Inflation in Disaggregated Small Open Economies

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Motivation

1 2

- Inflation rose everywhere in recent years

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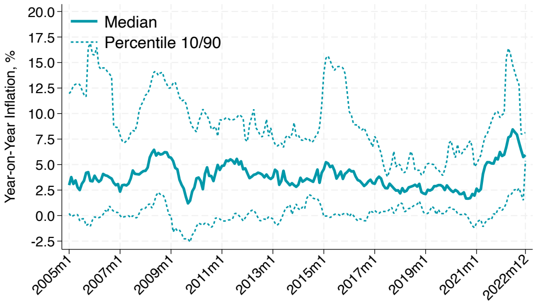
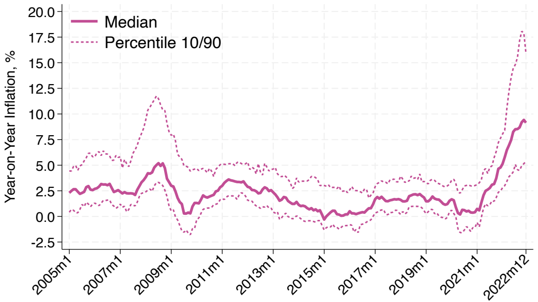
(a) Non Small Open Economies



(b) Small Open Economies



Source: Bank for International Settlements. Non SOE: 9, SOE: 47. SOE criteria: trade openness $\geq$ 30 % and share of world GDP $\leq$ 5 %.

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  1. Closed economy: US focus

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  2. Open economy: focus on Euro Area and US

     di Giovanni, Kalemli-Ozcan, Silva, and Yildirim (2023b), Fornaro and Romei (2022), Comin and Johnson (2022), Comin, Johnson and Jones (2023), Andrade, Sheremirov, and Arazi (2023), ...

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- Why?
  - Covid-19 scenario: a multitude of aggregate/sectoral, domestic/foreign shocks
    - How do they affect inflation in SOEs? How do we aggregate them?
  - Domestic sectors rely on international trade directly and *indirectly*
    - more so in SOEs

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- How? $\longrightarrow$ Theory and Empirics

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3. **COVID19 Application for United Kingdom and Chile (2020–2022)**
   * Outperforms model without networks in matching inflation (mean and std. dev.)

Related Literature

1. **Inflation in closed economy multi-sector models**

   Pasten et. al (2020), Guerrieri et. al (2021, 2022), Baqaee and Farhi (2022, 2023), La'O and Tahbaz-Salehi (2022), Rubbo (2023), Afrouzi and Bhattarai (2023), di Giovanni et al. (2022, 2023a), Ferrante et. al (2023), Luo and Villar (2023),...

   Contribution: Domestic production network relevant beyond shares + quantification

2. **Inflation in open economies**

   Gali and Monacelli (2005), Corsetti and Pesenti (2005), Comin and Johnson (2022), Fornaro and Romei (2022), Ho et. al (2022), di Giovanni et. al (2023b), Comin et. al (2023), Baqaee and Farhi (2023), Cardani et. al (2023) ...

   Contribution: Production networks alter CPI elasticities without frictions/distortions

3. **Supply-chain and indirect trade via production networks**

   Huneeus (2018), Dhyne et. al (2021), Adao et. al (2022), Antras and Chor (2022)

   Contribution: Why, and how much indirect trade matters for inflation

Outline

1. Model
2. Empirics
3. Application
4. Conclusion

Model

Small Open Economy with Production Networks

- Two period model: focus on the present period; take future as given.
- Perfect foresight.
- Domestically produced goods: $i \in N \longrightarrow$ prices P_i^D
- Multiple (non-produced) factors: $f \in F \longrightarrow$ factor prices: W_f
- Imported goods: $m \in M \longrightarrow$ import prices: P_m^M
- Perfectly competitive goods and factor markets

Household: Intertemporal Problem

- Representative household seeks to maximize

$$\log C + \beta \log C^*$$

- subject to the budget constraints

$$PC + \mathcal{E}B = (1 + i^f_{-1})\mathcal{E}B_{-1} + \sum_{f \in F} W_f \bar{L}_f + \sum_{i \in N} \Pi_i$$

$$P^*C^* + \mathcal{E}^*B^* = (1 + i^f)\mathcal{E}^*B + \sum_{f \in F} W^*_f \bar{L}^*_f + \sum_{i \in N} \Pi^*_i$$

- Euler Equation

$$\frac{1}{PC} = \frac{\mathcal{E}^*}{\mathcal{E}} \beta (1 + i^f) \frac{1}{P^*C^*}$$

Household: Intratemporal problem

- Intratemporal problem:

$$\min_{\{C_i^D\}_{i\in N},\{C_m^M\}_{m\in M}} \quad \sum_{i\in N} P_i^D C_i^D + \sum_{m\in M} P_m^M C_m^M \text{ subject to} \quad C \geq \bar{C}$$

- Cash-in-advance constraint

$$PC = \sum_{i\in N} P_i^D C_i^D + \sum_{m\in M} P_m^M C_m^M \leq \mathcal{M}$$

$\mathcal{M}$: money supply.

Firms

- Representative firm in each domestic sector $i \in N$

$$Q_i = Z_i F_i(\{L_{if}\}_{f \in F}, \{M_{ij}^D\}_{j \in N}, \{M_{im}^M\}_{m \in M})$$

- Given $(\boldsymbol{W}, \boldsymbol{P}_M, \boldsymbol{P}_D)$ and production function, firms solve

$$\min_{\{L_{if}\}_{f \in F}, \{M_{ij}^D\}_{j \in N}, \{M_{ij}^M\}_{m \in M}} \sum_{f \in F} W_f L_{if} + \sum_{j \in N} P_j^D M_{ij}^D + \sum_{m \in M} P_m^M M_{im}^M$$

$$\text{subject to} \quad Z_i F_i(\{L_{if}\}_{f \in F}, \{M_{ij}^D\}_{j \in N}, \{M_{im}^M\}_{m \in M}) \geq \bar{Q}_i$$

Market Clearing

- Factor markets clear

$$\bar{L}_f = \sum_{i \in N} L_{if} \quad f \in F$$

- Goods markets clear

$$Q_i = C_i^D + X_i + \sum_{j \in N} M_{ji}^D \quad i \in N$$

- Aggregate resource constraint

$$\sum_{i \in N} P_i^D X_i - \sum_{m \in M} P_m^M (C_m + \sum_{i \in N} M_{im}) = T$$

Equilibrium Static model

- Households maximize utility s.t. budget constraint.
- Firms minimize costs.
- Goods and factor markets clear.
- Aggregate resource constraint holds.
- Cash-in-advance constraint holds with equality.

Price changes

- Consider log-changes $(\widehat{\boldsymbol{W}},\ \widehat{\boldsymbol{Z}},\ \widehat{\boldsymbol{P}}_M)$ with $\widehat{\boldsymbol{Y}} = \mathrm{d}\log \boldsymbol{Y}$

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- Changes in domestic prices (to a first-order)

$$\widehat{P}_i^D = -\widehat{Z}_i + \sum_{f\in F} \underbrace{\frac{W_f L_{if}}{P_i^D Q_i}}_{\equiv a_{if}} \widehat{W}_f + \sum_{j\in N} \underbrace{\frac{P_j^D M_{ij}}{P_i^D Q_i}}_{\equiv \Omega_{ij}} \widehat{P}_j^D + \sum_{m\in M} \underbrace{\frac{P_m^M M_{im}}{P_i^D Q_i}}_{\equiv \Gamma_{im}} \widehat{P}_m^M \tag{1}$$

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$$\widehat{\boldsymbol{P}}_D = -\Psi\widehat{\boldsymbol{Z}} + \Psi\boldsymbol{A}\widehat{\boldsymbol{W}} + \Psi\Gamma\widehat{\boldsymbol{P}}_M \tag{2}$$

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- $\Psi = (\boldsymbol{I} - \Omega)^{-1} = \sum_{s=0}^{\infty} \Omega^s$: direct and indirect production network linkages across producers intuition det

Consumer Price Index Elasticities

- Notation

$$\bar{\lambda}_i = \frac{P_i^D Q_i}{E}; \quad \bar{\Lambda}_f = \frac{W_f \bar{L}_f}{E}; \quad \bar{b}_i = \frac{P_i^D C_i^D}{E}; \quad \bar{b}_m^M = \frac{P_m^M C_m^M}{E}; \quad \bar{x}_i = \frac{P_i^D X_i}{E}$$

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- CPI changes in data

$$\widehat{CPI} = \sum_{i \in N} \bar{b}_i \, \widehat{P}_i^D + \sum_{m \in M} \bar{b}_m^M \, \widehat{P}_m^M \tag{3}$$

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- CPI changes in small open economy with networks

$$\widehat{CPI} = -\left(\bar{\boldsymbol{\lambda}}^T - \tilde{\boldsymbol{\lambda}}^T\right) \widehat{\boldsymbol{Z}} + \left(\bar{\boldsymbol{\Lambda}}^T - \tilde{\boldsymbol{\Lambda}}^T\right) \widehat{\boldsymbol{W}} + \left((\bar{\boldsymbol{b}}^M)^T + (\tilde{\boldsymbol{b}}^M)^T\right) \widehat{\boldsymbol{P}}_M$$

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- Closed economy with networks: $\widehat{CPI} = -\boldsymbol{\lambda}^T \, \widehat{\boldsymbol{Z}} + \boldsymbol{\Lambda}^T \, \widehat{\boldsymbol{W}}$ Baqaee and Farhi, 2022

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- Closed economy with networks: $\widehat{CPI} = -\boldsymbol{\lambda}^T \, \widehat{\boldsymbol{Z}} + \boldsymbol{\Lambda}^T \, \widehat{\boldsymbol{W}}$ Baqaee and Farhi, 2022
- **Open economy + production networks changed relevant elasticities!**

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Dampening impact of sectoral technology shocks

$$\widehat{CPI} = -\left(\bar{\lambda}^T - \tilde{\lambda}^T\right)\hat{\boldsymbol{z}}$$

Model	Market Clearing	Vector	Adjustment
Closed Economy			
Small Open Economy			

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$$\widehat{CPI} = \left(\bar{\Lambda}^T - \tilde{\Lambda}^T\right)\hat{\boldsymbol{W}}$$

