Trade, Domestic Frictions, and Scale Effects (Redux)

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Ideas and Scale Effects

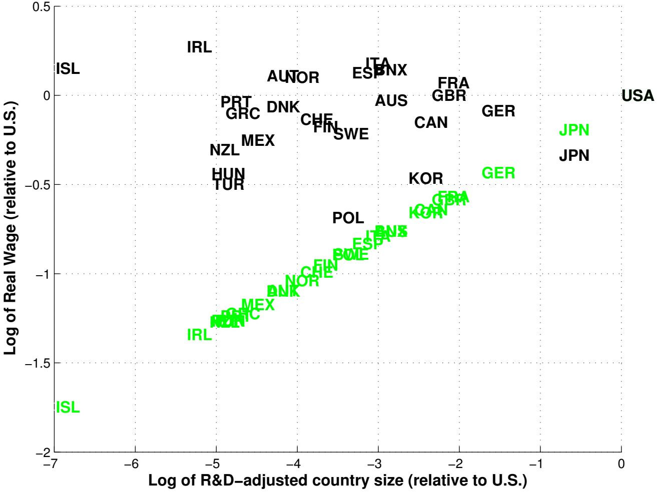
- Idea-based growth models naturally lead to scale effects
  - Jones (95), Kortum (97):

$$TFP \sim L^{\varepsilon}$$

- Jones (Handbook, 05): "*(the weak form of) scale effects is so inextricably tied to idea-based growth models that rejecting one is largely equivalent to rejecting the other.*"

Scale Effects versus Data

- Our baseline calibration: $\varepsilon = 1/4$



Scale Effects: Denmark

	TFP_{DNK} / TFP_{US}
Scale Effect	0.34
Data	0.94

Trade and Scale Effects

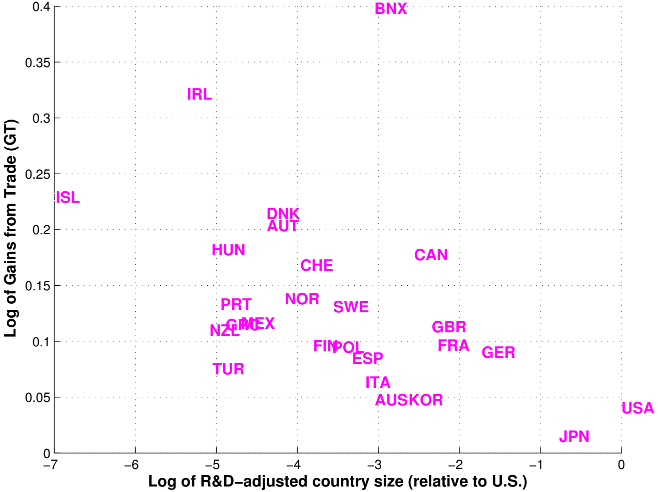
- Quantitative trade models are also idea-based models
  - Eaton and Kortum (01, 02), Krugman (80), Melitz (03)-Chaney (08)

- Gains from trade (GT) are generated by the same forces as those generating scale effects

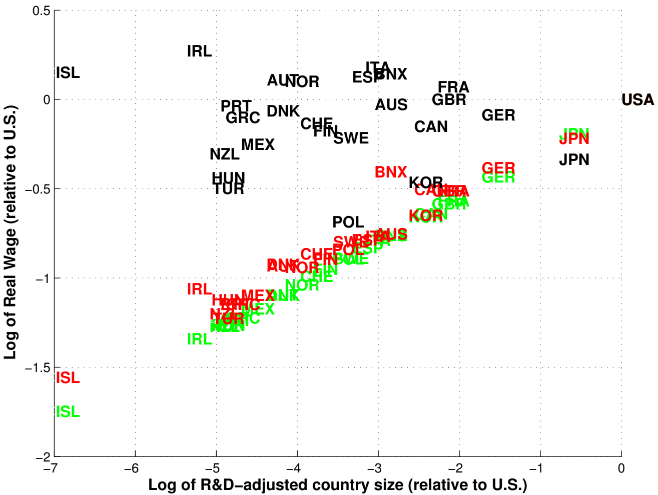
$$TFP \sim \underbrace{L^{\varepsilon}}_{\text{scale effect}} \times \underbrace{\lambda^{-\nu}}_{\text{GT}} = (L/\lambda)^{\varepsilon}$$

