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inflation, international trade, production networks, propagation of shocks

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The Trade-Inflation Nexus: The Role of Production Networks*

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Abstract

From the 1990s until the COVID-19 pandemic, the world experienced a sustained period of low and stable inflation, alongside a marked increase in trade integration among countries. This paper examines the impacts of international trade on inflation through domestic production networks. We first construct a theoretical model of an open economy to illustrate how domestic input-output networks propagate the price impacts of trade shocks. Using Australia as a case study, we find that the network impacts of trade shocks on inflation are as significant as their direct impacts, and primarily propagate upstream, based on data of 47 manufacturing industries from 2000 to 2023. Australia's low inflation before COVID benefited from increased exposure to China's low-cost exports, while inflation surged during episodes of global supply chain disruptions, among other factors. This paper underscores the importance of economic globalization and production structures for inflation, and offers several implications for monetary and trade policies.

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1 Introduction

Since the early 1990s, the world has experienced a sustained period of low and stable inflation. This was partially attributed to rapid globalization, which intensified the interdependence of production activities between countries. This trend became particularly pronounced after China's accession to the World Trade Organization (WTO) in 2001. China's rise as a global manufacturing powerhouse strengthened economic integration and reduced production costs, contributing to a stable inflationary environment worldwide. However, this era of stability ended with the COVID-19 pandemic, which severely disrupted global supply chains and drove inflation to unprecedented levels in the last three decades in many economies.

Price effects through international trade have long been a central focus in international macroeconomics. There are various established mechanisms through which trade openness can shape inflation: cheaper consumption goods from abroad can directly lower domestic consumption prices; trade increases technology transfer, international competition, comparative advantage and scales of economies, all resulting in faster productivity growth (Grossman and Helpman 1991); trade increases the trade-off between output and inflation through exchange rates, reducing central banks' incentives to engineer expansionary monetary policy (Romer 1993); exchange rate movements directly affect domestic prices of imported goods. These mechanisms focus on final consumption and aggregate production, with empirical evidence based on aggregate data (Terra, 1998; Bowdler and Nunziata, 2006; Wynne and Kersting, 2007; Aron and Muellbauer, 2007; Cooke, 2010; Samimi et al., 2012).

In recent decades, with the increase in economic specialization and globalization, intermediate goods have become increasingly important in production networks within and between countries. Disruptions to individual firms or industries can propagate through input-output (IO) linkages, turning microeconomic shocks into broader macroeconomic fluctuations. Therefore, small idiosyncratic shocks can persist and cause significant aggregate fluctuations through production networks (Acemoglu et al., 2012, 2015, 2016a, 2017). A growing empirical literature examines the propagation effects of production networks in various contexts (Di Giovanni and Levchenko, 2010; Di Giovanni et al., 2014; Carvalho, 2014; Acemoglu et al., 2016a,b; Barrot and Sauvagnat, 2016; Baqaee and Farhi, 2019; Luo, 2020).

Previous studies in the network approach often focus on employment and output in closed economies. Our paper instead applies the network approach to the trade-inflation nexus, examining how trade shocks propagate through domestic production networks and affect domestic inflation. In an open economy, global demand and supply shocks can be transmitted and amplified through domestic IO linkages, as industries are interconnected not only through direct global trade but also through intermediate IO relationships within domestic production networks. This study complements the traditional literature on the trade-inflation nexus by examining the role of domestic production networks, with a distinction between final consumption goods and intermediate production goods. Several empirical studies examine the effects of trade shocks on inflation through intermediate goods, highlighting a strong connection between international production linkages and the globalization of inflation (Auer and Saure, 2013; Auer and Mehrotra, 2014; Auer et al., 2019; Di Giovanni et al., 2022). In contrast, we examine not only the direct price effects of trade shocks through global supply chains, but also the indirect price effects transmitted through domestic production networks.

We first develop a theoretical IO model of a small open economy with multiple sectors to illustrate how trade shocks propagate through domestic production networks. In our model, import price shocks influence not only the consumption price of imported final goods but also the production prices of firms through the cost of imported inputs. Exports affect domestic prices through changes in external demand and induced labor costs. These direct effects are then transmitted across industries through IO linkages, amplifying their impact on domestic inflation. Our model is closely related to the small open-economy model developed by Silva (2024), but it differs in several respects. First, while Silva treats wage rates as an exogenous component of domestic prices, we endogenize wage rates and thereby fully determine domestic prices within the model. As wages are linked to external demand, our model connects domestic prices to exports in addition to imports. This formulation allows domestic IO linkages to transmit trade shocks into price responses through wage adjustments. Second, while Silva focuses on network effects as a whole, we distinguish between upstream and downstream effects of trade shocks, which is informative about the directional propagation of shocks within domestic supply chains.

Building on the theoretical model, we estimate the network effects of trade shocks on inflation using Australia as a case study. The empirical analysis draws on Australia's bilateral trade data with China across 47 manufacturing industries from 2000 to 2023, and estimates the price effects of trade shocks using both panel fixed-effects regressions and two-stage least squares (2SLS) with instrumental variables. The results support theoretical findings and reveal a positive relationship between producer price inflation and industrial import exposure, and a negative link with export exposure. The network impacts of trade shocks through upstream linkages are comparable in magnitude to the direct impacts of shocks. The contributions of downstream shock propagation remain negligible. The exchange rate effects are consistently negative and primarily operate through the direct channel. We also examine the price effects of trade shocks during the GFC and COVID disruptions, finding more pronounced network effects on inflation.

Our empirical focus on Chinese trade shocks is related to the literature that examines the impacts of China's global trade integration on its trading partners. Most empirical studies focus on large economies, particularly the United States, highlighting labor market and price adjustments from Chinese import competition (e.g., Autor et al. 2013, 2016, 2021; Jaravel and Sager 2019; Luo and Villar 2023). In contrast, evidence on macroeconomic adjustments in small open economies, such as Australia, remains relatively limited. Although studies like Bjørnland and Thorsrud (2016) and Dungey et al. (2020) have explored Australia's macroeconomic responses to China's demand for resources, the relationship between trade and inflation remains largely underexplored.

The remainder of this paper is organized as follows. Section 2 provides an overview of inflation dynamics and trade patterns in Australia over the past three decades. Section 3 presents a theoretical framework for a small open economy with production networks and illustrates the transmission of trade shocks to inflation through IO linkages. Section 4 outlines the empirical methodology and data, with the results reported and discussed in Section 5. Finally, Section 6 concludes the paper with some policy implications.

2 The Australian Economy

As our empirical analysis focuses on Australia, this section provides an overview of Australia's inflation and trade patterns from 1990 to 2023, with supporting data presented in Appendix A.

The early 1990s recession reduced consumer price index (CPI) inflation from 6.9% to 1.9% by the end of 1992. The RBA introduced its 2–3% inflation target in 1993, establishing the foundation of its inflation-targeting framework. This policy was successful in stabilizing inflation for several years. However, inflation picked up in 1995 as the economic recovery strengthened, aided by the depreciation of the Australian dollar, before easing again during the Asian Financial Crisis in 1997. Throughout the decade, tradable and non-tradable inflation moved closely together. Japan, Korea, and the United States dominated Australia's trade. Trade with China was relatively modest (less than 10% of Australia's trade) but gradually expanded.

The 2000s marked a period of substantial expansion in Australia's trade with China. China's rapid industrialization reshaped its position in Australia's trade, driving double-digit annual growth in bilateral flows and making it Australia's largest trading partner by the end of the decade. Imports from China rose sharply, while Australia's rich natural resources positioned it as a key supplier of iron ore, coal, and liquefied natural gas to China. Tradable CPI inflation fell sharply in 2001, widening its gap with non-tradable inflation. Inflationary pressures from the mid-2000s mining boom were offset by a stronger dollar and cheaper imports. The global financial crisis (GFC) temporarily pushed inflation higher before a sharp retrenchment. On average, both CPI and producer price index (PPI) inflation rates remained close to the upper bound of the RBA's inflation target (around 3%) over 2000–2009.

The 2010s saw persistently low inflation, with headline and producer price inflation averaging 2% and 1.7%, slightly below the RBA's lower target bound. During this period, China re-balanced its economy from investment to consumption, leading to a global plateau in Chinese manufacturing exports. Slower economic growth in China reduced its demand for Australia's commodities, which lowered commodity prices. The end of the commodity boom reduced mining investment and eased inflationary pressure. The imports of low-cost manufacturing goods from China reinforced this trend.

The 2020s began with severe global disruptions. As a global manufacturing powerhouse, disruptions in China during the COVID-19 pandemic had pronounced effects on global supply chains. Australia–China bilateral trade also contracted sharply, with China's share falling by 7.55% in 2022. Like other advanced economies, Australia experienced pronounced inflation volatility: inflation briefly dipped below zero in 2020 and then surged in 2021–22, amid global recovery, shipping bottlenecks, and rising energy shocks. Inflation peaked in late 2022, with CPI inflation reaching 7.8% and PPI inflation 6.4%, before moderating in 2023 under tighter monetary policy and easing trade constraints.

Broadly, Australian inflation and trade patterns have moved together over the past several decades, especially in relation to China. The remainder of this paper formally investigates these patterns through theoretical and empirical analysis.

3 Theoretical Model

This section presents an IO model to illustrate how inter-sectoral linkages influence the price response to trade shocks in an open economy. To start with, we set out some conventions of nomenclature for notation: lower-case letters for industry-level variables; upper-case letters for vectors and matrices and also for economy-wide scalar variables; I for an identity matrix; D for a diagonal matrix; V for a vector; $\hat{}$ for a percent change when the variable is measured in levels and a percentage-point change when the variable is measured as a share or rate; and * for variables in the rest of the world. For ease of reference, all the model notations are also listed in Table B1.

3.1 The Environment

Consider the static state of a small open economy with multiple industries. The economy engages in trade with the rest of the world. There are N industries in the economy and each industry i $(i = 1, 2, ..., N)$ produces a specific good in a competitive market, with p_i as the price in industry i. We assume a representative firm in each industry, and a representative household in the economy, with no government for simplicity. Total labor force in each industry is normalized to one. Labor is immobile across industries over the time horizon of trade shocks, and thus wages are heterogeneous across industries, denoted by w_i in industry i. Labor cannot move across countries either.

In the rest of the world, there are M industries and each industry m $(m = 1, 2, ..., M)$ produces a specific good. Foreign goods are differentiated from domestic goods. Even within the same industry classification, goods are distinguished by their country of origin according to the Armington assumption. The prices of foreign goods, denoted by p_m, are exogenous for the small economy.

3.2 Firms

The representative firm in each industry uses goods from other domestic industries, imported goods from the rest of the world, together with labor, to produce a specific output. The firm in each industry i follows a Cobb-Douglas production function of the form:

$$y_i = z_i l_i^{\alpha_i^l} \prod_{n=1}^{N} x_{in}^{a_{in}} \prod_{m=1}^{M} x_{im}^{a_{im}} \tag{1}$$

where y_i represents the output of industry i, z_i denotes productivity, and l_i is the labor employed in industry i. x_{in} represents the quantity of input produced by domestic industry n and used in production by industry i, while x_{im} is the quantity of input imported from foreign industry m in the rest of the world. The parameters α_i^l, a_{in}, and a_{im} represent, respectively, the output elasticities of industry i with respect to labor, domestic input from industry n, and imported input from foreign industry m. The elasticities satisfy:

$$\alpha_i^l + \sum_{n=1}^{N} a_{in} + \sum_{m=1}^{M} a_{im} = 1 \tag{2}$$

Taking as given the input and output prices and the wage rate, the firm minimizes its production cost:

$$v_i^y = \sum_{n=1}^{N} p_n x_{in} + \sum_{m=1}^{M} p_m x_{im} + w_i l_i \tag{3}$$

$$s.t. \quad y_i = \bar{y}_i \tag{4}$$

The marginal cost of production in industry i is

$$v_i = \frac{1}{z_i} \left(\frac{w_i}{\alpha_i^l} \right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{p_n}{a_{in}} \right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{p_m}{a_{im}} \right)^{a_{im}} \tag{5}$$

The marginal cost depends on the productivity level, domestic prices, foreign prices, and the wage rate. It does not depend on the output level because the production function has a constant return to scale. Log-linearizing the marginal cost function yields

$$\hat{v}_i = -\hat{z}_i + \alpha_i^l \hat{w}_i + \sum_{n=1}^{N} a_{in} \hat{p}_n + \sum_{m=1}^{M} a_{im} \hat{p}_m \tag{6}$$

The marginal cost equals the output price in competitive markets. Immediately,

$$\hat{p}_i = -\hat{z}_i + \alpha_i^l \hat{w}_i + \sum_{n=1}^{N} a_{in} \hat{p}_n + \sum_{m=1}^{M} a_{im} \hat{p}_m \tag{7}$$

In matrix form,

$$\hat{P} = -\hat{Z} + D_{\alpha_l} \hat{W} + A\hat{P} + A^* \hat{P}^* \tag{8}$$

Thus,

$$\hat{P} \quad = \quad (I - A)^{-1} \left[-\hat{Z} + A^* \hat{P}^* + D_{\alpha_l} \hat{W} \right] \tag{9}$$

where the vectors of variables represent:

$$\hat{P} = (\hat{p}_i)_N, \quad \hat{P}^* = (\hat{p}_m)_M, \quad \hat{W} = (\hat{w}_i)_N, \quad \hat{Z} = (\hat{z}_i)_N \tag{10}$$

and the matrices of coefficients represent:

$$D_{\alpha_l} = (\alpha_i^l)_{N \times N}, \quad A = (a_{ij})_{N \times N}, \quad A^* = (a_{im})_{N \times M} \tag{11}$$

The elements of the coefficient matrices can be derived from the above cost minimization problem as follows:

$$\alpha_i^l = \frac{w_i l_i}{p_i y_i}, \quad a_{ij} = \frac{p_j x_{ij}}{p_i y_i}, \quad a_{im} = \frac{p_m x_{im}}{p_i y_i} \tag{12}$$

The above matrix A, referred to as the domestic input matrix (hereafter, the input matrix), contains entries a_{ij} that represent the sales of domestic industry j to domestic industry i normalized by total sales of domestic industry i. Intuitively, this ratio implies how many dollars worth of industry j's output that industry i needs to purchase to produce one dollar worth of its own output. Similarly, the matrix A^*, referred to as the foreign-to-domestic input matrix, contains entries a_{im} that represent the sales of foreign industry m to domestic industry i normalized by total sales of domestic industry i.

