Australian National University

Crawford School of Public Policy

CAMA

Centre for Applied Macroeconomic Analysis

The Trade-Inflation Nexus: The Role of Production Networks

CAMA Working Paper 23/2025
April 2025

Thuy Hang Duong
Centre for Applied Macroeconomic Analysis, ANU

Weifeng Larry Liu
Centre for Applied Macroeconomic Analysis, ANU
Reserve Bank of Australia

Abstract

From the 1990s until COVID-19, 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 production networks. We first construct a theoretical model of an open economy to illustrate how 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 increasing exposure to China's low-cost exports, while inflation surged during COVID due to global supply chain disruptions, among other factors. This paper underscores the importance of economic globalization for inflation through production networks, and offers several implications for monetary and trade policies.

Keywords

inflation, international trade, production networks, propagation of shocks

JEL Classification

C67, D57, E31, F13, F41

Address for correspondence:

(E) cama.admin@anu.edu.au

ISSN 2206-0332

The Centre for Applied Macroeconomic Analysis in the Crawford School of Public Policy has been established to build strong links between professional macroeconomists. It provides a forum for quality macroeconomic research and discussion of policy issues between academia, government and the private sector.

The Crawford School of Public Policy is the Australian National University's public policy school, serving and influencing Australia, Asia and the Pacific through advanced policy research, graduate and executive education, and policy impact.

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

Thuy Hang Duong[1] and Weifeng Larry Liu[1,2]

[1]Centre for Applied Macroeconomic Analysis, Australian National University
[2]Economic Analysis Department, Reserve Bank of Australia

April 2025

Abstract

From the 1990s until COVID-19, 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 production networks. We first construct a theoretical model of an open economy to illustrate how 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 increasing exposure to China's low-cost exports, while inflation surged during COVID due to global supply chain disruptions, among other factors. This paper underscores the importance of economic globalization for inflation through production networks, and offers several implications for monetary and trade policies.

Keywords: Inflation, international trade, production networks, propagation of shocks

JEL Classification: C67, D57, E31, F13, F41

*We would like to thank Warwick McKibbin, Renée Fry-McKibbin, Blane Lewis and seminar participants at the Australian National University for their valuable comments. The views expressed in this paper are those of the authors and should not be attributed to the Reserve Bank of Australia. All errors are our own. Duong gratefully acknowledges financial support from the Australian Government Research Training Program Scholarship. E-mail: hang.duong@anu.edu.au; larry.wf.liu@anu.edu.au.

1 Introduction

Since the early 1990s, the world has experienced a sustained period of low and stable inflation. This prolonged stability was partially attributed to rapid globalization, which intensified the interdependence of production processes across countries. The interdependence became particularly pronounced following 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 more stable inflationary environment worldwide. However, this era of stability was markedly disrupted by the COVID-19 pandemic, after which inflation in many advanced economies surged to unprecedented levels in the last three decades. This surge was partly driven by supply chain disruptions, among other factors such as expansionary fiscal and monetary policies, and geopolitical tensions. The efforts to contain the pandemic resulted in severe disruptions to global production. As economies reopened, constraints on supply chains, combined with the recovery in demand, further exacerbated inflationary pressure.

Price effects through international trade have long been a central focus in open economy macroeconomics. There are various mechanisms through which trade openness can influence 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 (steeper Phillips curves) through exchange rates, reducing central banks' incentives to engineer surprise expansionary monetary policy (Romer 1993); exchange rate movements directly affect domestic prices of imported goods. These mechanisms primarily focus on final consumption or aggregate production, with limited attention given to the role of intermediate goods in production processes.

The critical role of production networks in propagating economic shocks has garnered growing attention (Acemoglu et al., 2012; Di Giovanni and Levchenko, 2010; Baqaee and Farhi, 2019; Barrot and Sauvagnat, 2016; Carvalho, 2014). This perspective rests on the network of transactions among numerous suppliers and customers in production processes. Disruptions to specific firms or industries can spread through input-output (IO) linkages, potentially turning localized microeconomic shocks into widespread macroeconomic fluctuations. This strand of studies focuses on the impacts of economic shocks on labor markets and aggregate output in closed economies. Our study extends the network approach to explore the classic trade-inflation topic. In an open economy, global demand and supply shocks can be transmitted and amplified by the domestic IO structure, as industries are interconnected not only through direct global trade linkages but also through intermediate IO relationships within domestic production.

To examine the price effects of trade shocks, we first develop a theoretical IO model of a small open economy with multiple sectors. Firms within each industry use both domestic and foreign inputs for production, with output used as inputs for other industries, consumed by households and the government, or exported to other countries. The model identifies direct and indirect channels through which international trade affects domestic inflation. In an open economy with production networks, import shocks directly influence prices through the costs of imported inputs. Export shocks directly affect prices through changes in external demand and induced labor costs. These effects are then transmitted to prices across industries through IO linkages.

Empirically, we quantify the impact of production networks on producer price inflation using Australian data from 47 manufacturing industries over the period of 2000-2023. The analysis focuses on bilateral trade between Australia and China. The empirical results support theoretical findings and reveals 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. Specially, a one-standard-deviation increase in import values raises inflation by 16.9% over two years through direct shocks and by 18.1% through the propagation of variations toward upstream industries. In contrast, a one-standard-deviation increase in export values leads to a decline in inflation by 2.2% and 2.4% through the direct and upstream channels, respectively. The contributions of downstream shock propagation remain negligible across various specifications. These responses of prices to trade shocks remain consistent when trade shocks are calculated from import prices and export quantity instead of trade values. The exchange rate effects are consistently negative but only statistically significant in the initial stage of propagation. We also examine potential changes in the price effects of trade shocks due to COVID disruptions. The network effects on inflation robustly dominated direct effects both before and after the pandemic. The indirect effects were strengthened after the pandemic.

This paper engages with several strands of literature. First, it contributes to the long-standing literature on mechanisms through which trade openness affects inflation, including its impacts on consumption, productivity, and monetary policy, as mentioned earlier. Empirical evidence, mainly based on aggregate data, remains mixed on the direction and magnitude of this relationship (Terra, 1998; Bowdler and Nunziata, 2006; Wynne and Kersting, 2007; Aron and Muellbauer, 2007; Cooke, 2010; Samimi et al., 2012). This study complements the traditional literature by examining the channel of domestic production networks, distinguishing between final consumption goods and intermediate production goods.

Second, this study aligns with the network literature on how firm and industry interconnections transmit microeconomic shocks to macroeconomic fluctuations. The literature suggests that small idiosyncratic shocks can persist and cause significant aggregate fluctuations in interconnected networks (Acemoglu et al., 2012, 2015, 2016a, 2017), highlighting the critical role of production networks in shock propagation. Empirical evidence supports the hypothesis (Acemoglu et al., 2016a,b; Di Giovanni and Levchenko, 2010; Di Giovanni et al., 2014; Carvalho, 2014; Barrot and Sauvagnat, 2016; Baqaee and Farhi, 2019; Luo, 2020). These studies focus on fluctuations in aggregate employment and output in closed economies. Our paper extends this network literature by investigating how trade shocks affect prices through production networks. Several studies examine the propagation of trade shocks to inflation through global IO linkages, 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). We examine not only the direct price effects of trade shocks via global supply chains but also the indirect price effects transmitted through domestic production networks. Silva (2024) develops a small open economy model with domestic IO linkages, and empirically illustrates the importance of domestic production networks on inflation during the COVID period in Chile and the United Kingdom. Our theoretical model is closely related to his small open-economy model, but differs by endogenizing wages and domestic prices as well as distinguishing upstream and downstream effects of trade shocks. These features enable us to examine how domestic IO interdependence drives heterogeneous price responses to international trade fluctuations.

Third, our empirical analysis of trade shocks originating from China relates to the literature on the impacts of China's global trade integration on its trading partners. Most empirical studies focus on large economies, particularly the United States. For example, Autor et al. (2013, 2016, 2021) find large negative impacts of Chinese imports on US manufacturing labor markets. Luo and Villar (2023) show that import exposure significantly affects US producer prices through production networks. Jaravel and Sager (2019) find that increased trade with China substantially reduced U.S. consumer prices, primarily by lowering markups on domestically produced goods. However, evidence on macroeconomic adjustments in small open economies, such as Australia, remains limited. China's rise in international trade has reshaped Australia's trade structures (see Section 2), indicating the importance of the China-Australia trade relationship. While some studies examine Australia's macroeconomic responses to Chinese resource demand (Bjørnland and Thorsrud, 2016; Dungey et al., 2020), this paper extends the literature by examining the impact of industry-level shocks from Chinese imports and exports on manufacturing prices in Australia.

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 of 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 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 as a case study, this section provides an overview of its inflation dynamics and trade patterns from 1990 to 2023, categorized into four episodes, with supporting data presented in Appendix A.

1990s: Declining Inflation and Increasing Economic Integration

Following the sharp economic contraction in the 1991 recession, Australia's inflation rate plunged from 6.9% to 1.2% between 1992 and 1993. To counter deflationary risks, the Reserve Bank of Australia (RBA) introduced an inflation-targeting monetary framework, aiming to stabilize prices within a target range of 2-3%. This policy was successful in averting severe deflation for several years. However, in 1997, deflationary pressures re-emerged driven by the Asian Financial Crisis. The crisis reduced Australia's exports to East Asia and lowered import prices, further intensifying disinflation (Debelle et al., 2018). Throughout this period, tradable and non-tradable inflation remained closely aligned.

Australia expanded economic integration with Asia during this period. Japan and Korea, together with the United States, stood as Australia's largest trading partners. Trade with China was relatively modest but gradually expanded. China's share in both Australian imports and exports remained below 10% throughout the period.

2000s: Low Inflation and Strengthening Trade Ties with China

Australia experienced relatively low inflation leading up to the global financial crisis (GFC) in 2008-2009. This period coincided with a substantial expansion in Australia's trade with China. China's industrialization throughout the 2000s drove its demand for commodities, while it also boosted global manufacturing output by leveraging its comparative advantage in producing lower-cost goods. Australia's imports from China, thus, surged, fueled by China's competitive prices. Concurrently, Australia, rich in natural resources, became a key supplier of iron ore, coal, and liquefied natural gas to China.

Bilateral trade between Australia and China expanded by 10-15% annually. This growth allowed China to surpass Japan and the United States to become Australia's largest trading partner by the end of the decade. While Australia's exports remained predominantly resource-based, imports of capital and intermediate goods from China rose significantly, reflecting China's deeper integration into Australia's supply chain.

China's robust demand for Australian commodities triggered a mining boom, leading to heavy investments in infrastructure, wage growth, and rising construction costs, which increased inflationary pressures. However, improved terms of trade led to an appreciation of the Australian dollar, and the influx of lower-cost imports from China alleviated cost burdens in the manufacturing sector, helping to offset these pressures. Prices for goods and services in Australia remained relatively stable. From 2001 to 2010, including the GFC, the average headline CPI and PPI inflation rates were both 2.8%, staying within the RBA's target range.

2010s: Low Inflation and Chinese Economic Transition

The 2010s saw persistently low inflation, with headline and producer price inflation averaging 2% and 1.7%, slightly below the RBA's target range. This low inflation resulted from a combination of global dis-inflationary synchronization (Ha et al., 2019a) and several domestic factors including low unemployment, weak wage growth, and technological advancements.

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 lower-cost manufacturing goods from China reinforced this trend. Australia's resource exports and capital imports became stable rather than continuing to expand.

2020s: High Inflation and Global Trade Disruptions

Australia, together with other advanced economies, experienced a brief dip in inflation in 2020, followed by a sharp rise from 2021, primarily due to the COVID pandemic. The pandemic caused a contraction in global demand and disrupted supply chains, with falling oil prices and currency depreciation adding to inflation volatility. However, global recovery and rising food and energy prices, exacerbated by the Russia-Ukraine war, pushed inflation to multi-decade highs in the post-COVID period (Ha et al., 2019b).

As a global manufacturing powerhouse, disruptions in China's economic activity during the pandemic significantly impacted global supply chains, particularly in manufacturing sectors. The post-COVID recovery, combined with sustained demand from China, exacerbated shipping bottlenecks and increased input costs, further accelerating recent spikes in global inflation.

China remained Australia's top trading partner. Fluctuations in China's supply and demand in the international goods market continued to influence Australia's import and export dynamics. Trade between the two nations declined, with China's share of Australia's total trade dropping by 7.55% in 2022. Australia's CPI and PPI inflation fell below zero in 2020 but surged to 7.8% and 6.4%, respectively, by late 2022, before moderating in 2023 due to improved trade terms and RBA efforts to control inflation.

Broadly, Australian inflation and trade patterns have moved together over the past three decades, especially in relation to China.

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 notations: 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; $D(\cdot)$ for a diagonal matrix; $V(\cdot)$ for a vector; $\hat{}$ for percent change; * for variables in the rest of the world.

Consider the static state of a small open economy with multiple sectors. 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. There is a representative firm in each industry, a representative household in the economy, and also a government. Total labor force is normalized to one. Labor cannot move across industries as we consider short and medium time horizons, 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. The foreign goods are different from the domestic goods. Even if they fall into the same industry classification, they differ 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.

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 dnotes productivity, and l_i is the labor employed in industry i. x_{in} represents the domestic input produced by industry n in the home economy, while x_{im} is the imported input produced by industry m in the rest of the world. α_i^l, α_{in}, and α_{im} represent the elasticities of output. Specially, α_i^l is the elasticity of the output in industry i to the input labor, a_{in} represents the elasticity of the output in industry i to the input of industry n, and a_{im} represents the elasticity of the output in industry i to the input from imported goods 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:

$$\begin{aligned} v_i^y = & \sum_{n=1}^{N} p_n x_{in} + \sum_{m=1}^{M} p_m x_{im} + w_i l_i & (3) \\ s.t. \quad & y_i = \bar{y}_i & (4) \end{aligned}$$

Thus, 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

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

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,

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

where the vectors of variables represent:

$$\hat{P} = (\hat{p}_i)_N, \quad \hat{P}^* = (\hat{p}_m)_M, \quad \hat{W} = (\hat{w}_i)_N, \quad \hat{Z} = (\hat{z}_i)_N \tag{9}$$

and the matrices of coefficients represent:

$$D(\alpha_l) = (\alpha_i^l)_{N\times N}, \quad A = (a_{ij})_{N\times N}, \quad A^* = (a_{im})_{N\times M} \tag{10}$$

Thus,

$$\hat{P} \quad = \quad (I - A)^{-1}\left[-\hat{Z} + A^*\hat{P}^* + D(\alpha_l)\hat{W}\right] \tag{11}$$

The Cobb-Douglas production functions and cost minimisation problem imply that the elements of the above coefficient matrices are

$$D(\alpha_l) : \alpha_i^l = \frac{w_i l_i}{p_i y_i}, \quad A : a_{ij} = \frac{p_j x_{ij}}{p_i y_i}, \quad A^* : a_{im} = \frac{p_m x_{im}}{p_i y_i} \tag{12}$$

The above matrix A, referred to as the input matrix, has entries a_{ij} capturing sales of industry j to industry i normalized by total sales of industry i. Intuitively, this ratio implies how many dollars worth of sector j's output that sector i needs to purchase to produce one dollar worth of its own output.