- Small countries gain more from trade than large ones
  - this could help to reconcile model with data

The Gains from Trade



Does Trade Openness Help to Match the Data?



The Role of Trade: Denmark

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This Paper: The Role of Domestic Frictions

- Explore and quantify an additional candidate solution
  - countries are not fully integrated domestically
- Quantitative model of trade and domestic geography
  - we extend EK(02) to include domestic frictions
  - key innovation: countries are collections of regions

Outline

- General EK-type Model of Regions
    - no domestic trade costs
    - symmetric regions
    - country-level gravity
    - the gains from trade
- Scale Effects
- Quantitative results
    - general case
    - alternative geographies

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- Labor is the only factor of production, available in quantity L_n in country n

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- Iceberg trade costs $d_{mk} \geq 1$ to export from k to m
    - $d_{mm} = 1$
    - triangular inequality: $d_{mk} \leq d_{ml} d_{lk}$ for all m, l, k

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    - Fréchet distribution with parameters $\kappa > 1$ and A_m

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- Let $\Psi_m \equiv \{z \text{ s.t. } z_m w_m / P_m \geq z_k w_k / P_k \text{ for all } k \in \Omega_n\}$

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- The share of workers that choose to live in region m is

$$\pi_m \equiv \int_{\Psi_m} dF_{n(m)}(z) = \frac{A_m \left(w_m / P_m\right)^{\kappa}}{\sum_{m \in \Omega_n} A_m \left(w_m / P_m\right)^{\kappa}}$$

while the expected real income of workers in country n is

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- Avg real income equalized across regions within each country

$$\frac{w_m}{P_m} \frac{E_m}{\pi_m L_n} = \gamma V_n$$

where $E_m \equiv L_{n(m)} \int_{\Psi_m} z_m dF_{n(m)}(z)$

Equilibrium

- Since $X_m = w_m E_m$, demand equal supply of labor in region m requires

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- Given wages, we can then solve for trade shares, price indices, real wages, and the allocation of workers to regions within countries

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- Let $\widetilde{w}_j \equiv \widetilde{X}_n / L_n$ denote the average nominal income per worker in country n (country wage)

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- Set $\tau_{nn} \equiv 1$ and define $\tau_{ni} \equiv d_{mk}$ for $m \in \Omega_n$ and $k \in \Omega_i$ for $n \neq i$

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- Country-level trade shares and prices indices are as in EK

$$\lambda_{ni} = \frac{\widetilde{T}_i \widetilde{w}_i^{-\theta} \tau_{ni}^{-\theta}}{\sum_j \widetilde{T}_j \widetilde{w}_j^{-\theta} \tau_{nj}^{-\theta}} \quad \text{and} \quad \widetilde{P}_n = \mu^{-1} \left(\sum_i \widetilde{T}_i \widetilde{w}_i^{-\theta} \tau_{ni}^{-\theta} \right)^{-1/\theta}$$

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- Country-level welfare

$$V_n = \gamma\mu\, \widetilde{T}_n^{1/\theta} \lambda_{nn}^{-1/\theta}$$

Symmetric Regions (Prop. 2)

A1. [Symmetry] *$A_m = A_{m'}$ and $T_m = T_{m'}$ for all $m, m' \in \Omega_n$, and $d_{mk} = d_{m'k'}$ for all $m, m' \in \Omega_n$ and $k, k' \in \Omega_i$.*

