.

The first order condition of $P_{i,z,t}^{*,m}$ yields:

$$E_t \sum_{j=0}^{\infty} \theta^j \left\{\mu_{i,t,t+j} Y_{i,z,t+j}^{m}\left(P_{i,z,t}^{*,m} - \frac{\eta_i^m}{\eta_i^m - 1}\frac{1}{A_{i,z,t+j}^{m}}\left(\frac{w_{i,t+j}^{m}}{\alpha}\right)^{\alpha}\left(\frac{P_{t+j}^T}{1-\alpha}\right)^{1-\alpha}\right)\right\} = 0.$$

Proposition 1 $\tilde{\pi}_{i,t} = \beta E_t\tilde{\pi}_{i,t+1} + \frac{\alpha k s_{i,NT}}{\varphi^{NT}}\tilde{l}_{i,t}^{NT} + \frac{\alpha k(1-s_{i,NT})}{1+\varphi^T} \times (\tilde{d}_t^T - \sum_{n=1}^{N} s_n^T \tilde{p}_{n,t})$

$$+ k s_{i,NT}\left(1-\alpha s_{i,NT}\right)\left(\tilde{p}_t^T - \tilde{p}_{i,t}^{NT}\right) - \alpha k \sum_{n=1}^{N} s_{i,n}^T s_{n,NT}\left(\tilde{p}_t^T - \tilde{p}_{n,t}^{NT}\right) + \tilde{z}_{i,t}, \quad (1)$$

where $k = \frac{(1-\theta\beta)(1-\theta)}{\theta}$, $\tilde{l}_{i,t}^{NT}$ indicates the slack in the non-tradable goods sector in economy i, $\tilde{d}_t^T$ captures global demand for tradable goods, $s_{i,n}^T = (1-s_{i,NT})s_n^T$, and $\tilde{z}_{i,t} = -k\sum_{n=1}^{N} s_{i,n}^T \int_{z\in I_n^T} s_{n,z}^T \tilde{a}_{n,z,t}^T dz - k s_{i,NT}\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT} dz$.

Proof: See Appendix A. *Q.E.D.*

Compared with a standard closed-economy Phillips curve, Proposition 1 demonstrates that external shocks introduce distinct new channels that drive domestic real marginal costs. These include shifts in global tradable demand, the relative price of tradable goods, and cross-border spillovers where foreign

non-tradable inflation raises the cost of imported tradable goods. Notably, while the price of tradables acts directly as a cost-push shock via intermediate inputs, global shocks also exert indirect pressure through the labor market. As global demand shifts or foreign living costs rise, workers bargain for proportionately higher nominal wages, thereby embedding global inflationary pressures directly into domestic production costs.

Through algebra similar to that used to prove Proposition 1, we obtain the following equation for $\tilde{\pi}_t^T$.

Proposition 2. The tradable goods price inflation satisfies the following equation:

$$\tilde{\pi}_t^T = \beta E_t \tilde{\pi}_{t+1}^T + \frac{\alpha k}{1+\varphi^T}(\tilde{d}_t^T - \sum_{n=1}^N s_n^T \tilde{p}_{n,t}) - \alpha k \sum_{n=1}^N s_n^T s_{n,NT}(\tilde{p}_t^T - \tilde{p}_{n,t}^{NT})$$

$$-k \sum_{n=1}^N s_n^T \int_{z \in I_n^T} s_{n,z}^T \tilde{a}_{n,z,t}^T dz. \quad (2)$$

2.3. Monetary Policy Rule

In this currency union, the central bank sets a common nominal interest rate, r_t, by responding to union-wide inflation rates—differentiating between tradable and non-tradable inflation—as well as to the global demand for tradable goods:

$$r_t = r^* + \phi^T E_t \tilde{\pi}_{t+1}^T + \phi^{NT} E_t \tilde{\pi}_{t+1}^{NT} + \phi^{y,T}(\tilde{d}_t^T - \tilde{p}_t^T) + \phi^{y,NT} \sum_{n=1}^N s_n^T \tilde{l}_{n,t}^{NT}.$$

The union-wide non-tradable goods price index $\tilde{p}_t^{NT}$ is defined as

$$\tilde{p}_t^{NT} = \sum_{n=1}^N s_n^T \tilde{p}_{n,t}^{NT}.$$

2.4 Equilibrium: A Static IS Curve

A vast empirical literature documents the persistent failures of the standard full-information rational expectations (FIRE) Euler equation, highlighting that aggregate consumption exhibits both excessive smoothness and a myopic sensitivity to current economic conditions (e.g., Campbell and Mankiw, 1989). Motivated by these empirical regularities, and to maintain a tractable state-space that clearly isolates the mechanics of supply-side overshooting, we depart from the FIRE benchmark. Following the behavioral New Keynesian framework of Gabaix (2020), we assume households exhibit cognitive discounting. By muting perfect intertemporal consumption smoothing, this behavioral friction collapses the dynamic Euler equation into a static IS relationship, where current demand is determined by the contemporaneous real policy rate rather than an infinite forward-looking path.

For tractability, we focus on characterizing how the demand of tradable goods, denoted by D_t^T, responds to changes in real interest rate:

$$\tilde{d}_t^T - \tilde{p}_t^T = z_t^T - \xi^T \left(r_t - \sum\nolimits_{n=1}^{N} s_n^T \, E_t \tilde{\pi}_{t+1}^T \right),$$

$$\sum\nolimits_{n=1}^{N} s_n^T \, \tilde{l}_{i,t}^{NT} = z_t^{NT} - \xi^{NT} \left(r_t - \sum\nolimits_{n=1}^{N} s_n^T \, E_t \tilde{\pi}_{n,t+1}^{NT} \right),$$

where $\tilde{p}_t^T$ is the aggregate tradable good price. Here, $\tilde{d}_{i,t}$ is the deviation of aggregate demand from the steady state. $z_{i,t}^C$ captures exogenous aggregate demand shocks, and r_t is the nominal interest rate set by the currency union's central bank. The term $E_t \tilde{\pi}_{n,t+1}^{NT}$ represents the expected deviation of non-tradable goods price inflation from its steady state, where gross inflation is defined as $\tilde{\pi}_{n,t+1}^{NT} \triangleq \frac{\tilde{p}_{n,t+1}^{NT}}{\tilde{p}_{n,t}^{NT}}$.

While empirical estimates of the IS curve often favor the inclusion of lagged output to capture habit formation (Fuhrer and Rudebusch, 2004), we abstract from habit persistence to maintain analytical tractability in the state-space. Crucially, our static specification captures the widely documented empirical failure of the forward-looking Euler equation—specifically, the finding that aggregate demand is primarily sensitive to contemporaneous real rates and current conditions, thereby circumventing the forward guidance puzzle (McKay, Nakamura, and Steinsson, 2016; Kaplan, Moll, and Violante, 2018).

For tractability, we further assume that there are idiosyncratic shocks such that $\tilde{l}_{i,t}^{NT}$ is exogenously given, and the transversality condition holds, passive fiscal policy balances the budgets of households and the government.

2.5 A Symmetric Case

In this section, we analyze the general equilibrium dynamics of the currency union in a symmetric case in which $s_{i,NT} = s_{NT}$ for all i.

Define $p_t = \sum_{n=1}^{N} s_n^T \, \tilde{p}_{n,t}$ and $f_{i,t}$ as the solution to the following difference equation:

$f_{i,t} - f_{i,t-1} = \beta E_t \left(f_{i,t+1} - f_{i,t} \right) - k(1 - \alpha s_{NT}) f_{i,t} + z_{i,t}$, where $z_{i,t} = \frac{\alpha k s_{NT}}{\varphi^{NT}} \left(\tilde{l}_{i,t}^{NT} - \sum_{n=1}^{N} s_n^T \, \tilde{l}_{n,t}^{NT} \right)$

$$-k s_{NT} \left[\int_{z \in I_i^{NT}} s_{i,z}^{NT} \, \tilde{a}_{i,z,t}^{NT} dz - \sum\nolimits_{n=1}^{N} s_n^T \left(\int_{z \in I_n^{NT}} s_{n,z}^{NT} \tilde{a}_{n,z,t}^{NT} dz \right) \right],$$

$f_{i,t_0} = \tilde{p}_{i,t_0} - p_{t_0}$.

Proposition 3 Under the conditions $\alpha, \beta, \theta \in (0,1)$, there is determinacy for $f_{i,t}$.

Proof: See Appendix A.

Proposition 3 implies that

$$\tilde{\pi}_{i,t} = p_t - p_{t-1} + f_{i,t} - f_{i,t-1}. \tag{3}$$

Equation (2) decomposes domestic inflation into a global and an idiosyncratic component. The global component, $p_t - p_{t-1}$, is determined by the monetary policy rule and global demand fluctuations. The idiosyncratic component, $f_{i,t} - f_{i,t-1}$, responds to local shocks affecting both sectoral slack, $\tilde{l}_{i,t}^{NT}$, and demand-supply imbalances in the non-tradable sector, captured by productivity shocks $\tilde{a}_{i,z,t}^{NT}$.

To further analyze the property of p_t,

Lemma 1 Define ε^T and ε^{NT} as: $\varepsilon^T = \phi^T - \xi^{NT}\phi^{y,NT}$, $\varepsilon^{NT} = \phi^{NT} - \xi^T\phi^{y,T}$, $\Delta = 1 + \xi^{NT}\phi^{y,NT} + \xi^T\phi^{y,T}$. $\tilde{d}_t^T - \tilde{p}_t^T = \frac{1}{\Delta}[(1 + \xi^{NT}\phi^{y,NT})(z_t^T - \xi^T r^*) - \xi^T\phi^{y,NT}(z_t^{NT} - \xi^{NT} r^*)$

$+\xi^T(1-\varepsilon^T)E_t\tilde{\pi}_{t+1}^T + \xi^T(1-\varepsilon^{NT})E_t\tilde{\pi}_{t+1}^{NT}] - \xi^T E_t\tilde{\pi}_{t+1}^{NT}$.

$\sum_{n=1}^{N} s_n^T \tilde{l}_{n,t}^{NT} = \frac{1}{\Delta}[-\xi^{NT}\phi^{y,T}(z_t^T - \xi^T r^*) + (1 + \xi^T\phi^{y,T})(z_t^{NT} - \xi^{NT} r^*)$

$+\xi^{NT}(1-\varepsilon^T)E_t\tilde{\pi}_{t+1}^T + \xi^{NT}(1-\varepsilon^{NT})E_t\tilde{\pi}_{t+1}^{NT}] - \xi^{NT}E_t\tilde{\pi}_{t+1}^T$.

Proof: See Appendix A.

Proposition 4 Define $\tilde{q}_t = \tilde{p}_t^T - \tilde{p}_t^{NT}$, the price dynamics in the equilibrium can be characterized by:

$$\begin{pmatrix} E_t\tilde{\pi}_{t+1}^{NT} \\ E_t\tilde{\pi}_{t+1}^T \\ q_t \end{pmatrix} = \begin{pmatrix} \Gamma_1^{NT} - 1 & \Gamma_3^{NT} & \Gamma_3^{NT} + \Gamma_4^{NT} \\ \Gamma_1^T & \Gamma_3^T - 1 & \Gamma_3^{NT} + \Gamma_4^{NT} - 1 \\ -1 & 1 & 1 \end{pmatrix} \begin{pmatrix} E_t\tilde{\pi}_t^{NT} \\ E_t\tilde{\pi}_t^T \\ q_{t-1} \end{pmatrix} + \begin{pmatrix} \Omega_t^{NT} \\ \Omega_t^T \\ 0 \end{pmatrix},$$

where $\Gamma_1^{NT} = 1 + \frac{\Gamma_{TT}(1+C_{gap}) + [(1-s_{NT})\Gamma_p + \Gamma_T]C_{gap,T}}{D}$, $\Gamma_2^{NT} = -\frac{\Gamma_{TT}}{D}$,

$\Gamma_3^{NT} = \frac{-(1 + s_{NT}C_{gap,T})[(1-s_{NT})\Gamma_p + \Gamma_T] + [1 - s_{NT}(1 + C_{gap})]\Gamma_{TT}}{s_{NT}D}$,

$\Gamma_4^{NT} = \frac{(1-s_{NT})(\Gamma_p - \Gamma_{TT}) + \Gamma_T}{s_{NT}D}$, $\Omega_t^{NT} = \frac{-\Omega_t\Gamma_{TT} + [(1-s_{NT})\Gamma_p + \Gamma_T](\frac{C_{TT}A_4}{\Delta} + \tilde{z}_t^T)}{s_{NT}D}$,

$\Gamma_1^T = -\frac{s_{NT}\left[\Gamma_{T_p}(1 + C_{gap}) + C_{gap,T}\Gamma_p\right]}{D}$, $\Gamma_2^T = \frac{s_{NT}\Gamma_{T_p}}{D}$,

$\Gamma_3^T = 1 + \frac{\Gamma_p(1 + s_{NT}C_{gap,T}) + \Gamma_{T_p}[s_{NT}C_{gap} - (1-s_{NT})]}{D}$, $\Gamma_4^T = \frac{(1-s_{NT})\Gamma_{T_p} - \Gamma_p}{D}$,

$D = \Gamma_p \left[\Gamma_{TT} - (1 - s_{NT})\Gamma_{T_p}\right] - \Gamma_T \Gamma_{T_p}, \Omega_t^T = \frac{\Gamma_{T_p}\Omega_t - \Gamma_p\left(\frac{C_{TT}A_4}{\Delta} + \tilde{z}_t^T\right)}{D},$

$\Omega_t = \frac{C_{NT}A_1 + C_T A_4}{\Delta} + \sum_{i=1}^{N} s_i^T \tilde{z}_{i,t}$. The appendix A further defines the underlying parameters.

Proof: See Appendix A.

