The Geographic and Sectoral Impact of Productivity

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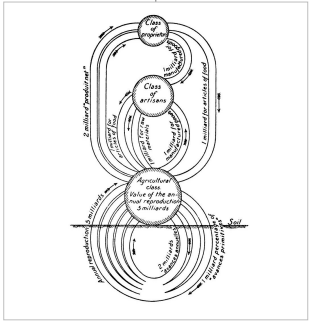
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October 16, 2026

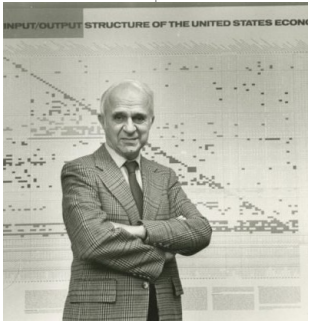
Motivation

We know what is traded, not where

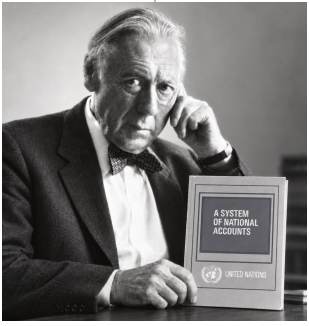
1755–1758
Cantillon and Quesnay



1932
Wassily Leontief



1968
Richard Stone



Why Is This Important?

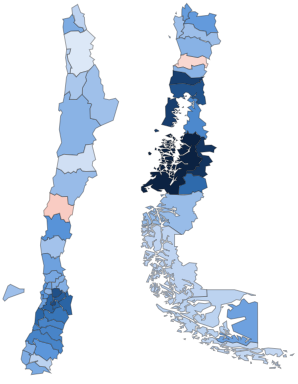
① **A shock hits one place**



② **The impact propagates**



③ **How much, and where?**

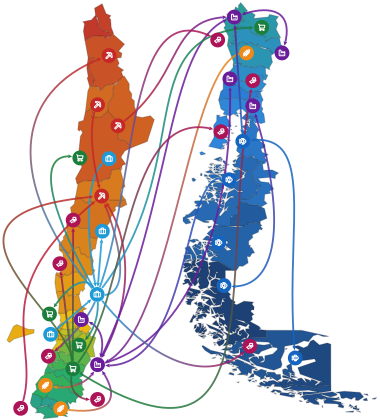


This Paper

We geographically disaggregate the sectors



National Accounts



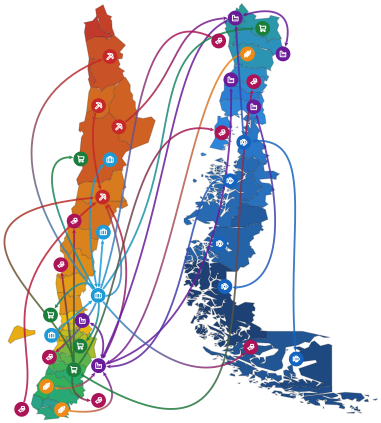
Disaggregated Economic Accounts

This Paper

1. Novel **geographically disaggregated** economic accounts
   - Geographic input–output matrix from **firm-to-firm transactions**

2. **Quantitative spatial** general equilibrium model (Caliendo et al., 2018)
   - Propagation through **several channels**

3. Two applications
   - Aggregate effects of **local productivity shocks**
   - Exit of the ***Huachipato*** steel plant



Findings

1. **Geography** matters for measuring **input-output linkages**
2. Location-sector **interactions** drive aggregate effects
   → 73% of the dispersion in GDP elasticities
3. **Domar weights** are informative, but **incomplete**
4. **Trade** and **production networks** sustain the dispersion
   → 54% and 44% of the dispersion in GDP elasticities
5. **Geographic IO** matters through **small and influential markets**
6. **Geographic IO** shapes the effects of a **local plant exit**
   → **Aggregate:** national IO coefficients understate its GDP elasticity (1.51 vs. 3.41)
   → **Distributional:** three-quarters of the losses occur outside its location-sector

Literature

1. **Disaggregated Economic Accounts**
   - Adão et al. (2022), Atkin et al. (2025), Rodríguez-Clare et al. (2025), and Andersen et al. (2026)

   → We **measure** the location-sector input-output matrix from firm-to-firm data, instead of imputing it

2. **Propagation Through Production Networks**
   - Hulten (1978), Long and Plosser (1983), Acemoglu et al. (2012), and Baqaee and Farhi (2019, 2020, 2024)

   → We show the role of **geography** in the propagation of productivity shocks

3. **Quantitative Spatial Economics**
   - Eaton and Kortum (2002), Caliendo and Parro (2015), and Caliendo et al. (2018, 2019)

   → We embed a **measured** geographic production network in a spatial general equilibrium model

Outline

1. **Disaggregated Economic Accounts**
   - Data
   - Descriptive Statistics
2. **Model**
3. **Quantitative Applications**
4. **Conclusion**

Outline

1. **Disaggregated Economic Accounts**
   - Data
   - Descriptive Statistics
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Data

Details

Administrative microdata
SII, 2018–2023: universe of formal firms

Official aggregates
Totals match the national accounts

Firm-to-firm transactions
every invoice, with **both parties' location**

Central Bank
regional GDP, capital and national IO tables

Balance sheets
sales, inputs, value added and **HQ location**

INE
employment, formal and informal

Employer-employee records
wages and employment of every formal worker

OECD ICIO
trade with the rest of the world

Microdata give the **shares** across locations and sectors; official aggregates give the **totals**

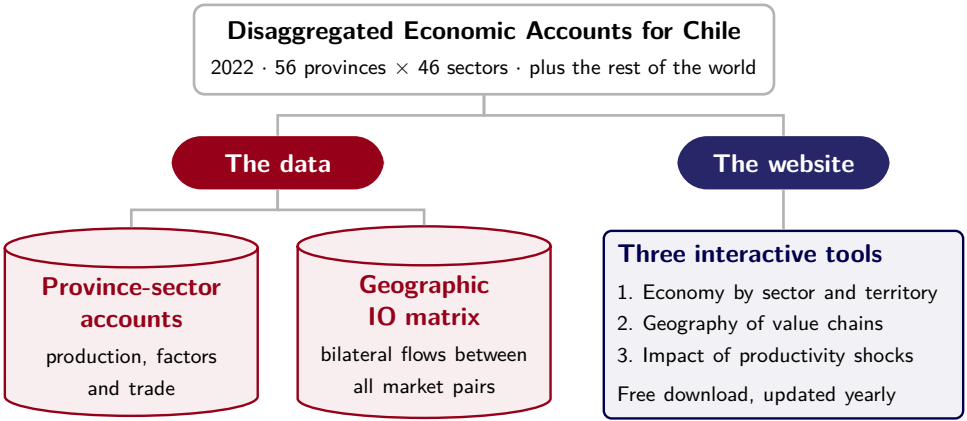
Consistency with Official National Accounts

Details

		Anchored to
1	**Clean the microdata** active firms, winsorized, averaged over 2018–2023	SII: 677k firms and 124M transactions
2	**Allocate GDP and employment** into **56 provinces** × **46 sectors** using microdata shares	Central Bank regional GDP; INE employment
3	**Reconstruct the other variables** sales, inputs and wages from firm ratios to value added	national IO sectoral totals
4	**Balance the input-output matrix** balanced with MR-GRAS (Temursho et al., 2021)	disaggregated sales and inputs; national IO
5	**Add the rest of the world** one foreign block; ICIO shares common across provinces	OECD ICIO 2020

Disaggregated Economic Accounts

Definitions

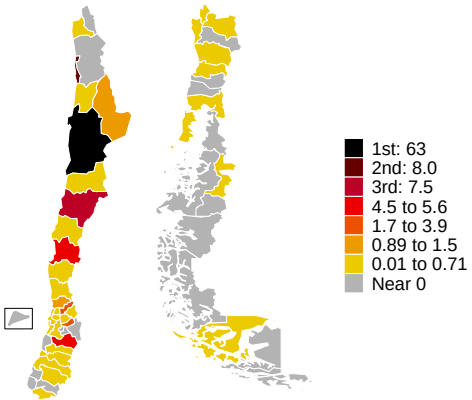


Outline

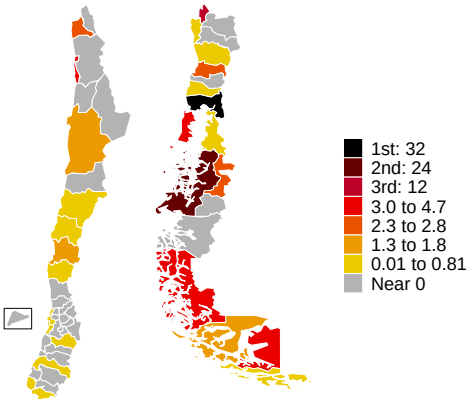
1. **Disaggregated Economic Accounts**
   - Data
   - Descriptive Statistics
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Sectors Across Space

More Sectors | Aggregate | Specialization | HHI



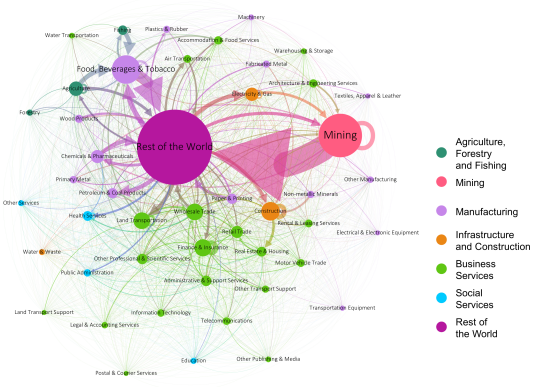
(a) Mining



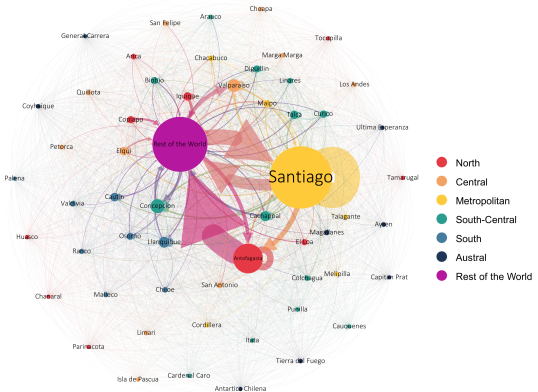
(b) Fishing

The Chilean Production Network

Importance of Trade | Trade Imbalances



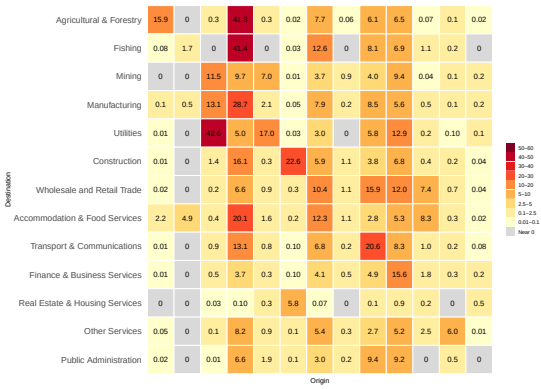
(a) Between Sectors



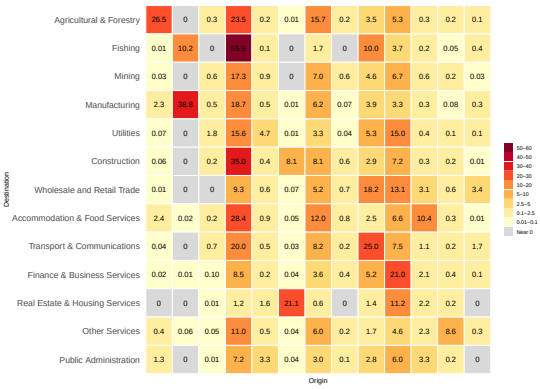
(b) Between Locations

Local Input-Output Matrices

Valparaíso vs Concepción



(a) Antofagasta

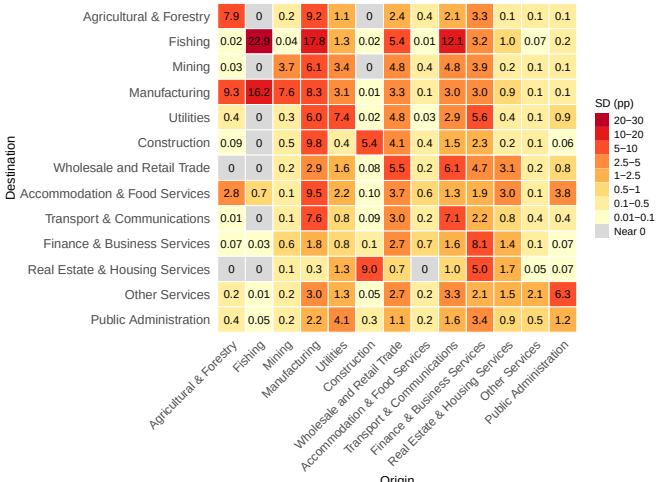


(b) Llanquihue

How Much Location Matters in Each Input-Output Link

Local vs National

1. Geography matters for measuring input-output linkages

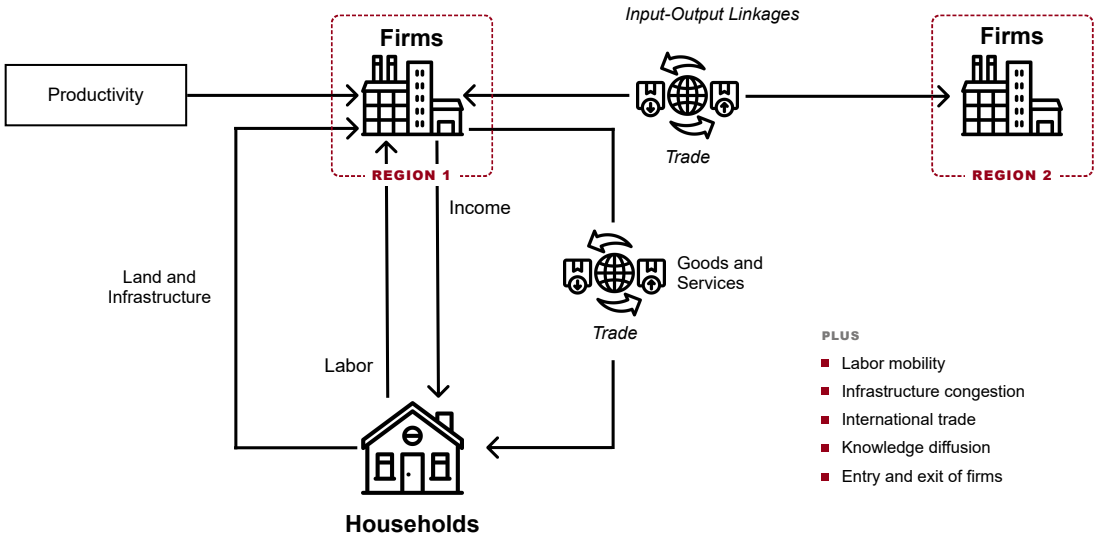


Outline

1. Disaggregated Economic Accounts
2. Model
3. Quantitative Applications
4. Conclusion

Model Overview

Details



PLUS

- Labor mobility
- Infrastructure congestion
- International trade
- Knowledge diffusion
- Entry and exit of firms

Households and Producers

- **Notation:** locations $i, u \in \mathcal{N} = \mathcal{D} \cup \mathcal{F}$ (domestic and foreign); sectors $k, h \in \mathcal{K}$
- **Households:** Cobb-Douglas, $u_i = \prod_{k \in \mathcal{K}} C_{i,k}^{\alpha_k}$, with indirect utility I_i / P_i; a **global portfolio** allows regional **trade imbalances**

$$\Upsilon_i \equiv \iota_i r_i \overline{H}_i - \chi L_i \tag{1}$$

- **Intermediate goods:** Fréchet varieties, constant returns, **lowest-cost origin**

$$x_{i,k} \propto \left(r_i^{\beta_i} w_i^{1-\beta_i} \right)^{\gamma_{i,k}} \prod_{h \in \mathcal{K}} P_{i,h}^{\gamma_{i,kh}} \tag{2}$$

→ **Productivity:** fundamentals plus **knowledge spillovers** (Leontief inverse)

$$A_{i,k} = \prod_{u \in \mathcal{N},\, h \in \mathcal{K}} \bar{A}_{u,h}^{\ell_{iu,kh}} \tag{3}$$

Prices and Trade Flows

Details

- **Final-good producers:** act as local **retailers**
  - → Buy each sector-k variety from its **cheapest origin**
  - → Aggregate them (CES) into a **non-tradable** good, used for consumption and as material inputs

- **Prices:** by the properties of the Fréchet distribution (Eaton & Kortum, 2002)

$$P_{i,k} \propto \left[\sum_{u \in \mathcal{N}} \left(\kappa_{iu,k} \, x_{u,k} \right)^{-\theta_k} A_{u,k}^{\theta_k \gamma_{u,k}} \right]^{-\frac{1}{\theta_k}} \tag{4}$$

- **Trade shares:** share of i's spending on sector k bought from origin u

$$\pi_{iu,k} = \frac{X_{iu,k}}{X_{i,k}} = \frac{\left(\kappa_{iu,k} \, x_{u,k} \right)^{-\theta_k} A_{u,k}^{\theta_k \gamma_{u,k}}}{\sum_{m \in \mathcal{N}} \left(\kappa_{im,k} \, x_{m,k} \right)^{-\theta_k} A_{m,k}^{\theta_k \gamma_{m,k}}} \tag{5}$$

Market Clearing and Labor Mobility

Market Clearing Mobility

- **Market clearing**, in every location (Equations 6–9):
  - → **Factor markets:** labor and structures are fully employed
  - → **Goods markets:** output is consumed or used as materials
  - → **Regional budget:** expenditure plus the trade imbalance equals revenue

- **Free mobility:** workers move until indirect utility is equalized, $I_i / P_i = \mathcal{U}$ for all $i \in \mathcal{N}$

- **Labor allocation:**

$$L_i = \frac{\left(\frac{\varpi_i}{\mathcal{U} P_i + v_i}\right)^{\frac{1}{\beta_i}} \overline{H}_i}{\sum_{u \in \mathcal{N}} \left(\frac{\varpi_u}{\mathcal{U} P_u + v_u}\right)^{\frac{1}{\beta_u}} \overline{H}_u} \overline{L} \tag{10}$$

  - → Labor flows toward **higher real returns** (ϖ_i: local factor prices; v_i: per-capita imbalance); fixed structures $\overline{H}_i$ act as **congestion**