We also define an output matrix B with entries b_{ij} capturing the distribution of industry outputs across other industries:

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

where b_{ij} shows sales of industry j to industry i normalized by the total sales of industry j. 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

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

where the Domar weight $s_i^y \equiv \dfrac{p_i y_i}{Y}$, with Y representing GDP. Log-linearizing the above equation yields:

$$\hat{w}_i = \alpha_i^l \hat{w}_i + \hat{Y} - \hat{p}_i - \hat{z}_i + \sum_{n=1}^{N} a_{in}\hat{p}_n + \sum_{m=1}^{M} a_{im}\hat{p}_m - \hat{l}_i + \hat{s}_i^y \tag{15}$$

In matrix form,

$$\hat{W} = D(\alpha_l)\hat{W} + V(1)\hat{Y} - \hat{Z} - (I - A)\hat{P} + A^*\hat{P}^* - \hat{L} + \hat{S}_y \tag{16}$$

where

$$\hat{S}_y = (\hat{s}_n^y)_N, \quad \hat{L} = (\hat{l}_n)_N \tag{17}$$

Households

The representative household has the following constant elasticity of substitution (CES) utility function:

$$u\left(\{c_n\}_{n=1}^{N}; \{c_m\}_{m=1}^{M}; \{l_n\}_{n=1}^{N}\right) = \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{1/\rho} \quad (18)$$

where c_n is final consumption of domestic good n, and c_m is final consumption of foreign good m; $1 - l_n$ represents leisure; β_n^l denotes the weights on leisure, and β_n and β_m denote the weights of domestic and foreign goods respectively. The weights satisfy:

$$\sum_{n=1}^{N} \beta_n^l + \sum_{n=1}^{N} \beta_n + \sum_{m=1}^{M} \beta_m = 1 \quad (19)$$

The consumer earns wage income and pays a lump-sum tax T. The consumer's budget constraint is:

$$\sum_{n=1}^{N} p_n c_n + \sum_{m=1}^{M} p_m c_m = \sum_{n=1}^{N} w_n l_n - T \quad (20)$$

The optimal consumption is derived as:

$$c_i = \frac{\left(\frac{\beta_i}{p_i}\right)^{1/(1-\rho)} \left(\sum_{n=1}^{N} w_n l_n - T\right)}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \quad (21)$$

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

$$P_C = \left[\sum_{n=1}^{N} \beta_n^{\frac{1}{1-\rho}} p_n^{-\frac{\rho}{1-\rho}} + \sum_{m=1}^{M} \beta_m^{\frac{1}{1-\rho}} p_m^{-\frac{\rho}{1-\rho}}\right]^{-\frac{1-\rho}{\rho}} \quad (22)$$

Total output is defined as

$$Y = \sum_{n=1}^{N} p_n c_n + \sum_{m=1}^{M} p_m c_m + \sum_{n=1}^{N} p_n g_n + \sum_{n=1}^{N} p_n e_n \quad (23)$$

The optimal labor supply is:

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

Log-linearizing labor supply yields

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

In matrix form,

$$\hat{L} = \frac{1}{1-\rho} D(\pi)\hat{W} - \frac{\rho}{1-\rho} V(\pi)\hat{P}_C - V(\pi)\hat{Y} \quad (26)$$

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

Government

The government imposes a lump-sum tax, T, to finance its consumption of all goods. The government spending on the output of industry i, g_i, is assumed to be wasted or spent on public goods.

$$T = \sum_{i=1}^{N} p_i g_i \tag{27}$$

The government spending and tax are exogenous.

Equilibrium

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

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

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

$$\frac{p_i y_i}{Y} = \sum_{j=1}^{N} \frac{p_i x_{ji}}{Y} + \frac{p_i c_i}{Y} + \frac{p_i g_i}{Y} + \frac{p_i e_i}{Y} \tag{29}$$

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

$$s_i^c = \frac{p_i c_i}{Y}, \quad s_i^g = \frac{p_i g_i}{Y}, \quad s_i^e = \frac{p_i e_i}{Y} \tag{30}$$

Thus,

$$s_i^y = \sum_{j=1}^{N} \frac{p_j y_j}{Y} a_{ji} + s_i^c + s_i^g + s_i^e = \sum_{j=1}^{N} s_j^y a_{ji} + s_i^c + s_i^g + s_i^e \tag{31}$$

Log-linearizing the above equation yields:

$$\hat{s}_i^y = \frac{1}{s_i^y} \left[\sum_{j=1}^{N} a_{ji} s_j^y \hat{s}_j^y + s_i^c \hat{s}_i^c + s_i^g \hat{s}_i^g + s_i^e \hat{s}_i^e \right] \tag{32}$$

Equivalently,

$$\hat{s}_i^y = \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \frac{s_i^c}{s_i^y} \hat{s}_i^c + \frac{s_i^g}{s_i^y} \hat{s}_i^g + \frac{s_i^e}{s_i^y} \hat{s}_i^e = \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \alpha_i^c \hat{s}_i^c + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \tag{33}$$

where $\alpha_i^c, \alpha_i^g, \alpha_i^e$ denote the sector-level shares of consumption, government expenditure and export:

$$\alpha_i^c = \frac{p_i c_i}{p_i y_i}, \quad \alpha_i^g = \frac{p_i g_i}{p_i y_i}, \quad \alpha_i^e = \frac{p_i e_i}{p_i y_i} \tag{34}$$

In matrix form,

$$\hat{S}_y = (I - B^T)^{-1}\left[-\frac{\rho}{1-\rho}D(\alpha_c)\hat{P} + \frac{\rho}{1-\rho}V(\alpha_c)(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*) + D(\alpha_g)\hat{S}_g + D(\alpha_e)\hat{S}_e\right] \quad (35)$$

We also put together all the notations of the model in Table A.1 for reference convenience.

Trade Shocks and Price Responses

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

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

$$\hat{P} = (I - Q_p)^{-1}\left[-Q_z\hat{Z} + Q_y\hat{Y} + Q_g\hat{S}_g + Q_{p^*}\hat{P}^* + Q_e\hat{S}_e\right] \quad (36)$$

where

$$\begin{aligned}
Q_p &= (I-A)^{-1}D(\eta) \times \left[-(I-A) - \frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)\left(V(1)^T - S_c^T\right) + \frac{\rho}{1-\rho}V(\pi)S_c^T\right] \\
Q_z &= (I-A)^{-1}\Big(I + D(\eta)\Big) \\
Q_y &= (I-A)^{-1}D(\eta)\Big(V(1) + V(\pi)\Big) \\
Q_g &= (I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_g) \\
Q_{p^*} &= (I-A)^{-1}D(\eta)\left[\left(D(\eta)^{-1} + I\right)A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T + \frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right] \\
Q_e &= (I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e) \\
D(\eta) &= D(\alpha_l)\left[I - D(\alpha_l) + \frac{1}{1-\rho}D(\pi)\right]^{-1}
\end{aligned}$$

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

Since our focus is to examine the price effects of foreign factors, we derive the partial derivatives of inflation with respect to import and export variables. We also disentangle the direct (own) effects of these shocks from their indirect effects to isolate each round of shock propagation. Propositions 2 and 3 below present mechanisms through which trade shocks directly and indirectly affect inflation, where higher order propagation effects are disregarded (see proofs in Appendix C.2).

Proposition 2 *The first-order effect of import prices on industrial prices is given by*

$$\begin{aligned}\hat{P} \quad &= \underbrace{\frac{\rho}{1-\rho}(\mathbf{A}-\mathbf{I})\Big(V(\alpha_c)+V(\pi)\Big)S_{c^*}^T\hat{P}^*}_{Downstream\ Effect} + \underbrace{\frac{\rho}{1-\rho}(\mathbf{B^T}-\mathbf{I})V(\alpha_c)S_{c^*}^T\hat{P}^*}_{Upstream\ Effect} \\ &+ \underbrace{\left(\Big(D(\eta)^{-1}+I\Big)A^* + \frac{\rho}{1-\rho}\Big(3V(\alpha_c)+2V(\pi)\Big)S_{c^*}^T\right)\hat{P}^*}_{Direct\ Effect} \end{aligned} \tag{37}$$

Proposition 3 *The first-order effect of exports on industrial prices is given by*

$$\hat{P} \quad = \underbrace{(\mathbf{A}-\mathbf{I})D(\eta)D(\alpha_e)\hat{S}_e}_{Downstream\ Effect} + \underbrace{D(\eta)(\mathbf{B^T}-\mathbf{I})D(\alpha_e)\hat{S}_e}_{Upstream\ Effect} + \underbrace{3D(\eta)D(\alpha_e)\hat{S}_e}_{Direct\ Effect} \tag{38}$$

Propositions 2 and 3 establish the first-order impacts of import and export shocks directly on industrial prices through international trade (*direct effect*). In an open economy with production networks, import price shocks directly influence domestic prices by changing the costs of imported inputs and the prices of imported consumption goods. Export shocks directly affect prices through changes in external demand and production factor costs such as wages.

Import and export shocks propagate both downstream and upstream, indirectly affecting the price decisions of downstream customers (*downstream effect*) and upstream suppliers (*upstream effect*) of the initially affected industries. Intuitively, when a trade shock occurs in a particular industry, it directly changes the price and quantity 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 network effects of import shocks on industrial prices hinge on the elasticity of substitution in consumption, whereas the effects of export shocks remain independent of the elasticity. The sensitivity of domestic prices to import prices declines as ρ decreases. This indicates that a lower elasticity of substitution results in a weaker sectoral price response to import price shocks. In the Cobb-Douglas case ($\rho = 0$, that is, the elasticity of substitution in consumption is one), equation 37 reduces to:

$$\hat{P} = \Big(D(\eta)^{-1}+I\Big)A^*\hat{P}^*$$

This indicates that import shocks affect industrial prices only through direct foreign purchases and the domestic production networks play no role in propagating trade shocks. The elasticity of substitution between inputs in production could also influence price responses (Luo and Villar, 2023). However, for simplicity, we consider a Cobb-Douglas production function, which eliminates the explicit appearance of the production elasticity in the price equation.

Second, if wages are homogeneous across industries, then shocks in imports and exports do not exert first-order effects on industrial prices through upstream propagation. When labor markets are segmented in the short run, the demand side effects of shocks are transmitted through changes in each industry's sale share relative to total production (the Domar weight), which influences wage rate adjustments within those industries. However, if wages remain uniform across industries, then industrial prices are unaffected by wage rates, leading to no price impact from upstream propagation. The empirical analysis in Section 5 shows the significant upstream influence of both import and export shocks on inflation. Therefore, the assumption of heterogeneous wage rates across industries is essential to generate price responses that fit the data.

4 Empirical Model and Data

Our empirical analysis quantifies the impacts of China's trade shocks on Australian prices over the past two decades. We first explain how these shocks are measured, and then present our empirical model together with our identification strategy, followed by the description of the data used in the analysis.

4.1 Trade Shocks

Trade shocks at the industry level are measured by evaluating the exposure of each industry to Chinese trade. In particular, the exposure of Australian industries to Chinese supply shocks in time t is derived from the ratio of Australia's imports (in the Australian dollar) from China in time t to the Australian market size of each industry in the base year:

$$Import_{i,t} = \frac{Australian\ Imports\ from\ China_{i,t}}{Australian\ Market\ Size_{i,base}} \tag{39}$$

Similarly, the exposure of Australian industries to Chinese demand shocks in time t is measured by the ratio of Australia's exports (in the Australian dollar) to China in time t to the Australian market size of each industry in the base year:

$$Export_{i,t} = \frac{Australian\ Exports\ to\ China_{i,t}}{Australian\ Market\ Size_{i,base}} \tag{40}$$

The direct shock on the own industry i in time t, denoted by $O_{i,t}$, is calculated as the first difference of trade exposures above. The trade shocks that are propagated upstream and downstream are denoted by $U_{i,t}$ and $D_{i,t}$, respectively. These network shocks are constructed as functions of the direct shock and the IO structure, following prepositions 2 and 3:

$$\begin{aligned}
O_{i,t} &= \Delta Import_{i,t}\ or\ \Delta Export_{i,t} \\
U_{i,t} &= \sum_{j=1}^{N} \left[(b_{ji} - 1_{j=i}) \cdot O_{j,t}\right] \\
D_{i,t} &= \sum_{j=1}^{N} \left[(a_{ij} - 1_{j=i}) \cdot O_{j,t}\right]
\end{aligned} \tag{41}$$

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; $1_{j=i}$ is an indicator function, taking the value of 1 for $j = i$ and 0 otherwise. In matrix form,

$$\begin{aligned} O_t &= \Delta Import_t \ or \ \Delta Export_t \\ U_t &= (\mathbf{B^T} - \mathbf{I}) \cdot O_t \\ D_t &= \textbf{(A-I)} \cdot O_t \end{aligned} \tag{42}$$

$Import_{i,t}$ and $Export_{i,t}$ are calculated based on the values of Australia's imports and exports, denominated in Australian dollars. On the import side, the value of imports depends on both the quantity and price of imports. Import price shocks can arise from changes in US dollar-denominated import prices or movements in the Australian exchange rate against the US dollar given international trade is commonly priced in the US dollar. Since the quantity of imported inputs is endogenous, we only consider changes in import prices and exchange rates as shocks to imports in our analysis. On the export side, the value of Australian-made exports is determined by the quantity of exports, the price of exports in US dollars, and the Australian exchange rate. The price of exports is determined not only by foreign demand but also by technological advancements in domestic production. Therefore, we exclude export prices from this analysis and focus on shocks to export quantity and the exchange rate. In total, we consider five shocks in our analysis: (i) import value, (ii) export value, (iii) import price, (iv) export quantity, and (v) the Australian exchange rate.