2.6 Numerical Analysis of the Symmetric Case

In this numerical analysis, we focus on how the response of monetary policy to tradable sector developments influences the determinacy of equilibrium. We choose baseline parameters as those listed in Table 1 and vary the values of monetary policy response to tradable and non-tradable inflation respectively. Unlike Hazell et al. (2022), which focuses on the empirical relevance of relative price as a channel, we further examine the implication of this channel for equilibrium determinacy. Figure 1 suggests that the region for determinacy to emerge is wider than what is required by the Taylor principle for a closed economy. For example, as long as the sensitivity with respect to non-tradable goods price inflation exceeds 0.66, the determinacy emerges regardless of how monetary policy responds to tradable goods price inflation. The intuition is that due to expenditure switching effects, the relative price of tradable goods becomes a stabilizing force, to weaken forces that may drive up the gap between tradable and non-tradable goods prices. Under the baseline parameters listed in Table 1, the stable eigenvalue for the relative price of tradable goods, which Proposition 4 suggests is a pre-determined variable, is 0.768. This suggests that the impact of global demand can be more persistent than the contemporaneous effects.

Figure 4 suggests that the determinacy of the equilibrium is heavily influenced by the underlying structural parameters and labor market rigidities. Higher labor share and increased output sensitivity to real interest rates significantly tighten the boundary, requiring more aggressive monetary policy to stabilize inflation. Conversely, the system's stabilization forces are strengthened by labor market rigidities. A lower Frisch elasticity of labor supply loosens the determinacy requirements, as a less elastic labor market enhances the expenditure-switching channel's ability to naturally anchor the economy. Notably, the non-traded consumption share and standard levels of price stickiness have almost negligible effects on shifting this boundary.

In terms of monetary policy design, a central bank's responsiveness to the output gap serves as a powerful substitute for its direct reaction to inflation. When the policy rule incorporates a stronger response to either the traded or non-traded output gap , the determinacy boundary shifts substantially inward, significantly shrinking the indeterminate region. The intuition is that by proactively stabilizing real

Table 1 Baseline Parameters

	Definition	Values
β	Degree of patience	0.99
φ^T	Inverse Frisch elasticity of labor supply	1
φ^{NT}	Inverse Frisch elasticity of labor supply	1
s_{NT}	Non-tradable goods consumption share	0.7
α	Labor share in production technology	0.6
η	Elasticity of substitution between varieties	3
η^T	Elasticity of substitution between intermediate tradable goods	3
θ	Calvo price stickiness	0.75
χ^T	Disutility scaloar of tradable goods labor supply	1
χ^{NT}	Disutility scaloar of non-tradable goods labor supply	1
ϕ^T	Monetary policy response to tradable inflation	0
ϕ^{NT}	Monetary policy response to non-tradable inflation	1.5
$\phi^{y,T}$	Monetary policy response to tradable output gap	0
$\phi^{y,NT}$	Monetary policy response to non-tradable output gap	0.125
ξ^T	Tradable output sensitivity to real interest rate	1
ξ^{NT}	Non-tradable output sensitivity to real interest rate	1

economic demand, the central bank dampens the underlying marginal cost fluctuations that drive price changes.

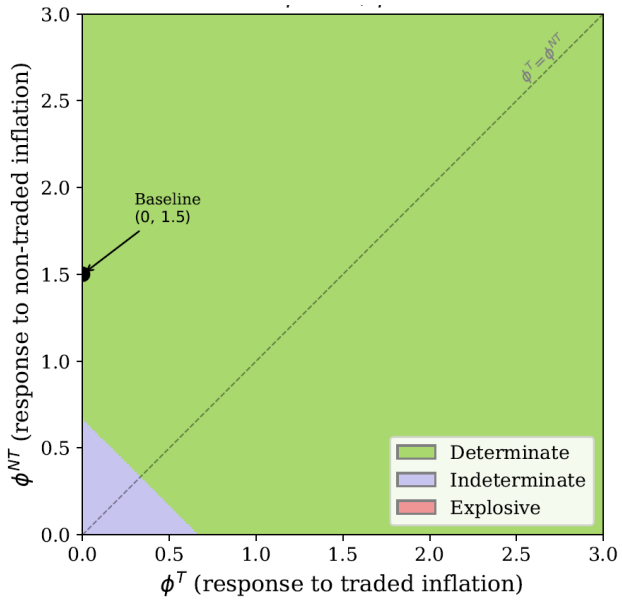
III. The Empirical Framework

The theoretical and numerical analysis in Section II yields the following empirical global Phillips curve specification:

$$\pi_{i,t} = \rho\Delta_t^{Oil} + \mu_{i,t} + \beta_i \sum_{j=0}^{\infty} \gamma_j \tilde{y}_{t-j} + \lambda_i \delta_t^T. \quad (4)$$

In this specification, Δ_t^{Oil} isolates the impact of oil price shocks, $\mu_{i,t}$ accounts for country-specific idiosyncratic shocks, and $\tilde{y}_{t-j}$ represents the global output gap, with γ_j capturing the common persistent channel across countries. The final term, δ_t^T, captures trends driven by equilibrium indeterminacy, productivity shocks, and slowly evolving demand-supply imbalances in the tradable goods sector that are not immediately reflected in aggregate global slack.

Figure 1 The Region of Equilibrium Determinacy



While δ_t^T acts mechanically as a residual, our theoretical framework suggests that it can act as a persistent global force rather than a catch-all for transitory cost-push shocks. Isolating this persistent trend from more standard drivers—like oil and global slack—allows us to vary its country-specific loadings over time. This may yield a novel explanation for structural breaks in global inflation: abrupt shifts can be driven by varying exposures to global trend forces, rather than ad-hoc changes in the slope of the Phillips curve. This distinction is crucial because the Phillips curve slope is a structural parameter invariant to how monetary policy reacts to tradable inflation, whereas global trend forces directly interact with these policy responses.

3.1 Construction of Global Factors

To construct global factors to capture the impact of global slack and the global inflation trend, we first calculate the average inflation of a group of economies deemed to have limited direct financial and trade linkages. To construct this group, we start from those classified as emerging market and developing

Figure 2 Effect of Model Parameters on the Determinacy Boundary

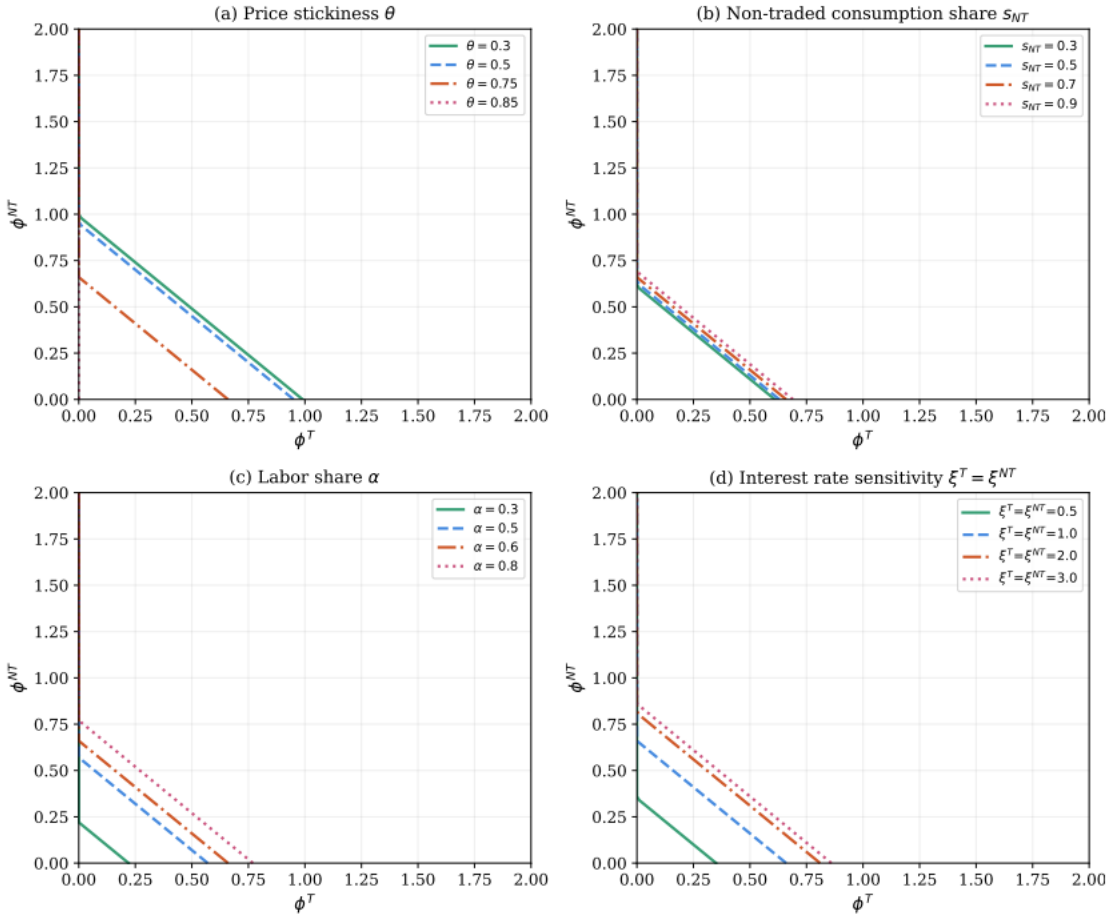


Figure 3 Effect of Labor Supply Elasticities on the Determinacy Boundary

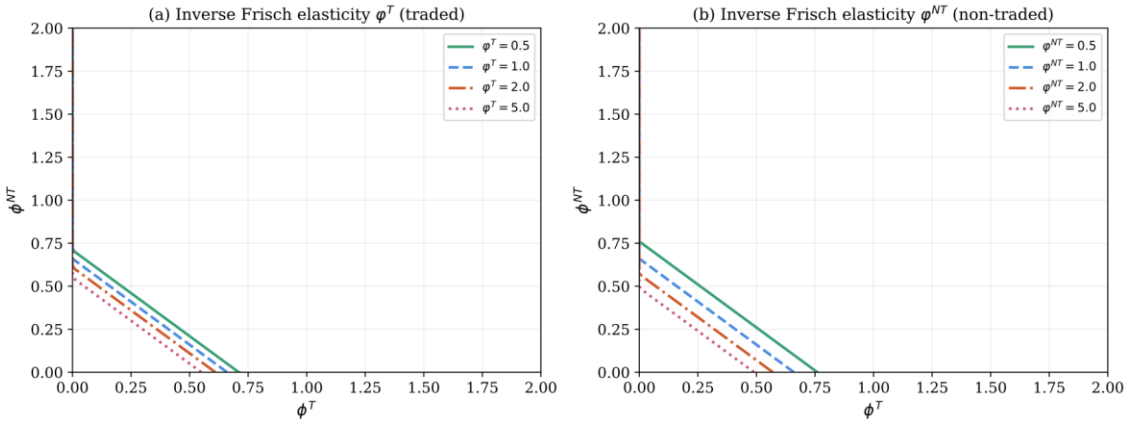
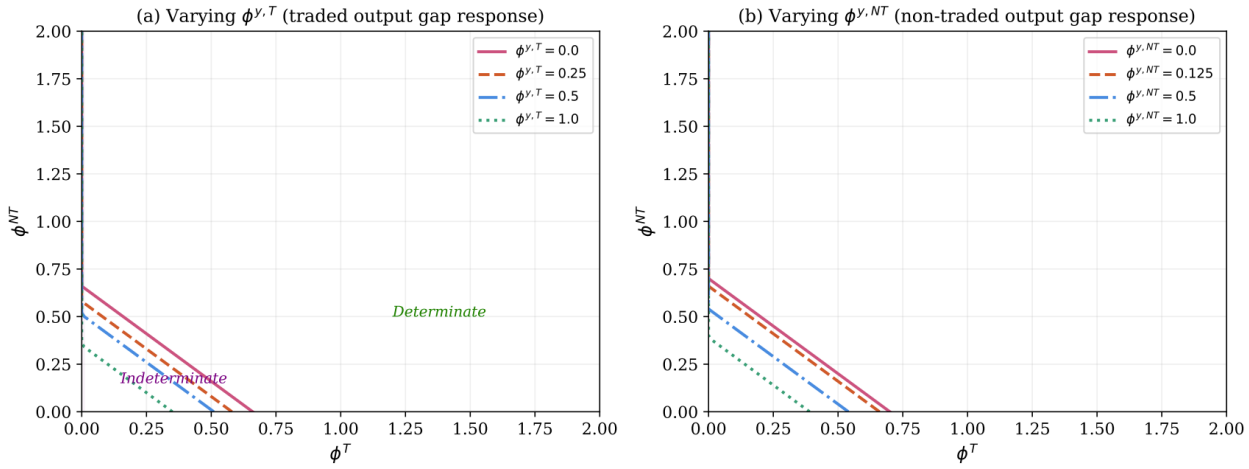


Figure 4 Effect of Output Gap Response on the Determinacy Boundary



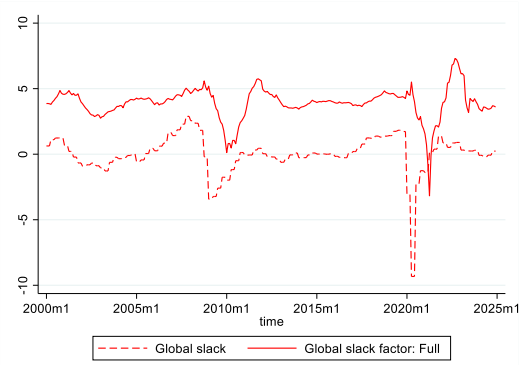
economies by the IMF's World Economic Outlook and having monthly CPI data available in Haver Analytics. Next, we use criteria to exclude large economies (GDP > Poland in 2024), those with hyperinflation episodes (YoY inflation > 30%), and those with missing observations between 1999 and 2024. This leaves 41 small open EMDEs in our sample.[3]

We regress the average inflation of these economies on the global output gap, its lags, and oil price inflation. As the benchmark exercise, we use 36 lags and a sample period from January 2000 to December 2024. We use the coefficients of the global output gap and its lags to calculate the global slack factor.