Given endowments $\{\overline{L}, \overline{H}_i\}$, fundamentals $\{\bar{A}_{i,k}\}$, trade costs $\{\kappa_{iu,k}\}$ and parameters, an **equilibrium** is a set of prices and allocations such that:

Condition	**Main objects**	**Equation**
Regional trade imbalances	Υ_i	(1)
Cost minimization	$x_{i,k}$ given $w_i, r_i, P_{i,h}$	(2)
Knowledge diffusion	$A_{i,k}$	(3)
Prices and trade shares	$P_{i,k}$, $\pi_{iu,k}$	(4)–(5)
Factor markets	$L_{i,k}$, $H_{i,k}$, w_i, r_i	(6)
Final-goods markets	$C_{i,k}$, $M_{i,hk}$, $X_{i,k}$	(7)–(8)
Trade balance condition	expenditure $+ \Upsilon_i =$ revenue	(9)
Labor mobility	L_i, $\mathcal{U}$	(10)

Solution: we solve the model in relative changes using **exact hat algebra**

Outcomes: Measured TFP and Real GDP

Derivations | Aggregation

- **Measured TFP:** deflated gross output, net of factors and inputs Mechanisms

$$\log \widehat{\text{TFP}}_{i,k} = \underbrace{\gamma_{i,k} \log \hat{A}_{i,k}}_{\text{direct effect on value added}} - \underbrace{(1/\theta_k) \log \hat{\pi}_{ii,k}}_{\text{entry and exit}}$$

- **Real GDP:** Mechanisms

$$\log \widehat{GDP}_{i,k} = \underbrace{\log \widehat{\text{TFP}}_{i,k}}_{\text{measured TFP}} + \underbrace{\log \hat{L}_{i,k}}_{\text{migration}} + \underbrace{\log \left(\hat{w}_i / \hat{x}_{i,k} \right)}_{\text{relative prices}}$$

- **Other outcomes:** productivity diffusion and welfare Productivity | Welfare

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1. Disaggregated Economic Accounts

2. Model

3. **Quantitative Applications**
   1. Aggregate Effects of Local Productivity Shocks
   2. The Exit of *Huachipato* Steel Plant

4. Conclusion

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Application 1: Aggregate Effects of Local Productivity Shocks

- **Question:** where does a productivity gain raise aggregate GDP the most?
  - → Where to target productivity policy: the largest *bang for the buck*
- **Exercise:** a 10% increase in fundamental productivity, $\hat{\bar{A}}_{i,k} = 1.1$
  - → One **location-sector** at a time (56×46), and whole locations or sectors
- **GDP elasticity:** the aggregate effect per unit of the cell's size

$$\text{GDP Elasticity}_{i,k} = \frac{d\text{GDP}}{(\text{VA}_{i,k}/\text{VA})\, d\bar{A}_{i,k}}$$

  - → Hulten benchmark: an elasticity of **one**
- **Mechanisms:** compare with economies without input-output, without trade, without both, and without geography in the IO

Location-Sector Productivity Shocks

Distribution

2. The relevant unit is the location-sector pair

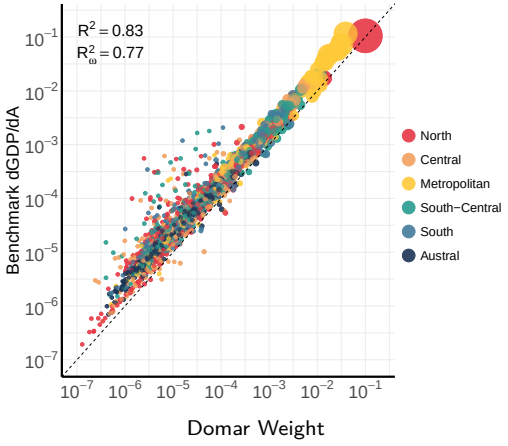
	Mean		Standard Deviation		Variance Decomposition		
	Simple (1)	Weighted (2)	Simple (3)	Weighted (4)	Geography (5)	Sectoral (6)	Interaction (7)
Panel A: Standard Statistics							
Domar Weight ($\times 100$)	0.06	1.78	0.32	2.67	21	4.8	75
Panel B: Aggregate GDP Elasticity							
Benchmark	2.24	2.04	1.09	0.63	12	16	73
No Production Networks	2.55	2.32	1.13	0.82	17	19	64
No Trade Flows	1.83	1.92	0.48	0.43	58	33	8.8
No Trade or Production Networks	1.99	1.97	0.41	0.36	81	18	0.41
No Geography on Input-Output	2.26	2.01	1.04	0.61	13	19	69

- **Location** or **sector** shocks alone: similar elasticity, **less dispersion** Details

Aggregate GDP Effects and Domar Weights

By Sector

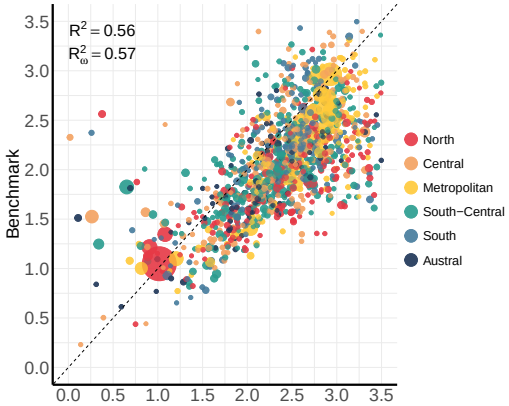
3. Domar weights are informative, but incomplete



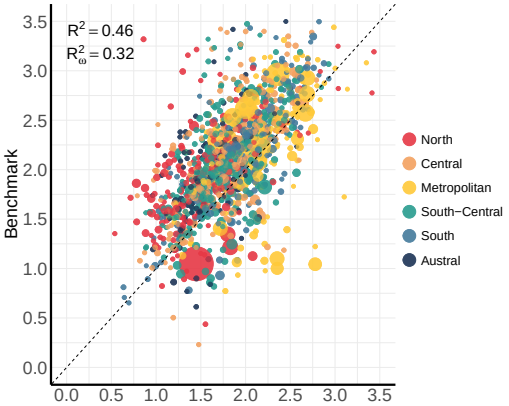
The Role of Trade and Production Networks

No Trade or Networks | By Sector

4. Trade shapes the dispersion more than production networks



(a) No Production Networks

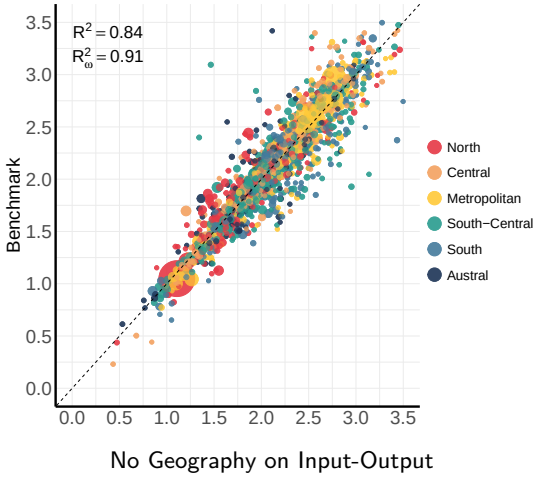


(b) No Trade Flows

The Role of the Geographic Input-Output Matrix

By Sector

5. Geographic IO matters through small and influential markets



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Application 2: The Exit of *Huachipato*

- **Background:** Chile's **largest steel plant**, in Concepción, closed in 2024 amid a surge in Chinese imports
- **Large locally, small nationally:** 75% of the sales of the Concepción–Primary Metals node
- **Experiment:** lower the node's fundamental productivity until its output falls by **75%**



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Chile's largest steel mill shuts amid surge in Chinese imports

The South American country had slapped tariffs on its largest trading partner in order to save the plant run by CAP

Steel workers protest against the closure of the Huachipato steel plant in Talcahuano, Chile © Guillermo Salgado/AFP/Getty Images

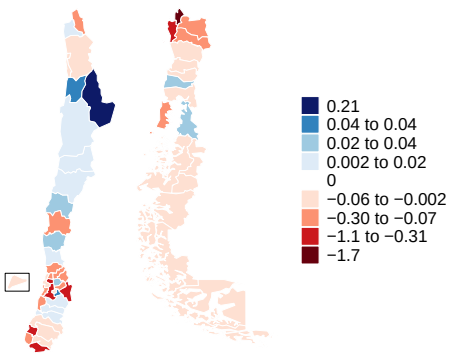
Aggregate Effects and Mechanisms

▸ By Region and Sector

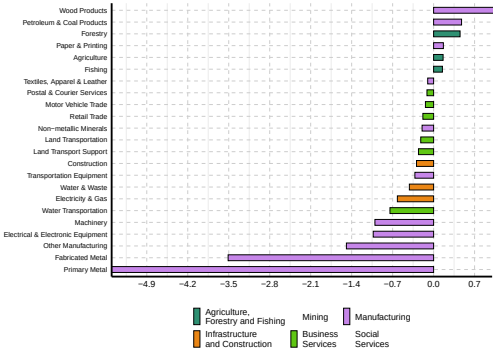
6. National IO coefficients understate the loss: 1.51 vs. 3.41

	National Elasticity			Variance Decomposition			Distance
	TFP	Employment	Real GDP	Geography	Sector	Interaction	R^2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Benchmark	0.10	3.49	3.41	5.5	25	70	41
No Production Networks	0.74	1.14	1.20	0.1	42	58	37
No Trade Flows	0.21	6.27	5.75	72	2.1	26	37
No Trade or Production Networks	2.66	8.65	6.87	81	0.9	18	35
No Geography on Input-Output	0.14	1.59	1.51	1.8	28	71	41
No Knowledge Spillovers	0.07	2.90	2.83	3.7	29	68	42

6. Three-quarters of the losses occur outside its location-sector



(a) Provincial GDP change (%)



(b) Sectoral GDP change (%)

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Conclusion

- **Data:** the first **geographic input-output matrix** measured from firm-to-firm transactions, consistent with national accounts
- **Model:** how local productivity shocks propagate through trade, production networks, labor mobility and others
- **Data + Model:**
  - → Where productivity policy has the largest *bang for the buck*
  - → The **interaction** of geography and sectors is key to the impact of productivity
  - → **Distributional** impacts are first-order: winners and losers across regions and sectors
- **Next steps:**
  - → Measurement: annual updates, invoice-level locations (not headquarters), finer sectors
  - → Model: labor frictions, local agglomeration, investment dynamics, natural capital
  - → Applications: innovation, infrastructure, environmental policy, and many others

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October 16, 2026

Appendix

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. Additional Results

Data Details: Sources

Return

- Administrative microdata for 2018−2023 from the Chilean Internal Revenue Service (Servicio de Impuestos Internos, SII).

1. **Electronic Tax Documents (DTEs):** Domestic firm-to-firm transactions
   - Since 2018, covers the universe of formal firms in Chile.
   - Tax identification numbers (RUT) of the seller and buyer, transaction date and value, and the municipalities of the establishments of both parties.
   - Transaction: Electronic invoices (code 33), Electronic VAT-exempt invoices (34), and Credit (61) and Debit (56) notes.
2. **Employer–Employee Records (DJ1879 and DJ1887):** Independent contractors (DJ1879) and formal employees (DJ1887)
   - DJ1879 contains information on independent contractor fees (box 3) and board members (boxes 4 and 5). We adjust for the statutory withholding rate.
   - DJ1887 reports total net taxable income (box 3), non-taxable income (box 8), and tax-exempt income (box 33).
   - We merge both forms using the firm's tax ID (RUT) and compute total labour payments as the sum across concepts.
   - We count the number of reported aliases (worker IDs) to obtain the headcount of employed persons.

Data Details: Sources

Return

3. **Balance Sheet and Tax Returns (F22 and F29):** Monthly VAT declaration (F29) and annual income tax return (F22)
   - From F22 we obtain information on fixed assets (box 647).
   - From F29, after aggregating to the annual level, we construct the following variables:
     - *Total Sales*: $538/0.19 + 142 + 587 + 20$
     - *Domestic Sales*: $538/0.19 + 142 + 587$
     - *Exports*: 20
     - *Total Intermediate Inputs*: $521 + 560 + 562 + (520 + 528 + 532 + 535)/0.19$
     - *Domestic Intermediate Inputs*: $521 + 562 + (520 + 528 + 532)/0.19$
     - *Imports*: $560 + 535/0.19$
     - *Investment*: $(525 + 553)/0.19$
     - *Value Added*: Total Sales $-$ Total Intermediate Inputs

Data Details: Matching

Return

- Due to the way information is reported in the tax forms, we implement a series of adjustments.

- **Merging the databases:**
  - We use the firm tax identification number (RUT) to merge all data sources.
  - For each RUT–year, we assign a unique location and sector. If these are not reported in that year, we carry forward the last observation over the 2005–2023 period.

Data Details: Firm Definition and Winsorization

Return

- **Active firms:** strictly positive sales, material expenditures and labor compensation, and at least two workers
- **Non-market production** (Administrative and Support Services, Public Administration, Education, Health, Other Services): sales are the maximum of reported sales and input costs (materials, labor and capital payments)
- **Winsorization by sector,** to limit outliers while preserving the sectoral totals used in the top-down step:
  - Sales: 5th–95th percentiles in Trade; 0.1st–99.9th elsewhere
  - Materials: 5th–95th in Mining, Construction, Trade, Hotels and Restaurants, Finance and Insurance, Education, Health, Other Services and Public Administration; 0.1st–99.9th elsewhere
  - Other firm-level variables: 1st–99th within each of the 46 sectors; transactions: 0.01st–99.99th
- **Result:** 124 million supplier-buyer-year transactions, 59 million firm pairs and 677 thousand firms

Data Details: Aggregation

Return

- **Averaging:** firm-level averages over 2018–2023 in 2018 prices, excluding zeros, to keep persistent relationships; the same for firm-to-firm transactions

- **Confidentiality:** the SII requires at least 11 firms per published cell
  - The construction works at **56 provinces** $\times$ **46 sectors**; other geographic or sectoral levels are re-aggregations of these cells

- **Internal consistency:**
  - If value added is negative, materials are scaled down so that value added equals sales
  - If labor and capital payments exceed value added, they are rescaled proportionally
  - Materials cannot exceed sales, and domestic materials match the tax records

Data Details: Mapping to National Accounts

Return

- **Top-down allocation:** Central Bank regional GDP (16 regions $\times$ 13 sectors) and INE employment (NENE 2022, 16 regions $\times$ 18 sectors) are split into 56 provinces $\times$ 46 sectors with microdata shares
  - Tax records locate firms by **headquarters**; regional GDP reflects **where production takes place**, so anchoring to it mitigates headquarters bias
  - Capital: official 10-sector totals allocated with province-sector shares of firm capital stocks

- **Reconstruction:** other variables from sector-level ratios to value added in the microdata, rescaled to the sectoral totals of the 2022 national input-output matrix

- **MR-GRAS** (Temursho et al., 2021): balances the firm-to-firm matrix to disaggregated sales, disaggregated materials and the sectoral totals of the national input-output table

Data Details: Rest of the World

Return

- **Source:** OECD Inter-Country Input-Output tables, 2020 release (76 countries, 45 ISIC sectors), with the TiM and TiVA indicators for employment, labor compensation, gross output and value added
- **One foreign block:** all countries other than Chile are aggregated into a single Rest of the World
- **Allocation:**
  - Province-sector exports and imports come from the reconciled Chilean accounts
  - They are distributed across foreign sectors with ICIO destination and origin shares, common across provinces
- Consistent with both Chile's national accounts and the ICIO structure, without extra geographic assumptions

Definitions: Locations

Return

Macro-zone	Region No.	Region	Provinces
North	15	Arica	1) Arica; 2) Parinacota
	1	Tarapacá	3) Iquique; 4) Tamarugal
	2	Antofagasta	5) Antofagasta; 6) El Loa; 7) Tocopilla
	3	Atacama	8) Copiapó; 9) Chañaral; 10) Huasco
Central	4	Coquimbo	11) Elqui; 12) Choapa; 13) Limarí
	5	Valparaíso	14) Valparaíso; 15) Easter Island; 16) Los Andes; 17) Petorca; 18) Quillota; 19) San Antonio; 20) San Felipe de Aconcagua; 21) Marga Marga
Metropolitan	13	Metropolitan	22) Santiago; 23) Cordillera; 24) Chacabuco; 25) Maipo; 26) Melipilla; 27) Talagante
South-Central	6	O'Higgins	28) Cachapoal; 29) Cardenal Caro; 30) Colchagua
	7	Maule	31) Talca; 32) Cauquenes; 33) Curicó; 34) Linares
	16	Ñuble	35) Diguillín; 36) Itata; 37) Punilla
	8	Biobío	38) Concepción; 39) Arauco; 40) Biobío
South	9	La Araucanía	41) Cautín; 42) Malleco
	14	Los Ríos	43) Valdivia; 44) Ranco
	10	Los Lagos	45) Llanquihue; 46) Chiloé; 47) Osorno; 48) Palena
Austral	11	Aysén	49) Coyhaique; 50) Aysén; 51) Capitán Prat; 52) General Carrera
	12	Magallanes	53) Magallanes; 54) Chilean Antarctica; 55) Tierra del Fuego; 56) Última Esperanza
Rest of the World			57) Rest of the World

Definitions: Sectors

Return

Macro Industries	Industry Group	Regional Sectors	ISIC Rev. 4 Codes	No.	Sectors
Primary	Agriculture, Forestry and Fishing	Agricultural & Forestry	A01	1	Agriculture
			A02	2	Forestry
		Fishing	A03	3	Fishing
	Mining	Mining	B	4	Mining
Secondary	Manufacturing	Manufacturing	C10T12	5	Food, Beverages & Tobacco
			C13T15	6	Textiles, Apparel & Leather
			C16	7	Wood Products
			C17_18	8	Paper & Printing
			C19	9	Petroleum & Coal Products
			C20−21	10	Chemicals & Pharmaceuticals
			C22	11	Rubber & Plastics
			C23	12	Non-metallic Minerals
			C24	13	Primary Metals
			C25	14	Fabricated Metal Products
			C26−27	15	Electronics & Electrical Equipment
			C28	16	Machinery & Equipment
			C29−30	17	Transport Equipment
			C31−33	18	Other Manufacturing & Repair
	Infrastructure and Construction	Utilities	D	19	Electricity and Gas
			E	20	Water and Waste
		Construction	F	21	Construction
Tertiary	Business Services	Wholesale and Retail Trade	G45	22	Motor Vehicle Trade
			G46	23	Wholesale Trade
			G47	24	Retail Trade
		Accommodation & Food Services	I	25	Accommodation & Food Services
		Transport & Communications	H49	26	Land Transportation
			H50	27	Water Transportation
			H51	28	Air Transportation
			H521	29	Warehousing & Storage
			H5221	30	Land Transport Support
			H5222−229	31	Other Transport Support
			H53	32	Postal & Courier Services
			J61	33	Telecommunications
			J62−63	34	Information Technology
			J58−60	35	Other Publishing & Media
		Real Estate & Housing	L	37	Real Estate & Housing
		Finance & Business Services	K	36	Finance & Insurance
			M69	38	Legal & Accounting Services
			M71	39	Architecture & Engineering Services
			M70 + M72−75	40	Other Professional & Scientific Services
			N77	41	Rental & Leasing Services
			N78−82	42	Administrative & Support Services
	Social Services	Public Administration	O	43	Public Administration
		Other Services	P	44	Education
			Q	45	Health Services
			R−S−T	46	Other Services

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. Additional Results

Model Environment

Return

- As in Caliendo et al. (2018), firms operate in geographic-sectoral cells:
  - The economy comprises D domestic regions and F foreign countries, indexed by $\{i, u\} \in \mathcal{N} \equiv \{1, \ldots, D\} \cup \{1, \ldots, F\}$.
  - Production occurs across K sectors, indexed by $\{k, h\} \in \mathcal{K} \equiv \{1, \ldots, K\}$.
- Factor endowments:
  - The economy is endowed with labor $\overline{L}$ and regional structures $\overline{H}_i$ (land and infrastructure).
  - Labor is freely mobile across locations and sectors and earns the regional wage w_i.
  - Structures are fixed in each region, freely allocated across sectors, and earn the rental rate r_i.
- Agents:
  - Households: supply one unit of labor, provide an infrastructure stock to firms, and choose a consumption bundle.
  - Firms: operate in all sectors k and regions i, combining labor, land, and intermediate inputs to produce output.
- Intermediate goods are traded across locations subject to iceberg costs $\kappa_{iu,k} \geq 1$, while final goods are non-tradable and used for local consumption or as material inputs.

