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Appendix

# Bilateral Trade Imbalances

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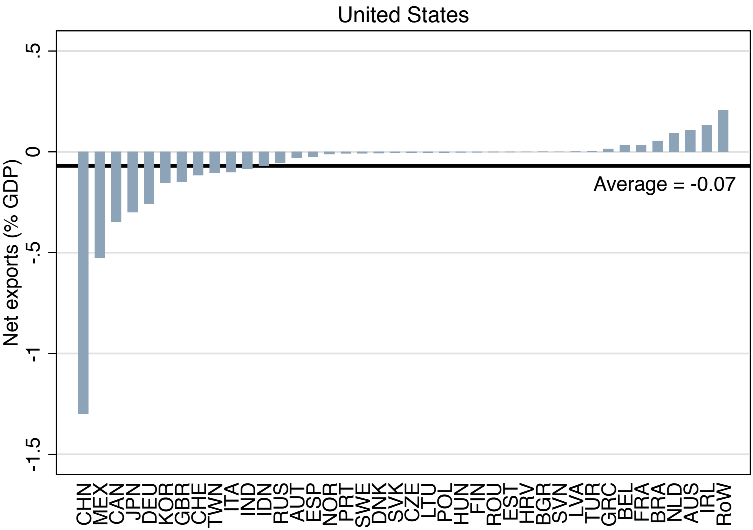
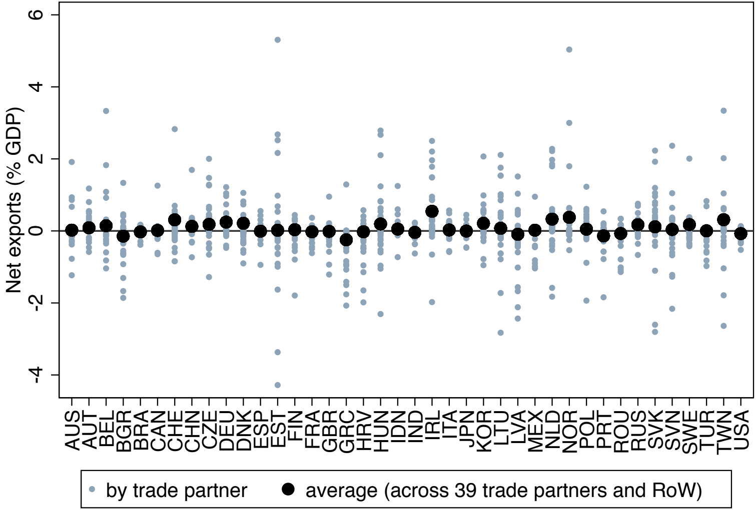
# 1 Motivation and Outline




*U.S. bilateral net exports (2010-14)*

# 1 Motivation and Outline




Note: excludes extreme values.

*Bilateral net exports for 40 countries (2010-14)*

# 1 Motivation and Outline



**Fact:** there is a lot more variation in countries' *bilateral* trade balances than in their overall net exports.

◂ CHN ◂ JPN ◂ GBR ◂ DEU

Why do some country pairs have bigger imbalances than others?

1. macroeconomic factors: overall trade surpluses/deficits
2. "triangular trade": differences in expenditure/production
3. asymmetric trade frictions?

(Almost) no formal study of relative importance of 1., 2. – and 3.!

We combine a quantitative trade model with sectoral-level data on production, spending, trade from WIOD to provide it.

# 1 Motivation and Outline



We calibrate the steady state of a dynamic many-country, many-sector quantitative trade model to match observed trade flows:

1. overall trade surpluses/deficits $\Leftarrow$ savings prefs., prod. techs.
2. expenditure/production differences $\Leftarrow$ cons. prefs., prod. techs.
3. sectoral bilateral trade flows $\Leftarrow$ "residual" trade wedges

**Findings:**

- Overall trade surpluses/deficits and triangular trade play a minor role.
- Sizeable trade-wedge asymmetries needed to match data!
- These account for ≈75% of the variation in bilateral balances.
- Equalisation of wedges $\Rightarrow$ big effects on trade flows, welfare.

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**Related Literature:**

1. **Bilateral trade imbalances:**
   Feenstra et al. (1998), Davis & Weinstein (2002), Felbermayr & Yotov (2019)
2. **International trade, aggregate net exports and income:**
   Eaton & Kortum (2002), Dekle et al. (2007, 2008), Reyes-Heroles (2016), Cuñat & Zymek (2017)
3. **Asymmetric trade frictions and income:**
   Waugh (2010)
4. **Gravity models, trade flows and trade costs:**
   Anderson (1979), Anderson & van Wincoop (2003, 2004), Costinot & Rodríguez-Clare (2014), Head & Mayer (2014), Fally (2015)

# 1 Motivation and Outline

1. Motivation and Outline
2. Bilateral Balance "Accounting"
3. Model
4. Counterfactuals
5. Summary and Conclusion

# 2 Bilateral Balance Accounting

Assume sector-level trade flows obey a gravity equation of the form

$$M_{sn'n} = \left( \frac{\tau_{sn'n}}{O_{sn'} P_{sn}} \right)^{-\theta_s} \frac{D_{sn'} E_{sn}}{D_s}$$

$M_{sn'n}$: expenditure by country $n$ from country $n'$ in sector $s$

$\tau_{sn'n}$: ad-valorem-equivalent trade "wedges" applying to $M_{sn'n}$

$\theta_s$: trade elasticity

$D_{sn'}$: value of country $n'$ output in sector $s$

$E_{sn}$: country $n$ expenditure in sector $s$

$D_s$ : arbitrary, potentially sector-specific "normaliser"

$$O_{sn'}^{-\theta_s} \equiv \left[ \sum_{n=1}^{N} \left( \frac{\tau_{sn'n}}{P_{sn}} \right)^{-\theta_s} \frac{E_{sn}}{D_s} \right], P_{sn}^{-\theta_s} \equiv \left[ \sum_{n'=1}^{N} \left( \frac{\tau_{sn'n}}{O_{sn'}} \right)^{-\theta_s} \frac{D_{sn'}}{D_s} \right]$$

# 2 Bilateral Balance Accounting



Sufficient conditions for expressions in previous slide:

1. $v_{sn'n} \equiv M_{sn'n}/E_{sn}$ can be expressed in multiplicatively separable form:

$$v_{sn'n} = \frac{F_{sn'}}{D_s}\left(\frac{\tau_{sn'n}}{P_{sn}}\right)^{-\theta_s}, \quad P_{sn}^{-\theta_s} D_s \equiv \sum_{n'=1}^{N} F_{sn'} \tau_{sn'n}^{-\theta_s}$$

2. Market clearing for each origin country:

$$D_{sn'} = \sum_{n=1}^{N} M_{sn'n} = F_{sn'} \sum_{n=1}^{N} \left(\frac{\tau_{sn'n}}{P_{sn}}\right)^{-\theta_s} \frac{E_{sn}}{D_s} \equiv F_{sn'} O_{sn'}^{-\theta_s}$$

Condition 1 is consistent with the Armington, Krugman, Eaton-Kortum, and Melitz models.

Condition 2 is satisfied in any standard G.E. trade model.

Bilateral imbalances:

$$M_{n'n} - M_{nn'} = D_{n'} E_n \sum_{s=1}^{S} \left( \frac{\tau_{sn'n}}{O_{sn'} P_{sn}} \right)^{-\theta_s} \frac{d_{sn'} e_{sn}}{D_s} +$$

$$- D_n E_{n'} \sum_{s=1}^{S} \left( \frac{\tau_{snn'}}{O_{sn} P_{sn'}} \right)^{-\theta_s} \frac{d_{sn} e_{sn'}}{D_s}$$

$$M_{n'n} \equiv \sum_s M_{sn'n}, \quad d_{sn} \equiv D_{sn}/D_n, \quad e_{sn} \equiv E_{sn}/E_n$$

$D_n$: value of country-$n$ aggregate output

$E_n = D_n - NX_n$: country-$n$ aggregate spending

$NX_n$: aggregate trade balance of country $n$

# 2 Bilateral Balance Accounting



The bilateral trade deficit $M_{n'n} - M_{nn'}$ is larger...

- ...the smaller $NX_n$ and the larger $NX_{n'}$.
- ...the higher the correlation between $d_{sn'}$ and $e_{sn}$ and the lower the correlation between $d_{sn}$ and $e_{sn'}$.
- ...the smaller $\tau_{sn'n}$ and the larger $\tau_{snn'}$.

Note that...

- ...if $NX_n = 0$ for all $n$, and...
- ...if $e_{sn} = e_s$ and $d_{sn} = d_s$ for all $s$ and $n$, and...
- ...if $\tau_{sn'n} = \tau_{snn'}$ for all $s$, $n'$ and $n$,...

...then $P_{sn} = O_{sn}$ for all $n$ and $s$, so that $M_{n'n} - M_{nn'} = 0$.