Together with the input matrix, we define an output matrix B that represents the allocation of each industry's output across all domestic industries:

$$B : b_{ij} = \frac{p_j x_{ij}}{p_j y_j} \tag{13}$$

where b_{ij} denotes the sales of industry j to industry i as a fraction of industry j's total sales. This ratio reflects the relative importance of industry i as a buyer of industry j's products.

The first-order condition for labor demand implies

$$w_i = \left(\alpha_i^l\right)^{(1-\alpha_i^l)} Y p_i^{-1} s_i^y l_i^{-1} z_i^{-1} w_i^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{p_n}{a_{in}}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{p_m}{a_{im}}\right)^{a_{im}} \tag{14}$$

where the Domar weight $s_i^y = \frac{p_i y_i}{Y}$, and Y denotes total output of the economy (GDP). GDP is measured as the sum of household consumption and exports:

$$Y = \sum_{n=1}^{N} p_n c_n + \sum_{m=1}^{M} p_m c_m + \sum_{n=1}^{N} p_n e_n \tag{15}$$

where c_n, c_m, e_n are household consumption of domestic goods, household consumption of imported goods, and export quantity, respectively.

Log-linearizing equation (14) yields:

$$\hat{w}_i = \alpha_i^l \hat{w}_i + \hat{Y} - \hat{p}_i - \hat{z}_i + \sum_{n=1}^{N} a_{in}\hat{p}_n + \sum_{m=1}^{M} a_{im}\hat{p}_m - \hat{l}_i + \hat{s}_i^y \tag{16}$$

In matrix form,

$$\hat{W} = D_{\alpha_l}\hat{W} + V_1\hat{Y} - \hat{Z} - (I - A)\hat{P} + A^*\hat{P}^* - \hat{L} + \hat{S}_y \tag{17}$$

where

$$\hat{S}_y = (\hat{s}_n^y)_N, \quad \hat{L} = (\hat{l}_n)_N \tag{18}$$

3.3 Households

The representative household follows a constant elasticity of substitution (CES) utility function:

$$u\left(\{c_n\}_{n=1}^{N}; \{c_m\}_{m=1}^{M}; \{l_n\}_{n=1}^{N}\right) = \left(\sum_{n=1}^{N} \beta_n^l (1 - l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{1/\rho} \tag{19}$$

where c_n is the final consumption of domestic good n, c_m is the final consumption of foreign good m, and $(1 - l_n)$ represents leisure. For simplicity, we assume that the household faces a common elasticity of substitution, $1/(1-\rho)$, between leisure, domestic consumption, and foreign consumption, with preference weights, β_n^l, β_n and β_m, satisfying

$$\sum_{n=1}^{N} \beta_n^l + \sum_{n=1}^{N} \beta_n + \sum_{m=1}^{M} \beta_m = 1 \tag{20}$$

The consumer earns wage income. The consumer's budget constraint is

$$\sum_{n=1}^{N} p_n c_n + \sum_{m=1}^{M} p_m c_m = \sum_{n=1}^{N} w_n l_n \tag{21}$$

The optimal consumption is derived as

$$c_i = \frac{\left(\frac{\beta_i}{p_i}\right)^{1/(1-\rho)} \sum_{n=1}^{N} w_n l_n}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \tag{22}$$

where i represents any domestic or foreign industry. The aggregate consumer price is defined as

$$P_C = \left[\sum_{n=1}^{N} \beta_n^{1/(1-\rho)} p_n^{-\rho/(1-\rho)} + \sum_{m=1}^{M} \beta_m^{1/(1-\rho)} p_m^{-\rho/(1-\rho)} \right]^{-(1-\rho)/\rho} \tag{23}$$

The optimal labor supply is

$$l_n = 1 - \frac{\left(\beta_n^l\right)^{1/(1-\rho)} P_C^{\rho/(1-\rho)}}{w_n^{1/(1-\rho)}} Y \tag{24}$$

Log-linearizing labor supply yields

$$\hat{l}_n = \frac{1-l_n}{(1-\rho)l_n}\hat{w}_n - \frac{\rho(1-l_n)}{(1-\rho)l_n}\hat{P}_C - \frac{1-l_n}{l_n}\hat{Y} \tag{25}$$

In matrix form,

$$\hat{L} = \frac{1}{1-\rho} D_\pi \hat{W} - \frac{\rho}{1-\rho} V_\pi \hat{P}_C - V_\pi \hat{Y} \tag{26}$$

where $\pi_n = \dfrac{1-l_n}{l_n}$ denotes the leisure to labor ratio in the steady state.

3.4 Equilibrium

The output of each industry is used as inputs for all industries, consumed by households, and exported to other countries. The market-clearing condition for industry i can be written as

$$y_i = \sum_{j=1}^{N} x_{ji} + c_i + e_i \tag{27}$$

The above condition does not involve imports because imported goods are different from domestic goods. The equilibrium condition determines the price of goods in industry i. Exports are exogenous, and do not depend on the prices but can affect the prices. The above equation can be rewritten as

$$\frac{p_i y_i}{Y} = \sum_{j=1}^{N} \frac{p_i x_{ji}}{Y} + \frac{p_i c_i}{Y} + \frac{p_i e_i}{Y} \tag{28}$$

Recall the Domar weight $s_i^y = \dfrac{p_i y_i}{Y}$, and now we denote the shares of household consumption and export out of total output by

$$s_i^c = \frac{p_i c_i}{Y}, \quad s_i^e = \frac{p_i e_i}{Y} \tag{29}$$

Thus,

$$s_i^y = \sum_{j=1}^{N} \frac{p_j y_j}{Y} a_{ji} + s_i^c + s_i^e = \sum_{j=1}^{N} s_j^y a_{ji} + s_i^c + s_i^e \tag{30}$$

Log-linearizing the above equation yields

$$\hat{s}_i^y = \frac{1}{s_i^y} \left[\sum_{j=1}^{N} a_{ji} s_j^y \hat{s}_j^y + s_i^c \hat{s}_i^c + s_i^e \hat{s}_i^e \right] \tag{31}$$

Equivalently,

$$\hat{s}_i^y = \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \alpha_i^c \hat{s}_i^c + \alpha_i^e \hat{s}_i^e \tag{32}$$

where α_i^c and α_i^e denote the industry-level shares of consumption and export, respectively:

$$\alpha_i^c = \frac{p_i c_i}{p_i y_i}, \quad \alpha_i^e = \frac{p_i e_i}{p_i y_i} \tag{33}$$

In matrix form,

$$\hat{S}_y = (I - B^T)^{-1} \left[-\frac{\rho}{1-\rho} D_{\alpha_c} \hat{P} + \frac{\rho}{1-\rho} V_{\alpha_c} (S_c^T \hat{P} + S_{c^*}^T \hat{P}^*) + D_{\alpha_e} \hat{S}_e \right] \tag{34}$$

3.5 Trade Shocks and Price Responses

Several propositions follow from the above model (see proofs in Appendix D). Proposition 1 demonstrates that domestic prices are jointly determined by domestic and foreign factors throughout the production network.

Proposition 1. *The changes in industrial prices are determined by*

$$\hat{P} = (I - Q_p)^{-1} \left[-Q_z \hat{Z} + Q_y \hat{Y} + Q_{p^*} \hat{P}^* + Q_e \hat{S}_e \right], \tag{35}$$

where

$$\begin{aligned}
Q_p &= -D_{\alpha\pi} - \frac{\rho}{1-\rho} (I - A)^{-1} D_{\alpha\pi} \left[(I - B^T)^{-1} V_{\alpha_c} \left(V_1^T - S_c^T \right) - V_\pi S_c^T \right], \\
Q_z &= (I - A)^{-1} \left(I + D_{\alpha\pi} \right), \\
Q_y &= (I - A)^{-1} D_{\alpha\pi} \left(V_1 + V_\pi \right), \\
Q_{p^*} &= (I - A)^{-1} \left(I + D_{\alpha\pi} \right) A^* + \frac{\rho}{1-\rho} (I - A)^{-1} D_{\alpha\pi} \left[(I - B^T)^{-1} V_{\alpha_c} S_{c^*}^T + V_\pi S_{c^*}^T \right], \\
Q_e &= (I - A)^{-1} D_{\alpha\pi} (I - B^T)^{-1} D_{\alpha_e}, \\
D_{\alpha\pi} &= D_{\alpha_l} \left[I - D_{\alpha_l} + \frac{1}{1-\rho} D_\pi \right]^{-1}
\end{aligned}$$

The matrices Q_p, Q_z and Q_y capture the sensitivity of changes in industrial prices to the first-order transmission of various domestic shocks, including changes in producer prices of other industries, industrial productivity, and total output. Q_{p^*} and Q_e capture the sensitivity of industrial price changes to the first-order transmission of foreign shocks, including import prices and export quantities (as a share of GDP). The matrix $(I-Q_p)^{-1}$ represents the general equilibrium multiplier, encapsulating the higher-order effects of shock transmission.

We then derive the partial derivatives of inflation with respect to the import and export variables, where higher-order propagation effects are disregarded. The results are presented in the following propositions.

Proposition 2. *The first-order effect of import price shocks on industrial price inflation is given by*

$$\begin{aligned}\hat{P} &= \underbrace{\frac{\rho}{1-\rho}(\mathbf{A}-\mathbf{I})\Big(V_{\alpha_c}+V_{\pi}\Big)S_{c^*}^T\hat{P}^*}_{\textit{Downstream Effect}} + \underbrace{\frac{\rho}{1-\rho}(\mathbf{B^T}-\mathbf{I})V_{\alpha_c}S_{c^*}^T\hat{P}^*}_{\textit{Upstream Effect}} \\ &\quad + \underbrace{\left[\Big(D_{\alpha\pi}^{-1}+I\Big)A^* + \frac{\rho}{1-\rho}\Big(3V_{\alpha_c}+2V_{\pi}\Big)S_{c^*}^T\right]\hat{P}^*}_{\textit{Direct Effect}} \qquad (36)\end{aligned}$$

Proposition 3. *The first-order effect of export quantity shocks on industrial price inflation is given by*

$$\hat{P} = \underbrace{(\mathbf{A}-\mathbf{I})D_{\alpha\pi}D_{\alpha_e}\hat{S}_e}_{\textit{Downstream Effect}} + \underbrace{D_{\alpha\pi}(\mathbf{B^T}-\mathbf{I})D_{\alpha_e}\hat{S}_e}_{\textit{Upstream Effect}} + \underbrace{3D_{\alpha\pi}D_{\alpha_e}\hat{S}_e}_{\textit{Direct Effect}} \qquad (37)$$

Propositions 2 and 3 establish the first-order impacts of import and export shocks on industrial price inflation, decomposed into three components: *the direct effect*, *downstream effect*, and *upstream effect*. Through the direct channel, import price shocks influence domestic prices by changing the costs of imported inputs (via the imported input matrix A^*) and the consumption of imported final goods ($S_{C^*}^T$). Export shocks affect prices through changes in external demand (reflected in the export share D_{α_e}) and production factors (captured by $D_{\alpha\pi}$). Import and export shocks propagate both downstream and upstream, indirectly affecting the price decisions of downstream customers and upstream suppliers of the initially affected industries.

