Essays on Production Networks and International Macroeconomics

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Maryland

April 8, 2024

Dissertation Outline

- Bring disaggregated view to questions in (international) macroeconomics.
- Dissertation
  1. "*Inflation in Disaggregated Small Open Economies*"
  2. "*Business Cycle Asymmetry and Input-Output Structure: The Role of Firm-to-Firm Networks*"

     with Miranda-Pinto and Young. Published at Journal of Monetary Economics, 2023.
  3. "*Commodity Prices and Production Networks in Small Open Economies*"

     with Caraiani, Miranda-Pinto, and Olaya-Agudelo, R&R at Journal of Economics Dynamics and Control

Chapter 1: Inflation in Disaggregated Small Open Economies

Motivation

- Inflation rose everywhere in recent years

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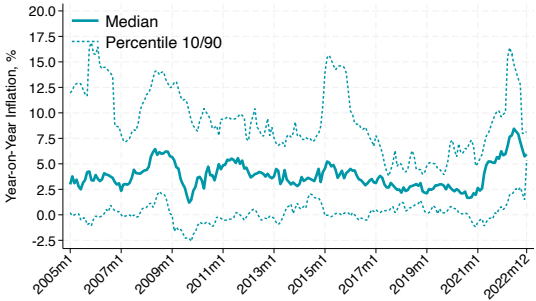
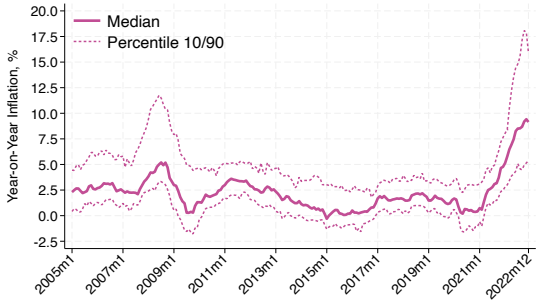
(a) Non Small Open Economies



(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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- Current debate on inflation: relevance of sectoral view

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     Krugman vs. Summers, Bernanke and Blanchard (2023), Shapiro (2022), Ferrante, Graves, and Iacoviello (2023), di Giovanni, Kalemli-Ozcan, Silva, and Yildirim (2022, 2023a), Rubbo (2023), Luo and Villar (2023), Werning and Lorenzoni (2023) ...

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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), ...

This paper

- What? $\longrightarrow$ Inflation in disaggregated small open economies (SOEs)

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- Why?
  - Covid-19 scenario: a multitude of aggregate/sectoral, domestic/foreign shocks
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  - Domestic sectors rely on international trade directly and *indirectly*
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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.)

Model Sketch

- Two period small open economy model

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$$\mathrm{d} \log CPI = -\sum_{k \in N} \lambda_k \mathrm{d} \log Z_k + \sum_{f \in F} \Lambda_f \mathrm{d} \log W_f$$ (Closed Economy, Baqaee and Farhi 2022)

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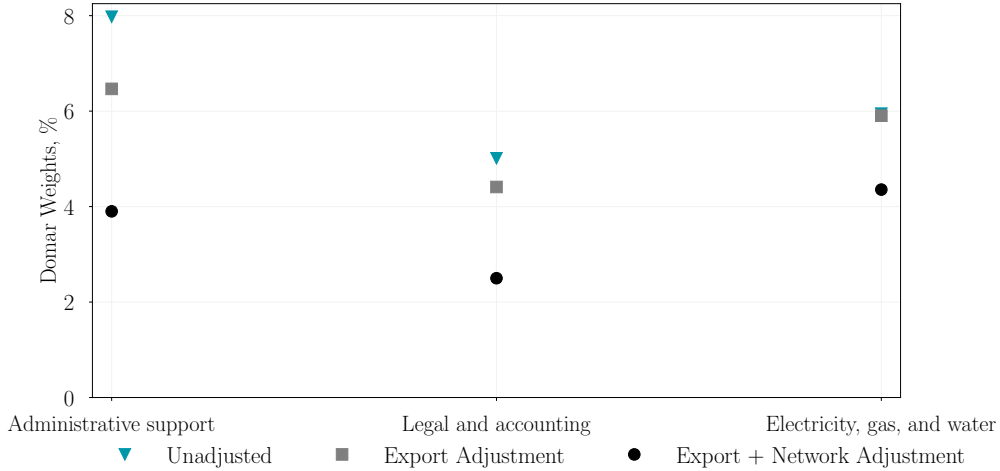
$$\mathrm{d} \log CPI = -\sum_{k \in N} (\lambda_k - \tilde{\lambda}_k) \mathrm{d} \log Z_k + \sum_{f \in F} (\Lambda_f - \tilde{\Lambda}_f) \mathrm{d} \log W_f + \sum_{m \in M} (b_m + \tilde{b}_m) \mathrm{d} \log P_m \qquad \text{(This paper)}$$