We construct $O_{i,t}$ for the import price and the exchange rate from logarithmic changes in their levels. The import price is denominated in US dollars and derived from volume and quantity of imports from China to Australia. On the other hand, we construct $O_{i,t}$ for export quantity by computing the annual change in the share of export quantity relative to the size of the Australian market in the base year, in the same way as we construct trade value shocks.

Finally, we standardize shocks by dividing them by their standard deviations over the sample period to ensure that the estimated effects of the shocks are more comparable. Changes in trade shocks are also winsorized to remove outliers, with values below the 1st percentile adjusted to the 1st percentile, and values above the 99th percentile adjusted to the 99th percentile.

4.2 Empirical Model

The empirical model is specified as follows:

$$\Delta \ln p_{i,t} = \sum_{k=1}^{2} \Big(\alpha_k \Delta \ln p_{i,t-k} + \beta_k^O O_{i,t-k} + \beta_k^U U_{i,t-k} + \beta_k^D D_{i,t-k} \Big) + \delta_t + \gamma_i + \epsilon_{i,t} \tag{43}$$

where i indexes industries, t indexes time, $\Delta \ln p_{i,t}$ denotes price inflation in industry i calculated as the log change in prices, δ_t the time fixed effect, γ_i the industry fixed effect, and $\epsilon_{i,t}$ is an error term. As already noted, $O_{i,t}$ is the own shock in industry i which represents the direct impact of the shock on the industry itself. $U_{i,t}$ and $D_{i,t}$ are indirect shocks spilling over through upstream and downstream production networks, respectively. $O_{i,t}$ is $\Delta\ Import_t$ (hereafter referred to as $O^M_{i,t}$) or $\Delta\ Export_t$ (hereafter referred to as $O^E_{i,t}$).

As trade value is decomposed into prices, quantity, and exchange rates, we perform regressions on these individual components. For imports, we consider import prices (MP) and exchange rates (EX) as follows:

$$\begin{aligned}\Delta \ln p_{i,t} &= \sum_{k=1}^{2}\Big(\alpha_k \Delta \ln p_{i,t-k} + \beta_k^{OMP} O^{MP}_{i,t-k} + \beta_k^{UMP} U^{MP}_{i,t-k} + \beta_k^{DMP} D^{MP}_{i,t-k} \\ &\quad + \beta_k^{OEX} O^{EX}_{i,t-k} + \beta_k^{UEX} U^{EX}_{i,t-k} + \beta_k^{DEX} D^{EX}_{i,t-k}\Big) + \delta_t + \gamma_i + \epsilon_{i,t} \qquad (44)\end{aligned}$$

where $O^{MP}_{i,t} = \Delta \ln MP_{i,t}$ and $O^{EX}_{i,t} = \Delta \ln EX_{i,t}$.

For exports, we consider export quantity (EQ) and exchange rates (EX) as follows:

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

where $O^{EQ}_{i,t} = \Delta EQ_{i,t}$ and $O^{EX}_{i,t} = \Delta \ln EX_{i,t}$.

The combined decomposition of import and export shocks is specified as follows:

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

The above specifications are applied to the full sample period from 2000 to 2023. Given the significant disruptions of production networks during the COVID pandemic, we incorporate a dummy variable representing the COVID period to capture potential shifts in the price effects of trade shocks. Let d^C_t denote the COVID and post-COVID periods (hereafter referred to as the COVID period), taking the value of 1 for $2020 \leq t \leq 2023$, and 0 otherwise. The model with the dummy variables is specified as below.

$$\begin{aligned}\Delta \ln p_{i,t} &= (1-d^C_t)\left[\sigma^{pre} + \sum_{k=1}^{2}\Big(\alpha_k^{pre} \Delta \ln p_{i,t-k} + \beta_k^{O^{pre}} O_{i,t-k} + \beta_k^{U^{pre}} U_{i,t-k} + \beta_k^{D^{pre}} D_{i,t-k}\Big)\right] \\ &\quad + d^C_t\left[\sigma^{post} + \sum_{k=1}^{2}\Big(\alpha_k^{post} \Delta \ln p_{i,t-k} + \beta_k^{O^{post}} O_{i,t-k} + \beta_k^{U^{post}} U_{i,t-k} + \beta_k^{D^{post}} D_{i,t-k}\Big)\right] \\ &\quad + \gamma_i + \epsilon_{i,t} \qquad (47)\end{aligned}$$

where each of O, U, and D can be export shocks, import shocks or joint shocks. The coefficients are distinguished by superscripts "pre"and "post" to reflect the periods before and since the onset of the pandemic, respectively.

4.3 Identification

The above OLS estimations are unbiased when trade shocks originating from China are exogenous to Australia. Ideally, $Import_{i,t}$ would capture only the supply-driven component of Chinese imports (i.e., competitiveness of Chinese manufacturers), and $Export_{i,t}$ would reflect China's demand-driven component (i.e., Chinese economic expansion or productivity change of China's non-Australian top exporters). However, these shocks may be correlated with unobserved factors, such as Australia's industrial productivity, that affect the prices in Australia. To address this potential endogeneity issue, we employ an instrumental variables (IV) strategy (Autor et al. 2013), using the growth of China's trade in countries not directly related to Australia. In particular, we instrument for $Import_{i,t}$ and $Export_{i,t}$ with exogenous components from bilateral trade between China and its major trading partners excluding Australia. The instrument for $Import_{i,t}$ is the ratio of import values from China by China's largest trading partners (USA, Japan, India, Germany, Netherlands, and Malaysia) to the Australian market size in the base year:

$$Import_{i,t}^{IV} = \frac{NonAustralian\ Imports\ from\ China_{i,t}}{Australian\ Market\ Size_{i,base}} \tag{48}$$

The instrument for $Export_{i,t}$ is the ratio of export values to China from China's largest export markets (USA, Japan, Germany, Brazil, United Kingdom, Chile, and Canada) to the Australian market size in the base year:

$$Export_{i,t}^{IV} = \frac{NonAustralian\ Exports\ to\ China_{i,t}}{Australian\ Market\ Size_{i,base}} \tag{49}$$

Thus, trade shocks in terms of instrumental variables are constructed as follows:

$$\begin{aligned} O_t^{IV} &= \Delta Import_t^{IV}\ or\ \Delta Export_t^{IV} \\ U_t^{IV} &= (B^T - I) \cdot O_t^{IV} \\ D_t^{IV} &= (A - I) \cdot O_t^{IV} \end{aligned} \tag{50}$$

These instruments are applied to estimate equation 43 in the two-stage least squares regressions.

4.4 Data

The data used in our analysis include IO tables, industrial prices, bilateral trade, and exchange rates, collected from multiple sources with details 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 IO tables are available at the 4-digit Input-Output Industry Groups (IOIG) level for each financial year. In our empirical analysis, the IO structure is pre-determined based on the IO table 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 pandemic.

Industrial Prices. We use the industrial prices from the Producer Price Index (PPI) for the output of manufacturing industries. The PPI data from the ABS is categorized 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 the IO table correspondence from the ABS. The quarterly PPI data are then aggregated into annual PPI using a geometric average.

International Trade. Trade shocks, in terms of value and quantity, are constructed from annual data of bilateral merchandise imports and exports sourced from the UN Comtrade. Import price shocks are derived from changes in the implied import prices based on trade value and quantity. The raw 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 sector. 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 (see details in Table A.3).

Market Size. The market size of each industry that we use to calculate the industrial trade exposure is measured by the industrial total supply net exports based on the ABS IO Table.

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

The time series data span from 2000 to 2023. We include 47 out of 52 manufacturing industries classified under the IOIG 2015 version, being mapped between price, trade data, and the IO table for use in our regressions. Table A.2 presents a list of these industry groups.

5 Empirical Results

The section first presents the results of trade value shocks, followed by the results of decomposed shocks. We also compare the estimates across the full sample period with those from the pre-COVID and COVID periods.

5.1 Propagation of Trade Value Shocks

Table 1 presents the results on the effects of trade value shocks, with columns 1, 3 and 5 showing OLS estimations, and columns 2, 4 and 6 showing 2SLS estimations.

Column 1 reveals that changes in import exposure at the industry level have positive effects on inflation primarily through direct shocks and upstream propagation. A one-standard-deviation increase in import values results in a 2.4% increase in industrial price inflation after one year and a 14.5% increase after two years. The results also show a comparable impact of upstream propagation. A one-standard-deviation increase in import values raises upstream industrial prices by 2.7% with a one-year lag and 15.4% with a two-year lag. The impact of import shocks on downstream customers shows mixed signs and is statistically insignificant across all lags.

Column 3 shows that the impacts of export value shocks have the opposite sign and weaker significance compared to import shocks. Specifically, when the industrial export value increases by one standard deviation, the price of the industry decreases by 2.2% after one year. The negative impact of this shock is transmitted upstream to the prices of the industry's suppliers, lowering inflation by 2.4%. Notably, both direct and upstream export shocks have a short-term impact on inflation within one year before dissipating. The impact of downstream propagation remains negligible.

Column 5 presents the joint effects of both import and export shocks. The upstream and downstream effects of the joint shocks are broadly consistent with the findings for the isolated shocks. The network impacts on the demand side continue to account for more fluctuations in inflation than the direct and downstream impacts.

Table 1: Propagation of Trade Value Shocks

	Import Shocks		**Export Shocks**		**Joint Shocks**	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
O^M, L1	0.024*	0.076			0.022	-0.070
	(0.013)	(0.047)			(0.013)	(0.107)
O^M, L2	0.145**	0.278***			0.146**	0.339**
	(0.062)	(0.066)			(0.063)	(0.162)
U^M, L1	0.027**	0.059			0.027**	0.005
	(0.013)	(0.059)			(0.013)	(0.126)
U^M, L2	0.154**	0.319***			0.156*	0.409*
	(0.075)	(0.084)			(0.080)	(0.224)
D^M, L1	-0.001	0.010			-0.003	-0.086
	(0.009)	(0.025)			(0.010)	(0.166)
D^M, L2	0.004	-0.035			0.002	-0.062
	(0.025)	(0.036)			(0.028)	(0.142)
O^E, L1			-0.022*	-0.237**	-0.026**	-0.236
			(0.012)	(0.100)	(0.012)	(0.150)
O^E, L2			0.024	-0.190*	0.025	-0.423***
			(0.041)	(0.110)	(0.044)	(0.139)
U^E, L1			-0.024**	-0.235**	-0.029**	-0.208
			(0.012)	(0.116)	(0.012)	(0.207)
U^E, L2			0.035	-0.162	0.036	-0.342
			(0.046)	(0.131)	(0.051)	(0.212)
D^E, L1			0.002	0.010	0.002	-0.014
			(0.003)	(0.027)	(0.004)	(0.106)
D^E, L2			-0.006	-0.025	-0.006	-0.093
			(0.005)	(0.062)	(0.006)	(0.193)
N	971	997	948	972	948	972
R^2	0.286	0.114	0.252	0.109	0.298	0.183

Notes: Columns of 2SLS results display the second-stage estimates (the first-stage results are reported in Appendix). In all columns, the dependent variable is the log of annual changes in the producer price index. The network explanatory variables are expressed as lagged changes in standardized and non-log values. O, U, D represent the direct and network effects of trade shocks, constructed according to the model as previously described. $L1$ and $L2$ indicate the number of lags. N is number of observations and R^2 is within R^2. 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.

Columns 2, 4, and 6 present the 2SLS estimation results of trade value shocks, using bilateral trade between China and non-Australian trading partners as instrumental variables. The IV estimates broadly align with those in the OLS estimation but exhibit larger magnitudes. Direct and upstream effects of shocks remain the primary drivers of variation in price inflation across industries, while the downstream impact of shocks remains relatively weak.

The results consistently demonstrate that inflation is more susceptible to trade shocks from imports than exports across all model specifications. The trade structure of Australia's manufacturing sector contributes to this asymmetry. Australian manufacturing production relies heavily on imported inputs, and consequently on global supply chains. Capital intensive intermediates, including motor vehicles, machinery, and electronic equipment, constitute a significant portion of imports into the manufacturing sector. Thus, fluctuations in import prices or disruptions to global supply chains have significant effects on production costs, which, in turn, affect domestic inflation. By contrast, Australia's export base in the manufacturing sector is narrower and constitutes a small portion of the sector's trade volume. The relatively low integration of Australian manufacturing industries into global supply chains on the export side limits the extent to which network transmission affects domestic prices.

5.2 Propagation of Trade Price and Quantity Shocks

Table 2 reports the results for decomposed shocks: import prices, export quantity, and exchange rates. The estimates reveal that these trade-related shocks significantly impact inflation through both foreign exchanges and domestic production.

Column 1 reports the estimated coefficients of import price shocks. The results show that a 1% increase in import prices generates a cumulative direct effect of 0.31% on price inflation over a two-year period. Specifically, when an industry experiences a 1% increase in import prices, the direct impact results in a 0.26% rise in prices after the first year, and diminishes to 0.05% in the second year. The upstream propagation of the shock strongly amplifies the price effects. A 1% increase in import prices generates an additional 0.33% increase through upstream propagation, with an increase of 0.29% in the first year and 0.04% in the second year. By contrast, the downstream effects of the shock are mixed in sign and statistically insignificant over the two-year period.

Column 2 shows the results for export quantity shocks. The sign and magnitude of the coefficients are similar to those for export values in the OLS estimation, and again primarily driven by shocks within one year. The joint effects of import price and export quantity shocks align with the results from the separate estimations. The upstream effects of these shocks outweigh the own and downstream effects. Furthermore, the results also show that inflation across industries is sensitive to exchange rate fluctuations but only in the first round of propagation. As a robustness check, we compare the impacts of standardized and non-standardized shocks. The results for non-standardized shocks in Table A.6 display similar patterns, reaffirming the robustness of our results.

