Explaining the Price Puzzle in Australia: A Small Open-Economy Perspective

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Abstract

This paper develops a small open-economy model to explain the persistence of the price puzzle in Australia. The model integrates three transmission channels: a direct interest-rate channel, an exchange-rate cost channel, and a financial accelerator channel. A US monetary tightening raises Australian interest rates via policy spillovers, depreciates the exchange rate, and tightens domestic credit conditions. When the economy is characterized by a high import share, strong financial frictions, and nominal rigidities, these supply-side cost-push effects dominate demand-side contraction, producing a positive inflation response to monetary tightening. The framework provides a theoretical foundation for the recent empirical results of Dwumfour, Harris, and Pan (2023), demonstrating how cross-border monetary linkages can generate non-standard inflation dynamics in open economies.

JEL classification: E31; E52; F41

Keywords: Price puzzle; Monetary policy spillovers; Small open economy; Australia

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1 Introduction

Empirical evidence frequently documents a "price puzzle", whereby a contractionary monetary policy shock is followed by a temporary rise in inflation rather than a decline. This counterintuitive phenomenon—first highlighted in VAR studies of monetary transmission—has motivated extensive debate on its sources and implications (see e.g., Sims, 1992; Hanson, 2004; Castelnuovo and Surico, 2010). Several explanations have been proposed, including the role of omitted variables capturing central bank information, cost-channel effects through working capital, and international spillovers arising from exchange-rate and financial linkages (Ravenna and Walsh, 2006; Bernanke, Gertler and Gilchrist, 1999; Kim and Roubini, 2000).

Recent evidence suggests that the price puzzle may not be limited to closed-economy dynamics but may also reflect cross-border monetary transmission. In particular, foreign monetary policy shocks can affect domestic inflation through exchange-rate depreciation, imported input costs, and financial accelerator mechanisms. For Australia—a small open economy with a high degree of import dependence and financial integration—the role of foreign policy spillovers is especially relevant. Dwumfour, Harris, and Pan (2023) highlight the persistent challenge of the price puzzle for Australia, noting that conventional VAR frameworks have consistently failed to resolve it (Bishop and Tulip, 2017). Their empirical analysis confirms that a contractionary Australian monetary policy shock, when identified through standard recursive VARs, leads to a counterintuitive rise in inflation.

This paper develops a theoretical model to explain the Australian price puzzle observed in empirical data. I construct a small open-economy framework with nominal rigidities, imported intermediate inputs, and financial frictions that interact with foreign monetary shocks. The model identifies three main transmission channels: i) the direct interest-rate channel, ii) the exchange-rate cost channel, and iii) the financial accelerator channel—whose relative strengths determine whether a contractionary foreign policy shock raises or lowers domestic prices. The analysis shows that when the import share, financial accelerator strength, and price stickiness are sufficiently large, supply-side cost-push effects dominate demand-side contraction, generating a theoretical foundation for the observed price puzzle in Australia.

By integrating exchange-rate pass-through, balance-sheet amplification, and Taylor-rule spillovers in a unified analytical setting, this paper contributes to the literature in two ways. First, it extends standard open-economy New Keynesian models to incorporate endogenous financial risk premia linked to firm net worth. Second, it provides a theoretical explanation for the empirical results of Dwumfour et al. (2023), demonstrating that the price puzzle can arise endogenously in a small open economy subject to foreign monetary tightening. The model thus offers a tractable framework for understanding how international policy spillovers can generate non-standard inflation dynamics in financially open economies such as Australia.

2 Model

In this section, I develop a theoretical model to to explain the "price puzzle" phenomenon—where contractionary monetary policy leads to price increases—in the context of international policy spillovers.

2.1 Household

Consider an economy populated by a continuum of identical, infinitely-lived households. The representative household maximizes expected lifetime utility defined over consumption and labor supply. The intertemporal utility function takes the following form:

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s [\frac{C_{t+s}^{1-\sigma}}{1-\sigma} - \frac{L_{t+s}^{1+\eta}}{1+\eta}] \tag{1}$$

where $\beta \in (0,1)$ denotes subjective discount factor, $\sigma > 0$ is the coefficient of relative risk aversion, $\eta > 0$ is the inverse Frisch elasticity of labor supply, C_t denotes consumption, L_t represents labor supply, $\mathbb{E}_t$ is expectation operator conditional on information available at time t.