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First-order Taylor-series expansion:

Proportional Imbalances

$$\frac{M_{n'n}-M_{nn'}}{M_{n'n}^{\frac{1}{2}}M_{nn'}^{\frac{1}{2}}}\simeq\sum_{s=1}^{S}\left(\frac{M_{sn'n}M_{snn'}}{M_{n'n}M_{nn'}}\right)^{\frac{1}{2}}\left[\ln\left(\frac{1-NX_n/D_n}{1-NX_{n'}/D_{n'}}\right)+\right.$$

$$\left.+\ln\left(\frac{d_{sn'}e_{sn}}{d_{sn}e_{sn'}}\right)-\theta_s\ln\left(\frac{\tau_{sn'n}}{\tau_{snn'}}\right)-\theta_s\ln\left(\frac{O_{sn}P_{sn'}}{O_{sn'}P_{sn}}\right)\right]$$

Estimating gravity equation $M_{sn'n}=e^{\Omega_{sn'}+\Pi_{sn}}\varepsilon_{sn'n}$ with PPML yields:

$$P_{sn}^{-\theta_s}=\frac{E_{sn}}{E_{sN}}e^{-\hat{\Pi}_{sn}},\; O_{sn'}^{-\theta_s}=E_{sN}\frac{D_{sn'}}{D_s}e^{-\hat{\Omega}_{sn'}},\; \tau_{sn'n}^{-\theta_s}=\hat{\varepsilon}_{sn'n}$$

$$\hat{\varepsilon}_{snn}=\frac{M_{snn}}{\sigma_{sn}\left(D_n-NX_n\right)}\Bigg/\frac{D_{sn}}{\sum_{n=1}^{N}D_{sn}}$$

# 2 Bilateral Balance Accounting: Data

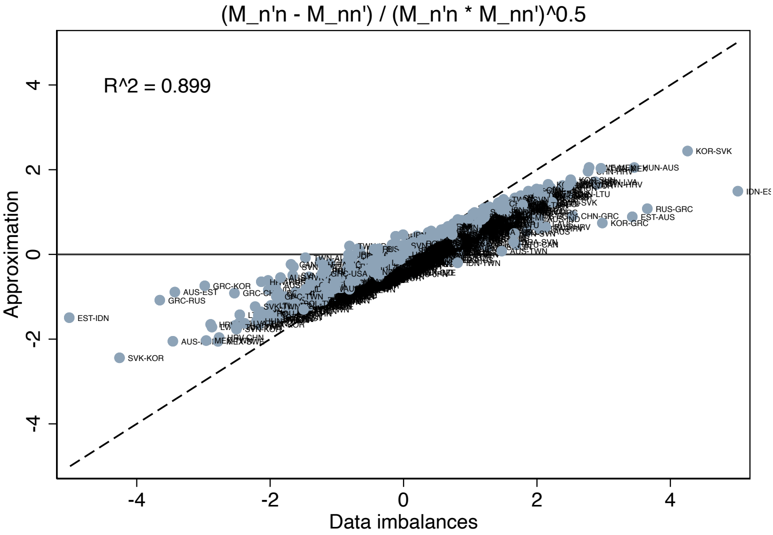
Trade flows, $\{M_{sn'nt}\}_{s,n',n}$, prod. and expend. structure $\{d_{sn}, e_{sn}\}_{s,n}$, net exports $\{nx_{nt}\}_n$: WIOT (Timmer et al., 2016) ◂ WIOT

- average of 5 most recent years: 2010-14
- aggregated to 31 sectors: 16 manufacturing, 15 service
- aggregated to 41 countries/regions:

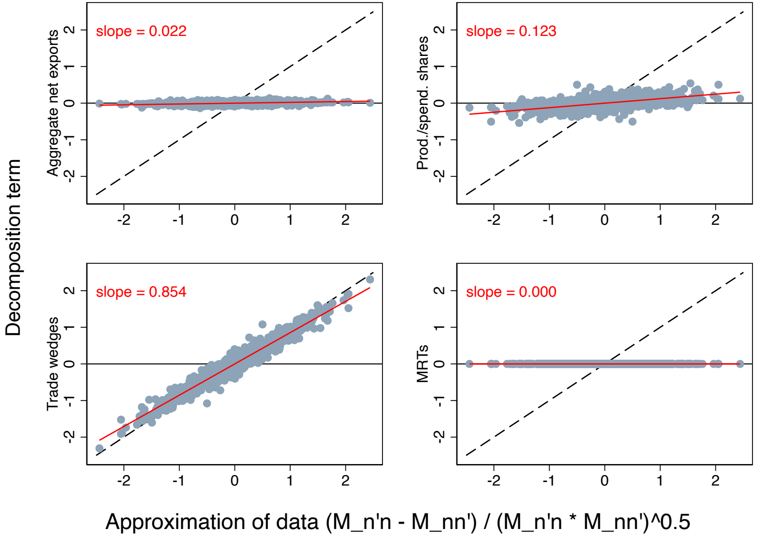
  Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, Turkey, UK, US, and "Rest of the World"

# 2 Bilateral Balance Accounting





# 2 Bilateral Balance Accounting



# 2 Bilateral Balance Accounting

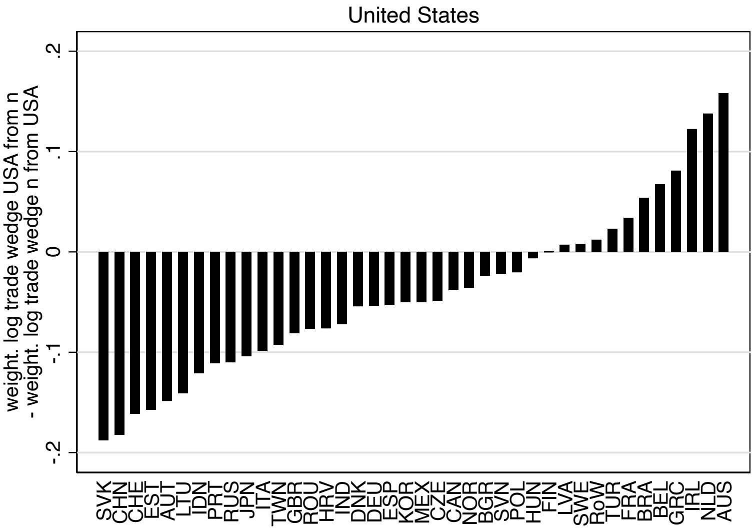
$$-\frac{1}{\theta}\text{Trade-wedges term} = \sum_s \left(\frac{M_{sn'n}M_{snn'}}{M_{n'n}M_{nn'}}\right)^{\frac{1}{2}} \frac{\theta_s}{\theta}\left(\ln \tau_{sn'n} - \ln \tau_{snn'}\right)$$

$$= \sum_s \left(\frac{M_{sn'n}M_{snn'}}{M_{n'n}M_{nn'}}\right)^{\frac{1}{2}} \frac{\ln \hat{\varepsilon}_{snn'} - \ln \hat{\varepsilon}_{sn'n}}{\theta}$$

$\theta = 4$

| $-\frac{1}{\theta}$Trade-wedges term $> 0$ | | | | | |
|---|---|---|---|---|---|
| # obs. | mean | st. dev. | 10th pctl. | median | 90th pctl. |
| 820 | .099 | .086 | .015 | .076 | .220 |

# 2 Bilateral Balance Accounting




◂ USA-CHN ◂ CHN ◂ JPN ◂ GBR ◂ DEU

# 3 Model



$N$ countries, each populated by a unit mass of agents.

Each period, a random fraction $\xi$ of agents dies, is replaced by $\xi$ new agents. The newly born have no assets.

Agents can accumulate assets through saving. Actuarily fair life insurance is available: agents hand all assets over if they die, and receive $1/(1-\xi)$ their assets if they live.

An agent born in country $n$ and period $t'$ maximises

$$E_{t'}\left[\sum_{t=t'}^{\infty}\left(\frac{1-\xi}{1+\rho_n}\right)^{t-t'}\ln C_{nt}(t')\right], \quad \rho_n > -\xi$$

$$P_{nt}^{C}C_{nt}(t')+B_{nt+1}(t')+P_{nt}^{I}I_{nt}(t') \leq \frac{R_t B_{nt}(t') + r_{nt}K_{nt}(t')}{1-\xi}+w_{nt}H_{nt}$$

$$K_{nt+1}(t') = I_{nt}(t') + (1-\delta)K_{nt}(t'); \quad \frac{H_{nt+1}}{H_{nt}} = \gamma \;\; \forall\, t$$

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# 3 Model

$S$ sectors, all producing under perfect competition Picture

Non-traded "all-purpose" good $X_{nt} = C_{nt} + \eta_n I_{nt} + \sum_s J_{snt}$

$$X_{nt} = \prod_s \left( \frac{X_{snt}}{\sigma_{sn}} \right)^{\sigma_{sn}}; \qquad X_{snt} = \left( \sum_{n'} \omega_{sn'n}^{\frac{1}{1+\theta_s}} x_{sn'nt}^{\frac{\theta_s}{1+\theta_s}} \right)^{\frac{1+\theta_s}{\theta_s}}$$

Armington assumption: $x_{sn}$ is a sector-country distinct good.