Table 2: Propagation of Trade Price and Quantity Shocks

	Import Price Shocks	**Export Quantity Shocks**	**Joint Shocks**
	(1)	(2)	(3)
O^{MP}, L1	0.262***		0.266***
	(0.022)		(0.022)
O^{MP}, L2	0.048**		0.006
	(0.019)		(0.026)
U^{MP}, L1	0.288***		0.297***
	(0.026)		(0.026)
U^{MP}, L2	0.038**		-0.004
	(0.016)		(0.024)
D^{MP}, L1	-0.018		-0.024
	(0.021)		(0.019)
D^{MP}, L2	0.002		0.003
	(0.008)		(0.008)
O^{EQ}, L1		-0.025**	-0.044***
		(0.009)	(0.015)
O^{EQ}, L2		0.037	0.029
		(0.025)	(0.021)
U^{EQ}, L1		-0.024**	-0.048**
		(0.010)	(0.018)
U^{EQ}, L2		0.043	0.030
		(0.030)	(0.024)
D^{EQ}, L1		-0.004	-0.000
		(0.004)	(0.004)
D^{EQ}, L2		-0.000	0.003
		(0.005)	(0.005)
O^{EX}, L1	-0.630***	-0.812***	-0.634***
	(0.144)	(0.199)	(0.136)
O^{EX}, L2	-0.561***	-0.675***	-0.646***
	(0.072)	(0.071)	(0.094)
U^{EX}, L1	-0.127	-0.259	-0.096
	(0.120)	(0.182)	(0.102)
U^{EX}, L2	-0.022	-0.049	-0.072
	(0.046)	(0.055)	(0.058)
D^{EX}, L1	0.014	0.028	0.008
	(0.020)	(0.026)	(0.019)
D^{EX}, L2	-0.016	-0.019	-0.014
	(0.015)	(0.015)	(0.019)
N	957	947	947
R^2	0.313	0.267	0.331

Notes: The dependent variable is the log of annual changes in the producer price index. Direct effects of import price (MP) and exchange rates (EX) are in logarithmic terms of standardized shocks. Direct effects of export quantity (EQ) are in the non-log terms of standardized shocks. Other terms are as in Table 1.

The empirical results align with our theoretical predictions. Both trade flows affect prices directly and also indirectly through production networks. The persistent and significant upstream effects of these trade shocks further validate the theoretical assumption of heterogeneous wage rates across industries.

5.3 Pre-COVID and COVID Periods

Table 3 presents the results of decomposed trade shocks for the pre-COVID (2000–2019) and COVID period (2020–2023). Before the COVID pandemic, low-cost imports played a key role in maintaining low inflation by reducing production costs for importers and moderating domestic demand for intermediate inputs. However, the pandemic disruptions intensified price spillovers, amplifying the transmission of external shocks to domestic inflation. During the COVID period, the surge in inflation was driven by a combination of increased inflationary pressures from rising import prices and the amplified effects of export quantity disruptions.

Before the pandemic, the co-movement between changes in import prices and inflation was predominantly driven by direct and indirect upstream effects. A 1% decrease in global material prices resulted in a 0.08% reduction in domestic inflation through direct adjustments in affected industries, with an additional 0.09% decline via upstream propagation. The transmission of shocks to downstream industries remained limited. However, the sharp fluctuations in import prices during the COVID pandemic significantly amplified inflation spillovers. A 1% increase in import prices raised direct inflationary effects to 0.21% and upstream effects to 0.30% within two years. Notably, elevated import prices during the pandemic intensified the downstream propagation of shocks.

On the other hand, the price impacts of export shocks are negative, primarily transmitted through indirect channels. Before the pandemic, fluctuations in exports had limited effects on inflation, mainly through supply adjustments. A one-standard-deviation increase in export quantity reduced domestic inflation by 0.01% via downstream transmission. However, the pandemic disruptions significantly increased volatility. This altered the transmission dynamics, placing a greater burden on demand side channels and amplifying upstream propagation. During the pandemic period, a one-standard-deviation negative export shock indirectly contributed to a 0.16% increase in inflation through upstream effects, surpassing the direct impact, which raised inflation by 0.14%.

The impact of exchange rate fluctuations on domestic prices was less pronounced during normal times compared to the pandemic period. The exchange rate exhibits a negative impact during the COVID period. However, the deflationary effect of Australian dollar appreciation was significantly dominated by increased import prices due to COVID disruptions.

These findings are robust when all shocks hit the economy simultaneously, as presented in the last two columns of the table. Overall, the results reinforce the significant network effects of trade shocks on inflation in Australia, aligning with the patterns discussed in previous sections.

Table 3: Propagation of Decomposed Trade Shocks in Pre-COVID and COVID periods

	Import Price Shocks		**Export Quantity Shocks**		**Joint Shocks**	
	Pre-COVID (2000-2019)	COVID (2020-2023)	Pre-COVID (2000-2019)	COVID (2020-2023)	Pre-COVID (2000-2019)	COVID (2020-2023)
	(1)	(2)	(3)	(4)	(5)	(6)
O^{MP}, L1	0.080**	0.055			0.081***	0.055
	(0.031)	(0.033)			(0.030)	(0.036)
O^{MP}, L2	-0.006	0.210***			-0.019	0.197***
	(0.011)	(0.059)			(0.022)	(0.045)
U^{MP}, L1	0.092**	0.084**			0.095**	0.092**
	(0.038)	(0.039)			(0.037)	(0.040)
U^{MP}, L2	-0.010	0.211***			-0.022	0.202***
	(0.015)	(0.063)			(0.026)	(0.047)
D^{MP}, L1	-0.002	-0.038***			-0.004	-0.043***
	(0.005)	(0.009)			(0.006)	(0.009)
D^{MP}, L2	0.004	-0.014			0.005	-0.013
	(0.003)	(0.011)			(0.003)	(0.029)
O^{EQ}, L1			0.009	-0.139**	0.001	-0.106***
			(0.025)	(0.063)	(0.016)	(0.034)
O^{EQ}, L2			0.051	-0.036	0.062*	-0.069
			(0.033)	(0.044)	(0.036)	(0.058)
U^{EQ}, L1			0.021	-0.159**	0.011	-0.109**
			(0.029)	(0.074)	(0.018)	(0.047)
U^{EQ}, L2			0.058	-0.028	0.070	-0.046
			(0.039)	(0.045)	(0.043)	(0.073)
D^{EQ}, L1			-0.011**	0.008	-0.009**	-0.007
			(0.005)	(0.022)	(0.003)	(0.027)
D^{EQ}, L2			-0.004	0.002	-0.005	-0.016
			(0.006)	(0.020)	(0.006)	(0.034)
O^{EX}, L1	-0.024	-0.178***	-0.032	-0.103***	-0.020	-0.141***
	(0.017)	(0.039)	(0.020)	(0.036)	(0.013)	(0.036)
O^{EX}, L2	-0.001	0.035	-0.000	-0.111***	-0.004	0.038
	(0.006)	(0.041)	(0.008)	(0.032)	(0.008)	(0.039)
U^{EX}, L1	-0.032	-0.123**	-0.038	-0.053	-0.027	-0.078
	(0.023)	(0.048)	(0.025)	(0.048)	(0.017)	(0.049)
U^{EX}, L2	-0.003	0.106**	0.000	-0.058	-0.004	0.111***
	(0.008)	(0.044)	(0.011)	(0.038)	(0.011)	(0.040)
D^{EX}, L1	0.002	0.009	-0.001	0.027	-0.002	0.013
	(0.004)	(0.013)	(0.003)	(0.016)	(0.002)	(0.026)
D^{EX}, L2	0.001	-0.033***	0.000	-0.000	0.002	-0.026**
	(0.002)	(0.009)	(0.004)	(0.009)	(0.003)	(0.011)
N	957		947		947	
R^2	0.304		0.286		0.340	

Notes: The dependent variable is the log of annual changes in the producer price index. Direct effects of import price (MP) and exchange rates (EX) are in logarithmic terms of standardized shocks. Direct effects of export quantity (EQ) are in the non-log terms of standardized shocks. Other terms are as in Table 1.

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 for open economies in terms of inflation. Indeed, the world has experienced a sustained period of low and stable inflation for several decades until the COVID pandemic. This finding is especially relevant for Australia, given its heavy reliance on international trade.

This analysis offers several implications for monetary policy. The results demonstrate that the transmission of trade shocks is amplified within the production network, with upstream shock propagation exerting a substantial influence on inflation. These findings suggest that, without considering the production network, the welfare costs of inflation could be underestimated. Additionally, the analysis 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.

References

Acemoglu, D., Akcigit, U., and Kerr, W. (2016a). Networks and the macroeconomy: An empirical exploration. *Nber Macroeconomics Annual*, 30(1):273–335.

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., and Price, B. (2016b). Import competition and the great US employment sag of the 2000s. *Journal of Labor Economics*, 34(S1):S141–S198.

Acemoglu, D., Carvalho, V. M., Ozdaglar, A., and Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5):1977–2016.

Acemoglu, D., Ozdaglar, A., and Tahbaz-Salehi, A. (2015). Networks, shocks, and systemic risk. Technical report, National Bureau of Economic Research.

Acemoglu, D., Ozdaglar, A., and Tahbaz-Salehi, A. (2017). Microeconomic origins of macroeconomic tail risks. *American Economic Review*, 107(1):54–108.

Aron, J. and Muellbauer, J. (2007). Inflation dynamics and trade openness.

Auer, R. and Saure, P. (2013). The globalisation of inflation: A view from the cross section. *BIS Paper*, (70m).

Auer, R. A., Levchenko, A. A., and Sauré, P. (2019). International inflation spillovers through input linkages. *Review of Economics and Statistics*, 101(3):507–521.

Auer, R. A. and Mehrotra, A. (2014). Trade linkages and the globalisation of inflation in Asia and the Pacific. *Journal of International Money and Finance*, 49:129–151.

Autor, D., Dorn, D., and Hanson, G. H. (2021). On the persistence of the China shock. Technical report, National Bureau of Economic Research.

Autor, D. H., Dorn, D., and Hanson, G. H. (2013). The China syndrome: Local labor market effects of import competition in the United States. *American Economic Review*, 103(6):2121–2168.

Autor, D. H., Dorn, D., and Hanson, G. H. (2016). The China shock: Learning from labor-market adjustment to large changes in trade. *Annual Review of Economics*, 8:205–240.

Baqaee, D. R. and Farhi, E. (2019). The macroeconomic impact of microeconomic shocks: Beyond Hulten's theorem. *Econometrica*, 87(4):1155–1203.

Barrot, J.-N. and Sauvagnat, J. (2016). Input specificity and the propagation of idiosyncratic shocks in production networks. *The Quarterly Journal of Economics*, 131(3):1543–1592.

Bjørnland, H. C. and Thorsrud, L. A. (2016). Boom or gloom? Examining the Dutch disease in two-speed economies. *The Economic Journal*, 126(598):2219–2256.

Bowdler, C. and Nunziata, L. (2006). Trade openness and inflation episodes in the OECD. *Journal of Money, Credit, and Banking*, 38(2):553–563.

Carvalho, V. M. (2014). From micro to macro via production networks. *Journal of Economic Perspectives*, 28(4):23–48.

Cooke, D. (2010). Openness and inflation. *Journal of Money, Credit and Banking*, 42(2-3):267–287.

Debelle, G. et al. (2018). Twenty-five years of inflation targeting in Australia| Conference–2018.

Di Giovanni, J., Kalemli-Özcan, Silva, A., and Yildirim, M. A. (2022). Global supply chain pressures, international trade, and inflation. Technical report, National Bureau of Economic Research.

Di Giovanni, J. and Levchenko, A. A. (2010). Putting the parts together: Trade, vertical linkages, and business cycle comovement. *American Economic Journal: Macroeconomics*, 2(2):95–124.

Di Giovanni, J., Levchenko, A. A., and Mejean, I. (2014). Firms, destinations, and aggregate fluctuations. *Econometrica*, 82(4):1303–1340.

Dungey, M., Fry-Mckibbin, R., and Volkov, V. (2020). Transmission of a resource boom: The case of Australia. *Oxford Bulletin of Economics and Statistics*, 82(3):503–525.

Grossman, G. M. and Helpman, E. (1991). *Innovation and growth in the global economy*. MIT press.

Ha, J., Kose, M. A., and Ohnsorge, F. (2019a). Global inflation synchronization.

Ha, J., Kose, M. A., and Ohnsorge, F. (2019b). Understanding inflation in emerging and developing economies. *World Bank Policy Research Working Paper*, (8761).

Jaravel, X. and Sager, E. (2019). What are the price effects of trade? Evidence from the US and implications for quantitative trade models. FEDS Working Paper.

Luo, S. (2020). Propagation of financial shocks in an input-output economy with trade and financial linkages of firms. *Review of Economic Dynamics*, 36:246–269.

Luo, S. and Villar, D. (2023). Propagation of shocks in an input-output economy: Evidence from disaggregated prices. *Journal of Monetary Economics*.

Romer, D. (1993). Openness and inflation: Theory and evidence. *The Quarterly Journal of Economics*, 108(4):869–903.

Samimi, A. J., Ghaderi, S., Hosseinzadeh, R., and Nademi, Y. (2012). Openness and inflation: New empirical panel data evidence. *Economics Letters*, 117(3):573–577.

Silva, A. (2024). Inflation in disaggregated small open economies. *FRB of Boston Public Policy Discussion Paper*, (24-12).

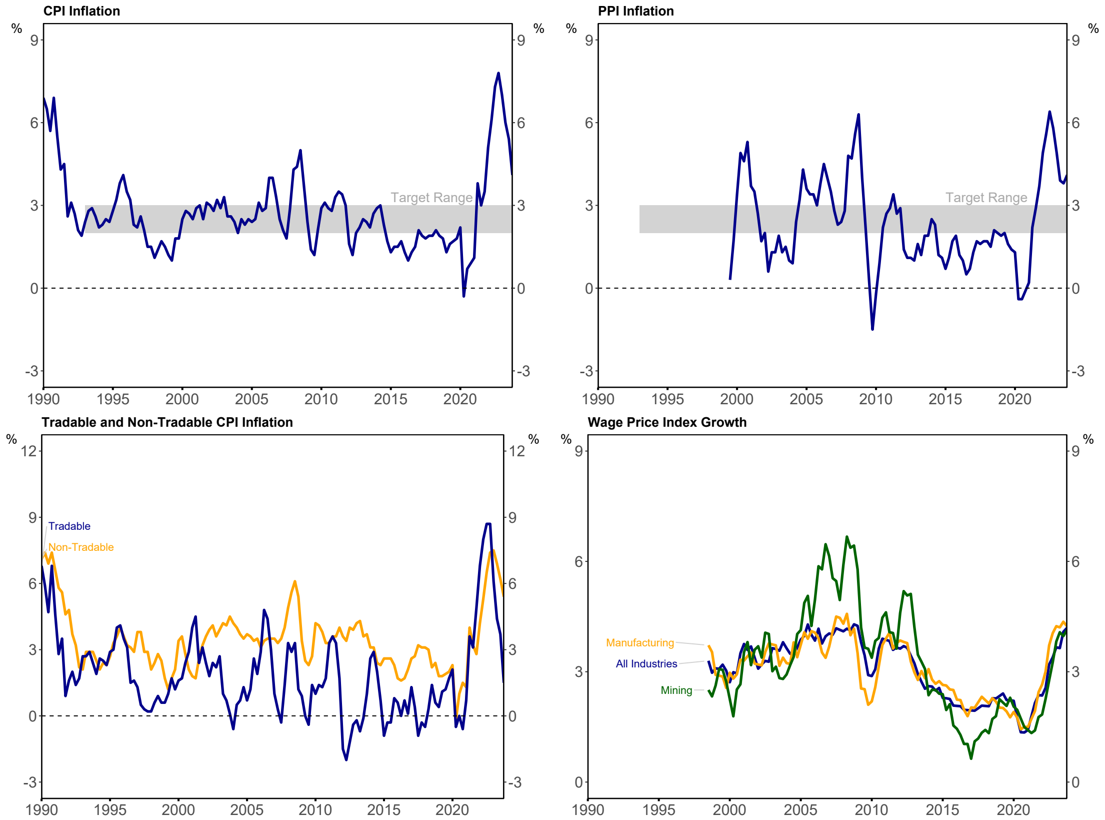
Terra, C. T. (1998). Openness and inflation: A new assessment. *The Quarterly Journal of Economics*, 113(2):641–648.

