The Evolution of TFP in Spain and Italy

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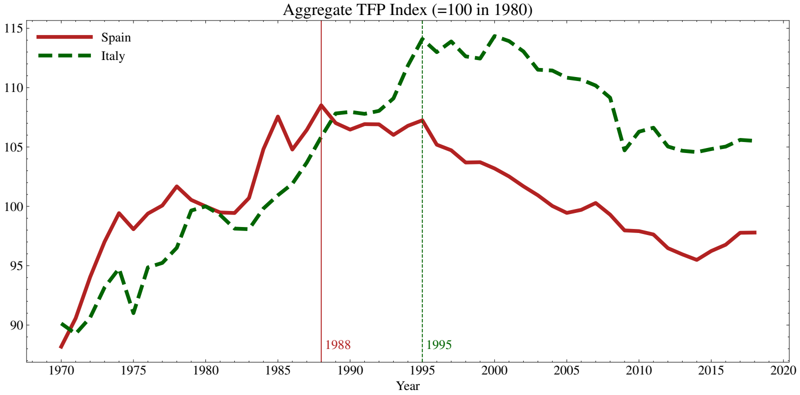
Motivation

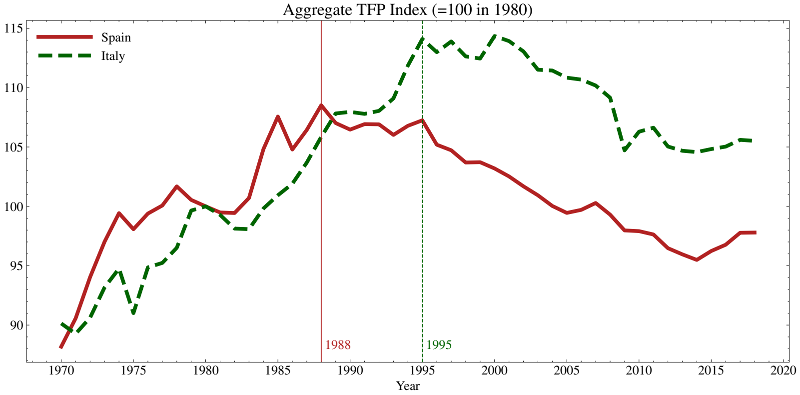
1. Dismal evolution of aggregate TFP in Spain and Italy



Notes. Index based on Solow's residual. KLEMS data.

Motivation

1. Dismal evolution of aggregate TFP in Spain and Italy



Notes. Index based on Solow's residual. KLEMS data.

2. Little consensus on the causes and their relative importance

Related literature

- **Previous work on TFP in Southern Europe emphasized different stories**: reallocation within and between sectors, capital deepening, management... (Reis 2013, Benigno Fornaro 2014, Diaz Franjo 2016, Gopinath et al. 2017, Fu Moral Benito 2018, Pellegrino Zingales 2019, Garcia-Santana et al. 2020, ...)
  - **Micro studies**: single industry, short time periods
  - **Macro studies**: growth accounting, mostly in undistorted and closed economy

- **This paper**: Growth accounting disaggregated + distorted + open economy
  - **Growth Accounting**. Solow 1957, Domar 1961, Hulten 1978, Hall 1988, Basu Fernald 2002, Chari et al. 2007, Baqaee and Farhi 2020, 2024,...
  - **Misallocation**. Restuccia Rogerson 2008, Hsieh Klenow 2009, ...
  - **International trade**. Young 1991, Melitz 2003, Kehoe Ruhl 2008, Menezes-Filho Muendler 2011, Autor et al. 2016, ...

Exercises and Findings

1. **Re-assess evolution of aggregate TFP in Spain and Italy**
   (Most measures of TFP ignore distortions, which matter for TFP measurement)
   - **Finding:** Previous studies overstate timing and magnitude of TFP declines

2. **Decompose TFP into technology, reallocation, and trade effects**
   (No existing paper offers comprehensive account of competing stories, despite observed secular rise in distortions and trade integration) ▸ Distortions ▸ Trade
   - **Finding:** Decline in TFP driven by reductions in technical efficiency and negative (domestic) reallocation effects; trade had positive influence

3. **Study welfare implications of TFP decline**
   (In closed economy, $\Delta\text{Welfare}_c \propto \Delta\text{TFP}_c$, which in open economy is not necessarily true)
   - **Finding:** Welfare increased despite declining TFP

Roadmap

1. TFP Measurement
2. TFP Mechanisms
   - Technology $\rightarrow$ TFP
   - Distortions $\rightarrow$ TFP
   - Trade $\rightarrow$ TFP
3. Theoretical Framework
4. TFP and Welfare Decompositions
5. Data and Estimation
6. Results

TFP Measurement

TFP Measurement with Distortions

- Consider aggregate production function $Y = AF(L_1, \ldots, L_F)$
- With market power in output markets, captured by markup $\mu \in [1, +\infty)$:

$$\underbrace{\Delta \log Y - \sum_f \Lambda_f \Delta \log L_f}_{\text{Solow residual}} = \underbrace{\Delta \log A}_{\text{TFP growth}} + \underbrace{\left(\frac{\mu - 1}{\mu}\right) \left\{\Delta \log Y - \Delta \log A\right\}}_{\text{Bias}}$$

$\Longrightarrow$ **With no distortions** ($\mu = 1$): Solow residual = TFP growth

$\Longrightarrow$ **With distortions** ($\mu > 1$): Solow residual = TFP growth + Bias

- **Solution**: **Use cost shares to weight input growth** (Hall 1988)

$$\underbrace{\Delta \log Y - \sum_f \tilde{\Lambda}_f \Delta \log L_f}_{\text{Distorted Solow residual}} = \underbrace{\Delta \log A,}_{\text{TFP growth}} \qquad \text{where} \quad \underbrace{\tilde{\Lambda}_f = \mu \Lambda_f = \frac{w_f L_f}{\sum_k w_k L_k}}_{\text{cost share}}.$$

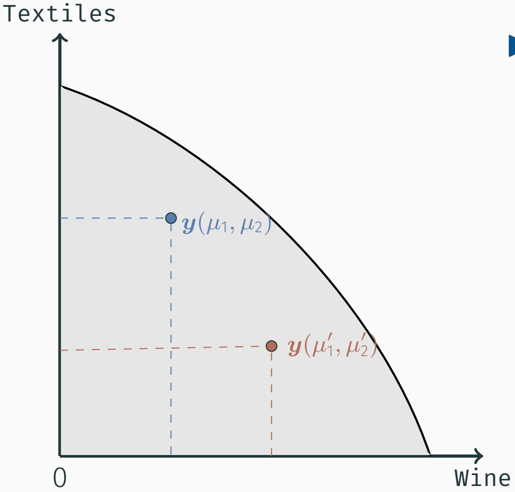
TFP Mechanisms

TFP Mechanisms

(Technology — TFP)

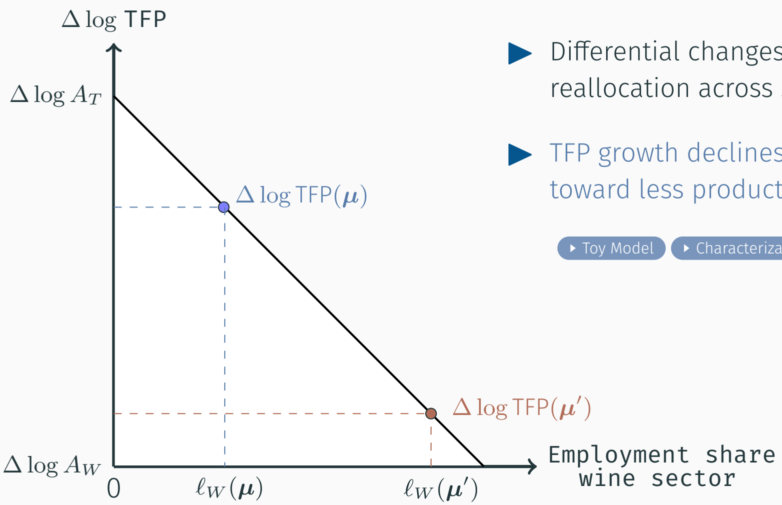
$$Y = AF(L_1, \ldots, L_F)$$

TFP Mechanisms
(Distortions — TFP)



- **ΔDistortions $\rightarrow$ Reallocation $\rightarrow$ ΔTFP**
- Differential changes in distortions induce factor reallocation across sectors