Households face the following period budget constraint:

$$P_t C_t + D_t + E_t B_t^* = (1 + r_{t-1}^d) D_{t-1} + (1 + r_{t-1}^*) E_t B_{t-1}^* + W_t L_t + \Pi_t \tag{2}$$

where P_t is domestic price level, D_t represents domestic nominal deposits, B_t^* denotes holdings of foreign nominal bonds, E_t is the nominal exchange rate (domestic currency per unit of foreign currency), r_t^d is the nominal interest rate on domestic deposits, r_t^* is the foreign nominal interest rate (i.e., exogenous US policy rate), W_t is the nominal wage rate, Π_t represents profits received from firms and banks. The left-hand side of the budget constraint represents household expenditures on consumption, domestic deposits, and foreign bonds, and the right-hand side comprises income from previous period assets, labor income, and profit distributions.

Forming the Lagrangian, we have:

$$\begin{aligned}\mathcal{L} =&\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \{ \frac{C_{t+s}^{1-\sigma}}{1-\sigma} - \frac{L_{t+s}^{1+\eta}}{1+\eta} + \lambda_{t+s}[(1+r_{t+s-1}^d)D_{t+s-1} + (1+r_{t+s-1}^*)E_{t+s}B_{t+s-1}^* \\ &+ W_{t+s}L_{t+s} + \Pi_{t+s} - P_{t+s}C_{t+s} - D_{t+s} - E_{t+s}B_{t+s}^*]\}\end{aligned}$$

Taking the first order conditons (F.O.C.), we get:

$$\frac{\partial \mathcal{L}}{\partial C_t} = C_t^{-\sigma} - \lambda_t P_t = 0 \tag{3}$$
$$\frac{\partial \mathcal{L}}{\partial L_t} = L_t^{\eta} - \lambda_t W_t = 0 \tag{4}$$
$$\frac{\partial \mathcal{L}}{\partial D_t} = \lambda_t - \beta \mathbb{E}_t[\lambda_{t+1}(1+r_t^d)] \tag{5}$$
$$\frac{\partial \mathcal{L}}{\partial B_t^*} = \lambda_t E_t - \beta \mathbb{E}_t[\lambda_{t+1}E_{t+1}(1+r_t^*)] \tag{6}$$

Combining Equations (3) and (4) yields the intratemporal optimality condition for labor supply:

$$L_t^{\eta} = C_t^{-\sigma} w_t \tag{7}$$

where $w_t \equiv \frac{W_t}{P_t}$ is the real wage. Substituting Equation (3) into (5) gives the consumption Euler equation:

$$C_t^{-\sigma} = \beta(1+r_t^d)\mathbb{E}_t[\frac{C_{t+1}^{-\sigma}}{\pi_{t+1}}] \tag{8}$$

where $\pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ denotes the gross inflation rate. Then combining Equations (5) and (6) yields the uncovered interest rate parity (UIP) condition:

$$\mathbb{E}_t[\frac{E_{t+1}}{E_t}] = \frac{1+r_t^d}{1+r_t^*} \tag{9}$$

It is the no-arbitrage condition equates the expected rate of nominal exchange rate depreciation to interest rate differential between domestic and foreign assets, ensuring indifference between investing in domestic and foreign bonds at the margin.

2.2 Firm The domestic economy contains a continuum of monopolistically competitive firms. Each firm produces a differentiated good using a Cobb-Douglas production technology that incorporates labor, capital, and imported intermediate inputs:

$$Q_t = A_t L_t^{\alpha} K_t^{1-\alpha} M_t^{\gamma}, \qquad \alpha + \gamma < 1 \tag{10}$$

where Q_t is output of firm, A_t represents total factor productivity, L_t denotes labor input, K_t represents capital input, M_t denotes imported intermediate inputs, $\alpha \in (0,1)$ is the labor share of output, $\gamma \in (0,1)$ is the share of imported intermediates, the restriction $\alpha + \gamma < 1$ ensures decreasing returns to scale in variable inputs.

Firms face a working capital constraint and must borrow to finance production costs prior to receiving revenue from sales. The nominal borrowing requirement B_t^f is given by:

$$B_t^f = W_t L_t + E_t P_t^* M_t \tag{11}$$

where P_t^* is the foreign currency price of imported intermediates. Then firm's nominal profit function is:

$$\Pi_t^f = P_t Q_t - (1 + r_t^l) B_t^f \tag{12}$$

where r_t^l is the nominal interest rate on loans.

Following Bernanke *et al.* (1999), I incorporate a financial accelerator mechanism where the loan interest rate includes an endogenous risk premium that depends on firm net worth. The relationship between the loan rate and the policy rate is given by:

$$1 + r_t^l = \frac{1 + r_t^m}{1 - \phi_t}, \qquad \phi_t = \kappa \mathbb{E}(-\nu N_t) \tag{13}$$

where r_t^m is the central bank's policy rate, $\phi_t \in (0,1)$ is the probability of default, N_t is the aggregate net worth of firms, $\kappa > 0$ scales the level of default risk, $\nu > 0$ governs the sensitivity of default risk to net worth.