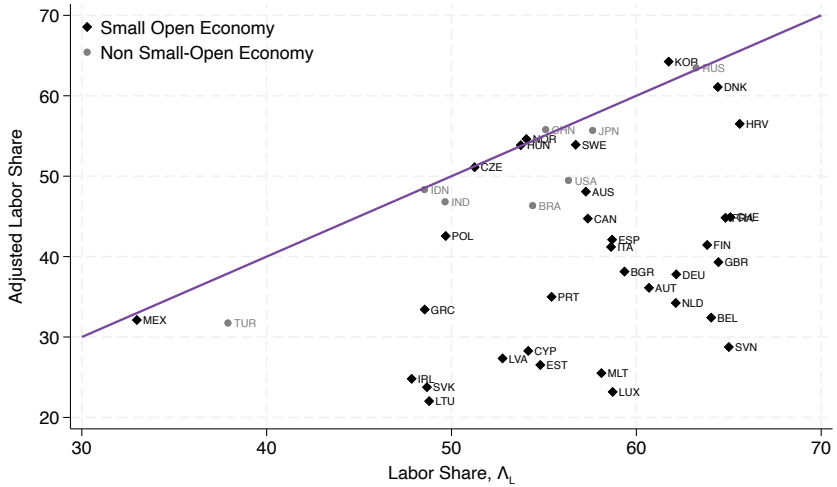
UK: 3 largest export adjustment + network ($\lambda_k - \tilde{\lambda}_k$)



- Electricity: **5.95%** → **5.90%** → **4.4%**
  - Export Adjustment
  - Production Network Adj.

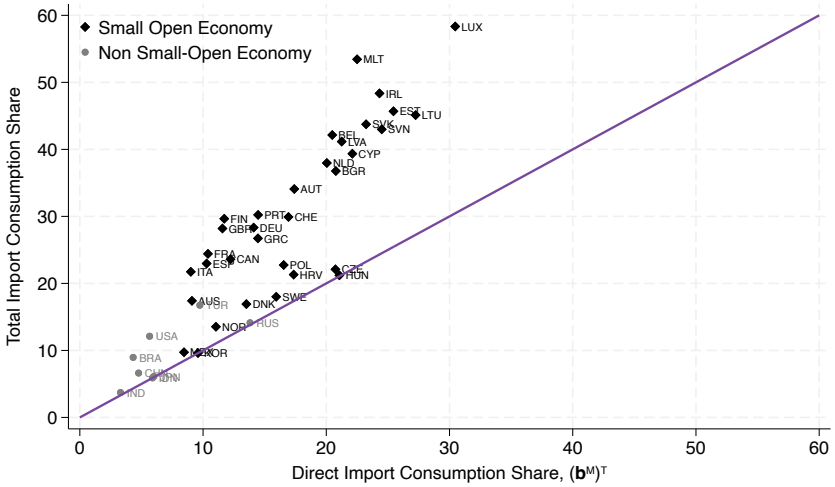
Elasticity to factor prices: $(\Lambda^T - \tilde{\Lambda}^T)\widehat{W}$

Cross-Country | Sectoral



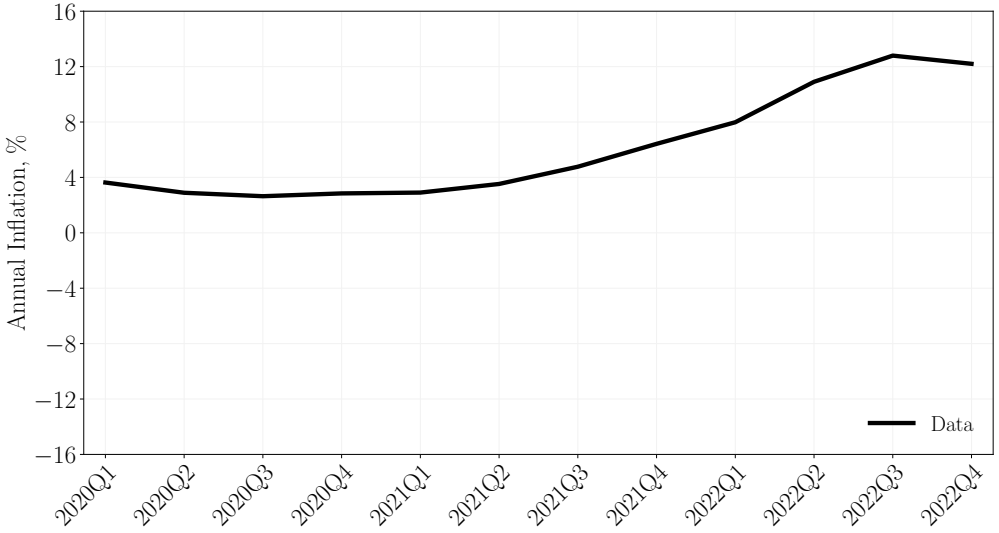
- Adjustment matters more for SOEs.

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



- Indirect consumption share as important as direct consumption share!