- Recall $\bar{\Lambda}^T = \bar{\boldsymbol{\lambda}}^T \boldsymbol{A} \implies \bar{\Lambda}_f = \sum_{i \in N} a_{if} \bar{\lambda}_i$

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Amplifying impact of import prices

$$\widehat{CPI} = \left((\bar{\boldsymbol{b}}^M)^T + (\tilde{\boldsymbol{b}}^M)^T \right) \widehat{\boldsymbol{P}}_M$$

- $\bar{\boldsymbol{b}}^M$: **not** relevant elasticities of CPI to import prices $(\bar{b}_M = P_m^M C_m / E)$

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- $\bar{\boldsymbol{b}}^M$: **not** relevant elasticities of CPI to import prices $(\bar{b}_M = P_m^M C_m / E)$
- CPI depends on import prices
  - Directly: $(\bar{\boldsymbol{b}}^M)^T$
  - Indirectly : $(\tilde{\boldsymbol{b}}^M)^T = \bar{\boldsymbol{b}}^T \boldsymbol{\Psi\Gamma}$

Networks matter beyond aggregate shares

$$\widehat{CPI} = -\left(\bar{\lambda}^T - \tilde{\lambda}^T\right)\hat{\boldsymbol{z}} + \left(\bar{\Lambda}^T - \tilde{\Lambda}^T\right)\widehat{\boldsymbol{W}} + \left((\bar{\boldsymbol{b}}^M)^T + (\tilde{\boldsymbol{b}}^M)^T\right)\widehat{\boldsymbol{P}}_M$$

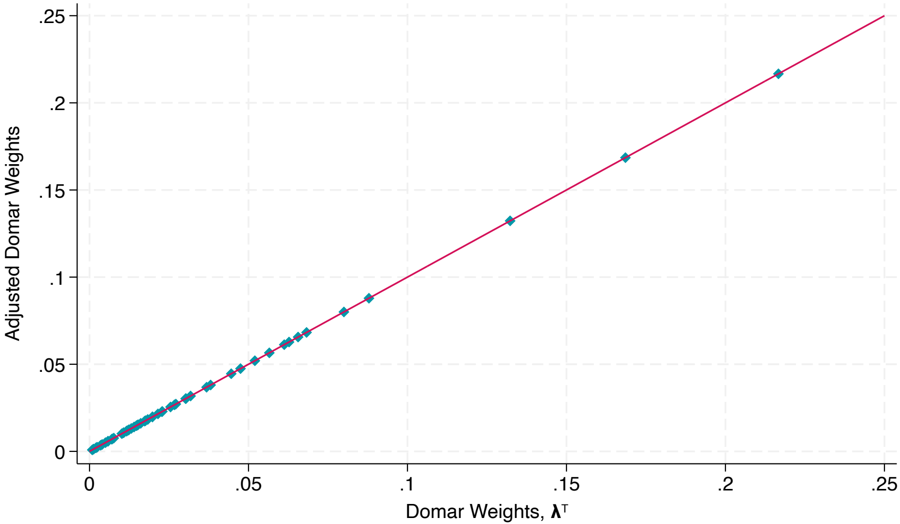
- $(\bar{\lambda}, \bar{\Lambda}, \bar{\boldsymbol{b}}^M)$ are **not** the relevant elasticities.
- **Need** production network structure to compute $\tilde{\lambda}_i, \tilde{\Lambda}_f, \tilde{b}_m$
- More in the paper:
    * Aggregate demand? Aggregate demand
    * Fully dynamic SOE model Dynamic
- Next step: measure these in the data

Empirics

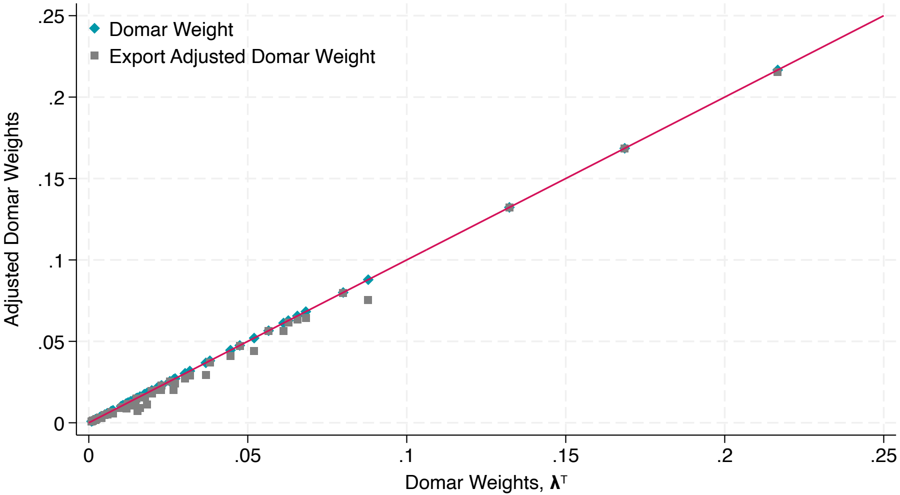
Data

- Data from the World Input-Output Table Release 2016
  - 56 sectors and 43 countries.
  - Detailed information on intermediate input usage, exports, imports, sales.
  - Domestic Input-Output Tables.
- Penn-World Table 9.0. Small Open Economies (1990 – 2019)
  - Share of World GDP $\leq 5\%$
  - Openness ((Exports + Imports)/nGDP) $\geq 30\%$
- All cross-sectional plots based on the year 2014 (last year available).

Domar weights in the United States

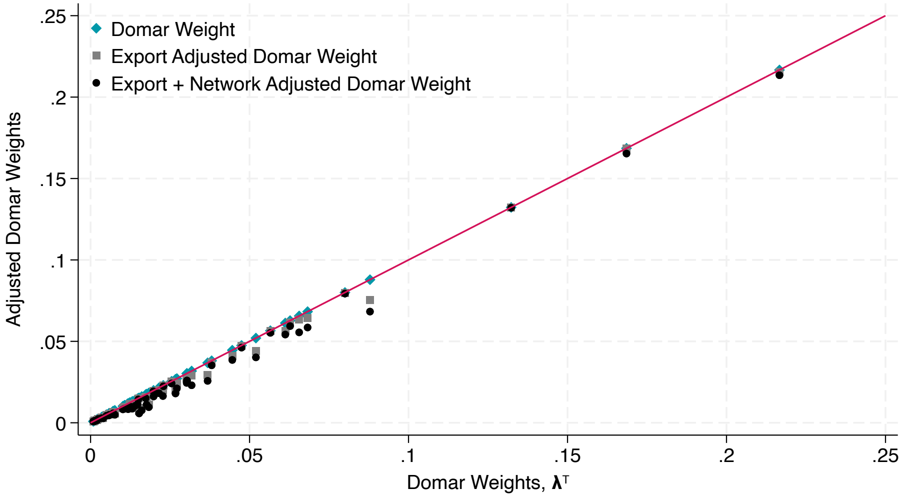


Export adjustment? Not much



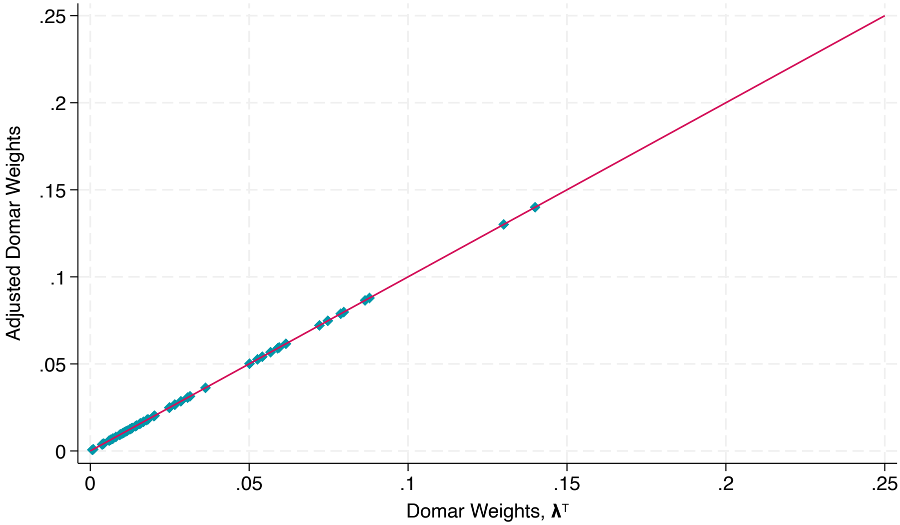
R-squared=0.996

Production network? Not much either

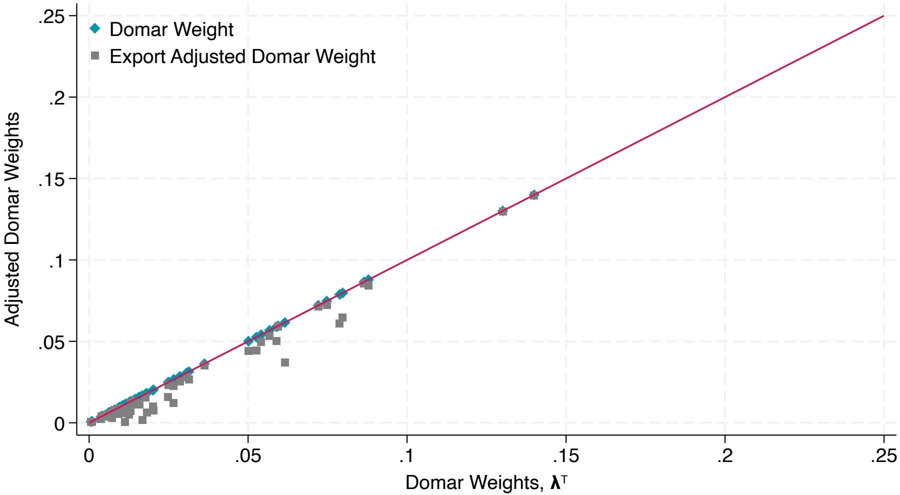


R^2(Export adjusted)=0.996, R^2(Full adjustment)=0.991

Domar weights in United Kingdom

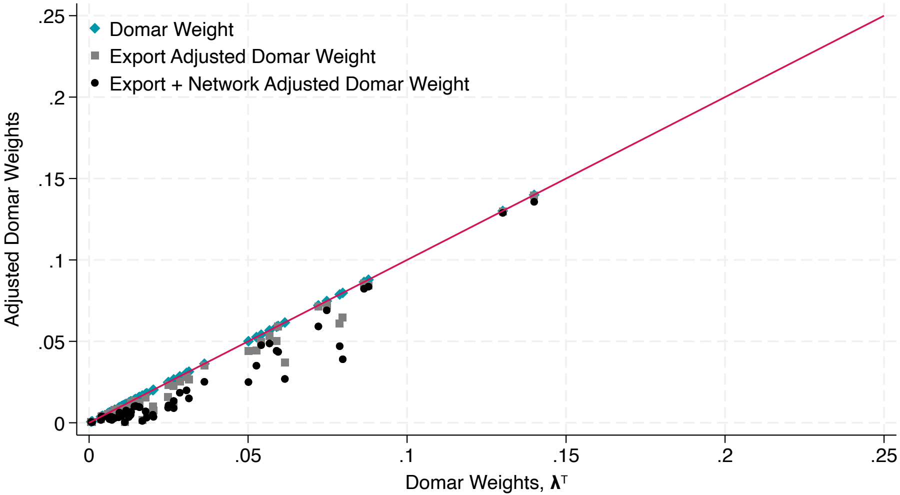


Export adjustment? Matters!