Mechanism: ΔDistortions $\rightarrow$ ΔTFP



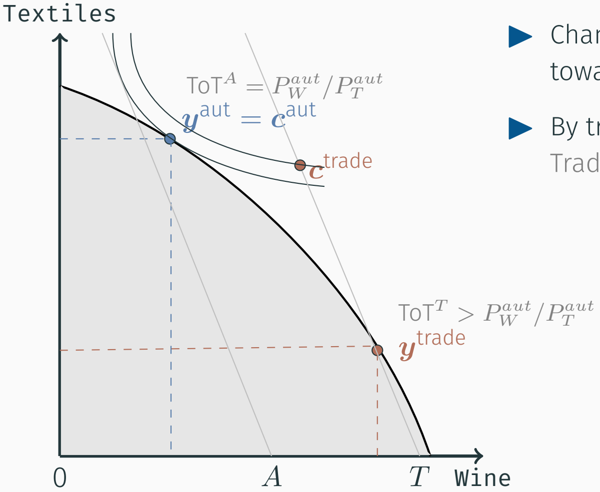
- **ΔDistortions $\rightarrow$ Reallocation $\rightarrow$ ΔTFP**
- Differential changes in distortions induce factor reallocation across sectors
- TFP growth declines when factors reallocate toward less productive sector (misallocation)

▸ Toy Model ▸ Characterization ▸ Key equations (TFP) ▸ Proposition

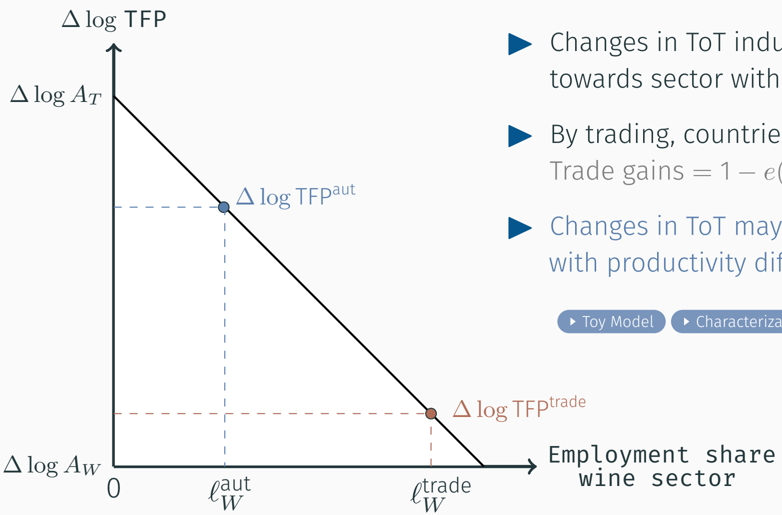
TFP Mechanisms

(Trade — TFP)

Mechanism: ΔTerms of Trade $\rightarrow$ ΔTFP



- **ΔToT $\rightarrow$ Factor reallocation $\rightarrow$ ΔTFP**
- Changes in the ToT induce factor reallocation towards sector with comparative advantage
- By trading, countries can increase welfare
  Trade gains $= 1 - e(\text{TOT}^A, \mathcal{W}^A)/e(\text{TOT}^A, \mathcal{W}^T)$



- **ΔToT → Factor reallocation → ΔTFP.**
- Changes in ToT induce factor reallocation towards sector with comparative advantage
- By trading, countries can increase welfare
  Trade gains $= 1 - e(\text{TOT}^A, \mathcal{W}^A)/e(\text{TOT}^A, \mathcal{W}^T)$
- Changes in ToT may cause TFP growth to decline with productivity differences across sectors

▸ Toy Model ▸ Characterization ▸ Key equations (TFP) ▸ Proposition

Theoretical Framework

Model Summary

Baqaee and Farhi (2024, ECMA) open-economy GE framework

- World economy: countries $(c \in \mathcal{C})$, producers $(i \in \mathcal{I})$, and factors $(f \in \mathcal{F})$
  - Factors and producers located in country c: $\mathcal{F}_c, \mathcal{I}_c$
  - Factors and firms can be owned by foreign residents
  - Factors are inelastically supplied
- Producers:
  - Minimize costs
  - Operate CRS technologies $y_i = A_i \times F_i\left(\{x_{ij}\}_{j \in \mathcal{I}}, \{\ell_{if}\}_{f \in \mathcal{F}_c}\right)$
  - Set prices $p_i = \mu_i \times \text{mc}_i$

Model Summary

- **Countries:**
  - Populated by representative household
  - Homothetic preferences $\mathcal{W}_c(\{c_{ci}\}_{i\in\mathcal{I}})$
  - Finance consumption with factor income, wedge income, and (foreign) transfers
- **Equilibrium:** Standard
- **Terminology:** National Accounts IO Networks

TFP and Welfare Decompositions

TFP Decomposition

- Following Baqaee and Farhi, I decompose changes in real output of country c (to first order) and then use definition of TFP

$$\Delta \log \mathrm{TFP}_c = \Delta \log Y_c - \sum_{f \in \mathcal{F}_c} \tilde{\Lambda}_f^{Y_c} \Delta \log L_f$$

to obtain first-order decomposition of TFP growth

Theorem (First-Order TFP Decomposition) ▸ Solow ▸ Hall ▸ Domar–Hulten ▸ Baqaee–Farhi (closed)

$$\Delta \log \mathrm{TFP}_c \approx \underbrace{\sum_{i \in \mathcal{I}_c} \tilde{\lambda}_i^{Y_c} \Delta \log A_i}_{\Delta \text{Technical efficiency}} - \underbrace{\sum_{i \in \mathcal{I}_c} \tilde{\lambda}_i^{Y_c} \Delta \log \mu_i}_{\Delta \text{Wedges}} - \underbrace{\sum_{f \in \mathcal{F}_c} \tilde{\Lambda}_f^{Y_c} \Delta \log \Lambda_f^{Y_c}}_{\Delta \text{Factor income shares}}.$$

$$+ \underbrace{\sum_{i \in \mathcal{I} - \mathcal{I}_c} \left(\tilde{\lambda}_i^{Y_c} - \lambda_i^{Y_c} \right) \left(\Delta \log q_{ci} - \Delta \log \lambda_i^{Y_c} \right)}_{\Delta \text{International trade}}$$

Welfare Decomposition

- Following Baqaee and Farhi, I decompose welfare growth (to first order), where welfare is real GNE per capita

Theorem (First-Order Welfare Decomposition)

$$\Delta \log \mathrm{W}_c \approx \underbrace{\underbrace{\sum_{i \in \mathcal{I}} \tilde{\lambda}_i^{W_c} \Delta \log A_i}_{\Delta\text{Technical efficiency}} + \underbrace{\sum_{f \in \mathcal{F}} \tilde{\Lambda}_f^{W_c} \Delta \log L_f}_{\Delta\text{Factors}}}_{\Delta\text{Technology}}$$

$$\underbrace{\underbrace{- \sum_{i \in \mathcal{I}} \tilde{\lambda}_i^{W_c} \Delta \log \mu_i}_{\Delta\text{Distortions}} + \underbrace{\sum_{f \in \mathcal{F}^*} \left(\Lambda_f^c - \tilde{\Lambda}_f^{W_c} \right) \Delta \log \Lambda_f}_{\Delta\text{Factor shares}} + \underbrace{\frac{\Delta T_c}{\mathrm{GNE}_c}}_{\Delta\text{Transfers}}}_{\Delta\text{Allocation}}$$

Data and Estimation

Data

Goal: Compute and decompose TFP and Welfare for Spain and Italy

- **Data sources:**
  1. WIOD: Sector-level data on IO linkages within and between countries ▸ Details
  2. KLEMS: Sector-level data on production factors
  3. BEA: Asset-specific depreciation rates
  4. World Bank: GDP and CPI deflators
- **Time period & frequency:** 1970–2010, annual data
- **Units of analysis:**
  - 24 countries + rest-of-world (RoW) region
  - 23 sectors (ISIC3 rev) per country ($\Longrightarrow$ Leontief inverses of dim 650×650 per year)

- **Three key inputs to estimate** (for each sector-country-year):
  1. Distortions, μ. Major challenge resides in operationalizing and estimating these
     - Preferred measure: distortions as "wedges" Alternative Measures
     - Estimated non-parametrically using wedge margins: Wedge Estimates Income Shares

$$\mu_i = 1 + \frac{\text{wedge margin}_i}{1 - \text{wedge margin}_i}$$

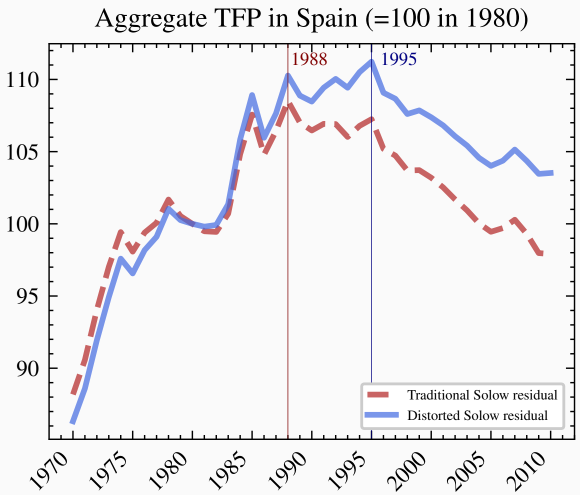
$$\text{Wedge margin}_i = \frac{\overbrace{p_i y_i}^{\text{sales}} - \overbrace{\sum_{j \in \mathcal{I}} p_j x_{ij}}^{\text{material expenditures}} - \overbrace{w_i \ell_i}^{\text{labor compensation}} - \overbrace{(r_i + \delta_i) k_i}^{\text{capital compensation}}}{p_i y_i}$$

