The TFP–Welfare Disconnect

Evidence from Southern Europe

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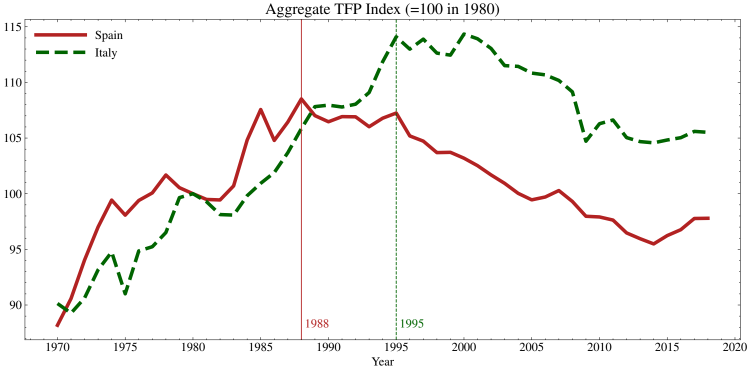
EAYE 2026, Bilbao

May 20, 2026

Motivation

- Puzzling evolution of aggregate TFP in Southern Europe



Notes. Index based on Solow's residual. Data from KLEMS.

- Important questions unanswered

Why has aggregate TFP declined? And how did this affected welfare?

What others have done

- Large literature has proposed many candidate explanations for the Southern European productivity decline
  - Between-sector misallocation: factors flow to low-productivity non-tradables
    [Reis 2013, Benigno Fornaro 2014]
  - Within-sector misallocation: financial and regulatory frictions prevent firms to reach optimal size / factors to be allocated to their most productive use
    [Gopinath et al 2017, Calligaris et al 2016, García-Santana et al 2020]
  - Technology, management, and institutions
    [Pellegrino Zingales 2019, Schivardi Schmitz 2020, Fu Moral–Benito 2018]

What's missing

1. **Limited time and industry coverage**

   Most studies focus on a single industry or a short window

2. **Some methodological caveats: no distortions + closed-economy framework**
   - Distortions matter for TFP measurement and for quantifying misallocation
   - Intl trade matters for understanding TFP decline and evolution of welfare
   - Data shows rising importance of both trade and distortions ▸ Distortions ▸ Trade

What's missing

1. **Limited time and industry coverage**

   Most studies focus on a single industry or a short window

2. **Some methodological caveats: no distortions + closed-economy framework**

   Distortions and intl trade matter for explaining evolution of both TFP and welfare

3. **No unified account of how forces interact**

   Lack quantification in a framework with many plausible competing explanations

4. **No welfare angle**

   Literature rarely asks how TFP decline affected welfare because in closed economy, ΔWelfare $\propto$ ΔTFP, but this is not necessarily true in open economy

Bottom line

Long list of competing explanations for TFP decline, no quantification of their relative importance, and no answer for whether this decline matters for welfare

This paper

- Re-examines evolution of TFP and welfare in Spain and Italy, 1970–2010
  - Growth-accounting GE framework [Baqaee Farhi 2024]: open economy + heterogeneous agents + IO linkages + distortions + international trade

- Makes two contributions
  1. Novel decomposition of aggregate TFP
     [technical efficiency + factor reallocation + domestic & foreign intermediates]
     - Why new? Existing decompositions (Hulten 1978, Basu–Fernald 2002, Baqaee–Farhi) don't feature factor reallocation. Factor reallocation here explicit component
  2. Construct and decompose distortion-adjusted TFP and welfare series

Preview of findings

1. **Standard measurement overstates timing and magnitude of TFP declines**
   Once distortions are accounted for, Spain's TFP decline starts 7 years later (1995 vs 1988) and is roughly half as large (3.5 vs 6.0 pp)

2. **Sources of TFP decline differ sharply across countries**
   TFP decline in Spain driven by factor reallocation toward low-productivity services, whereas in Italy it is driven by deteriorating technical efficiency

3. **TFP–welfare disconnect: welfare continued to rise despite declining TFP**
   Spain and Italy benefited from tech gains associated with intl integration, which more than offset domestic productivity losses

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. Empirical Findings

TFP Measurement

TFP measurement with distortions

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

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

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

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

- **Solution**: **Use cost shares to weight input growth** [Hall 1988]

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

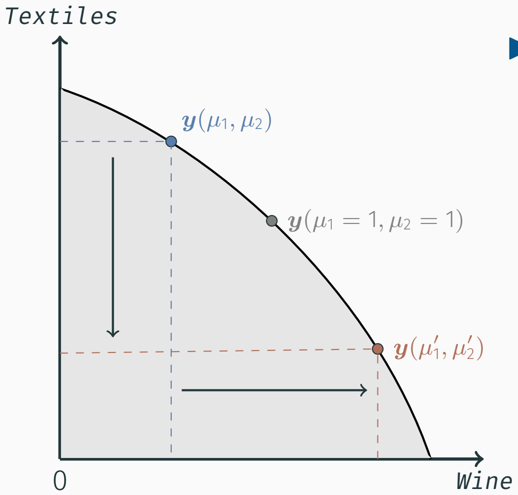
TFP Mechanisms

TFP Mechanisms
(Technology — TFP)

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

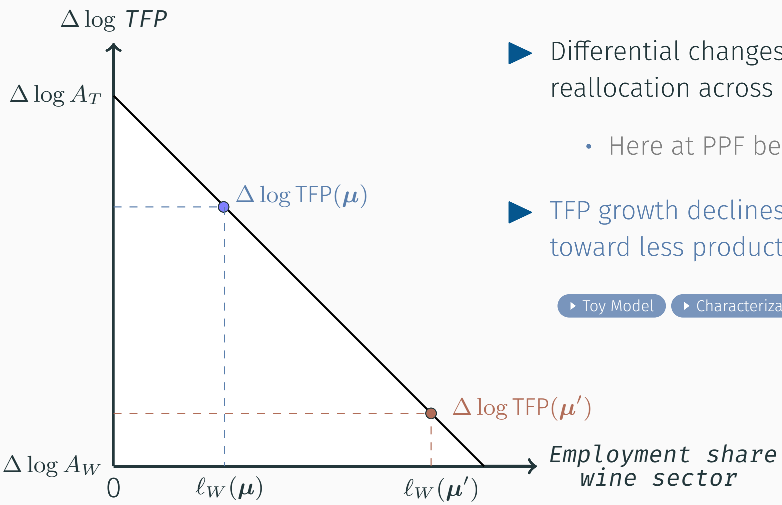
TFP Mechanisms
(Distortions — TFP)

Mechanism: ΔDistortions $\to$ ΔTFP



- **ΔDistortions $\to$ Reallocation $\to$ ΔTFP**
- Differential changes in distortions induce factor reallocation across sectors
  - Here at PPF because factors in fixed supply