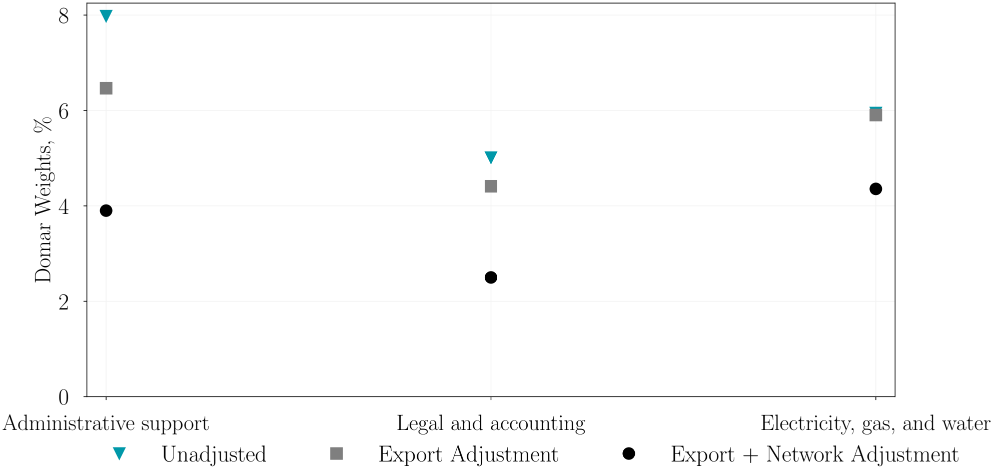
R-squared=0.973

Production network adjustment? Also matters!



R^2(Export adjusted)=0.973, R^2(Full adjustment)=0.930

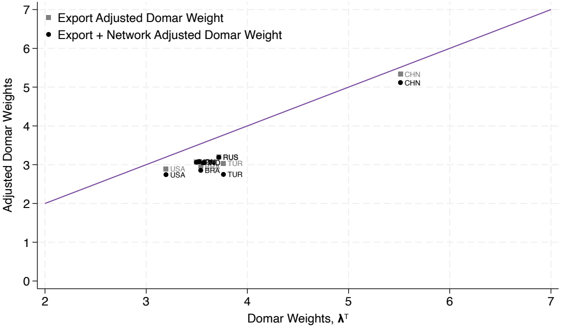
UK: 3 largest export adjustment + network



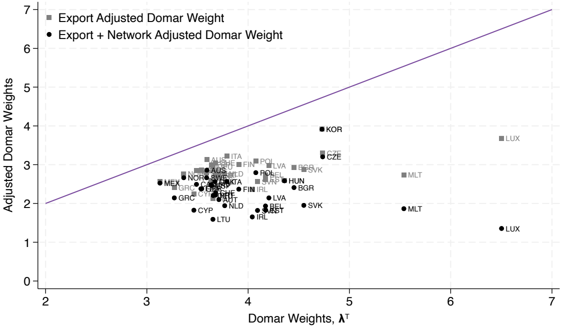
- Electricity: **5.95%** $\xrightarrow[\text{Export Adjustment}]{}$ **5.90%** $\xrightarrow[\text{Production Network Adj.}]{}$ **4.4%**

Average adjustments across countries Cross-Country Sectoral

(a) Non Small Open Economies



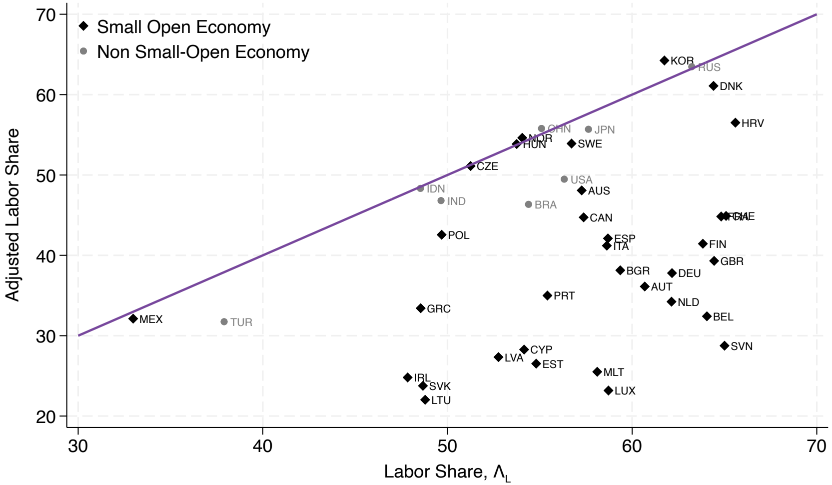
(b) Small Open Economies



- ▶ Full adjustment is small in non-SOEs but quantitatively important in SOEs

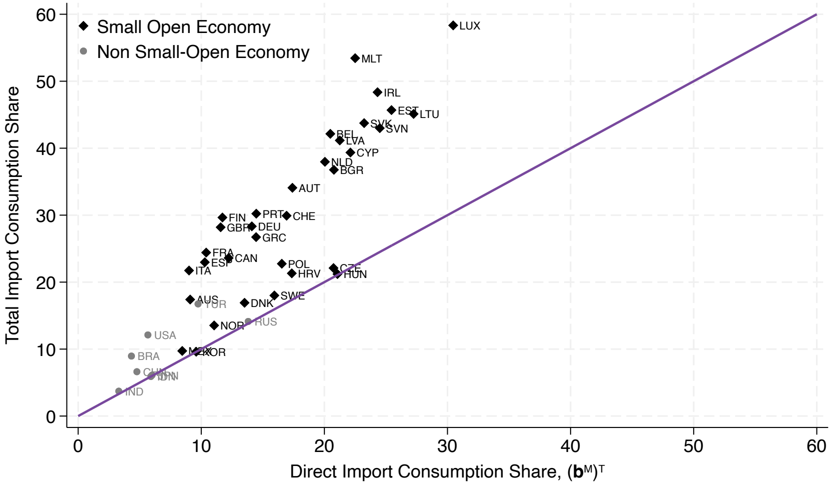
Elasticity to factor prices: $(\Lambda^T - \tilde{\Lambda}^T)\widehat{W}$

Cross-Country Sectoral



- Adjustment matters more for SOEs.

Elasticity to import prices: $(\bar{b}^M + \tilde{b}^M)\widehat{P}_M$



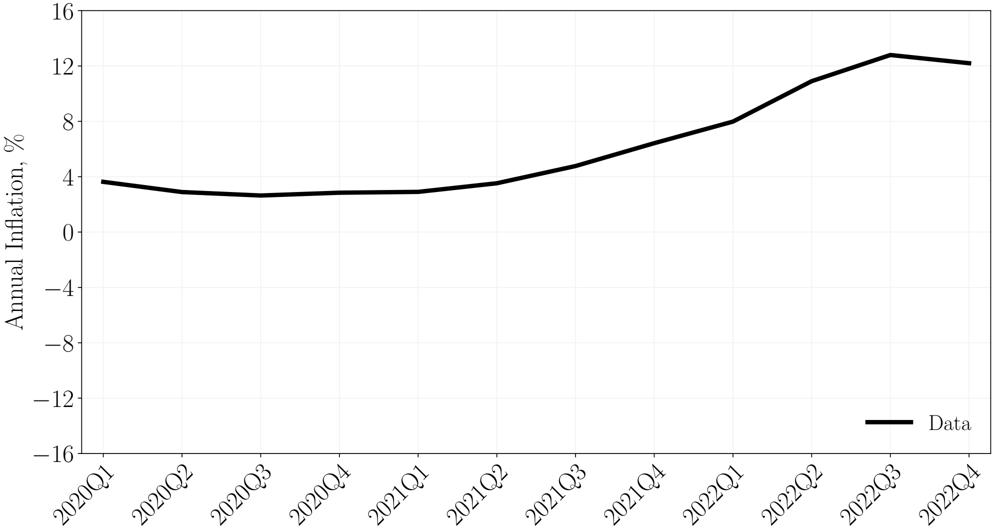
- Indirect consumption share as important as direct consumption share!