Firm net worth evolves according to:

$$N_t = (1 - \delta)N_{t-1} + \Pi_t^f \tag{14}$$

where $\delta \in (0,1)$ is the depreciation rate of net worth.

Following Calvo (1983), firms face nominal price rigidities. Each period, a randomly selected fraction $\theta \in [0,1)$ of firms cannot adjust their prices, while the remaining fraction $1-\theta$ can re-optimize. The optimal reset price $P_t^{optimal}$ solves:

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\theta)^s [\frac{P_t^{optimal}}{P_{t+s}} - \mu \cdot MC_{t+s}] Y_{t+s} = 0 \tag{15}$$

where $\mu \equiv \frac{\epsilon}{\epsilon - 1}$ is the desired gross markup, $\epsilon > 1$ is the elasticity of substitution between differentiated goods, MC_t is the nominal marginal cost, Y_t is the demand for firm's product. The forward-looking price-setting in Equation (15) implies that optimizing firms set prices as a markup over a weighted average of current and expected future marginal costs, with the weights determined by the probability of price non-adjustment θ.

2.3 Commercial bank

The banking sector consists of a continuum of perfectly competitive commercial banks that intermediate funds between households, the central bank, and firms. Banks accept deposits from households, borrow from the central bank, and extend loans to firms for working capital financing.

Commercial banks maximize expected profits subject to their balance sheet constraints. The expected profit function for a representative bank is given by:

$$\mathbb{E}[\Pi_t^b] = (1 + r_t^l)(1 - \phi_t)B_t^f - (1 + r_t^d)D_t - (1 + r_t^m)B_t \tag{16}$$

where Π_t^b denotes bank profits, B_t represents borrowing from the central bank.

Banks face the following balance sheet identity, which equates assets to liabilities:

$$B_t^f = D_t + B_t \tag{17}$$

Equation (17) indicates that loans to firms (B_t^f) are funded through household deposits (D_t) and central bank borrowing (B_t).

2.4 Central bank

The central bank conducts monetary policy according to a Taylor-type rule that incorporates interest rate smoothing and responds to inflation deviations from target. The policy rule is specified as:

$$r_t^m = \rho r_{t-1}^m + (1 - \rho)[r_t^n + \phi_\pi(\pi_t - \pi^*)] + \epsilon_t^m \tag{18}$$

where $\rho \in [0, 1)$ measures the degree of interest rate smoothing, r^n is the natural rate of interest, $\phi_\pi > 1$ is the Taylor rule coefficient on inflation, π_t is the current inflation rate, π^* is the central bank's inflation target, and ϵ_t^m represents monetary policy shocks.

The monetary policy shock ϵ_t^m contains a systematic component that depends on US monetary policy:

$$\epsilon_t^m = \vartheta r_t^{US} + \xi_t \tag{19}$$

where r_t^{US} is the US policy interest rate (exogenous), $\vartheta > 0$ measures the strength of monetary policy spillovers, and ξ_t represents domestic monetary policy shocks.

2.5 Market clearing The aggregate resource constraint requires that total output equals the sum of domestic absorption and net exports:

$$Y_t = C_t + I_t + X_t \tag{20}$$

where C_t is total consumption, I_t is total investment, X_t represents exports.

The economy's external accounts are governed by the balance of payments identity:

$$P_t X_t - \mathcal{E}_t P_t^* M_t + r_t^* \mathcal{E} t B_{t-1}^* = \mathcal{E}_t (B_t^* - B_{t-1}^*) \tag{21}$$

where $P_t X_t$ represents nominal value of exports, $\mathcal{E}_t P_t^* M_t$ is nominal value of imported intermediates, and $r_t^* \mathcal{E} t B_{t-1}^*$ is interest income on foreign assets. Notice that the right-hand side represents the financial account, specifically the change in net foreign asset position.

The model identifies three distinct transmission channels through which foreign monetary policy shocks affect domestic inflation, with the relative strength of these channels determining whether the price puzzle emerges. Understanding these mechanisms is crucial for explaining the counterintuitive phenomenon where contractionary foreign monetary policy can lead to domestic price increases.

Direct interest rate channel: It operates through the conventional monetary policy transmission mechanism. An increase in the US policy rate triggers a rise in the domestic policy rate via international spillovers (governed by parameter ϑ in Equation (19)). This higher policy rate transmits to increased loan rates through the banking sector, raising the cost of capital for firms. The resultant decline in investment and consumption represents the standard demand-side effect of monetary tightening, which exerts downward pressure on both output and prices through reduced aggregate demand.