  2. Net-of-depreciation user cost of capital, r. Method of van Vlokhoven (2022)
     - All sectors of given country face same user cost of capital
  3. Depreciation rates, δ. Capital-weighted asset-specific depr. rates See

Results

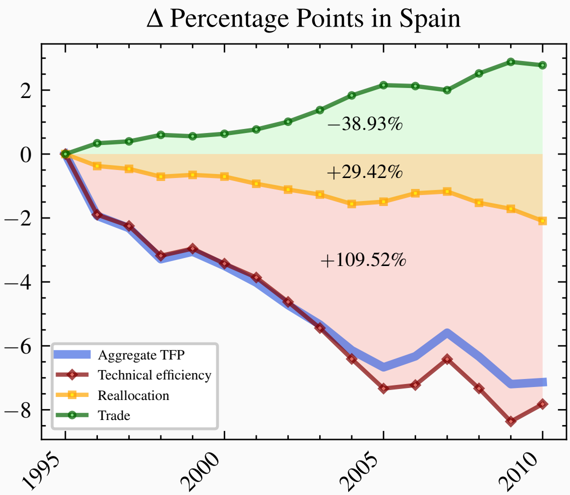
The Evolution of Aggregate TFP

Aggregate TFP less dismal than previously reported once distortions factored in

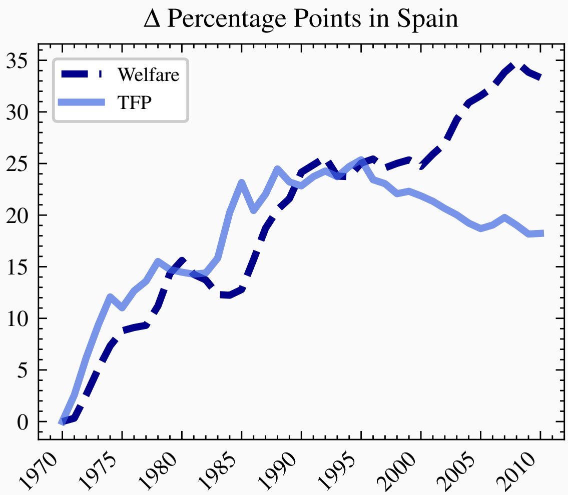


Explaining the TFP Decline

TFP decline driven by reductions in technical efficiency and reallocation effects

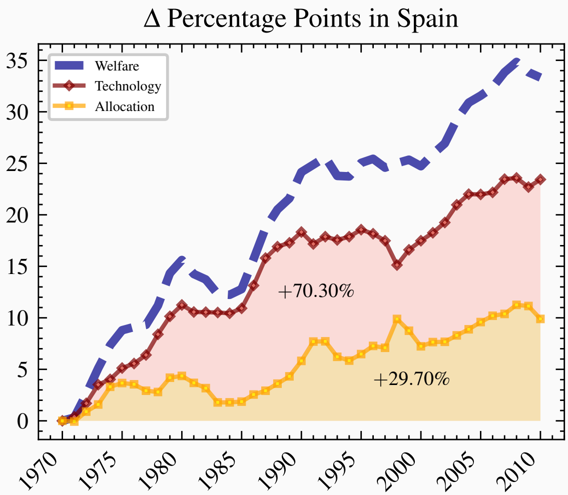


Welfare increased despite declining TFP



Why Did Welfare Increase?

Welfare gains due to global tech progress and increased allocative efficiency



Additional Results

- Italy: TFP evolution | TFP decomposition | TFP vs Welfare | Welfare Decomposition
- Income Shares: Spain | Italy
- Full-period TFP decompositions: Spain | Italy
- Contribution of trade partners to TFP growth: See
- Partial equilibrium exercises: Spain | Italy
- Robustness: Spain | Italy
- Empirical evidence: Distortions | Trade exposure | Reallocation | Trade-induced reallocation

Conclusion

- Study evolution of TFP in Spain and Italy, focusing on welfare implications
  - **Method**: growth accounting in open + distorted + disaggregated economies

- Findings:
  1. Previous studies overstate both timing and magnitude of TFP declines
  2. TFP declines driven by lower technical efficiency and reallocation effects
  3. Welfare increased despite TFP declines
  4. Welfare gains due to global technological progress and increased allocative eff.

Questions?

Thank You!

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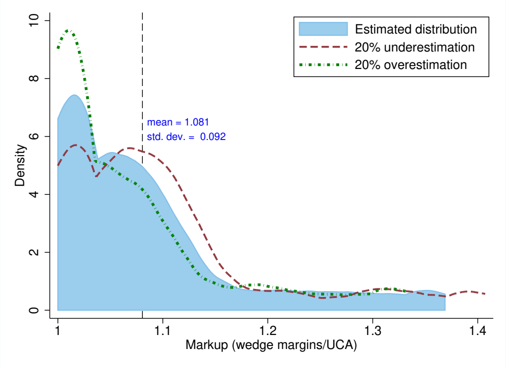
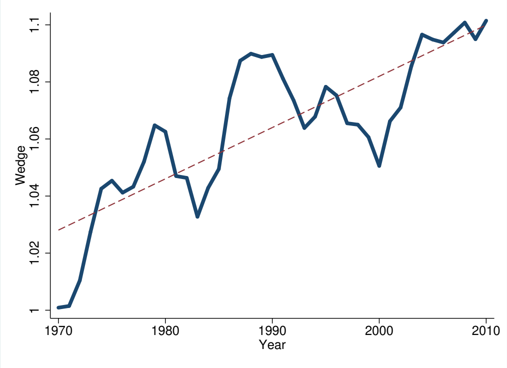
Distortion Estimates: Wedges in Spain

- Fat-tailed distribution of wedges
- Aggregate (harmonic sales-weighted) wedge rising since the 1970s

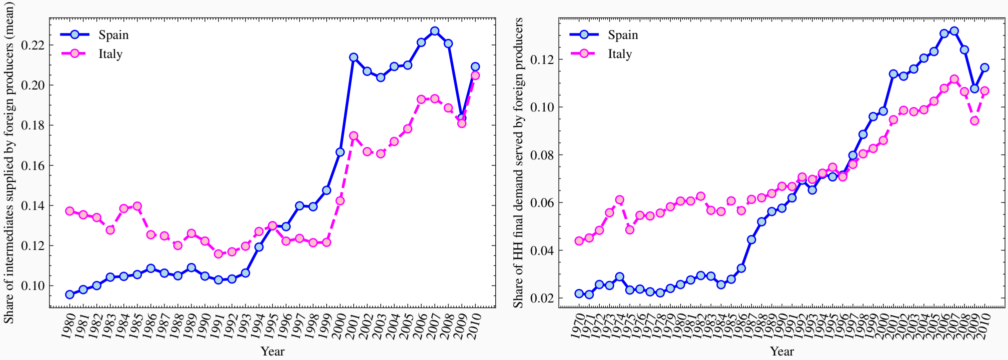




Back to Intro
Back to Estimation
Back to Additional Results

Trade Flows

- Rising demand for foreign goods, both as intermediates and final goods



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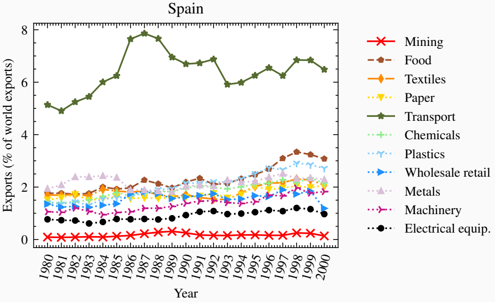
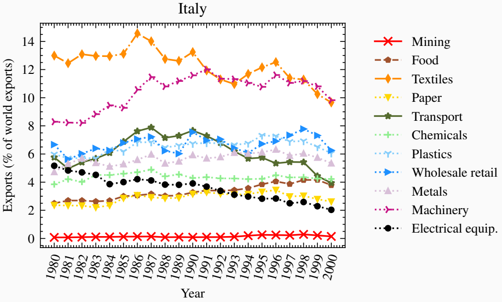
Exports

About the same ability to export, but exports have less “domestic content”





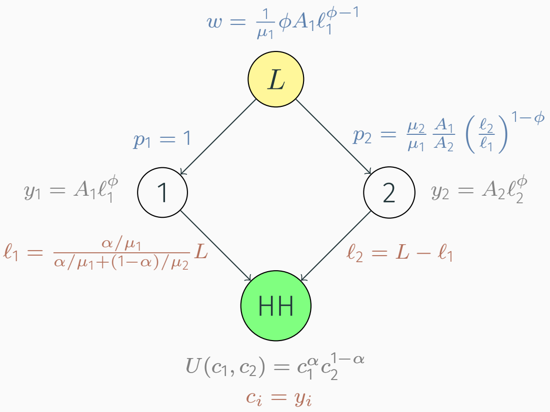
▸ Back to Intro
▸ Back to Additional Results

Stylized Model: Distortions–TFP

- Closed economy
- Three factors:
  - Labor (fully mobile across sectors)
  - Sector-specific factor (normalized to unity wlog)
- Two sectors: $i = 1, 2$
  - Technology: $y_i = A_i \ell_i^{\phi}$, $\phi \in (0, 1)$
  - Set prices: $p_i = \mu_i \times \mathrm{mc}_i$, where $\mu_i \geq 1$ is exogenous markup
- Representative household:
  - CD preferences: $U(\boldsymbol{c}) = c_1^{\alpha} c_2^{1-\alpha}$, $\alpha \in (0, 1)$
  - Budget constraint: $\sum_i p_i c_i \leq wL + \sum_i (r_i + \pi_i)$
- Equilibrium: standard + pricing rule Back

Characterization (Distortions – TFP)

Closed economy



Special case: $\mu_i \to 1,\ \forall i$, Efficient economy Back

Key Equations for TFP

- **Mechanism**: ΔDistortions $\rightarrow$ Factor reallocation $\rightarrow$ ΔTFP.