Wynne, M. A. and Kersting, E. (2007). Openness and inflation. *Federal Reserve Bank of Dallas Staff Papers*.

Appendices

A Australia's Inflation and Trade

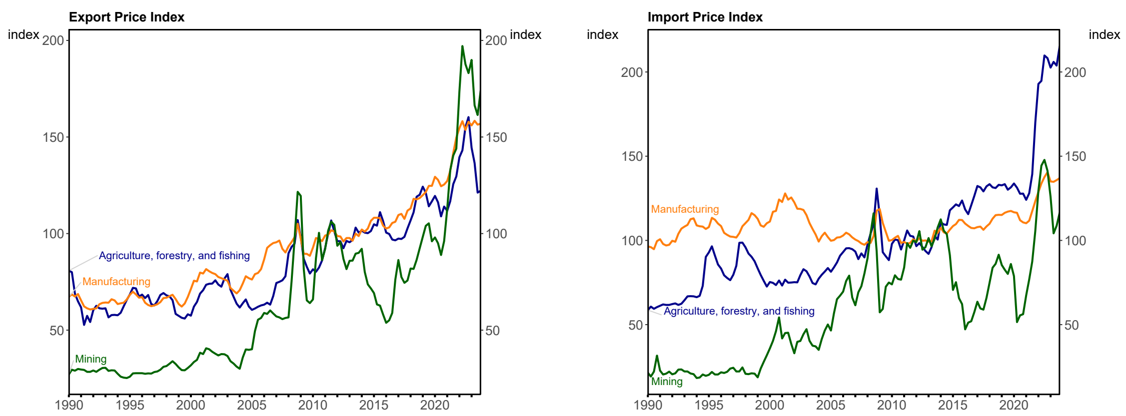
Figure A.1: Domestic Prices



Notes: CPI inflation is headline inflation (excl. interest charges and the tax changes). PPI is the output price. 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 the first panel presents the RBA's target range of inflation.

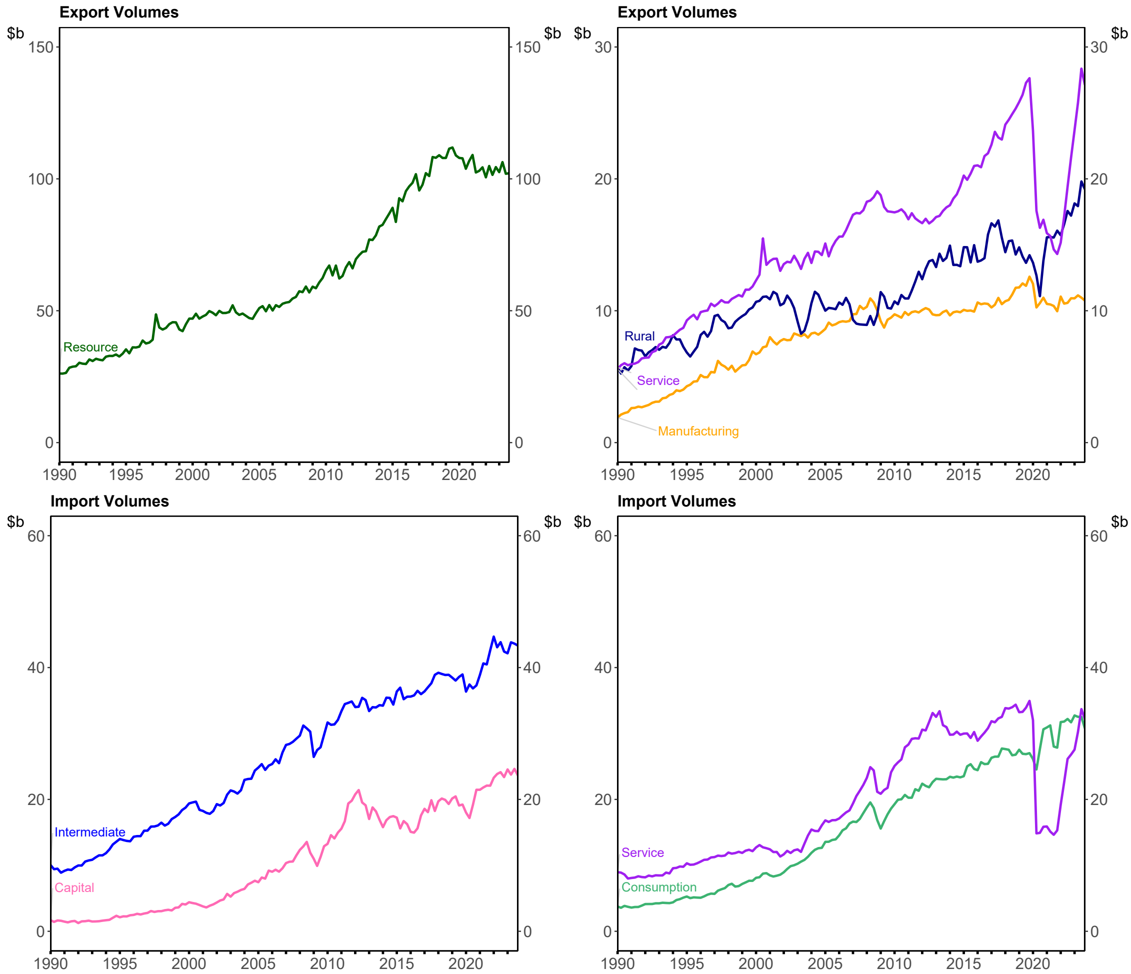
Sources: ABS; RBA

Figure A.2: Trade Prices



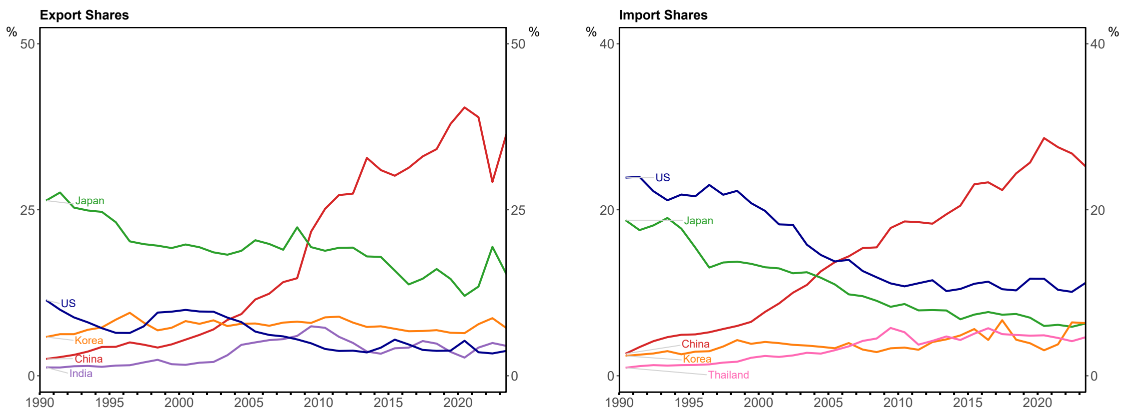
Sources: ABS; RBA

Figure A.3: Trade Volumes



Sources: ABS; RBA

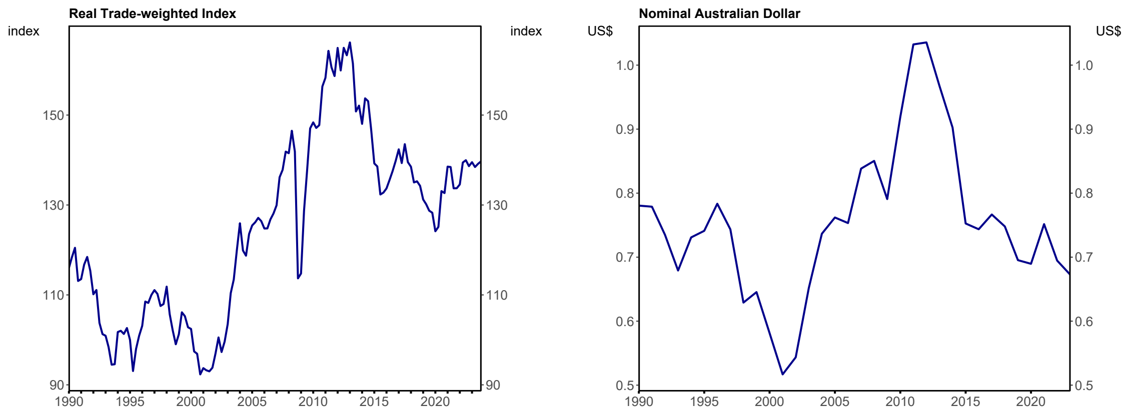
Figure A.4: Bilateral Trade



Notes: Share of total values, annual data derived from monthly data.

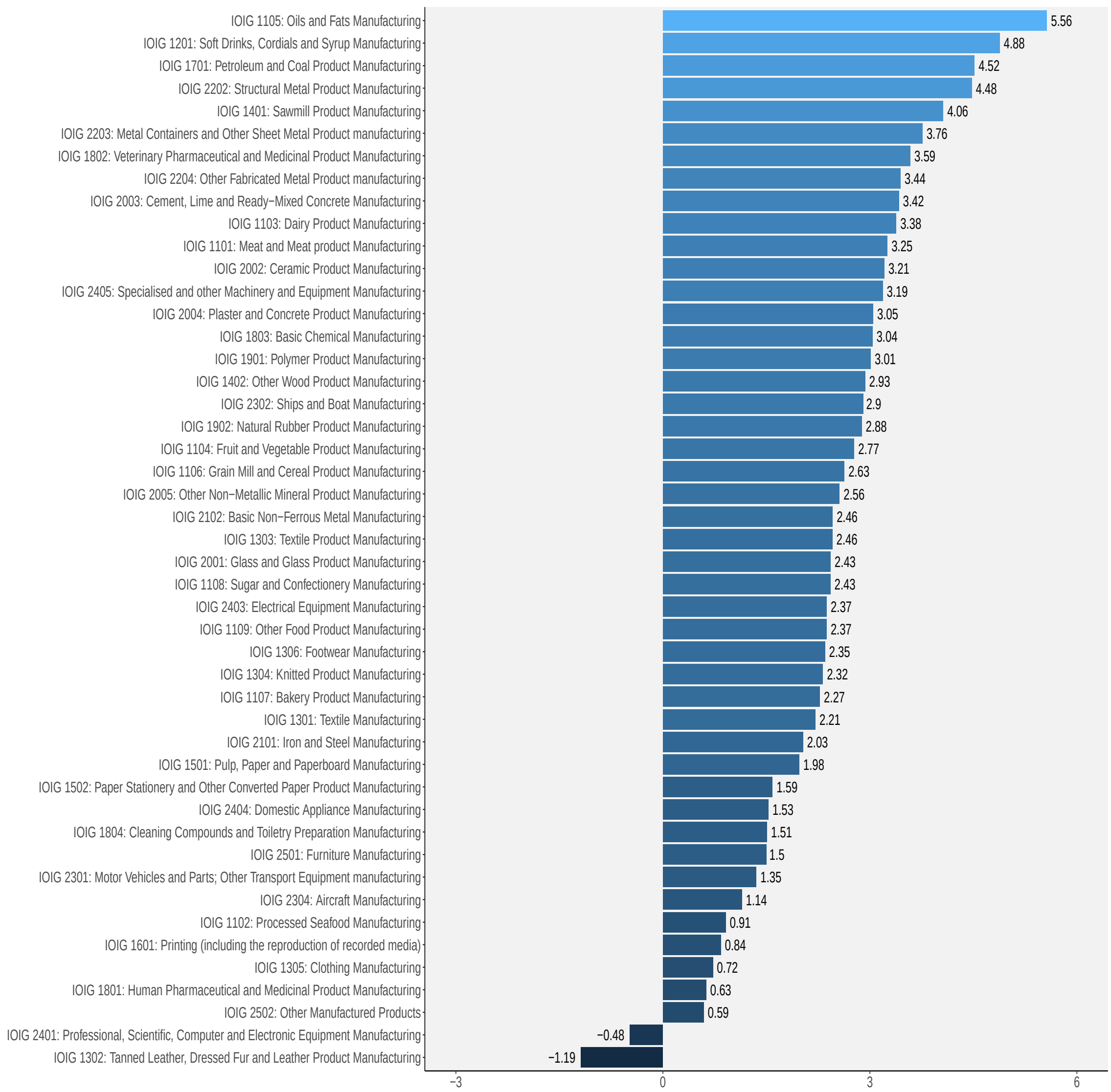
Sources: ABS; RBA; and authors' calculations

Figure A.5: Australian Dollar



Sources: RBA; OECD

Figure A.6: Average PPI Inflation in Manufacturing Industries (2000-2023)



B Optimization Problems

Firms

The Lagrangian for the firm's cost minimisation problem:

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

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

$$p_n = \frac{1}{\lambda}\frac{a_{in}}{x_{in}} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{a_{in}}{x_{in}} y_i \tag{A.2}$$

$$p_m = \frac{1}{\lambda}\frac{a_{im}}{x_{im}} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{a_{im}}{x_{im}} y_i \tag{A.3}$$

$$w_i = \frac{1}{\lambda}\frac{\alpha_i^l}{l_i} z_i l_i^{\alpha_i^l} \prod_{j=1}^{N} x_{ij}^{a_{ij}} \prod_{k=1}^{M} x_{ik}^{a_{ik}} = \frac{1}{\lambda}\frac{\alpha_i^l}{l_i} y_i \tag{A.4}$$