Intuitively, when a trade shock occurs in a particular industry, it directly changes the price and output of the industry. Through the production networks, the initial adjustments then propagate downstream via the input matrix, **(A-I)**, influencing other industries that rely on intermediate inputs supplied by the first-round affected industries. On the other hand, the shock also changes the demand of the directly affected industry for domestic intermediate inputs. This, in turn, propagates through the output matrix, $(\mathbf{B^T}-\mathbf{I})$, and potentially changes prices of upstream industries.

Several remarks follow from the above propositions. First, the propagation of import shocks through industrial prices critically depends on the elasticity of substitution in consumption, whereas the effects of export shocks remain independent of the elasticity. The lower the elasticity of substitution in consumption, the weaker the network effects. Domestic prices are less responsive to changes in import prices via the production channel. In the Cobb-Douglas case ($\rho = 0$, that is, the elasticity of substitution in consumption is one), equation (36) reduces to:

$$\hat{P} = \left(D_{\alpha\pi}^{-1} + I\right) A^* \hat{P}^*$$

This indicates that import shocks affect industrial prices only through the direct channel, and the first-order impact of domestic production networks disappears. The elasticity of substitution between inputs in production could also influence price responses. As we assume a Cobb-Douglas production function, the production elasticity does not explicitly appear in the price equation.

Second, if wages are homogeneous across industries, then import price shocks do not generate first-order effects on industrial prices through upstream propagation. In a frictionless labor market, the wage rate is independent of an industry's sales share relative to aggregate production (the Domar weight). Cost shocks may change the sales of upstream industries, but they do not affect their wage adjustments and thus leave upstream output prices unchanged. In this setting, trade-driven inflation is unresponsive to drivers such as labor supply and production through the wage channel, and Q_{p^*} in (35) reduces to $Q_{p^*} = (I - A)^{-1} A^*$, as shown in equation (9). Fluctuations in import prices propagate domestic inflation only through downstream effects. However, the empirical evidence in Section 5 demonstrates a significant upstream transmission of import shocks to inflation. This indicates that the assumption of segmented labor markets over the short and medium term in our theoretical framework fits the data.

4 Empirical Model and Data

We now estimate the network effects of Australia-China bilateral trade exposure on inflation from 2000 to 2023, a period of substantial expansion in trade between the two economies. We first construct trade shock measures, and then present our empirical model and identification strategy, followed by a description of the data.

4.1 Trade Shocks

The import price in industry i in year t, denoted by $MP_{i,t}$, is measured as the ratio of the import value (in US dollars) to the import volume of industry i's imports from China in year t. The export quantity in industry i in year t, denoted by $EQ_{i,t}$, is measured as the ratio of industry i's export value to China (evaluated at the base-year price) to its domestic market size in the base year.

We construct direct, upstream and downstream shocks in import prices and export quantities as follows. The direct shock to industry i in time t, denoted by $O_{i,t}$, is calculated as the logarithmic change in import prices faced by industry i or as the first difference in its export quantity to the Chinese market. Indirect trade shocks transmitted upstream and downstream, denoted by $U_{i,t}$ and $D_{i,t}$ respectively, are constructed as functions of the direct shock and the industry's IO relationship. Mathematically,

$$O_{i,t} = \Delta \ln MP_{i,t} \text{ or } \Delta EQ_{i,t} \tag{38}$$

$$U_{i,t} = \sum_{j=1}^{N} \left[(b_{ji} - \mathbf{1}_{j=i}) \cdot O_{j,t} \right] \tag{39}$$

$$D_{i,t} = \sum_{j=1}^{N} \left[(a_{ij} - \mathbf{1}_{j=i}) \cdot O_{j,t} \right] \tag{40}$$

where a_{ij} is the element of the input matrix, and b_{ij} is the element of the output matrix, as defined in our theoretical model; $\mathbf{1}_{j=i}$ is an indicator function, taking the value of 1 for $j = i$ and 0 otherwise. In matrix form,

$$O_t = \Delta \ln MP_t \text{ or } \Delta EQ_t \tag{41}$$

$$U_t = (\mathbf{B^T} - \mathbf{I}) \cdot O_t \tag{42}$$

$$D_t = (\mathbf{A} - \mathbf{I}) \cdot O_t \tag{43}$$

Since international trade is typically invoiced in US dollars, we also incorporate Australian–US nominal exchange rate movements to capture the exchange rate pass-through to domestic inflation.

To facilitate comparison, all trade shocks are standardized by dividing them by their sample standard deviations, so that estimated effects correspond to a one–standard-deviation shock. In addition, trade shocks are winsorized at the 1st and 99th percentiles to mitigate the influence of extreme outliers.

4.2 Empirical Model

The empirical model for import price shocks is specified as:

$$\begin{aligned}\Delta \ln p_{i,t} = \sum_{k=1}^{2} \Big(& \alpha_k \Delta \ln p_{i,t-k} + \beta_k^{OMP} O_{i,t-k}^{MP} + \beta_k^{UMP} U_{i,t-k}^{MP} + \beta_k^{DMP} D_{i,t-k}^{MP} \\ & + \beta_k^{OEX} O_{i,t-k}^{EX} + \beta_k^{UEX} U_{i,t-k}^{EX} + \beta_k^{DEX} D_{i,t-k}^{EX} \Big) + \delta_t + \gamma_i + \epsilon_{i,t}\end{aligned} \tag{44}$$

where i indexes industries, t indexes time, δ_t represents the time fixed effect, γ_i represents the industry fixed effect, and $\epsilon_{i,t}$ is an error term. The dependent variable, $\Delta \ln p_{i,t}$, denotes the price inflation in industry i calculated as the logarithmic change in industrial prices. $O_{i,t}^{MP}$, $U_{i,t}^{MP}$ and $D_{i,t}^{MP}$ represent, respectively, the direct shock, the upstream shock, and the downstream shock to the import price in industry i, denominated in US dollars. The exchange rate shock, $O_{i,t}^{EX}$, captures the direct pass-through of fluctuations in the Australian-US exchange rate, expressed in logarithmic differences. $U_{i,t}^{EX}$ and $D_{i,t}^{EX}$ denote the corresponding upstream and downstream shocks to the exchange rate transmitted through the production networks. To avoid potential simultaneity between the dependent variable and the shocks, we use two-period lags of all shocks while excluding contemporaneous terms.

Similarly, the empirical model for export quantity shocks is specified as:

$$\begin{aligned}\Delta \ln p_{i,t} \quad = \quad & \sum_{k=1}^{2} \Big(\alpha_k \, \Delta \ln p_{i,t-k} + \beta_k^{OEQ} O_{i,t-k}^{EQ} + \beta_k^{UEQ} U_{i,t-k}^{EQ} + \beta_k^{DEQ} D_{i,t-k}^{EQ} \\ & + \beta_k^{OEX} O_{i,t-k}^{EX} + \beta_k^{UEX} U_{i,t-k}^{EX} + \beta_k^{DEX} D_{i,t-k}^{EX} \Big) + \delta_t + \gamma_i + \epsilon_{i,t} \quad (45)\end{aligned}$$

where the direct export shock, $O_{i,t}^{EQ}$, is measured as the first difference in export quantities, with $U_{i,t}^{EQ}$ and $D_{i,t}^{EQ}$ representing the corresponding upstream and downstream shock, respectively.

The combined effects of import price shocks and export quantity shocks are therefore captured in the following model:

$$\begin{aligned}\Delta \ln p_{i,t} \quad = \quad & \sum_{k=1}^{2} \Big(\alpha_k \Delta \ln p_{i,t-k} + \beta_k^{OMP} O_{i,t-k}^{MP} + \beta_k^{UMP} U_{i,t-k}^{MP} + \beta_k^{DMP} D_{i,t-k}^{MP} \\ & + \beta_k^{OEQ} O_{i,t-k}^{EQ} + \beta_k^{UEQ} U_{i,t-k}^{EQ} + \beta_k^{DEQ} D_{i,t-k}^{EQ} \\ & + \beta_k^{OEX} O_{i,t-k}^{EX} + \beta_k^{UEX} U_{i,t-k}^{EX} + \beta_k^{DEX} D_{i,t-k}^{EX} \Big) + \delta_t + \gamma_i + \epsilon_{i,t} \quad (46)\end{aligned}$$

As our focus is on the responses of industrial prices to industrial trade shocks rather than to broader macroeconomic factors, our empirical analysis incorporates only the exchange rate as a covariate, which directly affects Australia's import prices and export competitiveness in global markets. Other macroeconomic variables such as oil prices and monetary policy shocks are omitted from the baseline specification. However, we acknowledge that macroeconomic variables may affect industries differently. Including interaction terms between macroeconomic variables and their related industry-specific measures (for example, oil prices and industry oil intensity) is conceptually desirable, but technically challenging due to data limitations, the complexity of decomposing direct, upstream and downstream channels, and the increased parameter space. To mitigate potential bias from omitting macroeconomic variables, we adopt several strategies: (i) incorporating time-fixed effects to capture shocks that are common to all industries at a given point in time, thereby removing the influence of economy-wide movements; (ii) employing instrumental variables to isolate exogenous variation in trade shocks, described in the next subsection; and (iii) introducing selected macroeconomic variables as controls in robustness checks.

4.3 Identification

The OLS estimations are unbiased when trade shocks originating from China are exogenous to Australia. Ideally, fluctuations in import prices ($MP_{i,t}$) would capture only the supply-driven component of Chinese exports, such as competitiveness of Chinese manufacturers, while fluctuations in export exposure ($EQ_{i,t}$) would reflect China's demand-driven component, such as Chinese economic expansion or productivity change of China's non-Australian exporters. In practice, however, these shocks may be correlated with unobserved factors, such as Australia's industrial productivity, that affect the prices in Australia. To address potential endogeneity, we employ an instrumental variables (IV) strategy following Autor et al. (2013).

Specially, we instrument $MP_{i,t}$ and $EQ_{i,t}$, using China's trade with its major trading partners other than Australia. The instrument for the import price ($MP_{i,t}^{IV}$) is constructed as the ratio of the import value to the import volume from China to the United States. The instrument for the export quantity exposure ($EQ_{i,t}^{IV}$) is defined as the average export quantity to China from its five main suppliers (Germany, Japan, Canada, the United Kingdom and Chile)[1], scaled by Australia's base-year market size.

Therefore, the instrumental variables for trade shocks are constructed as follows:

$$\begin{aligned} O_t^{IV} &= \Delta \ln MP_t^{IV} \text{ or } \Delta EQ_t^{IV} \\ U_t^{IV} &= (\mathbf{B}^{\mathbf{T}} - \mathbf{I}) \cdot O_t^{IV} \\ D_t^{IV} &= (\mathbf{A} - \mathbf{I}) \cdot O_t^{IV} \end{aligned} \tag{47}$$

where the superscript IV indicates the instrumental variable corresponding to the original variable defined above. The instruments are estimated using 2SLS regressions.

4.4 Data

The analysis uses annual data for 2000–2023. The sample starts in 2000 as producer price data are not available for earlier years, and covers the period of deepening Australia–China trade integration. We choose 2017 (pre-COVID) as the base year. Our analysis focuses on manufacturing industries, which are consistently mapped across the IO table, trade data, and price indices under the 2015 Input-Output Industry Groups (IOIG) classification. Figure A6 reports the list of 47 IOIG industries included in our data along with their average producer prices. All variables are compiled from multiple sources, as detailed below.

Input-Output Linkage. The construction of IO linkage among domestic industries is based on IO tables sourced from the Australian Bureau of Statistics (ABS). The ABS's IO tables are available at the 4-digit Input-Output Industry Groups level for each financial year. In our empirical analysis, the IO structure is pre-determined based on the IO table

[1]The China's five main exporters are identified based on their exports to China over the 2000-2023 period.

for the 2017/2018 financial year. This year is selected as the benchmark to ensure the use of a recent IO structure while avoiding the period of global trade disruption caused by the COVID-19 pandemic. For robustness, we also employ the more recent 2021/2022 IO table.

Industrial Prices. Industry-level prices are taken from the Producer Price Index (PPI) for the output of manufacturing industries, sourced from ABS. The PPI is classified under the Australian and New Zealand Standard Industrial Classification (ANZSIC) released in 2006. We map the industry PPI at 3- or 4-digit ANZSIC of Manufacturing Division (Division C) to 4-digit IOIG classification using ABS correspondence tables. Quarterly PPIs are aggregated to annual measures using a geometric average.