Inflation during COVID19: Chile UK



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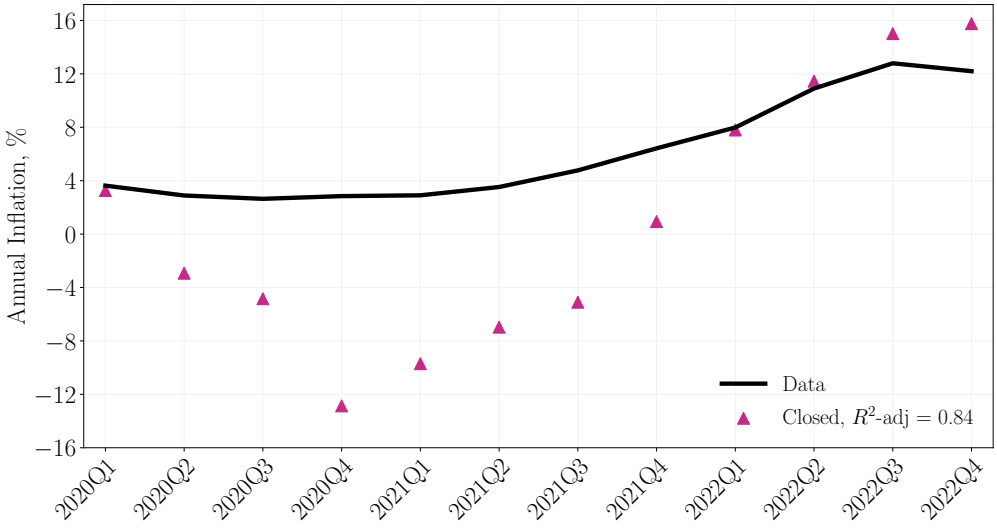

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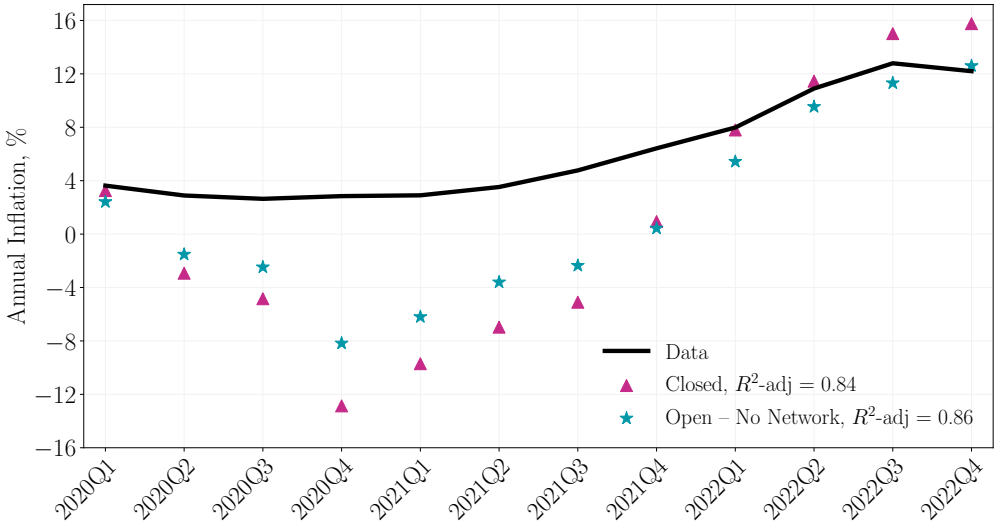

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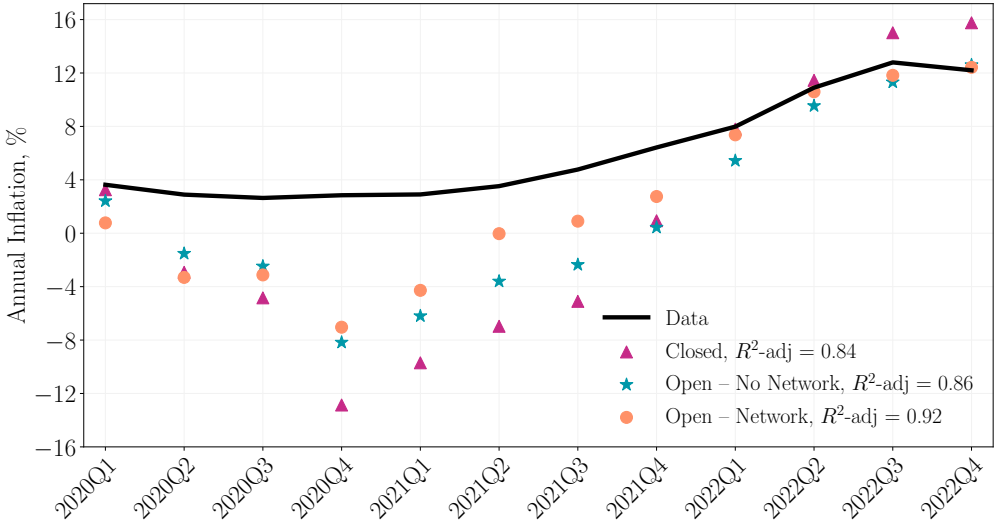


Conclusion Chapter 1

1. Domestic production network amplifies trade affecting CPI elasticities
   * Production networks matter to a first-order for CPI elasticities
2. Quantitatively important for small open economies
3. Helps to match inflation during Covid-19 in United Kingdom and Chile