Mechanism: ΔDistortions → ΔTFP

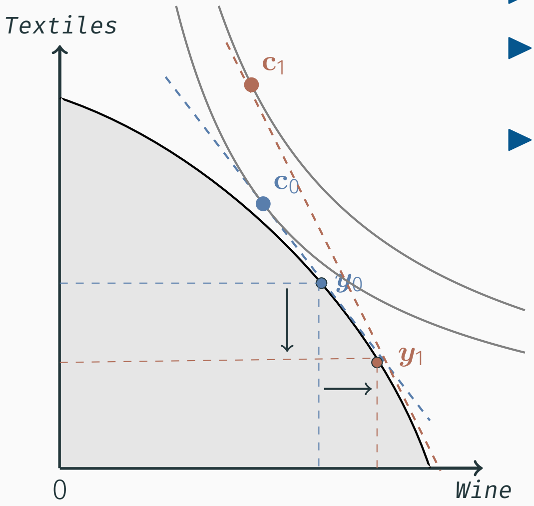


- **ΔDistortions → Reallocation → ΔTFP**
- Differential changes in distortions induce factor reallocation across sectors
  - Here at PPF because factors in fixed supply
- TFP growth declines when factors reallocate toward less productive sector (misallocation)

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

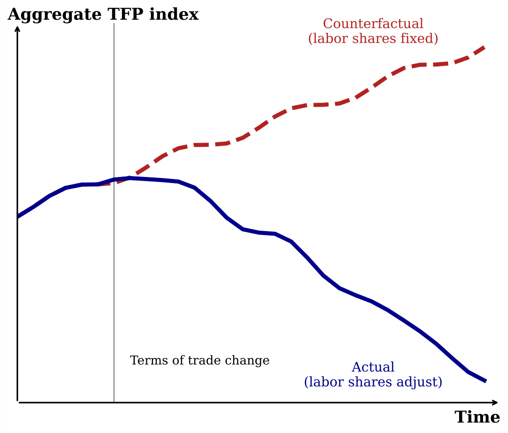
TFP Mechanisms
(Trade — TFP)

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 more, countries can increase welfare
  Trade gains $= 1 - e(\text{TOT}_0, \mathcal{W}_0)/e(\text{TOT}_0, \mathcal{W}_1)$

Mechanism: ΔTerms of Trade $\rightarrow$ ΔTFP



- ΔToT $\rightarrow$ **Factor reallocation** $\rightarrow$ 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 to decline with productivity differences across sectors
- **TFP–welfare disconnect**: TFP$\downarrow$, yet welfare$\uparrow$

▸ 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
    [But households are allowed to be heterogeneous across countries]
  - 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

Definition of aggregate TFP growth

$$\Delta \log \text{TFP}_{c,t} = \Delta \log Y_{c,t} - \sum_{f \in \mathcal{F}_c} \tilde{\Lambda}^{Y_c}_{f,t-1} \Delta \log L_{f,t}$$

Novel decomposition of aggregate TFP growth ▸ Factor reallocation decomposition ▸ Examples

$$\Delta \log \text{TFP}_{c,t} = \underbrace{\sum_{i \in \mathcal{I}_c} \lambda^{Y_c}_{i,t-1} \Delta \log A_{i,t}}_{\text{(I) technical efficiency}} + \underbrace{\sum_{f \in \mathcal{F}_c} \left[\sum_{i \in \mathcal{I}_c} \lambda^{Y_c}_{i,t-1} \mu_{i,t-1} \Omega_{if,t-1} \Delta \log L_{fi,t} - \tilde{\Lambda}^{Y_c}_{f,t-1} \Delta \log L_{f,t} \right]}_{\text{(II) factor reallocation}}$$

$$+ \underbrace{\sum_{i \in \mathcal{I}_c} \sum_{j \in \mathcal{I}} \lambda^{Y_c}_{i,t-1} (\mu_{i,t-1} - 1) \Omega_{ij,t-1} \Delta \log x_{ij,t}}_{\text{(III–IV) trade in intermediates (domestic } j \in \mathcal{I}_c \text{ and foreign } j \notin \mathcal{I}_c)} + \underbrace{\mathcal{R}_{c,t}}_{\text{residual}}$$

- Other decompositions: ▸ Solow ▸ Hall ▸ Domar–Hulten ▸ Baqaee–Farhi ▸ Empirics (BF comparison)

TFP decomposition: Understanding the contribution

- Main difference relative to Baqaee–Farhi 2024 is factor reallocation term
  [Here separate, interpretable channel rather than attributed to residual and/or other terms]
  - This distinction matters quantitatively in long-run growth accounting
    [BF approx. leaves 14% of cumulative TFP growth unexplained in Spain, 1970–2010]
    [Factor reallocation turns out to explain all of Spain's post-1995 TFP decline]
- Why factor reallocation doesn't appear in other TFP decompositions?
  - In efficient economies, envelope theorem implies *marginal* reallocations of factors have zero first-order effect on aggregate TFP
    [Factors paid MPs $\Longrightarrow$ gain from moving factor to one sector offset by withdrawal loss]
  - In inefficient economies only *part* of reallocation appears and does so implicitly
    [Distortion-driven part bundled into changes in wedges and income shares; composition effect unaccounted for or attributed to residual]

Welfare decomposition

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

First-order decomposition of welfare growth [Baqaee–Farhi 2024]

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

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

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

Estimation

- **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

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

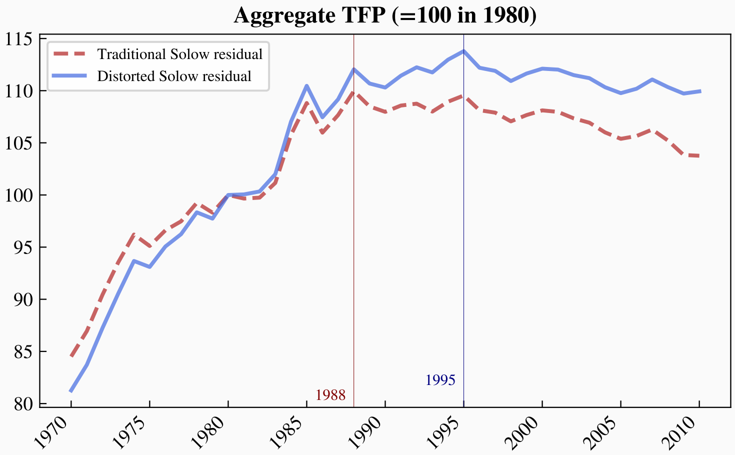
$$\text{Wedge margin}_i = \frac{\overbrace{p_i y_i}^{\text{sales}} - \overbrace{\sum_{j \in \mathcal{I}} p_j x_{ij}}^{\substack{\text{material}\\\text{expenditures}}} - \overbrace{w_i \ell_i}^{\substack{\text{labor}\\\text{compensation}}} - \overbrace{(r_i + \delta_i) k_i}^{\substack{\text{capital}\\\text{compensation}}}}{p_i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

