The Trade-Inflation Nexus:
The Role of Production Networks

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Outline

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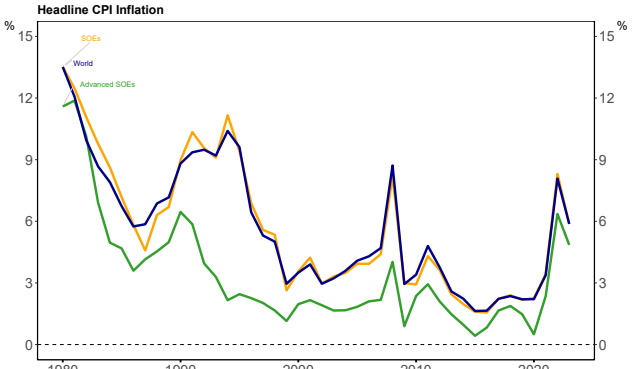
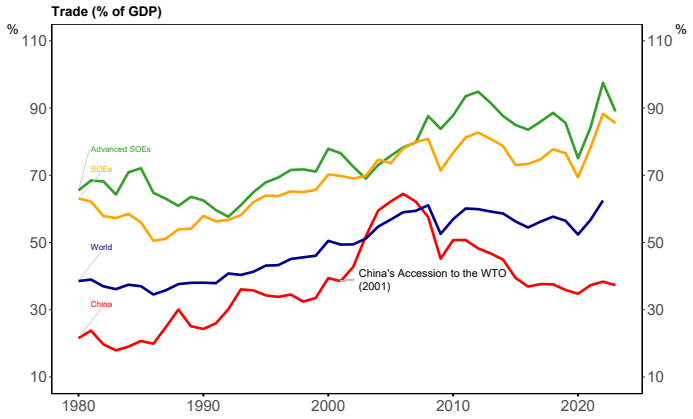
Global Inflation



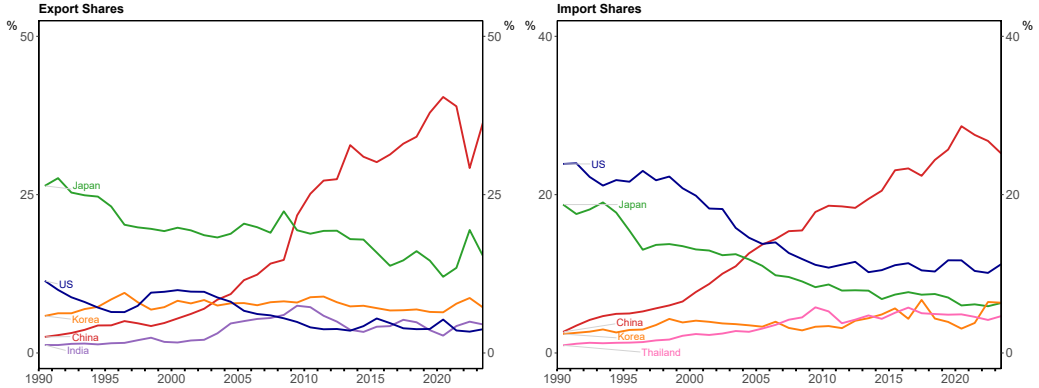
Source: Global database of inflation.
Notes: Median of annual average inflation; SOEs stands for small open economies that represent less than 5 percent of world GDP and have a trade openness larger than 30 percent of GDP.