Application

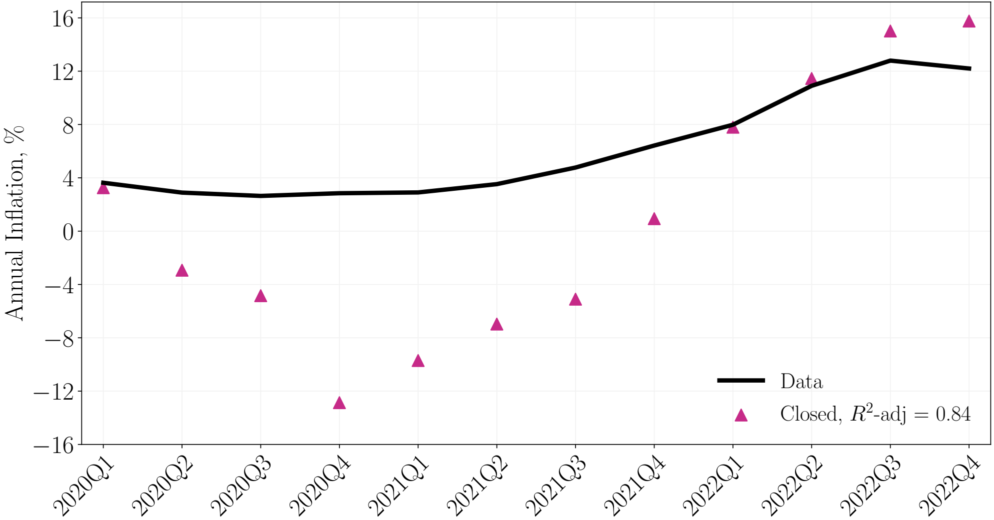
Inflation during COVID19: Application

- Collect data on sectoral wages, labor productivity, and import price
  - Two small open economies $\longrightarrow$ Chile and UK
- Calibrate relevant elasticities using Input-Output tables.
  - Model to data assumption: sector-specific labor and capital.
  - 20 sectors: SIC2 classification.
- Use data on $\hat{\boldsymbol{W}}, \hat{\boldsymbol{Z}}, \hat{P}_M$ + elasticities to construct model implied inflation.
  - Three scenarios: Closed, Open - No Network, and Open - Network

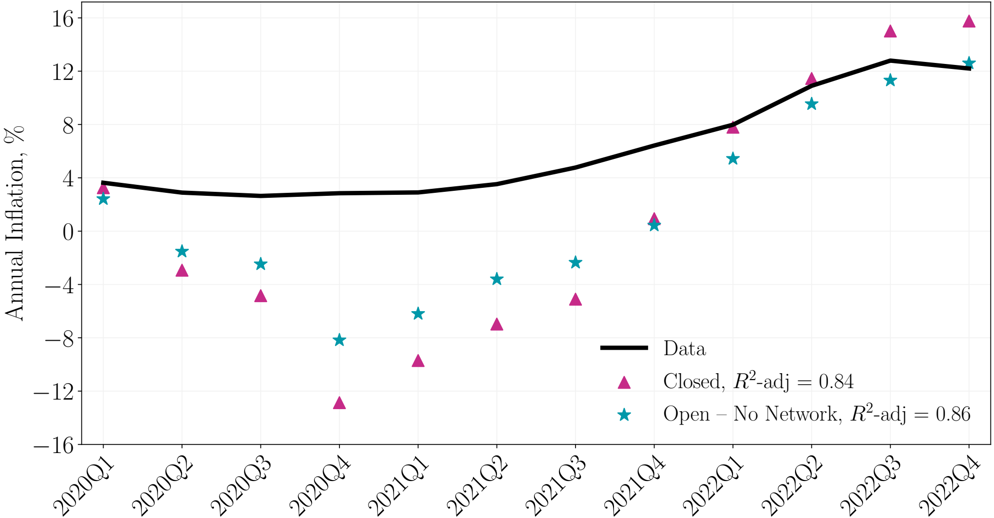
Inflation during COVID19: Chile



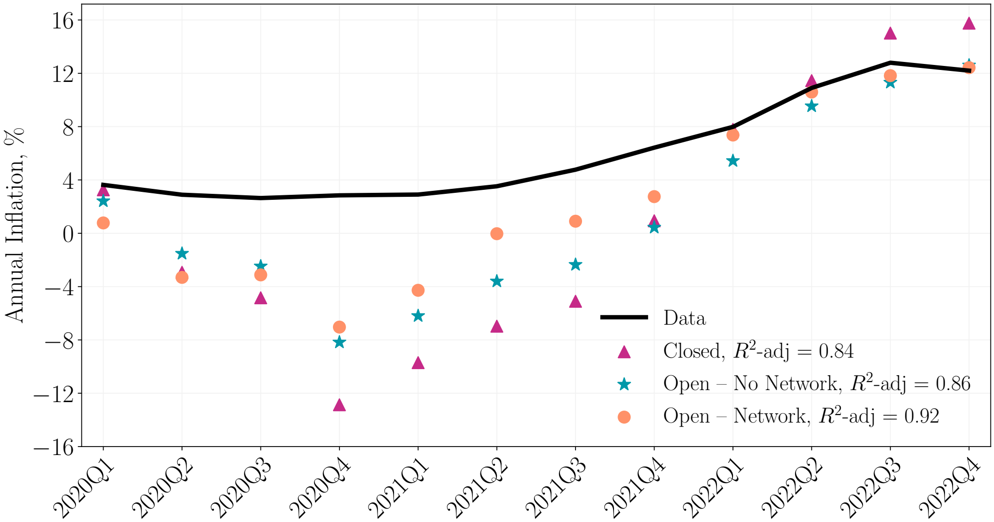
Inflation during COVID19: Chile



Inflation during COVID19: Chile

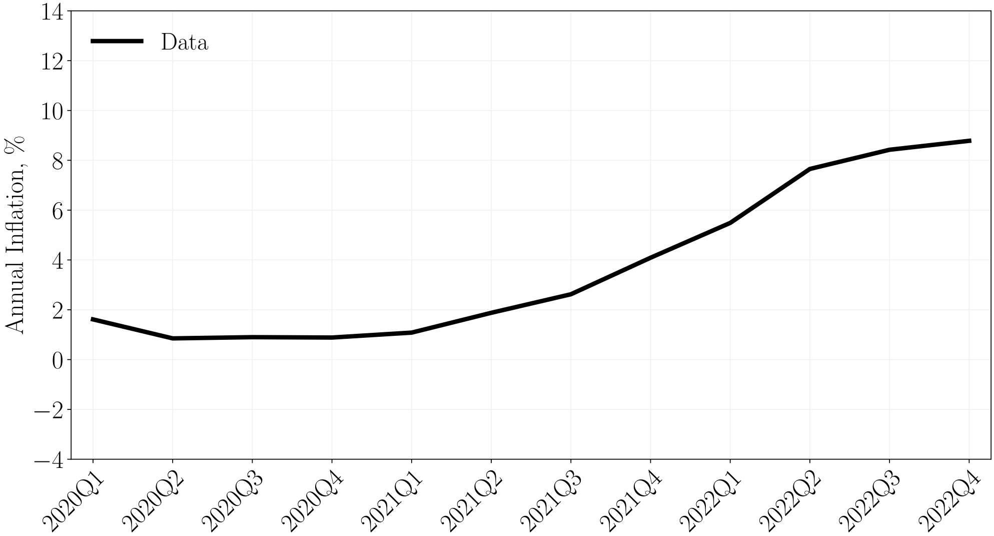


Inflation during COVID19: Chile



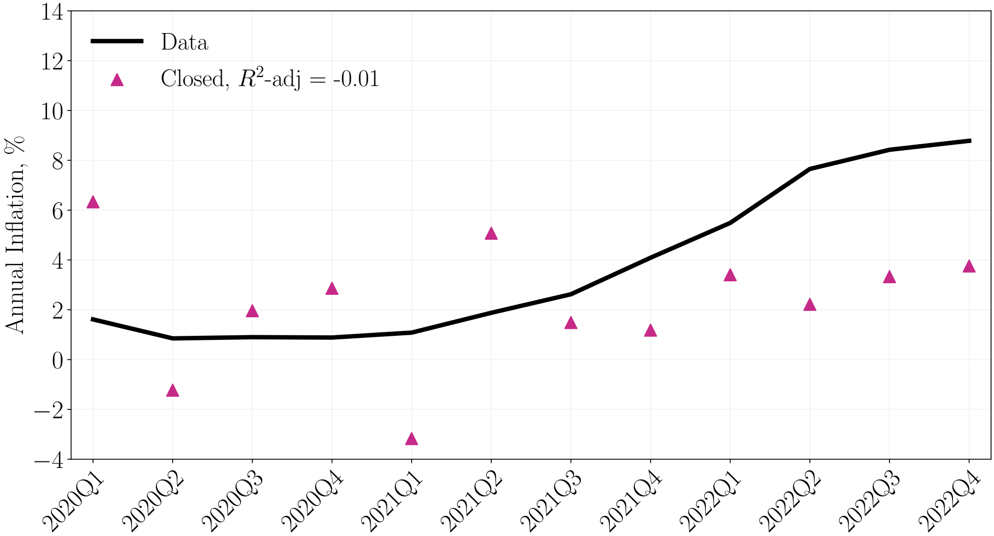
Inflation during COVID19: United Kingdom

Summary Stats



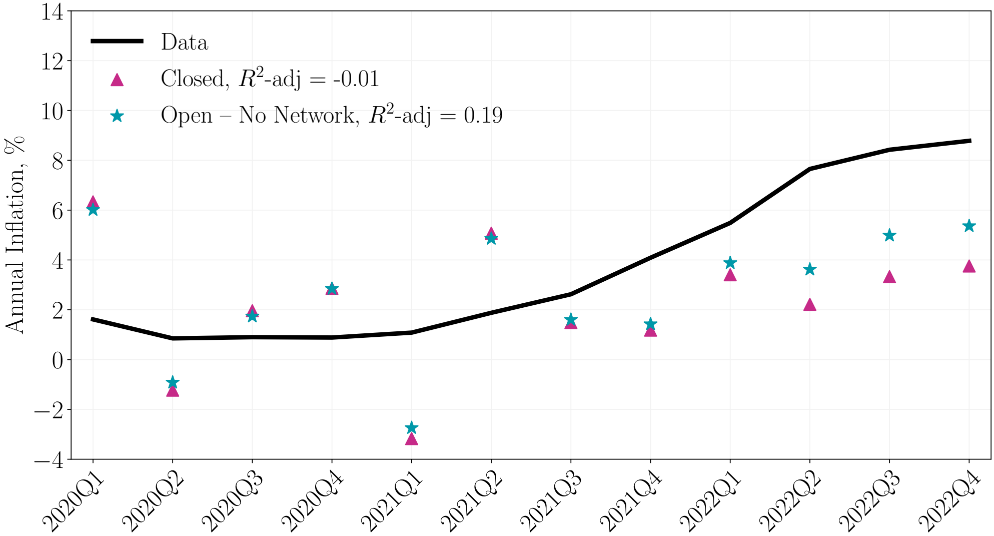
Inflation during COVID19: United Kingdom