Figure 5 compares the global slack factor and the global slack itself to illustrate the delayed impact of global slack. We describe the delayed impact by highlighting five episodes in Table 2. Four of them lasted 10 months, while one 28 months. We divide the change in the global slack factor, a proxied for the impact of global slack on the average inflation of small open EMDEs, by the change in the global slack, and call the ratio the implied slope, which is presented in the last column of the table.

[3] The 41 economies include: Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Congo Rep, Costa Rica, Cote d'Ivoire, Croatia, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Gabon, Georgia, Ghana, Guatemala, Guinea-Bissau, Honduras, Hungary, India, Indonesia, Iran, Iraq, Israel, Jamaica, Jordan, Kenya, Kosovo, Kuwait, Kyrgyz Republic, Laos, Lebanon, Lesotho, Macao, Malawi, Malaysia, Maldives, Mali, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Nigeria, Niger, North Macedonia, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Seychelles, South Africa, Sri Lanka, Sudan, Suriname, Tajikistan, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Türkiye, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Venezuela, Vietnam, and Zambia.

Figure 5 Global Slack Factor vs. Global Slack



Three patterns are clearly seen from Table 2. First, the implied slope is large in magnitude, varying between -7.3 and 6.8. Note that the typical estimation of the slope of Phillips curve for the United States is around 0.3 (Hazell et al. (2021)). The implied slope here is around 24 times larger than that. Second, the implied slope has the wrong sign in two episodes: April 2009 – January 2010, and November 2021 – September 2022. Finally, these episodes shed light on all three inflation puzzles. First, the delayed impact of global slack contributed to upward inflation pressure during the missing disinflation episode, especially between January 2010 – October 2011. During this episode, with the global output gap closing by 2.43 percentage points, the average EMDE inflation that can be attributed to the global slack rose by 5.49 percentage points. Such effects are likely omitted by empirical studies that do not consider the role of global slack or its contemporaneous effects.

Second, the delayed impact of global slack contributed to weak inflation seen by small open EMDEs in the missing reflation episode. While the global output gap contracted mildly between October 2011 and January 2014 by 0.72 percentage point, the average EMDE inflation attributed to the global slack declined by 2.17 percentage points. This decline is sufficient to offset a decline in unemployment gap of 7.2 percentage points if the slope of Phillips curve is 0.3.

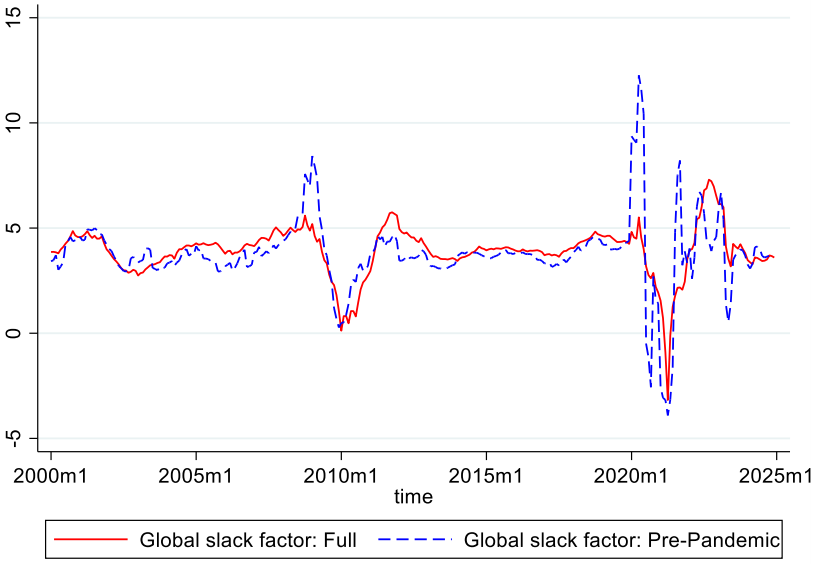
Finally, the delayed impact of global slack played a key role in the inflation surge in 2022 and its reversal after September 2022 for small open EMDEs. Despite a decline of global slack of 0.53 percentage point, the average EMDE inflation attributed to global slack rose by 3.87 percentage points between November 2021 and September 2022. In the following period, with the global slack contracting by only 0.61 percentage point, the average EMDE inflation attributed to global slack fell by 4.12 percentage points. Such a strong disinflation is equivalent to a rise of unemployment of 13.7 percentage points.

Table 2 Inflation Episodes with Strong Delayed Impact of Global Slack

	Length	Output gap at t_0	Output gap at t_1	Δ Output gap	Global slack factor at t_0	Global slack factor at t_1	Δ Global slack factor	Implied slope
(i) April 2009 – January 2010	10	-3.23	-1.98	1.25	4.48	0.12	-4.36	-3.50
(ii) January 2010 – October 2011	10	-1.98	0.45	2.43	0.12	5.60	5.48	2.25
(iii) October 2011 – January 2014	28	0.45	-0.27	-0.72	5.60	3.44	-2.17	3.01
(iv) November 2021 – September 2022	10	1.38	0.86	-0.53	3.44	7.30	3.87	-7.33
(v) September 2022 – June 2023	10	0.86	0.25	-0.61	7.30	3.18	-4.12	6.80

Notably, the exercises here control for oil price inflation, so these effects should not be caused by cost-push effects from oil prices. Figure 6 further suggests that the pattern of the global slack factor is not driven by the average EMDE inflation regression sample period. If we restrict the regression to be the pre-pandemic episode, we get noisier patterns, but the broad trends are the same as having the full sample period. In the rest of the paper, we use the full period as the global slack factor is less noisy.

Figure 6 Global Slack Factor by Sample Period: Full vs. Pre-Pandemic

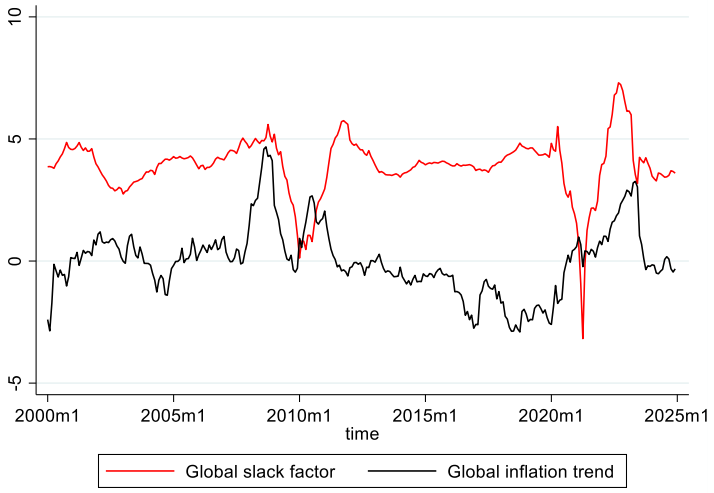


The global inflation trend appears to be quite volatile in some episodes while fluctuating around zero in the long run, as is illustrated in Figure 7. Notably, it played an important role in weakening headline inflation in the missing reflation episode, while driving the volatile inflation during 2022-2023. It declined from 2.67 in July 2010 to -2.544 in December 2019, when the global slack improved from -0.497 percentage point to 1.730 percentage points. The difference is 5.21 percentage points or an increase of unemployment gap of 17.4 percentage points if the slope of Philips curve is 0.3.

The strong impact of the global inflation trend is also seen during the COVID-19 pandemic episode. It reinforced the impact of global slack. For example, it increased from 0.549 percentage point to 1.971 percentage points, and the improvement of 1.422 percentage points is equivalent to a decline of unemployment rate by 4.74 percentage points if the slope of Phillips curve is 0.3.

It also contributed to the reversal of headline inflation from the 2022 surge. Between June 2023 and April 2024, it declined from 3.036 percentage points to -0.522. The decline of 3.558 percentage points is equivalent to a rise of unemployment gap by 11.86 percentage points if the slope of Phillips curve is 0.3.

Figure 7 Global inflation trend



3.2. The Persistence of Global Factors

To explore the persistence of global factors, we estimate the following equation:

$$\pi_{i,t}^{e,k,k+l} = \alpha_i + \sum_{j=1}^{J} \beta_{j,k} G_{j,t} + \varepsilon_{i,t},$$

where $\pi_{i,t}^{e,k,k+l}$ is the average inflation of country i between period $t+k$ and $t+k+l$ projected in period t. We use the information from the consensus economics database, which provides $k = 2$, 3, and 5 for $l = 1$, and $k = 6$ for $l = 4$. The sample consists of 33 economies classified as advanced economies by World Economic Outlook.[4] The sample period is between January 2000 and December 2024.

[4] The 33 economies include: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China, United Kingdom, United States.

We first present the results for global variables that are standard in the literature, which serve as a benchmark to evaluate the new global factors we constructed. Table 2 reports the estimation results for $\{G_{j,t}\} \triangleq \{\text{World outputgap}, \text{oil price}, \text{oil price inflation}\}$. We include both the level and change in oil price to capture the energy price's impact on both the expectation of price setters and the cost of production. Coibion and Gorodnichenko (2015) and Hasenzagl et al. (2022) argue for the importance of the expectation channel.

Table 3 confirms that oil price can have a persistent influence on headline inflation. A 50% change in oil price (2 standard deviations of the log level of oil price) shift 2-year ahead inflation expectation by 0.1 percent, and the effects remain to be statistically significant in the long run. Interestingly, the magnitude weakens by half when forecasters were asked to assess the 3 year-ahead expectation, but and is roughly stable for longer horizons.

Table 3 Persistent of Global Factors: Global Slack and Oil prices

	(1)	(2)	(3)	(4)	(5)	(6)
	2-yr	2-yr	2-yr	3-yr	3-yr	3-yr
VARIABLES	expectation	expectation	expectation	expectation	expectation	expectation
Global slack	0.0305***	0.0442***	0.0347***	0.0150***	0.0225***	0.0179***
	(0.00702)	(0.00694)	(0.00724)	(0.00562)	(0.00555)	(0.00581)
Oil price level	0.00206***		0.00224***	0.000958**		0.00108***
	(0.000504)		(0.000509)	(0.000404)		(0.000408)
Oil price inflation		-0.000384*	-0.000542**		-0.000292	-0.000368*
		(0.000233)	(0.000234)		(0.000186)	(0.000188)
Constant	1.862***	2.000***	1.856***	1.970***	2.036***	1.966***
	(0.0346)	(0.0111)	(0.0347)	(0.0278)	(0.00885)	(0.0278)
Observations	2,033	2,033	2,033	2,033	2,033	2,033
R-squared	0.470	0.466	0.471	0.521	0.520	0.521

	(7)	(8)	(9)	(10)	(11)	(12)
	5-yr	5-yr	5-yr	6-10-yr	6-10-yr	6-10-yr
VARIABLES	expectation	expectation	expectation	expectation	expectation	expectation
Global slack	0.000350	0.00738	0.00212	-0.00453	0.00137	-0.00328
	(0.00456)	(0.00451)	(0.00471)	(0.00425)	(0.00420)	(0.00439)
Oil price level	0.00116***		0.00124***	0.00104***		0.00109***
	(0.000328)		(0.000331)	(0.000306)		(0.000309)
Oil price inflation		-0.000140	-0.000227		-8.38e-05	-0.000161
		(0.000151)	(0.000152)		(0.000141)	(0.000142)
Constant	1.969***	2.046***	1.967***	1.965***	2.033***	1.963***
	(0.0225)	(0.00719)	(0.0226)	(0.0210)	(0.00671)	(0.0211)
Observations	2,031	2,031	2,031	2,029	2,029	2,029
R-squared	0.554	0.551	0.555	0.546	0.544	0.547

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As a contrast, global slack and oil price inflation have less persistent influence. An increase of global slack of 3 percentage points (around 2 standard deviations in the sample) raises the 2-year ahead inflation expectation and 3-year ahead inflation expectation by around 0.1 percent and 0.06 percent respectively. Such effects become insignificant beyond the 5-year horizon. Finally, oil price inflation has a strong mean-reverting process, and a rise in oil price inflation is expected to have a negative influence on medium-term inflation expectation, although the effects tend to be insignificant beyond the 2-year horizon.

We now turn to the case of $\{G_{j,t}\} \triangleq \{\text{Global slack factor, global inflation trend, oil price inflation}\}$. Table 4 reports the estimation results. The patterns for global slack and oil price inflation are broadly the same. An increase of global slack factor of 2.4 percentage points (around 2 standard deviations) raises 2-year ahead and 3-year ahead inflation expectation by around 0.16 percentage points and 0.07 percentage point. The oil price inflation has positive impact now, but the effects die down beyond the 3-year horizon.

The global inflation trend factor played a similar role as the oil price level seen in Table 3. The effects beyond 2 year are around half of the impact on the 2-year expectation, and an increase of 2.79 percentage points of global inflation trend (around 2 standard deviations) raises the 2-year expectation by around 0.19 percent. The oil price level effects capture around 63% of the global inflation trend effect at the 2-year horizon but falls to 52% at the 6-10 year horizon.

