Structural Change and Global Trade

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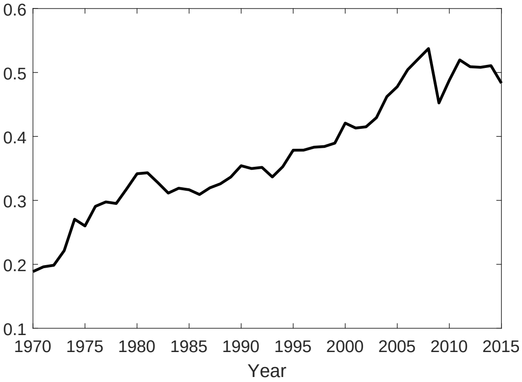
Introduction

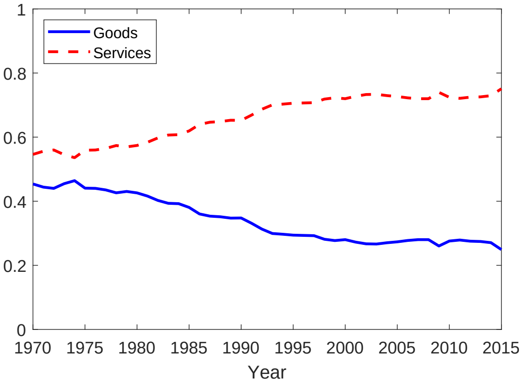
Figure 1: Global Trade to Expenditure Ratio



- Global trade openness more than doubles from 1970–2015.

Structural Change

Figure 2: Sectoral Expenditure Shares

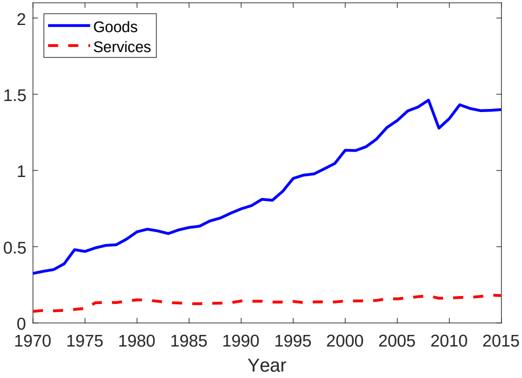


- Global expenditure switches from goods to services over time.

Sectoral Expenditure Derivation | Disaggregate

Sectoral Openness

Figure 3: Trade to Expenditure Ratios by Sector



- Goods are more tradable than services.

What we do

- We quantify the impact of structural change on long-run growth of global trade openness and gains from trade.
  - A simple empirical exercise
  - A general equilibrium trade model
- We find that structural change has substantially held back trade growth and gains from trade over the past five decades.
  - Global trade openness would have been 27 percent higher and the gains from trade would have been 40 percent higher by 2015 without structural change in expenditure shares.
- We find that ongoing structural change implies declining trade openness, absent further reductions in trade costs.

Literature

- **Trade affects structural change**
  - Matsuyama (2009); Uy, Yi, and Zhang (2013); Betts, Giri and Verma (2016); Teignier (2016); Sposi (2019); Kehoe, Ruhl and Steinberg (2016); Święcki (2016); Reyes-Heroles (2017)
- **Why does trade grow faster than GDP?**
  - Rose (2011); Baier and Bergstrand (2001); Imbs and Wacziarg (2003); Yi (2003)
- **Non-homothetic preferences help explain trade patterns**
  - Markusen (1986); Fieler (2011); Simonovska (2015)

Empirical Counterfactual

- Data openness (26 countries and ROW 1970-2015):

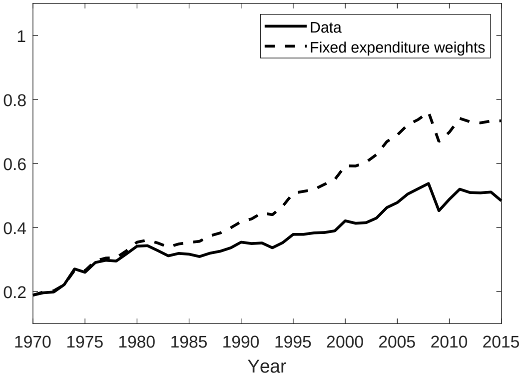
$$\frac{Trade_t}{Exp_t} = \frac{Trade_{gt}}{Exp_{gt}}\frac{Exp_{gt}}{Exp_t} + \frac{Trade_{st}}{Exp_{st}}\frac{Exp_{st}}{Exp_t}$$