Households: Details (1/2)

Return

- **Notation:** locations $i, u \in \mathcal{N} = \mathcal{D} \cup \mathcal{F}$, with **domestic** provinces $\mathcal{D}$ and **foreign** countries $\mathcal{F}$; sectors $k, h \in \mathcal{K}$
- **Preferences and budget:** Cobb-Douglas,

$$u_i = \prod_{k \in \mathcal{K}} C_{i,k}^{\alpha_k}, \qquad \sum_{k \in \mathcal{K}} P_{i,k} C_{i,k} = I_i$$

- **Income:** labor, local structures and the **global portfolio**

$$I_i = w_i + (1 - \iota_i)\, r_i \frac{\overline{H}_i}{L_i} + \chi, \qquad \chi = \frac{\sum_{n \in \mathcal{N}} \iota_n r_n \overline{H}_n}{\sum_{n \in \mathcal{N}} L_n}$$

- **Indirect utility:** I_i / P_i, with $P_i = \prod_{k \in \mathcal{K}} \left(P_{i,k} / \alpha_k\right)^{\alpha_k}$; used in labor mobility

Households: Details (2/2) Return

- **Global portfolio** (Caliendo et al., 2018):
  - → A share $1 - \iota_i$ of local structure rents $r_i \overline{H}_i$ goes to local residents
  - → The share ι_i is pooled across all locations and paid back as the same per-capita amount χ
  - → A location that puts more into the pool than it receives ($\iota_i r_i \overline{H}_i > \chi L_i$) runs a **trade surplus**, $\mathrm{Y}_i > 0$

- **Why:** a static device to rationalize the **observed provincial trade imbalances**; ι_i is calibrated by constrained least squares to match them

Intermediate Goods Producers: Details (1/3) Return

- **Varieties:** idiosyncratic draws $z_{i,k} \sim \text{Fréchet}(\theta_k)$ and deterministic productivity $A_{i,k}$, which scales value added
- **Technology:** constant returns, $\gamma_{i,k} + \sum_{h \in \mathcal{K}} \gamma_{i,kh} = 1$

$$q_{i,k}(z_{i,k}) = z_{i,k} \left(A_{i,k}\, h_{i,k}^{\beta_i}\, l_{i,k}^{1-\beta_i} \right)^{\gamma_{i,k}} \prod_{h \in \mathcal{K}} M_{i,kh}^{\gamma_{i,kh}}$$

- **Trade:** iceberg costs $\kappa_{iu,k} \geq 1$; under perfect competition each buyer pays the price of the **lowest-cost origin**

$$p_{i,k}(z_{i,k}) = \min_{u \in \mathcal{N}} \left\{ \frac{\kappa_{iu,k}\, x_{u,k}}{z_{u,k}\, A_{u,k}^{\gamma_{u,k}}} \right\}$$

Intermediate Goods Producers: Details (2/3)

Return

- **Notation:** factor and input demands are variety-specific, $h_{i,k}(z_{i,k})$, $l_{i,k}(z_{i,k})$, $M_{i,kh}(z_{i,k})$; the previous slide drops the argument $z_{i,k}$
- **Cost minimization:** given (w_i, r_i) and $\{P_{i,h}\}_{h\in\mathcal{K}}$, a producer with draw $z_{i,k}$ solves

$$\min_{l_{i,k},\, h_{i,k},\, \{M_{i,kh}\}_{h\in\mathcal{K}}} r_i h_{i,k} + w_i l_{i,k} + \sum_{h\in\mathcal{K}} P_{i,h} M_{i,kh} \quad \text{s.t.} \quad q_{i,k}(z_{i,k}) = 1$$

- **First-order conditions:** cost shares equal the Cobb-Douglas exponents

$$\frac{r_i h_{i,k}(z_{i,k})}{c_{i,k}(z_{i,k})} = \gamma_{i,k}\beta_i, \qquad \frac{w_i l_{i,k}(z_{i,k})}{c_{i,k}(z_{i,k})} = \gamma_{i,k}(1-\beta_i), \qquad \frac{P_{i,h} M_{i,kh}(z_{i,k})}{c_{i,k}(z_{i,k})} = \gamma_{i,kh}$$

Intermediate Goods Producers: Details (3/3) Return

- **Factor ratio:** from the first-order conditions,

$$r_i h_{i,k}(z_{i,k}) = \frac{\beta_i}{1-\beta_i} w_i l_{i,k}(z_{i,k}) \quad \Longrightarrow \quad r_i \overline{H}_i = \frac{\beta_i}{1-\beta_i} w_i L_i$$

  after aggregating with factor-market clearing (used in the migration condition)

- **Unit cost of a variety:** $c_{i,k}(z_{i,k}) = x_{i,k} / \left(z_{i,k} A_{i,k}^{\gamma_{i,k}}\right)$, with $x_{i,k}$ from Equation (2) and

$$B_{i,k} = \left(\gamma_{i,k}(1-\beta_i)^{1-\beta_i}\beta_i^{\beta_i}\right)^{-\gamma_{i,k}} \prod_{h\in\mathcal{K}} \gamma_{i,kh}^{-\gamma_{i,kh}}$$

- **Perfect competition:** prices equal unit costs

Varieties and Their Role

Return

- **What a variety is:** each sector k is a continuum of varieties ω; every location can produce every variety, and its efficiency in each one is its draw $z_{i,k}(\omega)$
- **Trade shares:** since each variety is bought from the cheapest origin (Eaton & Kortum, 2002)
  - $\rightarrow$ $\pi_{iu,k}$ is the share of sector-k varieties that i buys from u: the gravity equation for trade shares
  - $\rightarrow$ θ_k governs the dispersion of efficiencies: a low θ_k means strong comparative advantage *within* the sector and trade that is less sensitive to costs
- **Entry and exit:** a shock changes which origin is cheapest for each variety, so local producers enter or expand in some varieties and are displaced in others (the extensive margin)

Knowledge and Productivity: Details (1/2)

Return

- **Productivity:** own **fundamentals** and **external knowledge**

$$A_{i,k} = \bar{A}_{i,k}\, \Psi_{i,k}^{\varphi}, \qquad \varphi \in [0, 1)$$

- **External knowledge:** from technologically related sectors (λ_{kh}) within geographic reach (δ_{iu})

$$\Psi_{i,k} = \prod_{u \in \mathcal{N},\, h \in \mathcal{K}} A_{u,h}^{\lambda_{kh}\delta_{iu}}$$

- **In equilibrium:** $A_{i,k} = \prod_{u,h} \bar{A}_{u,h}^{\ell_{iu,kh}}$, where $\ell_{iu,kh}$ is the total (direct and indirect) effect of the fundamentals of (u, h) on (i, k)

Knowledge and Productivity: Details (2/2)

Return

- **Matrix form:** stacking logs, $\log \mathbf{A} = \log \bar{\mathbf{A}} + \varphi \mathbf{W} \log \mathbf{A}$, with $\mathbf{W} \equiv \mathbf{\Delta} \otimes \mathbf{\Lambda}$, $\mathbf{\Delta} = [\delta_{iu}]$, $\mathbf{\Lambda} = [\lambda_{kh}]$

$$\log \mathbf{A} = \mathbf{L} \log \bar{\mathbf{A}}, \qquad \mathbf{L} \equiv (\mathbf{I} - \varphi \mathbf{W})^{-1}$$

  - → $\ell_{iu,kh}$ is the $(i, k; u, h)$ element of $\mathbf{L}$: a Leontief inverse for knowledge

- **Benchmark calibration:**
  - → λ_{kh}: sectoral patent-citation shares, normalized by recipient sector (Liu & Ma, 2021; LaBelle et al., 2023)
  - → $\delta_{iu} = \mathbf{1}\{i = u\}$: knowledge diffuses across sectors **within** each location
  - → $\varphi = 0.07$ (Basso et al., 2025): moderate, conservative spillovers

Final Goods: Interpretation (1/4) Return

- **Role:** in each location-sector, final-good producers are the **buyers** of intermediate varieties; they add no value, they source and bundle them, like a retailer
- **Sourcing:** each variety is bought from the origin with the lowest delivered price, so every bilateral trade flow in the model is a purchase by a final-good producer
  - → $X_{i,k}$: total spending of i on sector-k varieties (for consumption and for intermediate use)
  - → $\pi_{iu,k}$: the share of that spending that goes to origin u
- **Output:** the bundle $Q_{i,k}$ is **non-tradable**: local households consume it (shares α_k) and local firms use it as materials (shares $\gamma_{i,kh}$), at price $P_{i,k}$
  - → Trade happens in varieties; final goods are local
- **In the data:** $\pi_{iu,k}$ comes from observed firm-to-firm flows, with a model-based allocation of final demand

Final Goods: Optimality (2/4) Return

- **Problem:** taking the delivered prices $p_{i,k}(z_k)$ and $P_{i,k}$ as given,

$$\max_{\{\tilde{q}_{i,k}(z_k)\}} \; P_{i,k} Q_{i,k} - \int p_{i,k}(z_k)\, \tilde{q}_{i,k}(z_k)\, d\Phi_k(z_k)$$

$$\text{s.t.} \quad Q_{i,k} = \left[\int \tilde{q}_{i,k}(z_k)^{1-\frac{1}{\eta_{i,k}}}\, d\Phi_k(z_k) \right]^{\frac{\eta_{i,k}}{\eta_{i,k}-1}}$$

  where $\Phi_k(z_k) = \exp\{-\sum_{n\in\mathcal{N}} z_{n,k}^{-\theta_k}\}$ is the joint distribution of draws across origins

- **First-order condition:** CES demand for each variety

$$\tilde{q}_{i,k}(z_k) = Q_{i,k} \left(\frac{p_{i,k}(z_k)}{P_{i,k}} \right)^{-\eta_{i,k}}$$

- **Zero profits** (free entry, perfect competition): the CES price index

$$P_{i,k} = \left[\int p_{i,k}(z_k)^{1-\eta_{i,k}}\, d\Phi_k(z_k) \right]^{\frac{1}{1-\eta_{i,k}}}$$

Final Goods: Intuition for the Price Index (3/4)

Return

- **What $P_{i,k}$ is:** the **minimum cost of one unit** of the bundle $Q_{i,k}$, given the variety prices $p_{i,k}(z_k)$; it is the dual (unit-cost function) of the CES technology
- **Where it comes from:** in the first-order condition, $P_{i,k}$ is the shadow value of one more unit of $Q_{i,k}$; free entry and zero profits, $P_{i,k}Q_{i,k} = \int p_{i,k}\,\tilde{q}_{i,k}\,d\Phi_k$, make it the market price of the final good
- **Why a power mean:** $P_{i,k}^{1-\eta_{i,k}} = \int p_{i,k}(z_k)^{1-\eta_{i,k}}\,d\Phi_k(z_k)$
  - → With $\eta_{i,k} > 1$, **cheap varieties weigh more**: the retailer substitutes toward them, and spending on each variety is proportional to $p_{i,k}^{1-\eta_{i,k}}$
  - → If every variety costs p, then $P_{i,k} = p$; a lower price anywhere lowers $P_{i,k}$
- **Why a closed form:** with Fréchet draws the lowest delivered price is Weibull, so the integral has the closed form in Equation (4): cheaper, more productive and closer origins lower $P_{i,k}$
- **Same logic for households:** $P_i = \prod_k \left(P_{i,k}/\alpha_k\right)^{\alpha_k}$ is the unit cost of utility under Cobb-Douglas

Final Goods: Prices and Trade Shares (4/4)

Return

- **Delivered prices:** from origin u, $p_{iu,k}(z_{u,k}) \equiv \dfrac{\kappa_{iu,k}\, x_{u,k}}{z_{u,k} A_{u,k}^{\gamma_{u,k}}}$, and the buyer pays $p_{i,k}(z_k) = \min_{u \in \mathcal{N}} p_{iu,k}(z_{u,k})$

- **Price competitiveness:** $\Omega_{iu,k} \equiv \left(\kappa_{iu,k} x_{u,k}\right)^{-\theta_k} A_{u,k}^{\theta_k \gamma_{u,k}}$, $\Omega_{i,k} \equiv \sum_{u \in \mathcal{N}} \Omega_{iu,k}$
  - → With Fréchet draws, the minimum price is Weibull: $\Pr\left(p_{i,k}(z_k) \leq p\right) = 1 - \exp\{-\Omega_{i,k}\, p^{\theta_k}\}$

- **Price index:** evaluating the CES integral gives Equation (4), $P_{i,k} = \Gamma(\xi_{i,k})^{\frac{1}{1-\eta_{i,k}}}\, \Omega_{i,k}^{-1/\theta_k}$, with $\xi_{i,k} = 1 + \frac{1-\eta_{i,k}}{\theta_k} > 0$
  - → $\eta_{i,k}$ only enters the constant, so it drops out of the counterfactuals in relative changes

- **Trade shares:** u supplies the varieties where it is cheapest, which happens with probability $\Omega_{iu,k}/\Omega_{i,k}$, so $\pi_{iu,k} = \dfrac{X_{iu,k}}{X_{i,k}} = \dfrac{\Omega_{iu,k}}{\Omega_{i,k}}$, which is Equation (5)

Market Clearing: Details (1/2)

Return

- **Factor markets:** labor and structures are fully employed in each location

$$\sum_{k \in \mathcal{K}} L_{i,k} = L_i, \qquad \sum_{k \in \mathcal{K}} H_{i,k} = \overline{H}_i \tag{6}$$

- **Final goods:** consumed by households or used as materials

$$L_i C_{i,k} + \sum_{h \in \mathcal{K}} M_{i,hk} = Q_{i,k} \tag{7}$$

→ In value, with optimal demands: **final demand** plus **intermediate demand**

$$X_{i,k} = \alpha_k L_i I_i + \sum_{h \in \mathcal{K},\, u \in \mathcal{N}} \gamma_{i,hk}\, \pi_{ui,h}\, X_{u,h} \tag{8}$$

- **Trade balance condition: expenditure** plus trade imbalance equals **revenue**

$$\sum_{k \in \mathcal{K},\, u \in \mathcal{N}} \pi_{iu,k} X_{i,k} + \mathrm{Y}_i = \sum_{k \in \mathcal{K},\, u \in \mathcal{N}} \pi_{ui,k} X_{u,k}, \qquad \text{for all } i \in \mathcal{N} \tag{9}$$

Market Clearing: Details (2/2)

Return

- **Aggregating over varieties:** $L_{i,k} = \int l_{i,k}(z)\,\phi_{i,k}(z)\,dz$, $H_{i,k} = \int h_{i,k}(z)\,\phi_{i,k}(z)\,dz$ and $M_{i,hk} = \int M_{i,hk}(z)\,\phi_{i,h}(z)\,dz$; nationally, $\sum_{i\in\mathcal{N}} L_i = L$

- **Reading the expenditure condition:** producers in (i, h) sell $\sum_u \pi_{ui,h} X_{u,h}$ to all destinations and spend a share $\gamma_{i,hk}$ of it on sector-k materials; households spend α_k of income $L_i l_i$

- **Reading the trade balance:** a regional accounting identity; net imports are financed by the net factor-income position Y_i
  - $\rightarrow$ Aggregate trade balances, $\sum_{i\in\mathcal{N}} \mathrm{Y}_i = 0$, under the model's ownership structure
  - $\rightarrow$ Productivity changes can alter both the size and the sign of regional imbalances

Labor Mobility: Derivation (1/2) Return

- **Starting point:** free mobility equalizes indirect utility in all populated locations, $I_i / P_i = \mathcal{U}$
- **Factor ratio:** the firms' first-order conditions give $r_i h_{i,k}(z_{i,k}) = \frac{\beta_i}{1-\beta_i} w_i l_{i,k}(z_{i,k})$; aggregating across varieties and sectors with factor-market clearing,

$$r_i \overline{H}_i = \frac{\beta_i}{1-\beta_i} w_i L_i \quad \Longleftrightarrow \quad \frac{r_i}{\beta_i} = \frac{w_i}{1-\beta_i} \frac{L_i}{\overline{H}_i}$$

- **Local factor-price index:** substituting the rental rate into ϖ_i,

$$\varpi_i \equiv \left(\frac{w_i}{1-\beta_i} \right)^{1-\beta_i} \left(\frac{r_i}{\beta_i} \right)^{\beta_i} \quad \Longrightarrow \quad \frac{w_i}{1-\beta_i} = \varpi_i \left(\frac{\overline{H}_i}{L_i} \right)^{\beta_i}$$

Labor Mobility: Derivation (2/2)