International Trade. Trade shocks are constructed using annual bilateral merchandise import and export data, obtained from the UN Comtrade. The raw trade data is categorized according to the Standard International Trade Classification Revision 3 (SITC3). We classify bilateral trade in commodities into industry groups of the manufacturing industry. We use the ABS's customs tariff historical correspondence (Catalog number 5489.0) and the IO table correspondence to map the trade data at SITC levels 4 and 5 to the IO industry groups through ANZSIC.

Market Size. Industry market size, required to compute the export exposure, is measured as total supply net of exports by industry, based on the ABS's IO tables.

Exchange Rate. The bilateral exchange rate is the normally quoted Australian dollar against the US dollar, sourced from the OECD Economic Outlook.

Control Variables. In robustness checks, we include wage growth and monetary supply growth as controls. Wage growth is measured as the annual logarithmic change in the wage price index for the manufacturing industry, constructed from the mean of quarterly ordinary-time hourly rates of pay (excluding bonuses) in both private and public sectors, sourced from ABS. Monetary supply growth is calculated as the annual growth rate in M3, aggregated from monthly RBA data.

5 Empirical Results

This section first presents our main results, including fixed effect OLS estimations and 2SLS estimations using IVs. We then report the results during major disruption episodes such as the GFC and the COVID-19 pandemic, in comparison with the results in normal periods. Finally, we conduct a series of robustness checks.

5.1 Main Results

The main results are reported in Table 1. The first column presents the shock variables, the next three columns show the results for import price shocks, the following two columns show the results for export quantity shocks, and the final two columns report the results for joint shocks. Overall, the results indicate that both import and export shocks have statistically significant impacts on producer prices, through direct changes in trade linkages and propagation along domestic supply chains.

We first look at the results for import price shocks. Column (1) presents the baseline OLS estimation, where import prices are denominated in US dollars and exchange rate shocks are included. Direct shocks to import prices are statistically significant at the 1% level for the first lag and the 5% level for the second lag. The sign confirms a positive relationship between import costs and domestic inflation. Specifically, a one-standard-deviation decline in import prices reduces producer inflation through the direct channel by 0.262 log points after the first year and 0.048 after the second year. The impacts on inflation are persistent relative to the monetary policy horizon. Similarly, the upstream effects are significant at the 1% level for the first lag and the 5% level for the second lag. A one-standard-deviation decline in import prices reduces producer inflation through the upstream channel by 0.288 log points after the first year and 0.038 after the second year. The magnitude of upstream effects is comparable to that of the direct impacts. By contrast, the downstream effects are statistically insignificant and quantitatively negligible.

Column (1-AUD) presents the OLS estimation where import prices are expressed in Australian dollars, thus incorporating exchange rate fluctuations. The results are consistent with the baseline findings. But exchange rate movements slightly reduce the magnitude of the effects and also dampen the persistence of shocks, with the second lag becoming statistically insignificant. This suggests that a flexible exchange rate may act as a stabilizer in response to import price shocks, mitigating their effects on domestic inflation.

The 2SLS estimation in column (2) shows larger impacts but weaker statistical significance. A one-standard-deviation decline in import prices reduces producer inflation through the direct channel by 0.333 log points after the first year and by 0.414 after the second year, with the first lag becoming insignificant. The magnitude of upstream effects is comparable to that of the direct impacts, while the downstream effects are statistically insignificant and quantitatively negligible. Appendix E presents the tests for instrument relevance and strength.

To put the magnitudes of the results into perspective, the average unweighted standard deviation of inflation across all industries over two years was approximately 0.14 log points. Thus, the price impact of import cost shocks transmitted through production networks represents a substantive source of variation in price dynamics.

The interpretation is consistent with the historical experience. Since China's accession to the WTO in 2001, Australian manufacturers, like those in many other economies, have benefited from a steady inflow of low-priced imports from China, interrupted only by brief periods of global disruption (Figure A4). The import price index for Australia's manufacturing industry fell by 18.4% in 2004 relative to its 2001 level and subsequently moved within a narrow range of 100–110 until the onset of COVID-19. This stable access to competitively priced inputs reduced production costs and producer prices,

Table 1: Propagation of Trade Shocks

	Import Price Shocks			Export Quantity Shocks		Joint Shocks	
	OLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(1-AUD)	(2)	(3)	(4)	(5)	(6)
O^{MP}, L1	0.262***	0.235***	0.333			0.266***	-0.520
	(0.022)	(0.043)	(0.246)			(0.022)	(1.001)
O^{MP}, L2	0.048**	0.013	0.414*			0.006	-0.916
	(0.019)	(0.027)	(0.240)			(0.026)	(1.359)
U^{MP}, L1	0.288***	0.257***	0.384			0.297***	-0.555
	(0.026)	(0.045)	(0.300)			(0.026)	(1.196)
U^{MP}, L2	0.038**	0.009	0.516*			-0.004	-0.904
	(0.016)	(0.025)	(0.303)			(0.024)	(1.623)
D^{MP}, L1	-0.018	-0.015	-0.038			-0.024	-0.029
	(0.021)	(0.015)	(0.082)			(0.019)	(0.297)
D^{MP}, L2	0.002	-0.003	-0.074			0.003	-0.147
	(0.008)	(0.007)	(0.088)			(0.008)	(0.398)
O^{EQ}, L1				-0.025**	0.017	-0.044***	-0.189
				(0.009)	(0.210)	(0.015)	(0.378)
O^{EQ}, L2				0.037	-0.329**	0.029	-0.215
				(0.025)	(0.140)	(0.021)	(0.186)
U^{EQ}, L1				-0.024**	0.026	-0.048**	-0.215
				(0.010)	(0.204)	(0.018)	(0.415)
U^{EQ}, L2				0.043	-0.326**	0.030	-0.170
				(0.030)	(0.134)	(0.024)	(0.312)
D^{EQ}, L1				-0.004	-0.001	-0.000	0.041
				(0.004)	(0.025)	(0.004)	(0.130)
D^{EQ}, L2				-0.000	-0.003	0.003	0.059
				(0.005)	(0.038)	(0.005)	(0.135)
O^{EX}, L1	-0.630***			-0.812***	-0.226*	-0.634***	-0.028
	(0.144)			(0.199)	(0.122)	(0.136)	(0.608)
O^{EX}, L2	-0.561***			-0.675***	0.054	-0.646***	0.440
	(0.072)			(0.071)	(0.149)	(0.094)	(0.678)
U^{EX}, L1	-0.127			-0.259	-0.267	-0.096	-0.026
	(0.120)			(0.182)	(0.183)	(0.102)	(0.776)
U^{EX}, L2	-0.022			-0.049	0.013	-0.072	0.324
	(0.046)			(0.055)	(0.195)	(0.058)	(0.826)
D^{EX}, L1	0.014			0.028	0.073	0.008	0.042
	(0.020)			(0.026)	(0.054)	(0.019)	(0.124)
D^{EX}, L2	-0.016			-0.019	-0.047	-0.014	0.055
	(0.015)			(0.015)	(0.050)	(0.019)	(0.338)
N	957	957	957	947	947	947	947

Notes: The dependent variable is the logarithmic annual change in the producer price index. The direct import price shock (O^{MP}) and the direct exchange rate shock (O^{EX}) are measured as logarithmic changes in winsorized and standardized series. Direct export quantity shock (O^{EQ}) is constructed from the non-log terms of standardized and winsorized series relative to the Australian base-year market size. Columns (1) and (6) present results for USD-denominated import prices. Columns (1-AUD) and (2) present results for AUD-denominated import prices. Columns of 2SLS results display the second-stage estimates (the first-stage results are reported in the Appendix E1). U and D represent the network upstream and downstream effects of trade shocks. $L1$ and $L2$ indicate the number of lags. N is number of observations. All regressions include year- and industry-fixed effects. *p < 0.10, **p < 0.05, ***p < 0.01. Standard errors are in parentheses and are clustered by industry and are unweighted.

underpinning a prolonged period of relatively low inflation, as discussed in Section 2.

We then turn to the results for export quantity shocks. Column (3) presents the baseline OLS estimation, where export quantity shocks and exchange rate shocks are included. Direct shocks to export quantities are statistically significant at the 5% level for the first lag and insignificant for the second lag. The sign suggests a negative relationship between external demand and domestic inflation. Specifically, a one-standard-deviation increase in exports reduces producer inflation through the direct channel by 0.025 log points after the first year. In standard macroeconomic settings, stronger external demand is expected to raise domestic producer inflation by tightening capacity and pushing up input costs, although it may reduce price pressure under certain conditions such as economies of scale (Melitz and Ottaviano, 2008). In Australia's case, however, manufacturing exports account for only a small fraction of total exports to China, and the estimated effects are quantitatively small. Also, the 2SLS estimation in column (4) shows much larger and more delayed impacts. Therefore, we interpret the results with caution and avoid drawing strong conclusions.

The last two columns present the combined effects of import price and export quantity shocks, estimated using OLS and 2SLS, respectively. The results are broadly consistent with the separate estimates. The network propagation of both import price and export quantity shocks remains evident when estimated jointly.

5.2 Disruption Episodes

During our sample period 2000-2023, global trade experienced major disruptions, most notably the GFC and the COVID-19 pandemic. The GFC triggered a sharp contraction in international demand, with global trade declining more than at any time since the Second World War (Baldwin, 2009; WTO, 2009). The COVID-19 pandemic generated both supply- and demand-side shocks worldwide. Public health measures aimed at containing the spread of the pandemic severely disrupted global manufacturing supply chains, while widespread labor shortages further constrained production. At the same time, surging consumer demand for durable goods, electronics, and medical equipment pushed freight rates and commodity prices to unprecedented levels (OECD, 2021; IMF, 2022).

Australia was not immune to these disruptions. During the GFC, manufacturing exports volumes contracted by 8.2% in 2009 relative to 2007, accompanied by a 2.7% decline in intermediate import volumes, while import prices initially rose sharply by 9.7% compared to the pre-GFC levels. At the onset of COVID-19 in 2020, Australia's total exports and imports fell by 4.2% and 5.4%, respectively, relative to the 2018 pre-COVID levels. Import prices persistently increased in the post-pandemic period and peaked by 19.6% in 2022 relative to the pre-COVID levels (Figures A2–A4).

To assess the transmission of trade shocks during crisis periods, we compare the estimated effects of trade shocks in normal times with those during major disruptions. We extend the baseline model by interacting trade shock variables with a crisis indicator,

C_t, which captures potential shifts in their price effects during episodes of disruptions. The model is given by:

$$\begin{aligned}\Delta \ln p_{i,t} &= (1 - C_t)\left(\sigma + \alpha \Delta \ln p_{i,t-1} + \beta^O O_{i,t-1} + \beta^U U_{i,t-1} + \beta^D D_{i,t-1}\right) \\ &\quad + C_t\left(\sigma_c + \alpha_c \Delta \ln p_{i,t-1} + \beta_c^O O_{i,t-1} + \beta_c^U U_{i,t-1} + \beta_c^D D_{i,t-1}\right) \\ &\quad + \gamma_i + \epsilon_{i,t} \end{aligned} \tag{48}$$

where O, U, and D denote, respectively, direct, upstream, and downstream shocks to either import prices or export quantities. The coefficients with a subscript c correspond to crisis periods. The crisis indicator takes the value $C_t = 1$ for the GFC period 2008–2010 and the COVID-19 period 2020–2023, and $C_t = 0$ otherwise. Introducing a crisis period adds additional parameters to estimate, so we include only one lag of the trade shocks to maintain parsimony and ensure reliable estimation. For the same reason, we estimate the two crisis episodes separately.

Table 2 presents the results separating the GFC period from normal times (2000-2019, excluding the GFC). Columns (1) and (2) show the results for import price shocks in US dollars for the GFC and non-GFC periods, respectively, while the following two columns present the results for import price shocks in Australian dollars for the two periods. The last two columns report the results for export quantity shocks for the two periods. The results for both the GFC and non-GFC periods are consistent with the baseline estimations. Direct shocks to import prices are statistically significant at the 1% level, with a positive relationship between import costs and domestic inflation. The upstream effects are significant at the 1% level, and comparable in magnitude to the direct impacts, while the downstream effects are statistically insignificant and quantitatively negligible.

Although the results for the GFC and non-GFC periods are broadly consistent, the effects during the GFC are moderately stronger than in normal times. Specifically, a one-standard-deviation decline in import prices in US dollars reduces producer inflation through the direct channel by 0.301 log points in normal times and 0.363 during the GFC. Through the upstream channel, a one-standard-deviation decline in import prices reduces producer inflation by 0.315 log points in normal times and 0.4 during the GFC. The differences in the results when import prices are measured in Australian dollars are similar.