- Counterfactual openness:

$$\frac{\widetilde{Trade_t}}{Exp_t} = \frac{Trade_{gt}}{Exp_{gt}}\frac{Exp_{g0}}{Exp_0} + \frac{Trade_{st}}{Exp_{st}}\frac{Exp_{s0}}{Exp_0}$$

Empirical Counterfactual

Figure 4: Aggregate Trade to Expenditure Ratio



- In the counterfactual, the trade/expenditure ratio is 52 percent or 25 ppts higher than in the data in 2015.

Discussion on Empirical Counterfactual

- Reduced form analysis shows substantial impact of structural change on global trade flows.
- On the other hand, the reduced form analysis is limited
  - Ignores endogenous responses of sectoral trade openness to structural change.
    - Ignores endogenous responses of prices and trade patterns.
    - Ignores input-output linkages.
- So we analyze the implications of structural change on international trade in a quantitative model.

Model

- A multi-country two-sector Eaton-Kortum trade model with two key features:

  1. Non-homothetic CES preferences generate the rising expenditure share of services over time.

  2. An input-output structure generates gross trade and accounts for linkages across sectors.

- The EK structure generates both intra- and inter-sector trade, which is crucial for matching bilateral trade patterns.

Model: Budget Constraint

- Representative household in each country.
- Earns labor income and spends on goods and services:

$$\underbrace{P_{ig}C_{ig} + P_{is}C_{is}}_{P_iC_i} = w_iL_i - \underbrace{(\rho_iw_iL_i - RL_i)}_{NX_i},$$

- Trade imbalances are introduced as in Caliendo, Parro, Rossi-Hansberg, and Sarte (2016).
  - A exogenous fraction ρ_i of income is sent to global portfolio.
  - Global portfolio disperses R to every worker to maintain zero balance.

Model: Preferences

- We use "non-homothetic CES" preferences, as in Gorman (1965); Hanoch (1975); Comin, Lashkari, and Mestieri (2020).

- Aggregate consumption, C_i, combines sectoral composite goods, C_{ik}, according to the implicitly defined function:

$$1 = \sum_{k=g,s} (\omega_k)^{\frac{1}{\sigma}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_k(1-\sigma)}{\sigma}} \left(\frac{C_{ik}}{L_i}\right)^{\frac{\sigma-1}{\sigma}},$$

  - σ gives elasticity of substitution between sectoral composites.
  - ϵ_k gives sector-specific income elasticity of demand.

Model: Optimality

- The sectoral expenditure shares are given by:

$$e_{ik} = \frac{P_{ik} C_{ik}}{P_i C_i} = \omega_k \left(\frac{P_{ik}}{P_i} \right)^{1-\sigma} \left(\frac{C_i}{L_i} \right)^{(1-\sigma)(\epsilon_k - 1)}$$

  - σ governs how relative prices affect expenditure shares.
  - ϵ_k governs how income affects expenditure shares.

- The average cost of real consumption:

$$P_i = \left[\sum_{k=g,s} \omega_k \left(\frac{C_i}{L_i} \right)^{(1-\sigma)(\epsilon_k - 1)} P_{ik}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

Model: Production

- Continuum of tradable varieties in each sector, $z \in [0,1]$.
- Production of variety z in sector k and country i:

$$Y_{ik}(z) = A_{ik}(z)(T_{ik} L_{ik}(z))^{\lambda_{ik}} \left[\Pi_{n=g,s} M_{ikn}^{\gamma_{ikn}}(z)\right]^{1-\lambda_{ik}}$$

  - $A_{ik}(z)$ is drawn from a Fréchet with shape parameter θ_k.
  - T_{ik} is value-added productivity.
- Sector composite ("absorption"), standard in EK.