  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

Empirical Findings

The evolution of aggregate TFP

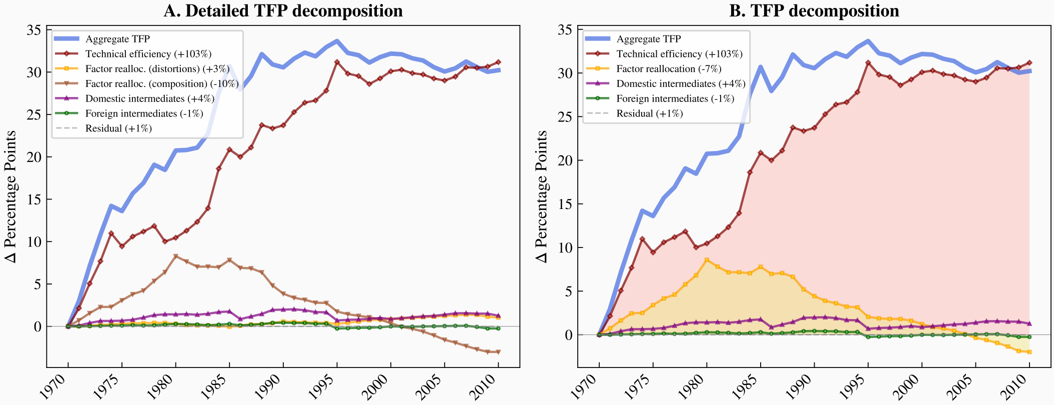
Spain's TFP decline starts 7 years later and is roughly half as large than what standard TFP measurement (traditional Solow residual) suggests



Explaining the TFP decline

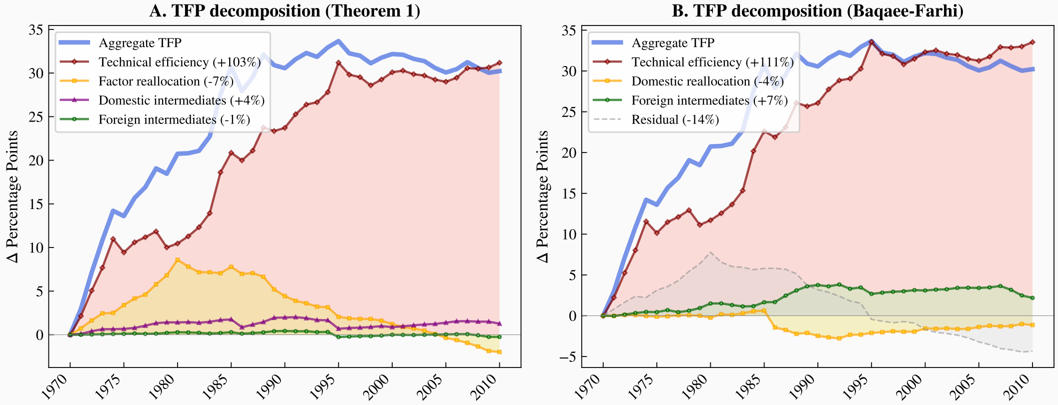
TFP decline in Spain fully accounted for by factor reallocation (composition effect)

[Reallocation from agriculture and manufacturing to real estate, hospitality, business services, ...]



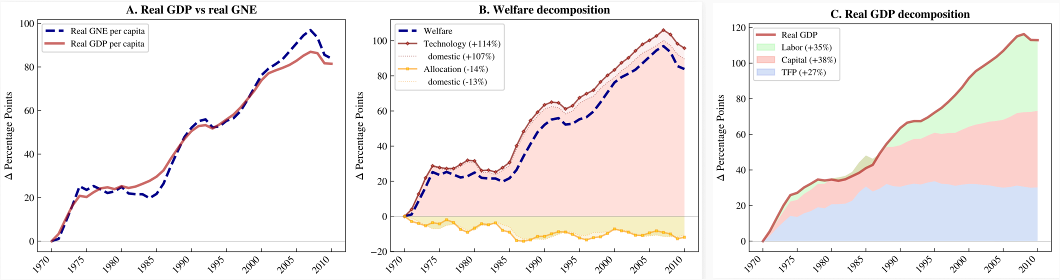
TFP decline in Spain fully accounted for by factor reallocation (left panel)

BF decomposition attributes the decline to residual or to tech efficiency (if computed residually)



The TFP–welfare disconnect

- **Panel A**: Welfare—real GNE per capita—increased despite declining TFP
- **Panel B**: Welfare gains due to technological progress (domestic + foreign)
- **Panel C**: Post-1995 GDP growth driven by factor accumulation, not productivity



Additional results

- Theory:
  - TFP decomposition: ▸ Illustrative examples + BF comparison
- Empirics:
  - Italy: ▸ TFP evolution ▸ TFP decomposition ▸ TFP–Welfare disconnect
  - Income Shares: ▸ Spain ▸ Italy
  - Counterfactuals: ▸ Spain ▸ Italy
  - Robustness: ▸ Spain ▸ Italy
  - Empirical evidence: ▸ Distortions ▸ Trade exposure ▸ Reallocation

Conclusion

- Study evolution of TFP in Spain and Italy, focusing on welfare implications

  → Growth and welfare accounting in open + distorted + disaggregated economies

- Two contributions:
  1. Methodological: Novel decomposition of aggregate TFP (w/ factor reallocation)
  2. New empirical findings:

     2.1 Conventional estimates overstate both timing and magnitude of Spain's TFP decline

     2.2 Factor reallocation toward low-productivity services explains TFP decline in Spain
     Deteriorating technical efficiency explains TFP decline in Italy

     2.3 **TFP–welfare disconnect**: welfare increased despite TFP declines

     2.4 Welfare gains due technological progress (domestic + foreign)

Questions?

Thank You!

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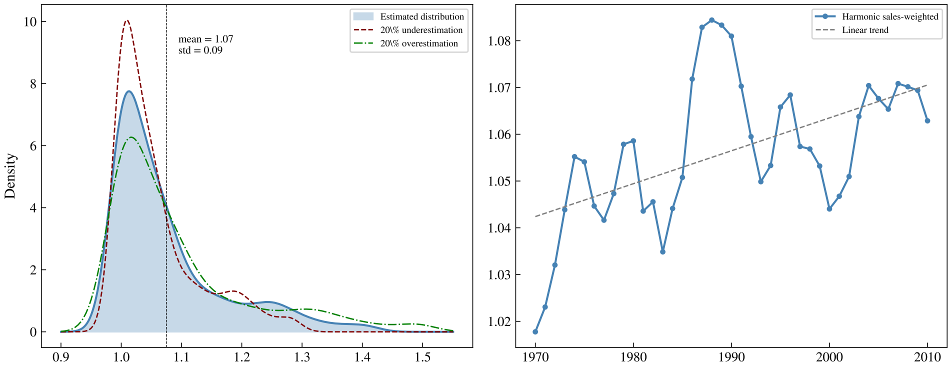
Distortion estimates: Wedges in Spain