Sector $s$ in $n$ uses:

$$Q_{snt} = z_{sn} \left( \frac{K_{snt}^{\alpha_n} H_{snt}^{1-\alpha_n}}{1-\mu_{sn}} \right)^{1-\mu_{sn}} \left( \frac{J_{snt}}{\mu_{sn}} \right)^{\mu_{sn}}$$

"Iceberg" transport cost: $p_{sn'nt} = \kappa_{sn'n} p_{sn't}$

$$C_{nt} \equiv \sum_{t'=-\infty}^{t} \xi (1-\xi)^{t-t'} C_{nt}(t'); \; I_{nt} = \sum_{t'=-\infty}^{t} \xi (1-\xi)^{t-t'} I_{nt}(t')$$

# 3 Model: Steady State

Competitive pricing:

$$P_n^C = P_n^J = \frac{P_n^I}{\eta_n} = \prod_s \left[ \sum_{n'} \left( \tau_{sn'n} p_{sn'} \right)^{-\theta_s} \right]^{-\frac{\sigma_{sn}}{\theta_s}} \equiv P_n$$

$$p_{sn} = \frac{1}{z_{sn}} f_n^{1-\mu_{sn}} P_n^{\mu_{sn}}; \quad f_n \equiv \left( \frac{r_n}{\alpha_n} \right)^{\alpha_n} \left( \frac{w_n}{1-\alpha_n} \right)^{1-\alpha_n}$$

$$\tau_{sn'n} \equiv \omega_{sn'n}^{-1/\theta_s} \kappa_{sn'n}$$

Efficient investment:

$$R = \frac{\alpha_n}{\eta_n} \frac{f_n}{P_n} k_n^{\alpha_n - 1} + 1 - \delta$$

$$k_n \equiv \frac{K_{nt}}{H_{nt}}$$

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Aggregate net exports ($nx_n \equiv \frac{NX_{nt}}{f_n k_n^{\alpha_n} H_{nt}}$):

$$nx_n = 1 - \frac{\alpha_n \left(1 - \frac{1-\delta}{\gamma}\right)}{\frac{R}{\gamma} - \frac{1-\delta}{\gamma}} - \frac{\xi\left(\rho_n + \xi\right)\frac{R}{\gamma}\left(1 - \alpha_n\right)}{\left[1 + \rho_n - \frac{R}{\gamma}\left(1 - \xi\right)\right]\left[\frac{R}{\gamma} - \left(1 - \xi\right)\right]}$$

Sectoral trade flows:

Gravity

$$M_{sn'nt} = \frac{\left(\tau_{sn'n} p_{sn'}\right)^{-\theta_s}}{\sum_{n''=1}^{N}\left(\tau_{sn''n} p_{sn''}\right)^{-\theta_s}} \sigma_{sn}\left(\sum_s p_{sn} Q_{snt} - NX_{nt}\right)$$

Market clearing:

$$p_{sn} Q_{snt} = \sum_{n'} M_{snn't}; \;\; f_n k_n^{\alpha_n} H_{nt} = \sum_s \left(1 - \mu_{sn}\right) p_{sn} Q_{snt}; \;\; \sum_n NX_{nt} = 0$$

# 3 Model: Exact Hat Algebra (Trade Block)

For any variable $x_n$, $\hat{x}_n \equiv \tilde{x}_n / x_n$, where $\tilde{x}_n$ is its new outcome.

1. Trade shares ($\hat{z}_{sn} = \hat{z}_n$ for all $s, n$):

◂ Spending Shares

$$\hat{v}_{sn'n} = \frac{\left[ \frac{\hat{\tau}_{sn'n} \hat{f}_{n'}}{\hat{z}_{n'}^{1+\mu_{sn'}/(1-\sum_s \sigma_{sn'}\mu_{sn'})}} \left( \prod_{s=1}^{S} \hat{v}_{sn'n'}^{\frac{1}{\theta_s} \frac{\sigma_{sn'}}{1-\sum_s \sigma_{sn'}\mu_{sn'}}} \right)^{\mu_{sn'}} \right]^{-\theta_s}}{\sum_{n'=1}^{N} \left[ \frac{\hat{\tau}_{sn'n} \hat{f}_{n'}}{\hat{z}_{n'}^{1+\mu_{sn'}/(1-\sum_s \sigma_{sn'}\mu_{sn'})}} \left( \prod_{s=1}^{S} \hat{v}_{sn'n'}^{\frac{1}{\theta_s} \frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}} \right)^{\mu_{sn'}} \right]^{-\theta_s} v_{sn'n}}$$

2. Market clearing ($h_n \equiv \frac{f_n k_n^{\alpha_n} H_{nt}}{\sum_n (f_n k_n^{\alpha_n} H_{nt})}$ , $q_n \equiv \frac{\sum_s p_{sn} Q_{snt}}{f_n k_n^{\alpha_n} H_{nt}}$):

$$\hat{f}_n \hat{k}_n^{\alpha_n} h_n = \sum_{s=1}^{S} (1-\mu_{sn}) \sum_{n'=1}^{N} \hat{v}_{snn'} v_{snn'} \sigma_{sn'} \left( \tilde{q}_{n'} - \tilde{nx}_{n'} \right) \hat{f}_{n'} \hat{k}_{n'}^{\alpha_{n'}} h_{n'}$$

$$\tilde{q}_n \hat{f}_n \hat{k}_n^{\alpha_n} h_n = \sum_{s=1}^{S} \sum_{n'=1}^{N} \hat{v}_{snn'} v_{snn'} \sigma_{sn'} \left( \tilde{q}_{n'} - \tilde{nx}_{n'} \right) \hat{f}_{n'} \hat{k}_{n'}^{\alpha_{n'}} h_{n'}$$

A model based on EK (2002) delivers isomorphic expressions.

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# 3 Model: Exact Hat Algebra (Intertemporal Block)

Financial Autarky

1. Aggregate net exports:

$$\tilde{nx}_n = 1 - \frac{\alpha_n \left(1 - \frac{1-\delta}{\gamma}\right)}{\frac{\tilde{R}}{\gamma} - \frac{1-\delta}{\gamma}} - \frac{\xi \left(\rho_n + \xi\right) \frac{\tilde{R}}{\gamma} \left(1 - \alpha_n\right)}{\left[1 + \rho_n - \frac{\tilde{R}}{\gamma}\left(1 - \xi\right)\right] \left[\frac{\tilde{R}}{\gamma} - \left(1 - \xi\right)\right]}$$

2. Asset market clearing:

$$\sum_{n=1}^{N} \tilde{nx}_n \hat{f}_n \hat{k}_n^{\alpha_n} h_n = 0$$

3. Efficient investment:

$$\frac{\tilde{R} - 1 + \delta}{R - 1 + \delta} = \hat{z}_n^{\frac{1}{1-\sum_s \sigma_{sn}\mu_{sn}}} \left(\prod_{s=1}^{S} \hat{v}_{snn}^{-\frac{1}{\theta_s} \frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}}\right) \hat{k}_n^{\alpha_n - 1}$$

# 4 Counterfactuals: Calibration

| Object | Data |
|---|---|
| $\xi$ | $=$ .13 (life expectancy: 60 years) |
| $\delta$ | $=$ .06 |
| $\gamma$ | $=$ 1.044 (PWT: 1985-2014) |
| $R$ | $=$ 1.030 (King and Low, 2014: 1985-2014) |
| $\{\rho_n\}_n$ | match $\{NX_{nt}/f_n k_n^{\alpha_n} H_{nt}\}_n$ (WIOT) |
| $\{\alpha_n\}_n$ | match 1− country-$n$ labour share (PWT) |
| $\{h_n\}_n$ | match country-$n$ share in world GDP (PWT) |
| $\{\sigma_{sn}\}_{s,n}$ | match country-$n$, sector-$s$ spending share (WIOT) |
| $\{\mu_{sn}\}_{s,n}$ | match country-$n$, sector-$s$ input share (WIOT) |
| $\{\theta_s\}_s$ | match trade elasticities (Caliendo and Parro, 2014; Costinot and Rodríguez-Clare, 2013) |
| $\{v_{sn'n}\}_{s,n,n'}$ | match country-$n'$trade share in country-$n$, sector-$s$ expenditure (WIOT) |

# 4 Counterfactuals

We run a number of counterfactual experiments:

1. Symmetric trade wedges
◂ Symmetric Trade Wedges
2. US-China trade war
◂ US-China Trade War
3. A move to financial autarky
◂ Financial Autarky

# 5 Summary and Conclusion

- There is **a lot of variation** in countries' bilateral trade balances. Typical interpretations:
  1. macroeconomic conditions
  2. "unfair trade"
- Standard models cannot explain ≈**75%** of this variation without asymmetric trade wedges.
  - Asymmetries are sizeable!
  - Have a significant effect on trade patterns, welfare and the international transmission of productivity changes.
- The rest is due mostly to expenditure/production differences.
- New agenda: what lies behind asymmetric trade wedges? (Policy? Model shortcomings? Data? Aggregation?)