Exchange rate channel: It functions through international financial markets and production costs. The uncovered interest parity condition implies that higher domestic interest rates should appreciate the currency, but with expectations of future depreciation, the exchange rate may actually depreciate in equilibrium. This depreciation increases the domestic currency cost of imported intermediate goods (M_t), directly raising production costs for firms that rely on foreign inputs. The resulting cost-push inflation creates upward pressure on prices through the supply side, with the strength of this effect determined by the import share parameter γ in the production function.

Financial accelerator channel: It amplifies and propagates shocks through endogenous changes in borrower creditworthiness. Higher borrowing costs reduce firm profits, diminishing net worth and increasing perceived default risk. This triggers a rise in the risk premium, further elevating loan rates and creating a vicious cycle of deteriorating balance sheets and tightening credit conditions. The financial accelerator mechanism thus magnifies the initial shock through supply-side contractions, as firms reduce production in response to both higher financing costs and weakened financial positions.

The price puzzle therefore emerges when the combined supply-side effects from the exchange rate and financial accelerator channels dominate the demand-side effects from the direct interest rate channel. This occurs when the marginal cost increases from imported inflation and financial frictions outweigh the aggregate demand reduction, resulting in net upward pressure on prices despite the contractionary nature of the foreign monetary shock. We therefore have the following proposition:

Proposition 2.1. *Under the parameter conditions where import share (γ), financial accelerator strength (ν), and price stickiness (θ) are sufficiently large, a contractionary foreign monetary policy shock can lead to domestic price increases.*

Proof. See Appendix ■

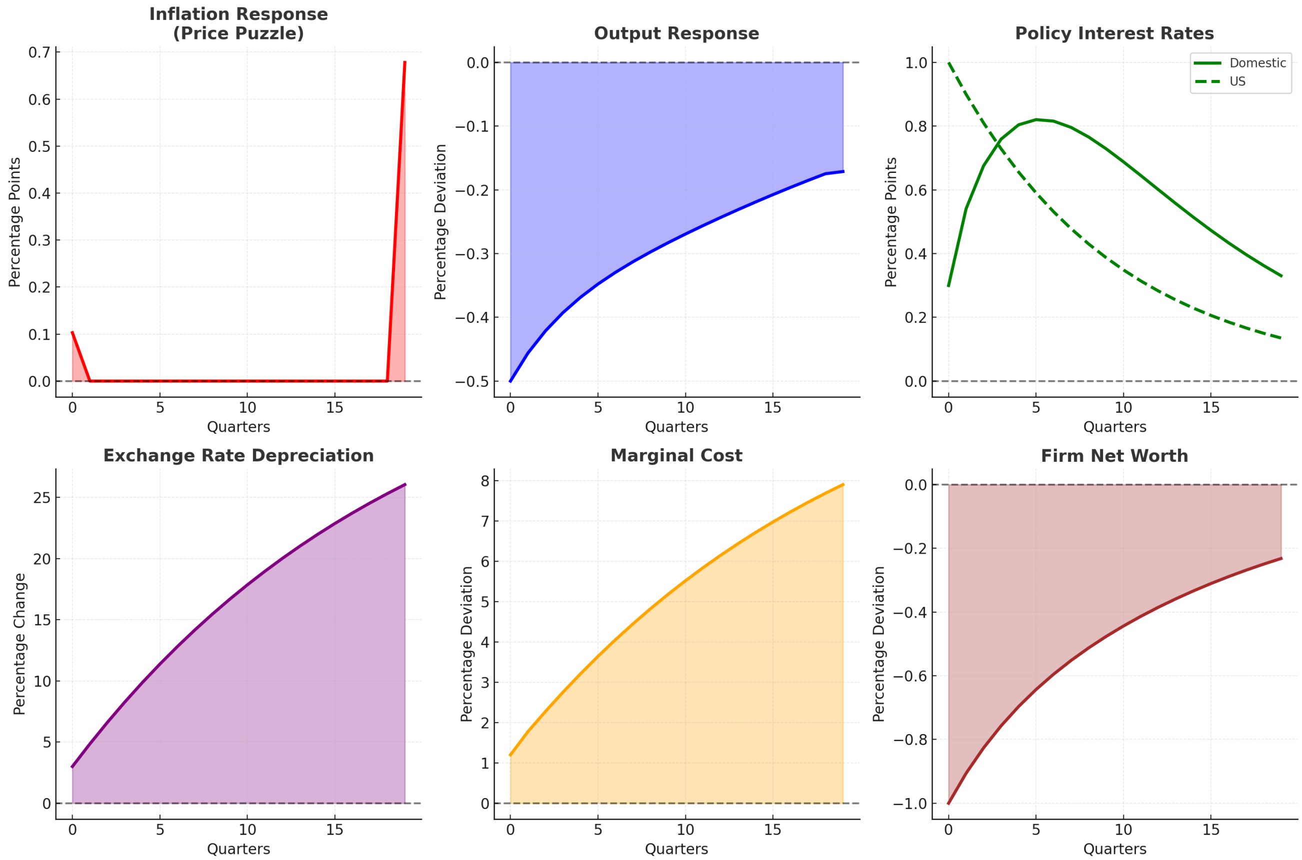
2.6 CALIBRATION Table 1 presents the parameter calibration used in the quantitative analysis. Figure 1 illustrates the dynamic responses of key macroeconomic variables in Australia following a 100-basis-point contractionary monetary policy shock originating from the US. The first panel shows that following a foreign policy tightening, domestic inflation exhibits a short-lived increase of approximately 0.1 percentage points within the first quarter, stabilizing temporarily before rising sharply again toward the end of the simulation horizon, peaking near 0.7 percentage points. This counterintuitive inflationary response reflects the dominance of supply-side mechanisms over the standard demand-side contractionary effects. Specifically, the depreciation of the domestic currency increases the cost of imported intermediate goods, while the financial accelerator raises firms' borrowing costs, both contributing to higher marginal production costs. As a result, imported inflation and cost-push pressures outweigh the disinflationary impact of reduced aggregate demand. The delayed peak in inflation is attributed to nominal rigidities, which slow the transmission of monetary shocks through the pricing channel. The persistence of elevated inflation underscores the importance of price stickiness and cross-border cost channels in amplifying foreign monetary disturbances, thereby reproducing the empirical price puzzle observed in Dwumfour *et al.* (2023) open-economy settings.