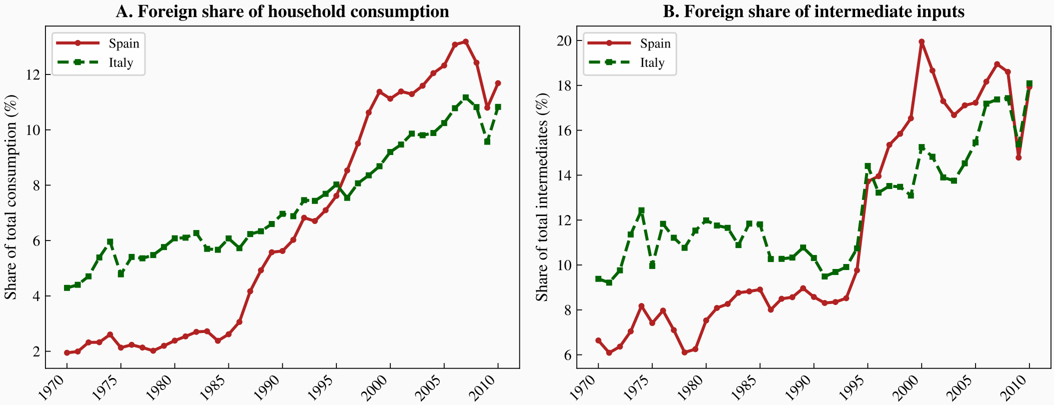
- Fat-tailed distribution of wedges
- Aggregate (harmonic sales-weighted) wedge rising since the 1970s



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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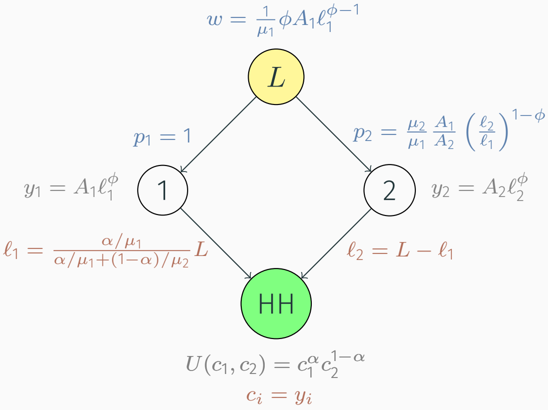
Back to Additional Results

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: $p_i = \mu_i \times \text{mc}_i$, 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:

$$1: \qquad A_2' = 1.02$$

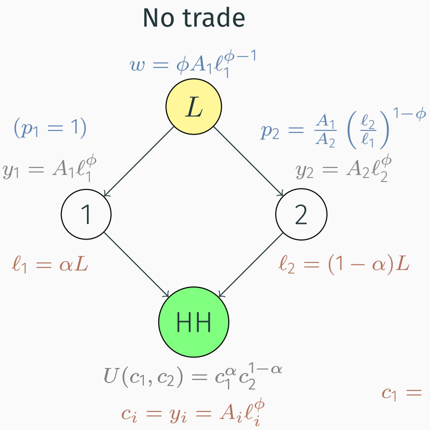
$$2: \qquad (A_2', \mu_2') = (1.02, 1.5)$$

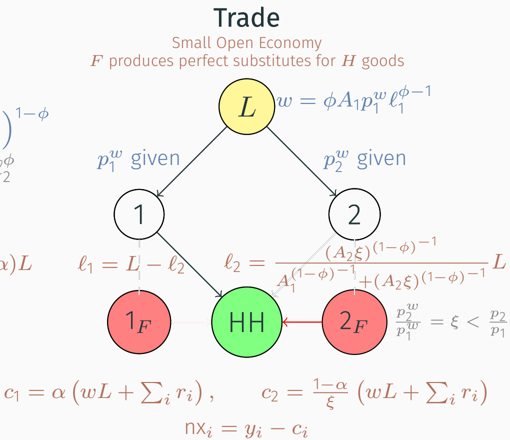
- Under 1, $\mathrm{d}\log \mathrm{TFP} > 0$. Under 2, $\mathrm{d}\log \mathrm{TFP} < 0$ ■ Back

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





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:

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

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

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

- 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:

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

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

- Under 1, $\mathrm{d}\log \text{TFP} > 0$. Under 2, $\mathrm{d}\log \text{TFP} < 0$
- 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** $\mathbf{p} = \text{diag}(\boldsymbol{\mu}) \times \mathbf{mc}$.
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:

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

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:

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

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:

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

▸ Back

Factor reallocation decomposition

- Factor reallocation can be decomposed into two terms:

1. **Distortion-driven reallocation** (non-zero when $\boldsymbol{\mu} \neq 1$):

$$\sum_{f \in \mathcal{F}} \lambda_{i,t-1}^{Y_c} (\mu_{i,t-1} - 1) \Omega_{if,t-1} \Delta \log L_{fi,t} \tag{IIa}$$

   Reallocating factors away from high-markup sectors lowers aggregate TFP

2. **Composition term** (can be non-zero even when $\boldsymbol{\mu} = 1$):

$$\sum_{f \in \mathcal{F}} \left[\sum_{i \in \mathcal{I}_c} \lambda_{i,t-1}^{Y_c} \Omega_{if,t-1} \Delta \log L_{fi,t} - \tilde{\Lambda}_{f,t-1}^{Y_c} \Delta \log L_{f,t} \right] \tag{IIb}$$

   This term vanishes under infinitesimal perturbations but can be quantitatively important over the multi-year horizons common in growth accounting

Back

TFP decomposition: Illustrative examples

- **Example I: Open, undistorted economy, no intermediate goods**
  [CD preferences $c_1^{\alpha} c_2^{1-\alpha}$ and CD production functions with fixed factors $y_i = A_i L_{\ell i}^{\phi}$]

$$\Delta \log \text{TFP}_{c,t} = \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{(I) technical efficiency}} + \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \Omega_{i\ell,t-1} \Delta \log L_{\ell i,t}}_{\text{(IIb) factor reallocation (composition)}} + \mathcal{R}_{c,t} \quad \text{(This paper)}$$

$$\Delta \log \text{TFP}_{c,t} = \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{technical efficiency}} + \mathcal{R}_{c,t} \quad \text{(Baqaee–Farhi 2024)}$$

EQUILIBRIA UNDER SELECTED PARAMETRIZATIONS

	$L_{\ell 1}$	$L_{\ell 2}$	w	y_1	y_2	GDP
$t-1$	0.5	0.5	0.86	0.62	0.62	1.23
t	0.66	0.34	0.79	0.74	0.48	1.12

TFP decomposition: Illustrative examples

- Example I: Open, undistorted economy, no intermediate goods

Term	This paper	Baqaee–Farhi 2024
Aggregate TFP growth	**−0.0308**	**−0.0308**
Technical efficiency	+0.0049	+0.0049
Factor reallocation	−0.0357	—
Distortion driven	0	—
Composition effect	−0.0357	—
Domestic reallocation	—	0
Sectoral distortions	—	0
Income shares	—	0
Domestic intermediates reallocation	0	—
Foreign intermediates reallocation	0	0
Residual	0	−0.0357