Return

- **Income per worker:** with the per-capita trade imbalance $v_i \equiv \mathrm{Y}_i / L_i = \iota_i r_i \overline{H}_i / L_i - \chi$,

$$I_i = w_i + r_i \frac{\overline{H}_i}{L_i} - v_i = \frac{w_i}{1-\beta_i} - v_i = \varpi_i \left(\frac{\overline{H}_i}{L_i} \right)^{\beta_i} - v_i$$

- **Free mobility** then requires $\mathcal{U}P_i + v_i = \varpi_i \left(\overline{H}_i / L_i \right)^{\beta_i}$, so, with $\beta_i \in (0,1)$,

$$L_i = \left(\frac{\varpi_i}{\mathcal{U}P_i + v_i} \right)^{1/\beta_i} \overline{H}_i$$

- **Adding up,** $\sum_{i \in \mathcal{N}} L_i = \overline{L}$, normalizes the allocation and gives Equation (10)
  - → Labor flows toward higher factor-price indices and larger fixed-factor endowments, and away from higher consumption prices and larger per-capita net payments to the global portfolio

Competitive Equilibrium: Formal Definition

Return

Definition 1 (Competitive Equilibrium in Levels). *Given factor endowments* $\{\overline{L}, \overline{H}_i\}$*, region-sector productivities* $\{\bar{A}_{i,k}\}$*, and iceberg trade costs* $\{\kappa_{iu,k}\}$*, a competitive equilibrium is characterized by a common level of utility* $\mathcal{U}$*; an allocation of population across regions* $\{L_i\}$ *and across sectors within each region* $\{L_{i,k}\}$*; land allocations* $\{H_{i,k}\}$*; sectoral expenditure, per capita consumption, and intermediate input use* $\{X_{i,k}, C_{i,k}, M_{i,kh}\}$*; final-goods and factor prices* $\{P_{i,k}, r_i, w_i\}$*; regional trade imbalances* $\{\Upsilon_i\}$*; bilateral expenditure shares on intermediate inputs* $\{\pi_{iu,k}\}$*; and deterministic productivity levels* $\{A_{i,k}\}$*, such that regional trade imbalances satisfy Equation* (1)*; intermediate-goods producers minimize unit costs as in Equation* (2)*; deterministic productivity is consistent with Equation* (3)*; final-goods prices and trade shares are given by Equations* (4) *and* (5)*; market clearing holds as in Equations* (6)*,* (7) *and* (8)*; the trade balance condition holds as in Equation* (9)*; and labor mobility is pinned down by Equation* (10)*.*

Exogenous Trade Imbalances

Return

- **Data:** Υ_i^{Data} = sales originating in i minus purchases by i, domestic and international
- **Model:** imbalances must be rationalized by the portfolio, $\Upsilon_i = \iota_i r_i \overline{H}_i - \chi L_i$, with $\iota_i \in [0, 1]$ calibrated by constrained least squares to match Υ_i^{Data}
- **Residual:** where the constraint binds, $S_i \equiv \Upsilon_i^{\text{Data}} - \Upsilon_i$ is **not explained** by the model
  - → **Benchmark:** the residual is removed from the model baseline ($S_i = 0$), so baseline imbalances satisfy the trade balance condition, Equation (9)
  - → **Extension:** S_i can enter as an exogenous transfer, replacing Υ_i by $\Upsilon_i + S_i$ in income, in the labor allocation and in the trade balance condition

Equilibrium in Relative Changes (1/4)

Return

Definition 2. *Given baseline data* $\{I_i, L_i, \Upsilon_i, \pi_{iu,k}, X_{i,k}\}$*, parameters* $\{\theta_k, \alpha_k, \beta_i, \iota_i, \gamma_{i,k}, \gamma_{i,kh}, \lambda_{kh}, \delta_{iu}, \varphi\}$ *and shocks* $\{\hat{\bar{A}}_{i,k}, \hat{\bar{H}}_i, \hat{\kappa}_{iu,k}\}$*, an equilibrium in relative changes is* $\{\hat{A}_{i,k}, \hat{x}_{i,k}, \hat{P}_{i,k}, \hat{P}_i, \hat{L}_i, \hat{\omega}_i\}$ *and* $\{\pi'_{iu,k}, X'_{i,k}, \chi', \Upsilon'_i\}$ *such that:*

1. *Productivity:*

$$\hat{A}_{i,k} = \prod_{u \in \mathcal{N},\, h \in \mathcal{K}} \left(\hat{\bar{A}}_{u,h}\right)^{\ell_{iu,kh}} \tag{11}$$

2. *Input-bundle costs:*

$$\hat{x}_{i,k} = \hat{\omega}_i^{\gamma_{i,k}} \prod_{h \in \mathcal{K}} \hat{P}_{i,h}^{\gamma_{i,kh}} \tag{12}$$

Equilibrium in Relative Changes (2/4) Return

3. *Final-goods prices:*

$$\hat{P}_{i,k} = \left[\sum_{u \in \mathcal{N}} \pi_{iu,k} \left(\hat{\kappa}_{iu,k} \hat{x}_{u,k} \right)^{-\theta_k} \hat{A}_{u,k}^{\theta_k \gamma_{u,k}} \right]^{-1/\theta_k}, \qquad \hat{P}_i = \prod_{k \in \mathcal{K}} \hat{P}_{i,k}^{\alpha_k} \tag{13}$$

4. *Trade shares:*

$$\pi'_{iu,k} = \pi_{iu,k} \left(\frac{\hat{x}_{u,k}}{\hat{P}_{i,k}} \hat{\kappa}_{iu,k} \right)^{-\theta_k} \hat{A}_{u,k}^{\theta_k \gamma_{u,k}} \tag{14}$$

Equilibrium in Relative Changes (3/4) Return

5. *Labor mobility*, with $\mu_i \equiv P_i\mathcal{U}/(P_i\mathcal{U}+v_i)$:

$$\hat{L}_i = \frac{\left[\dfrac{\hat{\omega}_i}{\mu_i\hat{P}_i\hat{\mathcal{U}}+(1-\mu_i)\hat{v}_i}\right]^{1/\beta_i}\hat{\bar{H}}_i}{\sum_{u\in\mathcal{N}}\left(\dfrac{L_u}{\bar{L}}\right)\left[\dfrac{\hat{\omega}_u}{\mu_u\hat{P}_u\hat{\mathcal{U}}+(1-\mu_u)\hat{v}_u}\right]^{1/\beta_u}\hat{\bar{H}}_u} \tag{15}$$

6. *Portfolio payments and regional imbalances:*

$$\begin{aligned}\chi' &= \frac{1}{\bar{L}}\sum_{n\in\mathcal{N}}\iota_n\beta_n\hat{\omega}_n\hat{\bar{H}}_n^{\beta_n}\hat{L}_n^{1-\beta_n}\left(L_nI_n+\mathrm{Y}_n\right)\\ \mathrm{Y}_i' &= \iota_i\beta_i\hat{\omega}_i\hat{\bar{H}}_i^{\beta_i}\hat{L}_i^{1-\beta_i}\left(L_iI_i+\mathrm{Y}_i\right)-\chi'\hat{L}_iL_i\end{aligned} \tag{16}$$

Equilibrium in Relative Changes (4/4)

Return

7. *Total expenditure:*

$$X'_{i,k} = \alpha_k \left(\hat{\omega}_i \hat{\bar{H}}_i^{\beta_i} \hat{L}_i^{1-\beta_i} \left(L_i I_i + \mathrm{Y}_i \right) - \mathrm{Y}'_i \right) + \sum_{h \in \mathcal{K},\, u \in \mathcal{N}} \gamma_{i,hk}\, \pi'_{ui,h}\, X'_{u,h} \tag{17}$$

8. *Regional factor prices:* factor income equals the value added of producers in i

$$\hat{\omega}_i = \frac{\sum_{k \in \mathcal{K},\, u \in \mathcal{N}} \gamma_{i,k}\, \pi'_{ui,k}\, X'_{u,k}}{\hat{\bar{H}}_i^{\beta_i} \hat{L}_i^{1-\beta_i} \left(L_i I_i + \mathrm{Y}_i \right)} \tag{18}$$

Computation

Return

Shocks: any combination of $\{\hat{\tilde{A}}_{i,k}, \hat{\overline{H}}_i, \hat{\kappa}_{iu,k}\}$. The system is solved as a **fixed point** in $\hat{\boldsymbol{\omega}} = \{\hat{\omega}_i\}$. Given a guess:

Step 1. Productivity: $\hat{A}_{i,k}$ from Equation (11)

Step 2. Costs and prices: solve Equations (12)–(13) jointly for $\hat{x}_{i,k}, \hat{P}_{i,k}$; then $\hat{P}_i$

Step 3. Trade shares: $\pi'_{iu,k}$ from Equation (14)

Step 4. Labor, portfolio and imbalances: $\hat{L}_i, \hat{\mathcal{U}}, \chi', \Upsilon'_i$ from Equations (15)–(16)

Step 5. Expenditure: solve the linear system in Equation (17) for the $N \times K$ unknowns $X'_{i,k}$

Step 6. Update: $\hat{\omega}_i^*$ from Equation (18)

Repeat until $\|\hat{\boldsymbol{\omega}}^* - \hat{\boldsymbol{\omega}}\| < \varepsilon$, dampening the update as a weighted average of the previous guess and $\hat{\boldsymbol{\omega}}^*$.

Outcomes: Productivity

Return

- **Productivity:** shocks $\hat{\hat{A}}_{u,h}$ spread through the **knowledge network** Mechanisms

$$\log \hat{A}_{i,k} = \sum_{u \in \mathcal{N},\, h \in \mathcal{K}} \ell_{iu,kh} \log \hat{\hat{A}}_{u,h}$$

- Without intermediate inputs, trade and spillovers, measured TFP equals fundamental productivity

Outcomes: Welfare

Return

- **Welfare:** sector-weighted real GDP per capita, plus **portfolio income**

Mechanisms

Derivation

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left(\log \widehat{\mathrm{TFP}}_{i,k} + \log \left(\nu_i \frac{\hat{w}_i}{\hat{x}_{i,k}} + (1 - \nu_i) \frac{\hat{\chi}}{\hat{x}_{i,k}} \right) \right)$$

→ ν_i: share of income from **local factors**; $1 - \nu_i$: from the **portfolio**

→ Without the portfolio ($\iota_i = 0$): $\chi = 0$ and $\nu_i = 1$

Outcomes: Derivation of Measured TFP

Return

- **Definition:** gross output deflated by the sectoral price index, net of the input bundle

$$\log \widehat{\text{TFP}}_{i,k} = \log \hat{x}_{i,k} - \log \hat{P}_{i,k}$$

- **Domestic trade share:** Equation (14) with $u = i$, and $\hat{\kappa}_{ii,k} = 1$ (internal trade costs are fixed)

$$\hat{\pi}_{ii,k} = \left(\frac{\hat{x}_{i,k}}{\hat{P}_{i,k}} \right)^{-\theta_k} \hat{A}_{i,k}^{\theta_k \gamma_{i,k}} \quad \Longleftrightarrow \quad \log \hat{x}_{i,k} - \log \hat{P}_{i,k} = \gamma_{i,k} \log \hat{A}_{i,k} - \frac{1}{\theta_k} \log \hat{\pi}_{ii,k}$$

- **Combining both:** the decomposition in the main slide, where $\hat{\pi}_{ii,k}$ summarizes the change in the set of varieties supplied by local producers
  - → If a local shock raises the domestic share $\pi_{ii,k}$, local producers now also supply varieties in which they are less efficient, so measured TFP rises by less than the direct effect

Outcomes: Derivation of Real GDP

Return

- **Nominal value added,** using the factor ratio $r_i \overline{H}_i = \frac{\beta_i}{1-\beta_i} w_i L_i$ (also cell by cell):

$$\mathrm{VA}_{i,k} = w_i L_{i,k} + r_i H_{i,k} = \frac{w_i L_{i,k}}{1-\beta_i}$$

- **Deflating by** $P_{i,k}$ and adding and subtracting $\log \hat{x}_{i,k}$:

$$\log \widehat{GDP}_{i,k} = \log \hat{w}_i + \log \hat{L}_{i,k} - \log \hat{P}_{i,k} = \log \widehat{\mathrm{TFP}}_{i,k} + \log \hat{L}_{i,k} + \log \left(\frac{\hat{w}_i}{\hat{x}_{i,k}} \right)$$

- **Recovering the terms:** wages from the factor-price index, and sectoral employment from labor demand (labor payments are a fixed share $\gamma_{i,k}(1-\beta_i)$ of revenue)

$$\hat{w}_i = \hat{\omega}_i \, \hat{\overline{H}}_i^{\beta_i} \hat{L}_i^{-\beta_i}, \qquad \hat{L}_{i,k} = \frac{\sum_{u \in \mathcal{N}} \pi'_{ui,k} X'_{u,k}}{\sum_{u \in \mathcal{N}} \pi_{ui,k} X_{u,k}} \frac{1}{\hat{w}_i}$$

Outcomes: Derivation of Welfare (1/2)

Return

- **Income:** local factor income plus the portfolio, using the factor ratio

$$I_i = \frac{(1-\beta_i \iota_i)\, w_i}{1-\beta_i} + \chi$$

- **Utility in levels,** common to every populated location by free mobility:

$$\mathcal{U} = \frac{I_i}{P_i} = \frac{(1-\beta_i \iota_i) w_i + (1-\beta_i)\chi}{(1-\beta_i) P_i}$$

- **In relative changes,** with ν_i the share of income from local factors:

$$\hat{\mathcal{U}} = \frac{\nu_i \hat{w}_i + (1-\nu_i)\hat{\chi}}{\hat{P}_i}, \qquad \nu_i = \frac{(1-\beta_i \iota_i) w_i}{(1-\beta_i \iota_i) w_i + (1-\beta_i)\chi}$$

Outcomes: Derivation of Welfare (2/2)

Return

- **Price index and measured TFP:** $\hat{P}_i = \prod_k \hat{P}_{i,k}^{\alpha_k}$ and $\log \hat{P}_{i,k} = \log \hat{x}_{i,k} - \log \widehat{\text{TFP}}_{i,k}$, so

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left[\log \widehat{\text{TFP}}_{i,k} + \log \left(\nu_i \frac{\hat{w}_i}{\hat{x}_{i,k}} + (1 - \nu_i) \frac{\hat{\chi}}{\hat{x}_{i,k}} \right) \right]$$

- **Without the portfolio** ($\iota_i = 0$, so $\chi = 0$ and $\nu_i = 1$), and using the real-GDP decomposition:

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left[\log \widehat{\text{TFP}}_{i,k} + \log \left(\frac{\hat{w}_i}{\hat{x}_{i,k}} \right) \right] = \sum_{k \in \mathcal{K}} \alpha_k \left(\log \widehat{GDP}_{i,k} - \log \hat{L}_{i,k} \right)$$

→ Welfare is a sector-weighted average of **real GDP per worker**

Outcomes: Sectoral Prices

Return

- **Sectoral prices from Equations 4 and 5:** by Eq. 4, the denominator of Eq. 5 is $\propto P_{i,k}^{-\theta_k}$; take the own origin $u = i$, with $\hat{\kappa}_{ii,k} = 1$, and solve for $\hat{P}_{i,k}$

$$\hat{\pi}_{ii,k} = \left(\frac{\hat{x}_{i,k} / \hat{A}_{i,k}^{\gamma_{i,k}}}{\hat{P}_{i,k}} \right)^{-\theta_k} \quad \Longrightarrow \quad \hat{P}_{i,k} = \hat{\pi}_{ii,k}^{1/\theta_k} \, \hat{x}_{i,k} / \hat{A}_{i,k}^{\gamma_{i,k}}$$

  - → The own trade share summarizes all other origins: buying more elsewhere ($\hat{\pi}_{ii,k} < 1$) lowers the price below local costs
  - → In measured TFP: $\log \widehat{\text{TFP}}_{i,k} = \log \hat{x}_{i,k} - \log \hat{P}_{i,k} = \gamma_{i,k} \log \hat{A}_{i,k} - (1/\theta_k) \log \hat{\pi}_{ii,k}$

- **Each counterfactual shuts down a different part:**

No input-output:	$\hat{P}_{i,k} = \hat{\pi}_{ii,k}^{1/\theta_k} \, \hat{\omega}_i / \hat{A}_{i,k}$	trade term stays, input costs go
No trade:	$\hat{P}_{i,k} = \hat{x}_{i,k} / \hat{A}_{i,k}^{\gamma_{i,k}}$	trade term goes, local input costs stay
Both:	$\hat{P}_{i,k} = \hat{\omega}_i / \hat{A}_{i,k}$	only local factor costs and productivity

Shutting Down Mechanisms: Measured TFP

Return

Counterfactual economies (Manuscript, Section 6.1): each shuts down one channel and keeps the rest of the model

- **No knowledge** ($\varphi = 0$): productivity changes stay local

$$\log \hat{A}_{i,k} = \log \hat{\tilde{A}}_{i,k}$$

- **No trade** ($\kappa_{iu,k} = \infty$ for $u \neq i$): $\hat{\pi}_{ii,k} = 1$, so the selection term vanishes

$$\log \widehat{\mathrm{TFP}}_{i,k} = \gamma_{i,k} \log \hat{A}_{i,k}$$

- **No input-output** ($\gamma_{i,kh} = 0$, $\gamma_{i,k} = 1$): gross output is all value added, so the shock is not diluted by purchased inputs; selection remains

$$\log \widehat{\mathrm{TFP}}_{i,k} = \log \hat{A}_{i,k} - (1/\theta_k) \log \hat{\pi}_{ii,k}$$

- **No trade and no input-output:** $\log \widehat{\mathrm{TFP}}_{i,k} = \log \hat{A}_{i,k}$

Shutting Down Mechanisms: Real GDP (1/4) Return

Channels, using $\hat{w}_i = \hat{\omega}_i \hat{L}_i^{-\beta_i}$ in the relative-price term:

$$\log \widehat{GDP}_{i,k} = \underbrace{\log \widehat{\text{TFP}}_{i,k}}_{\text{measured TFP}} + \underbrace{\log \hat{L}_{i,k}}_{\text{migration}} - \underbrace{\beta_i \log \hat{L}_i}_{\text{congestion}} + \underbrace{\log\left(\hat{\omega}_i / \hat{x}_{i,k}\right)}_{\text{input prices}}$$