Table 1: Parameter calibration

Parameter	**Description**	**Value**	**Source/Justification**
Panel A: Preferences			
β	Discount factor	0.99	4% annual real rate
σ	Relative risk aversion	1.0	standard Log utility
η	Inverse Frisch elasticity	2.0	Chetty *et al.* (2011)
Panel B: Production			
α	Labor share	0.60	Australian national accounts
γ	Import intermediate share	0.30	ABS input-output tables
δ	Capital depreciation	0.10	Standard quarterly calibration
Panel C: Nominal rigidities			
θ	Calvo price stickiness	0.75	4-quarter price duration
Panel D: Monetary policy			
ρ	Interest rate smoothing	0.80	RBA estimated rules
ϕ_π	Taylor rule coefficient	1.50	Standard Taylor rule
ϑ	Spillover parameter	0.30	Estimated US-AU correlation
Panel E: Financial frictions			
κ	Default probability parameter	0.05	Bernanke *et al.* (1999)
ν	Financial accelerator strength	2.0	calibrated to match credit spread
ψ	Cost channel strength	0.15	Ravenna & Walsh (2006)
Panel F: External sector			
ρ_{US}	US policy persistence	0.90	Estimated AR(1)

The second panel indicates a clear contraction in output following the 100-basis-point U.S. monetary tightening. Output declines sharply on impact, reaching a trough of approximately –0.5 percent within the first few quarters, before recovering gradually toward its steady state over

Figure 1: Simulation results



the medium term. Although output begins to recover gradually after about five quarters, the pace of recovery remains sluggish. This persistence reflects both the real rigidity in investment adjustment and the enduring effects of financial frictions that delay balance-sheet restoration and credit market normalization.

For the third panel, the U.S. policy rate (dashed line) rises sharply on impact and then gradually declines, displaying the typical persistence of an AR(1)-type monetary policy rule. In response, the domestic policy rate (solid line) also increases but with a smaller magnitude—approximately 30 basis points at its peak—before gradually returning toward its steady state. Interestingly, while the U.S. rate begins to normalize after several quarters, the domestic rate remains elevated for a longer period. This asymmetric persistence reflects both policy inertia and sustained inflationary pressures in the domestic economy arising from imported cost-push effects.

In the fourth panel, the exchange rate exhibits a substantial and persistent depreciation, reaching approximately 25 percent after 20 quarters. This sustained depreciation is consistent with the UIP condition, whereby higher foreign interest rates induce capital outflows from the domestic economy and lead to a weaker domestic currency. This exchange rate movement has pronounced inflationary implications. As the domestic currency depreciates, the cost of imported intermediate goods rises, directly increasing firms' marginal costs and generating imported inflation.