- **Key equations** (μ denote markups):

$$
\begin{aligned}
\text{(Sectoral labor)}: \quad & \ell_1 = \frac{\alpha/\mu_1}{\alpha/\mu_1 + (1-\alpha)/\mu_2} L \\
\text{(Sectoral output)}: \quad & y_i = A_i \ell_i^{\phi} \\
\text{(TFP change)}: \quad & \Delta \log \text{TFP} = \Delta \log Y - \sum_{f \in \mathcal{F}_c} \Lambda_f \times \Delta \log L_f \\
\text{(Output change)}: \quad & \Delta \log Y = \frac{p_1^w y_1}{PY} \Delta \log y_1 + \frac{p_2^w y_2}{PY} \Delta \log y_2 \\
\text{(Nominal GDP)}: \quad & PY = p_1^w y_1 + p_2^w y_2
\end{aligned}
$$

Back

Distortions – TFP Change

Proposition 1. Distortions–TFP

There exist parametrizations for the distorted economy in which:

(i) Absent markup shocks, TFP change is positive

(ii) For large-enough markup shocks, TFP change is negative

▸ Proof ▸ Back

Proof of Proposition 1

- Any equilibrium is characterized by:

$$p_1 = 1\,(\text{normalization}), \quad p_2 = \frac{\mu_2}{\mu_1}\frac{A_1}{A_2}\left(\frac{\ell_2}{\ell_1}\right)^{1-\phi}, \quad w = \frac{1}{\mu_1}\phi A_1 \ell_1^{\phi-1},$$

$$r_i = p_i^w y_i - w\ell_i, \qquad \pi_i = p_i y_i - w\ell_i - r_i,$$

$$c_i = y_i = A_i \ell_i^{\phi}, \qquad \ell_1 = \frac{\alpha/\mu_1}{\alpha/\mu_1 + (1-\alpha)/\mu_2} L, \qquad \ell_2 = L - \ell_1.$$

- Original equilibrium parametrized by

$$(\mu_1, \mu_2, A_1, A_2, L, \alpha, \phi) = (1, 1, 1, 1, 1, 0.5, 0.7)$$

- Consider perturbations:

$$\begin{aligned} 1: &\qquad A_2' = 1.02 \\ 2: &\qquad (A_2', \mu_2') = (1.02, 1.5) \end{aligned}$$

- Under 1, $\mathrm{d}\log \mathrm{TFP} > 0$. Under 2, $\mathrm{d}\log \mathrm{TFP} < 0$ ■

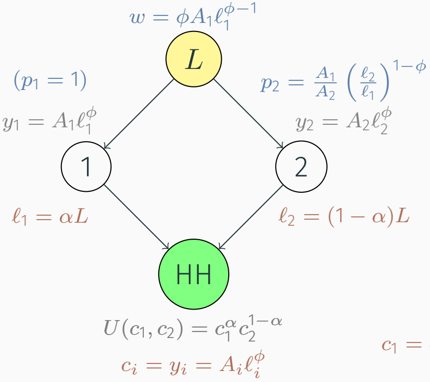
Back

Stylized Model: Trade – TFP

- **Small open economy**
- **Three factors**:
  - Labor (fully mobile across sectors)
  - Sector-specific factors (normalized to unity wlog)
- **Two sectors**: $i = 1, 2$
  - Tradable goods
  - Technology: $y_i = A_i \ell_i^{\phi}$, $\phi \in (0, 1)$
- **Representative household**:
  - CD preferences: $U(\boldsymbol{c}) = c_1^{\alpha} c_2^{1-\alpha}$, $\alpha \in (0, 1)$
  - Budget constraint: $\sum_i p_i^w c_i \leq wL + \sum_i r_i$
- **Equilibrium**: standard + BOP constraint Back

Characterization (Trade – TFP) Back

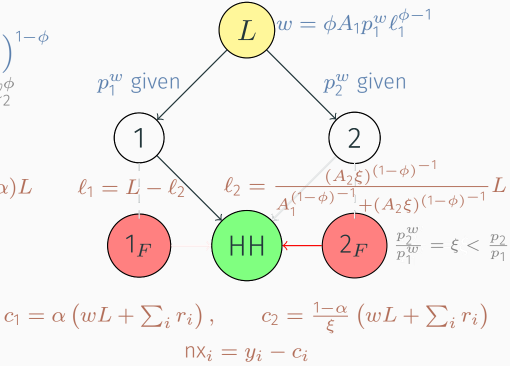
No trade



Trade

Small Open Economy

F produces perfect substitutes for H goods



Special case I: $\phi \to 1$, Ricardian model

Special case II: $\frac{p_2^w}{p_1^w} \to \frac{p_2}{p_1}$, Autarky

Key Equations for TFP

- **Mechanism**: ΔTerms of trade $\rightarrow$ Factor reallocation $\rightarrow$ ΔTFP
- **Key equations** (ξ governs terms of trade):

$$\text{(Sectoral labor)}: \quad \ell_2 = \frac{(A_2\xi)^{(1-\phi)^{-1}}}{A_1^{(1-\phi)^{-1}} + (A_2\xi)^{(1-\phi)^{-1}}} L$$

$$\text{(Sectoral output)}: \quad y_i = A_i \ell_i^{\phi}$$

$$\text{(TFP change)}: \quad \Delta \log \text{TFP} = \Delta \log Y - \sum_{f \in \mathcal{F}_c} \Lambda_f \times \Delta \log L_f$$

$$\text{(Output change)}: \quad \Delta \log Y = \frac{p_1^w y_1}{PY} \Delta \log y_1 + \frac{p_2^w y_2}{PY} \Delta \log y_2$$

$$\text{(Nominal GDP)}: \quad PY = p_1^w y_1 + p_2^w y_2$$

Back

Trade – TFP Change

Proposition 2. Trade–TFP

There exist parametrizations for the small open economy in which:

(i) Absent terms-of-trade shocks, TFP change is positive

(ii) For large-enough terms-of-trade shocks, TFP change is negative

(iii) Welfare is higher under (ii) than under (i)

▸ Proof ▸ Back

Proof of Proposition 2

- Any equilibrium is characterized by:

$$(p_1^w, p_2^w) \gg 0 \text{ given}, \quad \xi = \frac{p_2^w}{p_1^w}, \quad w = \phi p_1^w A_1 \ell_1^{\phi-1}, \quad r_i = p_i^w y_i - w\ell_i,$$

$$c_1 = \alpha(wL + r_1 + r_2), \qquad c_2 = \frac{1-\alpha}{\xi}(wL + r_1 + r_2),$$

$$\ell_1 = L - \ell_2, \qquad \ell_2 = \frac{(A_2\xi)^{(1-\phi)^{-1}}}{A_1^{(1-\phi)^{-1}} + (A_2\xi)^{(1-\phi)^{-1}}} L, \quad y_i = A_i \ell_i^{\phi}, \qquad \mathrm{nx}_i = y_i - c_i.$$

- Original eq. parametrized by $(p_1^w, p_2^w, A_1, A_2, L, \alpha, \phi) = (1, 1, 1, 1, 1, 0.5, 0.7)$
- Consider perturbations:

$$1: \qquad (A_1', A_2') = (0.99, 1.02)$$

$$2: \qquad (A_1', A_2', p_2^{w'}) = (0.99, 1.02, 0.8)$$

- Under 1, $\mathrm{d}\log \mathrm{TFP} > 0$. Under 2, $\mathrm{d}\log \mathrm{TFP} < 0$
- Welfare is higher under perturbation 2 than under 1 ∎ Back

Equilibrium

Back

Given productivities, wedges, ownership matrix, and transfers, $(\mathbf{A}, \boldsymbol{\mu}, \Phi, \mathbf{T})$, where transfers are such that $\sum_c T_c = 0$, an equilibrium is a set of prices $(\mathbf{p}, \mathbf{w})$, intermediate- and factor-input choices $(\mathbf{x}, \boldsymbol{\ell})$, outputs $\boldsymbol{y}$, and final consumptions $\mathbf{c}$ such that:

1. **Producers** choose $(\mathbf{x}, \boldsymbol{\ell})$ to **minimize costs** taking $(\mathbf{p}, \mathbf{w})$ as given.
2. Consumption good **prices satisfy** $\mathbf{p} = \mathrm{diag}(\boldsymbol{\mu}) \times \mathbf{mc}$.
3. **Households** choose $\mathbf{c}$ to **maximize utility** subject to their budget constraints taking $(\mathbf{p}, \mathbf{w})$ as given.
4. **Markets clear**:

$$\sum_{c \in \mathcal{C}} c_{ci} + \sum_{j \in \mathcal{I}} x_{ji} = y_i, \qquad \forall i, \tag{Goods}$$

$$\sum_{i \in \mathcal{I}} \ell_{if} = L_f, \qquad \forall f. \tag{Factors}$$

Terminology: National Accounts

- **Gross Domestic Product (GDP)**, value of final goods produced inside country:

$$\mathrm{GDP}_c := \underbrace{\sum_{i \in \mathcal{I}} p_i q_{ci}}_{\text{value of domestic production}} = \underbrace{\sum_{f \in \mathcal{F}_c} w_f L_f + \sum_{i \in \mathcal{I}_c} \left(1 - \frac{1}{\mu_i}\right) p_i y_i}_{\text{income earned by domestic factors and producers}},$$

where $q_{ci} = 1_{\{i \in \mathcal{I}_c\}} y_i - \sum_{j \in \mathcal{I}_c} x_{ji}$

- **Gross National Expenditure (GNE)** is final expenditures of country residents:

$$\mathrm{GNE}_c := \underbrace{\sum_{i \in \mathcal{I}} p_i c_{ci}}_{\text{consumption expenditures}} = \underbrace{\sum_{f \in \mathcal{F}} \Phi_{cf} w_f L_f + \sum_{i \in \mathcal{I}} \Phi_{ci} \left(1 - \frac{1}{\mu_i}\right) p_i y_i + T_c}_{\text{income accruing to domestic households}}$$

Back

Terminology: Input–Output Networks

- **(Revenue-based) Input-Output matrix** Ω is of dim $(C+I+F)\times(C+I+F)$:

$$\Omega_{ij} = 1_{\{i\in\mathcal{C}\ \wedge\ j\in\mathcal{I}\}}\frac{p_j c_{ij}}{\mathrm{GNE}_i} + 1_{\{i\in\mathcal{I}\ \wedge\ j\in\mathcal{I}\}}\frac{p_j x_{ij}}{p_i y_i} + 1_{\{i\in\mathcal{I}\ \wedge\ j\in\mathcal{F}\}}\frac{w_f \ell_{if}}{p_i y_i}$$

  Ω records direct links in world economy

- **(Revenue-based) Leontief-inverse matrix** Ψ:

$$\Psi = (\mathbf{I}-\Omega)^{-1} = \sum_{p=0}^{\infty}\Omega^p.$$

  Ψ encodes direct and indirect links in world economy

- **Cost-based counterparts** (relevant in distorted economies):

$$\tilde{\Omega} = \mathrm{diag}(\boldsymbol{\mu})\Omega, \qquad \tilde{\Psi} = (\boldsymbol{I}-\tilde{\Omega})^{-1}$$

Terminology: Input–Output Networks

- **Exposures**. Each $i \in \mathcal{C} + \mathcal{I} + \mathcal{F}$ is exposed to each $j \in \mathcal{C} + \mathcal{I} + \mathcal{F}$ through revenues Ψ_{ij} (backward links) and costs $\tilde{\Psi}_{ij}$ (forward links):

$$\lambda_i^{Y_c} = \sum_{j \in \mathcal{I}} \Omega_{Y_c,j} \Psi_{ji}, \qquad \tilde{\lambda}_i^{Y_c} = \sum_{j \in \mathcal{I}} \Omega_{Y_c,j} \tilde{\Psi}_{ji}, \qquad \text{(Exposures in GDP)}$$

$$\lambda_i^{W_c} = \sum_{j \in \mathcal{I}} \Omega_{c,j} \Psi_{ji}, \qquad \tilde{\lambda}_i^{W_c} = \sum_{j \in \mathcal{I}} \Omega_{c,j} \tilde{\Psi}_{ji}. \qquad \text{(Exposures in GNE)}$$

  Use Λ instead of λ to denote exposures when $i \in \mathcal{F}$.

- Exposures of GDP to a good $i \in \mathcal{I}_c$ or factor $f \in \mathcal{F}_c$ related to sales:

$$\lambda_i^{Y_c} = \frac{p_i y_i}{\mathrm{GDP}_c}, \qquad \Lambda_f^c = \Phi_{cf} \times \frac{w_f L_f}{\mathrm{GNI}_c}.$$

Back

Solow's TFP

- Solow (1957): Closed economy, rep. producer and consumer, no distortions
- No decomposition, just definition:

$$\Delta \log \text{TFP} := \Delta \log Y - \sum_{f \in \mathcal{F}} \Lambda_f \Delta \log L_f = \Delta \log A,$$

  where Λ_f are revenue shares of factors
- With Cobb–Douglas tech, two production factors (K, L), and usual notation:

$$\begin{aligned} \Delta \log \text{TFP} &= \Delta \log Y - \alpha \Delta \log K - (1 - \alpha) \Delta \log L \\ &= \Delta \log A \end{aligned}$$

Back

Hall's TFP

- Hall (1988, 1990): Closed economy, rep. producer and consumer, **distortions**

- No decomposition, just definition:

$$\Delta \log \mathrm{TFP} := \Delta \log Y - \sum_{f \in \mathcal{F}} \tilde{\Lambda}_f \Delta \log L_f = \Delta \log A,$$

  where $\tilde{\Lambda}_f$ are cost shares of factors

- With Cobb–Douglas technology and two factors (K, L):

$$\begin{aligned} \Delta \log \mathrm{TFP} &= \Delta \log Y - \hat{\alpha} \Delta \log K - (1 - \hat{\alpha}) \Delta \log L \\ &= \Delta \log A \end{aligned}$$

Back

Domar–Hulten's TFP

- Hulten (1978): Closed economy, **IO networks**, rep. consumer, no distortions

- Decomposition:

$$\Delta \log \mathsf{TFP} \approx \sum_{i \in \mathcal{I}} \lambda_i \Delta \log A_i,$$

  where λ_i is Domar weight of i (ie, producer sales over GDP)

- TFP growth as Domar-weighted individual producers' productivity growth

Back

Baqaee–Farhi's TFP in closed economy

- Baqaee Farhi (2020): Closed econ, **IO networks**, rep. consumer, **distortions**

- Decomposition:

$$\Delta \log \text{TFP} \approx \underbrace{\sum_{i \in \mathcal{I}} \tilde{\lambda}_i \Delta \log A_i}_{\Delta\text{Technical efficiency}} \underbrace{- \sum_{i \in \mathcal{I}} \tilde{\lambda}_i \Delta \log \mu_i - \sum_{f \in \mathcal{F}} \tilde{\Lambda}_f \Delta \log \Lambda_f}_{\Delta\text{Reallocation}},$$

  where $\tilde{\lambda}_i$ is cost-based Domar weight of i

- Distortions affect TFP through inefficient allocation of resources

Baqaee–Farhi's TFP in open economy

- Baqaee and Farhi (2024): Open economy, IO networks, distortions

- Decomposition:

$$\Delta \log \mathrm{TFP}_c \approx \underbrace{\sum_{i \in \mathcal{I}_c} \tilde{\lambda}_i^{Y_c} \Delta \log A_i}_{\Delta \text{Technical efficiency}} \underbrace{- \sum_{i \in \mathcal{I}_c} \tilde{\lambda}_i^{Y_c} \Delta \log \mu_i - \sum_{f \in \mathcal{F}_c} \tilde{\Lambda}_f^{Y_c} \Delta \log \Lambda_f^{Y_c}}_{\Delta \text{Domestic Reallocation}}$$

$$+ \underbrace{\sum_{i \in \mathcal{I} - \mathcal{I}_c} \left(\tilde{\lambda}_i^{Y_c} - \lambda_i^{Y_c} \right) \left(\Delta \log q_{ci} - \Delta \log \lambda_i^{Y_c} \right)}_{\Delta \text{International trade}}$$

where $\tilde{\lambda}_i^{Y_c}$ is cost-based Domar weight of producer i in country c

Back

- WIOTs provide complete picture of transactions that occur between sectors and consumers in all world countries/regions Back

Table 1: Two-country input-output table, following the conventions of WIOD's 2016 release.