The results for export quantity shocks are also broadly consistent with the baseline estimations. Direct shocks to export quantities in normal times are statistically significant, with negative but small effects, and become insignificant during the GFC. The downstream effects are statistically significant while the upstream effects are not.

Table 3 presents the results separating the COVID-19 period from the pre-COVID-19 period. The patterns are similar to those from the GFC and non-GFC comparison, but the impacts during COVID-19 were much more pronounced. A one-standard-deviation decline in import prices in US dollars reduces producer inflation through the direct channel by 0.208 log points in the pre-COVID period and 0.663 during COVID-19.

Table 2: Effects of GFC on Propagation of Trade Shocks

	Import Price Shocks (in USD)		Import Price Shocks (in AUD)		Export Quantity Shocks	
	Non-GFC	GFC	Non-GFC	GFC	Non-GFC	GFC
	(1)	(2)	(3)	(4)	(5)	(6)
O^{MP}, L1	0.301***	0.363***	0.251***	0.321**		
	(0.027)	(0.118)	(0.051)	(0.132)		
U^{MP}, L1	0.315***	0.400***	0.271***	0.379**		
	(0.031)	(0.120)	(0.059)	(0.145)		
D^{MP}, L1	-0.004	-0.011	-0.008	-0.032		
	(0.022)	(0.012)	(0.019)	(0.022)		
O^{EQ}, L1					-0.031**	0.023
					(0.015)	(0.019)
U^{EQ}, L1					-0.018	0.031
					(0.016)	(0.020)
D^{EQ}, L1					-0.013**	-0.015*
					(0.006)	(0.008)
O^{EX}, L1	-0.100	0.104			-0.294	0.124
	(0.106)	(0.103)			(0.185)	(0.085)
U^{EX}, L1	-0.143	0.135			-0.322	0.122
	(0.144)	(0.142)			(0.243)	(0.130)
D^{EX}, L1	0.036	-0.087***			0.046	-0.075**
	(0.025)	(0.020)			(0.036)	(0.032)
N	957		957		947	

Notes: The dependent variable is the logarithmic annual change in the producer price index. The direct import price shock (O^{MP}) and the direct exchange rate shock (O^{EX}) are measured as logarithmic changes in winsorized and standardized series. Direct export quantity shock (O^{EQ}) is constructed from the non-log terms of standardized shocks. GFC occurred between 2008-2010. Other terms are as in Table 1.

Through the upstream channel, a one-standard-deviation decline in import prices reduces producer inflation by 0.224 log points in the pre-COVID period and 0.733 during COVID-19. These pronounced impacts during COVID-19 reflect the widespread and severe disruptions to global supply chains.

Overall, the findings underscore that import price fluctuations continued to transmit strongly to domestic inflation through price adjustments in directly affected industries and their upstream suppliers, with effects becoming more pronounced during crisis periods.

5.3 Robustness Check

We run a set of additional regressions to assess the robustness of our baseline results: (i) excluding industries with negative average inflation from the sample to mitigate the influence of outliers; (ii) incorporating wage growth and money supply growth to capture economy-wide inflation drivers; and (iii) reconstructing the input–output structure using

Table 3: Effects of COVID-19 on Propagation of Trade Shocks

	Import Price Shocks (in USD)		Import Price Shocks (in AUD)		Export Quantity Shocks	
	Non-COVID	COVID	Non-COVID	COVID	Non-COVID	COVID
	(1)	(2)	(3)	(4)	(5)	(6)
O^{MP}, L1	0.208***	0.663***	0.160***	0.613***		
	(0.026)	(0.068)	(0.044)	(0.060)		
U^{MP}, L1	0.224***	0.733***	0.185***	0.629***		
	(0.031)	(0.107)	(0.054)	(0.092)		
D^{MP}, L1	0.000	-0.076	-0.007	-0.015		
	(0.017)	(0.051)	(0.016)	(0.057)		
O^{EQ}, L1					0.003	-0.188**
					(0.021)	(0.079)
U^{EQ}, L1					0.014	-0.218**
					(0.022)	(0.093)
D^{EQ}, L1					-0.012**	0.016
					(0.005)	(0.018)
O^{EX}, L1	-0.106	0.012			-0.203	-2.084***
	(0.086)	(0.250)			(0.121)	(0.565)
U^{EX}, L1	-0.146	0.254			-0.228	-1.370**
	(0.114)	(0.360)			(0.156)	(0.638)
D^{EX}, L1	0.006	0.087			0.003	0.258**
	(0.019)	(0.068)			(0.020)	(0.113)
N	957		957		947	

Notes: The dependent variable is the logarithmic annual change in the producer price index. The direct import price shock (O^{MP}) and the direct exchange rate shock (O^{EX}) are measured as logarithmic changes in winsorized and standardized series. Direct export quantity shock (O^{EQ}) is constructed from the non-log terms of standardized shocks. COVID-19 and its post span from 2020-2023. Other terms are as in Table 1.

the 2021/2022 IO table to test sensitivity to the choice of base year.

Columns (2)-(4) in Tables 4 and 5 present the results of robustness checks for import price shocks and export quantity shocks, respectively. The baseline results are presented in column (1). The alternative specifications yield variations in the magnitudes of estimated network effects, but the signs and overall patterns remain stable.

More specifically, column (2) in each table presents the results when the sample is refined by excluding two industries with negative average PPI inflation: *Professional, scientific, computer and electronic equipment* (IOIG 2401) and *Tanned leather, dressed fur and leather product* (IOIG 1302). The estimated direct and network effects of these trade shocks on inflation remain highly consistent in both sign and magnitude.

Column (3) replaces year fixed effects with macroeconomic controls, including contemporaneous manufacturing wage growth and one lag of money aggregate growth. The results remain broadly robust. Import price shocks continue to transmit into producer price inflation through two lags of direct and upstream shocks, while the downstream effects of export shocks become stronger and statistically significant. As expected, wage adjustments play a key role in driving inflation dynamics. In the presence of either import or export shocks, higher wage growth significantly raises inflation. Money supply growth is also statistically significant and has a positive impact, though it is smaller than that of wage growth.

Column (4) changes the base year from 2017/2018 to 2021/2022 to examine the sensitivity of the base year. The 2021/2022 IO table, the most recent available from the ABS at the time of our analysis, reflects trade linkages during the post-COVID recovery. The results are largely consistent with the baseline, with the exception that the second lagged effect of upstream import price shocks weakens in statistical significance.

6 Conclusion

The relationship between trade and inflation has long been a central focus in open economy macroeconomics. This study revisits the topic through the lens of the IO production network. Our theoretical and empirical findings emphasize the critical role of production networks in propagating the effects of trade exposure on domestic inflation.

The theoretical model illustrates the mechanisms through which industrial shocks from international trade are amplified and transmitted to domestic inflation. The empirical results for Australia reveal that increased trade exposure at the industrial level contributed to lower inflation over the past two decades until the COVID pandemic. This suggests that the expansion of global supply chains, driven by comparative advantage, offers significant benefits in terms of inflation for open economies. The findings are especially relevant for economies heavily reliant on international trade, such as Australia.

This analysis offers several implications for monetary policy. The results demonstrate that, in addition to direct effects, trade shocks can significantly influence inflation

Table 4: Robustness of Results on Import Price Shocks

	Baseline	Excl. Outliers	Macro Controls	2021/22 IO
	(1)	(2)	(3)	(4)
O^{MP}, L1	0.262***	0.263***	0.283***	0.291***
	(0.022)	(0.025)	(0.017)	(0.039)
O^{MP}, L2	0.048**	0.044**	0.063***	0.053**
	(0.019)	(0.020)	(0.016)	(0.024)
U^{MP}, L1	0.288***	0.291***	0.300***	0.330***
	(0.026)	(0.029)	(0.020)	(0.043)
U^{MP}, L2	0.038**	0.035*	0.045***	0.040*
	(0.016)	(0.018)	(0.015)	(0.020)
D^{MP}, L1	-0.018	-0.020	-0.008	-0.031
	(0.021)	(0.021)	(0.018)	(0.022)
D^{MP}, L2	0.002	0.000	0.009	0.006
	(0.008)	(0.009)	(0.009)	(0.011)
O^{EX}, L1	-0.630***	-0.656***	-0.071	-0.595***
	(0.144)	(0.141)	(0.078)	(0.121)
O^{EX}, L2	-0.561***	-0.557***	0.064**	-0.546***
	(0.072)	(0.073)	(0.030)	(0.070)
U^{EX}, L1	-0.127	-0.134	-0.112	-0.082
	(0.120)	(0.121)	(0.108)	(0.087)
U^{EX}, L2	-0.022	0.005	-0.021	0.001
	(0.046)	(0.040)	(0.047)	(0.043)
D^{EX}, L1	0.014	0.016	0.014	0.009
	(0.020)	(0.020)	(0.017)	(0.023)
D^{EX}, L2	-0.016	-0.019	-0.011	-0.027***
	(0.015)	(0.014)	(0.013)	(0.010)
Wage Growth			0.619**	
			(0.255)	
Money Growth			0.173***	
			(0.038)	
Year-Fixed	Yes	Yes	No	Yes
Industry-Fixed	Yes	Yes	Yes	Yes
N	957	915	957	957

Notes: The dependent variable is the logarithmic annual change in the producer price index. In the baseline model, direct import price shock (O^{MP}) and direct exchange rate shock (O^{EX}) are measured as logarithmic changes in winsorized and standardized series. Import prices are denominated in USD. The model in column (2) excludes industries with negative average inflation. The model in column (3) controls contemporaneous manufacturing wage growth and one lag of money aggregate growth. Upstream and downstream effects in column (4) are constructed using IO 2011/2022 structure. Other terms are as in Table 1.

Table 5: Robustness of Results on Export Quantity Shocks

	Baseline	Excl. Outliers	Macro Controls	2021/22 IO
	(1)	(2)	(3)	(4)
O^{EQ}, L1	-0.025**	-0.024**	-0.029***	-0.027***
	(0.009)	(0.009)	(0.010)	(0.008)
O^{EQ}, L2	0.037	0.037	0.028	0.034
	(0.025)	(0.025)	(0.022)	(0.027)
U^{EQ}, L1	-0.024**	-0.024**	-0.016	-0.024***
	(0.010)	(0.009)	(0.011)	(0.009)
U^{EQ}, L2	0.043	0.045	0.046	0.042
	(0.030)	(0.029)	(0.028)	(0.032)
D^{EQ}, L1	-0.004	-0.003	-0.015**	-0.006
	(0.004)	(0.004)	(0.007)	(0.005)
D^{EQ}, L2	-0.000	-0.002	-0.012*	-0.003
	(0.005)	(0.005)	(0.007)	(0.006)
O^{EX}, L1	-0.812***	-0.837***	-0.179	-0.767***
	(0.199)	(0.197)	(0.125)	(0.161)
O^{EX}, L2	-0.675***	-0.668***	0.018	-0.677***
	(0.071)	(0.073)	(0.038)	(0.074)
U^{EX}, L1	-0.259	-0.266	-0.239	-0.203
	(0.182)	(0.182)	(0.173)	(0.125)
U^{EX}, L2	-0.049	-0.020	-0.035	-0.051
	(0.055)	(0.048)	(0.057)	(0.047)
D^{EX}, L1	0.028	0.031	0.020	0.027
	(0.026)	(0.027)	(0.026)	(0.026)
D^{EX}, L2	-0.019	-0.021	-0.025	-0.032***
	(0.015)	(0.014)	(0.018)	(0.011)
Wage Growth			0.581**	
			(0.273)	
Money Growth			0.083*	
			(0.045)	
Year-Fixed	Yes	Yes	No	Yes
Industry-Fixed	Yes	Yes	Yes	Yes
N	947	905	947	947

Notes: The dependent variable is the logarithmic annual change in the producer price index. In the baseline model, direct exchange rate shock (O^{EX}) is measured as logarithmic changes in winsorized and standardized series. Direct export quantity shock (O^{EQ}) is constructed from the non-log terms of standardized and winsorized series relative to the market size. The model in column (2) excludes industries with negative average inflation. The model in column (3) controls contemporaneous manufacturing wage growth and one lags of money aggregate growth. Upstream and downstream effects in column (4) are constructed using IO 2021/2022 structure. Other terms are as in Table 1.

through production networks, particularly through upstream propagation. Without considering the production network in the analysis of inflation, the welfare costs of inflation could be underestimated. The analysis also reveals strong lag effects of network shocks, which can be attributed to the extended nature of the production process through IO linkages. Therefore, failing to contain inflation in the short run can lead to sustained inflationary pressures, diminishing the effectiveness of monetary policy.