- Same results as under no domestic trade costs, **but**

$$\tau_{nn} \equiv \left(\frac{1}{M_n} + \frac{M_n - 1}{M_n} \delta_n^{-\theta} \right)^{-1/\theta}$$

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- Under A2, country-level trade flows are given by (for $n \neq j$)

$$\widetilde{X}_{nj} = \mu^{\theta} \frac{\tau_{nj}^{-\theta} \widetilde{X}_n \widetilde{X}_j}{\widetilde{P}_n^{-\theta} \widetilde{\Xi}_j^{-\theta}}$$

where

$$\widetilde{\Xi}_j \equiv \left(\sum_{k \in \Omega_j} \frac{X_k}{\widetilde{X}_j} \frac{T_k \left(w_k \delta_k \right)^{-\theta}}{X_k} \right)^{1/\theta} \text{ and } \widetilde{P}_n \equiv \left(\sum_{m \in \Omega_n} \frac{X_m}{\widetilde{X}_n} \left(\frac{P_m}{\delta_m} \right)^{\theta} \right)^{1/\theta}$$

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  - define $\psi_{mk} \equiv X_{mk}/X_m$ as region-level trade shares

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- With $\hat{d}_{mk} = \infty$ for $m \neq k$ and $\hat{d}_{mk} = 1$ for $m = k$, $m, k \in \Omega_n$,

$$GT_n = \left(\sum_{m \in \Omega_n} \pi_m \hat{\psi}_{mm}^{-\kappa/\theta} \right)^{-1/\kappa},$$

where

$$\hat{\psi}_{mm} = \frac{\hat{w}_m^{-\theta}}{\sum_{k \in \Omega_n} \psi_{mk} \hat{w}_k^{-\theta}},$$

and $\hat{w}_m$ is given by the solution to the system, for $m \in \Omega_n$

$$X_m \hat{w}_m^{\kappa} \left(\sum_{l \in \Omega_n} \psi_{ml} \hat{w}_l^{-\theta} \right)^{\frac{\kappa-1}{\theta}} = \sum_{k \in \Omega_n} \frac{\psi_{km} \hat{w}_m^{-\theta}}{\sum_{l \in \Omega_n} \psi_{kl} \hat{w}_l^{-\theta}} X_k \hat{w}_k^{\kappa} \left(\sum_{l \in \Omega_n} \psi_{kl} \hat{w}_l^{-\theta} \right)^{\frac{\kappa-1}{\theta}}.$$

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  - GT_{CAN}: 6.35% (Prop 4) vs 6.48% (ACR)

Scale Effects

- Natural relation between technology levels and population (EK, 01)
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- Under A3 and A4, we have country-level scale effects

$$\widetilde{T}_n = \phi_n L_n$$

Scale Effects: No Domestic Trade Costs

- Real wage

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- Conditional on trade shares and innovation intensity, real income levels increase with country size with an elasticity $1/\theta$

Scale Effects: Domestic Trade Costs under Symmetry

- Real wage

$$V_n = \mu \times \underbrace{\phi_n^{1/\theta}}_{\text{R\&D Intensity}} \times \underbrace{L_n^{1/\theta}}_{\text{Pure Scale Effect}} \times \underbrace{\tau_{nn}^{-1}}_{\text{Domestic Frictions}} \times \underbrace{\lambda_{nn}^{-1/\theta}}_{\text{Gains from Trade}}$$

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- Economies of scale depend on how τ_{nn} is affected by country size, L_n
- Assume $L_n = \bar{L} M_n$ and $\delta_n = \delta$. Then,

$$\tau_{nn} \equiv \left(\frac{1}{L_n} + \frac{L_n - 1}{L_n} \delta^{-\theta} \right)^{-1/\theta} .$$