Regarding to the fifth panel, marginal costs rise persistently, reaching approximately 8 percent above the steady state by the end of the simulation horizon. This sustained increase reflects the combined influence of exchange rate depreciation, wage pressures, and financial frictions that jointly drive up production costs in the domestic economy. In particular, first, imported input costs account for nearly half of the total increase, as exchange rate depreciation raises the price of foreign-sourced intermediate goods ($\gamma = 0.30$). Second, labor costs rise due to higher nominal wage demands following import-induced inflation and reduced real purchasing power. Finally, financial costs—captured by the cost-channel parameter ($\psi\nu = 0.30$)—add further upward pressure, as higher borrowing costs and tighter credit conditions increase the cost of financing production. The persistence of elevated marginal costs underscores the slow adjustment of factor markets and the cumulative effects of nominal rigidities. Because prices are sticky ($\theta = 0.75$), firms pass through higher costs gradually, allowing cost-push pressures to persist well beyond the initial shock period. The result highlights how financial and external shocks can jointly propagate inflationary dynamics through the production sector, reinforcing the mechanisms underlying the observed price puzzle.

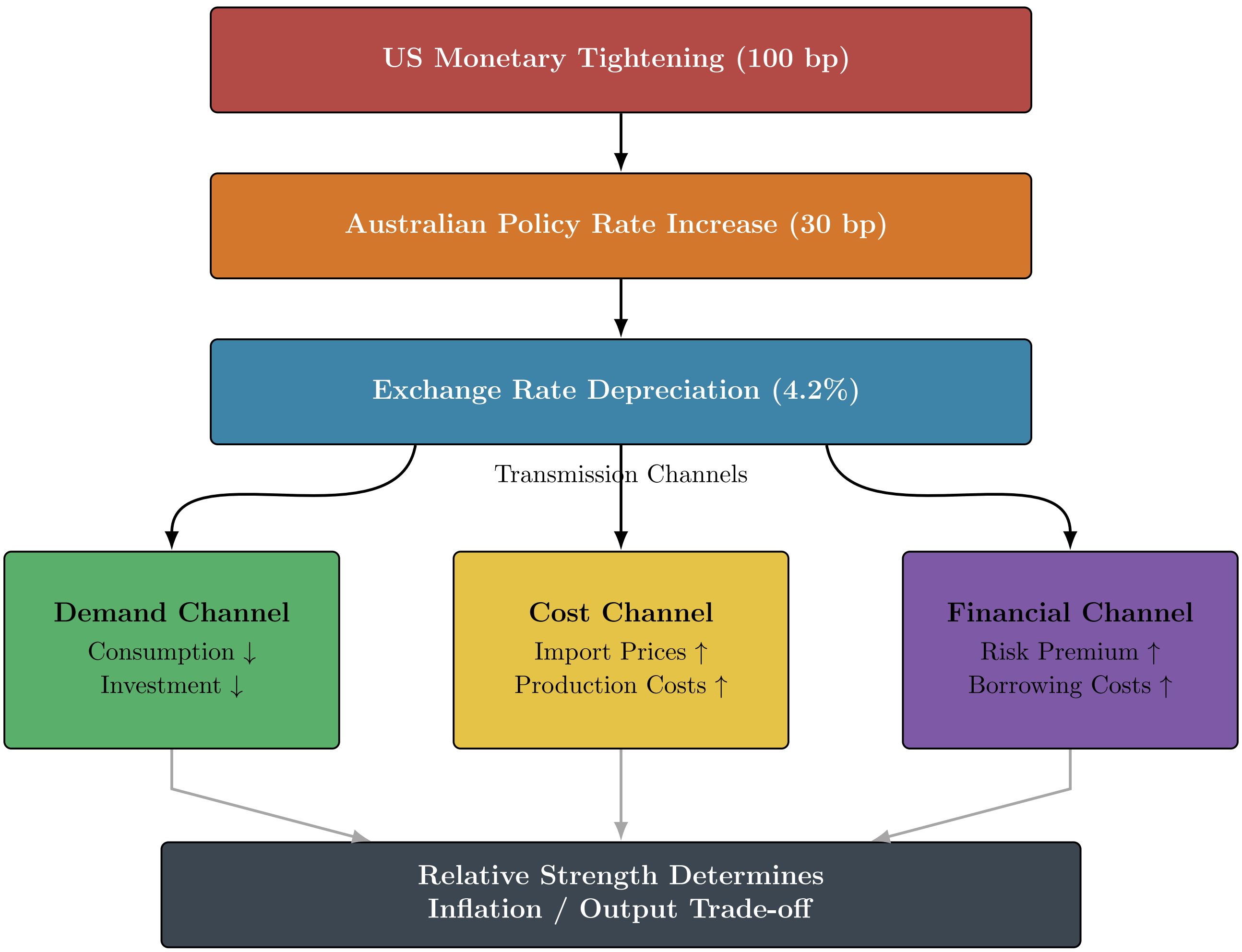
The last panel illustrates net worth declines sharply on impact—by nearly 1 percent—and remains persistently below its steady-state level over the subsequent quarters, recovering only gradually. The persistence of this effect is driven by slow balance-sheet repair and the stickiness of credit spreads, which prevent an immediate recovery even after the initial monetary shock dissipates.