This paper also sheds light on the inflationary implications of trade policy in the current global context. Industrial trade policies that increase prices on certain industries or products, such as tariffs, would increase inflationary pressures across the broader economy in the medium term. These measures not only directly raise the prices of protected industries but also indirectly impact the prices of other industries through production networks. Even when national security and geopolitical factors are at play, it is essential to exercise caution when implementing trade protection policies, particularly those affecting manufacturing goods. This is especially relevant for manufacturing import-intensive countries, where the price effects of such policies can be substantial.

As a caveat, our identification strategy mitigates, but may not fully rule out, potential endogeneity, including "round-tripping" trade between Australia and China, where Australian demand shocks feed back into Chinese demand for Australian inputs. Future research could incorporate multi-country production-network data or more granular firm- or product-level data when available. Such granular approaches can trace global value-chain feedback mechanisms more explicitly.

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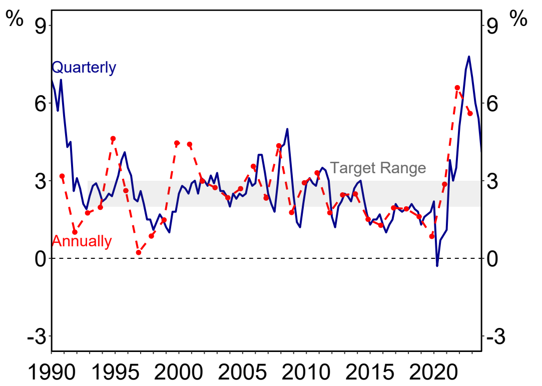
Appendix A Australia: Inflation and Trade, 1990–2023

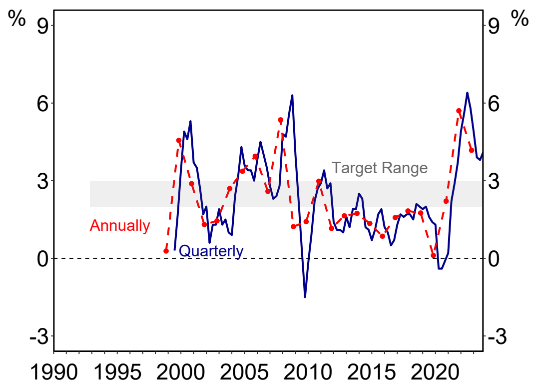
See Figures A1 - A6.

Figure A1: Domestic Prices

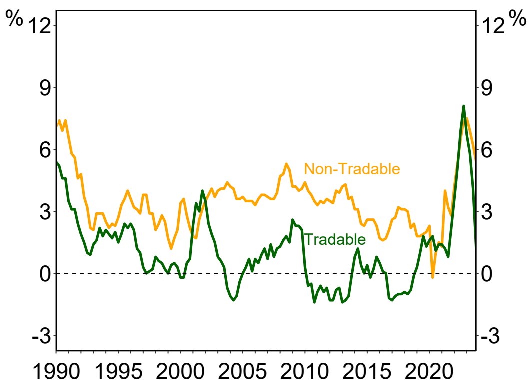
(a) CPI Inflation



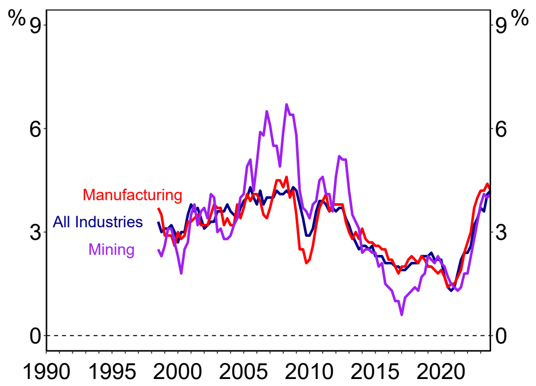
(b) PPI Inflation



(c) Tradable and Non-tradable CPI Inflation
(Quarterly)



(d) Wage Growth
(Quarterly)

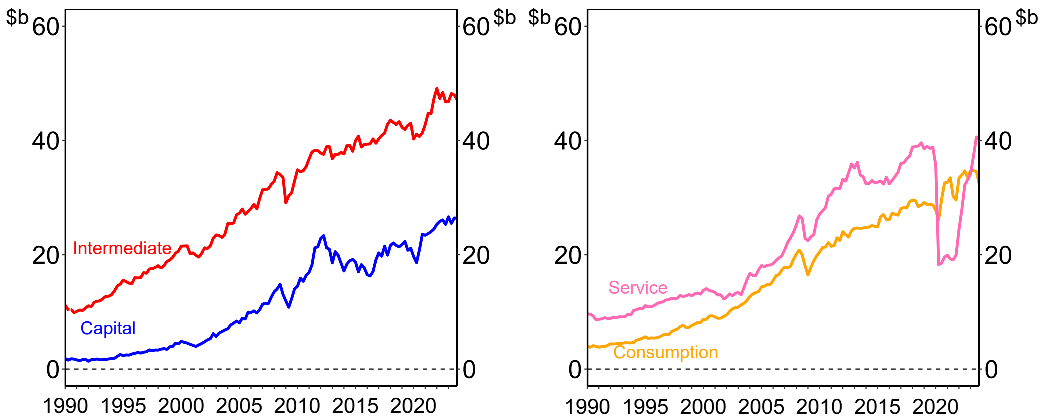


Notes: CPI inflation is headline inflation (excl. interest charges and the tax changes). PPI inflation is producer price inflation of the output price index. Tradable CPI inflation excludes volatile items and tobacco. Non-tradable CPI inflation excludes interest charges and deposit & loan facilities. Wage growth is the annual change in ordinary time hourly rates of pay, excluding bonuses. The shaded grey area in panels (a) and (b) presents the RBA's inflation target band. Annual CPI and PPI inflation rates are the YoY percentage changes in the annual averages of quarterly CPI and PPI.

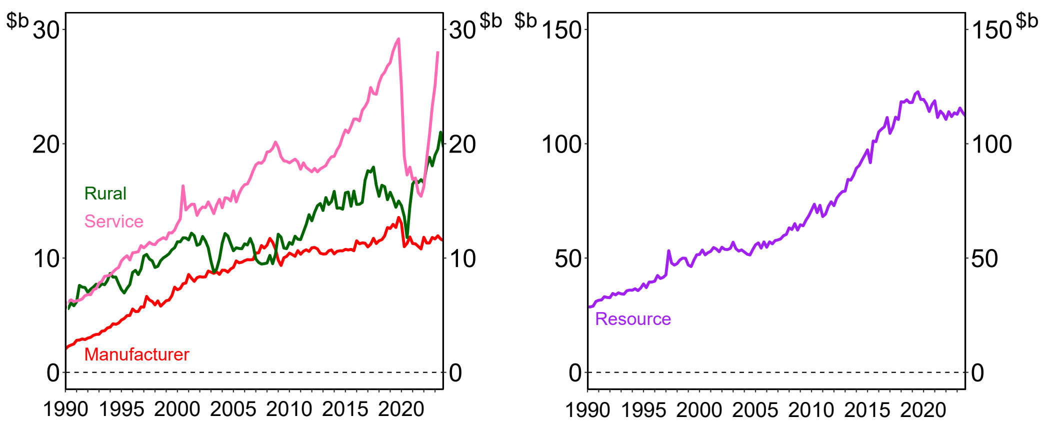
Sources: ABS; RBA; and authors' calculation

FIGURE A2: TRADE VOLUMES

(a) Import Volumes
(Quarterly)



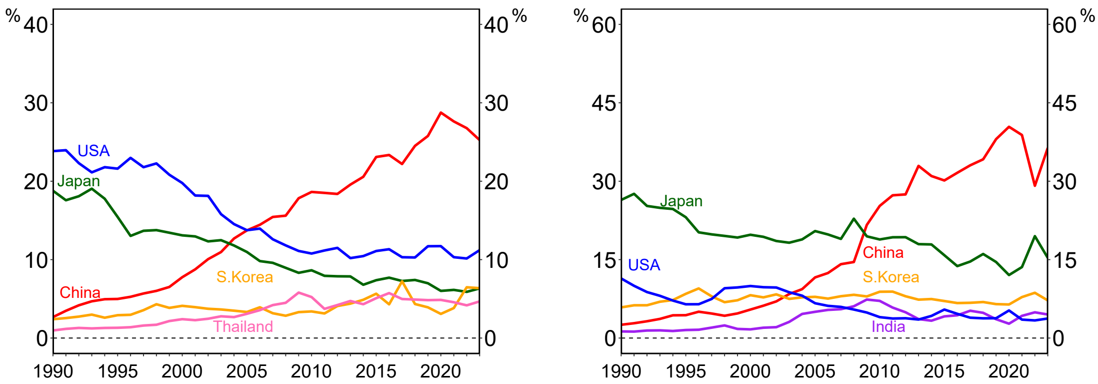
(b) Export Volumnes
(Quarterly)



Sources: ABS; RBA

Figure A3: Bilateral Trade

(a) Merchandise Import Shares (Annual) | (b) Merchandise Export Shares (Annual)

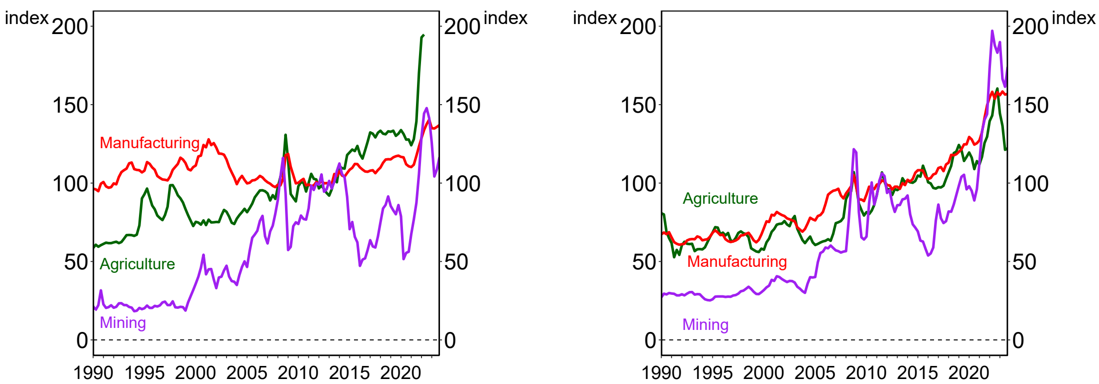


Notes: Share of total values. Annual series are aggregated from monthly data. Merchandise import values are on a customs-value basis; merchandise export values are on an FOB basis. China excludes Hong Kong and Macao SARs and Taiwan. S. Korea denotes South Korea.

Sources: ABS; and authors' calculations

Figure A4: Trade Prices

(a) Import Price Index (Quarterly) | (b) Export Price Index (Quarterly)



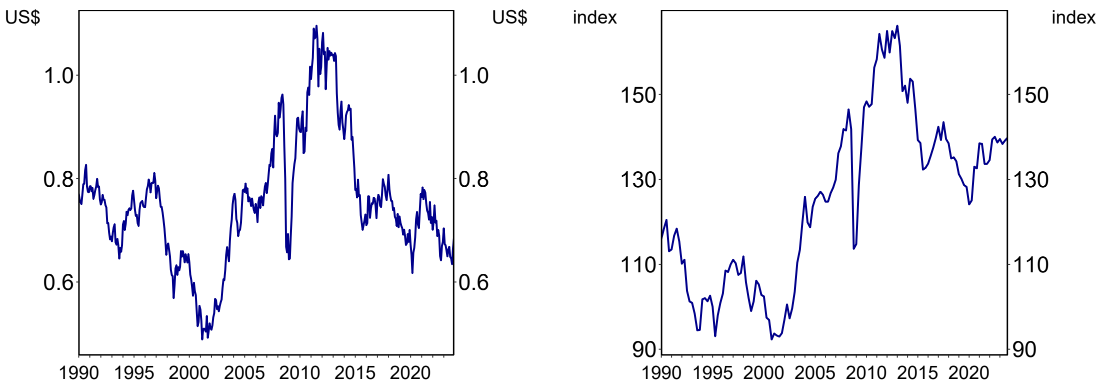
Notes: Agriculture includes agriculture, forestry, and fishing.