Immediately,

$$x_{in} = \frac{a_{in} y_i}{p_n \lambda}, \quad x_{im} = \frac{a_{im} y_i}{p_m \lambda}, \quad l_i = \frac{\alpha_i^l y_i}{w_i \lambda} \tag{A.5}$$

Substituting them into the production function yields:

$$y_i = z_i \left(\frac{\alpha_i^l y_i}{w_i \lambda}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{a_{in} y_i}{p_n \lambda}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{a_{im} y_i}{p_m \lambda}\right)^{a_{im}} \tag{A.6}$$

Thus,

$$\lambda = z_i \left(\frac{\alpha_i^l}{w_i}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{a_{in}}{p_n}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{a_{im}}{p_m}\right)^{a_{im}} \tag{A.7}$$

Substituting λ into the demand function yields:

$$x_{in} = \frac{a_{in} y_i}{p_n \lambda} = \frac{a_{in} y_i}{p_n}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N}\left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M}\left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.8}$$

$$x_{im} = \frac{a_{im} y_i}{p_m \lambda} = \frac{a_{im} y_i}{p_m}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N}\left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M}\left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.9}$$

$$l_i = \frac{\alpha_i^l y_i}{w_i \lambda} = \frac{\alpha_i^l y_i}{w_i}\frac{1}{z_i}\left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N}\left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M}\left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.10}$$

Therefore,

$$p_n x_{in} = a_{in} \frac{y_i}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.11}$$

$$p_m x_{im} = a_{im} \frac{y_i}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.12}$$

$$w_i l_i = \alpha_i^l \frac{y_i}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{j=1}^{N} \left(\frac{p_j}{a_{ij}}\right)^{a_{ij}} \prod_{k=1}^{M} \left(\frac{p_k}{a_{ik}}\right)^{a_{ik}} \tag{A.13}$$

The cost function is

$$\begin{aligned} v_i^y &= \sum_{n=1}^{N} p_n x_{in} + \sum_{m=1}^{M} p_m x_{im} + w_i l_i \\ &= \left[\sum_{n=1}^{N} a_{in} + \sum_{m=1}^{M} a_{im} + \alpha_i^l\right] \left[\frac{y_i}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{p_n}{a_{in}}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{p_m}{a_{im}}\right)^{a_{im}}\right] \\ &= \frac{y_i}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{p_n}{a_{in}}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{p_m}{a_{im}}\right)^{a_{im}} \end{aligned} \tag{A.14}$$

Immediately, the marginal cost function is

$$v_i = \frac{dv_i^y}{dy_i} = \frac{1}{z_i} \left(\frac{w_i}{\alpha_i^l}\right)^{\alpha_i^l} \prod_{n=1}^{N} \left(\frac{p_n}{a_{in}}\right)^{a_{in}} \prod_{m=1}^{M} \left(\frac{p_m}{a_{im}}\right)^{a_{im}} \tag{A.15}$$

Households

The Lagrangian for the household's utility maximisation problem is

$$\begin{aligned} &\mathfrak{L}\left(\{c_n\}_{n=1}^N, \{c_m\}_{m=1}^M, \{l_n\}_{n=1}^N\right) \\ &= \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{1/\rho} + \lambda \left(\sum_{n=1}^{N} w_n l_n - T - \sum_{n=1}^{N} p_n c_n - \sum_{m=1}^{M} p_m c_m\right) \end{aligned} \tag{A.16}$$

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

$$\lambda p_n = \beta_n c_n^{-(1-\rho)} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{\frac{1-\rho}{\rho}} \tag{A.17}$$

$$\lambda p_m = \beta_m c_m^{-(1-\rho)} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho\right)^{\frac{1-\rho}{\rho}} \tag{A.18}$$

Thus,

$$p_n = \frac{\beta_n c_n^{-(1-\rho)}}{\lambda} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho \right)^{\frac{1-\rho}{\rho}} \tag{A.19}$$

$$p_m = \frac{\beta_m c_m^{-(1-\rho)}}{\lambda} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho \right)^{\frac{1-\rho}{\rho}} \tag{A.20}$$

$$\lambda = \frac{\beta_n c_n^{-(1-\rho)} \left(\sum_{n=1}^{N} \beta_n^l (1-l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho \right)^{\frac{1-\rho}{\rho}}}{p_n} \tag{A.21}$$

Immediately,

$$\frac{p_{n=1} c_{n=1}^{1-\rho}}{\beta_{n=1}} = \ldots = \frac{p_{n=N} c_{n=N}^{1-\rho}}{\beta_{n=N}} = \frac{p_{m=1} c_{m=1}^{1-\rho}}{\beta_{m=1}} = \ldots = \frac{p_{m=M} c_{m=M}^{1-\rho}}{\beta_{m=M}} \tag{A.22}$$

Combining the above equations with the budget constraint yields:

$$c_n = \frac{\left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} \left(\sum_{n=1}^{N} w_n l_n - T\right)}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \tag{A.23}$$

Thus,

$$\frac{p_n c_n}{Y} = \frac{p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)}}{\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)}} \tag{A.24}$$

$$s_n^c = \frac{p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)}}{P_C^{-\rho/(1-\rho)}} = \left(\frac{p_n^{-\rho} \beta_n}{P_C^{-\rho}}\right)^{1/(1-\rho)} = \left(p_n^{-\rho} \beta_n P_C^\rho\right)^{1/(1-\rho)} \tag{A.25}$$

where consumption share $s_n^c = \frac{p_n c_n}{Y}$ and the aggregate price is defined in Eq. (22). Log-linearizing:

$$\hat{s}_n^c = \frac{\rho}{1-\rho} \left(-\hat{p}_n + \hat{P}_C\right) \tag{A.26}$$

Log-linearizing the aggregate price in (22) yields:

$$\begin{aligned} \hat{P}_C &= -\frac{1-\rho}{\rho} \frac{-\frac{\rho}{1-\rho} \sum_{n=1}^{N} \beta_n^{1/(1-\rho)} p_n^{-\rho/(1-\rho)} \hat{p}_n - \frac{\rho}{1-\rho} \sum_{m=1}^{M} \beta_m^{1/(1-\rho)} p_m^{-\rho/(1-\rho)} \hat{p}_m}{\sum_{n=1}^{N} p_n^{-\rho/(1-\rho)} \beta_n^{1/(1-\rho)} + \sum_{m=1}^{M} p_m^{-\rho/(1-\rho)} \beta_m^{1/(1-\rho)}} \\ &= \sum_{n=1}^{N} \frac{\beta_n^{1/(1-\rho)} p_n^{-\rho/(1-\rho)}}{P_C^{-\rho/(1-\rho)}} \hat{p}_n - \sum_{m=1}^{M} \frac{\beta_m^{1/(1-\rho)} p_m^{-\rho/(1-\rho)}}{P_C^{-\rho/(1-\rho)}} \hat{p}_m \\ &= \sum_{n=1}^{N} s_n^c \hat{p}_n + \sum_{m=1}^{M} s_m^c \hat{p}_m \end{aligned} \tag{A.27}$$

In matrix form,

$$\hat{P}_C = S_c^T \hat{P} + S_{c^*}^T \hat{P}^* \tag{A.28}$$

The first order condition with respect to l_n is

$$\lambda w_n = \beta_n^l (1 - l_n)^{-(1-\rho)} \left(\sum_{n=1}^{N} \beta_n^l (1 - l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho \right)^{\frac{1-\rho}{\rho}} \tag{A.29}$$

Combining the above equation and (A.21) yields:

$$\frac{\beta_n^l}{(1 - l_n)^{(1-\rho)}} = \frac{\lambda w_n}{\left(\sum_{n=1}^{N} \beta_n^l (1 - l_n)^\rho + \sum_{n=1}^{N} \beta_n c_n^\rho + \sum_{m=1}^{M} \beta_m c_m^\rho \right)^{\frac{1-\rho}{\rho}}} = \frac{w_n \beta_n}{c_n^{(1-\rho)} p_n} \tag{A.30}$$

We have:

$$\begin{aligned} c_n^{1-\rho} p_n &= \frac{\beta_n (\sum_{n=1}^{N} w_n l_n - T)^{1-\rho}}{\left(\sum_{n=1}^{N} p_n \left(\frac{\beta_n}{p_n}\right)^{1/(1-\rho)} + \sum_{m=1}^{M} p_m \left(\frac{\beta_m}{p_m}\right)^{1/(1-\rho)} \right)^{1-\rho}} \\ &= \frac{\beta_n Y^{1-\rho}}{P_C^{-\rho}} = \beta_n Y^{1-\rho} P_C^\rho \end{aligned} \tag{A.31}$$

Substitute into (A.30):

$$\frac{\beta_n^l}{(1 - l_n)^{(1-\rho)}} = \frac{w_n}{Y^{1-\rho} P_C^\rho} \tag{A.32}$$

The optimal labor supply is:

$$l_n = 1 - \frac{\left(\beta_n^l\right)^{1/(1-\rho)} Y P_C^{\rho/(1-\rho)}}{w_n^{1/(1-\rho)}} \tag{A.33}$$

Log-linearizing (A.32):

$$\frac{l_n}{1 - l_n} \hat{l}_n = \frac{1}{1-\rho} \hat{w}_n - \frac{\rho}{1-\rho} \hat{P} - \hat{Y} \tag{A.34}$$

Thus,

$$\hat{l}_n = \frac{1}{1-\rho} \frac{1 - l_n}{l_n} \hat{w}_n - \frac{\rho}{1-\rho} \frac{1 - l_n}{l_n} \hat{P}_C - \frac{1 - l_n}{l_n} \hat{Y} \tag{A.35}$$

In matrix form,

$$\begin{aligned} \hat{L} &= \frac{1}{1-\rho} D(\pi) \hat{W} - \frac{\rho}{1-\rho} V(\pi) \hat{P}_C - V(\pi) \hat{Y} \\ &= \frac{1}{1-\rho} D(\pi) \hat{W} - \frac{\rho}{1-\rho} V(\pi) (S_c^T \hat{P} + S_{c^*}^T \hat{P}^*) - V(\pi) \hat{Y} \end{aligned} \tag{A.36}$$

where

$$\pi_n = \frac{1 - l_n}{l_n}, \quad V(\pi) = (\pi_n) \tag{A.37}$$

From the market-clearing condition (28), we have:

$$\frac{p_i y_i}{Y} = \sum_{j=1}^{N} \frac{p_i x_{ji}}{Y} + \frac{p_i c_i}{Y} + \frac{p_i g_i}{Y} + \frac{p_i e_i}{Y} \tag{A.38}$$

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 government expenditure share $s_i^g = \frac{p_i g_i}{Y}$, and export share $s_i^e = \frac{p_i e_i}{Y}$, then:

$$s_i^y = \sum_{j=1}^{N} \frac{p_j y_j}{Y} a_{ji} + s_i^c + s_i^g + s_i^e = \sum_{j=1}^{N} s_j^y a_{ji} + s_i^c + s_i^g + s_i^e \tag{A.39}$$

Log-linearizing yields:

$$\hat{s}_i^y = \frac{1}{s_i^y} \left[\sum_{j=1}^{N} a_{ji} s_j^y \hat{s}_j^y + s_i^c \hat{s}_i^c + s_i^g \hat{s}_i^g + s_i^e \hat{s}_i^e \right] \tag{A.40}$$

We define

$$b_{ji} = a_{ji} \frac{s_j^y}{s_i^y} = \frac{a_{ji} p_j y_j}{p_i y_i} = \frac{p_i x_{ji}}{p_i y_i} \tag{A.41}$$

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

$$\begin{aligned} \hat{s}_i^y &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \frac{s_i^c}{s_i^y} \hat{s}_i^c + \frac{s_i^g}{s_i^y} \hat{s}_i^g + \frac{s_i^e}{s_i^y} \hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \frac{p_i c_i}{p_i y_i} \hat{s}_i^c + \frac{p_i g_i}{p_i y_i} \hat{s}_i^g + \frac{p_i e_i}{p_i y_i} \hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \alpha_i^c \hat{s}_i^c + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \end{aligned} \tag{A.42}$$

where sector-level shares of consumption, government expenditure and export are $\alpha_i^c = \frac{p_i c_i}{p_i y_i}$, $\alpha_i^g = \frac{p_i g_i}{p_i y_i}$, $\alpha_i^e = \frac{p_i e_i}{p_i y_i}$, respectively.