$$Q_{ik} = \left(\int_0^1 Q_{ik}(z)^{\frac{\eta-1}{\eta}} dz\right)^{\frac{\eta}{\eta-1}}$$

  - Absorption is split between final consumption and input usage:

$$Q_{ik} = C_{ik} + \sum_{n=g,s} M_{ink}$$

Model: Trade

- Sectors source from the cheapest place with trade costs τ_{ijk}.
- Bilateral import shares:

$$\pi_{ijk} = \frac{T_{jk}^{\theta\lambda_{jk}} \left(\nu_{jk}\tau_{ijk}\right)^{-\theta}}{\sum_{s=1}^{I} T_{jk}^{\theta\lambda_{jk}} \left(\nu_{sk}\tau_{isk}\right)^{-\theta}}$$

  where

$$\nu_{ik} = B_{ik} w_i^{\lambda_{ik}} \left(\Pi_{n=g,s} \left(P_{in}\right)^{\gamma_{ikn}}\right)^{1-\lambda_{ik}}$$

- Market clearing:

$$\sum_{j=1}^{I} P_{jk} Q_{jk} \pi_{jik} = P_{ik} Y_{ik}$$

$$\sum_{i=1}^{I} \rho_i w_i L_i = R \sum_{i=1}^{I} L_i$$

Model: Equilibrium

- *A competitive equilibrium* is a sequence of output and factor prices $\{w_i, P_{ig}, P_{is}, P_i\}_{i=1}^{I}$, allocations $\{L_{ig}, L_{is}, M_{igg}, M_{igs}, M_{isg}, M_{iss}, Q_{ig}, Q_{is}, Y_{ig}, Y_{is}, C_{ig}, C_{is}, C_i\}_{i=1}^{I}$, transfers from the global portfolio, R, and trade shares $\{\pi_{ijg}, \pi_{ijs}\}_{i,j=1,..I}$ over time, such that

    1. given prices, allocations are optimal in each period;
    2. markets clear in each period.

Calibration

- 26 countries and ROW aggregate over 1970–2015
- Two sectors: goods and services
- Labor endowment $\{L_i\}$: employment data.
- Trade imbalances $\{\rho_i\}$: net exports data
- Production coefficients $\{\lambda_{ik}, \gamma_{ikn}\}$: WIOD
- Fréchet parameters θ_k: 4.0 (Simonovska and Waugh 2014)
- Preference parameters $\{\sigma, \epsilon_k\}$: estimate using FOC
- Trade costs $\{\tau_{ijg}, \tau_{ijs}\}$ & productivities $\{T_{ig}, T_{is}\}$:
  - Calibrate to match trade flows and sectoral expenditures

Calibration of Production Parameters

- World Input-Output database (WIOD) (1995–2014).
  - Extend to the full time period (1970–2015).
- Parameter values (cross-country, cross-time averages):

λ_g	Value added share in sector g	0.38
λ_s	Value added share in sector s	0.59
γ_{gg}	Share of g's Intermediate input from g	0.67
γ_{ss}	Share of s's Intermediate input from s	0.69

Calibration of Preferences

- Estimate $\{\sigma, \varepsilon_s\}$ with constrained NLS to minimize distance between observed and predicted relative expenditure shares:

$$\min_{\{\sigma,\varepsilon_s\}} \quad \sum_{t=1}^{T}\sum_{i=1}^{I}\left(\left(\frac{\omega_s}{\omega_g}\right)\left(\frac{\widehat{P}_{ist}}{\widehat{P}_{igt}}\right)^{1-\sigma}\left(\frac{C_{it}}{\widehat{L}_{it}}\right)^{(1-\sigma)(\varepsilon_s-\varepsilon_g)} - \left(\frac{\widehat{E}_{ist}}{\widehat{E}_{igt}}\right)\right)^2$$

$$\text{s.t.} \quad \epsilon_g = 1$$

$$\frac{\widehat{E}_{igt}+\widehat{E}_{ist}}{\widehat{L}_{it}} = \left(\sum_{k=g,s}\omega_k \widehat{P}_{ikt}^{1-\sigma}\left(\frac{C_{it}}{\widehat{L}_{it}}\right)^{(1-\sigma)\varepsilon_k}\right)^{\frac{1}{1-\sigma}}, \forall (i,t)$$

  - Unobserved consumption/utility C_{it} is imputed with the expenditure function.