- **Measured TFP:** productivity, diluted by purchased inputs ($\gamma_{i,k}$) and net of selection ($\hat{\pi}_{ii,k}$)
- **Migration:** workers move toward higher real returns, which depend on $\hat{\omega}_i$ and $\hat{P}_i = \prod_k \hat{P}_{i,k}^{\alpha_k}$ (Eq. 10), with sectoral prices $\hat{P}_{i,k}$ Prices
- **Congestion:** with fixed structures, arrivals lower the relative wage, $\hat{L}_i^{-\beta_i}$
- **Input prices:** local factor costs relative to the input bundle, which moves with the prices of intermediate inputs

Shutting Down Mechanisms: Real GDP (2/4) Return

- **No input-output** ($\gamma_{i,kh} = 0$, $\gamma_{i,k} = 1$): firms use only **labor and structures**
  - → **Measured TFP:** not diluted by purchased inputs, selection remains, $\log \hat{A}_{i,k} - (1/\theta_k) \log \hat{\pi}_{ii,k}$
  - → **Migration:** prices keep the trade term but lose input costs, $\hat{P}_{i,k} = \hat{\pi}_{ii,k}^{1/\theta_k} \hat{\omega}_i / \hat{A}_{i,k}$
  - → **Congestion:** arrivals lower the relative wage, $\hat{L}_i^{-\beta_i}$
  - → **Input prices:** none, $\hat{x}_{i,k} = \hat{\omega}_i$

$$\log \widehat{GDP}_{i,k} = \log \widehat{\text{TFP}}_{i,k} + \log \hat{L}_{i,k} - \beta_i \log \hat{L}_i$$

Shutting Down Mechanisms: Real GDP (3/4)

Return

- **No trade**: firms and consumers buy only from **local suppliers**
  - → **Measured TFP:** no selection, still diluted by purchased inputs, $\gamma_{i,k} \log \hat{A}_{i,k}$
  - → **Migration:** prices lose the trade term but keep local input costs, $\hat{P}_{i,k} = \hat{x}_{i,k} / \hat{A}_{i,k}^{\gamma_{i,k}}$
  - → **Congestion:** arrivals lower the relative wage, $\hat{L}_i^{-\beta_i}$
  - → **Input prices:** local only, $\hat{x}_{i,k} = \hat{\omega}_i^{\gamma_{i,k}} \prod_h \left(\hat{x}_{i,h} / \hat{A}_{i,h}^{\gamma_{i,h}} \right)^{\gamma_{i,kh}}$

$$\log \widehat{GDP}_{i,k} = \gamma_{i,k} \log \hat{A}_{i,k} + \log \hat{L}_{i,k} - \beta_i \log \hat{L}_i + \log \left(\hat{\omega}_i / \hat{x}_{i,k} \right)$$

Shutting Down Mechanisms: Real GDP (4/4) Return

- **No trade and no input-output:** only **local factors** and **local suppliers**
  - → **Measured TFP:** no dilution and no selection, $\log \hat{A}_{i,k}$
  - → **Migration:** prices reflect only local factor costs and productivity, $\hat{P}_{i,k} = \hat{\omega}_i / \hat{A}_{i,k}$
  - → **Congestion:** arrivals lower the relative wage, $\hat{L}_i^{-\beta_i}$
  - → **Input prices:** none, $\hat{x}_{i,k} = \hat{\omega}_i$

$$\log \widehat{GDP}_{i,k} = \log \hat{A}_{i,k} + \log \hat{L}_{i,k} - \beta_i \log \hat{L}_i$$

Shutting Down Mechanisms: Welfare (1/4)

Return

Channels: those of real GDP, with employment entering through congestion, plus portfolio income:

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left(\underbrace{\log \widehat{\mathrm{TFP}}_{i,k}}_{\text{measured TFP}} + \log \left(\nu_i \underbrace{\hat{L}_i^{-\beta_i}}_{\text{congestion}} \underbrace{\hat{\omega}_i / \hat{x}_{i,k}}_{\text{input prices}} + (1 - \nu_i) \underbrace{\hat{\chi} / \hat{x}_{i,k}}_{\text{portfolio income}} \right) \right)$$

- **Measured TFP, congestion and input prices:** as in real GDP
- **Per capita:** sectoral employment $\hat{L}_{i,k}$ drops out; migration affects welfare only through total employment $\hat{L}_i$ in congestion
- **Portfolio income:** returns to the global portfolio, deflated by the input bundle; ν_i is the share of income from local factors

Shutting Down Mechanisms: Welfare (2/4) Return

- **No input-output** ($\gamma_{i,kh} = 0$, $\gamma_{i,k} = 1$): firms use only **labor and structures**
  - → **Measured TFP:** as in real GDP, $\log \hat{A}_{i,k} - (1/\theta_k) \log \hat{\pi}_{ii,k}$
  - → **Congestion:** labor income relative to local costs, $\hat{w}_i / \hat{\omega}_i = \hat{L}_i^{-\beta_i}$
  - → **Input prices:** none, $\hat{x}_{i,k} = \hat{\omega}_i$
  - → **Portfolio income:** deflated by local factor prices, $\hat{\chi} / \hat{\omega}_i$

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left(\log \widehat{\text{TFP}}_{i,k} + \log \left(\nu_i \hat{L}_i^{-\beta_i} + (1 - \nu_i) \frac{\hat{\chi}}{\hat{\omega}_i} \right) \right)$$

Shutting Down Mechanisms: Welfare (3/4) Return

- **No trade**: firms and consumers buy only from **local suppliers**
  - → **Measured TFP:** as in real GDP, $\gamma_{i,k} \log \hat{A}_{i,k}$
  - → **Congestion:** labor income relative to local costs, $\hat{w}_i / \hat{\omega}_i = \hat{L}_i^{-\beta_i}$
  - → **Input prices:** local only, $\hat{\omega}_i / \hat{x}_{i,k}$ with $\hat{x}_{i,k}$ as in real GDP
  - → **Portfolio income:** deflated by local input costs, $\hat{\chi} / \hat{x}_{i,k}$

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left(\gamma_{i,k} \log \hat{A}_{i,k} + \log \left(\nu_i \hat{L}_i^{-\beta_i} \frac{\hat{\omega}_i}{\hat{x}_{i,k}} + (1 - \nu_i) \frac{\hat{\chi}}{\hat{x}_{i,k}} \right) \right)$$

Shutting Down Mechanisms: Welfare (4/4) Return

- **No trade and no input-output:** only **local factors** and **local suppliers**
  - → **Measured TFP:** as in real GDP, $\log \hat{A}_{i,k}$
  - → **Congestion:** labor income relative to local costs, $\hat{w}_i / \hat{\omega}_i = \hat{L}_i^{-\beta_i}$
  - → **Input prices:** none, $\hat{x}_{i,k} = \hat{\omega}_i$
  - → **Portfolio income:** deflated by local factor prices, $\hat{\chi} / \hat{\omega}_i$

$$\log \hat{\mathcal{U}} = \sum_{k \in \mathcal{K}} \alpha_k \left(\log \hat{A}_{i,k} + \log \left(\nu_i \hat{L}_i^{-\beta_i} + (1 - \nu_i) \frac{\hat{\chi}}{\hat{\omega}_i} \right) \right)$$

Aggregation: TFP

Return

- **Weights:** gross revenue $Y_{i,k}$; domestic aggregates only over domestic locations $\mathcal{D}$
- **Regional:**

$$\log \widehat{\text{TFP}}_i = \sum_{k \in \mathcal{K}} \left(\frac{Y_{i,k}}{\sum_{h \in \mathcal{K}} Y_{i,h}} \right) \log \widehat{\text{TFP}}_{i,k}$$

- **Sectoral (domestic):**

$$\log \widehat{\text{TFP}}_k = \sum_{i \in \mathcal{D}} \left(\frac{Y_{i,k}}{\sum_{u \in \mathcal{D}} Y_{u,k}} \right) \log \widehat{\text{TFP}}_{i,k}$$

- **Aggregate (domestic):**

$$\log \widehat{\text{TFP}} = \sum_{i \in \mathcal{D}} \sum_{k \in \mathcal{K}} \left(\frac{Y_{i,k}}{\sum_{u \in \mathcal{D}} \sum_{h \in \mathcal{K}} Y_{u,h}} \right) \log \widehat{\text{TFP}}_{i,k}$$

Aggregation: GDP

Return

- **Weights:** baseline value added $\text{VA}_{i,k}$ (constant prices); domestic aggregates only over $\mathcal{D}$
- **Regional:**

$$\log \widehat{GDP}_i = \sum_{k \in \mathcal{K}} \left(\frac{\text{VA}_{i,k}}{\sum_{h \in \mathcal{K}} \text{VA}_{i,h}} \right) \log \widehat{GDP}_{i,k}$$

- **Sectoral (domestic):**

$$\log \widehat{GDP}_k = \sum_{i \in \mathcal{D}} \left(\frac{\text{VA}_{i,k}}{\sum_{u \in \mathcal{D}} \text{VA}_{u,k}} \right) \log \widehat{GDP}_{i,k}$$

- **Aggregate (domestic):**

$$\log \widehat{GDP} = \sum_{i \in \mathcal{D}} \sum_{k \in \mathcal{K}} \left(\frac{\text{VA}_{i,k}}{\sum_{u \in \mathcal{D}} \sum_{h \in \mathcal{K}} \text{VA}_{u,h}} \right) \log \widehat{GDP}_{i,k}$$

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. Additional Results

Exact-Hat Algebra Calibration

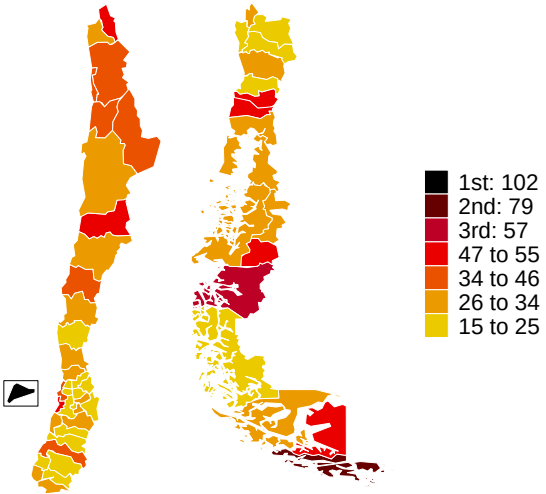
Return

	Value	Description	Type	Source / Target
Baseline Data				
I_i	Figure 6	Income per worker	Observed	Computed as $I_i = (VA_i - Y_i)/L_i$
L_i	Figure 7	Employment share	Observed	Employment records
Y_i	Figure 8	Trade imbalances	Constructed	Provincial trade balances from location-sector accounts
$\pi_{iu,k}$	Figure 9 and 11	Bilateral trade shares	Constructed	Observed firm-to-firm flows with model-based final-demand allocation
Structural Parameters				
α_k	Figure 12	Final consumption share	Observed	Sectoral final demand measured as sales net of intermediate sales
$1-\beta_i$	Figure 13	Labor share	Observed	Observed labor income over value added
$\gamma_{i,k}$	Figure 14	Value-added share	Observed	Observed value added over total sales
$\gamma_{i,kh}$	Figure 15	Local input-output linkages	Observed	Observed intermediate input transactions by location-sector
ι_i	Figure 17	Global portfolio contribution	Calibrated	Constrained least squares to match provincial trade balances
θ_k	Figure 18	Productivity dispersion	Literature	Caliendo & Parro (2015) and Caliendo et al. (2018)
λ_{kh}	Figure 19	Knowledge network	Constructed	Sectoral patent citation shares from LaBelle et al. (2023)
δ_{iu}	$\mathbf{1}\{i=u\}$	Geographic knowledge diffusion	Assumption	Within-location diffusion
φ	0.07	Knowledge-spillover elasticity	Literature	Basso et al. (2025)

Income per Worker

Return

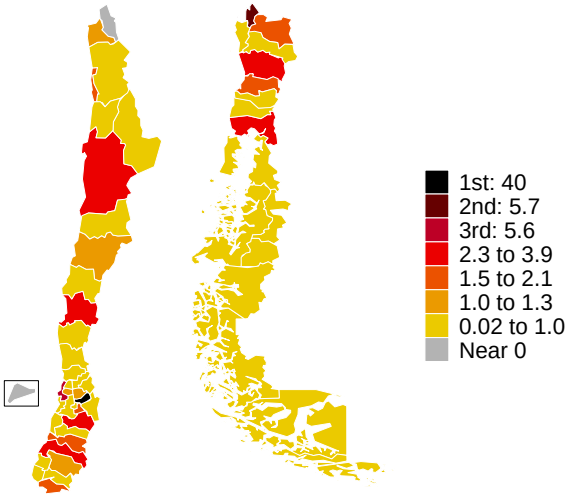
Figure 6: Income per Worker (I_i)



Employment Shares

Return

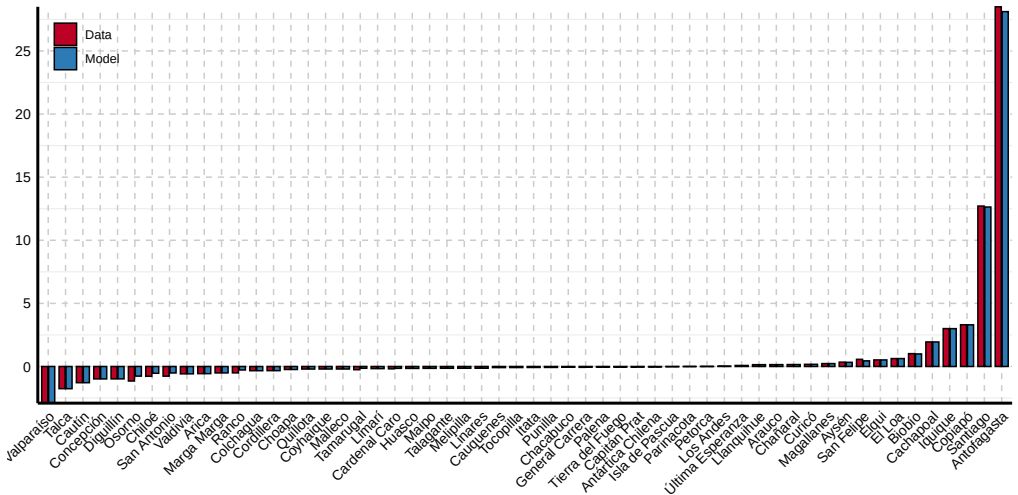
Figure 7: Employment Shares (L_i)



Provincial Trade Imbalances

Return

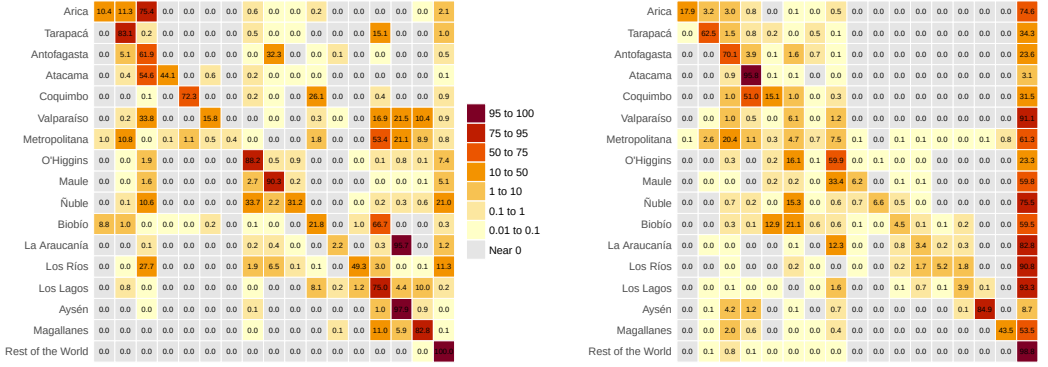
Figure 8: Provincial Trade Imbalances in Chile, 2022 (Billion USD)



Bilateral Trade Shares: Examples 1

Return

Figure 9: Bilateral Trade Shares ($\pi_{iu,k}$): Illustrative Examples



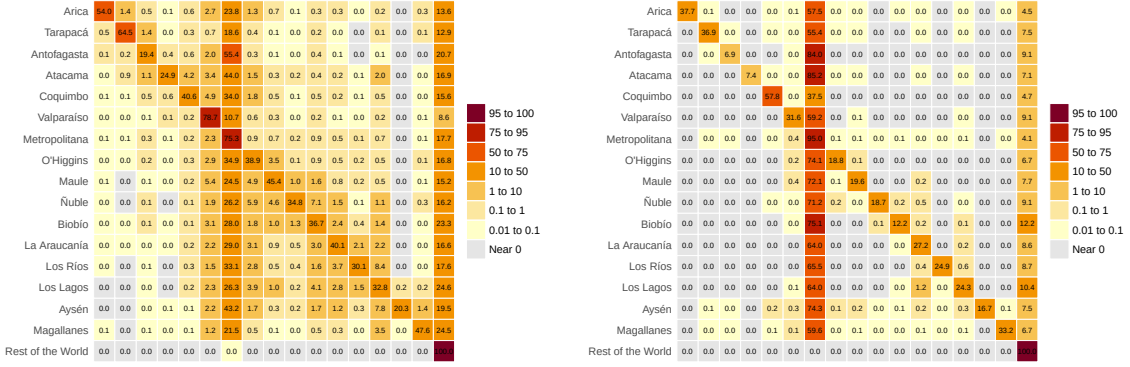
(a) Fishing

(b) Mining

Bilateral Trade Shares: Examples 2

Return

Figure 11: Bilateral Trade Shares ($\pi_{iu,k}$): Illustrative Examples



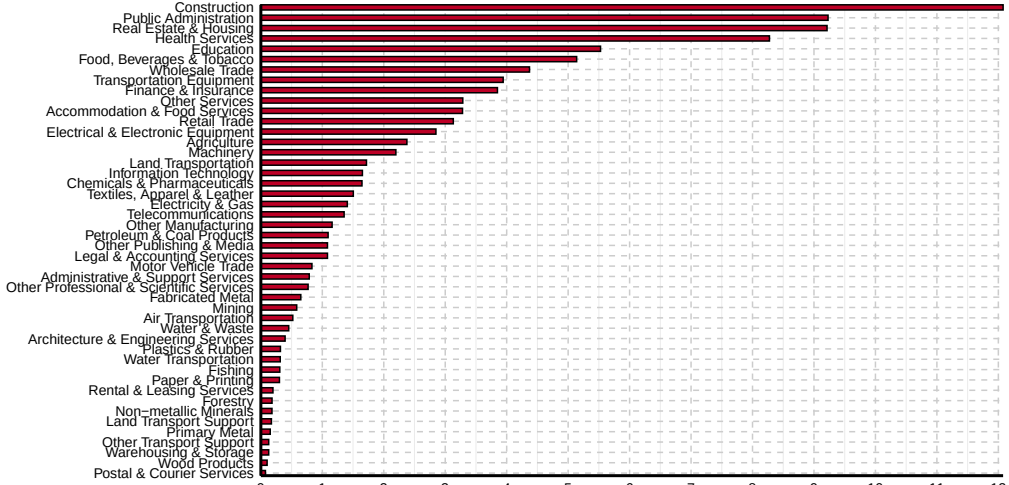
(a) Wholesale Trade

(b) Finance & Insurance

Final Consumption Shares

Return

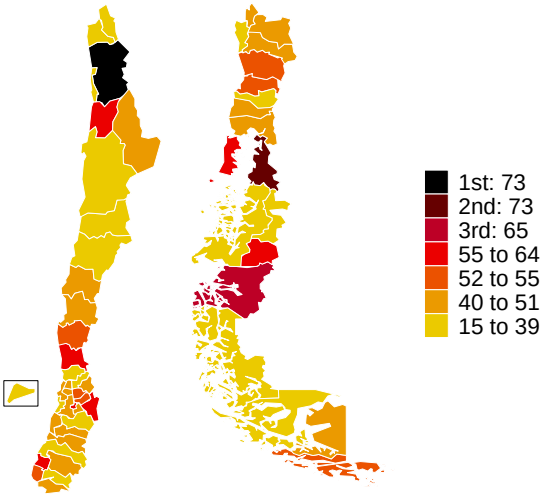
Figure 12: Final Consumption Shares by Sector (α_k)