Table 4 Persistence of Global Factors: Oil Price Inflation, Global Slack Factor, and Global Inflation Trend

	(1)	(2)	(3)	(4)
VARIABLES	**2-yr expectation**	**3-yr expectation**	**5-yr expectation**	**10-yr expectation**
Oil price inflation	0.00105***	0.000348*	5.51e-05	-7.36e-05
	(0.000252)	(0.000205)	(0.000166)	(0.000154)
Global slack factor	0.0663***	0.0281***	0.00926	0.00121
	(0.00865)	(0.00703)	(0.00569)	(0.00530)
Global inflation trend	0.0691***	0.0391***	0.0361***	0.0360***
	(0.00723)	(0.00587)	(0.00475)	(0.00443)
Constant	1.738***	1.926***	2.016***	2.036***
	(0.0376)	(0.0305)	(0.0247)	(0.0230)
Observations	2,000	2,000	1,998	1,996
R-squared	0.497	0.532	0.565	0.559

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To summarize, the results in this section suggest that both global slack and the global inflation trend can potentially have persistent effects on headline inflation, as suggested by their significant impact on medium term inflation expectations. The pattern is particularly salient for the global inflation trend. While we find a strong connection with the role of oil price level on the expectation of price setters, we find patterns to suggest that around half of the medium-term effects of global inflation trend is captured by oil price level effects.

IV. Empirical Puzzles

In this section, we present reduced-form results to suggest that the global factors we identified in the previous section have a strong connection with empirical puzzles debated in the literature. We use the following reduced-form analysis to explore this issue:

$$\pi_{i,t} = \alpha_i + \sum_{j=1}^{J} \beta_{j,k} G_{j,t} + \rho_i u_{i,t} + \varepsilon_{i,t},$$

where $\{G_{j,t}\} \triangleq \{\text{Global slack factor, global inflation trend, oil price inflation}\}$ and $u_{i,t}$ is the unemployment rate.

4.1 Augmented Phillips Curve

Table 5 presents the estimation results and contrasts them with an alternative specification in which we drop the global slack factor and global inflation trend. There are several patterns to suggest that domestic slack fails to capture the impact of these two global factors. First, both global factors have statistically significant coefficients in the regressions of almost all economies. Second, there is no consistent pattern to suggest that these global factors weaken the coefficient of unemployment rate. If these variables are highly correlated, we may see the inclusion of the global factors weaken the explanatory power of unemployment rate. However, for the Czech Republic, Germany, Israel, Japan, Macao, Malta, Taiwan, and the United Kingdom, we see an increase in the coefficient size of unemployment rate. Since the global slack correlated with unemployment rate during global business cycles, it is not surprising to see that for many cases, the coefficient of unemployment rate does decline after the two additional global factors are controlled for. These patterns overall suggest that the two global factors capture additional inflation drivers omitted by the conventional Phillips curve framework.

4.2 Explaining Inflation Puzzles

Figure 8 shows how the three-global factor Phillips curve helps resolve inflation puzzles in the United States. It plots the actual inflation as the black long-dash line, and the two predicted values from the oil price inflation augmented Phillips curve and the three global factor augmented Phillips curve as the blue

Table 5 Phillips Curve Estimation Results

VARIABLES	(1) Austria	(2) Austria	(3) Belgium	(4) Belgium	(5) Canada	(6) Canada	(7) Cyprus	(8) Cyprus	(9) Czech Republic	(10) Czech Republic
Unemployment rate	-0.753***	0.0861	-0.698***	-0.507***	-0.567***	-0.372***	-0.312***	-0.183***	-0.609***	-0.644***
	(0.139)	(0.124)	(0.0874)	(0.0560)	(0.0551)	(0.0552)	(0.0274)	(0.0206)	(0.0830)	(0.0545)
Oil price inflation	0.00534**	0.0157***	0.0132***	0.0215***	0.0120***	0.0162***	0.0221***	0.0335***	0.0139***	0.0279***
	(0.00268)	(0.00227)	(0.00250)	(0.00162)	(0.00156)	(0.00148)	(0.00266)	(0.00192)	(0.00469)	(0.00316)
Global inflation trend		0.626***		0.670***		0.294***		0.659***		1.258***
		(0.0626)		(0.0447)		(0.0385)		(0.0561)		(0.0883)
Global slack factor		0.898***		0.927***		0.378***		0.962***		1.588***
		(0.0820)		(0.0575)		(0.0554)		(0.0638)		(0.109)
Constant	6.417***	-1.684*	7.258***	2.152***	6.034***	3.144***	4.015***	-0.862***	6.257***	0.0768
	(0.751)	(0.862)	(0.641)	(0.522)	(0.393)	(0.540)	(0.240)	(0.327)	(0.484)	(0.566)
Observations	301	300	301	300	301	300	301	300	301	300
R-squared	0.112	0.466	0.240	0.715	0.399	0.556	0.465	0.755	0.165	0.657

VARIABLES	(11) Denmark	(12) Denmark	(13) Estonia	(14) Estonia	(15) Finland	(16) Finland	(17) France	(18) France	(19) Germany	(20) Germany
Unemployment rate	-0.499***	0.00151	-0.344***	-0.217***	-0.825***	-0.295***	-0.807***	-0.497***	-0.201***	-0.290***
	(0.101)	(0.0662)	(0.0711)	(0.0394)	(0.0939)	(0.0698)	(0.0595)	(0.0528)	(0.0337)	(0.0220)
Oil price inflation	0.0107***	0.0187***	0.0297***	0.0487***	0.00874***	0.0165***	0.00668***	0.0122***	0.0112***	0.0185***
	(0.00284)	(0.00185)	(0.00600)	(0.00322)	(0.00239)	(0.00171)	(0.00141)	(0.00116)	(0.00217)	(0.00143)
Global inflation trend		0.697***		1.770***		0.674***		0.286***		0.623***
		(0.0456)		(0.0899)		(0.0484)		(0.0347)		(0.0403)
Global slack factor		0.792***		2.311***		0.858***		0.497***		0.718***
		(0.0604)		(0.116)		(0.0623)		(0.0398)		(0.0483)
Constant	3.889***	-1.380***	6.804***	-3.544***	8.628***	0.801	8.703***	3.974***	2.984***	0.625***
	(0.449)	(0.445)	(0.650)	(0.672)	(0.784)	(0.710)	(0.528)	(0.531)	(0.217)	(0.240)
Observations	217	216	300	299	301	300	301	300	301	300
R-squared	0.175	0.715	0.133	0.776	0.236	0.653	0.441	0.671	0.150	0.667

VARIABLES	(21) Greece	(22) Greece	(23) Iceland	(24) Iceland	(25) Ireland	(26) Ireland	(27) Israel	(28) Israel	(29) Italy	(30) Italy
Unemployment rate	-0.235***	-0.137***	0.182*	0.194**	-0.371***	-0.307***	-0.0116	-0.0880***	-0.358***	0.0694
	(0.0200)	(0.0175)	(0.103)	(0.0787)	(0.0340)	(0.0242)	(0.0455)	(0.0337)	(0.0618)	(0.0482)
Oil price inflation	0.0176***	0.0288***	0.000985	0.00304	0.0131***	0.0239***	0.0113***	0.0157***	0.00859***	0.0196***
	(0.00325)	(0.00256)	(0.00520)	(0.00386)	(0.00331)	(0.00242)	(0.00316)	(0.00242)	(0.00311)	(0.00216)
Global inflation trend		0.654***		1.600***		0.785***		0.841***		0.823***
		(0.0752)		(0.0992)		(0.0654)		(0.0678)		(0.0642)
Global slack factor		0.928***		0.675***		1.148***		0.446***		0.987***
		(0.0802)		(0.135)		(0.0835)		(0.0817)		(0.0696)
Constant	5.543***	0.200	4.016***	1.325*	4.850***	-0.248	1.494***	0.372	5.129***	-2.786***
	(0.358)	(0.467)	(0.529)	(0.793)	(0.296)	(0.433)	(0.300)	(0.412)	(0.589)	(0.581)
Observations	253	252	265	264	302	300	205	204	253	252
R-squared	0.462	0.707	0.012	0.548	0.335	0.690	0.060	0.522	0.163	0.650

VARIABLES	(31) Japan	(32) Japan	(33) Latvia	(34) Latvia	(35) Lithuania	(36) Lithuania	(37) Luxembourg	(38) Luxembourg	(39) Macao	(40) Macao
Unemployment rate	-0.819***	-0.879***	-0.535***	-0.384***	-0.440***	-0.336***	-0.291***	-0.0425	-1.152***	-1.343***
	(0.0601)	(0.0548)	(0.0681)	(0.0294)	(0.0584)	(0.0343)	(0.0499)	(0.0360)	(0.0878)	(0.0754)
Oil price inflation	-0.00158	0.00118	0.0261***	0.0489***	0.0187***	0.0367***	0.0124***	0.0201***	0.00610*	0.0155***
	(0.00150)	(0.00133)	(0.00643)	(0.00276)	(0.00586)	(0.00347)	(0.00172)	(0.00124)	(0.00349)	(0.00304)
Global inflation trend		0.304***		2.091***		1.819***		0.434***		0.647***
		(0.0388)		(0.0764)		(0.0958)		(0.0337)		(0.0850)
Global slack factor		0.300***		2.622***		2.039***		0.624***		0.912***
		(0.0465)		(0.0990)		(0.123)		(0.0418)		(0.102)
Constant	3.574***	2.591***	9.473***	-2.638***	7.500***	-1.723**	3.520***	-0.263	6.167***	3.132***
	(0.237)	(0.309)	(0.767)	(0.585)	(0.637)	(0.693)	(0.266)	(0.285)	(0.314)	(0.478)
Observations	301	300	301	300	301	300	301	300	301	300
R-squared	0.388	0.551	0.208	0.870	0.187	0.746	0.278	0.677	0.367	0.570

Table 5 Phillips Curve Estimation Results (continued)

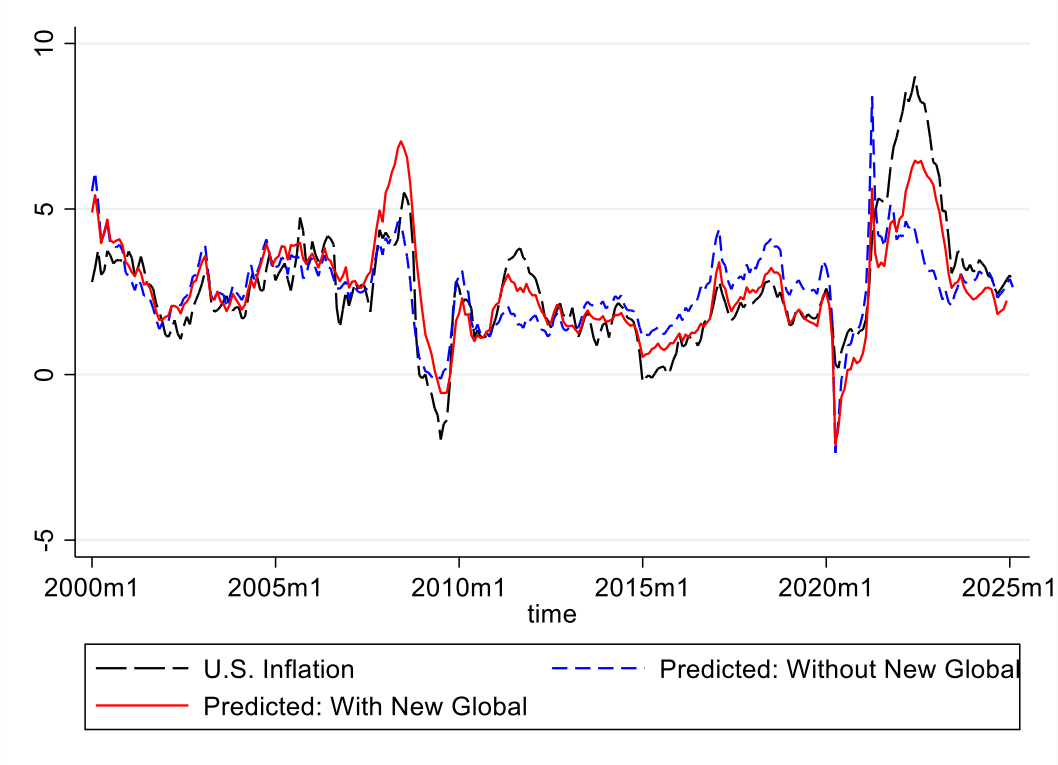
VARIABLES	(41) Malta	(42) Malta	(43) Netherlands	(44) Netherlands	(45) Norway	(46) Norway	(47) Portugal	(48) Portugal	(49) Slovak Republic	(50) Slovak Republic
Unemployment rate	-0.0996	-0.183***	-0.730***	-0.526***	-0.371***	0.262*	-0.196***	-0.152***	0.115**	0.125***
	(0.0639)	(0.0404)	(0.0776)	(0.0667)	(0.136)	(0.154)	(0.0317)	(0.0214)	(0.0462)	(0.0387)
Oil price inflation	0.00245	0.00893***	0.00396	0.0117***	0.00491**	0.00888***	0.00722***	0.0160***	0.0213***	0.0353***
	(0.00230)	(0.00147)	(0.00281)	(0.00246)	(0.00209)	(0.00208)	(0.00269)	(0.00189)	(0.00531)	(0.00461)
Global inflation trend		0.689***		0.389***		0.389***		0.662***		0.729***
		(0.0416)		(0.0647)		(0.0617)		(0.0511)		(0.128)
Global slack factor		0.749***		0.769***		0.373***		0.923***		1.619***
		(0.0507)		(0.0791)		(0.0786)		(0.0639)		(0.158)
Constant	2.810***	0.276	6.376***	2.119***	3.840***	-0.151	3.907***	-0.228	2.356***	-4.277***
	(0.374)	(0.328)	(0.466)	(0.550)	(0.542)	(0.811)	(0.326)	(0.358)	(0.587)	(0.829)
Observations	301	300	265	264	300	300	301	300	301	300
R-squared	0.012	0.635	0.271	0.515	0.045	0.189	0.152	0.627	0.076	0.371