Sources: ABS

Figure A5: Australian Dollar

(a) Nominal USD/AUD
(Monthly)

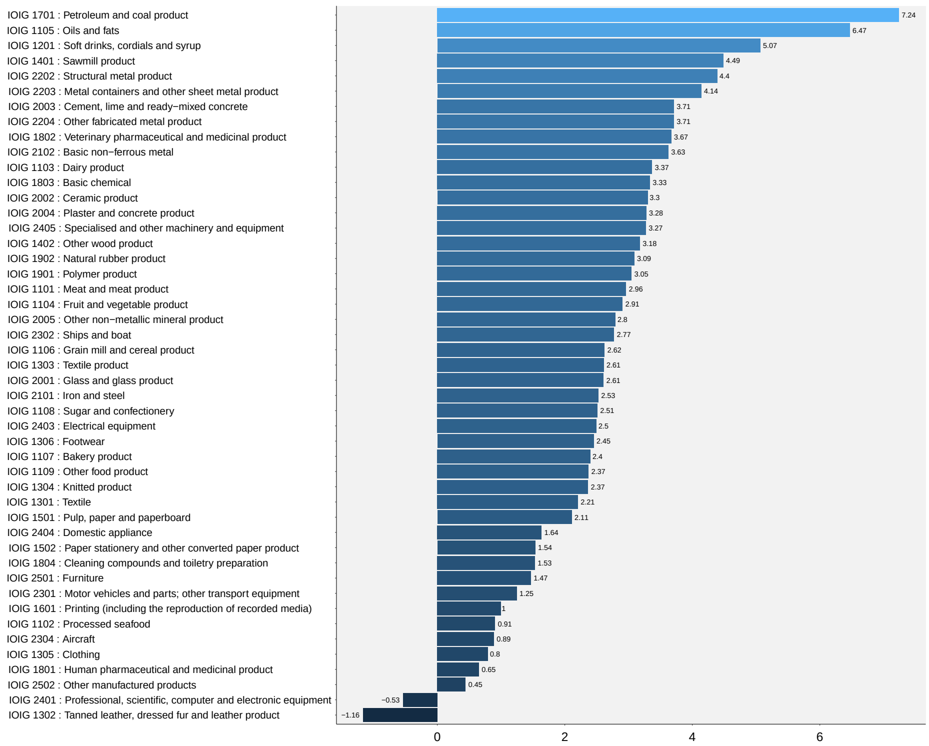
(b) Real Trade-weighted Index
(Quarterly)



Notes: Nominal USD/AUD is A$ 1 = US$. Trade-weighted exchange rate index is adjusted for relative consumer price levels, March 1995=100.

Sources: RBA; OECD; WM/Reuters

Figure A6: Average PPI Inflation in IOIG Manufacturing Industries
(%, 2000-2023)



Sources: ABS and authors' calculations.

Appendix B Table of Notations

See Table B1.

TABLE B1: TABLE OF NOTATIONS

Name	Notation	Expression	Matrix Form
I. Economy-wide Variables			
GDP	Y		
Aggregate price	P_C		
II. GDP-based Shares			
Domar weight	s_i^y	$p_i y_i / Y$	S_y
Domestic good consumption share	s_i^c	$p_i c_i / Y$	S_c
Imported good consumption share	$s_i^{c^*}$	$p_i^* c_i^* / Y$	S_{c^*}
Export share	s_i^e	$p_i e_i / Y$	S_e
III. Sectoral Shares			
Domestic input elements	a_{ij}	$p_j x_{ij} / (p_i y_i)$	A
Domestic output elements	b_{ij}	$p_j x_{ij} / (p_j y_j)$	B
Imported input elements	a_{im}	$p_m x_{im} / (p_i y_i)$	A^*
Labor share to output	α_i^l	$w_i l_i / (p_i y_i)$	α_l
Consumption share to output	α_i^c	$p_i c_i / (p_i y_i)$	α_c
Export share to output	α_i^e	$p_i e_i / (p_i y_i)$	α_e
Steady state leisure to labor	π_i	$(1 - l_i)/l_i$	π

Appendix C Optimization Problems

Firms

The Lagrangian for the firm's cost minimization problem:

$$\begin{aligned} &\mathfrak{L}\left(\{x_{in}\}_{n=1}^N, \{x_{im}\}_{m=1}^M, \{l_i\}_{i=1}^N\right) \\ &= z_i l_i^{\alpha_i^l} \prod_{n=1}^N x_{in}^{a_{in}} \prod_{m=1}^M x_{im}^{a_{im}} + \lambda \left(y_i - \sum_{n=1}^N p_n x_{in} - \sum_{m=1}^M p_m x_{im} \right) \end{aligned} \tag{C1}$$

where λ is a Lagrangian multiplier. The first-order conditions with respect to x_{in}, x_{im} and l_i are respectively:

$$p_n = \frac{1}{\lambda}\frac{a_{in}}{x_{in}} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{a_{in}}{x_{in}} y_i \tag{C2}$$

$$p_m = \frac{1}{\lambda}\frac{a_{im}}{x_{im}} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{a_{im}}{x_{im}} y_i \tag{C3}$$

$$w_i = \frac{1}{\lambda}\frac{\alpha_i^l}{l_i} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{\alpha_i^l}{l_i} y_i \tag{C4}$$

Immediately,

$$x_{in} = \frac{a_{in} y_i}{p_n \lambda}, \quad x_{im} = \frac{a_{im} y_i}{p_m \lambda}, \quad l_i = \frac{\alpha_i^l y_i}{w_i \lambda} \tag{C5}$$

Substituting them into the production function yields:

$$y_i = z_i \left(\frac{\alpha_i^l y_i}{w_i \lambda}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{a_{in} y_i}{p_n \lambda}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{a_{im} y_i}{p_m \lambda}\right)^{a_{im}} \tag{C6}$$

Thus,

$$\lambda = z_i \left(\frac{\alpha_i^l}{w_i}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{a_{in}}{p_n}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{a_{im}}{p_m}\right)^{a_{im}} \tag{C7}$$

Substituting λ into the demand function yields:

$$x_{in} = \frac{a_{in} y_i}{p_n \lambda} = \frac{a_{in} y_i}{p_n}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C8}$$

$$x_{im} = \frac{a_{im} y_i}{p_m \lambda} = \frac{a_{im} y_i}{p_m}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C9}$$

$$l_i = \frac{\alpha_i^l y_i}{w_i \lambda} = \frac{\alpha_i^l y_i}{w_i}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C10}$$

Therefore,

$$p_n x_{in} = a_{in}\frac{y_i}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C11}$$

$$p_m x_{im} = a_{im}\frac{y_i}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C12}$$

$$w_i l_i = \alpha_i^l\frac{y_i}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{C13}$$

The cost function is

$$\begin{aligned} v_i^y &= \sum_{n=1}^{N} p_n x_{in} + \sum_{m=1}^{M} p_m x_{im} + w_i l_i \\ &= \left[\sum_{n=1}^{N} a_{in} + \sum_{m=1}^{M} a_{im} + \alpha_i^l\right]\left[\frac{y_i}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l}\prod_{n=1}^{N}\left(\frac{p_n}{a_{in}}\right)^{a_{in}}\prod_{m=1}^{M}\left(\frac{p_m}{a_{im}}\right)^{a_{im}}\right] \\ &= \frac{y_i}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l}\prod_{n=1}^{N}\left(\frac{p_n}{a_{in}}\right)^{a_{in}}\prod_{m=1}^{M}\left(\frac{p_m}{a_{im}}\right)^{a_{im}} \end{aligned} \tag{C14}$$

Immediately, the marginal cost function is

$$v_i = \frac{dv_i^y}{dy_i} = \frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l}\prod_{n=1}^{N}\left(\frac{p_n}{a_{in}}\right)^{a_{in}}\prod_{m=1}^{M}\left(\frac{p_m}{a_{im}}\right)^{a_{im}} \tag{C15}$$

Households

The Lagrangian for the household's utility maximization problem is

$$\mathfrak{L}\left(\{c_n\}_{n=1}^{N}, \{c_m\}_{m=1}^{M}, \{l_n\}_{n=1}^{N}\right) \tag{C16}$$

$$= \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{1/\rho} + \lambda\left(\sum_{n=1}^{N} w_n l_n - \sum_{n=1}^{N} p_n c_n - \sum_{m=1}^{M} p_m c_m\right)$$

The first-order conditions with respect to c_n, c_m are:

$$p_n = \frac{\beta_n c_n^{-(1-\rho)}}{\lambda}\left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{\frac{1-\rho}{\rho}} \tag{C17}$$

$$p_m = \frac{\beta_m c_m^{-(1-\rho)}}{\lambda}\left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{\frac{1-\rho}{\rho}} \tag{C18}$$

$$\lambda = \frac{\beta_n c_n^{-(1-\rho)}\left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{\frac{1-\rho}{\rho}}}{p_n} \tag{C19}$$

Immediately,

$$\frac{p_{n=1} c_{n=1}^{1-\rho}}{\beta_{n=1}} = \dots = \frac{p_{n=N} c_{n=N}^{1-\rho}}{\beta_{n=N}} = \frac{p_{m=1} c_{m=1}^{1-\rho}}{\beta_{m=1}} = \dots = \frac{p_{m=M} c_{m=M}^{1-\rho}}{\beta_{m=M}} \tag{C20}$$

Combining the above equations with the budget constraint yields:

$$c_n = \frac{\left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} \sum_{n=1}^{N} w_n l_n}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \tag{C21}$$

Thus,

$$\frac{p_n c_n}{Y} = \frac{p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)}}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \tag{C22}$$

$$s_n^c = \frac{p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)}}{P_C^{-\rho/(1-\rho)}} = \left(\frac{p_n^{-\rho}\beta_n}{P_C^{-\rho}}\right)^{1/(1-\rho)} = (p_n^{-\rho}\beta_n P_C^{\rho})^{1/(1-\rho)} \tag{C23}$$

where consumption share $s_n^c = \frac{p_n c_n}{Y}$. Log-linearizing:

$$\hat{s}_n^c = \frac{\rho}{1-\rho}\left(-\hat{p}_n + \hat{P}_C\right) \tag{C24}$$

Log-linearizing the aggregate price in (23) yields:

$$\begin{aligned} \hat{P}_C &= \sum_{n=1}^{N} \frac{\beta_n^{1/(1-\rho)} p_n^{-\rho/(1-\rho)}}{P_C^{-\rho/(1-\rho)}}\hat{p}_n - \sum_{m=1}^{M} \frac{\beta_m^{1/(1-\rho)} p_m^{-\rho/(1-\rho)}}{P_C^{-\rho/(1-\rho)}}\hat{p}_m \\ &= \sum_{n=1}^{N} s_n^c \hat{p}_n + \sum_{m=1}^{M} s_m^c \hat{p}_m \end{aligned} \tag{C25}$$

In matrix form,

$$\hat{P}_C = S_c^T \hat{P} + S_{c^*}^T \hat{P}^* \tag{C26}$$

The first-order condition with respect to l_n is

$$\lambda w_n = \beta_n^l (1-l_n)^{-(1-\rho)} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^{\rho} + \sum_{n=1}^{N} \beta_n c_n^{\rho} + \sum_{m=1}^{M} \beta_m c_m^{\rho}\right)^{\frac{1-\rho}{\rho}} \tag{C27}$$

Combining the above equation and (C19) yields:

$$\frac{\beta_n^l}{(1-l_n)^{(1-\rho)}} = \frac{w_n \beta_n}{c_n^{(1-\rho)} p_n} \tag{C28}$$

We also have:

$$\begin{aligned} c_n^{1-\rho} p_n &= \frac{\beta_n (\sum_{n=1}^{N} w_n l_n)^{1-\rho}}{\left(\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}\right)^{1-\rho}} \\ &= \beta_n Y^{1-\rho} P_C^{\rho} \end{aligned} \tag{C29}$$

Substitute into (C28):

$$\frac{\beta_n^l}{(1-l_n)^{(1-\rho)}} \quad = \quad \frac{w_n}{Y^{1-\rho} P_C^{\rho}} \tag{C30}$$

The optimal labor supply is:

$$l_n = 1 - \frac{\left(\beta_n^l\right)^{1/(1-\rho)} Y P_C^{\rho/(1-\rho)}}{w_n^{1/(1-\rho)}} \tag{C31}$$

Log-linearizing (C30):

$$\frac{l_n}{1-l_n}\hat{l}_n \quad = \quad \frac{1}{1-\rho}\hat{w}_n - \frac{\rho}{1-\rho}\hat{P} - \hat{Y} \tag{C32}$$

Thus,

$$\hat{l}_n \quad = \quad \frac{1}{1-\rho}\frac{1-l_n}{l_n}\hat{w}_n - \frac{\rho}{1-\rho}\frac{1-l_n}{l_n}\hat{P}_C - \frac{1-l_n}{l_n}\hat{Y} \tag{C33}$$