Labor Share

Return

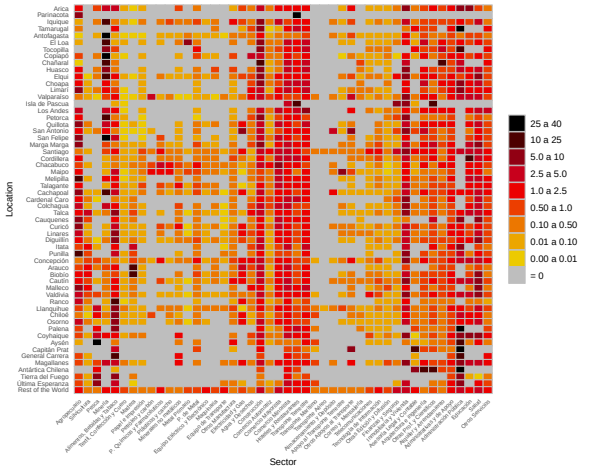
Figure 13: Labor Share of Value Added by Province $(1 - \beta_i)$



Value Added Share

Return

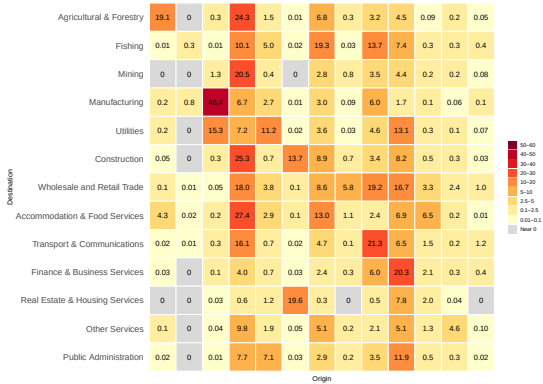
Figure 14: Value Added Share in Gross Output by Province-Sector ($\gamma_{i,k}$)



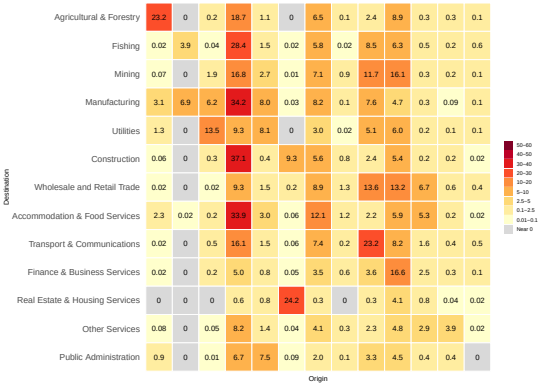
Local Input-Output Linkages: Examples 2

Return Calibration Return Descriptive

Figure 15: Material Shares in Sales ($\gamma_{i,kh}$): Illustrative Examples



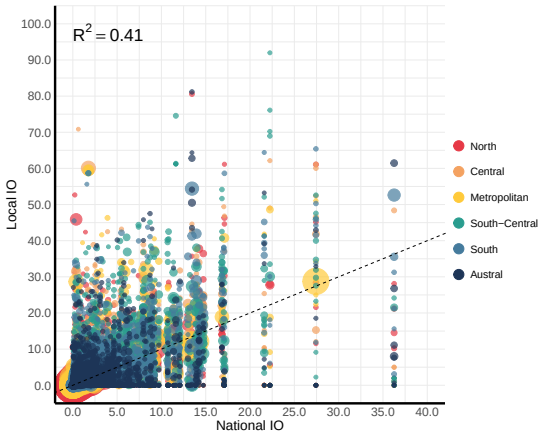
(a) Valparaíso



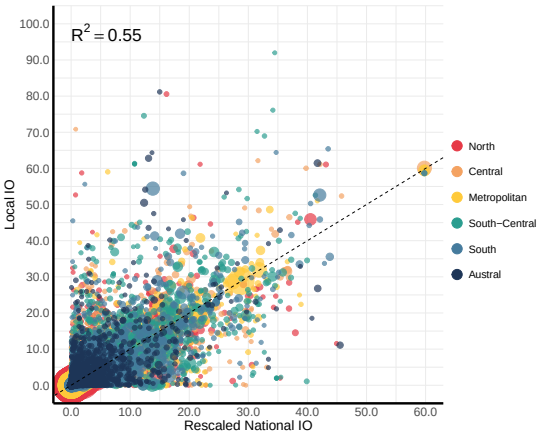
(b) Concepción

Local versus National Input-Output Shares

Return Calibration Return Descriptive



(a) National IO

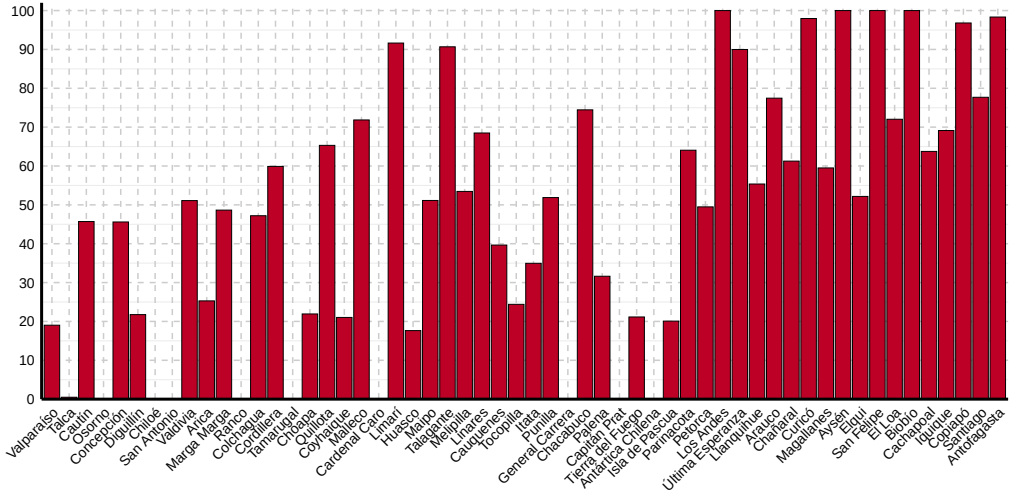


(b) Rescaled National IO

Global Portfolio Contribution

Return

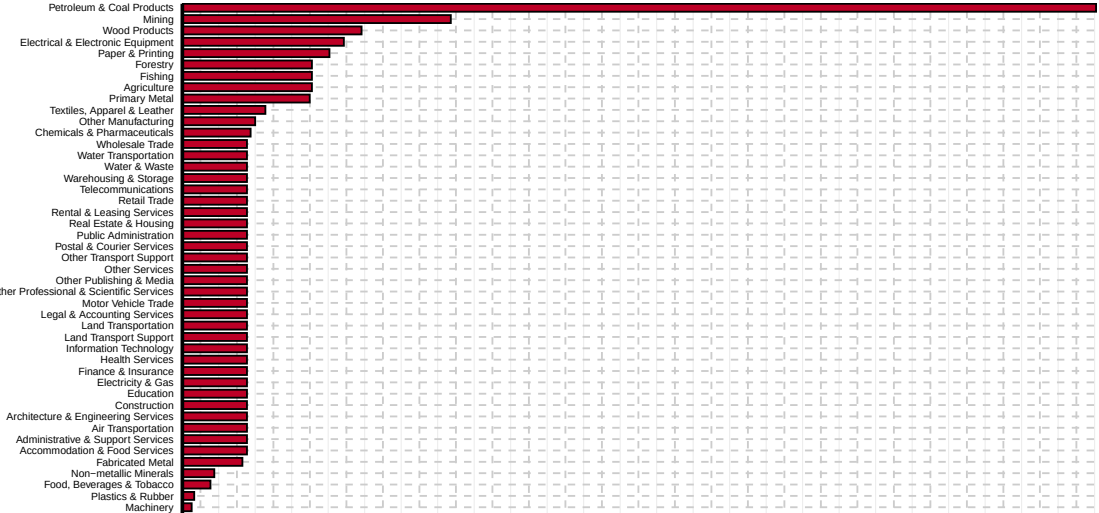
Figure 17: Global Portfolio Contribution Across Locations (ι_i)



Productivity Dispersion

Return

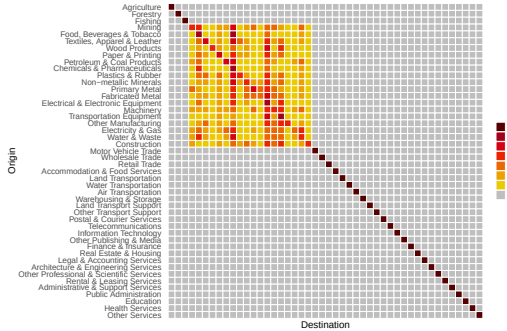
Figure 18: Productivity Dispersion by Sector (θ_k)



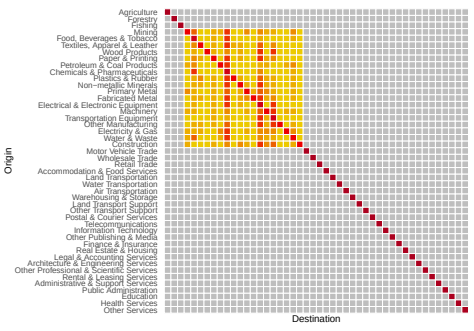
Knowledge Network

Return

Figure 19: Knowledge Network and Diffusion



(a) Knowledge Network Across Sectors



(b) Leontief Inverse Across Sectors, $\times 100$

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. **Additional Results**
   - Descriptive Statistics
   - Aggregate Effects of Local Productivity Shocks
   - The Exit of the *Huachipato* Steel Plant

Outline

5. Data Details

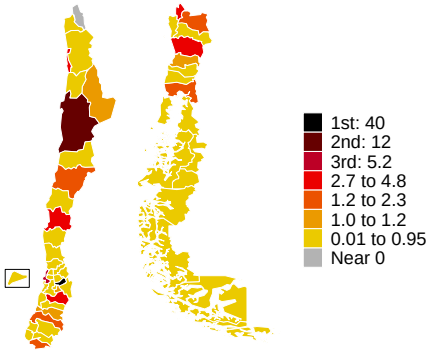
6. Model Details

7. Calibration Results

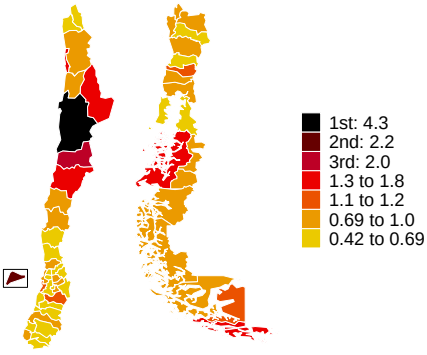
8. **Additional Results**
   - Descriptive Statistics
   - Aggregate Effects of Local Productivity Shocks
   - The Exit of the *Huachipato* Steel Plant

Geographic Distribution of Economic Activity

Employment and Wages
Sectorial Distribution
Return



(a) Share of National GDP (%)

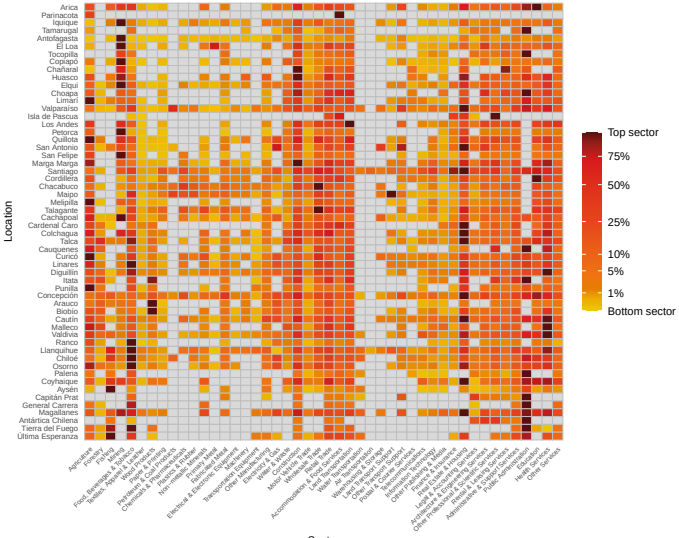


(b) GDP per worker (relative to aggregate)

Notes: Figures report provincial shares of national GDP, in percent, and GDP per worker expressed relative to the national average. National GDP per worker in 2022 is USD 34,089.

Geographic-Sector Distribution of Economic Activity

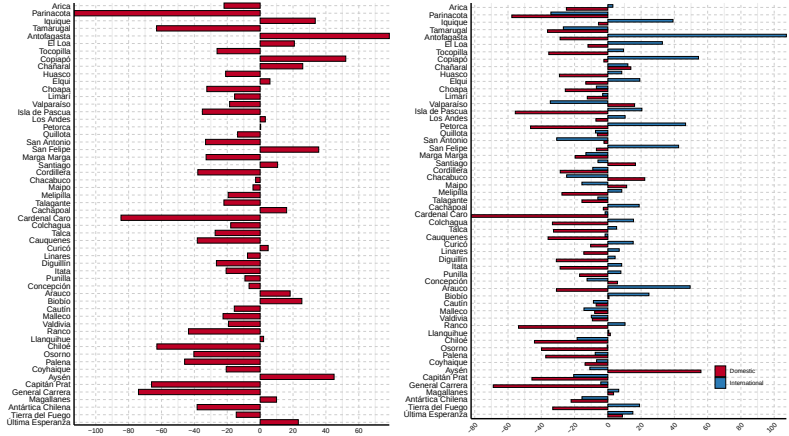
Return



Trade Imbalances Across Space

Trade Imbalances in Levels | Return

Figure 21: Provincial Trade Imbalances as a Share of Provincial GDP

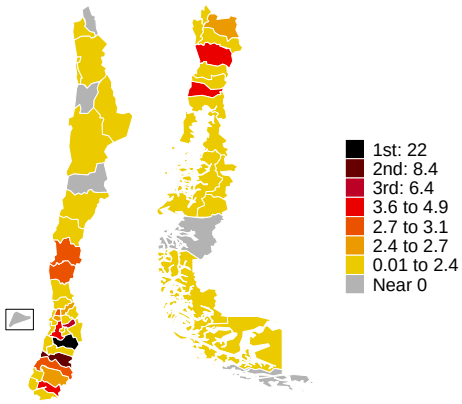


(a) Net Trade Imbalance (Exports − Imports)

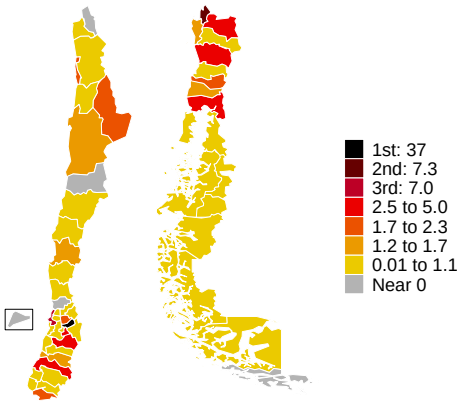
(b) Domestic vs. International Decomposition

Spatial Distribution of GDP: Agriculture and Manufacturing

Return



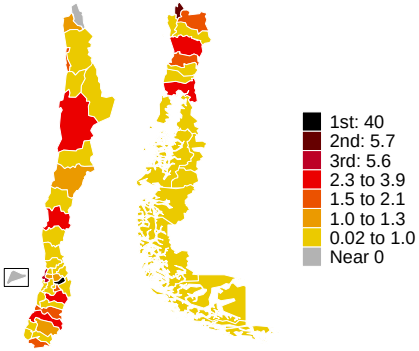
(a) Agriculture



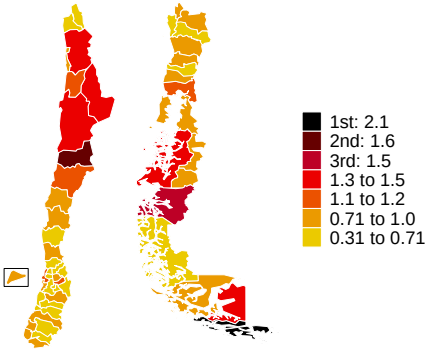
(b) Manufacturing

Spatial Distribution of Economic Activity in Chile: Employment and Wages

Return



(a) Share of National Employment (%)

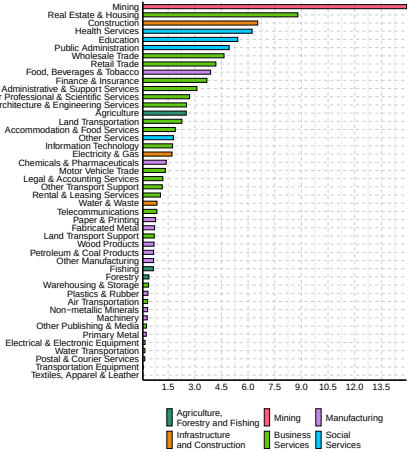


(b) Wages per worker (relative to aggregate)