Summary Stats



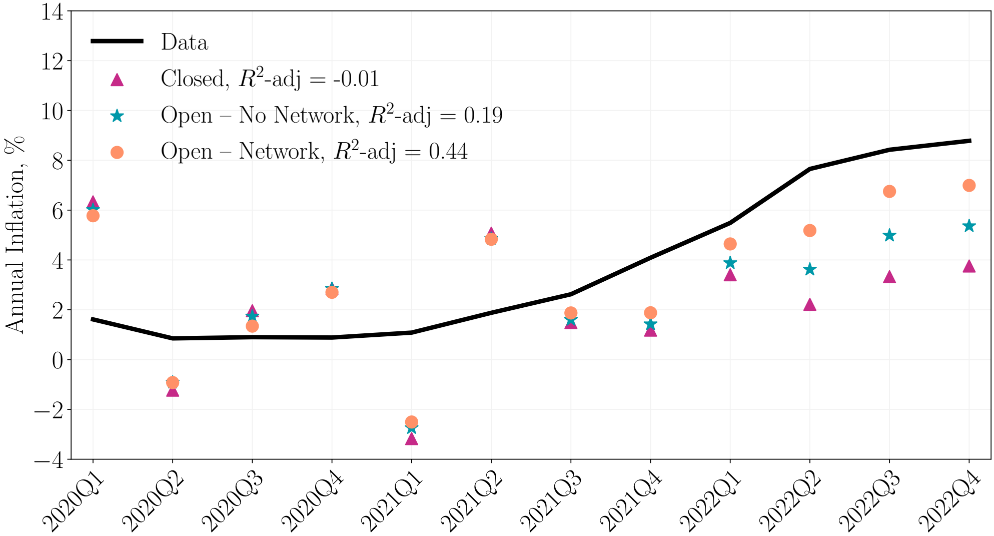
Inflation during COVID19: United Kingdom

Summary Stats



Inflation during COVID19: United Kingdom

Summary Stats



Conclusion

Conclusion

1. Domestic production network amplifies trade affecting CPI elasticities
    * Production networks matter to a first-order for CPI

2. Quantitatively important for small open economies

3. Helps to match inflation during Covid-19 in United Kingdom and Chile

Conclusion

1. Domestic production network amplifies trade affecting CPI elasticities
   * Production networks matter to a first-order for CPI

2. Quantitatively important for small open economies

3. Helps to match inflation during Covid-19 in United Kingdom and Chile

Research agenda

* “*Optimal monetary and exchange rate policy in small open economies with production networks*"
* “*Inflation persistence via production networks*"
* “*Pandemic-era inflation drivers and global spillovers*"

(with di Giovanni, Kalemli-Özcan, and Yıldırım)

Thank you!

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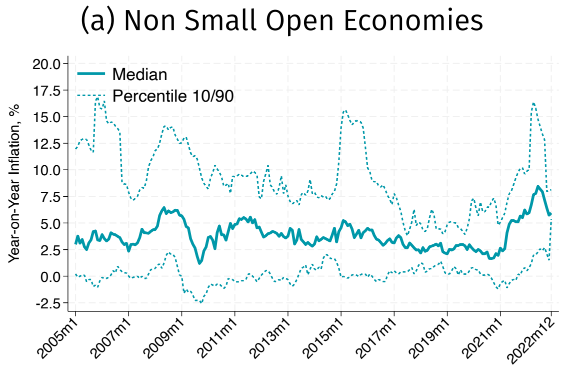
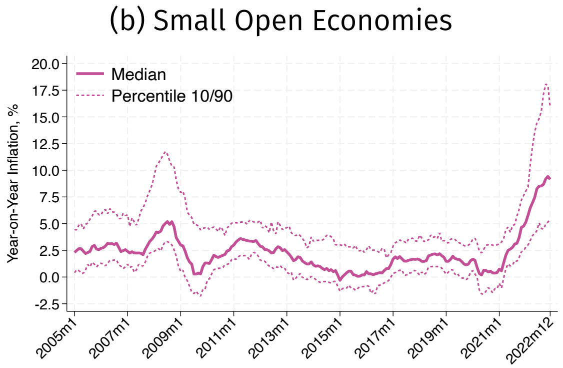
Fact 1: Inflation strikes back Back



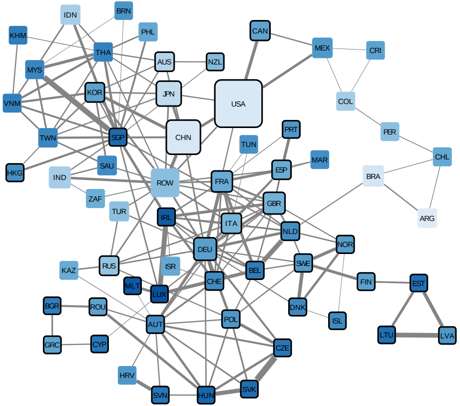


Source: Bank for International Settlements. Non SOE: 9, SOE: 47.

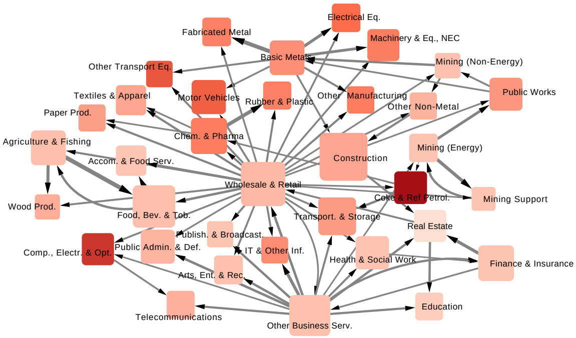
SOE criteria: trade openness $\geq$ 30 % and share of world GDP $\leq$ 5 %.

Fact 2: Economies are networks! Back

(a) International Production Network



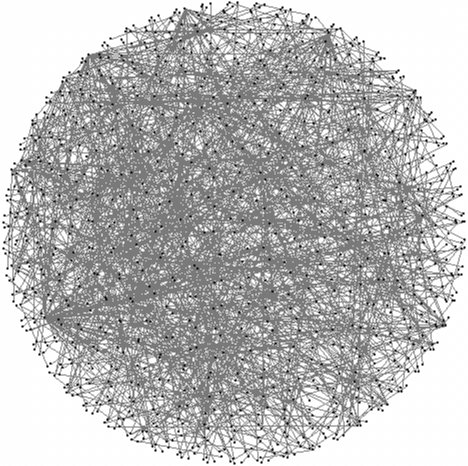
(b) Sectoral Production Network



Source: Cakmakli, Demiralp, Kalemli-Özcan, Yeşiltaş, and Yıldırım (2022) based on OECD Input-Output Tables 2018.

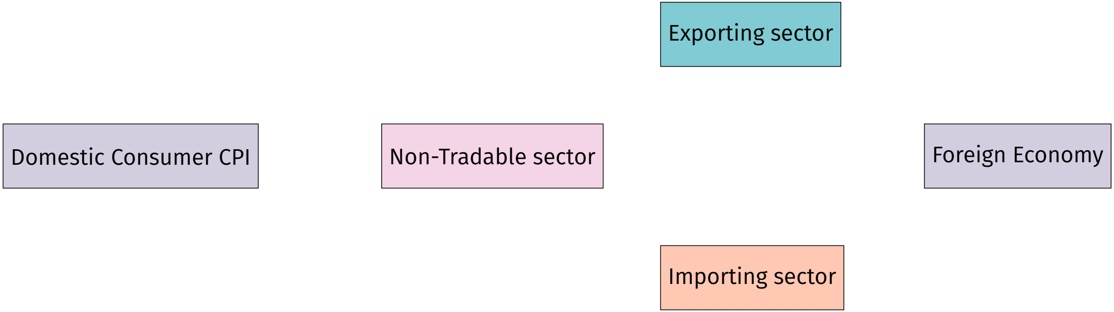
Fact 2: Economies are networks! Back

(c) Chile's Firm-to-Firm Level Production Network

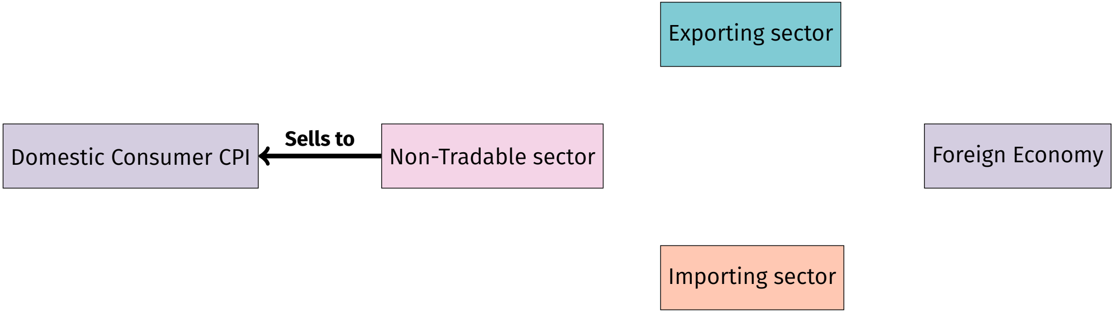


Note: Chilean firm-to-firm level network 2019Q4: 2000 firms random sample, intermediate input sales represent at least 10% of client's total intermediate input purchases. Source: Miranda-Pinto, Silva, and Young (2023).