- Estimation results: $\sigma = 0.16$ and $\varepsilon_s = 1.73$

Reduced form

Calibration of Productivity and Trade Costs

- Target expenditure shares and bilateral trade shares:
  - Find $\{P_{ig}, P_{is}\}$ consistent with expenditure shares

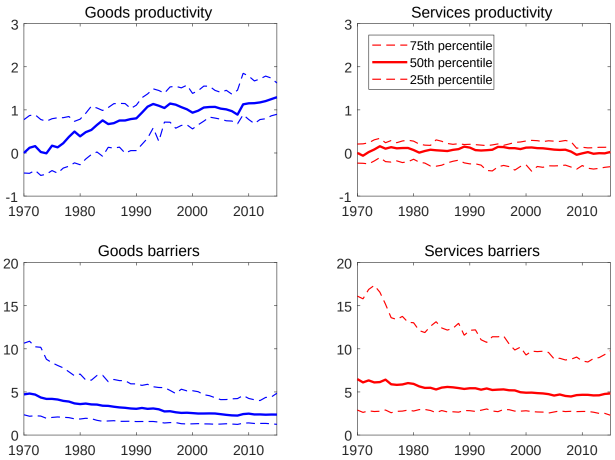
$$\frac{E_{is}}{E_{ig}} = \left(\frac{\omega_s}{\omega_g}\right)\left(\frac{C_i}{L_i}\right)^{\epsilon_s-\epsilon_g}\left(\frac{P_{is}}{P_{ig}}\right)$$

  - Calibrate T_{ik} and τ_{ijk} using $\{P_{ig}, P_{is}\}$ and π_{ijk}:

$$T_{ik}^{\lambda_{ik}} = \frac{B_{ik}\nu_{ik}}{\Gamma_k^{-1} P_{ik} \left(\pi_{iik}\right)^{-\frac{1}{\theta_k}}}$$

$$\tau_{ijk} = \left(\frac{\pi_{ijk}}{\pi_{jjk}}\right)^{-\frac{1}{\theta_k}}\left(\frac{P_{ik}}{P_{jk}}\right)$$

Summary of Productivity and Trade Costs



- Productivity growth is faster in goods than in services.
- Trade barriers decline faster and are lower for goods.

Model Fit

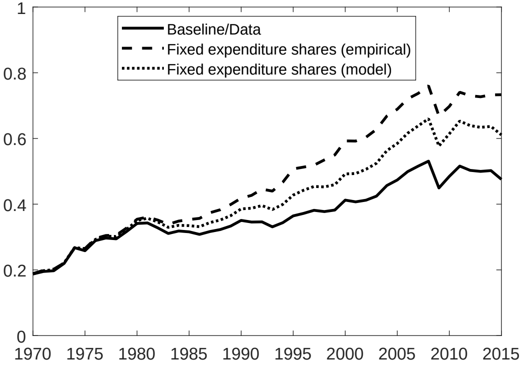
Goods Prices
Services Prices
Services employment share
Model
Data
Data
Data
45°
2
1
0
-1
-2
0.5
0.2
0.4
0.6
0.8

Model-based Counterfactual

- Solve the model counterfactuals by setting $\varepsilon_k = 1$, $\sigma = 1$, and $\omega_{ik} = e_{ik0}$.
  - No income effects: $\epsilon_g = \epsilon_s = 1$.
  - No relative price effects: $\sigma = 1$.
- Keep all other baseline driving forces unchanged.
- Compare the resulting changes in trade-to-expenditure ratios to the baseline model solution.

Model-Based v.s. Empirical Counterfactual

Figure 5: Global Trade to Expenditure Ratio



- By 2015, the model-based counterfactual is 13 ppts or 27 percent higher than the data. Goods expenditure share
- The empirical counterfactual overestimates the impact of structural change on global openness by 12 ppts.

Counterfactual v.s. Data

- Why did the empirical and model-based counterfactual differ?