			Intermediate use						Final use										Total use
			Country A			Country B			Country A					Country B					
			Industries			Industries			Final demand					Final demand					GO
			1	⋯	I_A	1	⋯	I_B	HHs	NPOs	GVT	GFCG	INVEN	HHs	NPOs	GVT	GFCG	INVEN	
Supply Country-Industry	Country A	1																	x_1^A
		⋮		z_{ij}^{AA}			z_{ij}^{AB}		$f_{i,\mathrm{H}}^{AA}$	$f_{i,\mathrm{N}}^{AA}$	$f_{i,\mathrm{G}}^{AA}$	$f_{i,\mathrm{K}}^{AA}$	$f_{i,\mathrm{I}}^{AA}$	$f_{i,\mathrm{H}}^{AB}$	$f_{i,\mathrm{N}}^{AB}$	$f_{i,\mathrm{G}}^{AB}$	$f_{i,\mathrm{K}}^{AB}$	$f_{i,\mathrm{I}}^{AB}$	⋮
		I_A																	$x_{I_A}^A$
	Country B	1																	x_1^B
		⋮		z_{ij}^{BA}			z_{ij}^{BB}		$f_{i,\mathrm{H}}^{BA}$	$f_{i,\mathrm{N}}^{BA}$	$f_{i,\mathrm{G}}^{BA}$	$f_{i,\mathrm{K}}^{BA}$	$f_{i,\mathrm{I}}^{BA}$	$f_{i,\mathrm{H}}^{BB}$	$f_{i,\mathrm{N}}^{BB}$	$f_{i,\mathrm{G}}^{BB}$	$f_{i,\mathrm{K}}^{BB}$	$f_{i,\mathrm{I}}^{BB}$	⋮
		I_B																	$x_{I_B}^B$
II_FOB				z_j^A			z_j^B		f_H^A	f_N^A	f_G^A	f_K^A	f_I^A	f_H^B	f_N^B	f_G^B	f_K^B	f_I^B	
TXSP				tax_j^A			tax_j^B		$\mathrm{tax}_\mathrm{H}^A$	$\mathrm{tax}_\mathrm{N}^A$	$\mathrm{tax}_\mathrm{G}^A$	$\mathrm{tax}_\mathrm{K}^A$	$\mathrm{tax}_\mathrm{I}^A$	$\mathrm{tax}_\mathrm{H}^B$		⋯		$\mathrm{tax}_\mathrm{I}^B$	
EXP_ADJ				adj_j^A			adj_j^B		$\mathrm{adj}_\mathrm{H}^A$	$\mathrm{adj}_\mathrm{N}^A$	$\mathrm{adj}_\mathrm{G}^A$	$\mathrm{adj}_\mathrm{K}^A$	$\mathrm{adj}_\mathrm{I}^A$	$\mathrm{adj}_\mathrm{H}^B$		⋯		$\mathrm{adj}_\mathrm{I}^B$	
PURR									$\mathrm{par}_\mathrm{H}^A$	$\mathrm{par}_\mathrm{N}^A$	$\mathrm{par}_\mathrm{G}^A$	$\mathrm{par}_\mathrm{K}^A$	$\mathrm{par}_\mathrm{I}^A$	$\mathrm{par}_\mathrm{H}^B$		⋯		$\mathrm{par}_\mathrm{I}^B$	
PURNR									$\mathrm{pdn}_\mathrm{H}^A$	$\mathrm{pdn}_\mathrm{N}^A$	$\mathrm{pdn}_\mathrm{G}^A$	$\mathrm{pdn}_\mathrm{K}^A$	$\mathrm{pdn}_\mathrm{I}^A$	$\mathrm{pdn}_\mathrm{H}^B$				$\mathrm{pdn}_\mathrm{I}^B$	
VA				VA_j^A			VA_j^B												
INTTTM				trans_j^A			trans_j^B		$\mathrm{trans}_\mathrm{H}^A$	$\mathrm{trans}_\mathrm{N}^A$	$\mathrm{trans}_\mathrm{G}^A$	$\mathrm{trans}_\mathrm{K}^A$	$\mathrm{trans}_\mathrm{I}^A$	$\mathrm{trans}_\mathrm{H}^B$	$\mathrm{trans}_\mathrm{N}^B$	$\mathrm{trans}_\mathrm{G}^B$	$\mathrm{trans}_\mathrm{K}^B$	$\mathrm{trans}_\mathrm{I}^B$	
GO				x_j^A		x_1^B	⋯	$x_{I_B}^B$											

Alternative Measures of Distortions

1. **Production Function Approach**
   - Control Function (doesn't work well in practice with sector-level data))
   - **Cost Shares** (= wedge margins if non-operating expenses are 0)

$$\mu_i = \underbrace{\frac{\partial y_i}{\partial x_{ij}} \frac{x_{ij}}{y_i}}_{\equiv \epsilon(y_i, x_{ij})} \times \frac{p_i y_i}{p_j x_{ij}}, \qquad \epsilon(y_i, x_{ij}) = \frac{p_j x_{ij}}{\sum_{j \in \mathcal{I}} p_j x_{ij} + \sum_{f \in \mathcal{F}} w_f \ell_{if}}$$

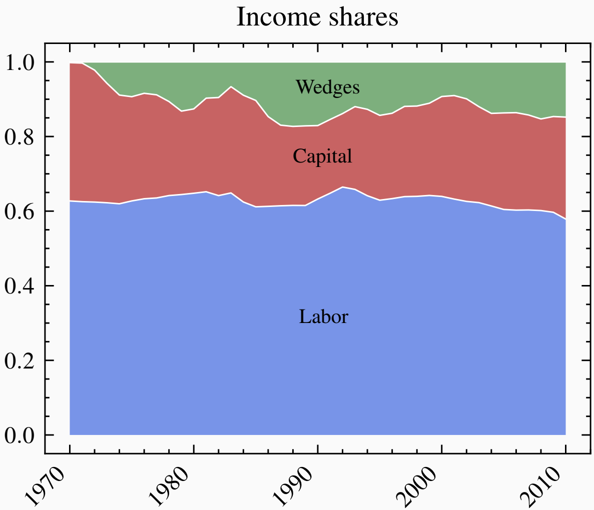
2. **Accounting Profits**. Special case of wedge margins with $r_K = 0$

3. **Gross Margins**. Special case of wedge margins with $w_K = r_K + \delta_K = 0$

Back

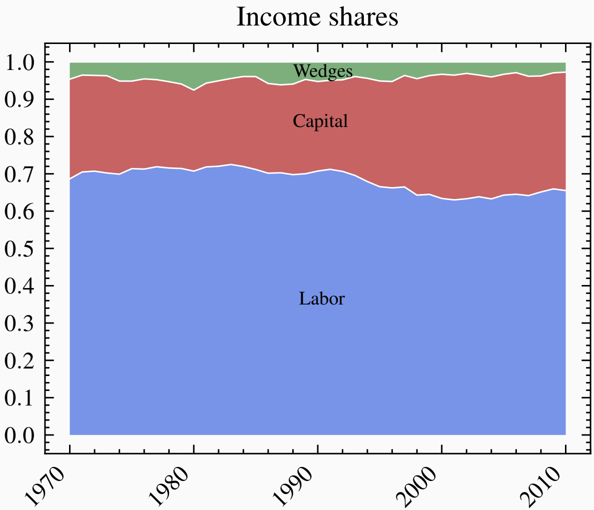
Income Shares in Spain

- Declining labor share: 5 percentage points since 1990s ‣ Empirics ‣ Additional Results



Income Shares in Italy

- Declining labor share: 7 percentage points since 1990s ▸ Empirics ▸ Additional Results



User Cost of Capital: van Vlokhoven's Method

- Estimate net-of-depreciation user cost following van Vlokhoven (2022)
- Method exploits cross-sectional variation in input choices. OLS regression:

$$\frac{p_i y_i}{\text{COGS}_i} = \overline{\psi} + \overline{\psi r^{\text{gross}}} \frac{p_i^K K_i}{\text{COGS}_i} + \varepsilon_i$$

$p_i y_i$: sales $\text{COGS}_i = \sum_{j \in \mathcal{I}} p_j x_{ij} + w\ell_i$: costs of goods sold $\overline{\psi}$: avg. ratio of price to avg. cost

$\overline{r^{\text{gross}}}$: common gross-of-depreciation cost of capital $p_i^K K_i$: producer i's nominal capital stock

- Common user cost: $\overline{r^{\text{gross}}} = \overline{\psi r^{\text{gross}}} / \overline{\psi}$
- Estimation details:
  - 3-year-rolling-window pooled-OLS procedure
  - Imposing same user cost for all sectors within countries at any given year

Back

Sector-Specific Depreciation Rates

- Sector-specific depreciation rates using data from BEA (asset-specific depreciation rates) and KLEMS (capital composition on 8 types of capital):

$$\delta_{ict} = \sum_j \text{Share in capital stock}_{jict} \times \delta_{jt},$$

$$\text{Share in capital stock}_{jict} = \frac{K_{jict}}{K_{ict}}$$

j: capital type $\quad i$: sector $\quad c$: country $\quad t$: time

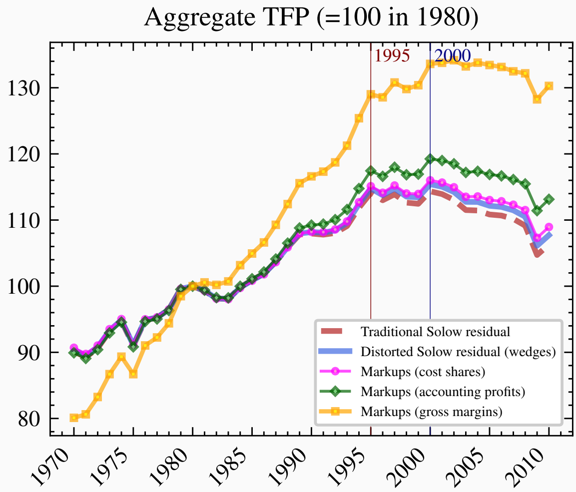
Sector in Spain	Code	1970	1980	1990	2000	2010
Hotels and Restaurants	H	0.047	0.047	0.049	0.060	0.065
Post and Telecommunications	I64	0.058	0.063	0.068	0.084	0.094