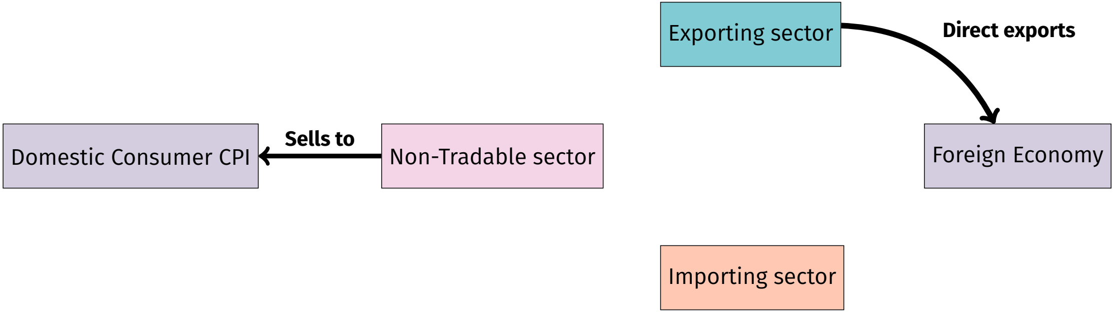
Overall idea of the paper in one diagram



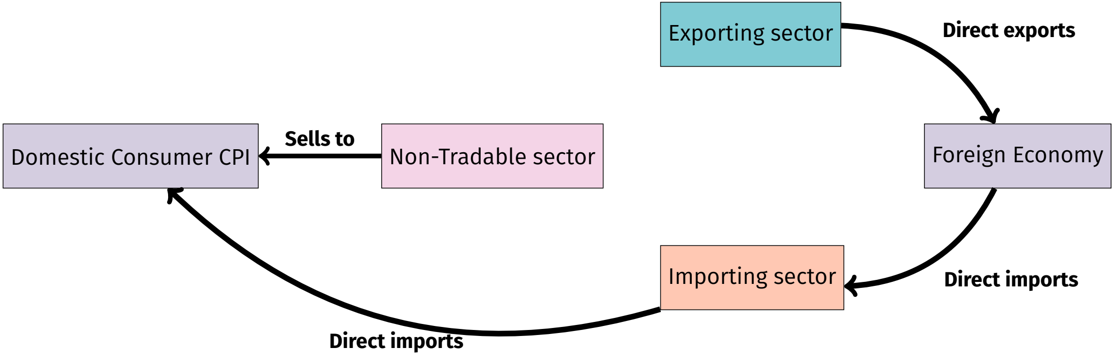
Non-tradable sells to domestic consumers only



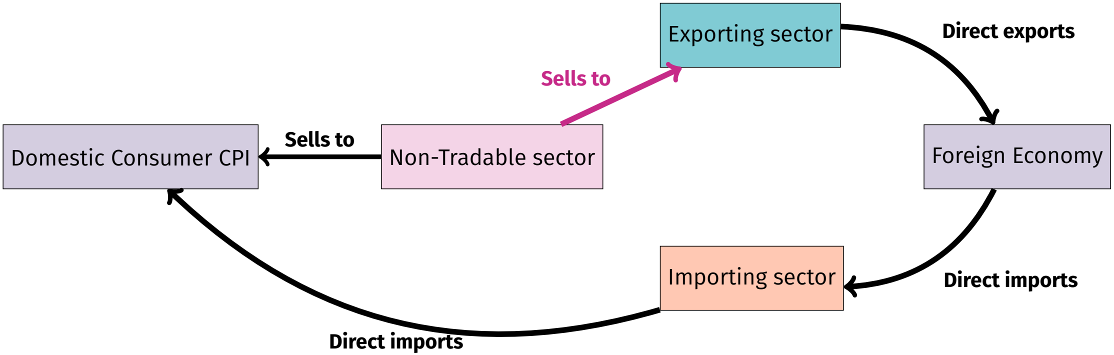
Exporters sells abroad



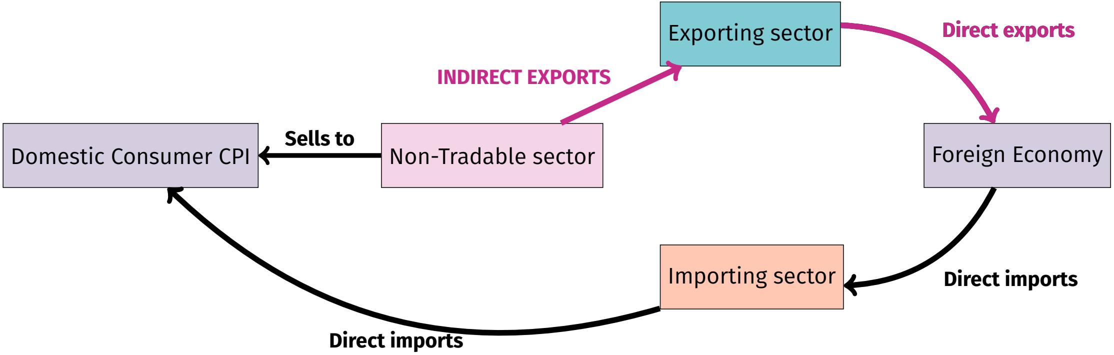
Imports from abroad to consume



By selling to exporting sector...

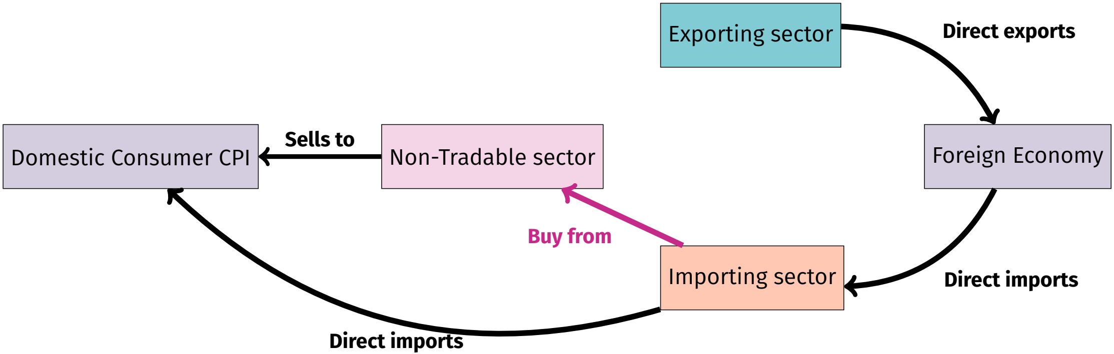


Non-tradable becomes an indirect exporter!

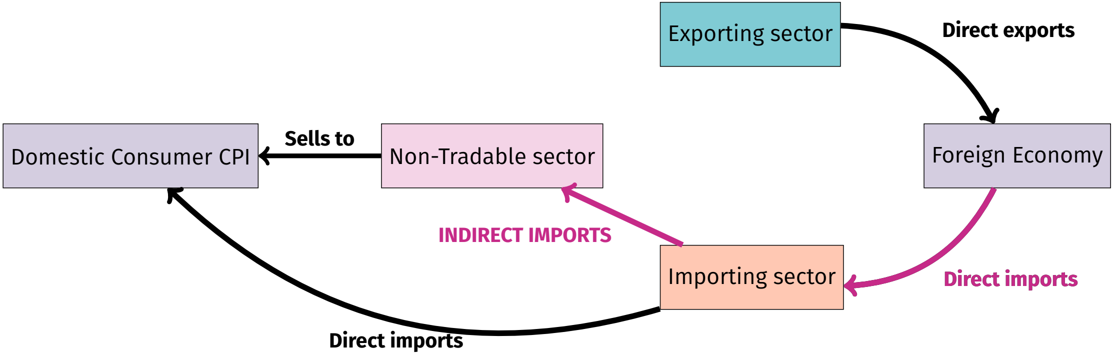


- Less exposed to changes affecting non-tradable sector price

By buying from importing sector...

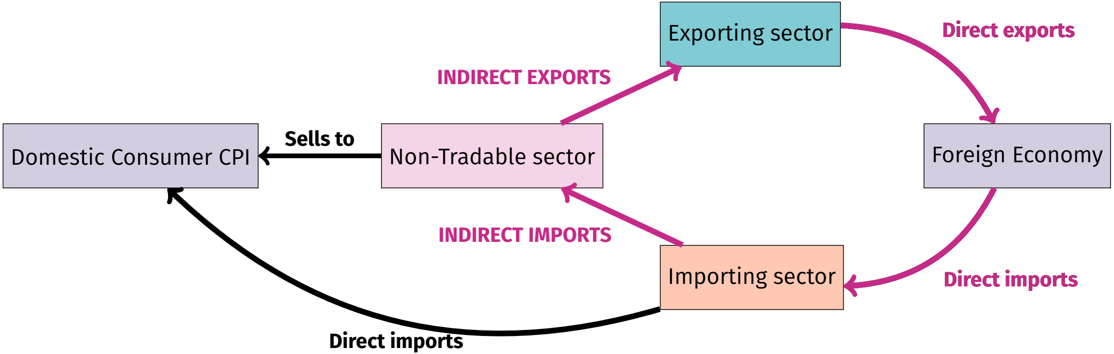


Non-tradable becomes an indirect importer!



- More exposed to import price changes

Production network amplifies trade



- Reducing CPI exposure to changes affecting non-tradable sector price
- Increasing CPI exposure to import price changes

Leontieff-Inverse Intuition Back

$$\downarrow Z_A \longrightarrow \uparrow P_A \longrightarrow \uparrow P_{B_1} = \Omega_{B_1,A} d\log P_A \text{ (1st round)} \rightarrow P_{B_2} = \Omega_{B_2,B_1} d\log P_{B_1} \text{ (2nd round)}$$

$\Psi = \sum_{s=0}^{\infty} \Omega^s$ takes into account all these higher order effects!

Equilibrium Back

1. Given sequences $(\boldsymbol{W}, \boldsymbol{P}_D, \Pi, \boldsymbol{P}_M)$ and exogenous parameters $(T, \mathcal{M})$, the household chooses $(\boldsymbol{C}_D, \boldsymbol{C}_M)$ to maximize its utility subject to its budget constraint and the cash-in-advanced constraint.
2. Given $(\boldsymbol{W}, \boldsymbol{P}_D, \boldsymbol{P}_M)$ and production technologies, firms choose $(\boldsymbol{L}_i, \boldsymbol{M}_i)$ to minimize their cost of production.
3. Given $\boldsymbol{X}$, goods and factor markets clears.