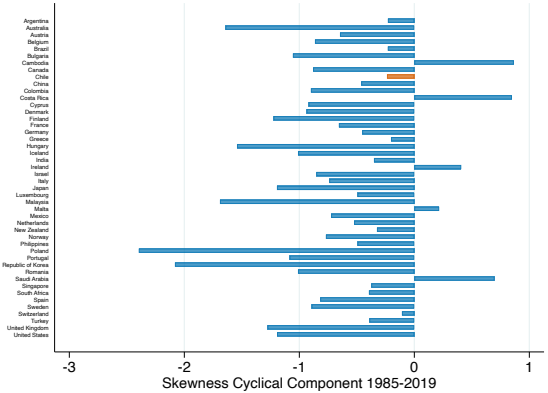
Chapter 2: Business Cycle Asymmetry and Input-Output Structure: The Role of Firm-to-Firm Networks

with Miranda-Pinto and Young

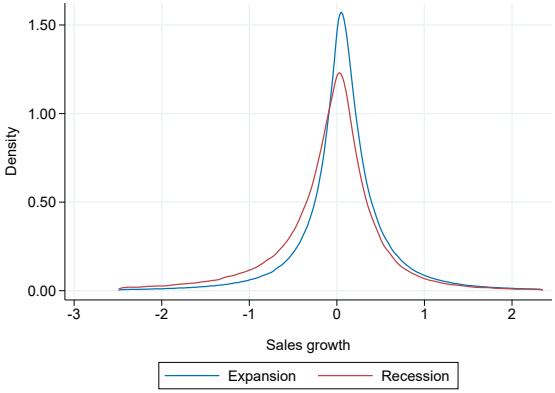
Published at Journal of Monetary Economics, 2023

Business Cycle Asymmetries

(a) Skewness of Real GDP Cycle



(b) Sales growth distribution Chile



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   - Negative skewness of real GDP growth
     - Financial frictions — see Ordoñez, 2013, Jensen et al., 2020
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   - Intuition: Symmetric productivity shocks + gross-complement inputs
   - Calibrated model to Chilean firm-to-firm network matches facts

Data

- Universe of private Chilean firms:
  - Firm-to-firm transactions (2014–2020)
  - Monthly survey on firms' total sales/employment/materials (2005 – 2020)
  - Annual sales data from tax declarations (2005–2020)

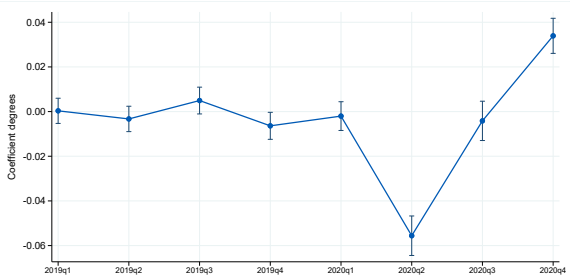
- Filters:
  - Firms with more than 5 employees,
  - Firms observed at for least 20 quarters (5 years)
  - Firms in which annual sum of monthly sales (F29) represents between 90-110% annual sales (F22)
  - Drop observations in the bottom 1% and top 1% of the distribution of sales growth

- Final sample represents $\approx$ 50% of total GDP (raw data $\approx$ 60%)

More connected firms performed worse during COVID-19

$$\Delta \log y_i(t) = \alpha(t) + \beta(t) \log degree_i^{2017q4} + \Gamma(t) \cdot controls_i(t) + \epsilon_i(t),$$

- Covid: Firms with 10% higher degrees $\rightarrow$ 0.6 percentage points smaller sales growth



Controls: industry fixed effects, log sales, intermediate input share, and export share.

Model Sketch

- Framework/model follows closely Baqaee and Farhi (2019)
- Closed economy with N sectors
- Supply Side
  - Firms use other firms output as inputs
  - F factors of production
  - Constant returns to scale technology: $Q_i = A_i F(\{L_{if}\}_{f \in F}, \{M_{ij}\}_{j \in N})$
- Demand side
  - Representative household consumes all goods in the economy
  - Receive factors rents
- Study the general equilibrium of this economy absent distortions/frictions
  - All markets clear

Aggregate skewness

- Second-order app. of output (Y) to a productivity shock to sector i ($d \log A_i$)

$$d \log Y = \lambda_i d \log A_i + \frac{1}{2} \frac{d\lambda_i}{d \log A_i} (d \log A_i)^2,$$

Baqaee and Farhi (2019)

- $\frac{d\lambda_i}{d \log A_i} < 0$: negative shocks amplified, positive shocks dampened
  $\rightarrow$ aggregate output is concave on A_i.

- New: denser networks shows a more negative $\frac{d\lambda_i}{d \log A_i}$
  - Price response is larger in denser networks
  - Effect on sales is stronger when elasticities of substitution $\longrightarrow 0$

Calibration

- Calibrate the model to match
  - the IO structure of the 46 countries in our sample
  - firm-to-firm network in Chile in 2019q2
- Elasticity of substitution between inputs during COVID-19 of 0.55 Cevallos et al., 2022
- Proxy the decline in productivity using revenue labor productivity (LP).

	Annual Change LP	Skewness
2020Q1	0.5%	-0.09
2020Q2	-3.8%	-0.1

  - Quantitative exercise: hit the economy with the COVID-19 shock to then:
    - Study cross-sectional relationship between degrees and output growth

Counterfactual exercise: the non-linear role of degrees

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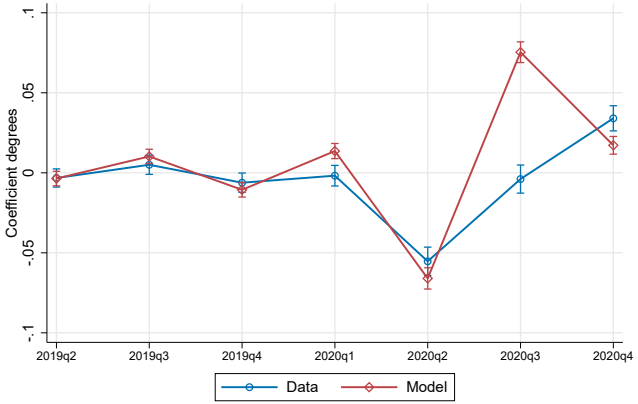