- Because sector openness is not immune to structural change.

$$\frac{Trade_{it}}{Exp_{it}} = \left(\frac{Trade_{igt}}{Exp_{igt}}\right) e_{ig0} + \left(\frac{Trade_{ist}}{Exp_{ist}}\right) e_{is0}$$

- Decompose sectoral openness

$$\frac{Trade_{ikt}}{Exp_{ikt}} = \left(\frac{Trade_{ikt}}{Absorption_{ikt}}\right)\left(\frac{Absorption_{ikt}}{Exp_{ikt}}\right)$$

- Input-output linkages:

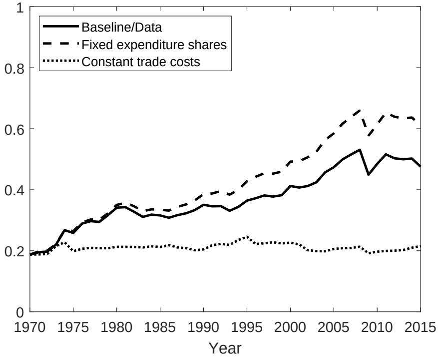
$$\frac{Absorption_{igt}}{Exp_{igt}} \downarrow = \frac{Exp_{igt} \uparrow + Int_{iggt} \uparrow + Int_{isgt} \downarrow}{Exp_{igt} \uparrow}$$

▸ Figures

Counterfactual with Fixed Trade Costs

- Set $\tau_{ijkt} = \tau_{ijk0}$

Figure 6: Global Trade over Expenditure: Constant Trade Costs



- Impact of structural change on global trade growth is half as strong as that of trade barriers

Implication of Structural Change on Gains from Trade

- Under homothetic preferences gains from trade are changes in real income or consumption
- Under nonhomothetic preferences, gains from trade are *equivalent variation* between trade and autarky.

Table 1: Gains from trade

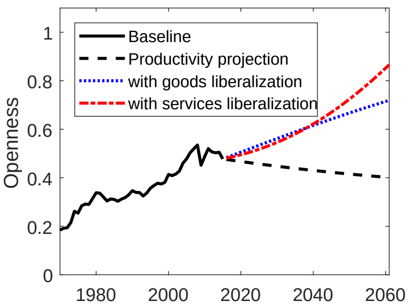
	1970	2015	Δppts
Baseline	4.1%	9.4%	5.3
Fixed expenditure shares	4.2%	12.0%	7.8

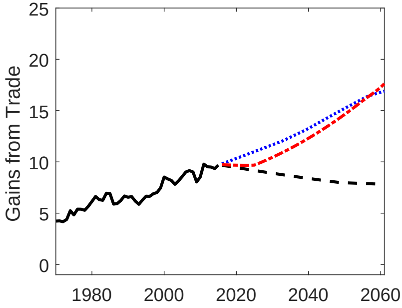
- Measured gains from trade of 2015 are 2.6 ppts lower in the baseline than in the counterfactual.
- Trade integration occurs mainly in goods, but expenditure shifts away from goods with structural change.

Projection of Productivity

- Assume that sectoral productivity grows at the average rate for next 46 years with other parameters at 2015 levels.

Figure 7: Projection of Productivity



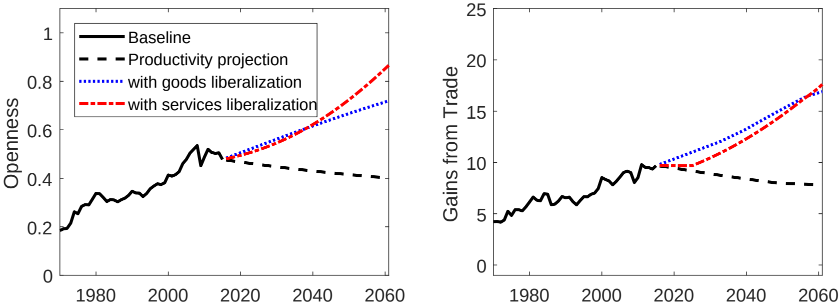


- Global trade openness would fall to 40% in 2061.

Projection of Trade Policy

- Further assume that trade costs continue to decline at 1.5% per year for another 46 years, for either goods or services.