Trade Openness



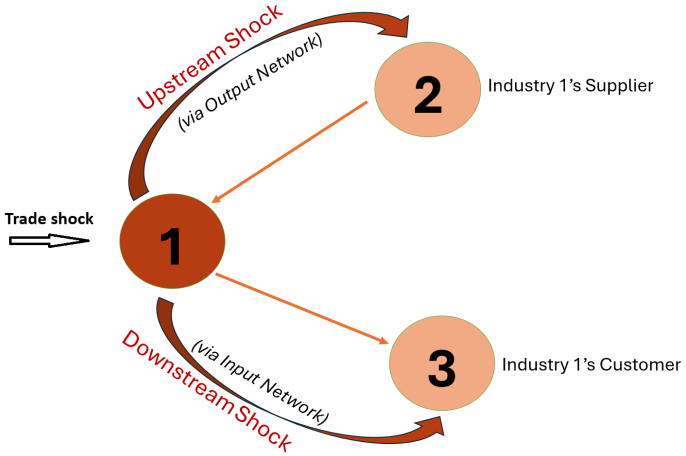
Source: World Bank, *World Development Indicators*
Notes: Data for SOEs and Advanced SOEs is the median of trade (import + export) as a percentage of GDP in SOEs and Advanced SOEs.

Australia-China Bilateral Trade



Source: ABS; RBA; and authors' calculations
Notes: Share of total values, annual data derived from monthly data.

Trade and Production Networks



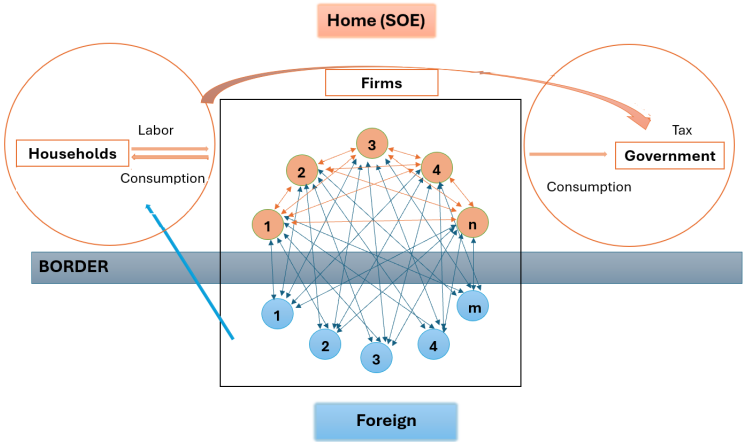
What is the role of production networks
in transmitting price effects of trade shocks?

- **Theoretical IO model**: illustrate the role of production networks in propagating price effects of trade shocks.
- **Empirical analysis**: estimate direct and indirect effects of China's trade shocks on PPI inflation in Australian manufacturing sectors over 2000-2023.

Literature

- **Trade-inflation**:
  - Different mechanisms: Romer (1993), Terra (1998), Aron and Muellbauer (2007), Cooke (2010), and Samimi et al. (2012)
- **Microeconomic origins of aggregate fluctuations**:
  - Aggregate employment and production: Acemoglu, Carvalho, et al. (2012), Acemoglu, Ozdaglar, et al. (2015), and Acemoglu, D. Autor, et al. (2016)
- **Propagation of trade shocks within IO networks to inflation**:
  - Global inflation: R. Auer and Saure (2013), R. A. Auer and Mehrotra (2014), R. A. Auer, Levchenko, et al. (2019), and Di Giovanni et al. (2022)
  - U.S. inflation: Jaravel and Sager (2019) and Luo and Villar (2023)
- **Impacts of China's integration into global trade**:
  - Global inflation dynamics: Eickmeier and Kühnlenz (2018)
  - U.S. manufacturing labor market: D. H. Autor et al. 2013; D. H. Autor et al. 2016; Acemoglu, D. Autor, et al. 2016; D. Autor et al. 2021
  - Australia: Bjørnland and Thorsrud (2016) and Dungey et al. (2020)

Theoretical Model



Firms

- A representative firm in each industry i:

$$y_i = z_i l_i^{\alpha_i^l} \prod_{n=1}^{N} x_{in}^{a_{in}} \prod_{m=1}^{M} x_{im}^{a_{im}}, \quad \text{where} \quad \alpha_i^l + \sum_{n=1}^{N} a_{in} + \sum_{m=1}^{M} a_{im} = 1$$

- The firm minimizes its production cost:

$$v_i^y = \sum_{n=1}^{N} p_n x_{in} + \sum_{m=1}^{M} p_m x_{im} + w_i l_i$$
$$s.t. \quad y_i = \bar{y}_i$$