TFP decomposition: Illustrative examples

- **Example II: Closed, distorted economy, no intermediate goods**
  [CD preferences $c_1^{\alpha} c_2^{1-\alpha}$ and CD production functions with fixed factors $y_i = A_i L_{\ell i}^{\phi}$]

$$\Delta \log \text{TFP}_{c,t} = \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{(I) technical efficiency}} + \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \mu_{i,t-1} \Omega_{if,t-1} \Delta \log L_{\ell i,t}}_{\text{(II) factor reallocation}} + \mathcal{R}_{c,t}$$

$$\Delta \log \text{TFP}_{c,t} = \underbrace{\sum_i \tilde{\lambda}_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{technical efficiency}} \underbrace{- \sum_{i \in \mathcal{I}_c} \tilde{\lambda}_{i,t-1}^{Y_c} \Delta \log \mu_{i,t} - \sum_{f \in \mathcal{F}_c} \tilde{\Lambda}_{f,t-1} \Delta \log \Lambda_{f,t}}_{\text{domestic reallocation}} + \mathcal{R}_{c,t}$$

(Baqaee–Farhi 2024)

EQUILIBRIA UNDER SELECTED PARAMETRIZATIONS

	$L_{\ell 1}$	$L_{\ell 2}$	p_1	p_2	w	y_1	y_2	GDP
$t-1$	0.6	0.4	1	1.33	0.83	0.70	0.53	1.40
t	0.7	0.3	1	1.86	0.77	0.79	0.42	1.58

TFP decomposition: Illustrative examples

- Example II: Closed, distorted economy, no intermediate goods

Term	This paper	Baqaee–Farhi 2024
Aggregate TFP growth	**−0.0468**	**−0.0468**
Technical efficiency	+0.0099	+0.0149
Factor reallocation	−0.0568	—
Distortion driven	−0.0393	—
Composition effect	−0.0175	—
Domestic reallocation	—	−0.2611
Sectoral distortions	—	−0.3831
Income shares	—	+0.1220
Domestic intermediates reallocation	0	—
Foreign intermediates reallocation	0	0
Residual	0	+0.1994

TFP decomposition: Illustrative examples

- **Example III: Closed, distorted economy, intermediate goods**

  [CD preferences $c_1^{\alpha} c_2^{1-\alpha}$ and production functions $y_1 = A_1 L_1^{\phi} x_{12}^{1-\phi}$ and $y_2 = A_2 L_2$; $\boldsymbol{\mu}$ fixed]

$$\Delta \log \mathrm{TFP}_{c,t} = \underbrace{\sum_i \lambda_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{(I) technical efficiency}} + \underbrace{\lambda_{1,t-1}^{Y_c} (\mu_{1,t-1} - 1) \Omega_{12,t-1} \Delta \log x_{12,t}}_{\text{(III) reallocation in domestic intermediates}} + \mathcal{R}_{c,t}$$

$$\Delta \log \mathrm{TFP}_{c,t} = \underbrace{\sum_i \tilde{\lambda}_{i,t-1}^{Y_c} \Delta \log A_{i,t}}_{\text{technical efficiency}} + \mathcal{R}_{c,t} \qquad \text{(Baqaee–Farhi 2024)}$$

EQUILIBRIA UNDER SELECTED PARAMETRIZATIONS

	L_1	L_2	p_1	p_2	w	y_1	$y_2 = x_{12}$	GDP
$t-1$	0.5	0.5	3	1	1	0.5	0.5	1.5
t	0.5	0.5	2.86	0.91	1	0.52	0.55	1.5

TFP decomposition: Illustrative examples

- Example III: Closed, distorted economy, intermediate goods

Term	This paper	Baqaee–Farhi 2024
Aggregate TFP growth	**+0.0447**	**+0.0447**
Technical efficiency	+0.0318	+0.0318
Factor reallocation	0	—
Distortion driven	0	—
Composition effect	0	—
Domestic reallocation	—	0
Sectoral distortions	—	0
Income shares	—	0
Domestic intermediates reallocation	+0.0159	—
Foreign intermediates reallocation	0	0
Residual	0	+0.0159

Back to TFP Decomposition Back to Additional Results

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:

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

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

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

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

▸ Back

Domar–Hulten's TFP

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

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

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

WIOD

- 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, Industries	1																	x_1^A
	⋮		z_{ij}^{AA}			z_{ij}^{AB}		$f_{i,H}^{AA}$	$f_{i,N}^{AA}$	$f_{i,G}^{AA}$	$f_{i,K}^{AA}$	$f_{i,I}^{AA}$	$f_{i,H}^{AB}$	$f_{i,N}^{AB}$	$f_{i,G}^{AB}$	$f_{i,K}^{AB}$	$f_{i,I}^{AB}$	⋮
	I_A																	$x_{I_A}^A$
Supply Country-Industry: Country B, Industries	1																	x_1^B
	⋮		z_{ij}^{BA}			z_{ij}^{BB}		$f_{i,H}^{BA}$	$f_{i,N}^{BA}$	$f_{i,G}^{BA}$	$f_{i,K}^{BA}$	$f_{i,I}^{BA}$	$f_{i,H}^{BB}$	$f_{i,N}^{BB}$	$f_{i,G}^{BB}$	$f_{i,K}^{BB}$	$f_{i,I}^{BB}$	⋮
	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		tax_H^A	tax_N^A	tax_G^A	tax_K^A	tax_I^A	tax_H^B		⋯		tax_I^B	
EXP_ADJ			adj_j^A			adj_j^B		adj_H^A	adj_N^A	adj_G^A	adj_K^A	adj_I^A	adj_H^B		⋯		adj_I^B	
PURR								par_H^A	par_N^A	par_G^A	par_K^A	par_I^A	par_H^B		⋯		par_I^B	
PURNR								pdn_H^A	pdn_N^A	pdn_G^A	pdn_K^A	pdn_I^A	pdn_H^B				pdn_I^B	
VA			VA_j^A			VA_j^B												
INTTTM			$trans_j^A$			$trans_j^B$		$trans_H^A$	$trans_N^A$	$trans_G^A$	$trans_K^A$	$trans_I^A$	$trans_H^B$	$trans_N^B$	$trans_G^B$	$trans_K^B$	$trans_I^B$	
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)