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^{T}\,\widehat{\boldsymbol{Z}} - \boldsymbol{\Lambda}^{T}\,\widehat{\bar{\boldsymbol{L}}}$$

Baqaee and Farhi, 2022

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \lambda^{T}\,\hat{\boldsymbol{z}} - \Lambda^{T}\,\hat{\boldsymbol{L}}$$

Baqaee and Farhi, 2022

- Small open economy with production networks

$$\widehat{CPI} =$$

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^T \widehat{\boldsymbol{Z}} - \Lambda^T \widehat{\boldsymbol{L}}$$

Baqaee and Farhi, 2022

- Small open economy with production networks

$$\widehat{CPI} = -\left(\boldsymbol{\lambda}^T - \tilde{\boldsymbol{\lambda}}\right)\widehat{\boldsymbol{Z}} + \left((\boldsymbol{b}^M)^T + \boldsymbol{b}^T \Psi \Gamma\right)\widehat{\boldsymbol{P}}_M$$

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^T \widehat{\boldsymbol{Z}} - \Lambda^T \widehat{\bar{\boldsymbol{L}}}$$

Baqaee and Farhi, 2022

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- Lower effect of aggregate demand forces

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^T \widehat{\boldsymbol{Z}} - \Lambda^T \widehat{\bar{\boldsymbol{L}}}$$

Baqaee and Farhi, 2022

- Small open economy with production networks

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- Dampens factor supply shocks effect through factor content of exports.

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^T \widehat{\boldsymbol{Z}} - \boldsymbol{\Lambda}^T \widehat{\bar{\boldsymbol{L}}}$$

Baqaee and Farhi, 2022

- Small open economy with production networks

$$\widehat{CPI} = -\left(\boldsymbol{\lambda}^T - \tilde{\boldsymbol{\lambda}}\right)\widehat{\boldsymbol{Z}} + \left((\boldsymbol{b}^M)^T + \boldsymbol{b}^T \boldsymbol{\Psi}\boldsymbol{\Gamma}\right)\widehat{\boldsymbol{P}}_M + (1 - \tilde{\boldsymbol{\Lambda}}^T \mathbf{1}_F)\widehat{\mathcal{M}} + \frac{\mathrm{d}T}{E}$$
$$-\left(\bar{\boldsymbol{\Lambda}}^T - \tilde{\boldsymbol{\Lambda}}^T\right)\widehat{\bar{\boldsymbol{L}}} - \tilde{\boldsymbol{\Lambda}}^T \widehat{\tilde{\boldsymbol{\Lambda}}}$$

- Factor share reallocation term: dampens inflation from factor prices

Role of aggregate demand Back

- Closed economy with production networks

$$\widehat{CPI} = \widehat{\mathcal{M}} - \boldsymbol{\lambda}^T \widehat{\boldsymbol{Z}} - \boldsymbol{\Lambda}^T \widehat{\bar{\boldsymbol{L}}}$$

Baqaee and Farhi, 2022

- Small open economy with production networks

$$\widehat{CPI} = -\left(\boldsymbol{\lambda}^T - \tilde{\boldsymbol{\lambda}}\right)\widehat{\boldsymbol{Z}} + \left((\boldsymbol{b}^M)^T + \boldsymbol{b}^T \Psi \Gamma\right)\widehat{\boldsymbol{P}}_M + (1 - \tilde{\boldsymbol{\Lambda}}^T \boldsymbol{1}_F)\widehat{\mathcal{M}} + \frac{\mathrm{d}T}{E}$$
$$-\left(\bar{\boldsymbol{\Lambda}}^T - \tilde{\boldsymbol{\Lambda}}^T\right)\widehat{\bar{\boldsymbol{L}}} - \tilde{\boldsymbol{\Lambda}}^T \widehat{\bar{\boldsymbol{\Lambda}}}$$

- Bottom line: **network + openness do matter for inflation!**

Household Back

- Intertemporal problem

$$\max_{\{C_t, B_t, B_t^*\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma} - 1}{1-\sigma}$$
$$\text{subject to } P_t C_t + \mathcal{E}_t B_t^* + B_t \leq W_t \bar{L}_t + (1 + i_{t-1}^*)\mathcal{E}_t B_{t-1}^* + (1 + i_{t-1}) B_{t-1}, \tag{4}$$

- Intratemporal problem

$$\min_{C_N, C_M, C_X} P_N C_N + P_M C_M + P_X C_X \text{ subject to } C \geq \bar{C}, \tag{5}$$
$$\text{where } C = \left(b_N^{\frac{1}{\chi}} C_N^{\frac{\chi-1}{\chi}} + b_M^{\frac{1}{\chi}} C_M^{\frac{\chi-1}{\chi}} + (1 - b_N - b_M)^{\frac{1}{\chi}} C_X^{\frac{\chi-1}{\chi}} \right)^{\frac{\chi}{\chi-1}}$$

Household Optimality Conditions

- Intertemporal

$$C_t : C_t^{-\sigma} = \lambda_t P_t, \tag{6}$$

$$B_t : \lambda_t = \beta(1 + i_t)\mathbb{E}_t \lambda_{t+1}, \tag{7}$$

$$B_t^* : \lambda_t = \beta(1 + i_t^*)\mathbb{E}_t \lambda_{t+1} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}, \tag{8}$$

- Intratemporal

$$C_N = b_N \left(\frac{P_N}{P}\right)^{-\chi} C; \quad C_M = b_M \left(\frac{P_M}{P}\right)^{-\chi} C; \quad C_X = (1 - b_N - b_M) \left(\frac{P_X}{P}\right)^{-\chi} C \tag{9}$$

$$P = (b_N P_N^{1-\chi} + b_M P_M^{1-\chi} + (1 - b_N - b_M) P_X^{1-\chi})^{\frac{1}{1-\chi}} \tag{10}$$

Production

$$Q_i = Z_i \left(a_i^{\frac{1}{\sigma_i}} L_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - a_i)^{\frac{1}{\sigma_i}} M_i^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}} \tag{11}$$

$$M_i = \left(\omega_i^{\frac{1}{\varepsilon_i}} M_{iN}^{\frac{\varepsilon_i - 1}{\varepsilon_i}} + (1 - \omega_i)^{\frac{1}{\varepsilon_i}} M_{iT}^{\frac{\varepsilon_i - 1}{\varepsilon_i}} \right)^{\frac{\varepsilon_i}{\varepsilon_i - 1}} \tag{12}$$

$$M_{iT} = \left(\omega_{iX}^{\frac{1}{\varepsilon_i^T}} M_{iX}^{\frac{\varepsilon_i^T - 1}{\varepsilon_i^T}} + (1 - \omega_{iX})^{\frac{1}{\varepsilon_i^T}} M_{iM}^{\frac{\varepsilon_i^T - 1}{\varepsilon_i^T}} \right)^{\frac{\varepsilon_i^T}{\varepsilon_i^T - 1}} \tag{13}$$

Production side optimality conditions

$$L_i = a_i \left(\frac{W}{MC_i} \right)^{-\sigma} Z_i^{\sigma_i - 1} Q_i; \quad M_i = (1 - a_i \left(\frac{P_i^I}{MC_i} \right)^{-\sigma} Z_i^{\sigma_i - 1} Q_i \tag{14}$$

$$M_{iN} = \omega_i \left(\frac{P_N}{P_i^I} \right)^{-\varepsilon_i} M_i; \quad M_{iT} = (1 - \omega_i) \left(\frac{P_i^T}{P_i^I} \right)^{-\varepsilon_i} M_i \tag{15}$$

$$M_{iX} = \omega_{iX} \left(\frac{P_X}{P_i^T} \right)^{-\varepsilon_i^T} M_{iT}; \quad M_{iM} = (1 - \omega_{iX}) \left(\frac{P_M}{P_i^T} \right)^{-\varepsilon_i^T} M_{iT} \tag{16}$$

$$MC_i = Z_i^{-1} \left(a_i W^{1-\sigma_i} + (1 - a_i)(P_i^I)^{1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}}, \tag{17}$$

$$P_i^I = \left(\omega_i P_N^{1-\varepsilon_i} + (1 - \omega_i)(P_i^T)^{1-\varepsilon_i} \right)^{\frac{1}{1-\varepsilon_i}}, \tag{18}$$

$$P_i^T = \left(\omega_{iX} P_X^{1-\varepsilon_i^T} + (1 - \omega_{iX})(P_M)^{1-\varepsilon_i^T} \right)^{\frac{1}{1-\varepsilon_i^T}}. \tag{19}$$

Exogenous Processes and Nominal Anchor

$$\log Z_{Nt} = \rho_{Z_N} \log Z_{Nt-1} + \nu_t^N \tag{20}$$

$$\log P^*_{Mt} = \rho_{P_M} \log P^*_{Mt-1} + \nu_t^{P_M} \tag{21}$$

$$\mathcal{M}_t = P_t C_t \tag{22}$$

Equilibrium

- Goods market clearing conditions

$$Q_{Nt} = C_{Nt} + M_{NNt} + M_{XNt} \tag{23}$$

$$\bar{L}_t = L_{Nt} + L_{Xt} \tag{24}$$

- Domestic bond in zero net supply: $B_t = 0$.
- Current Account

$$B_t^* - B_{t-1}^* = i_{t-1}^* B_{t-1}^* - \underbrace{\frac{1}{\mathcal{E}_t}\left(P_{Xt}(C_{Xt} + M_{XXt} + M_{NXt} - Q_{Xt}) + P_{Mt}(C_{Mt} + M_{NMt} + M_{XMt})\right)}_{\text{Net exports in foreign currency}} \tag{25}$$