		Production sector					Intermediate output	Final demand	Total output
		1	…	j	…	n			
Production sector	1								
	…								
	i			X_{ij}			$X_{i.}$	Y_i	X_i
	…								
	n								
Intermediate input				$X_{.j}$					
Value added				V_j				Y=V	
Total input				X_j					

Input matrix A : $a_{ij} = \frac{p_j x_{ij}}{p_i y_i}$ Output matrix B : $b_{ij} = \frac{p_j x_{ij}}{p_j y_j}$

- Industrial prices:

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

- Industrial wages:

$$\hat{W} = (I - D(\alpha_I))^{-1}\left[V(1)\hat{Y} - \hat{Z} - (I - A)\hat{P} + A^{*}\hat{P}^{*} - \hat{L} + \hat{S}_y\right]$$

Households

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

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

$$s.t.\quad \sum_{n=1}^{N}p_n c_n+\sum_{m=1}^{M}p_m c_m=\sum_{n=1}^{N}w_n l_n-T$$

Government

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

Equilibrium

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

- ***Proposition 1:*** Industrial prices:

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

- ***Proposition 2:*** The first-order impact of import prices on industrial prices:

$$\hat{P} = \underbrace{\left(\alpha_{A^*}A^* + \frac{\rho}{1-\rho}\alpha_{S_{c^*}^T}S_{c^*}^T\right)\hat{P}^*}_{\text{Direct impact}} + \underbrace{\frac{\rho}{1-\rho}(\mathbf{A}-\mathbf{I})\Big(V(\alpha_c)+V(\pi)\Big)S_{c^*}^T\hat{P}^*}_{\text{Downstream impact}} + \underbrace{\frac{\rho}{1-\rho}(\mathbf{B^T}-\mathbf{I})V(\alpha_c)S_{c^*}^T\hat{P}^*}_{\text{Upstream impact}}$$

- ***Proposition 3:*** The first-order impact of export values on industrial prices:

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

- Direct channels
  - Import shocks through the costs of imported inputs
  - Export shocks through changes in expenditures and wages
- Indirect channels
  - Upstream networks
  - Downstream networks

Empirical Methodology

- **Trade exposure**

$$Import_{i,t} = \frac{Australian\ Imports\ from\ China_{i,t}}{Australian\ Market\ Size_{i,2017/18}}$$

$$Export_{i,t} = \frac{Australian\ Exports\ to\ China_{i,t}}{Australian\ Market\ Size_{i,2017/18}}$$

- **Trade shocks**

$$Own: \quad O_{i,t} = \Delta Import_{i,t}\ or\ \Delta Export_{i,t}$$

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

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

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

Identification

- **Instrument variables (D. H. Autor et al. 2013)**: China's trade with other countries

$$Import^{IV}_{i,t} = \frac{NonAustralian\ Imports\ from\ China_{i,t}}{Australian\ Market\ Size_{i,2017/18}}$$

$$Export^{IV}_{i,t} = \frac{NonAustralian\ Exports\ to\ China_{i,t}}{Australian\ Market\ Size_{i,2017/18}}$$

$$O^{IV}_t = \Delta Import^{IV}_t \text{ or } \Delta Export^{IV}_t, \qquad U^{IV}_t = (B^T - I) \cdot O^{IV}_t, \qquad D^{IV}_t = (A - I) \cdot O^{IV}_t$$

[1] Import values from China by China's largest trading partners: USA, Japan, India, Germany, Netherlands, and Malaysia

[2] Export values to China from China's largest export markets: USA, Japan, Germany, Brazil, United Kingdom, Chile, and Canada

Data

47 manufacturing industries classified under the IOIG 2015 version over 2000-2023.

Input-Output Linkage:

- The Input-Output tables (ABS), at the 4-digit Input-Output Industry Groups (IOIG) level.

Industrial Prices:

- The Producer Price Index (PPI) for the output of manufacturing industries (ABS).
- Map from 3- or 4-digit Australian and New Zealand Standard Industrial Classification (ANZSIC) to 4-digit IOIG.