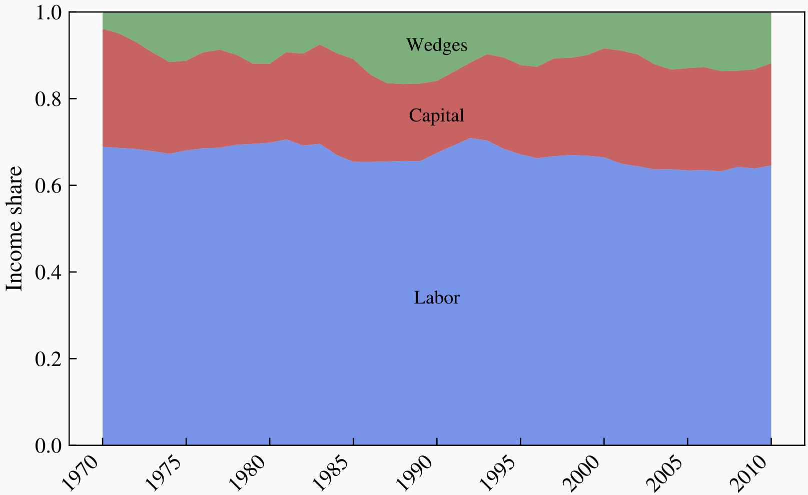
$$\mu_i = \underbrace{\frac{\partial y_i}{\partial x_{ij}} \frac{x_{ij}}{y_i}}_{\equiv \epsilon(y_i, x_{ij})} \times \frac{p_i y_i}{p_j x_{ij}}, \qquad \epsilon(y_i, x_{ij}) = \frac{p_j x_{ij}}{\sum_{j \in \mathcal{I}} p_j x_{ij} + \sum_{f \in \mathcal{F}} w_f \ell_{if}}$$

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

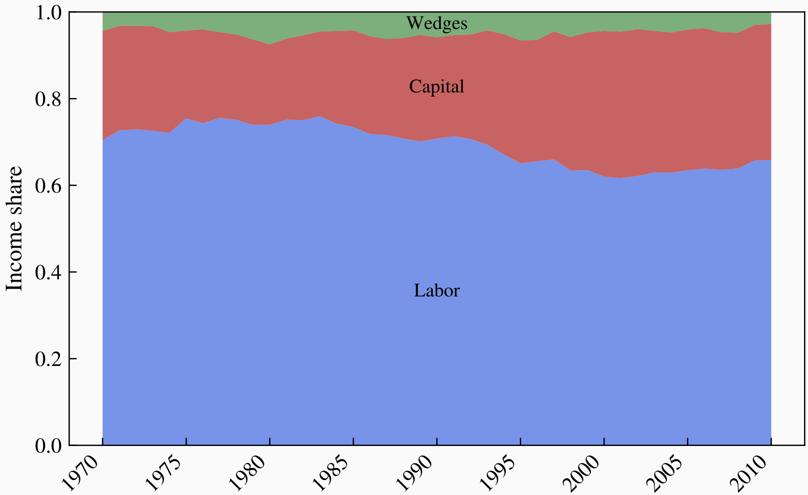
3. **Gross Margins**. Special case of wedge margins with $w_K = r_K + \delta_K = 0$

Back

Income shares in Spain



Income shares in Italy



▸ 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):

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

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

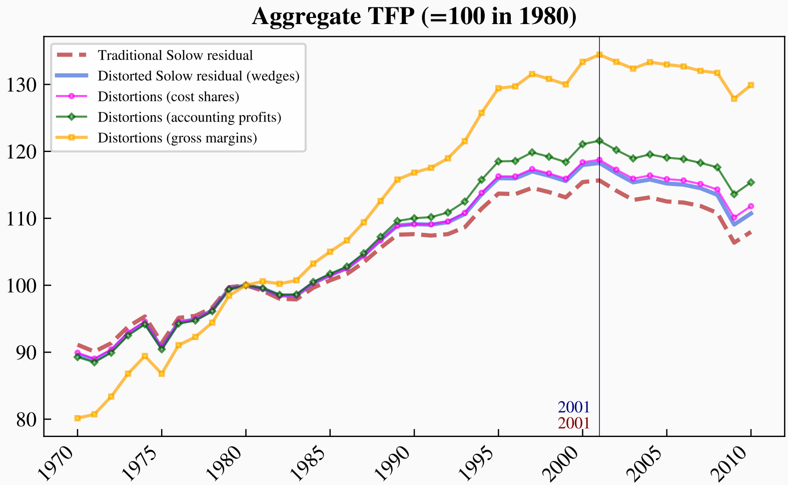
j: capital type i : sector c : country t : time

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

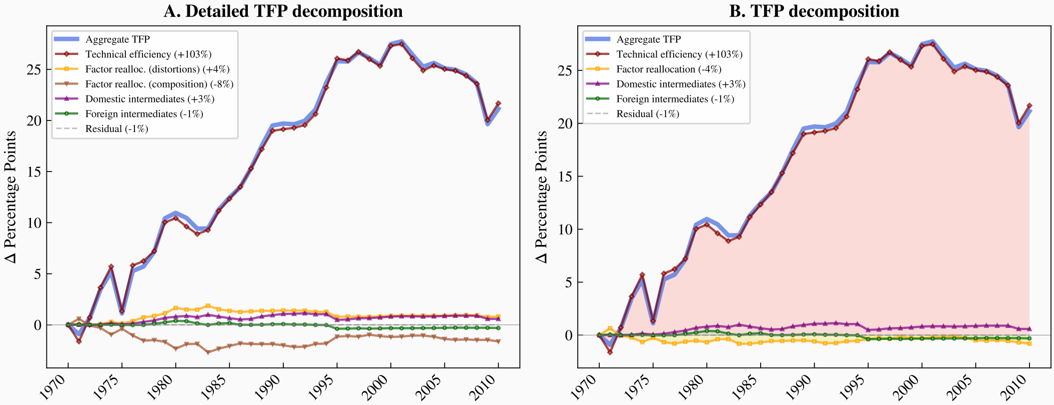
The evolution of aggregate TFP: Italy ▸ Back

Same timing and magnitude of TFP decline with and w/o distortions (level effect)



Explaining the TFP decline

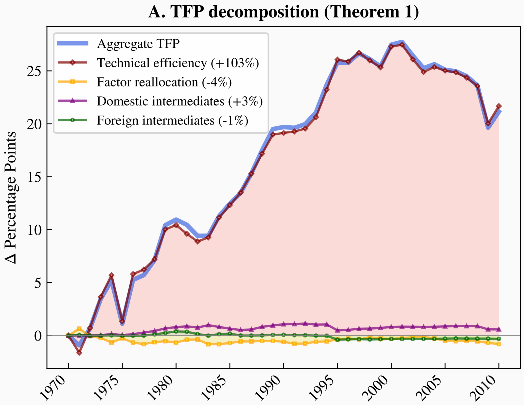
TFP decline in Italy fully accounted for by deteriorating technical efficiency