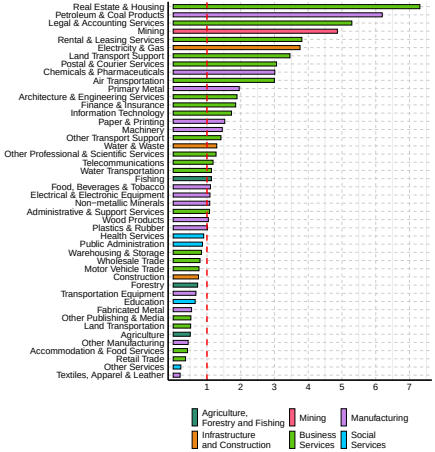
Sectorial Distribution of Economic Activity in Chile

Return

Figure 24: Sectorial Distribution of Economic Activity in Chile



(a) Share of National GDP (%)

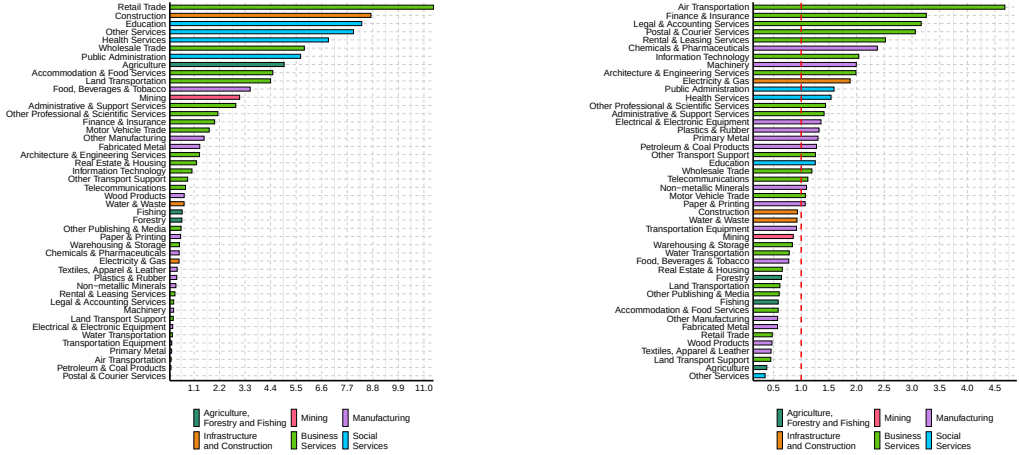


(b) GDP per worker (relative to aggregate)

Sectorial Distribution of Economic Activity in Chile: Employment and Wages

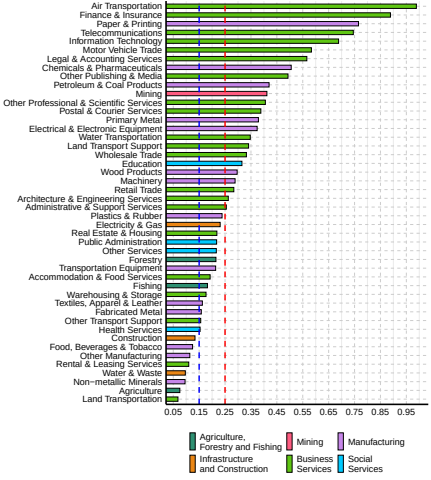
Return

Figure 25: Sectoral Distribution of Economic Activity in Chile: Employment and Wages

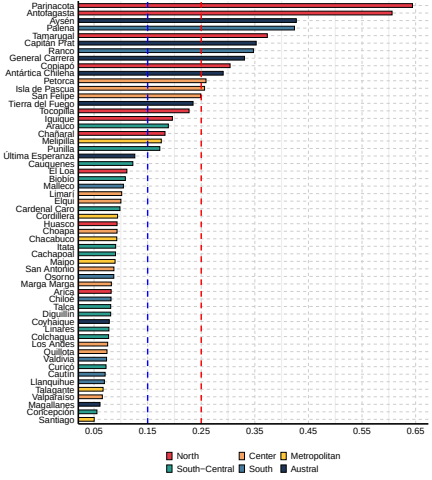


Spatial and Sectoral Concentration of GDP: HHI

Return



(a) Spatial concentration by sector (HHI)



(b) Sectoral concentration by province (HHI)

Variance Decomposition of Productivity in Chile

Return

Table 1: Variance Decomposition of Productivity in Chile

	log(GDP/Worker)	log(Wages/Worker)
Panel A: Between versus Within Locations		
Between	0.10	0.12
Within	0.90	0.88
Panel B: Between versus Within Sectors		
Between	0.62	0.54
Within	0.38	0.46
Panel C: Two-Way Across Locations and Sectors		
Spatial	0.08	0.10
Sectoral	0.56	0.47
Spatial-Sectoral	0.36	0.43

Importance of Trade

Return

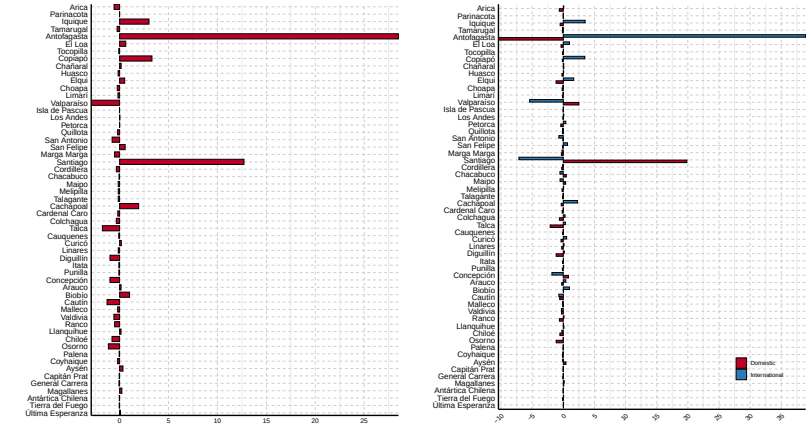
Table 2: The Chilean Production Network Flows

	Billion USD	% of Total Trade	% of GDP
Panel A: Domestic Flows Across Locations			
Within	114.7	26.5	38.1
Between	123.8	28.6	41.1
Panel B: Domestic Flows Across Sectors			
Within	49.2	11.4	16.3
Between	189.3	43.8	62.8
Panel C: Domestic Flows Across Locations and Sectors			
Within	32.0	7.4	10.6
Between	206.5	47.7	68.5
Panel D: Aggregate Flows			
International	194.0	44.9	64.4
Domestic	238.5	55.1	79.2
Total Trade	432.5	100.0	143.6

Provincial Trade Imbalances in Billions USD

Return

Figure 27: Provincial Trade Imbalances in Billion USD



(a) Net Trade Imbalance (Exports − Imports)

(b) Domestic vs. International Decomposition

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. **Additional Results**
   - Descriptive Statistics
   - Aggregate Effects of Local Productivity Shocks
   - The Exit of the *Huachipato* Steel Plant

Location and Sectoral Productivity Shocks

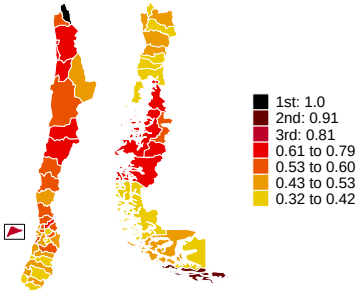
Return Locations Sectors

Effects depend on where and in which sector the shock hits

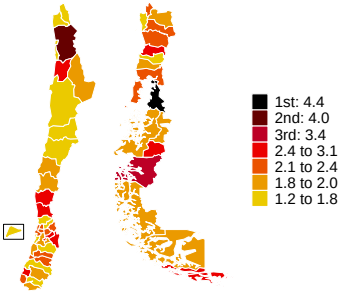
	Measured TFP		GDP		Welfare	
	Mean (1)	SD (2)	Mean (3)	SD (4)	Mean (5)	SD (6)
Panel A: Regional Shocks						
North	0.57	0.06	1.39	0.28	3.19	1.37
Central	0.53	0.05	2.03	0.25	0.84	0.13
Metropolitan	0.52	0.04	2.37	0.11	1.33	0.11
South-Central	0.46	0.07	1.93	0.19	0.93	0.22
South	0.42	0.06	2.18	0.30	0.89	0.19
Austral	0.54	0.10	1.86	0.24	1.02	0.36
Total	0.52	0.07	2.04	0.42	1.55	1.06
Panel B: Sectoral Shocks						
Agriculture, Forestry, and Fishing	0.42	0.08	1.68	0.14	0.86	0.11
Mining	0.70	—	1.22	—	1.78	—
Manufacturing	0.31	0.09	1.77	0.68	1.09	0.21
Infrastructure and Construction	0.44	0.10	1.98	0.14	1.08	0.05
Business Services	0.59	0.19	2.26	0.28	1.10	0.06
Social Services	0.74	0.08	2.24	0.06	1.15	0.02
Total	0.58	0.19	1.97	0.49	1.22	0.28

Aggregate Elasticities of Regional Productivity Shocks

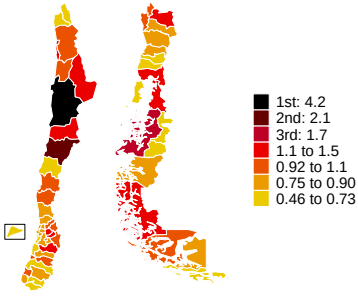
Return



(a) Measured TFP



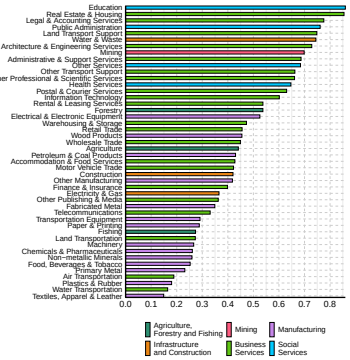
(b) GDP



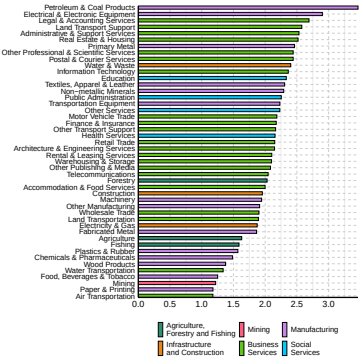
(c) Welfare

Aggregate Elasticities of Sectoral Productivity Shocks

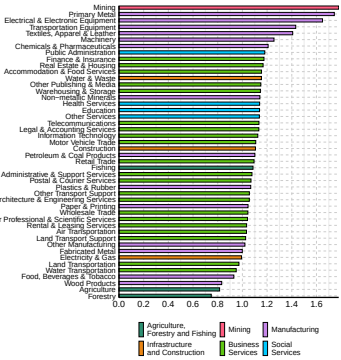
Return



(a) Measured TFP



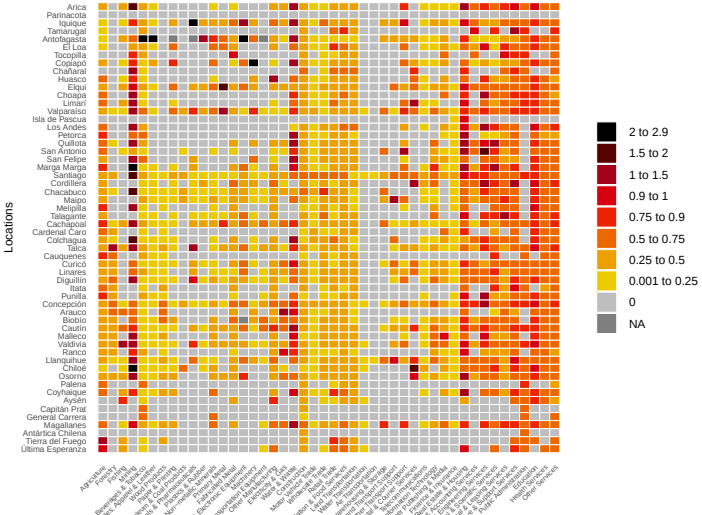
(b) GDP



(c) Welfare

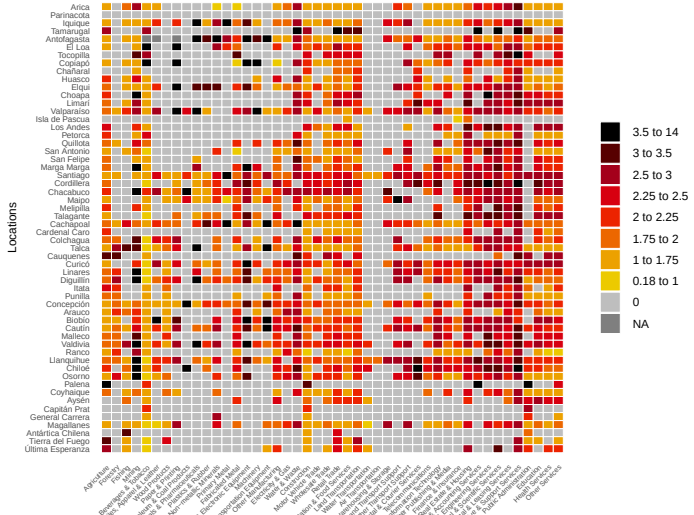
Aggregate Elasticities of Location-Sector Productivity Shocks:TFP

Return



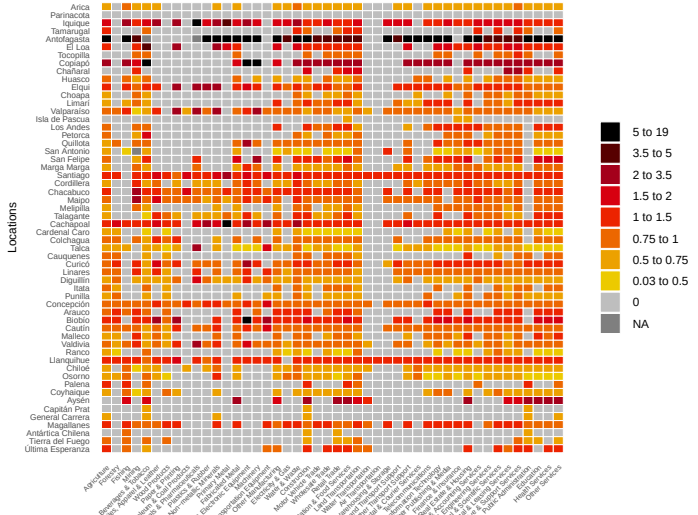
Aggregate Elasticities of Location-Sector Productivity Shocks: GDP

Return



Aggregate Elasticities of Location-Sector Productivity Shocks: Welfare

Return



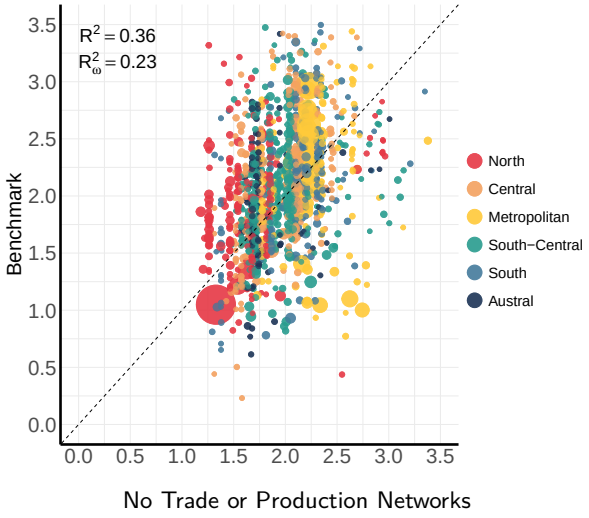
Aggregate Elasticities to Location-Sector Productivity Shocks: Resume

Return

	Measured TFP		GDP		Welfare	
	Mean (1)	SD (2)	Mean (3)	SD (4)	Mean (5)	SD (6)
Panel A: Regional Aggregation						
North	0.60	0.22	1.45	0.62	3.15	1.84
Central	0.65	0.29	2.10	0.50	0.84	0.20
Metropolitan	0.65	0.28	2.33	0.51	1.28	0.16
South-Central	0.59	0.26	1.95	0.49	0.93	0.28
South	0.55	0.27	2.09	0.59	0.87	0.18
Austral	0.63	0.23	1.82	0.46	1.01	0.39
Total	0.62	0.27	2.04	0.63	1.50	1.18
Panel B: Sectoral Aggregation						
Agriculture, Forestry, and Fishing	0.54	0.27	1.79	0.35	0.99	0.41
Mining	0.74	0.31	1.22	0.35	2.85	1.27
Manufacturing	0.33	0.23	1.56	0.78	1.21	1.86
Infrastructure and Construction	0.47	0.17	1.99	0.37	1.44	1.25
Business Services	0.63	0.25	2.36	0.43	1.26	0.71
Social Services	0.76	0.11	2.30	0.40	1.26	0.73
Total	0.62	0.27	2.04	0.63	1.50	1.18

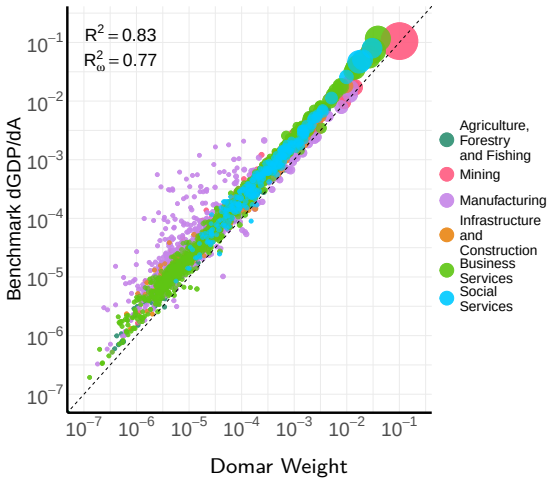
Mechanisms: No Trade or Production Networks

Return



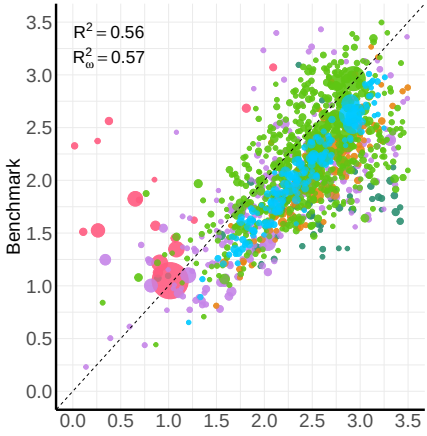
Domar Weights: Colors by Sector

Return

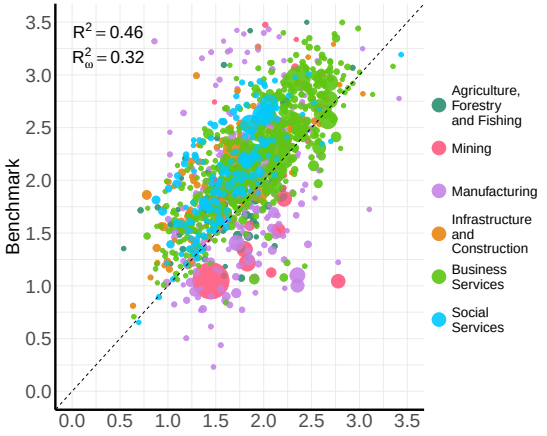


Mechanisms: Colors by Sector (1/2)