Back

Evolution of Aggregate TFP in Italy

▸ Back

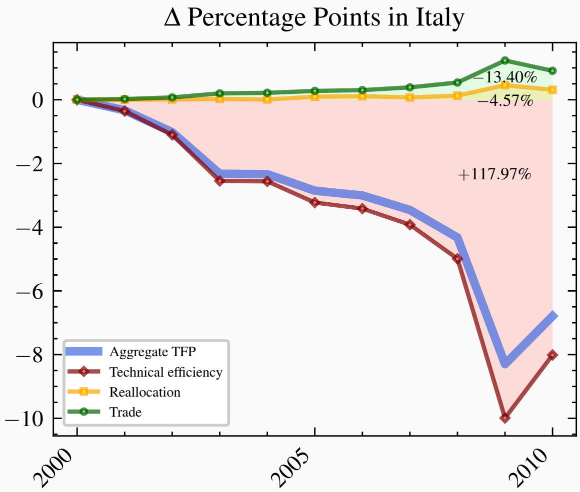
Distortion-adjusted index very similar to traditional one



Decomposition of TFP Growth in Italy

▸ Back

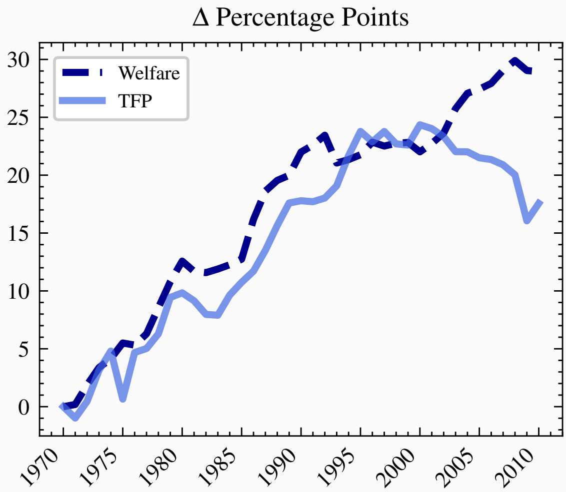
TFP decline entirely accounted for by declines in technical efficiency



Decomposition of TFP Growth in Italy

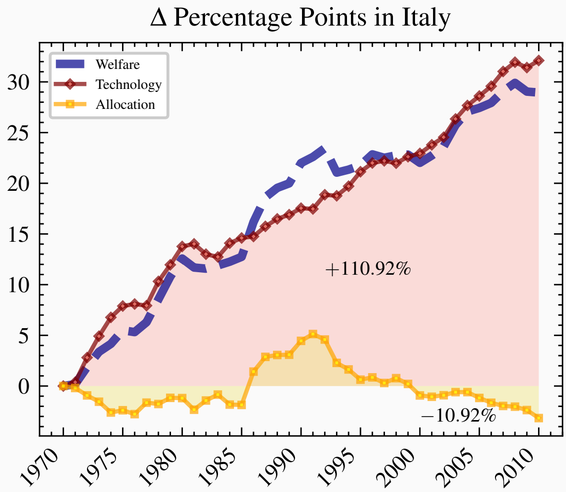
Back

Welfare increased despite declining TFP



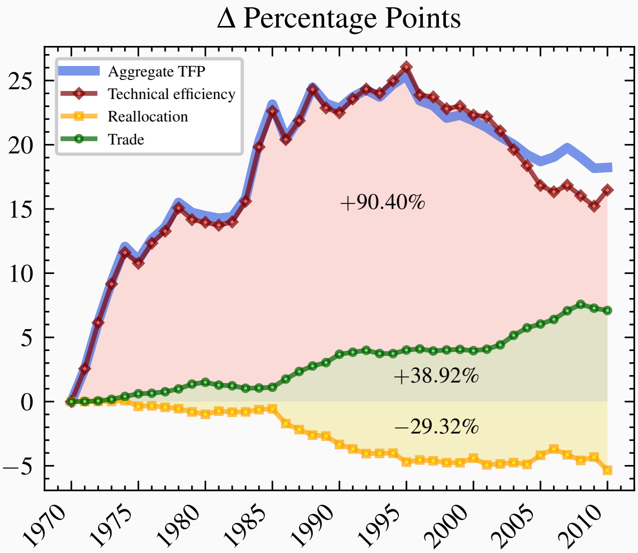
Decomposition of TFP Growth in Italy ▸ Back

Welfare gains entirely attributed to global technological progress



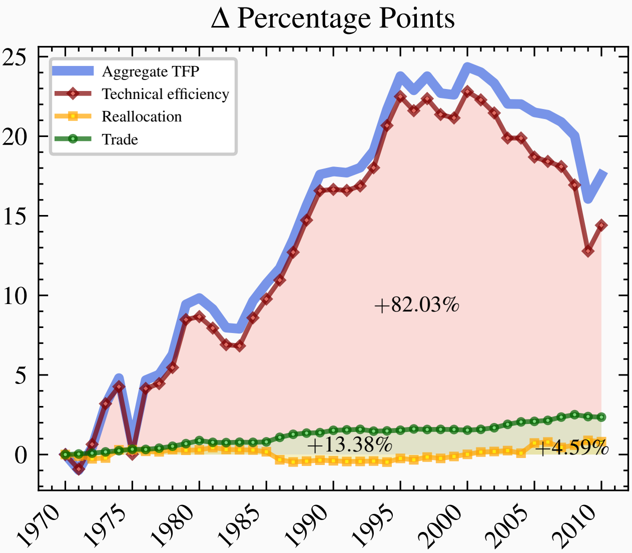
Full-Period TFP Decomposition for Spain

▸ Back



Full-Period TFP Decomposition for Italy

Back



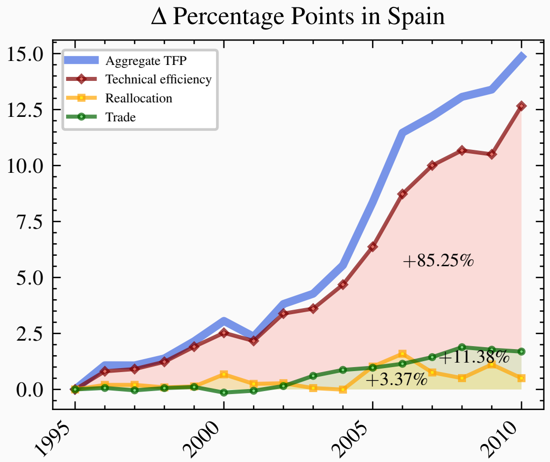
Contributions of Trade Partners to TFP Growth in Spain

Back

Time Period	Δ TFP	Δ Technical Efficiency	Δ Distortions	Δ Factor Shares	Δ Trade
1970–2010	+18.24 pp	+16.48 pp	−25.71 pp	+20.37 pp	+7.10 pp
(Overall period)	(100%)	(+90.40%)	(−140.95%)	(+111.63%)	(+38.92%)
Trade with:					
European countries*					+3.58 pp
China					+0.08 pp
India					+0.01 pp
Rest of world					+3.43 pp
1995–2010	−7.12 pp	−9.58 pp	−5.55 pp	+4.93 pp	+3.08 pp
(Peak to end)	(100%)	(+134.55%)	(+77.95%)	(−69.24%)	(−43.26%)
Trade with:					
European countries*					+1.59 pp
China					+0.07 pp
India					+0.00 pp
Rest of world					+1.42 pp

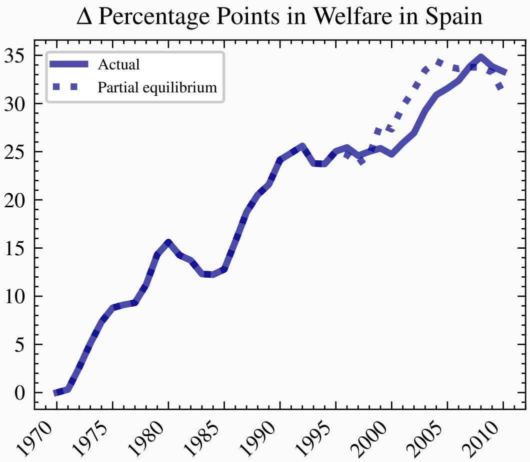
Partial Equilibrium Exercise: TFP Growth in Spain

- **Exercise**: Keep allocation of factors at 1995 levels (year of TFP peak), get TFP
- **Finding**: TFP would have increased 15pp instead of declining 7pp