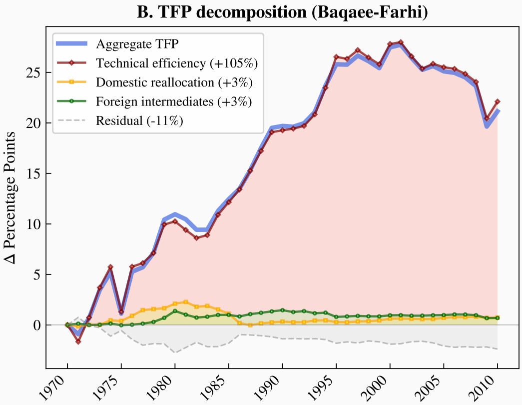


TFP decomposition: Comparison to Baqaee–Farhi 2024

TFP decline in Italy fully accounted for by deteriorating technical efficiency

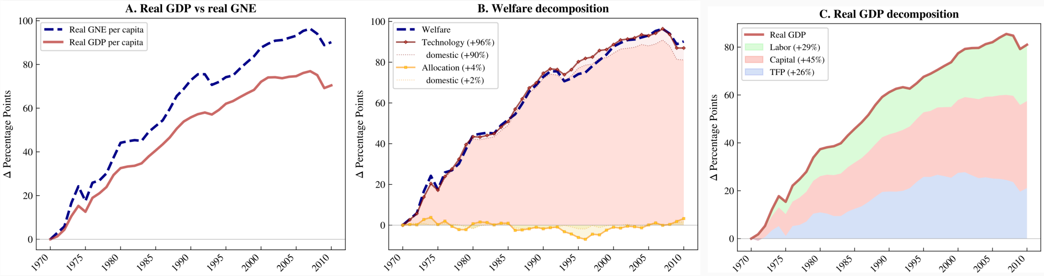
Same conclusion with the Baqaee–Farhi decomposition ▸ Back





The TFP–welfare disconnect: Italy

- **Panel A**: Welfare—real GNE per capita—increased despite declining TFP
- **Panel B**: Welfare gains due to technological progress (domestic + foreign)
- **Panel C**: Post-2001 GDP growth driven by factor accumulation, not productivity

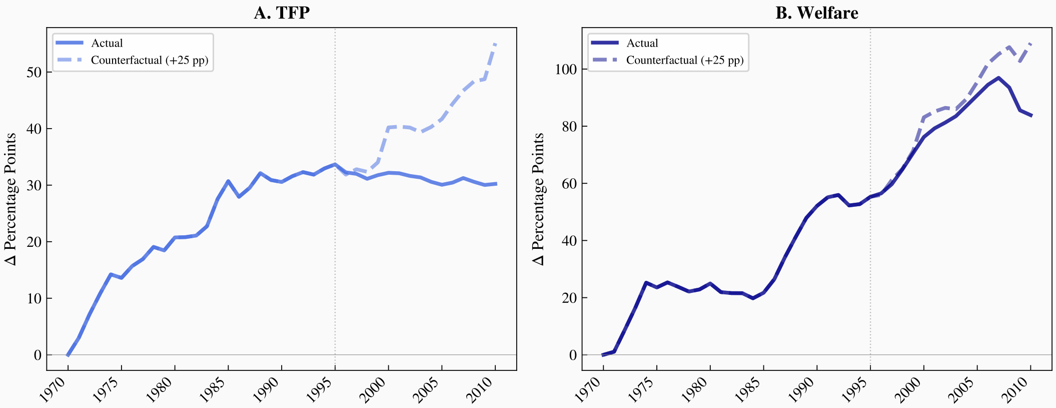


Back

TFP–welfare counterfactuals: Spain

- **Exercise**: Keep allocation of factors at 1995 levels (year of TFP peak) and compute TFP and welfare letting everything else evolve as observed in data
- **Findings**: TFP and welfare would each be 25 pp higher

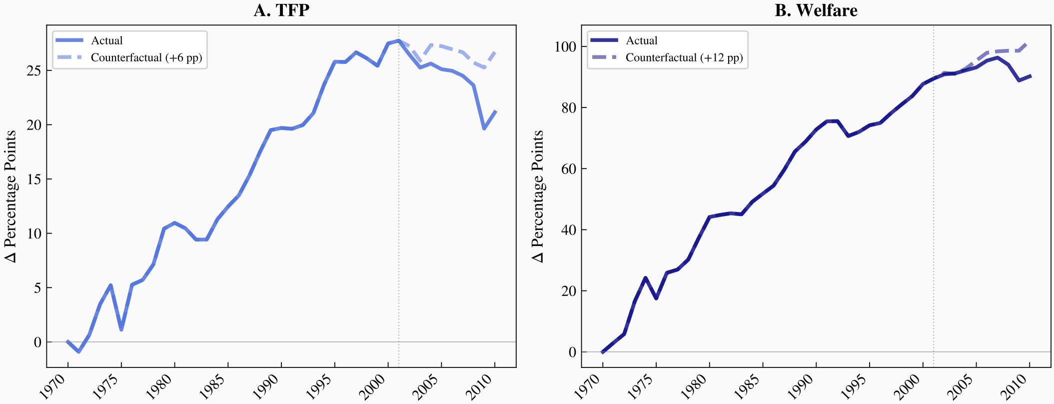
Back



TFP–welfare counterfactuals: Italy

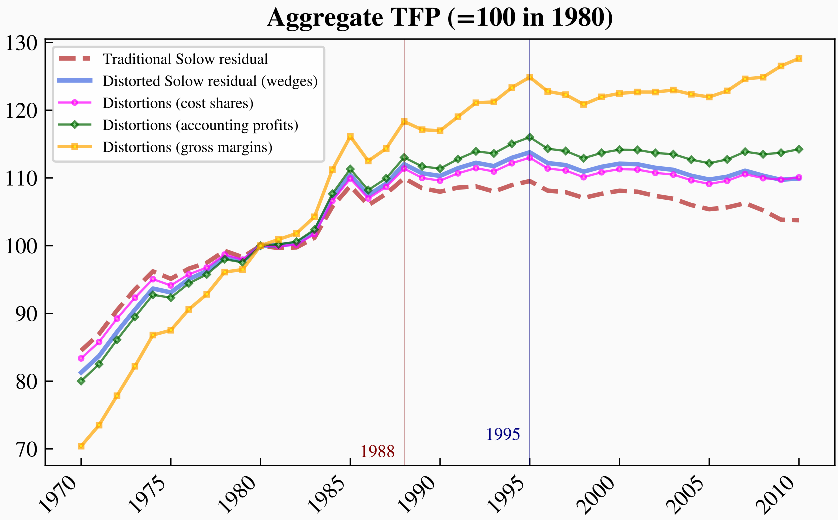
- **Exercise**: Keep allocation of factors at 2000 levels (year of TFP peak) and compute TFP and welfare letting everything else evolve as observed in data
- **Findings**: TFP and welfare would be 6 and 12 pp higher than observed