Return



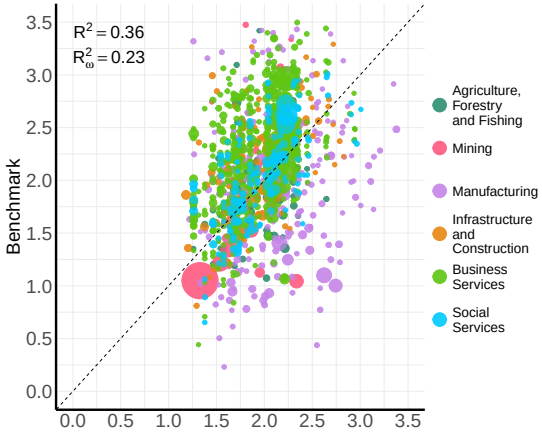
(a) No Production Networks



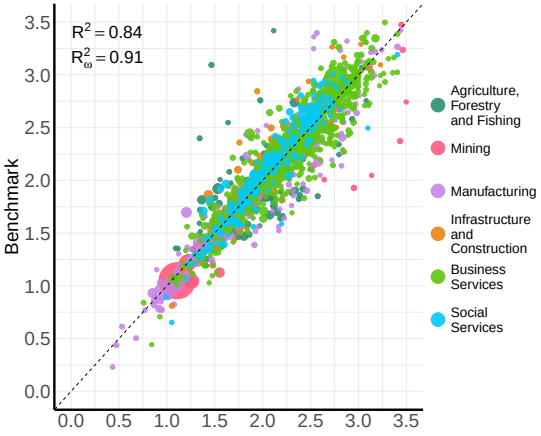
(b) No Trade Flows

Mechanisms: Colors by Sector (2/2)

Return



(a) No Trade, No Production Networks



(b) No Geography on Input-Output

Outline

5. Data Details

6. Model Details

7. Calibration Results

8. **Additional Results**
   - Descriptive Statistics
   - Aggregate Effects of Local Productivity Shocks
   - The Exit of the *Huachipato* Steel Plant

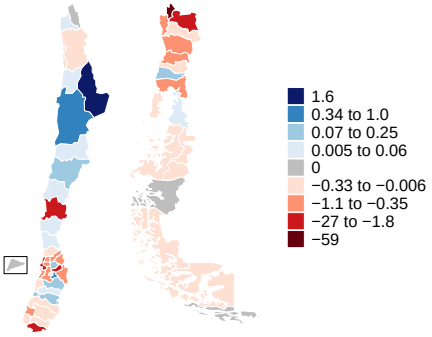
Huachipato: Aggregate Effects by Region and Sector

Return

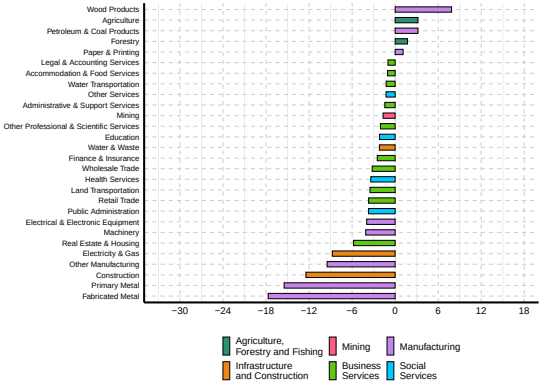
	Measured TFP (1)	Employment (2)	Real GDP (3)
Panel A: National			
Total	−0.03	−0.17	−0.14
Elasticity	0.10	3.49	3.41
Panel B: Across Space			
Biobío			
Total	−0.36	−1.3	−1.3
Elasticity	1.26	26.71	33.28
Other Regions			
Total	−0.002	−0.07	−0.06
Elasticity	0.01	1.54	1.40
Panel C: Across Sectors			
Manufacturing			
Total	−0.10	−0.38	−0.45
Elasticity	0.36	8.01	11.27
Other Sectors			
Total	−0.008	−0.13	−0.09
Elasticity	0.03	2.79	2.34

Huachipato: Contributions to the GDP Loss

Return



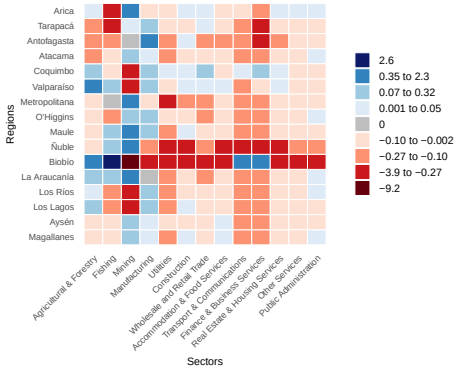
(a) Provincial contribution share (%)



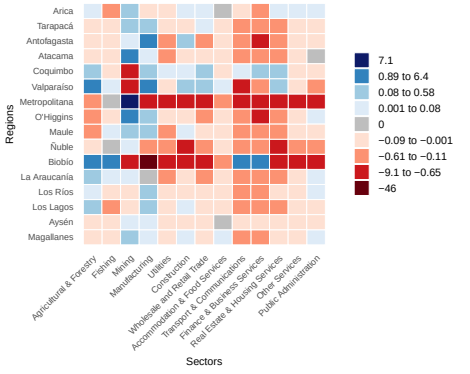
(b) Sectoral contribution share (%)

Huachipato: Region-Sector Propagation

Return

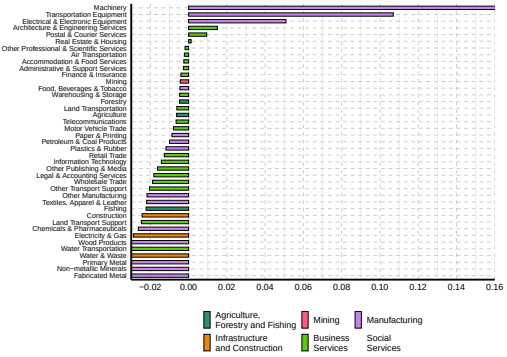


(a) Region-sector GDP change (%)

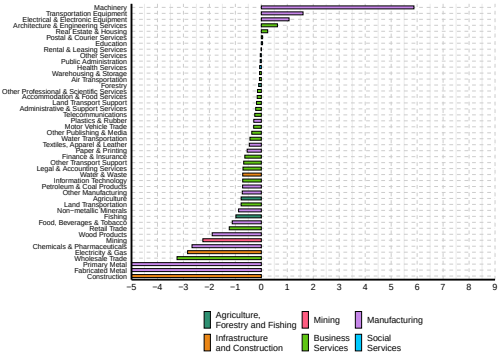


(b) Region-sector contribution share (%)

Propagation Across Sectors of the Exit of *Huachipato*: Measured TFP



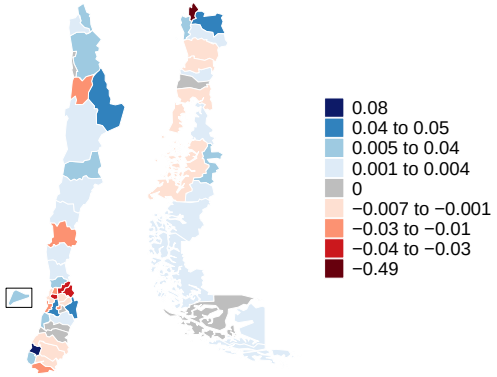
(a) Sectoral measured TFP change (%)



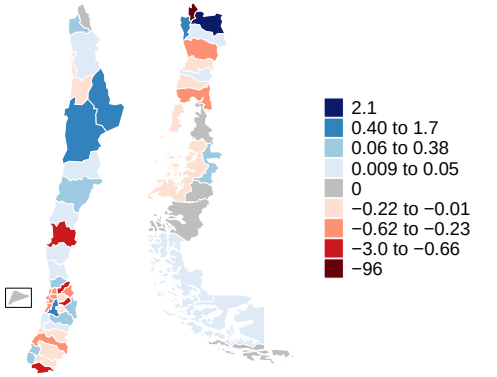
(b) Sectoral contribution share (%)

Note: Sectoral plots are truncated for readability.

Propagation Across Space of the Exit of *Huachipato*: Measured TFP

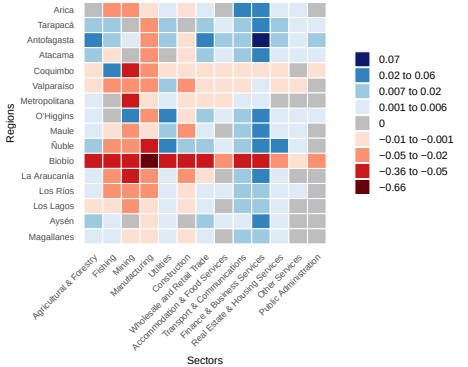


(a) Provincial measured TFP change (%)

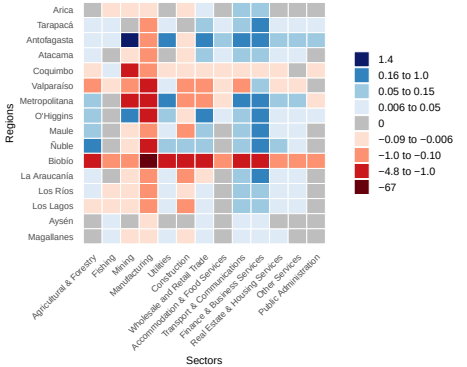


(b) Provincial contribution share (%)

Propagation Across Space and Sector of the Exit of *Huachipato*: Measured TFP



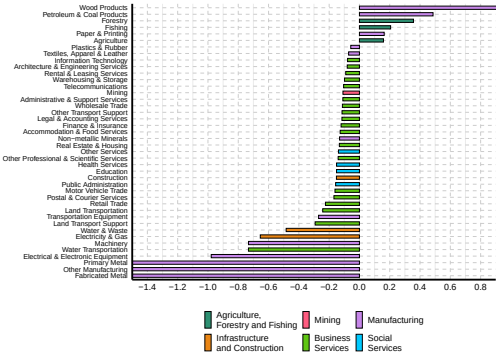
(a) Region-sector measured TFP change (%)



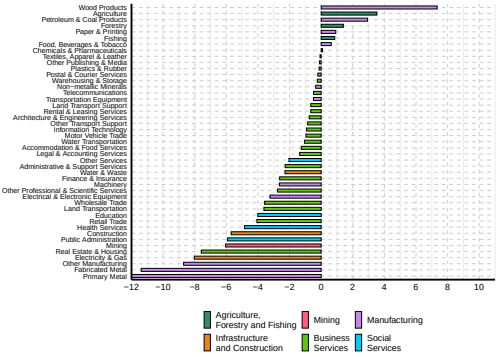
(b) Region-sector contribution share (%)

Note: Left panels show measured TFP changes; right panels show contribution shares (sum to 100%). Small values are truncated/omitted for readability.

Propagation Across Sectors of the Exit of *Huachipato*: Employment



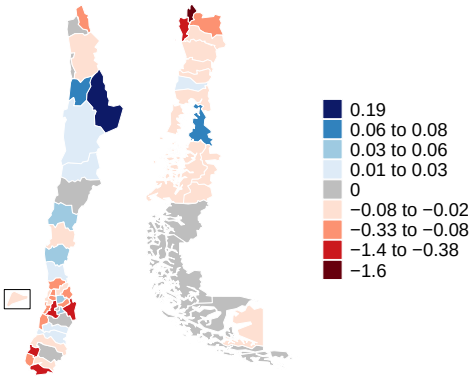
(a) Sectoral employment change (%)



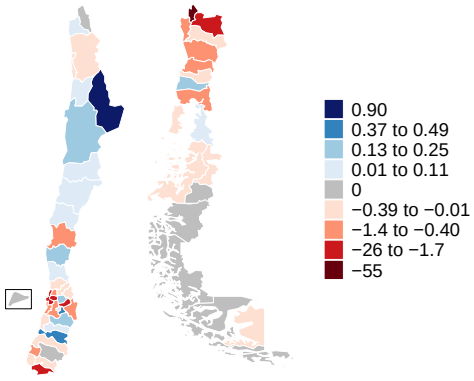
(b) Sectoral contribution share (%)

Note: Sectoral plots are truncated for readability.

Propagation Across Space of the Exit of *Huachipato*: Employment

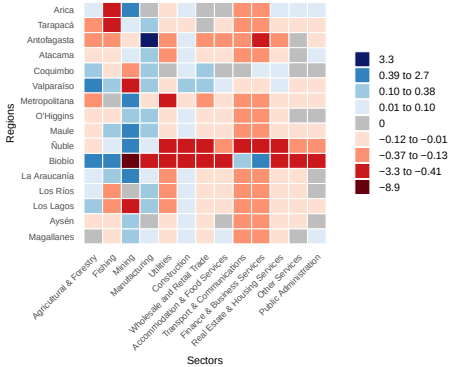


(a) Provincial employment change (%)

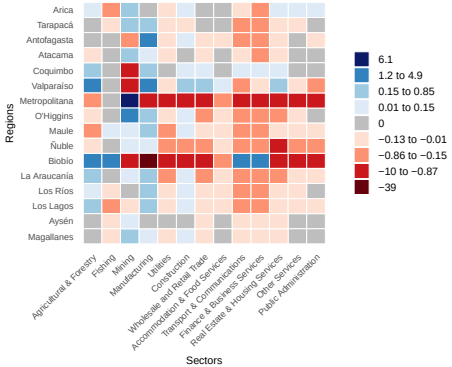


(b) Provincial contribution share (%)

Propagation Across Space and Sector of the Exit of *Huachipato*: Employment



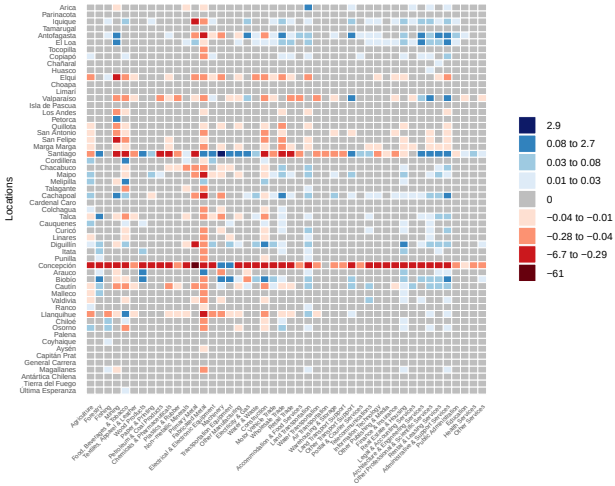
(a) Region-sector employment change (%)



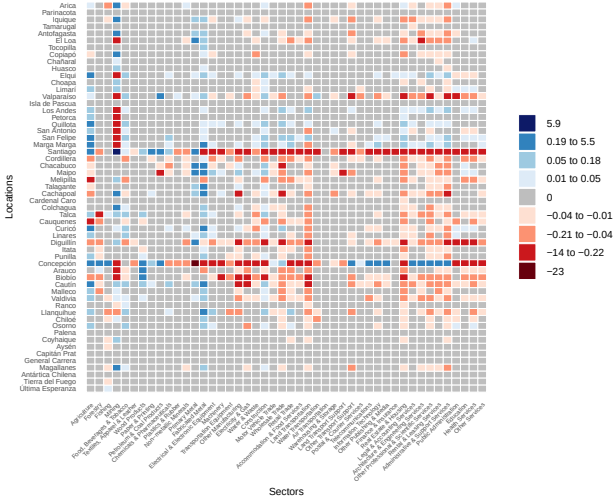
(b) Region-sector contribution share (%)

Note: Left panels show employment changes; right panels show contribution shares (sum to 100%). Small values are truncated/omitted for readability.

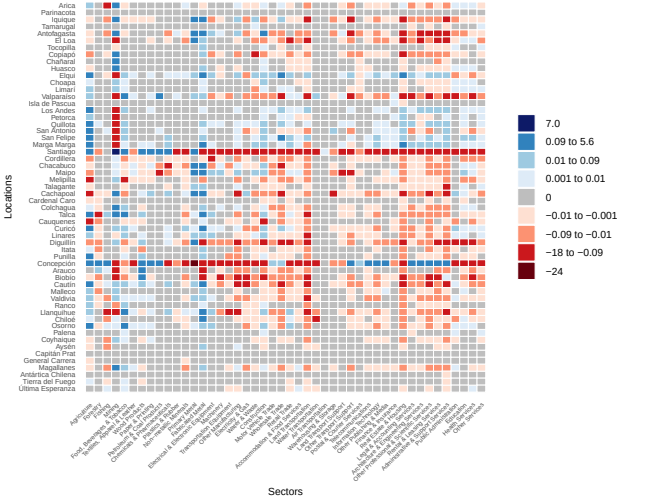
Province-Sector Contributions to National Aggregate Effects: Measured TFP



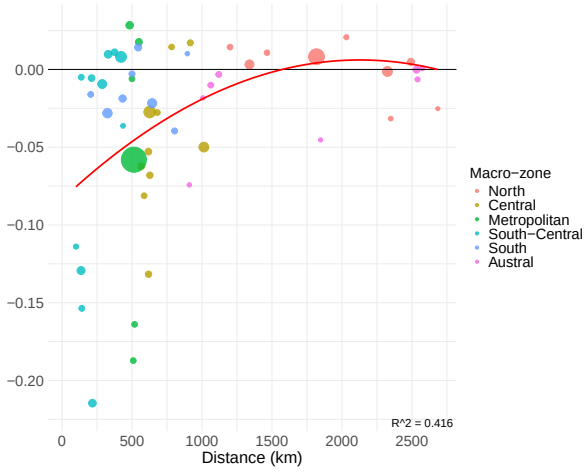
Province-Sector Contributions to National Aggregate Effects: Employment



Province-Sector Contributions to National Aggregate Effects: GDP



Propagation of the Exit of *Huachipato* by Distance: GDP



Note: Provincial GDP change vs. distance to Concepción; R^2 from a quadratic fit.