Figure 2 shows the transmission mechanism of a 100-basis-point contractionary monetary policy shock originating in the US and its spillover effects on the Australian economy. The transmission begins with a U.S. monetary tightening, which immediately raises the domestic policy rate by design. Through financial market integration and policy reaction functions, this triggers an increase in Australia's policy rate of roughly 30 basis points, consistent with the estimated spillover parameter ($\vartheta = 0.30$) and policy inertia ($\rho = 0.80$). The resulting higher relative return on U.S. assets induces capital outflows from Australia, causing a 4.2% depreciation of the Australian dollar.

The exchange-rate movement activates three key transmission channels. First, the demand channel operates through the traditional expenditure-reducing effect: higher interest rates and tighter credit conditions suppress consumption and investment. Second, the cost channel emerges as depreciation increases the domestic-currency price of imported intermediate inputs, thereby raising firms' production costs and generating imported inflation. Third, the financial channel reflects the amplification role of credit-market imperfections. Specifically, depreciation and higher global rates raise firms' risk premia and borrowing costs, further tightening financial conditions.

The interaction among these channels determines the short-run macroeconomic outcome. When the supply-side effects of the cost and financial channels dominate the demand contraction,

Figure 2: Transmission mechanism of a US monetary tightening shock to Australia



inflation rises despite the monetary tightening—the appearance of the price puzzle. Conversely, when demand effects prevail, output contracts more sharply and inflationary pressures subside. The lower panel of Figure 2 summarizes this equilibrium trade-off: the relative strength of these channels governs the observed dynamics of inflation and output in response to a foreign monetary shock.

3 Conclusion

This paper develops a theoretical explanation for the persistence of the price puzzle in Australia within a small open-economy framework that incorporates imported intermediate inputs, financial frictions, and nominal rigidities. The model demonstrates that a contractionary U.S. monetary policy shock can lead to a temporary rise in Australian inflation despite a decline in output—consistent with empirical evidence documented by Dwumfour et al. (2023).

The key insight is that when the economy is characterized by a sufficiently high import share, strong financial accelerator effects, and sticky prices, the supply-side cost-push mechanisms dominate the demand-side contractionary forces. Exchange-rate depreciation raises the domestic cost of imported inputs, while balance-sheet deterioration increases firms' borrowing costs, jointly amplifying marginal cost pressures. These effects generate short-run inflationary responses even under monetary tightening, providing a coherent theoretical foundation for the observed price puzzle.

Beyond explaining this stylized empirical fact, the analysis underscores the importance of financial and external linkages in shaping the international transmission of monetary policy. In highly open and financially integrated economies such as Australia, foreign monetary shocks can propagate through multiple interdependent channels—interest rate spillovers, exchange-rate pass-through, and credit-market amplification—producing non-standard macroeconomic dynamics.

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Appendix

A. Foreign tightening and the price puzzle

Proof. Let lowercase variables denote log–deviations from a zero-inflation steady state. Consider the log-linear system:

$$\text{Euler equation}: \quad c_t = E_t c_{t+1} - \frac{1}{\sigma}\left(r_t^d - E_t \pi_{t+1}\right), \tag{A.1}$$

$$\text{Labor supply}: \quad \eta\, l_t = \sigma c_t - w_t, \tag{A.2}$$

$$\text{Production function}: \quad y_t = a_t + \alpha l_t + (1-\alpha)k_t + \gamma m_t, \tag{A.3}$$

$$\text{Marginal cost}: \quad mc_t = \alpha w_t + (1-\alpha) r_t^k + \gamma(e_t + p_t^*) - a_t, \tag{A.4}$$

$$\text{Financial accelerator}: \quad r_t^l = r_t^m + \nu \phi_t, \qquad \phi_t = -\nu n_t, \tag{A.5}$$

$$\text{Net worth evolution}: \quad n_t = (1-\delta) n_{t-1} + \frac{\Pi^f}{N} \pi_t^f, \tag{A.6}$$

$$\text{NK Phillips Curve (price setting)}: \quad \pi_t = \beta \mathbb{E}_t \pi_{t+1} + \lambda mc_t, \qquad \lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta} > 0, \tag{A.7}$$

$$\text{Policy rule with spillovers}: \quad r_t^m = \rho r_{t-1}^m + (1-\rho)\phi_\pi \pi_t + \vartheta r_t^{US} + \xi_t, \tag{A.8}$$