Conclusion Chapter 2

- Cross-country: production network interconnectedness $\longrightarrow$ more negative skewness of output at business cycle frequency
  - $\approx$ less resilience to negative shocks
- Firm-level: more interconnected firms are less resilient to negative shocks
  - $\approx$ conditional on size and industry
- Off the shelf production network model rationalizes the evidence
  - Able to deliver aggregate times series and cross-sectional evidence
- Empirical and theoretical support for non-linear role of production networks

Chapter 3: Commodity Prices and Production Networks in Small Open Economies

with Caraiani, Miranda-Pinto, and Olaya-Agudelo

R&R at Journal of Economics Dynamics and Control

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- What? $\longrightarrow$ Commodity price propagation through production networks

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- Why?
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- What? $\longrightarrow$ Commodity price propagation through production networks
- Why?
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  - Commodity sectors are central as suppliers and buyers in production networks
- How? $\longrightarrow$ Theory and Empirics

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   - Shows that commodity sectors are central in the production network

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     - Downstream (suppliers $\longrightarrow$ buyers) in prices
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2. **Theory**
   - Small open economy model with a commodity sector linked to domestic economy
   - Model predicts to a first-order:
     - Downstream propagation of commodity prices on prices
     - Upstream propagation on quantities under certain conditions

Data

- Intermediate input and factor shares from WIOD IO tables 1995

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- Infer elasticities from empirical response of sectoral output to commodity prices
  - Output and prices data from the WIOD for the period 1995-2009(2011) (34 sectors)
  - Commodity prices data from UNComtrade and IMF PCPS data (44 different commodities, HS 1992-4 digits) Fernández et al. (2018)
  - Final sample 9 countries: Australia, Bulgaria, Brazil, Canada, Denmark, India, Lithuania, Mexico, and Russia
  - Three commodity sectors: agriculture, mining and food

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- Construct centrality measures

$$Supplier_i = \sum_{j=1}^{N} \Psi_{ji},; \qquad Customer_i = \sum_{j=1}^{N} \widetilde{\Psi}_{ij}$$

Commodity sectors: central in domestic production network

	Customer Centrality			*Supplier Centrality*		
Country	Agric.	Mining	Food	Agric.	Mining	Food
Australia	10	11	3	13	6	17
Bulgaria	2	8	1	2	9	13
Brazil	14	25	2	7	14	10
Canada	6	18	3	4	10	15
Denmark	6	33	1	8	17	11
India	9	25	6	3	9	23
Lithuania	1	33	3	2	34	9
Mexico	10	18	1	7	1	15
Russia	3	6	2	5	3	14
Average	**7**	**20**	**2**	**6**	**11**	**14**

Note: Source: WIOD Input-Output database, 1995. Supplier centrality is obtained using the Leontief inverse elements of the IO network with a typical element $\Omega_{ji} = \frac{P_i M_{ji}}{P_j Q_j}$. Customer centrality is calculated using the Leontief inverse elements of a typical element $\tilde{\Omega}_{ji} = \Omega_{ji} \frac{P_j Q_j}{P_i Q_i} = \frac{P_i M_{ji}}{P_i Q_i}$.

Commodity prices propagate through the network

$$y_{ict} = \delta_t + \alpha_{i,c} + \delta_{c,t} + \phi_1 Upstream_{ict} + \phi_2 Downstream_{ict} + \boldsymbol{\nu}' \mathbf{X}_{ict-1} + \epsilon_{ict},$$

$$Upstream_{ict} = \sum_{k \in \mathcal{K}} \left(\tilde{\Psi}_{kic} - \mathbf{1}_{i=k} \right) \cdot \tilde{p}_{kct}, \qquad Downstream_{ict} = \sum_{k \in \mathcal{K}} \left(\Psi_{ikc} - \mathbf{1}_{i=k} \right) \cdot \tilde{p}_{kct}$$

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	Panel (a): Quantity			Panel (b): Prices		
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{ict}$	0.0067**	0.0080**	0.0072***	0.0004	0.0067	0.0019
	(0.0031)	(0.0031)	(0.0022)	(0.0067)	(0.0075)	(0.0024)
$Downstream_{ict}$	0.0022	0.0018	-0.0007	0.0104*	0.0099**	0.0082***
	(0.0017)	(0.0016)	(0.0012)	(0.0054)	(0.0049)	(0.0026)
Observations	3906	3906	3906	3906	3906	3906
Within R^2	0.924	0.777	0.766	0.959	0.737	0.694
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Country × Sector F.E.		Yes	Yes		Yes	Yes
Country × Year F.E.			Yes			Yes

Note: Controls include one lag of the dependent and independent variables. Double clustered country-year standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Model Sketch

- Static model
- $N + 1$ sectors: $i = 1, 2, ..., N$ non-tradable, sector $N + 1$ commodity sector.