VARIABLES	(51) Slovenia	(52) Slovenia	(53) Korea	(54) Korea	(55) Spain	(56) Spain	(57) Sweden	(58) Sweden	(59) Switzerland	(60) Switzerland
Unemployment rate	-0.502***	-0.246***	-1.019***	-0.0313	-0.151***	-0.0764***	-0.554***	-0.0173	-0.769***	-0.463***
	(0.0881)	(0.0747)	(0.154)	(0.114)	(0.0180)	(0.0128)	(0.145)	(0.132)	(0.0710)	(0.0586)
Oil price inflation	0.0194***	0.0310***	0.0121***	0.0152***	0.0204***	0.0301***	0.00962***	0.0167***	0.0127***	0.0154***
	(0.00404)	(0.00346)	(0.00171)	(0.00117)	(0.00236)	(0.00169)	(0.00349)	(0.00294)	(0.00109)	(0.000849)
Global inflation trend		0.825***		0.618***		0.575***		0.734***		0.310***
		(0.0963)		(0.0355)		(0.0459)		(0.0774)		(0.0233)
Global slack factor		1.133***		0.456***		0.857***		0.955***		0.317***
		(0.118)		(0.0411)		(0.0571)		(0.108)		(0.0325)
Constant	6.264***	0.0765	5.907***	0.634	4.445***	-0.175	6.009***	-1.804	2.696***	0.536**
	(0.589)	(0.745)	(0.542)	(0.465)	(0.299)	(0.344)	(1.086)	(1.248)	(0.211)	(0.260)
Observations	301	300	302	300	301	300	290	288	302	300
R-squared	0.180	0.468	0.225	0.670	0.388	0.726	0.068	0.422	0.457	0.714

VARIABLES	(61) Taiwan	(62) Taiwan	(63) United Kingdom	(64) United Kingdom	(65) United States	(66) United States
Unemployment rate	-0.643***	-0.640***	-0.180**	-0.216***	-0.325***	-0.260***
	(0.0807)	(0.0765)	(0.0755)	(0.0572)	(0.0385)	(0.0305)
Oil price inflation	0.0128***	0.0153***	0.00470*	0.0105***	0.0229***	0.0285***
	(0.00130)	(0.00115)	(0.00251)	(0.00190)	(0.00187)	(0.00144)
Global inflation trend		0.294***		0.681***		0.457***
		(0.0325)		(0.0536)		(0.0393)
Global slack factor		0.282***		0.673***		0.589***
		(0.0418)		(0.0664)		(0.0516)
Constant	3.647***	2.498***	3.378***	0.872*	4.143***	1.399***
	(0.340)	(0.419)	(0.426)	(0.462)	(0.235)	(0.324)
Observations	301	300	299	299	302	300
R-squared	0.383	0.588	0.032	0.503	0.460	0.727

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 8 Inflation Dynamics in the United States: With and Without Global Factors

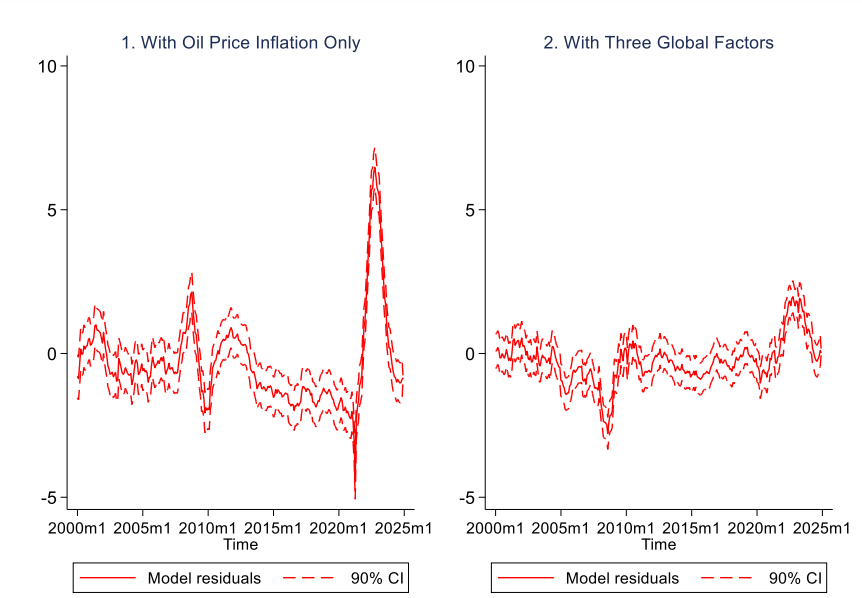


dash line and the red solid line respectively. The gap between the blue dash line and the black long-dash line, as is discussed above, points to three inflation puzzles, and the inclusion of the two new global factors helps resolve the missing disinflation puzzle around 2011 and the missing reflation puzzle in the 2010s very well. While the three-factor Phillips curve only explains a portion of the COVID-19 inflation patterns, it is interesting to see that it captures the turning points around mid-2022 very well.

Figure 9 further demonstrates the ability of the three-global-factor Phillips curve in resolving inflation puzzles on the international level. It plots the distributions of residuals from the oil-price-inflation augmented Phillips curve and those from the three-global-factor augmented Phillips curve, both estimated separately for each advanced economy. We exclude the United States in constructing the patterns in Figure 9 to reinforce the point that inflation puzzles also existed in other advanced economies.

Figure 9 shows that after including the two new global factors, in the post-global financial crisis period, inflation residuals have much less volatile movements. In particular, the two inflation puzzles before the COVID-19 pandemic largely disappear. These patterns are consistent with those in Figure 8 for the United States.

Figure 9 Phillips Curve Residuals: AEs excluding the United States



4.3 Structural Changes of Inflation Processes

The three-global-factor Phillips curve allows a richer exercise to explore the impact of global shocks on inflation processes, where we allow the coefficients of all three global factors and the unemployment rate to be time-varying:

$$\pi_{i,t} = \alpha_i + \sum_{j=1}^{J} \beta_{j,k,t} G_{j,t} + \rho_{i,t} u_{i,t} + v_{i,t}.$$

We split the sample period into four episodes: (i) the pre-global financial crisis period, which is defined as before September 2008; (ii) the post-GFC and pre-COVID-19-pandemic period, which is between September 2008 and February 2020; (iii) the COVID-19-pandemic period, which is between March 2020 and May 2023; and (iv) the post-COVID-19-pandemic period, which is between June 2023 and December 2024.

This exercise can shed light on several interesting questions: (i) whether the global shocks affect the slope of Phillips curve? (ii) whether the global shocks affect the coefficients of global factors? (iii) Can the three-global-factor Phillips curve explain the inflation patterns during the COVID-19 pandemic better after accounting for the structural changes? (iv) Are these patterns robust if we separate the sample economies into G7 and non-G7 economies?

Table 6 reports the estimation results. There are a rich set of patterns that are consistently found for both G7 and non-G7 economies. First, there was a steepening of reduced-form Phillips curve during the post-

GFC-pre-COVID period. Second, the COVID-19 pandemic had actually a flattening of reduced-form Phillips curve relative to the post-GFC-pre-COVID period. Third, the slope of reduced-form Phillips curve steepened again during the post-COVID period. Fourth, the coefficients of global slack factor increased sharply during the COVID-19 pandemic, and the pattern is even more dramatic for the post-COVID period. Fifth, the sharp rise in the coefficients in the COVID-19 pandemic and in the post-COVID period also occurred for the global inflation trend.

There is also some interesting differences between G7 economies and non-G7 economies. First, the coefficients of global slack and global inflation trend are much smaller for G7 economies than non-G7 economies before the COVID-19 pandemic. For example, the G7 economies' global slack coefficient is around 1/3 of that of non-G7 economies before the global financial crisis, and the ratio increases to 0.65 in the post-GFC and pre-COVID period, and further to 0.69 and 1.01 during the COVID and post-COVID periods. Similarly, the ratio of G7 coefficient over non-G7 coefficient for the global inflation trend is 0.56, 0.42, 0.81, and 0.98. These patterns suggest a new way for inflation expectations to see its anchoring being weakened: the sensitivity of inflation with respect to global factors increases sharply. Intuitively, this may reflect the reluctance of firms in absorbing the cost-push pressure from the large swings in global forces, especially if they are perceived to be persistent, as suggested by the results in Section 5.2.

Figure 10 plots the residuals of the three-global-factor Phillips curve. The pattern suggests that all the puzzles are fully resolved once structural breaks are further considered. Figure 11 confirms this by showing the performance of the Phillips curve with structural breaks, which is a significant improvement than those presented in Figure 9, especially for the COVID-19 pandemic period.

Table 6 Structural Changes of Inflation Processes

VARIABLES	(1) **Full**	(2) **G7**	(3) **Non-G7**
Unemployment rate	-0.0652***	0.0264	-0.0677***
	(0.0118)	(0.0214)	(0.0133)
Oil price inflation	0.0130***	0.00847***	0.0143***
	(0.000931)	(0.000935)	(0.00114)
Global slack	0.702***	0.303***	0.824***
	(0.0556)	(0.0570)	(0.0681)
Global inflation trend	0.407***	0.253***	0.449***
	(0.0308)	(0.0307)	(0.0379)
Unemployment rate · 1{t >= 2008M9 & t <= 2020M2}	-0.115***	-0.173***	-0.109***
	(0.0119)	(0.0227)	(0.0133)
Oil price inflation · 1{t >= 2008M9 & t <= 2020M2}	0.00883***	0.0112***	0.00813***
	(0.00129)	(0.00130)	(0.00158)
Global slack · 1{t >= 2008M9 & t <= 2020M2}	0.0146	0.206***	-0.0469
	(0.0622)	(0.0636)	(0.0761)
Global inflation trend · 1{t >= 2008M9 & t <= 2020M2}	0.136***	0.0105	0.166***
	(0.0360)	(0.0362)	(0.0442)
Unemployment rate · 1{t >= 2020M3 & t <= 2023M5}	-0.00380	-0.0944***	0.00292
	(0.0202)	(0.0288)	(0.0237)
Oil price inflation · 1{t >= 2020M3 & t <= 2023M5}	0.0134***	0.0127***	0.0134***
	(0.00127)	(0.00132)	(0.00155)
Global slack · 1{t >= 2020M3 & t <= 2023M5}	0.419***	0.524***	0.368***
	(0.0615)	(0.0636)	(0.0751)
Global inflation trend · 1{t >= 2020M3 & t <= 2023M5}	0.833***	0.786***	0.841***
	(0.0522)	(0.0551)	(0.0634)
Unemployment rate · 1{t >= 2023M6}	-0.172***	-0.392***	-0.143***
	(0.0313)	(0.0451)	(0.0360)
Oil price inflation · 1{t >= 2023M6}	0.0193**	0.0270***	0.0172*
	(0.00785)	(0.00831)	(0.00951)
Global slack · 1{t >= 2023M6}	1.244***	1.652***	1.121***
	(0.231)	(0.246)	(0.280)
Global inflation trend · 1{t >= 2023M6}	0.947***	1.079***	0.909***
	(0.133)	(0.141)	(0.162)
1{t >= 2008M9 & t <= 2020M2}	0.596**	0.370	0.754**
	(0.271)	(0.314)	(0.328)
1{t >= 2020M3 & t <= 2023M5}	-1.111***	-0.654*	-1.031***
	(0.292)	(0.337)	(0.352)
1{t >= 2023M6}	-2.552***	-2.408**	-2.347**
	(0.868)	(0.942)	(1.049)
Constant	-0.192	0.0921	-0.471
	(0.248)	(0.292)	(0.300)
Observations	9,732	2,051	7,681
R-squared	0.594	0.789	0.581

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 10 Phillips Curve Residuals: AEs