- Stationarity device: debt elastic interest rate premium

$$i_t^* = \bar{i}^* + \psi(e^{\bar{B}^* - B_t^*} - 1), \tag{26}$$

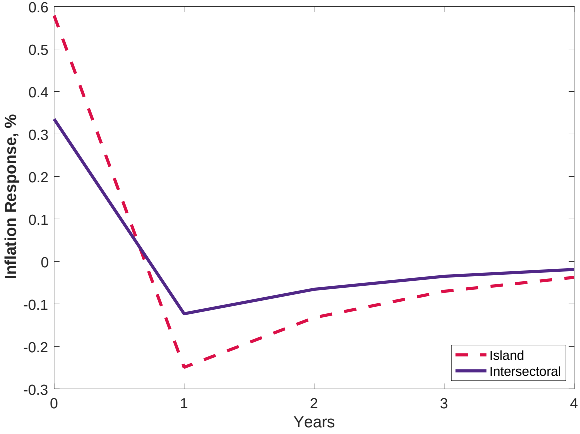
Calibration and Scenarios

Parameters	Value	Description	Source
Shares			
$a_N = a_X$	0.66	Labor Share	Benigno et. al (2013)
b_N	0.70	Consumption share on non-tradables	Bianchi (2011)
b_X	0.03	Consumption share on exportable	Table 8.2 Uribe and Schmitt-Grohe (2017)
b_M	0.27	Consumption share on importable	Table 8.2 Uribe and Schmitt-Grohe (2017)
Elasticities			
χ	1	Elasticity of substitution in consumption	Cobb-Douglas specification
σ	2	Intertemporal Elasticity of Substitution	Table 8.2 Uribe and Schmitt-Grohe (2017)
$\sigma_N = \sigma_X$	1	Elasticity between value-added and intermediates	Cobb-Douglas specification
$\varepsilon_N = \varepsilon_X$	1	Elasticity across intermediates	Cobb-Douglas specification
$\varepsilon_N^T = \varepsilon_X^T$	1	Elasticity across tradable intermediates	Cobb-Douglas specification
Other Parameters			
$\rho_{z_N} = \rho_{P_M}$	0.53	AR(1) non-tradable productivity and import price	Table 7.1 Uribe and Schmitt-Grohe (2017)
$\bar{B}^*$	0	Steady-state foreign assets position	Zero trade balance
ψ	0.000742	Interest rate sensitivity to foreign assets	Schmitt-Grohe and Uribe (2003)
$\bar{i}^*$	0.04	Steady-state foreign interest rate	Bianchi (2011)
β	$\frac{1}{(1+i^*)} = 0.9615$	Discount Factor	

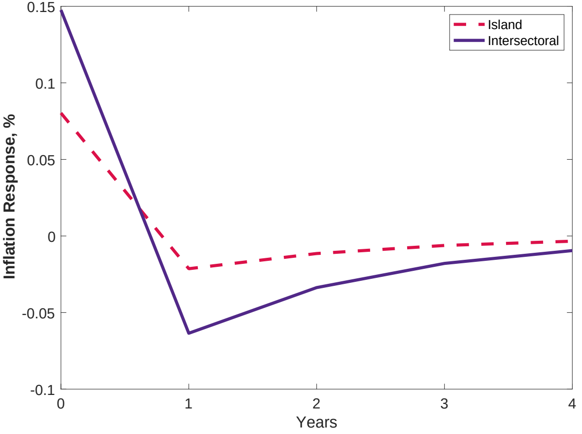
- Two scenarios
  1. Island: $(\omega_N, \omega_X, \omega_{NX}, \omega_{XX})$ = $(1, 0, 0, 0.5)$ $\rightarrow$ buy intermediates from itself not from other sector.
  2. Intersectoral linkages: $(\omega_N, \omega_X, \omega_{NX}, \omega_{XX})$ = $(0, 1, 1, 0.5)$. $\rightarrow$ buy intermediates from other sector.

Dynamic Model Impulse Responses

(a) Negative Productivity Shock in Non-Tradable Sector

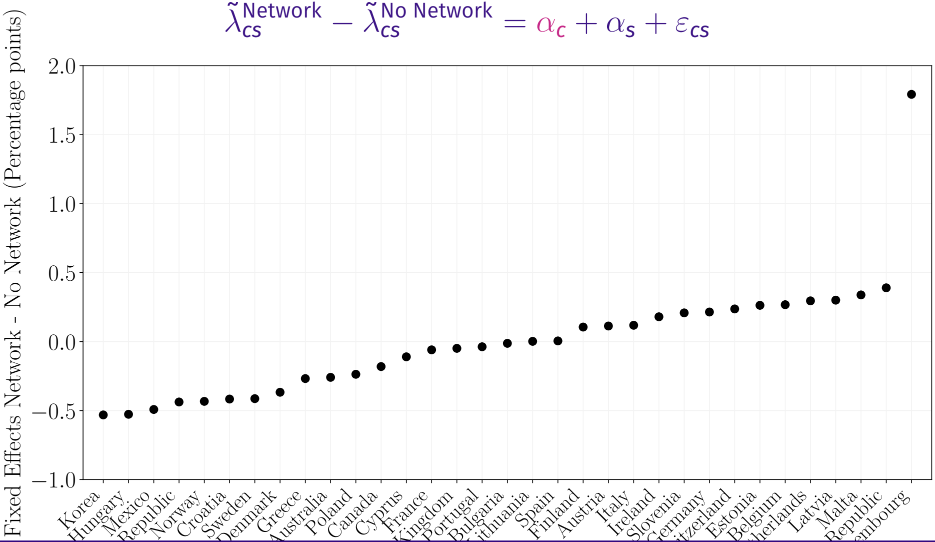


(b) Import Price Shock



Cross-Country Evidence Back

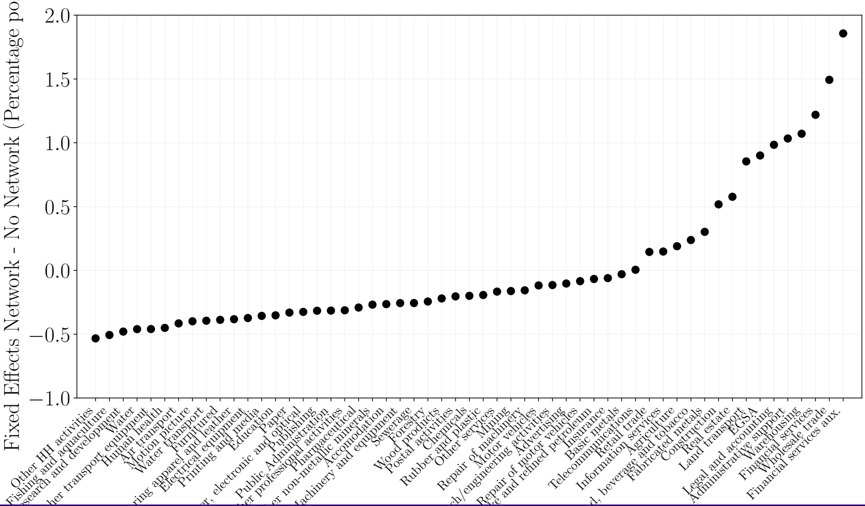
$$\tilde{\lambda}_{cs}^{\text{Network}} - \tilde{\lambda}_{cs}^{\text{No Network}} = \alpha_c + \alpha_s + \varepsilon_{cs}$$



Sectoral Evidence

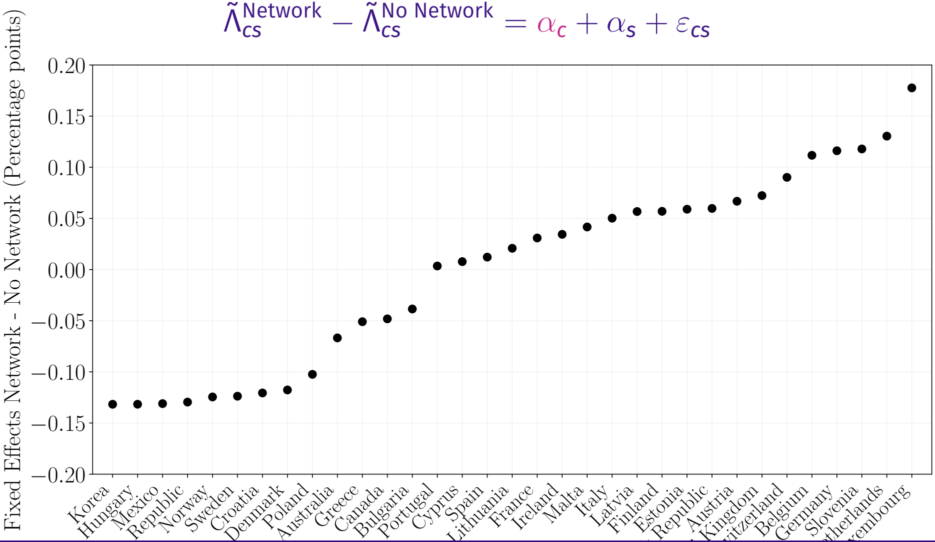
Back

$$\tilde{\lambda}_{cs}^{\text{Network}} - \tilde{\lambda}_{cs}^{\text{No Network}} = \alpha_c + \alpha_s + \varepsilon_{cs}$$



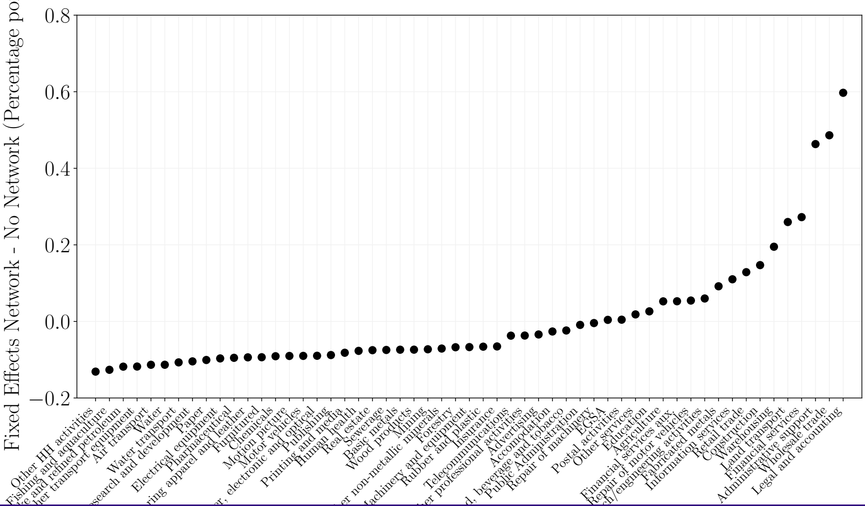
Cross-Country Evidence Back

$$\tilde{\Lambda}_{cs}^{\text{Network}} - \tilde{\Lambda}_{cs}^{\text{No Network}} = \alpha_c + \alpha_s + \varepsilon_{cs}$$



Sectoral Evidence Back

$$\tilde{\Lambda}_{cs}^{\text{Network}} - \tilde{\Lambda}_{cs}^{\text{No Network}} = \alpha_c + \alpha_s + \varepsilon_{cs}$$



Summary Statistics Back

	Panel (a): Chile		Panel (b): United Kingdom	
	Mean	Std. Dev.	Mean	Std. Dev
Data	6.13	3.89	3.69	3.11
Model				
Closed	0.98	9.69	2.27	2.57
SOE no Network	1.45	6.88	2.72	2.64
SOE - Network	2.41	6.67	3.21	3.00