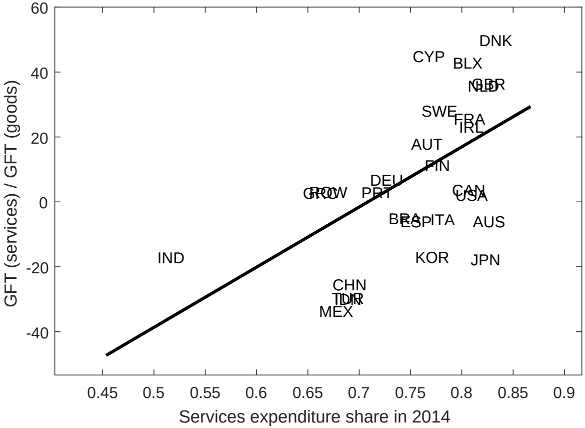
Figure 8: Projection of Trade Policy



- The boost to global trade openness is increasingly large with declining services trade costs.

Gains from Trade Comparison

Figure 9: Gains from trade comparison



- Higher income countries tend to benefit more from the reduction in services trade costs.

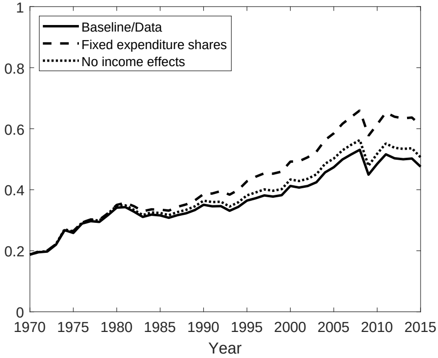
Conclusion

- Structural change dragged down global trade growth over the past five decades.
- Our model estimates that global trade openness would be 27 percent higher if structural change had not occurred.
  - Structural change held back global trade growth roughly as much as reductions in trade costs boosted it.
- Structural change is critical for estimating gains from trade.
  - GFT is lower with structural change.
- Global openness might decrease in coming years if the effect of structural change dominates that of trade costs.

Counterfactual with no income effect

- Set $\varepsilon_s = 1$

Figure 10: Global Trade over Expenditure: No Income Effects



- Income effect less important than price effect for the dampening effect of structural change on trade

Country List

Australia, Austria, Belgium-Luxembourg, Brazil, Canada, China, Cyprus, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Portugal, Spain, Sweden, Turkey, United Kingdom, and United States, plus a “Rest of World”

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Figure 11: Derivation of Sectoral Expenditure

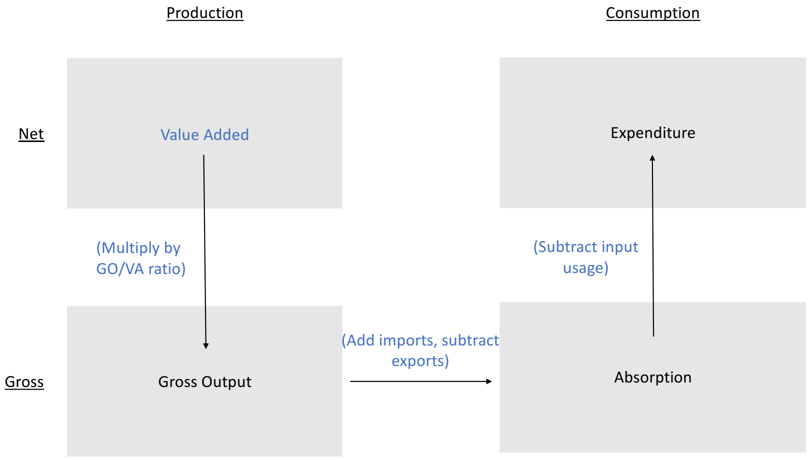

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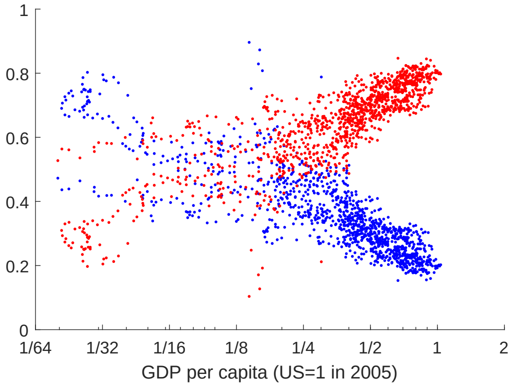
Figure 12: Expenditure shares and income per capita