Figure 11 Phillips Curves with Structural Breaks

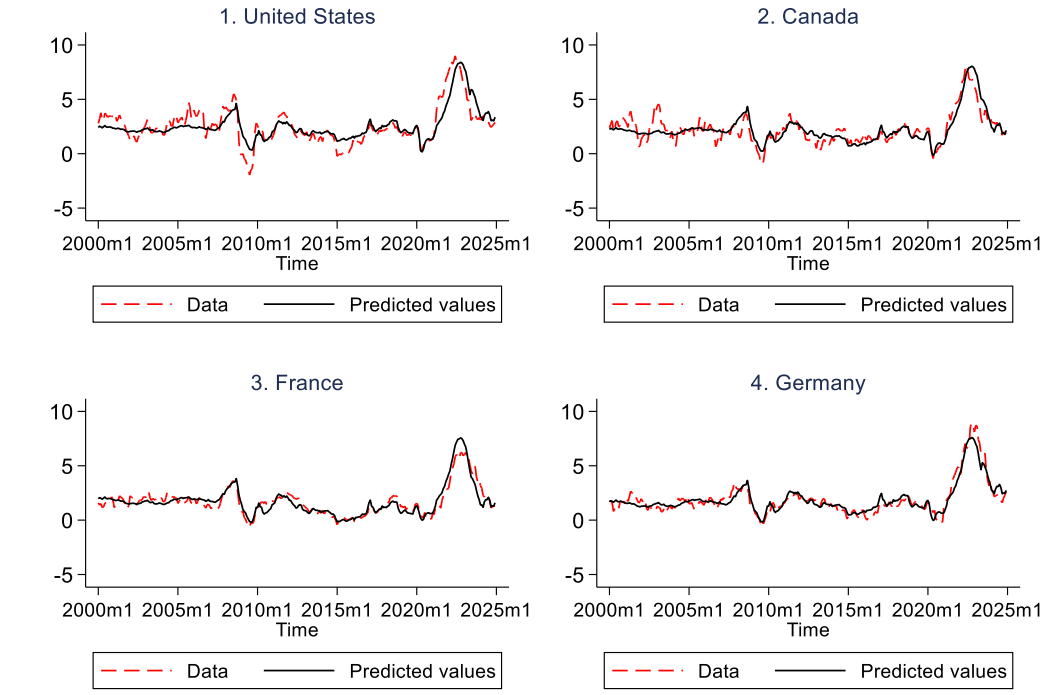
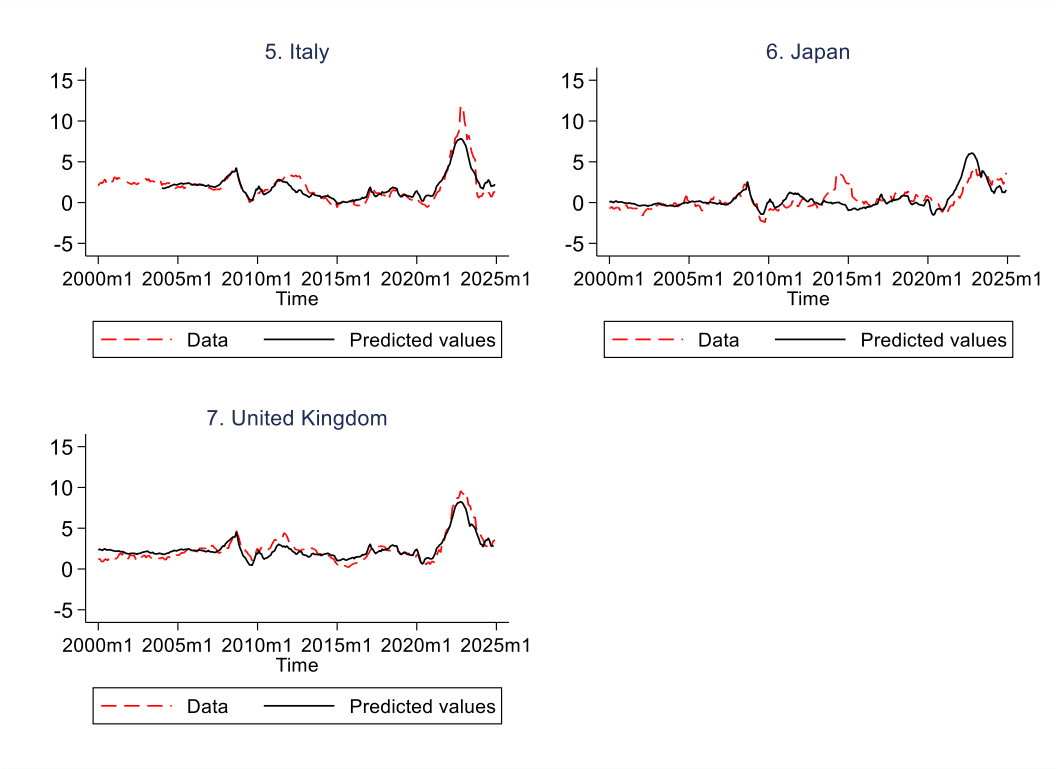


Figure 11 Phillips Curves with Structural Breaks (continued)



V. Concluding Remarks

This paper develops a framework to understand inflation dynamics in a global economy where exchange rate insulation is weak and tradable goods prices transmit persistent global forces into domestic inflation. We show that these forces—operating through a distributed lag of global slack and a global common trend in inflation—can generate equilibrium indeterminacy under empirically relevant monetary policy rules. Empirically, we find that these global components play a central role in shaping both realized inflation and inflation expectations, and provide a unified explanation for key post–GFC inflation puzzles. Our findings suggest that inflation dynamics are governed by global factors that lie outside the direct control of individual central banks. As a result, stabilizing inflation may require a broader policy perspective that accounts for potentially persistent global forces.

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Appendix A Proofs of Propositions and Lemmas

A.1. Proof of proposition 1

We follow the standard analysis of the Phillips curve (Gali and Gertler, 1999) to derive the structural inflation equation through log-linearization.

Step 1. Log-linearization for the first-order condition of $\tilde{p}_{i,z,t}^{*,m}$ yields

$$\tilde{p}_{i,z,t}^{*,m} = (1-\theta\beta)E_t \sum_{j=0}^{\infty} (\theta\beta)^j \left(-\tilde{a}_{i,z,t+j}^{m} + \alpha\tilde{w}_{i,t+j}^{m} + (1-\alpha)\tilde{p}_{t+j}^{T}\right), \qquad (A1)$$

Equation (A1) has a simple intuition: given the constant markup charged by firms, the deviation of prices from the steady state $\tilde{p}_{i,z,t}^{*,m}$ reflects current and expected future real marginal costs. There are three forces affecting the costs: (i) productivity shocks ($\tilde{a}_{i,z,t+j}^{m}$), (ii) labor cost $\left(\tilde{w}_{i,t+j}^{m}\right)$, and (iii) the costs of tradable goods ($\tilde{p}_{t+j}^{T}$). The impact of wage inflation is stronger if the labor share α is larger. Notably, $(1-\alpha)\tilde{p}_{t+j}^{T}$ is common across all economies and contributes to the common channels for global shocks to influence inflation across them.

Step 2. Under Calvo pricing, only a fraction $1-\theta$ of firms optimally reset their prices in period t, while the remaining fraction θ keep their prices from period $t-1$. Therefore, the log-linearized aggregate price level for any sector evolves as a weighted average of past prices and the newly set prices:

$$\tilde{p}_{i,t}^{T} = \theta \tilde{p}_{i,t-1}^{T} + (1-\theta) \int s_{i,z}^{T} \tilde{p}_{i,z,t}^{*,T} dz,$$

$$\tilde{p}_{i,t}^{NT} = \theta \tilde{p}_{i,t-1}^{NT} + (1-\theta) \int s_{i,z}^{NT} \tilde{p}_{i,z,t}^{*,NT} dz,$$

where

$$s_{i,z}^{T} = \frac{(\bar{P}_{i,z}^{T})^{1-\eta}}{(\bar{P}_{i}^{T})^{1-\eta}}, s_{i,z}^{NT} = \frac{(\bar{P}_{i,z}^{NT})^{1-\eta}}{(\bar{P}_{i}^{NT})^{1-\eta}}.$$

By substituting these sectoral price indexes into the aggregate CPI equation ($\tilde{p}_{i,t} = (1 - s_{i,NT}) \sum_{n=1}^{N} s_{n}^{T} \tilde{p}_{n,t}^{T} + s_{i,NT} \tilde{p}_{i,t}^{NT}$), we can define the evolution of the overall CPI as:

$$\tilde{p}_{i,t} = \theta \tilde{p}_{i,t-1} + (1-\theta) \tilde{p}_{i,t}^{*}, \qquad (A2)$$

where $\tilde{p}_{i,t}^{*}$ is the aggregate reset price index across all sectors and origin countries:

$$\tilde{p}_{i,t}^{*} \triangleq (1 - s_{i,NT}) \sum_{n=1}^{N} s_{n}^{T} \int_{z \in I_{n}^{T}} s_{n,z}^{T} \tilde{p}_{n,z,t}^{*,T} dz + s_{i,NT} \int_{z \in I_{i}^{NT}} s_{i,z}^{NT} \tilde{p}_{i,z,t}^{*,NT} dz.$$

From the firm's first-order condition (A1), we can express the optimal reset price recursively as:

$$\tilde{p}_{n,z,t}^{*,m} = (1-\theta\beta) \widehat{mc}_{n,z,t}^{m} + \theta\beta E_{t} \tilde{p}_{n,z,t+1}^{*,m},$$

where the marginal cost is $\widehat{mc}_{n,z,t}^{m} = -\tilde{a}_{n,z,t}^{m} + \alpha \tilde{w}_{n,t}^{m} + (1-\alpha) \tilde{p}_{t}^{T}$.

By aggregating this recursive formula across all firms and sectors using our CES weights, the aggregate reset price index becomes:

$$\tilde{p}_{i,t}^{*} = (1-\theta\beta) \widehat{MC}_{i,t} + \theta\beta E_{t} \tilde{p}_{i,t+1}^{*},$$

where $\widehat{MC}_{i,t}$ is the aggregate nominal cost:

$$\widehat{MC}_{i,t} = (1 - s_{i,NT}) \sum_{n=1}^{N} s_{n}^{T} \int_{z \in I_{n}^{T}} s_{n,z}^{T} \widehat{mc}_{n,z,t}^{T} dz + s_{i,NT} \int_{z \in I_{i}^{NT}} s_{i,z}^{NT} \widehat{mc}_{i,z,t}^{NT} dz.$$

Finally, we substitute the definition of the aggregate reset price $\tilde{p}_{i,t}^{*} = \frac{\tilde{p}_{i,t} - \theta \tilde{p}_{i,t-1}}{1-\theta}$ from equation (A2) into the recursive equation:

$$\tilde{p}_{i,t} - \theta\tilde{p}_{i,t-1} = \theta\beta E_t\left(\tilde{p}_{i,t+1} - \theta\tilde{p}_{i,t}\right) + (1-\theta)(1-\theta\beta)\widehat{MC}_{i,t},$$

which yields

$$\tilde{\pi}_{i,t} = \beta E_t\tilde{\pi}_{i,t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\widehat{MC}_{i,t} - \tilde{p}_{i,t}\right). \tag{A3}$$

Step 3. To further transform (A3), by log-linearizing the optimal labor supply condition ($\left(L_{n,t}^m\right)^{\frac{1}{\varphi^m}} = \left(\frac{1}{\chi_n^m}\right)\left(\frac{w_{n,t}^m}{P_{n,t}}\right)$), we can write the wage index as a function of the overall CPI and the labor market slack:

$$\tilde{w}_{n,t}^m = \tilde{p}_{n,t} + \frac{1}{\varphi^m}\tilde{l}_{n,t}^m = \left(1 - s_{n,NT}\right)\tilde{p}_t^T + s_{n,NT}\tilde{p}_{n,t}^{NT} + \frac{1}{\varphi^m}\tilde{l}_{n,t}^m.$$

By substituting the wage index into the marginal cost equation ($\widehat{mc}_{n,z,t}^m = -\tilde{a}_{n,z,t}^m + \alpha\tilde{w}_{n,t}^m + (1-\alpha)\tilde{p}_t^T$), we can write the marginal cost of sector m as a function of productivity shocks $\tilde{a}_{n,z,t}^m$, the cost of living driven by non-tradable goods prices $\tilde{p}_{n,t}^{NT}$, the tradable goods sector slack $\tilde{l}_{n,t}^m$, and the price of the aggregate tradable goods $\tilde{p}_t^T$:

$$\widehat{mc}_{n,z,t}^m = -\tilde{a}_{n,z,t}^m + \alpha s_{n,NT}\tilde{p}_{n,t}^{NT} + \frac{\alpha}{\varphi^m}\tilde{l}_{n,t}^m + \left(1 - \alpha s_{n,NT}\right)\tilde{p}_t^T.$$

By substituting the marginal cost of individual firms into the aggregate marginal cost equation ($\widehat{MC}_{i,t} = \left(1 - s_{i,NT}\right)\sum_{n=1}^N s_n^T \int_{z\in I_n^T} s_{n,z}^T \widehat{mc}_{n,z,t}^T dz + s_{i,NT}\int_{z\in I_i^{NT}} s_{i,z}^{NT}\widehat{mc}_{i,z,t}^{NT} dz$), we can write the aggregate marginal cost as a function of productivity shocks

$$\widehat{MC}_{i,t} = -\sum_{n=1}^N s_{i,n}^T \int_{z\in I_n^T} s_{n,z}^T \tilde{a}_{n,z,t}^T dz - s_{i,NT}\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT} dz$$

$$+\left(\alpha\sum_{n=1}^N s_{i,n}^T s_{n,NT}\tilde{p}_{n,t}^{NT} + \alpha\left(s_{i,NT}\right)^2\tilde{p}_{i,t}^{NT}\right) + \frac{\alpha}{\varphi^T}\sum_{n=1}^N s_{i,n}^T\tilde{l}_{n,t}^T + \frac{\alpha s_{i,NT}}{\varphi^{NT}}\tilde{l}_{i,t}^{NT}$$

$$+[\sum_{n=1}^N s_{i,n}^T\left(1 - \alpha s_{n,NT}\right) + s_{i,NT}(1 - \alpha s_{i,NT})]\tilde{p}_t^T$$

where $s_{i,n}^T \triangleq (1 - s_{i,NT})s_n^T$.