In matrix form,

$$\begin{aligned} \hat{L} \quad &= \quad \frac{1}{1-\rho} D_\pi \hat{W} - \frac{\rho}{1-\rho} V_\pi \hat{P}_C - V_\pi \hat{Y} \\ &= \quad \frac{1}{1-\rho} D_\pi \hat{W} - \frac{\rho}{1-\rho} V_\pi (S_c^T \hat{P} + S_{c^*}^T \hat{P}^*) - V_\pi \hat{Y} \end{aligned} \tag{C34}$$

where

$$\pi_n = \frac{1-l_n}{l_n}, \quad V_\pi = (\pi_n) \tag{C35}$$

From the market-clearing condition (27), we have:

$$\frac{p_i y_i}{Y} = \sum_{j=1}^{N} \frac{p_i x_{ji}}{Y} + \frac{p_i c_i}{Y} + \frac{p_i g_i}{Y} + \frac{p_i e_i}{Y} \tag{C36}$$

We have defined $x_{ji} = \frac{p_j y_j a_{ji}}{p_i}$ and consumption share $s_i^c = \frac{p_i c_i}{Y}$, now denote export share $s_i^e = \frac{p_i e_i}{Y}$, then:

$$s_i^y = \sum_{j=1}^{N} \frac{p_j y_j}{Y} a_{ji} + s_i^c + s_i^e = \sum_{j=1}^{N} s_j^y a_{ji} + s_i^c + s_i^e \tag{C37}$$

Log-linearization yields:

$$\hat{s}_i^y = \frac{1}{s_i^y}\left[\sum_{j=1}^{N} a_{ji} s_j^y \hat{s}_j^y + s_i^c \hat{s}_i^c + s_i^e \hat{s}_i^e\right] \tag{C38}$$

We further define

$$b_{ji} = a_{ji}\frac{s_j^y}{s_i^y} = \frac{a_{ji}p_jy_j}{p_iy_i} = \frac{p_ix_{ji}}{p_iy_i} \tag{C39}$$

measures the share of output in industry i used in industry j to the output of industry i. So,

$$\begin{aligned}\hat{s}_i^y &= \sum_{j=1}^{N} b_{ji}\hat{s}_j^y + \frac{s_i^c}{s_i^y}\hat{s}_i^c + \frac{s_i^e}{s_i^y}\hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji}\hat{s}_j^y + \alpha_i^c\hat{s}_i^c + \alpha_i^e\hat{s}_i^e \end{aligned} \tag{C40}$$

where industry-level shares of consumption and export are $\alpha_i^c = \frac{p_ic_i}{p_iy_i}$, $\alpha_i^e = \frac{p_ie_i}{p_iy_i}$, respectively.

Thus,

$$\begin{aligned}\hat{s}_i^y &= \sum_{j=1}^{N} b_{ji}\hat{s}_j^y + \alpha_i^c\hat{s}_i^c + \alpha_i^e\hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji}\hat{s}_j^y - \frac{\rho}{1-\rho}\alpha_i^c\hat{p}_i + \frac{\rho}{1-\rho}\alpha_i^c(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*) + \alpha_i^e\hat{s}_i^e \end{aligned} \tag{C41}$$

In matrix form,

$$\hat{S}_y = (I - B^T)^{-1}\left[-\frac{\rho}{1-\rho}D_{\alpha_c}\hat{P} + \frac{\rho}{1-\rho}V_{\alpha_c}(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*) + D_{\alpha_e}\hat{S}_e\right] \tag{C42}$$

Appendix D Proofs of Propositions

Proof of Proposition 1

Substitute $\hat{S}_y$ in (C42) and $\hat{L}$ in (C34) into (17) yields:

$$\begin{aligned}\hat{W} &= D_{\alpha_l}\hat{W} + V_1\hat{Y} - \hat{Z} - (I-A)\hat{P} + A^*\hat{P}^* - \hat{L} + \hat{S}_y \\ &= D_{\alpha_l}\hat{W} + V_1\hat{Y} - \hat{Z} - (I-A)\hat{P} + A^*\hat{P}^* \\ &\quad -\left[\frac{1}{1-\rho}D_\pi\hat{W} - \frac{\rho}{1-\rho}V_\pi\left(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*\right) - V_\pi\hat{Y}\right] \\ &\quad +[I-B^T]^{-1}\left[-\frac{\rho}{1-\rho}D_{\alpha_c}\hat{P} + \frac{\rho}{1-\rho}V_{\alpha_c}\left(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*\right) + D_{\alpha_e}\hat{S}_e\right] \end{aligned} \tag{D1}$$

Denote $D_{\alpha\pi} = D_{\alpha_l}\left[I - D_{\alpha_l} + \frac{1}{1-\rho}D_\pi\right]^{-1}$, and substitute in the price function (9):

$$
\begin{aligned}
\hat{P} \quad = \quad & -(I-A)^{-1}\Big(I + D_{\alpha\pi}\Big)\hat{Z} + (I-A)^{-1}D_{\alpha\pi}\Big(V_1 + V_\pi\Big)\hat{Y} \\
& +(I-A)^{-1}D_{\alpha\pi}\Bigg[-(I-A) - \frac{(}{I} - B^T)^{-1}V_{\alpha_c}\left(V_1^T - S_c^T\right) + \frac{\rho}{1-\rho}V_\pi S_c^T\Bigg]\hat{P} \\
& +(I-A)^{-1}D_{\alpha\pi}\Bigg[\Big(D_{\alpha\pi}^{-1} + I\Big)A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1}V_{\alpha_c}S_{c^*}^T + \frac{\rho}{1-\rho}V_\pi S_{c^*}^T\Bigg]\hat{P}^* \\
& +(I-A)^{-1}D_{\alpha\pi}(I-B^T)^{-1}D_{\alpha_e}\hat{S}_e
\end{aligned}
\tag{D2}
$$

Thus,

$$
\hat{P} = (I - Q_p)^{-1}\left[-Q_z\hat{Z} + Q_y\hat{Y} + Q_{p^*}\hat{P}^* + Q_e\hat{S}_e\right], \tag{D3}
$$

where

$$
\begin{aligned}
Q_p &= -D_{\alpha\pi} - \frac{\rho}{1-\rho}(I-A)^{-1}D_{\alpha\pi}\Bigg[(I-B^T)^{-1}V_{\alpha_c}\left(V_1^T - S_c^T\right) - V_\pi S_c^T\Bigg], \\
Q_z &= (I-A)^{-1}\Big(I + D_{\alpha\pi}\Big), \\
Q_y &= (I-A)^{-1}D_{\alpha\pi}\Big(V_1 + V_\pi\Big), \\
Q_{p^*} &= (I-A)^{-1}\left(I + D_{\alpha\pi}\right)A^* + \frac{\rho}{1-\rho}(I-A)^{-1}D_{\alpha\pi}\Bigg[(I-B^T)^{-1}V_{\alpha_c}S_{c^*}^T + V_\pi S_{c^*}^T\Bigg], \\
Q_e &= (I-A)^{-1}D_{\alpha\pi}(I-B^T)^{-1}D_{\alpha_e}, \\
D_{\alpha\pi} &= D_{\alpha_l}\left[I - D_{\alpha_l} + \frac{1}{1-\rho}D_\pi\right]^{-1}
\end{aligned}
$$

Proof of Proposition 2

The sensitivity of the industrial price to the industrial import price shock is

$$
\begin{aligned}
\frac{\partial \hat{P}}{\partial \hat{P}^*} &= Q_p^{-1} Q_{p^*} \\
&= \left\{ I + (I-A)^{-1} D_{\alpha\pi} \times \left[-(I-A) - \frac{\rho}{1-\rho}(I-B^T)^{-1} V_{\alpha_c} \left(V_1^T - S_c^T \right) + \frac{\rho}{1-\rho} V_\pi S_c^T \right] \right\} \\
&\quad \times \left\{ (I-A)^{-1} D_{\alpha\pi} \left[\left(D_{\alpha\pi}^{-1} + I \right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V_{\alpha_c} S_{c^*}^T + \frac{\rho}{1-\rho} V_\pi S_{c^*}^T \right] \right\} \\
&\quad + \text{Higher order} \\
&= \frac{\rho}{1-\rho}(A-I)\left(V_{\alpha_c} + V_\pi \right) S_{c^*}^T + \frac{\rho}{1-\rho}(B^T - I) V_{\alpha_c} S_{c^*}^T \\
&\quad + \left[\left(D_{\alpha\pi}^{-1} + I \right) A^* + \frac{\rho}{1-\rho}\left(3V_{\alpha_c} + 2V_\pi \right) S_{c^*}^T \right] + \text{Higher order} \qquad \text{(D4)}
\end{aligned}
$$

Proof of Proposition 3

The sensitivity of the industrial price to the industrial export quantity shock is

$$
\begin{aligned}
\frac{\partial \hat{P}}{\partial \hat{S}_e} &= Q_p^{-1} Q_e \\
&= \left\{ I + (I-A)^{-1} D_{\alpha\pi} \times \left[-(I-A) - \frac{\rho}{1-\rho}(I-B^T)^{-1} V_{\alpha_c} \left(V_1^T - S_c^T \right) + \frac{\rho}{1-\rho} V_\pi S_c^T \right] \right\} \\
&\quad \times \left\{ (I-A)^{-1} D_{\alpha\pi} (I-B^T)^{-1} D_{\alpha_e} \right\} + \text{Higher order} \\
&= (A-I) D_{\alpha\pi} D_{\alpha_e} + D_{\alpha\pi}(B^T - I) D_{\alpha_e} + 3 D_{\alpha\pi} D_{\alpha_e} + \text{Higher order} \qquad \text{(D5)}
\end{aligned}
$$

Appendix E Instrumental Variables Diagnostics

This section reports tests of the validity of instruments for import and export shocks, identified in Section 4.3. Instrument relevance is evaluated using the first-stage estimates from the 2SLS regressions (Table E1) and the joint significance tests of the instruments' effects on the endogenous shocks. Instrument strength is assessed using the identifiability test of Cragg and Donald (1993), which is widely used in linear instrumental-variable models to detect weak instruments.

Recall that the import price shocks are instrumented by the ratio of the import value to the import volume from China to the United Sates. The results of the first-stage regressions indicate that the instruments are statistically significant predictors of the

Table E1: First Stage of 2SLS Estimations

	Import Price Shocks (AUD)				Export Quantity Shocks		
	O^{MP}, L1	U^{MP}, L1	D^{MP}, L1		O^{EQ}, L1	U^{EQ}, L1	D^{EQ}, L1
$O^{IV_{MP}}$, L1	-0.312***	0.206**	0.182*	$O^{IV_{EQ}}$, L1	-0.092	0.167	0.278
	(0.101)	(0.098)	(0.100)		(0.289)	(0.278)	(0.286)
$O^{IV_{MP}}$, L2	-0.045	0.061	0.061	$O^{IV_{EQ}}$, L2	-0.241	0.192	0.175
	(0.103)	(0.100)	(0.101)		(0.303)	(0.292)	(0.299)
$U^{IV_{MP}}$, L1	-0.288**	0.197	0.329***	$U^{IV_{EQ}}$, L1	-0.095	0.184	-0.028
	(0.129)	(0.125)	(0.127)		(0.347)	(0.334)	(0.343)
$U^{IV_{MP}}$, L2	-0.188	0.206	0.129	$U^{IV_{EQ}}$, L2	-0.190	0.152	0.121
	(0.131)	(0.127)	(0.128)		(0.359)	(0.346)	(0.355)
$D^{IV_{MP}}$, L1	-0.023	0.007	-0.153**	$D^{IV_{EQ}}$, L1	-0.039	0.035	0.348***
	(0.071)	(0.069)	(0.070)		(0.103)	(0.100)	(0.102)
$D^{IV_{MP}}$, L2	0.044	-0.049	0.029	$D^{IV_{EQ}}$, L2	-0.057	0.049	0.065
	(0.072)	(0.070)	(0.071)		(0.102)	(0.098)	(0.101)
N	957	957	957	N	947	947	947

Notes: The instruments of decomposed trade shocks are identified as in Section 4.3. The variables O^x, U^x, D^x denote endogenous trade shocks measured by trade values; and $O^{IV_x}, U^{IV_x}, D^{IV_x}$ are their corresponding instruments. The notations of other terms are as those in Table 1.

endogenous regressors. The joint hypothesis test rejects the null of no instrument relevance with a *p*-value of 0.0074, and the Cragg–Donald F-statistic of 14.42 exceeds the conventional threshold of 10, suggesting that the instruments are sufficiently strong in this case.

However, the results for export shocks are more tentative. The instruments for export quantity shocks, based on the average export quantity to China from its five largest suppliers, are not statistically relevant for Australia–China trade shocks. This is likely due to the relatively small share of manufacturing in Australia's total exports. Therefore, as mentioned in the main text, we interpret the 2SLS estimates as suggestive. The main conclusions of the paper rest on the baseline estimates, complemented by robustness specifications.