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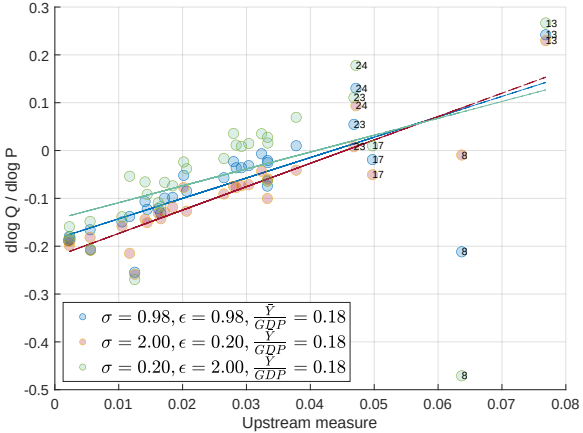
- First-order quantity response

$$\mathrm{d}\log Q_i = \Big(\overbrace{\underbrace{\beta_i}_{\text{IO Substitution}} + \underbrace{\gamma_i^D}_{\text{Domestic Demand}} + \underbrace{\gamma_i^F}^{\text{Foreign Demand}}}^{\text{Upstream Effect}} - \underbrace{\tilde{a}_{i,N+1}}_{\text{Downstream Effect}}\Big)\mathrm{d}\log P_{N+1}$$

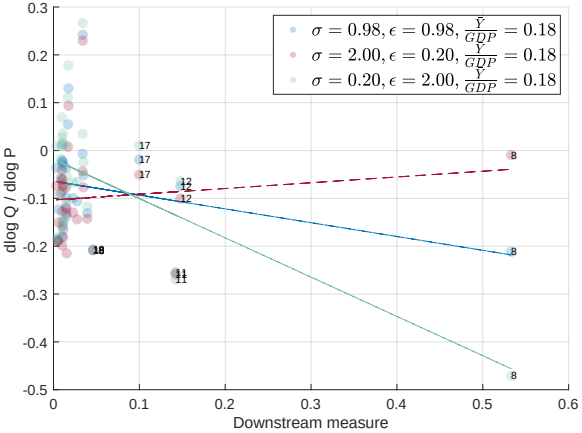
The Role of Elasticities

Sectoral Classification

(a) Upstream



(b) Downstream



- σ subst. btw. value-added and intermediates. ε subst. among intermediates

Conclusion Chapter 3

- Commodity sectors
  $\Longrightarrow$ central in the production network of commodity exporters
- Propagates and amplifies commodity price effects to non-commodity sectors

Concluding Remarks

- Disaggregated view matters for both aggregate outcomes and propagation

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- Disaggregated view matters for both aggregate outcomes and propagation
- Future research
  - Empirically estimated elasticities of substitution
  - Dynamics in production networks and aggregate outcomes
  - Optimal policy and welfare

Thank you!

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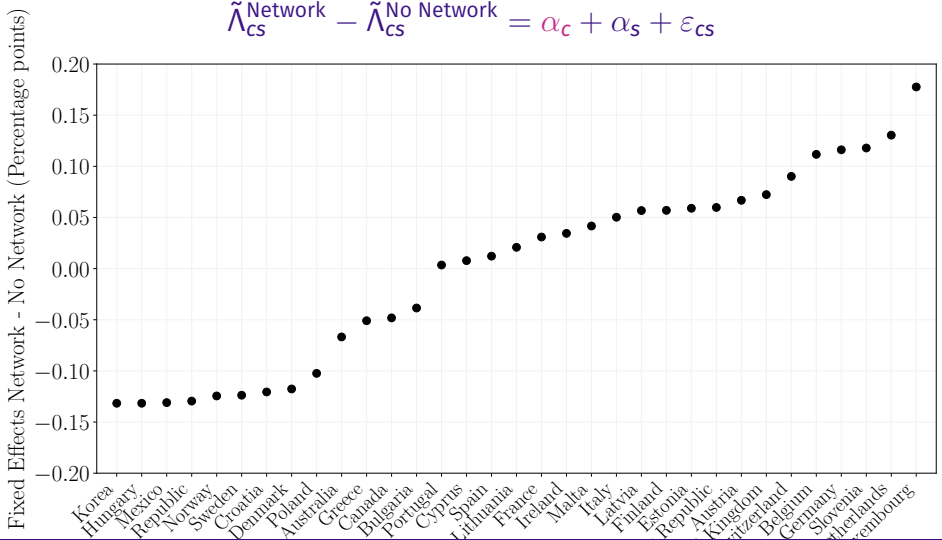
Appendix Ch. 1

Cross-Country Evidence

Back

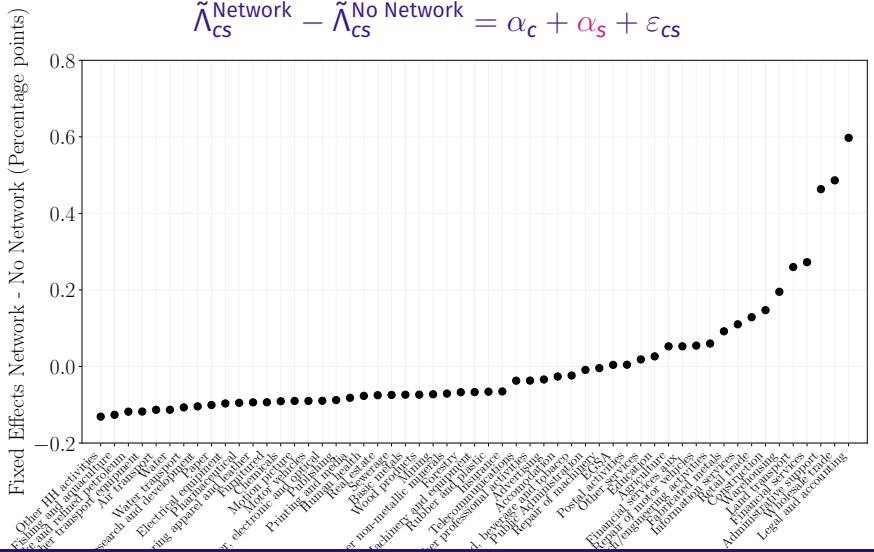
$$\tilde{\Lambda}_{cs}^{\text{Network}} - \tilde{\Lambda}_{cs}^{\text{No Network}} = \alpha_c + \alpha_s + \varepsilon_{cs}$$