The real marginal cost is therefore:

$$\widehat{MC}_{i,t} - \tilde{p}_{i,t} = -\sum_{n=1}^N s_{i,n}^T \int_{z\in I_n^T} s_{n,z}^T \tilde{a}_{n,z,t}^T dz - s_{i,NT}\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT} dz$$

$$+\frac{\alpha}{\varphi^T}\sum_{n=1}^{N} s_{i,n}^T \tilde{l}_{n,t}^T + \frac{\alpha s_{i,NT}}{\varphi^{NT}} \tilde{l}_{i,t}^{NT} + s_{i,NT}\left(1-\alpha s_{i,NT}\right)\left(\tilde{p}_t^T - \tilde{p}_{i,t}^{NT}\right) - \alpha \sum_{n=1}^{N} s_{i,n}^T s_{n,NT}\left(\tilde{p}_t^T - \tilde{p}_{n,t}^{NT}\right). (A4)$$

To complete the proof, we further transform $\sum_{n=1}^{N} s_{i,n}^T \tilde{l}_{n,t}^T$. Let D_t^T denote the global demand for tradable goods. From the household's optimal consumption choice ($Y_{i,n,z,t}^T =$

$(\zeta_n^T)^\eta \left(\frac{P_{n,z,t}^T}{P_{n,t}^T}\right)^{-\eta_n^T} \left(\frac{P_{n,t}^T}{P_t^T}\right)^{-\eta} \left(\frac{P_t^T}{P_{i,t}}\right)^{-\eta} C_{i,t}$), we obtain

$$\frac{\int_z P_{n,z,t}^T Y_{n,z,t}^T dz}{\int_z P_{m,z,t}^T Y_{m,z,t}^T dz} = \frac{(\zeta_n^T)^\eta \left(\int_z \left(P_{n,z,t}^T\right)^{1-\eta_n^T} dz\right)(P_{n,t}^T)^{\eta_n^T-\eta}}{(\zeta_m^T)^\eta \left(\int_z \left(P_{m,z,t}^T\right)^{1-\eta_m^T} dz\right)(P_{m,t}^T)^{\eta_m^T-\eta}} = \frac{(\zeta_n^T)^\eta (P_{n,t}^T)^{1-\eta}}{(\zeta_m^T)^\eta (P_{m,t}^T)^{1-\eta}}.$$

A similar relationship holds for the expenditures of firms for tradable intermediate goods. Let $D_{n,t}^T$ denote the value of tradable goods produced by country *n*. $D_{n,t}^T$ satisfies:

$$D_{n,t}^T = s_{n,t}^T D_t^T, \text{ where } s_{n,t}^T = \frac{(\zeta_n^T)^\eta (P_{n,t}^T)^{1-\eta}}{\sum_{k=1}^{N} (\zeta_k^T)^\eta (P_{k,t}^T)^{1-\eta}}.$$

By log-linearizing the labor market clearing condition of country *n* ($\alpha s_{n,t}^T D_t^T = w_{n,t}^T L_{n,t}^T$), we derive the labor demand as a function of global demand for tradable goods: $\tilde{l}_{n,t}^T = \tilde{d}_t^T + \tilde{s}_{n,t}^T - \tilde{w}_{n,t}^T$. By substituting the wage as a function of the cost of living and the labor market slack ($\tilde{w}_{n,t}^T = \tilde{p}_{n,t} + \frac{1}{\varphi^T}\tilde{l}_{n,t}^T$) into it, we get the labor slack as a function of global tradable goods demand $\tilde{d}_t^T$, the share of country *n* in the global tradable goods market $\tilde{s}_{n,t}^T$, and the cost of living $\tilde{p}_{n,t}$:

$$l_{n,t}^T = \frac{\varphi^T}{1+\varphi^T}\left(\tilde{d}_t^T + \tilde{s}_{n,t}^T - \tilde{p}_{n,t}\right),$$

which yields:

$$\sum_{n=1}^{N} \frac{1}{\varphi^T} s_{i,n}^T \tilde{l}_{n,t}^T = \frac{1}{1+\varphi^T}\left(\sum_{n=1}^{N} s_{i,n}^T\right)\tilde{d}_t^T + \frac{1}{1+\varphi^T}\sum_{n=1}^{N} s_{i,n}^T \tilde{s}_{n,t}^T - \frac{1}{1+\varphi^T}\sum_{n=1}^{N} s_{i,n}^T \tilde{p}_{n,t}. (A5)$$

By substituting $\sum_{n=1}^{N} \frac{1}{\varphi^T} s_{i,n}^T \tilde{l}_{n,t}^T$ as a function of $\tilde{d}_t^T$, $\sum_{n=1}^{N} s_{i,n}^T \tilde{s}_{n,t}^T$, and $\sum_{n=1}^{N} s_{i,n}^T \tilde{p}_{n,t}$ as described in (A5) in (A4) and further substituting $\widehat{MC}_{i,t} - \tilde{p}_{i,t}$ in (A3), we obtain the augmented Phillips curve as:

$$\tilde{\pi}_{i,t} = \beta E_t \tilde{\pi}_{i,t+1} + \frac{\alpha k s_{i,NT}}{\varphi^{NT}} \tilde{l}_{i,t}^{NT} + \frac{\alpha k\left(1-s_{i,NT}\right)}{1+\varphi^T} \times \left(\tilde{d}_t^T - \sum_{n=1}^{N} s_n^T \tilde{p}_{n,t}\right)$$

$$+ s_{i,NT}\left(1-\alpha s_{i,NT}\right) k\left(\tilde{p}_t^T - \tilde{p}_{i,t}^{NT}\right) - \alpha k \sum_{n=1}^{N} s_{i,n}^T s_{n,NT}\left(\tilde{p}_t^T - \tilde{p}_{n,t}^{NT}\right)$$

$$-k\sum_{n=1}^{N} s_{i,n}^{T}\int_{z\in I_n^T} s_{n,z}^{T}\tilde{a}_{n,z,t}^{T}dz - ks_{i,NT}\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT}dz$$

where $k=\frac{(1-\theta\beta)(1-\theta)}{\theta}$. *Q.E.D*

A.2. Proof of Proposition 2

Similar to the proof of Proposition 1, we have the following relationship for

$$\tilde{\pi}_t^T=\beta E_t\tilde{\pi}_{t+1}^T+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\widehat{MC}_t^T-\tilde{p}_t^T\right)$$

The real marginal cost $\widehat{MC}_t^T-\tilde{p}_t^T$ can be derived through the following steps:

$$\widehat{MC}_t^T=\sum_{n=1}^{N} s_n^T\int_{z\in I_n^T} s_{n,z}^T\widehat{mc}_{n,z,t}^T dz$$

$$=-\sum_{n=1}^{N} s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz+\alpha\sum_{n=1}^{N} s_n^T s_{n,NT}\tilde{p}_{n,t}^{NT}+\frac{\alpha}{\varphi^T}\sum_{n=1}^{N} s_n^T\tilde{l}_{n,t}^T+\sum_{n=1}^{N} s_n^T\left(1-\alpha s_{n,NT}\right)\tilde{p}_t^T,$$

$$\widehat{MC}_t^T-\tilde{p}_t^T=-\sum_{n=1}^{N} s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz+\frac{\alpha}{\varphi^T}\sum_{n=1}^{N} s_n^T\tilde{l}_{n,t}^T-\alpha\sum_{n=1}^{N} s_n^T s_{n,NT}\left(\tilde{p}_t^T-\tilde{p}_{n,t}^{NT}\right).$$

The tradable inflation equation can be re-written as:

$$\tilde{\pi}_t^T=\beta E_t\tilde{\pi}_{t+1}^T+\frac{\alpha k}{\varphi^T}\sum_{n=1}^{N} s_n^T\tilde{l}_{n,t}^T-k\sum_{n=1}^{N} s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz$$

$$-\alpha k\sum_{n=1}^{N} s_n^T s_{n,NT}\left(\tilde{p}_t^T-\tilde{p}_{n,t}^{NT}\right),$$

where $k=\frac{(1-\theta)(1-\theta\beta)}{\theta}$.

Substituting $\sum_{n=1}^{N}\frac{1}{\varphi^T}s_n^T\tilde{l}_{n,t}^T$ based on the equation (A5), which implies that $\sum_{n=1}^{N}\frac{1}{\varphi^T}s_n^T\tilde{l}_{n,t}^T=$

$\frac{1}{1+\varphi^T}\left(\sum_{n=1}^{N} s_n^T\right)\tilde{d}_t^T+\frac{1}{1+\varphi^T}\sum_{n=1}^{N} s_n^T\tilde{s}_{n,t}^T-\frac{1}{1+\varphi^T}\sum_{n=1}^{N} s_n^T\tilde{p}_{n,t}$, we obtain the tradable inflation equation as:

$\tilde{\pi}_t^T=\beta E_t\tilde{\pi}_{t+1}^T+\frac{\alpha k}{1+\varphi^T}\sum_{n=1}^{N} s_n^T\left(\tilde{d}_t^T-\tilde{p}_{n,t}\right)-\alpha k\sum_{n=1}^{N} s_n^T s_{n,NT}\left(\tilde{p}_t^T-\tilde{p}_{n,t}^{NT}\right)-$

$k\sum_{n=1}^{N} s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz$. Q.E.D.

A.3. Proof of Proposition 3

Equation (1) implies

$$\tilde{\pi}_{i,t} - \tilde{\pi}_{j,t} = \beta E_t(\tilde{\pi}_{i,t+1} - \tilde{\pi}_{j,t+1}) - ks_{NT}(1-\alpha s_{NT})\left(\tilde{p}_{i,t}^{NT} - \tilde{p}_{j,t}^{NT}\right)$$

$$+\frac{\alpha k s_{NT}}{\varphi^{NT}}\left(\tilde{l}_{i,t}^{NT} - \tilde{l}_{j,t}^{NT}\right) - ks_{NT}\left(\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT}dz - \int_{z\in I_j^{NT}} s_{j,z}^{NT}\tilde{a}_{j,z,t}^{NT}dz\right).$$

Substituting $\tilde{p}_{i,t}^{NT} - \tilde{p}_{j,t}^{NT}$ with $\frac{\tilde{p}_{i,j,t}}{s_{NT}}$, we obtain

$\tilde{p}_{i,j,t} - \tilde{p}_{i,j,t-1} = \beta E_t\left(\tilde{p}_{i,j,t+1} - \tilde{p}_{i,j,t}\right) - k(1-\alpha s_{NT})\tilde{p}_{i,j,t} + z_{i,j,t}^{p}$, where $z_{i,j,t}^{p} = \frac{\alpha k s_{NT}}{\varphi^{NT}}\left(\tilde{l}_{i,t}^{NT} - \tilde{l}_{j,t}^{NT}\right)$

$-ks_{NT}\left(\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT}dz - \int_{z\in I_j^{NT}} s_{j,z}^{NT}\tilde{a}_{j,z,t}^{NT}dz\right)$, which implies that

$f_{i,t} - f_{i,t-1} = \beta E_t\left(f_{i,t+1} - f_{i,t}\right) - k(1-\alpha s_{NT})f_{i,t} + z_{i,t}^{f}$, where $z_{i,t}^{f} = \frac{\alpha k s_{NT}}{\varphi^{NT}}\left(\tilde{l}_{i,t}^{NT} - \sum_{n=1}^{N} s_n^C\,\tilde{l}_{n,t}^{NT}\right)$

$$-ks_{NT}\left(\int_{z\in I_i^{NT}} s_{i,z}^{NT}\tilde{a}_{i,z,t}^{NT}dz - \int_{z\in I_j^{NT}} \sum_{n=1}^{N} s_n^C\, s_{n,z}^{NT}\tilde{a}_{n,z,t}^{NT}dz\right),$$

Define $X_t^{i,j} = f_{i,t-1}$ and $Y_t^{i,j} = f_{i,t}$.

$$\begin{pmatrix} X_{t+1}^{i,j} \\ E_t Y_{t+1}^{i,j} \end{pmatrix} = \begin{bmatrix} 0 & 1 \\ -\frac{1}{\beta} & \frac{1+\beta+k(1-\alpha s_{NT})}{\beta} \end{bmatrix}\begin{pmatrix} X_t^{i,j} \\ Y_t^{i,j} \end{pmatrix} + \begin{pmatrix} 0 \\ -\frac{z_{i,t}^{f}}{\beta} \end{pmatrix}.$$

The eigenvalue equation of the system matrix is $Q^{\mathrm{i,j}}(\lambda) = \lambda^2 - \frac{1+\beta+k(1-\alpha s_{NT})}{\beta}\lambda + \frac{1}{\beta} = 0$. The Blanchard and Kahn (1980) conditions for determinacy are satisfied, since $Q^{\mathrm{i,j}}(0) = \frac{1}{\beta} > 1$, $Q^{\mathrm{i,j}}(1) = -\frac{k(1-\alpha s_{NT})}{\beta} < 0$.

A.4. Proof of Lemma 1

We substitute r_t with the monetary policy rule to derive $\tilde{d}_t^T - \tilde{p}_t^T$ and $\sum_{n=1}^{N} s_n^T\,\tilde{l}_{n,t}^{NT}$ as functions of inflation expectations and exogenous shocks.

$$\tilde{d}_t^T - \tilde{p}_t^T = z_t^T + \xi^T \sum_{n=1}^{N} s_n^T\, E_t\tilde{\pi}_{t+1}^T$$

$$-\xi^T\left[r^* + \phi^T E_t\tilde{\pi}_{t+1}^T + \phi^{NT} E_t\tilde{\pi}_{t+1}^{NT} + \phi^{y,T}\left(\tilde{d}_t^T - \tilde{p}_t^T\right) + \phi^{y,NT}\sum_{n=1}^{N} s_n^T\,\tilde{l}_{i,t}^{NT}\right],$$

$$\sum_{n=1}^{N} s_n^T\,\tilde{l}_{n,t}^{NT} = z_t^{NT} + \xi^{NT}\sum_{n=1}^{N} s_n^T\, E_t\tilde{\pi}_{n,t+1}^{NT}$$

$$-\xi^{NT}\left[r^* + \phi^T E_t\tilde{\pi}_{t+1}^T + \phi^{NT} E_t\tilde{\pi}_{t+1}^{NT} + \phi^{y,T}\left(\tilde{d}_t^T - \tilde{p}_t^T\right) + \phi^{y,NT}\sum_{n=1}^{N} s_n^T\,\tilde{l}_{i,t}^{NT}\right].$$

We solve these two equations and obtain

$$\tilde{d}_t^T - \tilde{p}_t^T = \frac{1}{\Delta}[(1+\xi^{NT}\phi^{y,NT})(z_t^T - \xi^T r^*) - \xi^T\phi^{y,NT}(z_t^{NT} - \xi^{NT} r^*)$$

$$+\xi^T(1-\varepsilon^T)E_t\tilde{\pi}_{t+1}^T + \xi^T(1-\varepsilon^{NT})E_t\tilde{\pi}_{t+1}^{NT}] - \xi^T E_t\tilde{\pi}_{t+1}^{NT}.$$

$$\sum_{n=1}^{N} s_n^T\, \tilde{l}_{n,t}^{NT} = \frac{1}{\Delta}[-\xi^{NT}\phi^{y,T}(z_t^T - \xi^T r^*) + (1+\xi^T\phi^{y,T})(z_t^{NT} - \xi^{NT} r^*)$$

$$+\xi^{NT}(1-\varepsilon^T)E_t\tilde{\pi}_{t+1}^T + \xi^{NT}(1-\varepsilon^{NT})E_t\tilde{\pi}_{t+1}^{NT}] - \xi^{NT}E_t\tilde{\pi}_{t+1}^T.$$