Trade Variables:

- Import and Export (value, quantity) from bilateral merchandise imports and exports (UN Comtrade).
- Map from 4- or 5-digit Standard International Trade Classification Revision 3 (SITC3) to 4-digit IOIG.

Australia's Market Size:

- The industrial total supply net exports based on the ABS's Input-Output Table.

Exchange Rate:

- The exchange rate is the normally quoted Australian dollar against the US dollar (OECD Economic Outlook).

Empirical Results

	Import Shocks			Export Shocks	
	OLS	2SLS		OLS	2SLS
O^M, L1	0.024*	0.076	O^E, L1	-0.022*	-0.237**
	(0.013)	(0.047)		(0.012)	(0.100)
O^M, L2	0.145**	0.278***	O^E, L2	0.024	-0.190*
	(0.062)	(0.066)		(0.041)	(0.110)
U^M, L1	0.027**	0.059	U^E, L1	-0.024**	-0.235**
	(0.013)	(0.059)		(0.012)	(0.116)
U^M, L2	0.154**	0.319***	U^E, L2	0.035	-0.162
	(0.075)	(0.084)		(0.046)	(0.131)
D^M, L1	-0.001	0.010	D^E, L1	0.002	0.010
	(0.009)	(0.025)		(0.003)	(0.027)
D^M, L2	0.004	-0.035	D^E, L2	-0.006	-0.025
	(0.025)	(0.036)		(0.005)	(0.062)
N	971	997		948	972
R^2	0.286	0.114		0.252	0.109

Notes: 2SLS columns report second-stage coefficients. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses are clustered by industry.

value = price * quantity

- import prices (*MP*)
- export quantity (*EQ*)
- exchange rates (*EX*)

	Import Price Shocks				Export Quantity Shocks		
	Full Sample (2000-2023)	Pre-COVID (2000-2019)	COVID (2020-2023)		Full Sample (2000-2023)	Pre-COVID (2000-2019)	COVID (2020-2023)
O^{MP}, L1	0.262***	0.080**	0.055	O^{EQ}, L1	-0.025**	0.009	-0.139**
	(0.022)	(0.031)	(0.033)		(0.009)	(0.025)	(0.063)
O^{MP}, L2	0.048**	-0.006	0.210***	O^{EQ}, L2	0.037	0.051	-0.036
	(0.019)	(0.011)	(0.059)		(0.025)	(0.033)	(0.044)
U^{MP}, L1	0.288***	0.092**	0.084**	U^{EQ}, L1	-0.024**	0.021	-0.159**
	(0.026)	(0.038)	(0.039)		(0.010)	(0.029)	(0.074)
U^{MP}, L2	0.038**	-0.010	0.211***	U^{EQ}, L2	0.043	0.058	-0.028
	(0.016)	(0.015)	(0.063)		(0.030)	(0.039)	(0.045)
D^{MP}, L1	-0.018	-0.002	-0.038***	D^{EQ}, L1	-0.004	-0.011**	0.008
	(0.021)	(0.005)	(0.009)		(0.004)	(0.005)	(0.022)
D^{MP}, L2	0.002	0.004	-0.014	D^{EQ}, L2	-0.000	-0.004	0.002
	(0.008)	(0.003)	(0.011)		(0.005)	(0.006)	(0.020)
N	957	957			947	947	
R^2	0.313	0.304			0.267	0.286	

Notes: *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses are clustered by industry.

- Direct import shocks: significant and positive.
- Direct export shocks: significant and negative.
- Upstream shocks: significant with similar magnitude to direct shocks.
- Downstream shocks: insignificant and negligible.

Conclusion

- Trade shocks are transmitted through production networks to domestic inflation.
- Australia's increased imports of low-cost manufacturing goods from China contributed to reduced inflation through consumption and production channels.

- Trade shocks affect inflation on both the demand and supply sides. Supply-side effects can be persistent due to the extended production process.
- Trade policies such as tariffs would increase inflation directly and indirectly.