Thus,

$$\begin{aligned} \hat{s}_i^y &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \alpha_i^c \hat{s}_i^c + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y + \alpha_i^c \left[\frac{\rho}{1-\rho} \left(-\hat{p}_i + \hat{P}_C \right) \right] + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y - \frac{\rho}{1-\rho} \alpha_i^c \hat{p}_i + \frac{\rho}{1-\rho} \alpha_i^c \hat{P}_C + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \\ &= \sum_{j=1}^{N} b_{ji} \hat{s}_j^y - \frac{\rho}{1-\rho} \alpha_i^c \hat{p}_i + \frac{\rho}{1-\rho} \alpha_i^c (S_c^T \hat{P} + S_{c^*}^T \hat{P}^*) + \alpha_i^g \hat{s}_i^g + \alpha_i^e \hat{s}_i^e \end{aligned} \tag{A.43}$$

In matrix form,

$$\hat{S}_y = (I - B^T)^{-1} \left[-\frac{\rho}{1-\rho} D(\alpha_c) \hat{P} + \frac{\rho}{1-\rho} V(\alpha_c)(S_c^T \hat{P} + S_{c^*}^T \hat{P}^*) + D(\alpha_g) \hat{S}_g + D(\alpha_e) \hat{S}_e \right] \tag{A.44}$$

C Proofs

C.1 Proof of Proposition 1

Substitute $\hat{S}_y$ in (A.44) and $\hat{L}$ in (A.36) into (16) yields:

$$
\begin{aligned}
\hat{W} &= D(\alpha_l)\hat{W} + V(1)\hat{Y} - \hat{Z} - (I-A)\hat{P} + A^*\hat{P}^* - \hat{L} + \hat{S}_y \qquad \text{(B.1)}\\
&= D(\alpha_l)\hat{W} + V(1)\hat{Y} - \hat{Z} - (I-A)\hat{P} + A^*\hat{P}^*\\
&\quad -\left[\frac{1}{1-\rho}D(\pi)\hat{W} - \frac{\rho}{1-\rho}V(\pi)\left(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*\right) - V(\pi)\hat{Y}\right]\\
&\quad +[I-B^T]^{-1}\left[-\frac{\rho}{1-\rho}D(\alpha_c)\hat{P} + \frac{\rho}{1-\rho}V(\alpha_c)\left(S_c^T\hat{P} + S_{c^*}^T\hat{P}^*\right) + D(\alpha_g)\hat{S}_g + D(\alpha_e)\hat{S}_e\right]
\end{aligned}
$$

Therefore,

$$
\begin{aligned}
&\left[I - D(\alpha_l) + \frac{1}{1-\rho}D(\pi)\right]\hat{W}\\
&= (V(1)+V(\pi))\hat{Y} - \hat{Z} - \left[(I-A)\hat{P} + \frac{\rho}{1-\rho}(I-B^T)^{-1}D(\alpha_c)\hat{P}\right]\\
&\quad +A^*\hat{P}^* + \frac{\rho}{1-\rho}\left[V(\pi) + (I-B^T)^{-1}V(\alpha_c)\right]\left[S_c^T\hat{P} + S_{c^*}^T\hat{P}^*\right]\\
&\quad +(I-B^T)^{-1}D(\alpha_g)\hat{S}_g + (I-B^T)^{-1}D(\alpha_e)\hat{S}_e\\
&= (V(1)+V(\pi))\hat{Y} - \hat{Z}\\
&\quad -\Bigg[(I-A) + \frac{\rho}{1-\rho}(I-B^T)^{-1}D(\alpha_c) - \frac{\rho}{1-\rho}V(\pi)S_c^T\\
&\qquad -\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_c^T\Bigg]\hat{P}\\
&\quad +\left[A^* + \frac{\rho}{1-\rho}V(\pi)S_{c^*}^T + \frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T\right]\hat{P}^*\\
&\quad +(I-B^T)^{-1}D(\alpha_g)\hat{S}_g + (I-B^T)^{-1}D(\alpha_e)\hat{S}_e\\
&= (V(1)+V(\pi))\hat{Y} - \hat{Z}\\
&\quad -\left[(I-A) + \frac{\rho}{1-\rho}(I-B^T)^{-1}\left(D(\alpha_c) - V(\alpha_c)S_c^T\right) - \frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P}\\
&\quad +\left[A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T + \frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^*\\
&\quad +(I-B^T)^{-1}D(\alpha_g)\hat{S}_g + (I-B^T)^{-1}D(\alpha_e)\hat{S}_e \qquad \text{(B.2)}
\end{aligned}
$$

Denote $D(\eta) = D(\alpha_l)\left[I - D(\alpha_l) + \frac{1}{1-\rho}D(\pi)\right]^{-1}$, then:

$$
\begin{aligned}
D(\alpha_l)\hat{W} \;=\; & D(\eta)\Bigg\{(V(1)+V(\pi))\hat{Y}-\hat{Z} \\
& -\left[(I-A)+\frac{\rho}{1-\rho}(I-B^T)^{-1}\left(D(\alpha_c)-V(\alpha_c)S_c^T\right)-\frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P} \\
& +\left[A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^* \\
& +(I-B^T)^{-1}D(\alpha_g)\hat{S}_g+(I-B^T)^{-1}D(\alpha_e)\hat{S}_e\Bigg\} \qquad \text{(B.3)}
\end{aligned}
$$

Substitute into the price function (11):

$$
\begin{aligned}
& (I-A)\hat{P}=-\hat{Z}+A^*P^*+D(\alpha_l)\hat{W} \\
& =-\hat{Z}+A^*P^*+D(\eta)\Bigg\{(V(1)+V(\pi))\hat{Y}-\hat{Z} \\
& \quad -\left[(I-A)+\frac{\rho}{1-\rho}(I-B^T)^{-1}\left(D(\alpha_c)-V(\alpha_c)S_c^T\right)-\frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P} \\
& \quad +\left[A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^* \\
& \quad +(I-B^T)^{-1}D(\alpha_g)\hat{S}_g+(I-B^T)^{-1}D(\alpha_e)\hat{S}_e\Bigg\} \\
& =-\Big(I+D(\eta)\Big)\hat{Z}+D(\eta)\Big(V(1)+V(\pi)\Big)\hat{Y} \\
& \quad +D(\eta)\left[-(I-A)-\frac{\rho}{1-\rho}(I-B^T)^{-1}\left(D(\alpha_c)-V(\alpha_c)S_c^T\right)+\frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P} \\
& \quad +D(\eta)\left[\left(D(\eta)^{-1}+I\right)A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^* \\
& \quad +D(\eta)(I-B^T)^{-1}D(\alpha_g)\hat{S}_g+D(\eta)(I-B^T)^{-1}D(\alpha_e)\hat{S}_e \qquad \text{(B.4)}
\end{aligned}
$$

$$
\begin{aligned}
& \hat{P}=-(I-A)^{-1}\Big(I+D(\eta)\Big)\hat{Z}+(I-A)^{-1}D(\eta)\Big(V(1)+V(\pi)\Big)\hat{Y} \\
& \quad +(I-A)^{-1}D(\eta)\left[-(I-A)-\frac{\rho}{1-\rho}(I-B^T)^{-1}\left(D(\alpha_c)-V(\alpha_c)S_c^T\right)+\frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P} \\
& \quad +(I-A)^{-1}D(\eta)\left[\left(D(\eta)^{-1}+I\right)A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^* \\
& \quad +(I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_g)\hat{S}_g+(I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e)\hat{S}_e \qquad \text{(B.5)}
\end{aligned}
$$

So,

$$
\begin{aligned}
\hat{P} = &-(I-A)^{-1}\Big(I+D(\eta)\Big)\hat{Z}+(I-A)^{-1}D(\eta)\Big(V(1)+V(\pi)\Big)\hat{Y} \\
&+(I-A)^{-1}D(\eta)\left[-(I-A)-\frac{(}{I}-B^T)^{-1}V(\alpha_c)\left(V(1)^T-S_c^T\right)+\frac{\rho}{1-\rho}V(\pi)S_c^T\right]\hat{P} \\
&+(I-A)^{-1}D(\eta)\left[\left(D(\eta)^{-1}+I\right)A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right]\hat{P}^* \\
&+(I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_g)\hat{S}_g+(I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e)\hat{S}_e \qquad \text{(B.6)}
\end{aligned}
$$

Thus,

$$
\hat{P}=Q_p^{-1}\left[-Q_z\hat{Z}+Q_y\hat{Y}+Q_g\hat{S}_g+Q_{p^*}\hat{P}^*+Q_e\hat{S}_e\right] \qquad \text{(B.7)}
$$

where

$$
\begin{aligned}
Q_p &= I-(I-A)^{-1}D(\eta)\times \\
&\quad\times\left[-(I-A)-\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)\left(V(1)^T-S_c^T\right)+\frac{\rho}{1-\rho}V(\pi)S_c^T\right] \\
Q_z &= (I-A)^{-1}\Big(I+D(\eta)\Big) \\
Q_y &= (I-A)^{-1}D(\eta)\Big(V(1)+V(\pi)\Big) \\
Q_g &= (I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_g) \\
Q_{p^*} &= (I-A)^{-1}D(\eta)\left[\left(D(\eta)^{-1}+I\right)A^*+\frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)S_{c^*}^T+\frac{\rho}{1-\rho}V(\pi)S_{c^*}^T\right] \\
Q_e &= (I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e)
\end{aligned}
$$

C.2 Proof of Proposition 2

$$\begin{aligned}
&\frac{\partial \hat{P}}{\partial \hat{P}^*} = Q_p^{-1} Q_{p^*} \\
&= \Bigg\{ I + (I-A)^{-1} D(\eta) \times \\
&\quad \times \Bigg[-(I-A) - \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c)\left(V(1)^T - S_c^T\right) + \frac{\rho}{1-\rho} V(\pi) S_c^T \Bigg] \Bigg\} \\
&\quad \times \Bigg\{ (I-A)^{-1} D(\eta) \Bigg[\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \Bigg] \Bigg\} \\
&\quad + \text{Higher order} \\
&= (I-A)^{-1} D(\eta) \Bigg[\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \Bigg] \\
&\quad + \text{Higher order} \\
&= \Bigg(I + A + \text{Higher order} \Bigg) D(\eta) \\
&\quad \times \Bigg(\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \Bigg) \\
&\quad + \text{Higher order} \\
&= \left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \\
&\quad + A \Bigg(\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}(I-B^T)^{-1} V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \Bigg) \\
&\quad + \text{Higher order}
\end{aligned} \tag{B.8}$$

$$\begin{aligned}
&\frac{\partial \hat{P}}{\partial \hat{P}^*} \\
&= \left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}\Bigg(I + B^T + \text{Higher order} \Bigg) V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \\
&\quad + A \Bigg(\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}\Bigg(I + B^T + \text{Higher order} \Bigg) V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \Bigg) \\
&\quad + \text{Higher order} \\
&= \left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}\Bigg((B^T - I) + 2I \Bigg) V(\alpha_c) S_{c^*}^T + \frac{\rho}{1-\rho} V(\pi) S_{c^*}^T \\
&\quad \frac{\rho}{1-\rho} A \Bigg(V(\alpha_c) + V(\pi) \Bigg) S_{c^*}^T + \text{Higher order} \\
&= \frac{\rho}{1-\rho}(A - I)\Bigg(V(\alpha_c) + V(\pi) \Bigg) S_{c^*}^T + \frac{\rho}{1-\rho}(B^T - I) V(\alpha_c) S_{c^*}^T \\
&\quad + \Bigg[\left(D(\eta)^{-1} + I\right) A^* + \frac{\rho}{1-\rho}\Bigg(3V(\alpha_c) + 2V(\pi) \Bigg) S_{c^*}^T \Bigg] + \text{Higher order}
\end{aligned} \tag{B.9}$$

Thus, the sensitivity of industrial price to industrial import price shock is

$$\frac{\partial \hat{P}}{\partial \hat{P}^*} = Q_p^{-1} Q_{p^*} \tag{B.10}$$
$$= \frac{\rho}{1-\rho}\textbf{(A-I)}\Big(V(\alpha_c) + V(\pi)\Big)S_{c^*}^T + \frac{\rho}{1-\rho}(\mathbf{B^T} - \mathbf{I})V(\alpha_c)S_{c^*}^T$$
$$+ \left[\Big(D(\eta)^{-1} + I\Big)A^* + \frac{\rho}{1-\rho}\Big(3V(\alpha_c) + 2V(\pi)\Big)S_{c^*}^T\right] + \text{Higher order}$$

C.3 Proof of Proposition 3

$$\frac{\partial \hat{P}}{\partial \hat{S}_e} = Q_p^{-1} Q_e$$
$$= \Bigg\{I + (I-A)^{-1}D(\eta) \times$$
$$\times \left[-(I-A) - \frac{\rho}{1-\rho}(I-B^T)^{-1}V(\alpha_c)\Big(V(1)^T - S_c^T\Big) + \frac{\rho}{1-\rho}V(\pi)S_c^T\right]\Bigg\}$$
$$\times \Big\{(I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e)\Big\} + \text{Higher order}$$
$$= (I-A)^{-1}D(\eta)(I-B^T)^{-1}D(\alpha_e) + \text{Higher order}$$
$$= \Big(I + A + \text{Higher order}\Big)D(\eta)\Big(I + B^T + \text{Higher order}\Big)D(\alpha_e) + \text{Higher order}$$
$$= D(\eta)\Big(I + B^T\Big)D(\alpha_e) + AD(\eta)\Big(I + B^T\Big)D(\alpha_e) + \text{Higher order}$$
$$= D(\eta)\Big(I + B^T\Big)D(\alpha_e) + AD(\eta)D(\alpha_e) + \text{Higher order}$$
$$= D(\eta)\Big((B^T - I) + 2I\Big)D(\alpha_e) + \Big((A-I) + I\Big)D(\eta)D(\alpha_e) + \text{Higher order}$$
$$= (A-I)D(\eta)D(\alpha_e) + D(\eta)(B^T - I)D(\alpha_e) + 3D(\eta)D(\alpha_e) + \text{Higher order} \tag{B.11}$$

Thus, the sensitivity of industrial price to industrial export shock is

$$\frac{\partial \hat{P}}{\partial \hat{S}_e} = Q_p^{-1} Q_e \tag{B.12}$$
$$= \textbf{(A-I)}D(\eta)D(\alpha_e) + D(\eta)(\mathbf{B^T} - \mathbf{I})D(\alpha_e) + 3D(\eta)D(\alpha_e) + \text{Higher order}$$

D Supplemental Tables

Table A.1: Table of Notations

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

Table A.2: 47 Mapped Manufacturing Input-Output Industry Groups IOIG(2015)

Code	Short Descriptor	Full Descriptor
1101	Meat	Meat and Meat product Manufacturing
1102	Seafood	Processed Seafood Manufacturing
1103	DairyProd	Dairy Product Manufacturing
1104	FruitVeg	Fruit and Vegetable Product Manufacturing
1105	OilFat	Oils and Fats Manufacturing
1106	Cereal	Grain Mill and Cereal Product Manufacturing
1107	Bakery	Bakery Product Manufacturing
1108	Sugar	Sugar and Confectionery Manufacturing
1109	OtherFood	Other Food Product Manufacturing
1201	Drinks	Soft Drinks, Cordials and Syrup Manufacturing
1301	Textile	Textile Manufacturing
1302	Leather	Tanned Leather, Dressed Fur and Leather Product Manufacturing
1303	TextileProd	Textile Product Manufacturing
1304	KnittedProd	Knitted Product Manufacturing
1305	Clothing	Clothing Manufacturing
1306	Footwear	Footwear Manufacturing
1401	Sawmill	Sawmill Product Manufacturing
1402	OtherWood	Other Wood Product Manufacturing
1501	Paperboard	Pulp, Paper and Paperboard Manufacturing
1502	PaperStat	Paper Stationery and Other Converted Paper Product Manufacturing
1601	Printing	Printing (including the reproduction of recorded media)
1701	PetroCoal	Petroleum and Coal Product Manufacturing
1801	HumPhar	Human Pharmaceutical and Medicinal Product Manufacturing
1802	VetPhar	Veterinary Pharmaceutical and Medicinal Product Manufacturing
1803	Chemical	Basic Chemical Manufacturing
1804	Cleaning	Cleaning Compounds and Toiletry Preparation Manufacturing
1901	Polymer	Polymer Product Manufacturing
1902	Rubber	Natural Rubber Product Manufacturing
2001	Glass	Glass and Glass Product Manufacturing
2002	Ceramic	Ceramic Product Manufacturing
2003	Cement	Cement, Lime and Ready-Mixed Concrete Manufacturing
2004	Plaster	Plaster and Concrete Product Manufacturing
2005	NonMetMineral	Other Non-Metallic Mineral Product Manufacturing
2101	IronSteel	Iron and Steel Manufacturing
2102	NonFerMetal	Basic Non-Ferrous Metal Manufacturing
2202	StruMetal	Structural Metal Product Manufacturing
2203	MetalCont	Metal Containers and Other Sheet Metal Product manufacturing
2204	OtherFabMetal	Other Fabricated Metal Product manufacturing
2301	Motor	Motor Vehicles and Parts; Other Transport Equipment manufacturing
2302	ShipBoat	Ships and Boat Manufacturing
2304	Aircraft	Aircraft Manufacturing
2401	ProfEquip	Professional, Scientific, Computer and Electronic Equipment Manufacturing
2403	ElecEquip	Electrical Equipment Manufacturing
2404	DomesApp	Domestic Appliance Manufacturing
2405	SpecEquip	Specialised and other Machinery and Equipment Manufacturing
2501	Furniture	Furniture Manufacturing
2502	Other	Other Manufactured Products