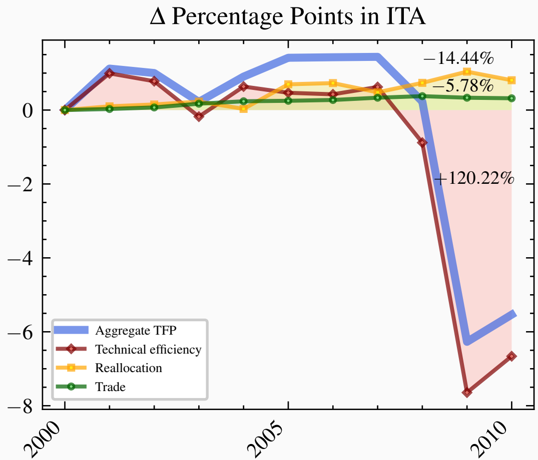
Partial Equilibrium Exercise: Welfare Change in Spain

- **Exercise**: Keep allocation of factors at 1995 levels, get welfare
- **Finding**: Welfare initially larger, but similar at end of 15-year period Back



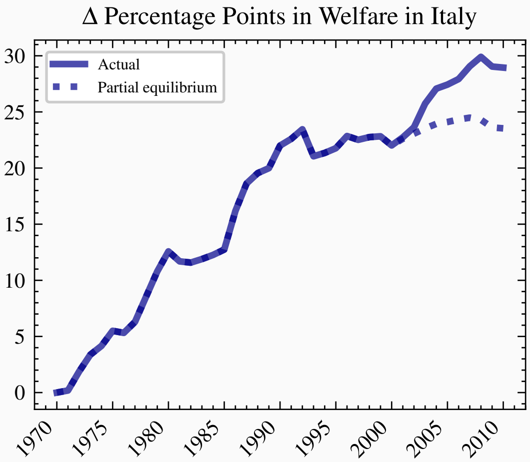
Partial Equilibrium Exercise: TFP Growth in Italy

- **Exercise**: Keep allocation of factors at 2000 levels (year of TFP peak), get TFP
- **Finding**: Similar TFP decline, all occurring in 2007 crises instead of since 2000



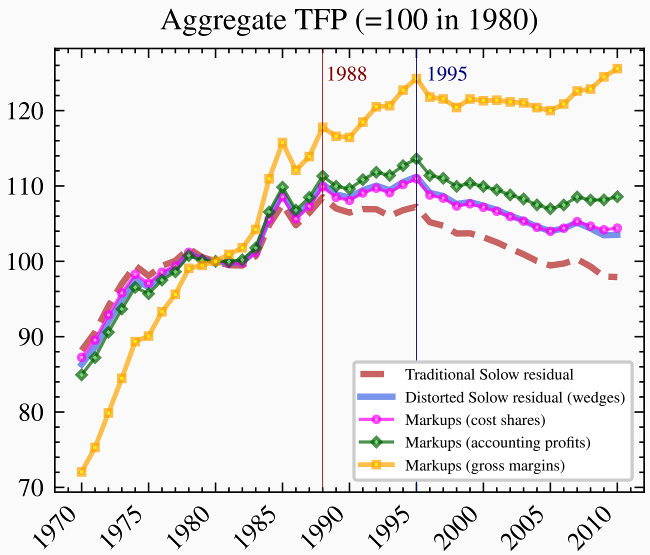
Partial Equilibrium Exercise: Welfare Change in Italy

- **Exercise**: Keep allocation of factors at 2000 levels, get welfare
- **Finding**: Welfare would have been 6pp lower at end of 10-year period Back



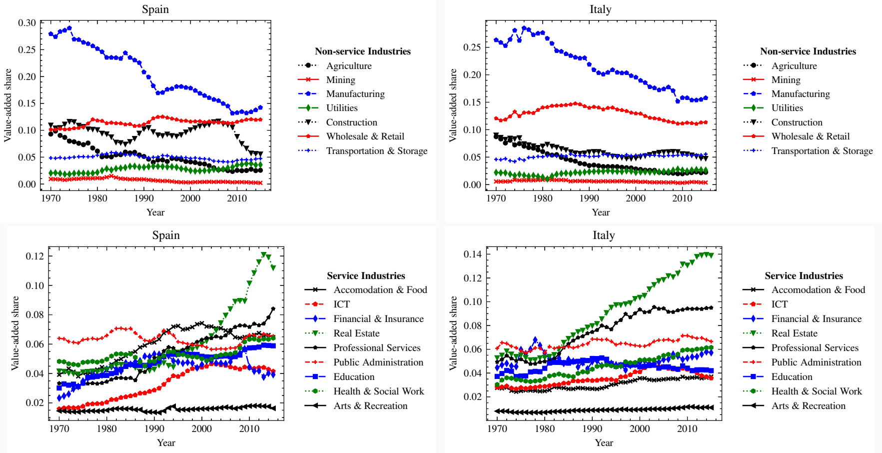
Robustness: Evolution of TFP in Spain

Back



Reallocation of Value Added

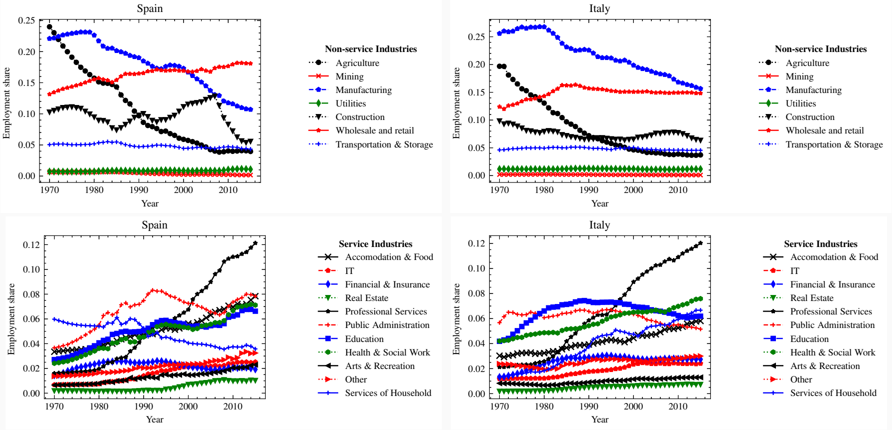
Reallocation of value added toward Professional Services, Hospitality, Real Estate



Source. KLEMS.

Labor Reallocation

Reallocation of labor toward Professional Services, Hospitality, Education, Health

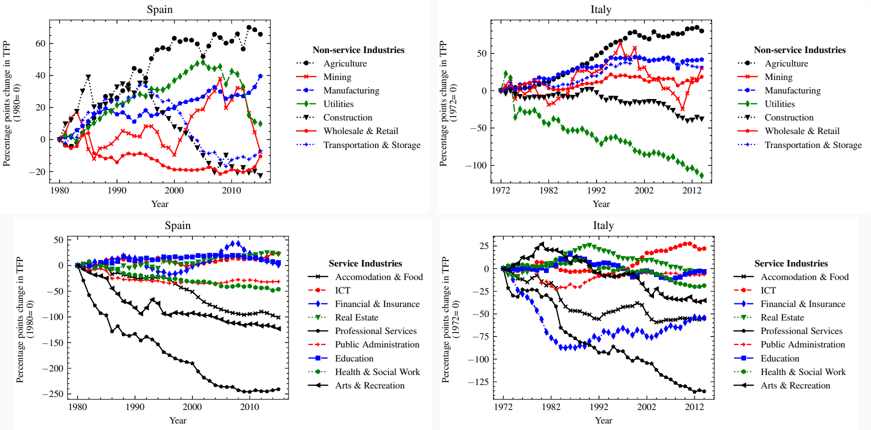


Source. KLEMS.

Reallocation to Industries with Declining TFP

TFP declines much more accentuated (×2-6) than in “control” countries

Back



Source. KLEMS.

Trade-Induced Labor Reallocation in Southern Eruope

Back

$$\underbrace{\Delta \log(\text{EMPshare}^{NT})_{ct}}_{\substack{\text{\% Change employment share} \\ \text{non-tradable sector}}} = \beta_1 \underbrace{\Delta \log \text{ToT}_{ct}}_{\substack{\text{\% Change} \\ \text{terms of trade}}} + \beta_2 \underbrace{\Delta \log \text{ToT}_{ct} \times D_{SE}}_{\substack{\text{\% Change terms of trade} \\ \times \text{ Southern Europe}}} + \alpha_c + \xi_t + \varepsilon_{ct}$$

c : country $\quad$ t : time $\quad$ NT : Non-tradables $\quad$ ToT : Terms of trade $\quad$ D_{SE} : Dummy for SE

Coefficient	(1)	(2)	(3)
$\Delta \log \text{ToT}_{ct}$	0.03	0.07	0.03
$\Delta \log \text{ToT}_{ct} \times D_{SE}$	**$-0.28^{\star\star}$**	$-0.22^{\star\star}$	$-0.35^{\star\star\star}$
Country FE	✓	✓	–
Time FE	✓	–	–
Obs.	466	466	466