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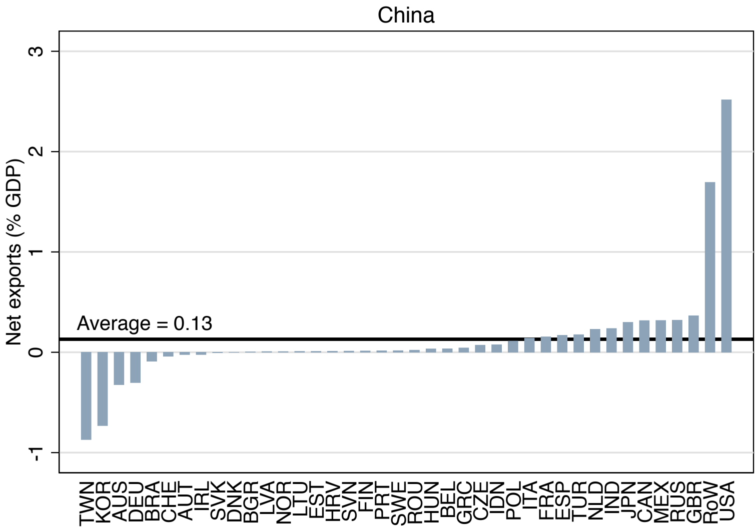


*Bilateral net exports of China (2010-14)*

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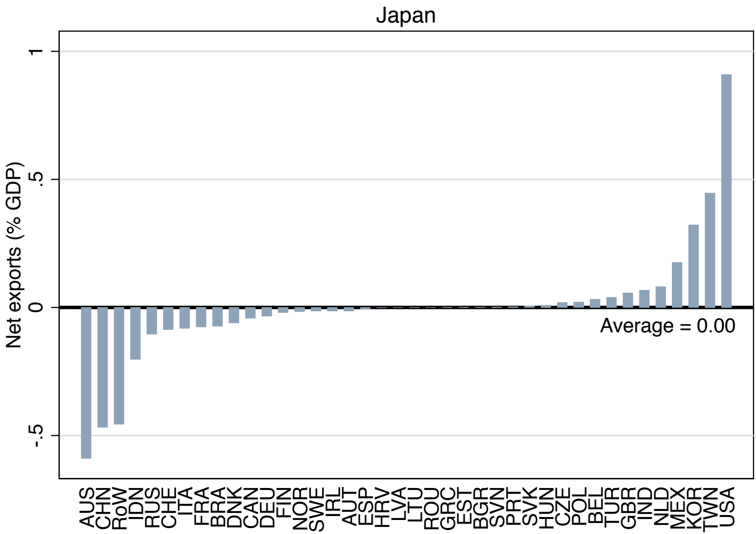
# 1 Motivation and Outline






*Bilateral net exports of Japan (2010-14)*

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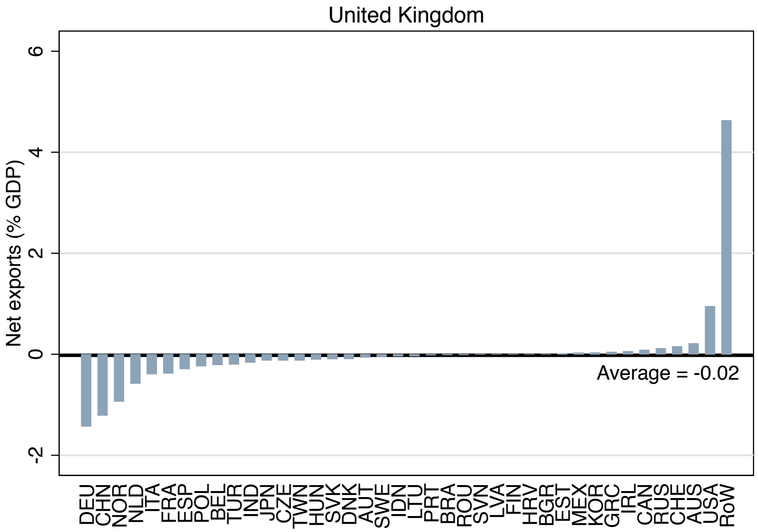


*UK bilateral net exports (2010-14)*

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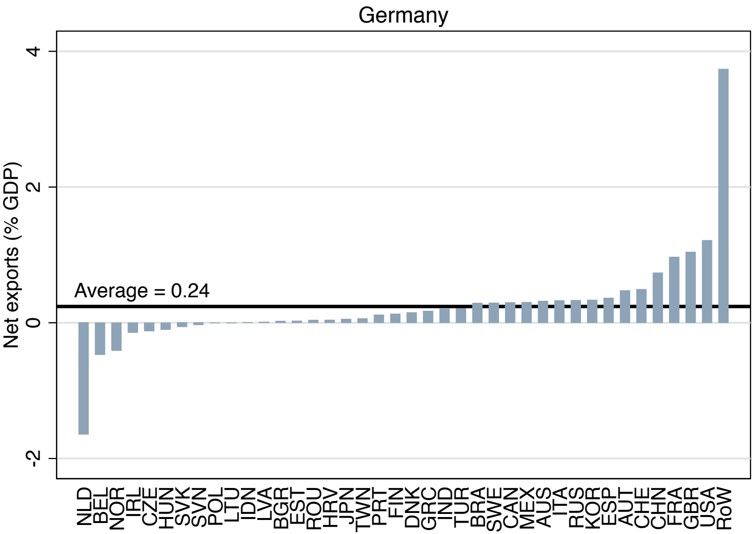


*Bilateral net exports of Germany (2010-14)*

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# 2 Bilateral Balance Accounting

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Bilateral imbalances depend on country size:

$$M_{n'n} - M_{nn'} = M_{n'n}^{\frac{1}{2}} M_{nn'}^{\frac{1}{2}} \times \frac{M_{n'n} - M_{nn'}}{M_{n'n}^{\frac{1}{2}} M_{nn'}^{\frac{1}{2}}}$$

$M_{n'n}^{\frac{1}{2}} M_{nn'}^{\frac{1}{2}}$ depends on well-understood "gravity forces":

$$M_{n'n}^{\frac{1}{2}} M_{nn'}^{\frac{1}{2}} = \frac{D_{n'} D_n}{D} \left(1 - \frac{NX_n}{D_n}\right)^{\frac{1}{2}} \left(1 - \frac{NX_{n'}}{D_{n'}}\right)^{\frac{1}{2}} \times$$

$$\times \left[\sum_{s=1}^{S} \left(\frac{\tau_{sn'n}}{O_{sn'} P_{sn}}\right)^{-\theta_s} \frac{d_{sn'} e_{sn}}{d_s}\right]^{\frac{1}{2}} \left[\sum_{s=1}^{S} \left(\frac{\tau_{snn'}}{O_{sn} P_{sn'}}\right)^{-\theta_s} \frac{d_{sn} e_{sn'}}{d_s}\right]^{\frac{1}{2}}$$

$D \equiv \sum_n \sum_s D_{sn}, \quad d_s \equiv D_s / D$

Proportional imbalances do not depend on country size:

$$\frac{M_{n'n} - M_{nn'}}{M_{n'n}^{\frac{1}{2}} M_{nn'}^{\frac{1}{2}}} = \sum_{s=1}^{S} \frac{M_{sn'n} - M_{snn'}}{M_{sn'n}^{\frac{1}{2}} M_{snn'}^{\frac{1}{2}}} \left(\frac{M_{sn'n} M_{snn'}}{M_{n'n} M_{nn'}}\right)^{\frac{1}{2}}$$

World Input-Output Table for a given year:

| | | | **Use by country-industries** | | | | | | | **Final use by countries** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Country 1 | | | … | Country $N$ | | | Country 1 | … | Country $N$ |
| | | | Industry 1 | … | Industry $S$ | … | Industry 1 | … | Industry $S$ | | | |
| **Supply from country-industries** | Country 1 | Industry 1 | | | | | | | | | | |
| | | … | | | | | | | | | | |
| | | Industry $S$ | | | | | | | | | | |
| | … | … | | | | | | | | | | |
| | Country $N$ | Industry 1 | | | | | | | | | | |
| | | … | | | | | | | | | | |
| | | Industry $S$ | | | | | | | | | | |
| **Gross output** | | | | | | | | | | | | |
| **Value added** | | | | | | | | | | | | |

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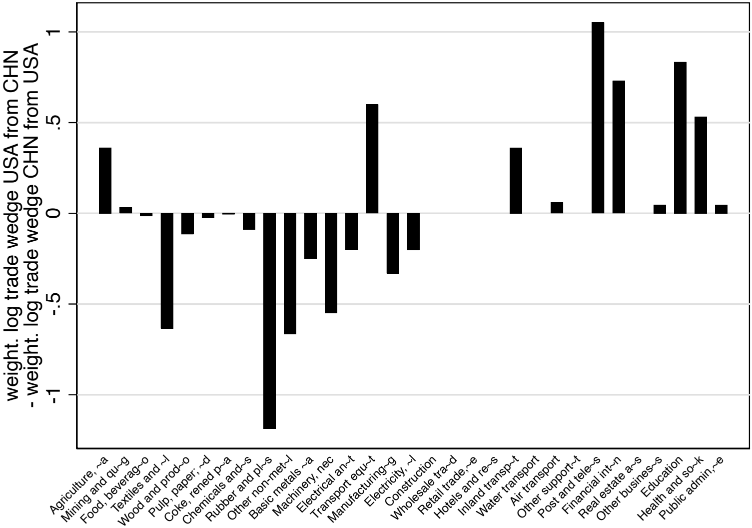