Back

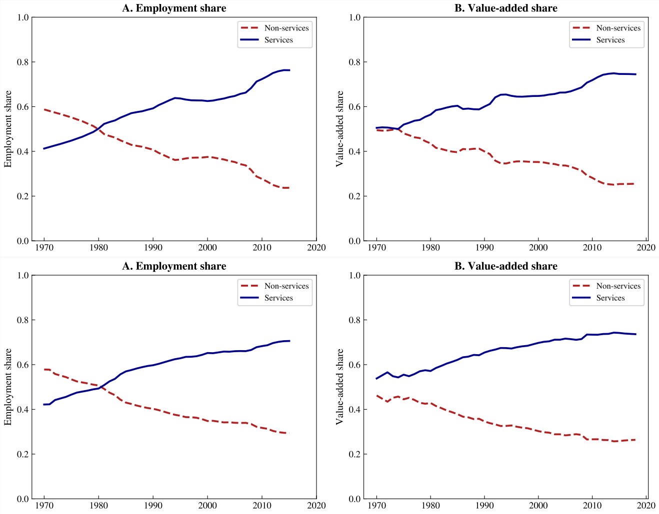


Robustness: Evolution of TFP in Spain

Back



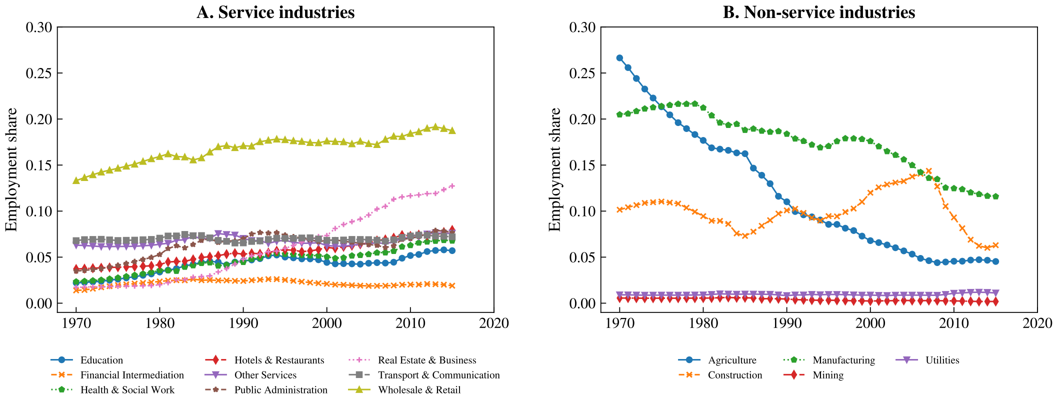
Reallocation: Spain (top) and Italy (bottom)



Source. KLEMS.

Labor reallocation: Spain

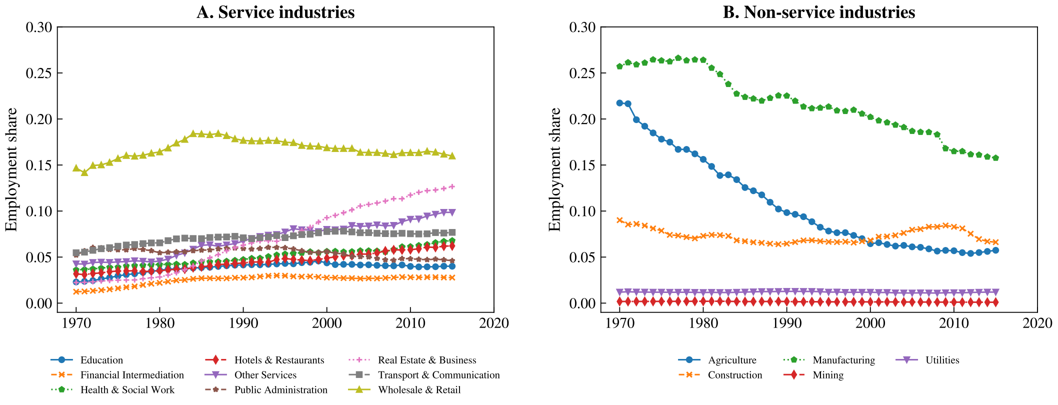
Reallocation toward Real Estate, Business Services, Wholesale & Retail Trade, Health and Social Work, Hospitality



Source. KLEMS.

Labor reallocation: Italy

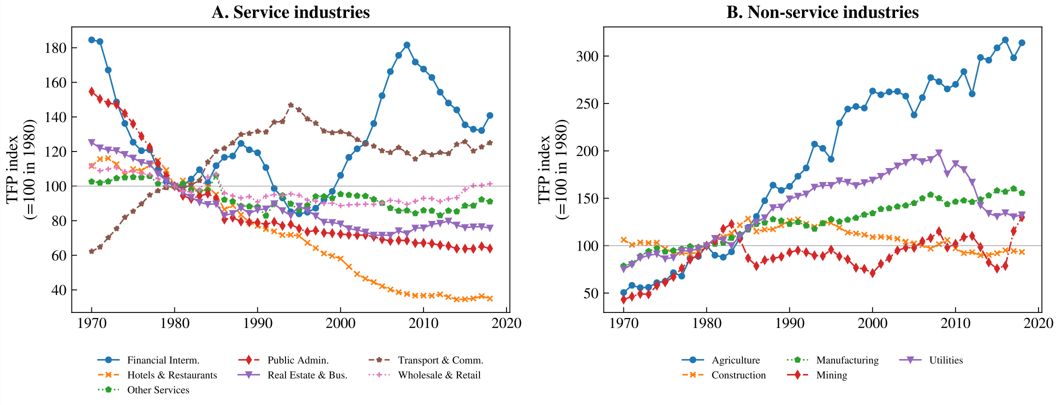
Reallocation toward Real Estate, Hospitality, Health and Social Work



Source. KLEMS.

Reallocation toward sectors with declining TFP: Spain

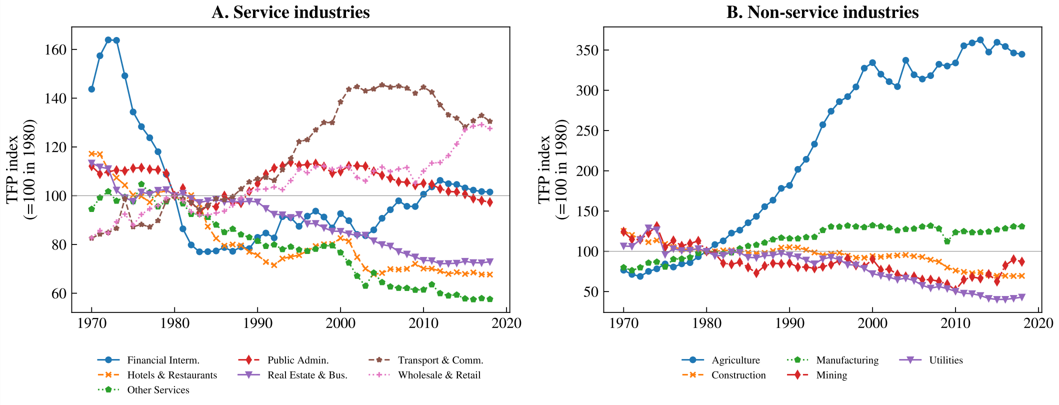
Expanding sectors registered TFP declines



Notes. TFP indices constructed using traditional Solow residual. **Source**. KLEMS.

Reallocation toward sectors with declining TFP: Italy

Expanding sectors registered TFP declines



Notes. TFP indices constructed using traditional Solow residual. **Source**. KLEMS. ▸ Back