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Empirical Importance of Nonhomothetic Preferences

$$\log\left(\frac{e_{is}}{e_{ig}}\right) = \text{const} + (1-\sigma)\log\left(\frac{P_{is}}{P_{ig}}\right) + (1-\sigma)(\varepsilon_s - \varepsilon_g)\log\left(\frac{C_i}{L_i}\right)$$

Variable	Prices & income	Prices only
σ^{OLS}	0.28	0.33
	(0.19)	(0.38)
$\epsilon_s^{OLS} - \epsilon_g^{OLS}$	0.76	
	(0.25)	
constant	-4.62	1.11
	(0.63)	(0.33)
N	1242	1242
R^2	0.65	0.06

- The income effect is key for structural change

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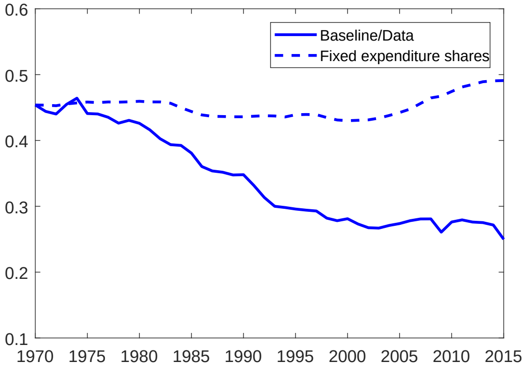
Counterfactual Global Expenditure Shares

Figure 13: Global Expenditure Share on Goods



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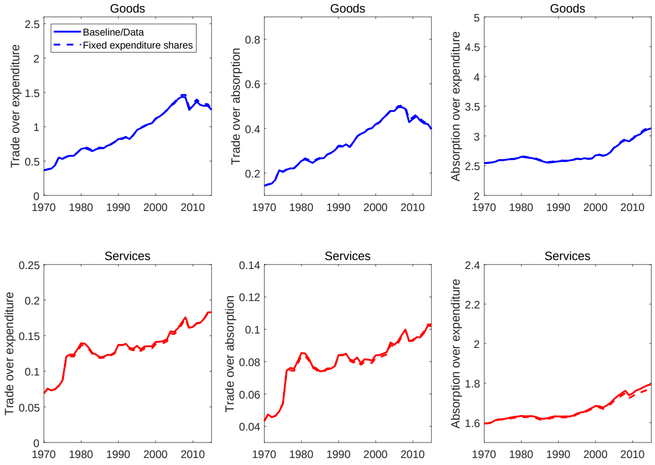
Sectoral openness and input-output linkages

Figure 14: Model without input-output linkages



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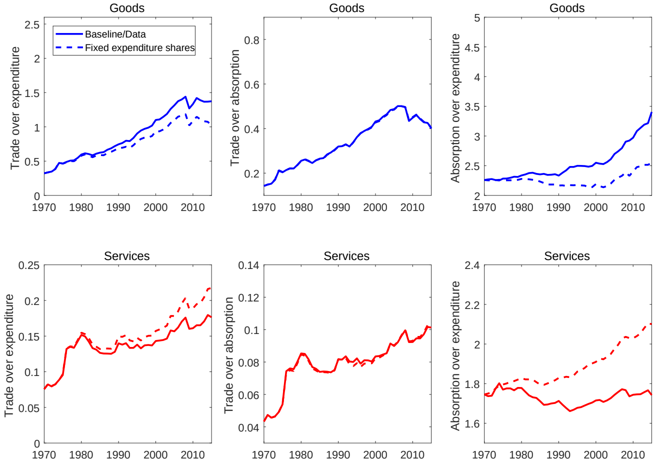
Sectoral openness and input-output linkages

Figure 15: Baseline model with input-output linkages



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