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# 2 Balance Accounting

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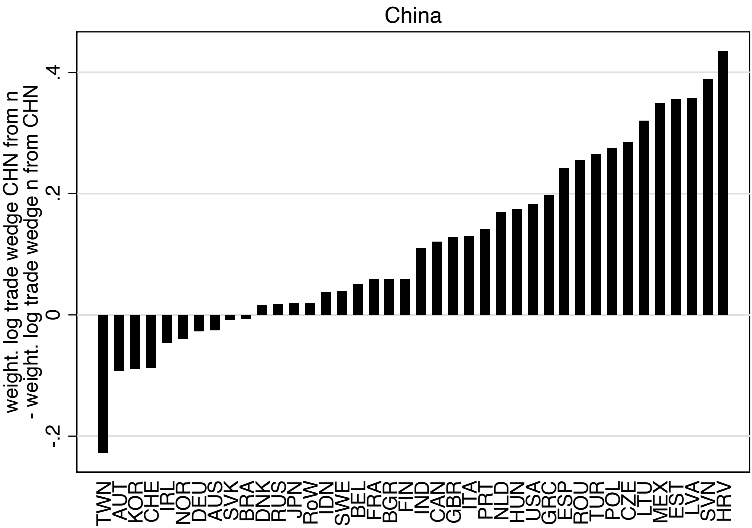


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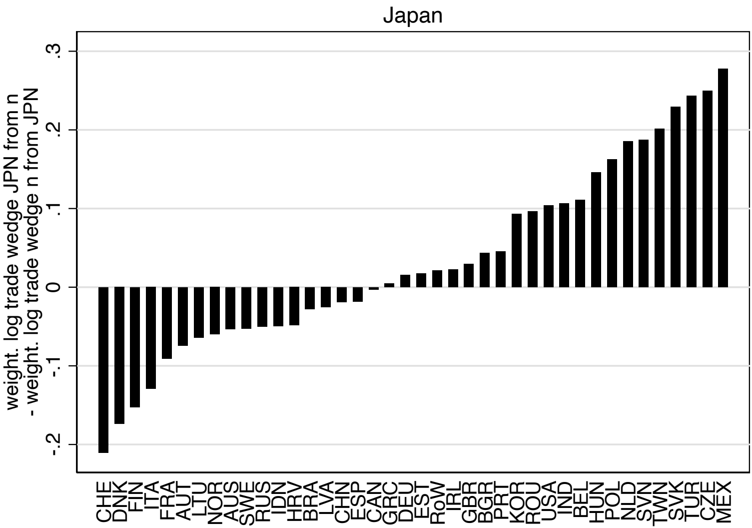
# 2 Balance Accounting



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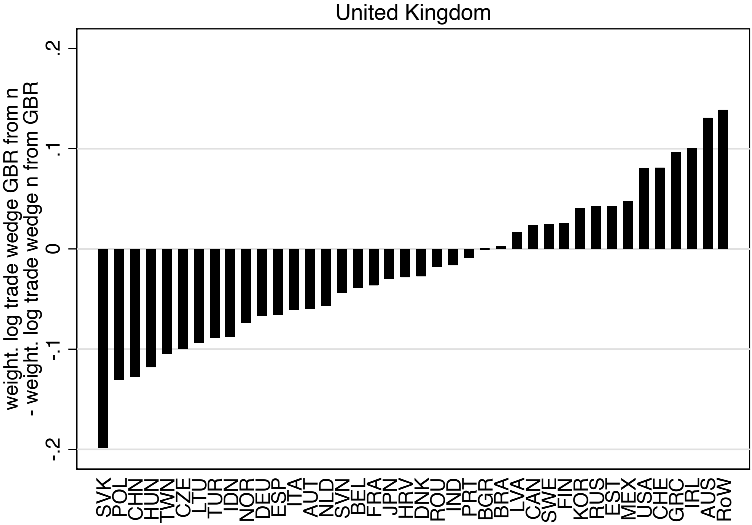
# 2 Balance Accounting

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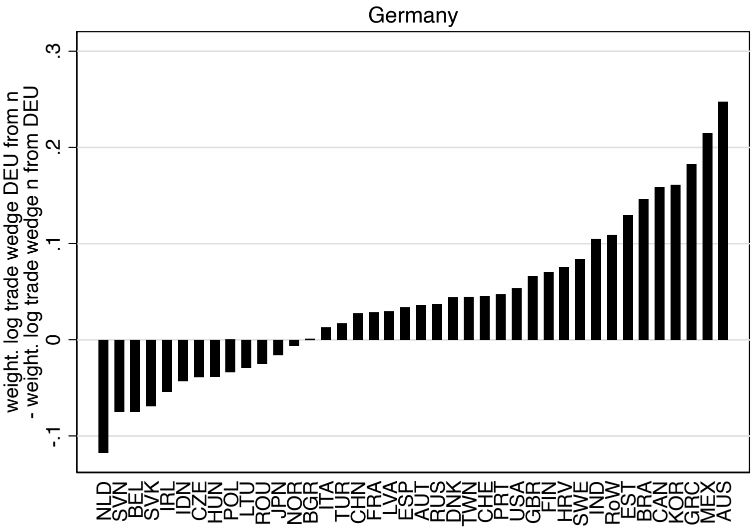
# 2 Balance Accounting

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# 3 Model



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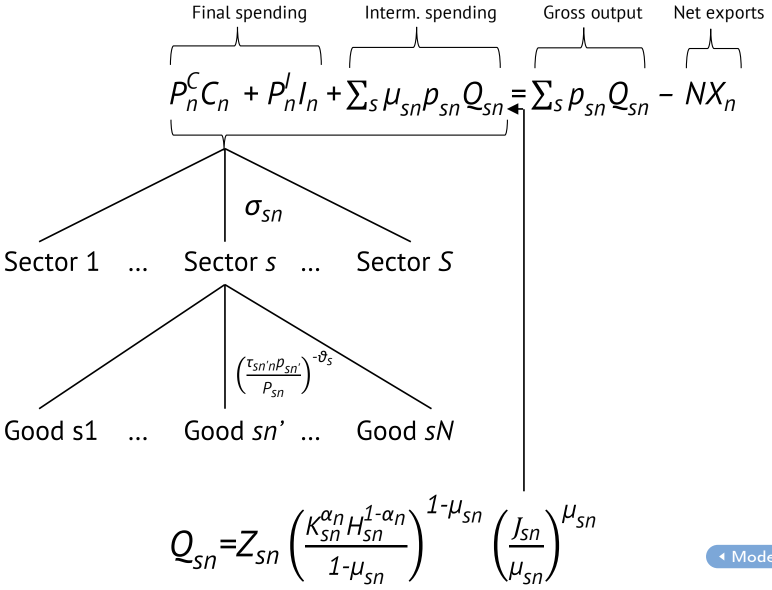


Model

Bilateral Trade Imbalances

A. Cuñat
R. Zymek

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$$M_{sn'nt} = \frac{\left(\tau_{sn'n} p_{sn'}\right)^{-\theta_s}}{\sum_{n''=1}^{N} \left(\tau_{sn''n} p_{sn''}\right)^{-\theta_s}} \sigma_{sn} \left( \sum_s p_{sn} Q_{snt} - NX_{nt} \right) =$$

$$= \frac{F_{sn'} \tau_{sn'n}^{-\theta_s}}{\sum_{n''=1}^{N} F_{sn''} \tau_{sn''n}^{-\theta_s}} E_{sn} = v_{sn'n} E_{sn}$$

From

$$v_{sn'n} = \frac{F_{sn'}}{D_s} \left( \frac{\tau_{sn'n}}{P_{sn}} \right)^{-\theta_s}, \quad P_{sn}^{-\theta_s} D_s \equiv \sum_{n'=1}^{N} F_{sn'} \tau_{sn'n}^{-\theta_s}$$

$$D_{sn'} = \sum_{n=1}^{N} M_{sn'n} = F_{sn'} \sum_{n=1}^{N} \left( \frac{\tau_{sn'n}}{P_{sn}} \right)^{-\theta_s} \frac{E_{sn}}{D_s} \equiv F_{sn'} O_{sn'}^{-\theta_s}$$

we obtain

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$$M_{sn'n} = \left( \frac{\tau_{sn'n}}{O_{sn'} P_{sn}} \right)^{-\theta_s} \frac{D_{sn'} E_{sn}}{D_s}$$

# 3 Model: Exact Hat Algebra

Re-write the following equilibrium conditions in terms of "own spending" shares:

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$$P_n = \frac{f_n}{Z_n} \prod_{s=1}^{S} v_{snn}^{\frac{1}{\theta_s} \frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}}; \quad Z_n \equiv \prod_{s=1}^{S} \left( \frac{z_{sn}}{\tau_{snn}} \right)^{\frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}}$$

$$p_{sn} = \frac{f_n}{z_{sn} Z_n^{\mu_{sn}}} \left( \prod_{s=1}^{S} v_{snn}^{\frac{1}{\theta_s} \frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}} \right)^{\mu_{sn}}$$

$$v_{sn'n} \equiv \frac{\left(\tau_{sn'n} p_{sn'}\right)^{-\theta_s}}{\sum_{n'=1}^{N} \left(\tau_{sn'n} p_{sn'}\right)^{-\theta_s}} = \left( \frac{\tau_{sn'n} p_{sn'}}{\tau_{snn} p_{sn}} \right)^{-\theta_s} v_{snn}$$

$$R = \frac{\alpha_n}{\eta_n} \left( \prod_{s=1}^{S} v_{snn}^{-\frac{1}{\theta_s} \frac{\sigma_{sn}}{1-\sum_s \sigma_{sn}\mu_{sn}}} \right) Z_n k_n^{\alpha_n - 1} + 1 - \delta$$

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A move to financial autarky ($\hat{\tau}_{sn'n} = \hat{z}_{sn} = 1$ for all $s$, $n$, $n'$):

1. Balanced trade ($\tilde{nx}_n = 0$):

$$0 = 1 - \frac{\alpha_n \left(1 - \frac{1-\delta}{\gamma}\right)}{\frac{R_n}{\gamma} - \frac{1-\delta}{\gamma}} - \frac{\xi\left(\rho_n + \xi\right) \frac{R_n}{\gamma} \left(1 - \alpha_n\right)}{\left[1 + \rho_n - \frac{R_n}{\gamma}\left(1 - \xi\right)\right] \left[\frac{R_n}{\gamma} - \left(1 - \xi\right)\right]}$$

2. Efficient investment:

$$\frac{R_n - 1 + \delta}{R - 1 + \delta} = \left( \prod_{s=1}^{S} \hat{v}_{snn}^{-\frac{1}{\theta_s} \frac{\sigma_{sn}}{1 - \sum_s \sigma_{sn}\mu_{sn}}} \right) \hat{k}_n^{\alpha_n - 1}$$

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**Global impact of symmetric trade wedges:**

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Counterfactual:

$$\tilde{\tau}_{sn'n} = \tau_{sn'n}^{\frac{1}{2}} \tau_{snn'}^{\frac{1}{2}} \Longleftrightarrow \hat{\tau}_{sn'n} = \left( \frac{\tau_{snn'}}{\tau_{sn'n}} \right)^{\frac{1}{2}} \qquad \text{for all } s, n', n$$

1. What is the effect on trade imbalances?
   1. Remaining portion of the variation in bilateral imbalances?
   2. What happens to aggregate net exports?
2. What is the effect on real GDP and consumption?
3. How does a country's productivity change affect its trading partners' GDP?

# 4 Counterfactuals: Symmetric Trade Wedges

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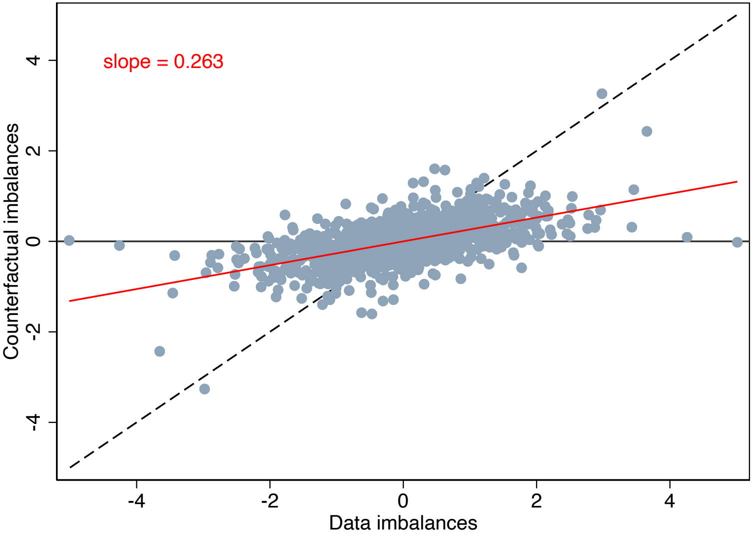

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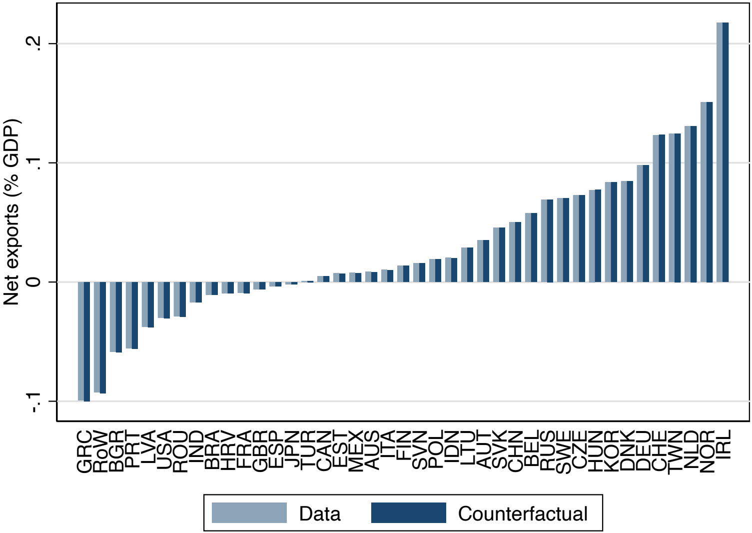


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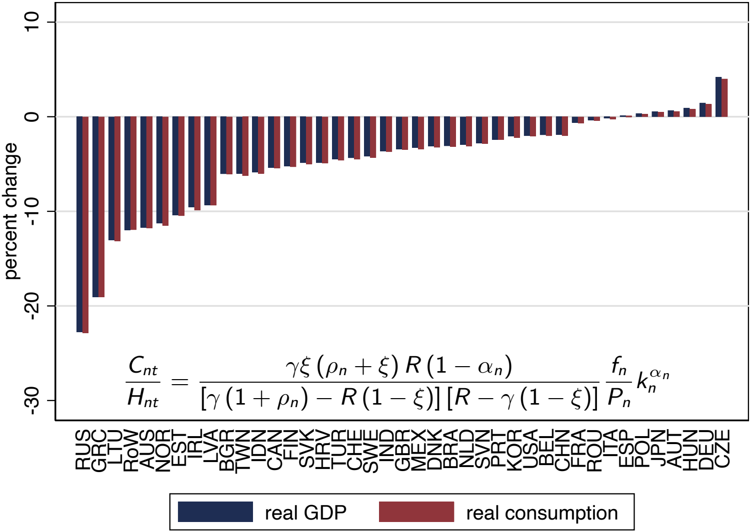
# 4 Counterfactuals: Symmetric Trade Wedges




$$\frac{C_{nt}}{H_{nt}} = \frac{\gamma\xi\left(\rho_n+\xi\right)R\left(1-\alpha_n\right)}{\left[\gamma\left(1+\rho_n\right)-R\left(1-\xi\right)\right]\left[R-\gamma\left(1-\xi\right)\right]}\frac{f_n}{P_n}k_n^{\alpha_n}$$

# 4 Counterfactuals: Symmetric Trade Wedges

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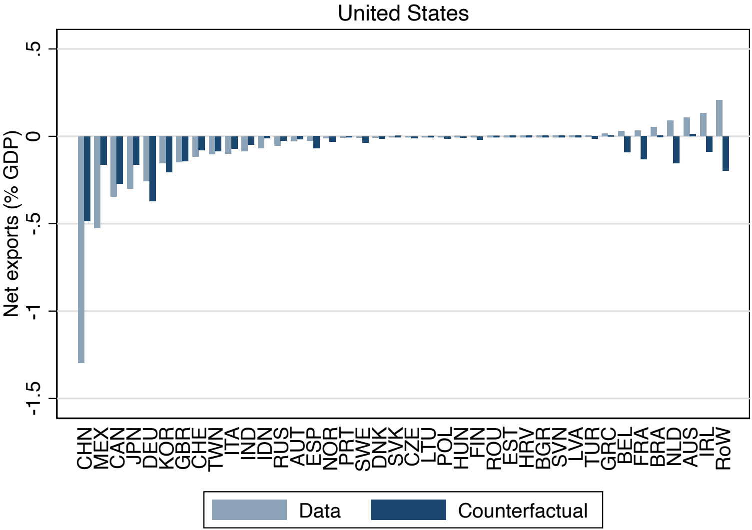

# 4 Counterfactuals: Symmetric Trade Wedges

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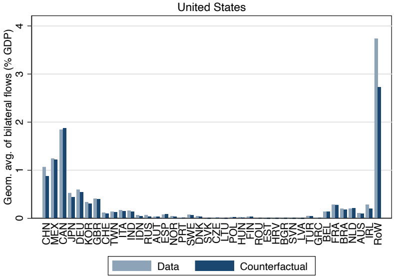
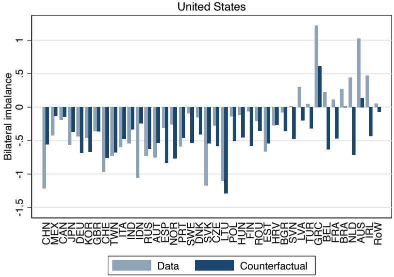



$$\frac{M_{nnt}^{\frac{1}{2}} M_{n'n't}^{\frac{1}{2}}}{f_n k_n^{\alpha n} H_{nt}}$$




$$\frac{M_{nn't} - M_{n'nt}}{M_{nn}^{\frac{1}{2}} M_{n'n'}^{\frac{1}{2}}} \simeq \ln M_{nn't} - \ln M_{n'nt}$$

# 4 Counterfactuals: Symmetric Trade Wedges

We allow for a 1% increase in productivity in a country, and check how this affects GDP in other countries.