Table A.3: Mapping Divisions and Sectors of Tradable Products to Australia's Manufacturing Input-Output Industries

SITC3 Code	SITC3 Descriptor	IOIG(2015) Input-Output Industry
0	Food and live animals	Meat and Meat product Manufacturing
01	Meat and meat preparations	Meat and Meat product Manufacturing
02	Dairy products and birds' eggs	Dairy Product Manufacturing
03	Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof	Processed Seafood Manufacturing
04	Cereals and cereal preparations	Grain Mill and Cereal Product Manufacturing
05	Vegetables and fruit	Fruit and Vegetable Product Manufacturing
06	Sugars, sugar preparations and honey	Dairy Product Manufacturing
07	Coffee, tea, cocoa, spices, and manufactures thereof	Other Food Product Manufacturing
08	Feeding stuff for animals (not including unmilled cereals)	Meat and Meat product Manufacturing
09	Miscellaneous edible products and preparations	Oils and Fats Manufacturing
1	Beverages and tobacco	Soft Drinks, Cordials and Syrup Manufacturing
11	Beverages	Soft Drinks, Cordials and Syrup Manufacturing
2	Crude materials, inedible, except fuels	Tanned Leather, Dressed Fur and Leather Product Manufacturing
21	Hides, skins and furskins, raw	Tanned Leather, Dressed Fur and Leather Product Manufacturing
23	Crude rubber (including synthetic and reclaimed)	Basic Chemical Manufacturing
24	Cork and wood	Other Wood Product Manufacturing
25	Pulp and waste paper	Pulp, Paper and Paperboard Manufacturing
26	Textile fibres (other than wool tops and other combed wool) and their wastes (not manufactured into yarn or fabric)	Textile Manufacturing
27	Crude fertilizers, other than those of division 56, and crude minerals (excluding coal, petroleum and precious stones)	Plaster and Concrete Product Manufacturing
28	Metalliferous ores and metal scrap	Iron and Steel Manufacturing
29	Crude animal and vegetable materials, n.e.s.	Meat and Meat product Manufacturing
3	Mineral fuels, lubricants and related materials	Petroleum and Coal Product Manufacturing
33	Petroleum, petroleum products and related materials	Petroleum and Coal Product Manufacturing
4	Animal and vegetable oils, fats and waxes	Meat and Meat product Manufacturing
41	Animal oils and fats	Meat and Meat product Manufacturing
42	Fixed vegetable fats and oils, crude, refined or fractionated	Oils and Fats Manufacturing
43	Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin; inedible mixtures or preparations of animal or vegetable fats or oils, n.e.s.	Oils and Fats Manufacturing
5	Chemicals and related products, n.e.s.	Basic Chemical Manufacturing
51	Organic chemicals	Petroleum and Coal Product Manufacturing
52	Inorganic chemicals	Basic Chemical Manufacturing
53	Dyeing, tanning and colouring materials	Basic Chemical Manufacturing
54	Medicinal and pharmaceutical products	Human Pharmaceutical and Medicinal Product Manufacturing
55	Essential oils and resinoids and perfume materials; toilet, polishing and cleansing preparations	Basic Chemical Manufacturing
56	Fertilizers (other than those of group 272)	Basic Chemical Manufacturing
57	Plastics in primary forms	Basic Chemical Manufacturing
58	Plastics in non-primary forms	Human Pharmaceutical and Medicinal Product Manufacturing

Mapping Divisions and Sectors of Tradable Products to Australia's Manufacturing Input-Output Industries (continued)

SITC3 Code	SITC3 Descriptor	IOIG(2015) Input-Output Industry
59	Chemical materials and products, n.e.s.	Basic Chemical Manufacturing
6	Manufactured goods classified chiefly by material	Tanned Leather, Dressed Fur and Leather Product Manufacturing
61	Leather, leather manufactures, n.e.s., and dressed furskins	Tanned Leather, Dressed Fur and Leather Product Manufacturing
62	Rubber manufactures, n.e.s.	Textile Manufacturing
63	Cork and wood manufactures (excluding furniture)	Other Wood Product Manufacturing
64	Paper, paperboard and articles of paper pulp, of paper or of paperboard	Pulp, Paper and Paperboard Manufacturing
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products	Textile Manufacturing
66	Non-metallic mineral manufactures, n.e.s.	Other Wood Product Manufacturing
67	Iron and steel	Iron and Steel Manufacturing
68	Non-ferrous metals	Basic Non-Ferrous Metal Manufacturing
69	Manufactures of metals, n.e.s.	Structural Metal Product Manufacturing
7	Machinery and transport equipment	Electrical Equipment Manufacturing
71	Power-generating machinery and equipment	Metal Containers and Other Sheet Metal Product manufacturing
72	Machinery specialized for particular industries	Specialised and other Machinery and Equipment Manufacturing
73	Metalworking machinery	Specialised and other Machinery and Equipment Manufacturing
74	General industrial machinery and equipment, n.e.s., and machine parts, n.e.s.	Professional, Scientific, Computer and Electronic Equipment Manufacturing
75	Office machines and automatic data-processing machines	Professional, Scientific, Computer and Electronic Equipment Manufacturing
76	Telecommunications and sound-recording and reproducing apparatus and equipment	Professional, Scientific, Computer and Electronic Equipment Manufacturing
77	Electrical machinery, apparatus and appliances, n.e.s., and electrical parts thereof (including non-electrical counterparts, n.e.s., of electrical household-type equipment)	Electrical Equipment Manufacturing
78	Road vehicles (including air-cushion vehicles)	Motor Vehicles and Parts; Other Transport Equipment manufacturing
79	Other transport equipment	Professional, Scientific, Computer and Electronic Equipment Manufacturing
8	Miscellaneous manufactured articles	Structural Metal Product Manufacturing
81	Prefabricated buildings; sanitary, plumbing, heating and lighting fixtures and fittings, n.e.s.	Ceramic Product Manufacturing
82	Furniture, and parts thereof; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings	Textile Product Manufacturing
83	Travel goods, handbags and similar containers	Tanned Leather, Dressed Fur and Leather Product Manufacturing
84	Articles of apparel and clothing accessories	Clothing Manufacturing
85	Footwear	Footwear Manufacturing
87	Professional, scientific and controlling instruments and apparatus, n.e.s.	Professional, Scientific, Computer and Electronic Equipment Manufacturing
88	Photographic apparatus, equipment and supplies and optical goods, n.e.s.; watches and clocks	Professional, Scientific, Computer and Electronic Equipment Manufacturing
89	Miscellaneous manufactured articles, n.e.s.	Other Fabricated Metal Product manufacturing
9	Commodities and transactions not classified elsewhere in the SITC	Basic Non-Ferrous Metal Manufacturing
97	Gold, non-monetary (excluding gold ores and concentrates)	Basic Non-Ferrous Metal Manufacturing

Table A.4: Robustness Results on Trade Value Shocks

	Baseline	Fixed Effects	Excluded Outliers	2021/22 IO	Non-standardized
	(1)	(2)	(3)	(4)	(5)
			I. Import Shocks		
O^M, L1	0.024*	0.048***	0.024*	0.031*	0.204
	(0.013)	(0.013)	(0.013)	(0.016)	(0.320)
O^M, L2	0.145**	0.144**	0.142**	0.157**	0.233
	(0.062)	(0.058)	(0.063)	(0.073)	(0.414)
U^M, L1	0.027**	0.029	0.025*	0.026	0.164
	(0.013)	(0.019)	(0.013)	(0.017)	(0.307)
U^M, L2	0.154**	0.165**	0.157**	0.155*	0.296
	(0.075)	(0.078)	(0.076)	(0.086)	(0.263)
D^M, L1	-0.001	0.020	-0.002	0.007	0.076
	(0.009)	(0.013)	(0.009)	(0.015)	(0.162)
D^M, L2	0.004	-0.007	-0.003	0.014	-0.066
	(0.025)	(0.027)	(0.023)	(0.033)	(0.228)
Year-Fixed	Yes	No	Yes	Yes	Yes
Industry-Fixed	Yes	Yes	Yes	Yes	Yes
N	971	971	929	971	971
R^2	0.286	0.167	0.298	0.284	0.242
			II. Export Shocks		
O^E, L1	-0.022*	-0.043***	-0.025**	-0.019*	-0.250**
	(0.012)	(0.012)	(0.011)	(0.011)	(0.095)
O^E, L2	0.024	-0.005	0.024	0.018	-0.079
	(0.041)	(0.037)	(0.041)	(0.037)	(0.176)
U^E, L1	-0.024**	-0.037**	-0.029**	-0.020*	0.037
	(0.012)	(0.014)	(0.011)	(0.011)	(0.116)
U^E, L2	0.035	0.012	0.037	0.031	-0.209
	(0.046)	(0.044)	(0.047)	(0.043)	(0.143)
D^E, L1	0.002	-0.004	0.003	0.001	-0.224*
	(0.003)	(0.004)	(0.002)	(0.002)	(0.133)
D^E, L2	-0.006	-0.011*	-0.007	-0.007	0.205
	(0.005)	(0.006)	(0.005)	(0.005)	(0.153)
Year-Fixed	Yes	No	Yes	Yes	Yes
Industry-Fixed	Yes	Yes	Yes	Yes	Yes
N	948	948	906	948	948
R^2	0.252	0.123	0.261	0.251	0.258

Notes: Excluded outliers are industries with negative average inflation outside the sample.

Table A.5: First Stage of 2SLS Estimations for Trade Value Instruments

	Import Shocks				Export Shock		
	O^M, L1	U^M, L1	D^M, L1		O^E, L1	U^E, L1	D^E, L1
O^{MIV}, L1	0.161	0.221*	0.166	O^{EIV}, L1	-0.338	0.580*	0.497
	(0.138)	(0.129)	(0.129)		(0.343)	(0.328)	(0.345)
O^{MIV}, L2	0.037	-0.083	-0.061	O^{EIV}, L2	0.862**	-0.724**	-0.634*
	(0.140)	(0.131)	(0.131)		(0.349)	(0.334)	(0.352)
U^{MIV}, L1	-0.223	0.573***	-0.005	U^{EIV}, L1	-0.495	0.770*	0.870*
	(0.184)	(0.172)	(0.172)		(0.441)	(0.422)	(0.445)
U^{MIV}, L2	-0.224	0.146	0.014	U^{EIV}, L2	0.922**	-0.841*	-1.633***
	(0.187)	(0.176)	(0.175)		(0.453)	(0.433)	(0.457)
D^{MIV}, L1	0.096	-0.063	0.456***	D^{EIV}, L1	-0.072	0.029	-0.193
	(0.092)	(0.086)	(0.086)		(0.232)	(0.221)	(0.233)
D^{MIV}, L2	0.257***	-0.223**	-0.075	D^{EIV}, L2	-0.002	0.057	0.945***
	(0.096)	(0.090)	(0.089)		(0.238)	(0.227)	(0.239)
N	997	997	997	N	972	972	972

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

Table A.6: Robustness Results on Trade Price and Quantity Shocks

Shocks	Baseline		Non-standardized Shocks	
	Import Price	Export Quantity	Import Price	Export Quantity
	(1)	(2)	(3)	(4)
O^{MP}, L1	0.262***		0.259***	
	(0.022)		(0.024)	
O^{MP}, L2	0.048**		0.048***	
	(0.019)		(0.018)	
U^{MP}, L1	0.288***		0.285***	
	(0.026)		(0.028)	
U^{MP}, L2	0.038**		0.040**	
	(0.016)		(0.015)	
D^{MP}, L1	-0.018		-0.019	
	(0.021)		(0.021)	
D^{MP}, L2	0.002		0.002	
	(0.008)		(0.008)	
O^{EQ}, L1		-0.025**		-0.389**
		(0.009)		(0.156)
O^{EQ}, L2		0.037		0.442
		(0.025)		(0.363)
U^{EQ}, L1		-0.024**		-0.406*
		(0.010)		(0.217)
U^{EQ}, L2		0.043		0.053
		(0.030)		(0.382)
D^{EQ}, L1		-0.004		0.009
		(0.004)		(0.252)
D^{EQ}, L2		-0.000		0.395
		(0.005)		(0.411)
O^{EX}, L1	-0.630***	-0.812***	-0.636***	-0.782***
	(0.144)	(0.199)	(0.145)	(0.203)
O^{EX}, L2	-0.561***	-0.675***	-0.564***	-0.659***
	(0.072)	(0.071)	(0.073)	(0.068)
U^{EX}, L1	-0.127	-0.259	-0.130	-0.262
	(0.120)	(0.182)	(0.119)	(0.194)
U^{EX}, L2	-0.022	-0.049	-0.020	-0.050
	(0.046)	(0.055)	(0.045)	(0.046)
D^{EX}, L1	0.014	0.028	0.014	0.033
	(0.020)	(0.026)	(0.019)	(0.030)
D^{EX}, L2	-0.016	-0.019	-0.017	-0.016
	(0.015)	(0.015)	(0.015)	(0.011)
N	957	947	957	947
R^2	0.313	0.267	0.312	0.257

Notes: The dependent variable is the log of annual changes in the producer price index. In columns 1 and 2, the direct effects of shocks are standardized with import price (MP) and exchange rates (EX) expressed in logarithmic terms. In columns 3 and 4, the shocks are constructed without standardization. Other terms are as in Table 1.