Sectoral Evidence

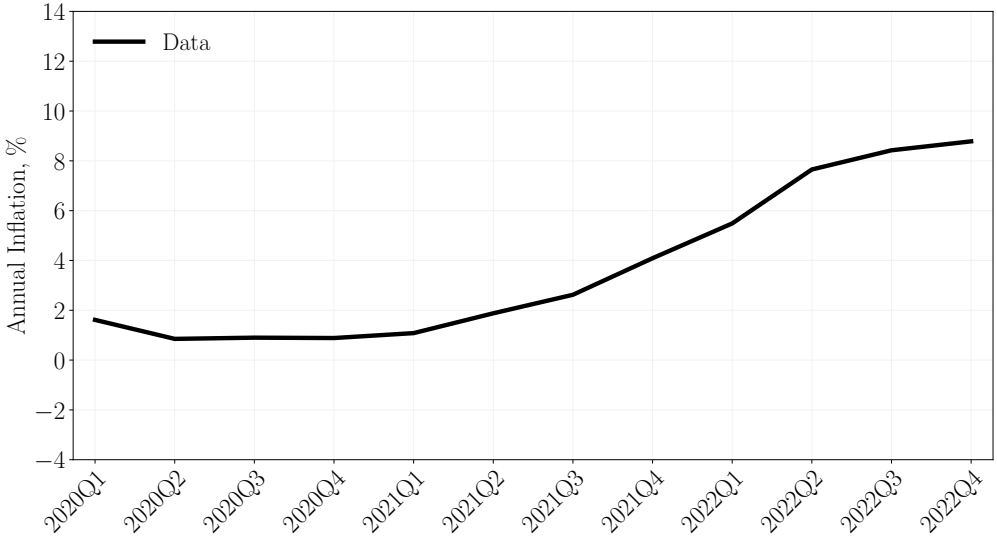
Back

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



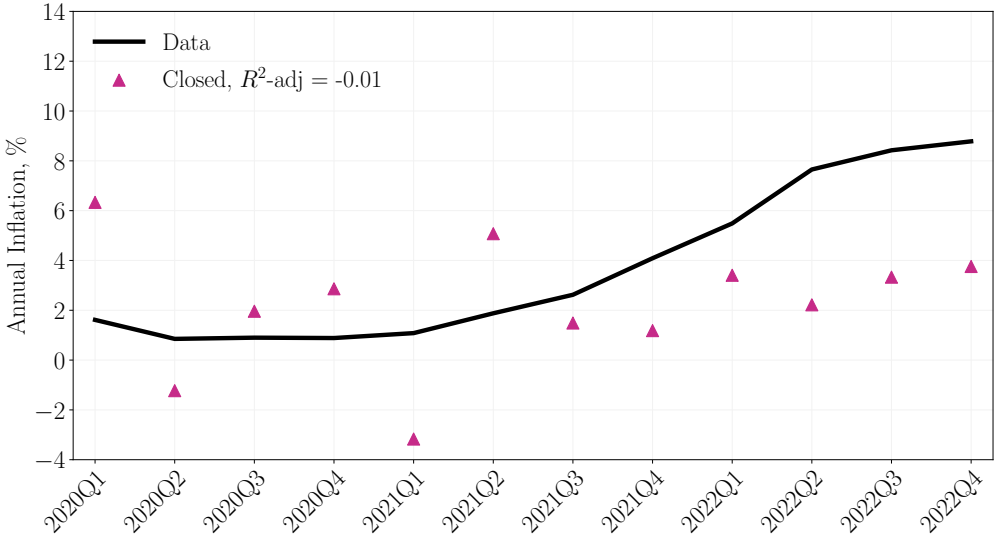
Inflation during COVID19: United Kingdom