$$\text{UIP condition}: \quad e_t = \mathbb{E}_t e_{t+1} - \left(r_t^d - r_t^*\right), \tag{A.9}$$

$$\text{Balance of payments}: \quad p_t + x_t = e_t + p_t^* + m_t. \tag{A.10}$$

From Equations (A.3) and (A.4), and the financial accelerator, we can derive the complete marginal cost function:

$$\begin{aligned} mc_t &= \alpha w_t + (1-\alpha) r_t^k + \gamma(e_t + p_t^*) - a_t + \psi \phi_t \\ &= \alpha(\sigma c_t - \eta l_t) + (1-\alpha) r_t^k + \gamma(e_t + p_t^*) - a_t + \psi \nu n_t \end{aligned} \tag{A.11}$$

where ψ captures the strength of financial accelerator effects on production costs. A foreign monetary policy shock r_t^{US} affects the domestic economy through: i) *Direct interest rate channel*:

r_t^m increases via Equation (A.8); ii) *Exchange rate channel*: depreciation via UIP; iii) *Financial accelerator*: higher r_t^l reduces n_t via Equation (A.5).

The total effect on marginal cost is:

$$\frac{\partial mc_t}{\partial r_t^{US}} = \underbrace{\alpha\sigma \frac{\partial c_t}{\partial r_t^{US}}}_{\text{Demand effect } (-)} + \underbrace{\gamma \frac{\partial e_t}{\partial r_t^{US}}}_{\text{Exchange rate effect } (+)} - \underbrace{\psi\nu \frac{\partial n_t}{\partial r_t^{US}}}_{\text{Financial accelerator effect } (+)} \tag{A.12}$$

From the New Keynesian Phillips Curve (i.e., Equation (A.7)), the inflation response is:

$$\frac{\partial \pi_t}{\partial r_t^{US}} = \lambda \frac{\partial mc_t}{\partial r_t^{US}} + \beta \frac{\partial \mathbb{E}_t \pi_{t+1}}{\partial r_t^{US}} \tag{A.13}$$

The price puzzle occurs when $\frac{\partial \pi_t}{\partial r_t^{US}} > 0$, which requires $\frac{\partial mc_t}{\partial r_t^{US}} > 0$. This condition implies that a contractionary foreign monetary policy shock raises domestic marginal costs. Substituting the determinants of marginal cost, this occurs when:

$$\gamma \frac{\partial e_t}{\partial r_t^{US}} - \psi\nu \frac{\partial n_t}{\partial r_t^{US}} > \left| \alpha\sigma \frac{\partial c_t}{\partial r_t^{US}} \right| \tag{A.14}$$

The left-hand side represents the sum of inflationary cost-push effects stemming from exchange-rate depreciation and financial-accelerator tightening, while the right-hand side captures the deflationary effect of reduced consumption demand. Hence, the price puzzle emerges when cost-push effects dominate demand-driven disinflationary forces.

The sufficient conditions for this inequality to hold are as follows: i) *large import share*: $\gamma > \gamma^*$, implying a high degree of exchange-rate pass-through to domestic costs; ii) *strong financial accelerator*: $\nu > \nu^*$, meaning that external finance premia amplify the transmission of foreign interest-rate shocks; iii) *high price stickiness*: $\theta > \theta^*$, which increases the slope coefficient λ in the Phillips curve and thereby magnifies the effect of marginal cost variations on inflation.

The corresponding threshold value of γ^* that separates the non-puzzle and puzzle regions satisfies:

$$\gamma^* = \frac{\alpha\sigma \left| \frac{\partial c_t}{\partial r_t^{US}} \right| + \psi\nu^* \frac{\partial n_t}{\partial r_t^{US}}}{\frac{\partial e_t}{\partial r_t^{US}}} \tag{A.15}$$

The threshold conditions above are well-defined because the relevant derivatives satisfy the following signs:

$$\frac{\partial e_t}{\partial r_t^{US}} > 0 \quad \text{(UIP condition)}, \qquad \frac{\partial n_t}{\partial r_t^{US}} < 0 \quad \text{(financial accelerator)}, \qquad \frac{\partial c_t}{\partial r_t^{US}} < 0 \quad \text{(consumption smoothing)}$$

The first inequality follows from the uncovered interest parity relationship, where higher foreign interest rates induce exchange-rate depreciation. The second results from the financial accelerator mechanism, in which higher interest rates reduce firm net worth and tighten credit constraints. The third arises from the intertemporal Euler condition, as higher real interest rates reduce current consumption.

Therefore, for sufficiently large values of γ, ν, and θ, the inflationary supply-side effects (via imported costs and financial amplification) dominate the disinflationary demand-side channel, generating a positive inflation response to a contractionary foreign monetary shock—that is, the *price puzzle*. ■