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Average country's GDP change in response to China/US productivity change:

| | Asymmetric wedges | Symmetric wedges |
|---|---|---|
| China | 0.128% | 0.118% |
| US | -0.067% | -0.072% |

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**US-China trade war:**

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Simulate the effect of tariffs imposed by the U.S. on China between January 2018 and June 2019, and the retaliatory tariffs by China:

- U.S. increased average tariffs on Chinese imports by 14.4 percentage points.
- China increased average tariffs on U.S. imports by 13.5 percentage points.

Counterfactual: new long-run steady state of the world economy, relative to 2010-14, if the new tariffs imposed are permanent.

1. How does the trade war affect the U.S.-China trade imbalance?
2. Who gains/loses from the trade war?

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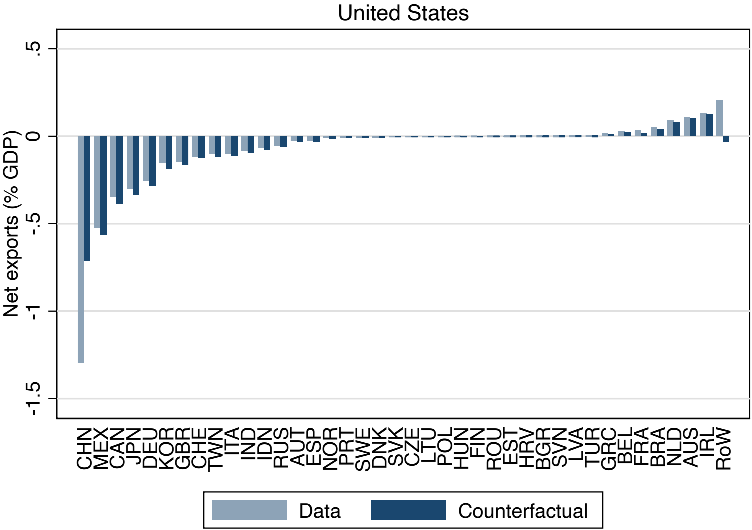


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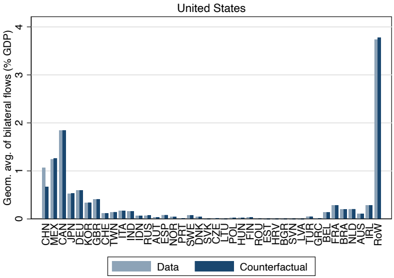
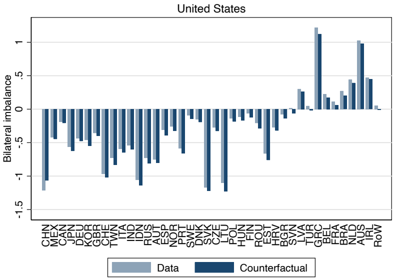
# 4 Counterfactuals: US-China Trade War





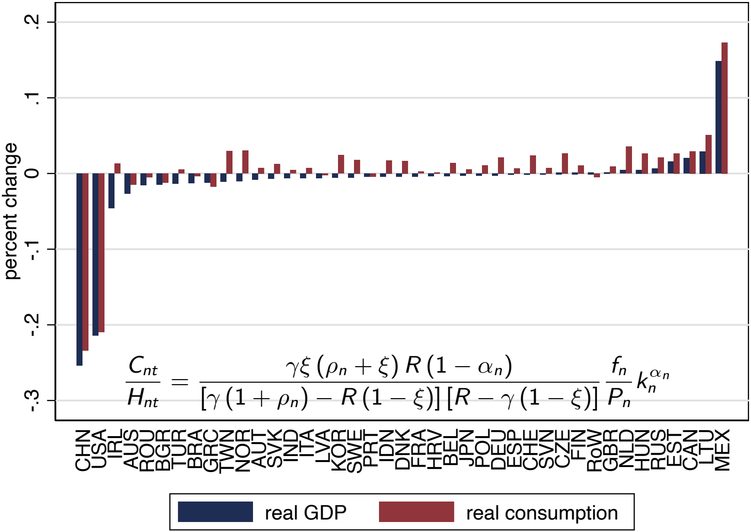

$$\frac{M_{nnt}^{\frac{1}{2}} M_{n'n't}^{\frac{1}{2}}}{f_n k_n^{\alpha n} H_{nt}}$$




$$\frac{M_{nn't} - M_{n'nt}}{M_{nn}^{\frac{1}{2}} M_{n'n'}^{\frac{1}{2}}} \simeq \ln M_{nn't} - \ln M_{n'nt}$$

# 4 Counterfactuals: US-China Trade War





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**A move to financial autarky**:

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- Balanced trade: $\tilde{nx}_n = 0$ for all $n$, each country has its own $R_n$.

- We compare with the case in which $\alpha_n = 0$ for all $n$ ($\Leftrightarrow$ no capital accumulation).

1. How are bilateral imbalances affected by financial autarky?
2. What are the losses from financial autarky?
3. How do results with and without capital accumulation differ?

# 4 Counterfactuals: Financial Autarky



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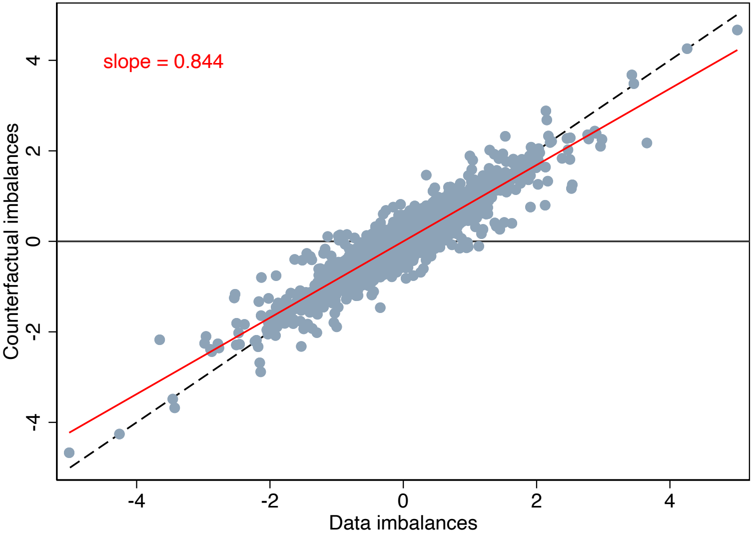

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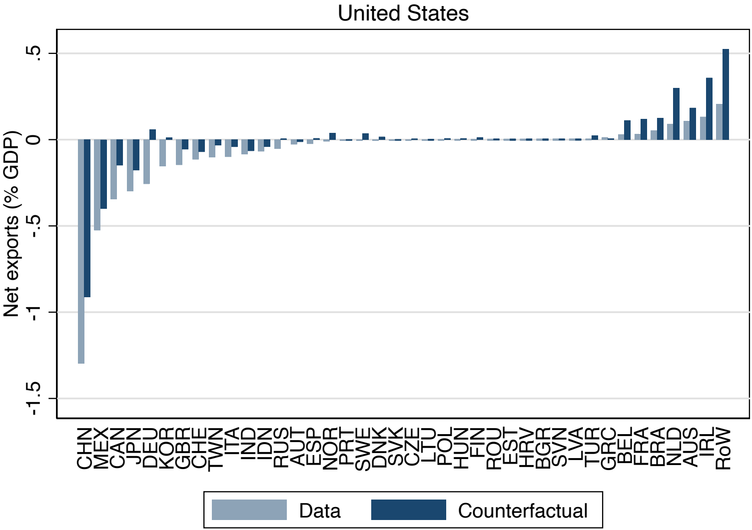
United States
Net exports (% GDP)
.5
0
-.5
-1
-1.5
CHN
MEX
CAN
JPN
DEU
KOR
GBR
CHE
TWN
ITA
IND
IDN
RUS
AUT
ESP
NOR
PRT
SWE
DNK
SVK
CZE
LTU
POL
HUN
FIN
ROU
EST
HRV
BGR
SVN
LVA
TUR
GRC
BEL
FRA
BRA
NLD
AUS
IRL
RoW
Data
Counterfactual