A5. Proof of Proposition 4

Multiplying both sides of equation (1) by s_i^T and taking the sum across *i*, we obtain

$$\sum_{i=1}^{N} s_i^T\tilde{\pi}_{i,t} = \beta E_t\sum_{i=1}^{N} s_i^T\tilde{\pi}_{i,t+1} + \frac{\alpha k s_{NT}}{\varphi^{NT}}\sum_{i=1}^{N} s_i^T\,\tilde{l}_{i,t}^{NT} + \frac{\alpha k(1-s_{NT})}{1+\varphi^T}\times(\tilde{d}_t^T - \tilde{p}_t^T)$$

$$+\frac{\alpha k(1-s_{NT})}{1+\varphi^T}(\tilde{p}_t^T - \tilde{p}_t) + k s_{NT}(1-\alpha)\left(\tilde{p}_t^T - \sum_{i=1}^{N} s_i^T\,\tilde{p}_{i,t}^{NT}\right) + \sum_{i=1}^{N} s_i^T\,\tilde{z}_{i,t}.$$

Substituting $\sum_{i=1}^{N} s_i^T\tilde{\pi}_{i,t}$ by $(1-s_{NT})(\tilde{p}_t^T - \tilde{p}_{t-1}^T) + s_{NT}(\tilde{p}_t^{NT} - \tilde{p}_{t-1}^{NT})$ and $\sum_{i=1}^{N} s_i^T\tilde{\pi}_{i,t+1}$ accordingly, we obtain

$$(1-s_{NT})(\tilde{p}_t^T - \tilde{p}_{t-1}^T) + s_{NT}(\tilde{p}_t^{NT} - \tilde{p}_{t-1}^{NT}) = \beta E_t[(1-s_{NT})(\tilde{p}_{t+1}^T - \tilde{p}_t^T) + s_{NT}(\tilde{p}_{t+1}^{NT} - \tilde{p}_t^{NT})]$$

$$+[\frac{\alpha k(1-s_{NT})s_{NT}}{1+\varphi^T} + k s_{NT}(1-\alpha)](\tilde{p}_t^T - \tilde{p}_t^{NT})$$

$$+\frac{\alpha k s_{NT}}{\varphi^{NT}}\sum_{i=1}^{N} s_i^T\,\tilde{l}_{i,t}^{NT} + \frac{\alpha k(1-s_{NT})}{1+\varphi^T}\times\left(\tilde{d}_t^T - \tilde{p}_t^T\right) + \sum_{i=1}^{N} s_i^T\,\tilde{z}_{i,t}. \qquad (AL2.1)$$

Substituting $\sum_{i=1}^{N} s_i^T\,\tilde{l}_{i,t}^{NT}$ and $\left(\tilde{d}_t^T - \tilde{p}_t^T\right)$ based on Lemma 1, we can further transform $(AL2.1)$ as:

$$(1-s_{NT})(\tilde{p}_t^T - \tilde{p}_{t-1}^T) + s_{NT}(\tilde{p}_t^{NT} - \tilde{p}_{t-1}^{NT}) = \beta E_t[(1-s_{NT})(\tilde{p}_{t+1}^T - \tilde{p}_t^T) + s_{NT}(\tilde{p}_{t+1}^{NT} - \tilde{p}_t^{NT})]$$

$$+s_{NT}C_{gap}(\tilde{p}_t^T - \tilde{p}_t^{NT}) + C_{NT}\{\frac{A_1}{\Delta} + \frac{\xi^{NT}}{\Delta}[(1-\varepsilon^T)(E_t\tilde{p}_{t+1}^T - \tilde{p}_t^T) + (1-\varepsilon^{NT})(E_t\tilde{p}_{t+1}^{NT} - \tilde{p}_t^{NT})] -$$

$$-\xi^{NT}(E_t\tilde{p}_{t+1}^T - \tilde{p}_t^T)\} + C_T\{\frac{A_4}{\Delta} + \frac{\xi^T}{\Delta}[(1-\varepsilon^T)(E_t\tilde{p}_{t+1}^T - \tilde{p}_t^T) + (1-\varepsilon^{NT})(E_t\tilde{p}_{t+1}^{NT} - \tilde{p}_t^{NT})]\}$$

$$-C_T\xi^T(E_t\tilde{p}_{t+1}^{NT} - \tilde{p}_t^{NT}) + \sum_{i=1}^{N} s_i^T\,\tilde{z}_{i,t},$$

where

$$A_1 = -\xi^{NT}\phi^{y,T}(z_t^T - \xi^T r^*) + (1+\xi^T\phi^{y,T})(z_t^{NT} - \xi^{NT} r^*),$$

$$A_2 = (1-\varepsilon^T) + (1-\varepsilon^{NT})\left(1-\frac{1}{s_{NT}}\right), A_3 = \frac{1-\varepsilon^{NT}}{s_{NT}},$$

$$A_4 = (1+\xi^{NT}\phi^{y,NT})(z_t^T - \xi^T r^*) - \xi^T\phi^{y,NT}(z_t^{NT} - \xi^{NT} r^*).$$

$$C_{NT} = \frac{\alpha k s_{NT}}{\varphi^{NT}}, C_T = \frac{\alpha k(1-s_{NT})}{1+\varphi^T}.$$

It can be further transformed as:

$$E_t\tilde{p}_{t+1}^{NT} = \Phi_1\tilde{p}_t^{NT} + \Phi_2\tilde{p}_{t-1}^{NT} + \Phi_3 E_t\tilde{p}_{t+1}^T + \Phi_4\tilde{p}_t^T + \Phi_5\tilde{p}_{t-1}^T + z_t^{NT}, \quad (AL2.2)$$

where $\Phi_1 = \frac{1+\Gamma_p + C_{gap}}{\Gamma_p}, \Phi_2 = -\frac{1}{\Gamma_p}, \Phi_3 = -\frac{1-s_{NT}}{s_{NT}} - \frac{\Gamma_T}{s_{NT}\Gamma_p},$

$$\Phi_4 = \frac{(1-s_{NT})(\Gamma_p+1) + \Gamma_T - s_{NT}C_{gap}}{s_{NT}\Gamma_p}, \Phi_5 = -\frac{1-s_{NT}}{s_{NT}\Gamma_p},$$

$$z_t^{NT} = -\frac{1}{s_{NT}\Gamma_p}(C_{NT}\frac{A_1}{\Delta} + C_T\frac{A_4}{\Delta} + \sum_{i=1}^N s_i^T\tilde{z}_{i,t}), \Gamma_p = \beta + C_{NT}\frac{\xi^{NT}}{\Delta}A_3 + C_T\xi^T\left(\frac{A_3}{\Delta} - \frac{1}{s_{NT}}\right),$$

$$\Gamma_T = C_{NT}\xi^{NT}\left(\frac{A_2}{\Delta} - 1\right) + C_T\xi^T\left(\frac{A_2}{\Delta} - 1 + \frac{1}{s_{NT}}\right),$$

$$C_{gap} = k\left[(1-\alpha) + \frac{\alpha(1-s_{NT})}{1+\varphi^T}\right].$$

We now turn to the tradable goods price inflation. Based on Lemma 1, we can transform equation (2) into

$$\tilde{p}_t^T - \tilde{p}_{t-1}^T = \beta(E_t\tilde{p}_{t+1}^T - \tilde{p}_t^T) - s_{NT}\frac{\alpha k\varphi^T}{1+\varphi^T}(\tilde{p}_t^T - \tilde{p}_t^{NT})$$

$$+\frac{\alpha k}{1+\varphi^T}\{\frac{1}{\Delta}[A_4 + \xi^T(1-\varepsilon^T)E_t\tilde{\pi}_{t+1}^T + \xi^T(1-\varepsilon^{NT})E_t\tilde{\pi}_{t+1}^{NT}] - \xi^T E_t\tilde{\pi}_{t+1}^{NT}\}$$

$$-k\sum_{n=1}^N s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz,$$

which can be further transformed as

$$E_t\tilde{p}_{t+1}^T = \Phi_1^T\tilde{p}_t^T + \Phi_2^T\tilde{p}_{t-1}^T + \Phi_3^T E_t\tilde{p}_{t+1}^{NT} + \Phi_4^T\tilde{p}_t^{NT} + z_t^T, \quad (AL2.3)$$

where $\Phi_1^T = \frac{1+\Gamma_{TT}+s_{NT}C_{gap,T}}{\Gamma_{TT}}, \Phi_2^T = -\frac{1}{\Gamma_{TT}}, \Phi_3^T = -\frac{s_{NT}\Gamma_{Tp}}{\Gamma_{TT}}, \Phi_4^T = \frac{s_{NT}(\Gamma_{Tp}-C_{gap,T})}{\Gamma_{TT}},$

$$z_t^T = -\frac{1}{\Gamma_{TT}}(\frac{C_{TT}A_4}{\Delta} - k\sum_{n=1}^N s_n^T\int_{z\in I_n^T} s_{n,z}^T\tilde{a}_{n,z,t}^T dz), \Gamma_{TT} = \beta + \frac{C_{TT}\xi^T(1-\varepsilon^T)}{\Delta},$$

$$\Gamma_{T_p} = \mathrm{C}_{TT}\xi^T\left(\frac{A_3}{\Delta} - \frac{1}{\mathrm{s}_{NT}}\right), \mathrm{C}_{TT} = \frac{\alpha k}{1+\varphi^T}, \mathrm{C}_{gap,T} = \frac{\alpha k \varphi^T}{1+\varphi^T}.$$

We can solve $E_t\tilde{p}_{t+1}^{NT}$ and $E_t\tilde{p}_{t+1}^{T}$ from (AL2.2) and (AL2.3) as:

$$E_t\tilde{p}_{t+1}^{NT} = \frac{(\Phi_1 + \Phi_3\Phi_4^T)\tilde{p}_t^{NT} + \Phi_2\tilde{p}_{t-1}^{NT} + (\Phi_4 + \Phi_3\Phi_1^T)\tilde{p}_t^{T} + (\Phi_5 + \Phi_3\Phi_2^T)\tilde{p}_{t-1}^{T} + (z_t^{NT} + \Phi_3 z_t^T)}{1 - \Phi_3\Phi_3^T}.$$

$$E_t\tilde{p}_{t+1}^{T} = \frac{(\Phi_4^T + \Phi_3^T\Phi_1)\tilde{p}_t^{NT} + \Phi_3^T\Phi_2\tilde{p}_{t-1}^{NT} + (\Phi_1^T + \Phi_3^T\Phi_4)\tilde{p}_t^{T} + (\Phi_2^T + \Phi_3^T\Phi_5)\tilde{p}_{t-1}^{T} + (z_t^{T} + \Phi_3^T z_t^{NT})}{1 - \Phi_3\Phi_3^T}.$$

We can clean up the equations to obtain:

$$E_t\tilde{p}_{t+1}^{NT} = \Gamma_1^{NT}\tilde{p}_t^{NT} + \Gamma_2^{NT}\tilde{p}_{t-1}^{NT} + \Gamma_3^{NT}\tilde{p}_t^{T} + \Gamma_4^{NT}\tilde{p}_{t-1}^{T} + \Omega_t^{NT}, \quad (AL2.4)$$

$$E_t\tilde{p}_{t+1}^{T} = \Gamma_1^{T}\tilde{p}_t^{NT} + \Gamma_2^{T}\tilde{p}_{t-1}^{NT} + \Gamma_3^{T}\tilde{p}_t^{T} + \Gamma_4^{T}\tilde{p}_{t-1}^{T} + \Omega_t^{T}, \quad (AL2.5)$$

where

$$\Gamma_1^{NT} = 1 + \frac{\Gamma_{TT}(1+C_{gap}) + [(1-s_{NT})\Gamma_p + \Gamma_T]C_{gap,T}}{D}, \Gamma_2^{NT} = -\frac{\Gamma_{TT}}{D},$$

$$\Gamma_3^{NT} = \frac{-(1+s_{NT}C_{gap,T})[(1-s_{NT})\Gamma_p + \Gamma_T] + [1-s_{NT}(1+C_{gap})]\Gamma_{TT}}{s_{NT}D},$$

$$\Gamma_4^{NT} = \frac{(1-s_{NT})(\Gamma_p - \Gamma_{TT}) + \Gamma_T}{s_{NT}D}, \Omega_t^{NT} = \frac{-\Omega_t\Gamma_{TT} + [(1-s_{NT})\Gamma_p + \Gamma_T](\frac{C_{TT}A_4}{\Delta} + \tilde{z}_t^T)}{s_{NT}D},$$

$$\Gamma_1^{T} = -\frac{s_{NT}\left[\Gamma_{T_p}(1+C_{gap}) + C_{gap,T}\Gamma_p\right]}{D}, \Gamma_2^{T} = \frac{s_{NT}\Gamma_{T_p}}{D},$$

$$\Gamma_3^{T} = 1 + \frac{\Gamma_p(1+s_{NT}C_{gap,T}) + \Gamma_{T_p}[s_{NT}C_{gap} - (1-s_{NT})]}{D}, \Gamma_4^{T} = \frac{(1-s_{NT})\Gamma_{T_p} - \Gamma_p}{D},$$

$$D = \Gamma_p\left[\Gamma_{TT} - (1-s_{NT})\Gamma_{T_p}\right] - \Gamma_T\Gamma_{T_p}, \Omega_t^{T} = \frac{\Gamma_{T_p}\Omega_t - \Gamma_p\left(\frac{C_{TT}A_4}{\Delta} + \tilde{z}_t^T\right)}{D},$$

$$\Omega_t = \frac{C_{NT}A_1 + C_T A_4}{\Delta} + \sum_{i=1}^{N} s_i^T\,\tilde{z}_{i,t}.$$

Through algebra, we can further transform the equation system and obtain the results in Proposition 4. *Q.E.D.*