Back



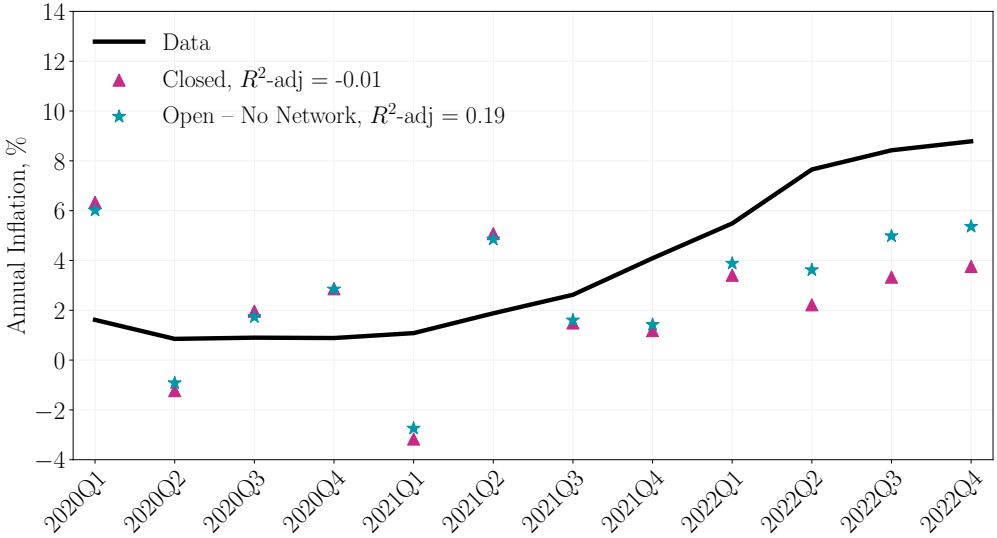
Inflation during COVID19: United Kingdom

Back



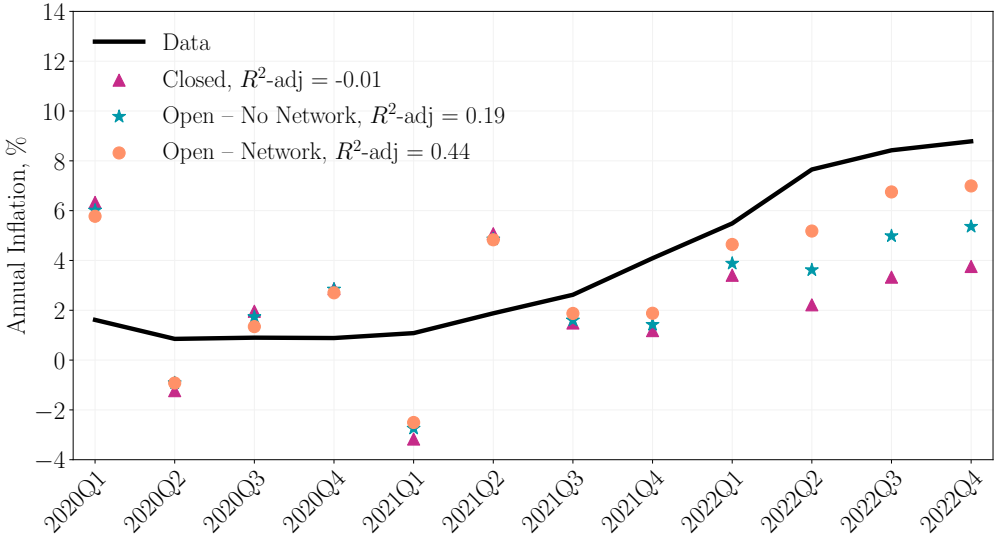
Inflation during COVID19: United Kingdom

Back



Inflation during COVID19: United Kingdom

Back



Appendix Ch. 2

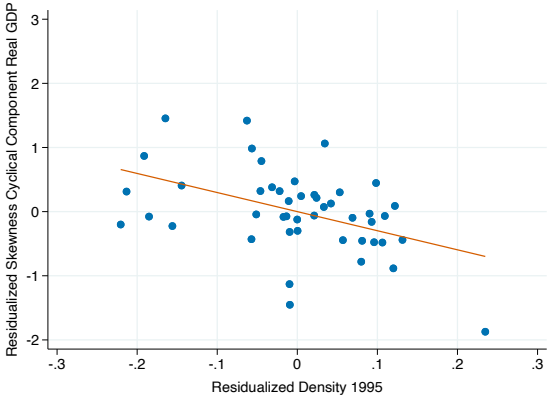
Skewness is more negative in denser networks

$$\text{Density} = \frac{\text{fraction of non-zero off diagonal links}}{\text{total off diagonal links}}$$

- Holds unconditionally and conditionally

  controlling for GDP per capita, GDP growth volatility, and weighted network degree measures.

- Coefficient: -3.7
  Robust standard error: 1.1



Appendix Ch. 3

Sectoral Classification

Back

Sector Number	Sector Name
1	Agriculture, Hunting, Forestry and Fishing
2	Mining and Quarrying
3	Food, Beverages, and Tobacco
4	Textiles and Textile Products
5	Leather, Leather, and Footwear
6	Wood and Products of Wood and Cork
7	Pulp, Paper, Paper, Printing, and Publishing
8	Coke, Refined Petroleum and Nuclear Fuel
9	Chemicals and Chemical Products
10	Rubber and Plastics
11	Other Non-Metallic Mineral
12	Basic Metals and Fabricated Metal
13	Machinery, Nec
14	Electrical and Optical Equipment
15	Transport Equipment
16	Manufacturing, Nec; Recycling
17	Electricity, Gas and Water Supply
18	Construction
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles
20	Wholesale Trade and Commission Trade
21	Retail Trade
22	Hotels and Restaurants
23	Inland Transport
24	Water Transport
25	Air Transport
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	Post and Telecommunications
28	Financial Intermediation
29	Real Estate Activities
30	Renting of M&Eq and Other Business Activities
31	Public Admin and Defence; Compulsory Social Security
32	Education
33	Health and Social Work
34	Other Community, Social and Personal Services