# 4 Counterfactuals: Financial Autarky

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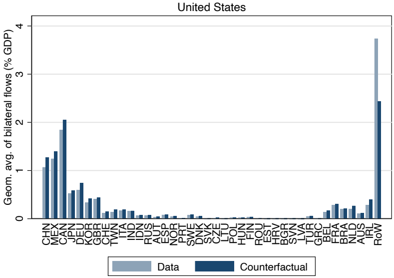
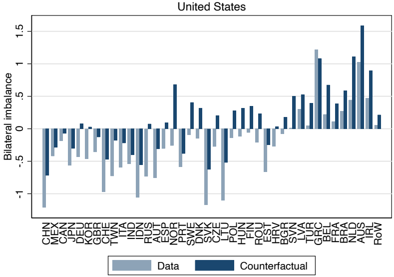


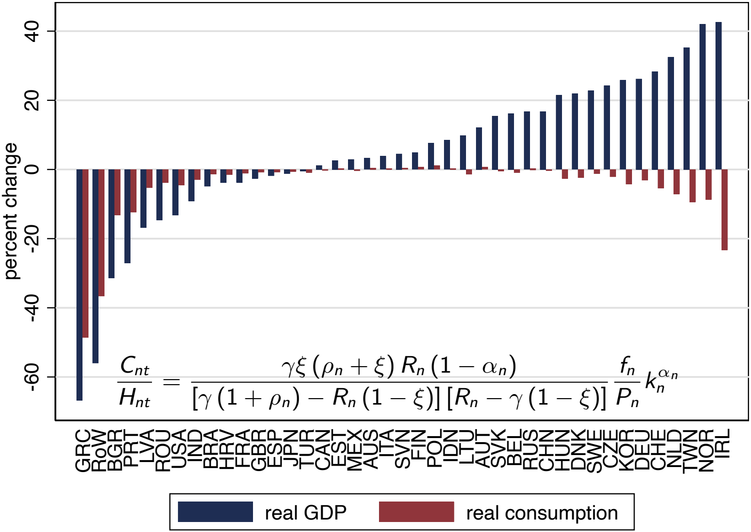

$$\frac{M_{nnt}^{\frac{1}{2}} M_{n'n't}^{\frac{1}{2}}}{f_n k_n^{\alpha n} H_{nt}}$$




$$\frac{M_{nn't} - M_{n'nt}}{M_{nn}^{\frac{1}{2}} M_{n'n'}^{\frac{1}{2}}} \simeq \ln M_{nn't} - \ln M_{n'nt}$$

# 4 Counterfactuals: Financial Autarky






$$\frac{C_{nt}}{H_{nt}} = \frac{\gamma\xi\left(\rho_n+\xi\right)R_n\left(1-\alpha_n\right)}{\left[\gamma\left(1+\rho_n\right)-R_n\left(1-\xi\right)\right]\left[R_n-\gamma\left(1-\xi\right)\right]}\frac{f_n}{P_n}k_n^{\alpha_n}$$

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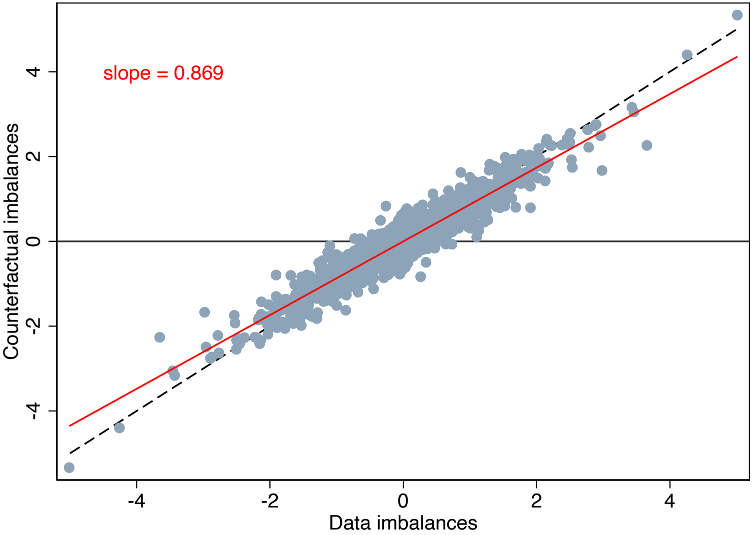
slope = 0.869
Counterfactual imbalances
Data imbalances
-4
-2
0
2
4

# 4 Counterfactuals: Financial Autarky ($\alpha_n = 0$)

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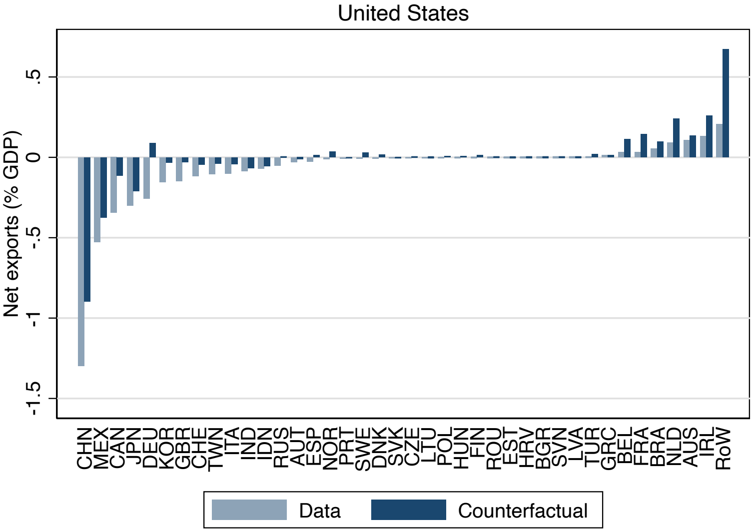

# 4 Counterfactuals: Financial Autarky ($\alpha_n = 0$)

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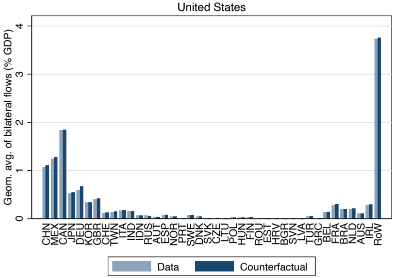
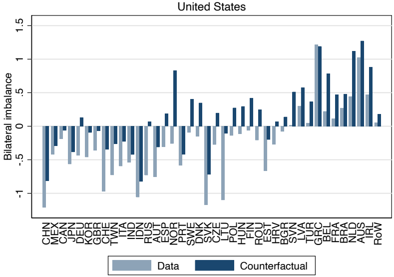


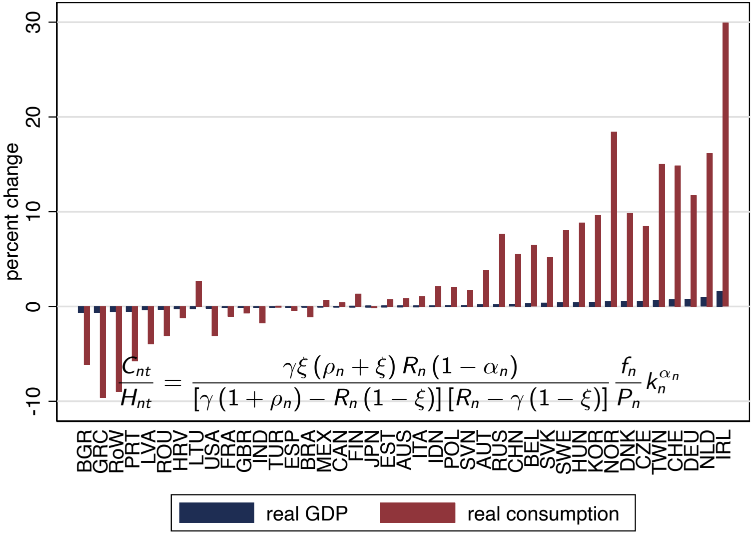

$$\frac{M_{nnt}^{\frac{1}{2}} M_{n'n't}^{\frac{1}{2}}}{f_n k_n^{\alpha_n} H_{nt}}$$




$$\frac{M_{nn't} - M_{n'nt}}{M_{nn}^{\frac{1}{2}} M_{n'n'}^{\frac{1}{2}}} \simeq \ln M_{nn't} - \ln M_{n'nt}$$

# 4 Counterfactuals: Financial Autarky ($\alpha_n = 0$)






$$\frac{C_{nt}}{H_{nt}} = \frac{\gamma\xi\left(\rho_n+\xi\right)R_n\left(1-\alpha_n\right)}{\left[\gamma\left(1+\rho_n\right)-R_n\left(1-\xi\right)\right]\left[R_n-\gamma\left(1-\xi\right)\right]}\frac{f_n}{P_n}k_n^{\alpha_n}$$