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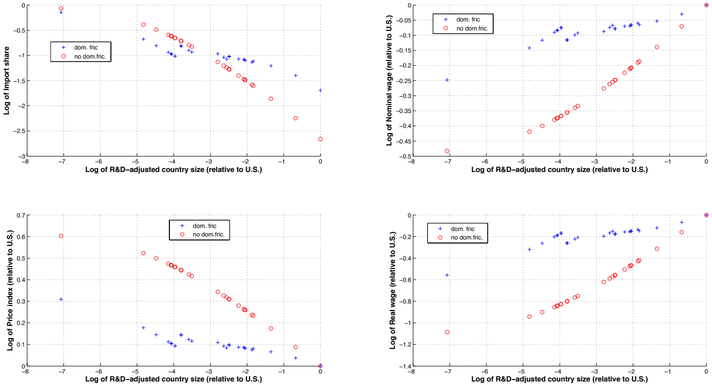
- Income-size elasticity is $(1/\theta)(\delta/\tau_{nn})^{-\theta} \leq 1/\theta$

Scale Effects with Endogenous Trade Shares (Prop. 5)

A5. [Uniform Trade Costs and Innovation Intensity] $\delta_n = \delta$ for all n, $\tau_{ni} = \tau$ for all $n \neq i$ and $\phi_i = \phi$ for all i.

- Assume A1, A3, and A5. If $\tau > \delta$ then larger countries have lower import shares, higher wages, and lower price levels. If $\tau = \delta$ then larger countries have lower import shares, but wages and prices do not vary with country size.



Equivalences Across Models

- RRS: symmetric costs + domestic frictions

$$\tau_{ni}^{RRS} = \nu_{ni} = \nu_{in} \quad , \quad \widetilde{T}_i^{RRS} = \phi_i L_i$$

- EK: asymmetric costs with importer specific effect, no dom. fric.

$$\tau_{ni}^{EK} = F_n \nu_{ni} \quad , \quad F_n = 1/\tau_{nn}^{RRS} \quad , \quad \widetilde{T}_i^{EK} = \widetilde{T}_i^{RRS}$$

- W: asymmetric costs with exporter specific effect, no dom. fric.

$$\tau_{ni}^{W} = F_i \nu_{ni} \quad , \quad F_i = 1/\tau_{ii}^{RRS} \quad , \quad \widetilde{T}_i^{W} = \widetilde{T}_i^{RRS} (\tau_{ii}^{RRS})^{-\theta}$$

Equivalences Across Models

- The RRS, EK, and W models generate the same equilibrium wages and trade flows, but
  - the model W implies $\widetilde{T}_i^W / L_i$ systematically higher for small countries

$$\frac{\widetilde{T}_i^W}{L_i} = \phi_i (\tau_{ii}^{RRS})^{-\theta}$$

  - the model EK implies prices systematically higher for small countries

$$P_n^{EK} = \tau_{nn}^{-1} P_n^{RRS}$$

Calibration: Key Parameters

- $\kappa = 1.3$
  - Suarez-Serrato and Zidar (2014)
- $\theta = 4$
  - trade: $\theta \in [2.5; 5.5]$ (Simonovska and Waugh, 13; Head and Mayer, 13)
  - growth: $\theta = 4.8$ (Jones, 02)
  - scale: $\theta = 3.3$ (Alcala and Ciccone, 04)
- Technology: $T_m = \phi_n \pi_m L_n$
  - L_n: equipped labor (K-RC, 05), avg 96-01
  - ϕ_n: share of R&D employment (WDI), avg 96-01
  - π_m: implied by the model's eq (*)
- Number of regions: M_n
  - number of metro areas in the data, for 26 OECD countries ($M = 287$)
- A_m for region $m \in \Omega_n$, for all n
  - exactly match pop share of region m in country n observed in the data (*)

Calibration of Trade Costs d_{mk}

- Trade flows between regions are not available
- Impose $d_{mm} = 1$ and, for $m \neq k$,

$$d_{mk} = \beta_0^{I_{mk}} \beta_1^{1-I_{mk}} dist_{mk}^{\beta_2 I_{mk} + \beta_3 (1-I_{mk})}$$

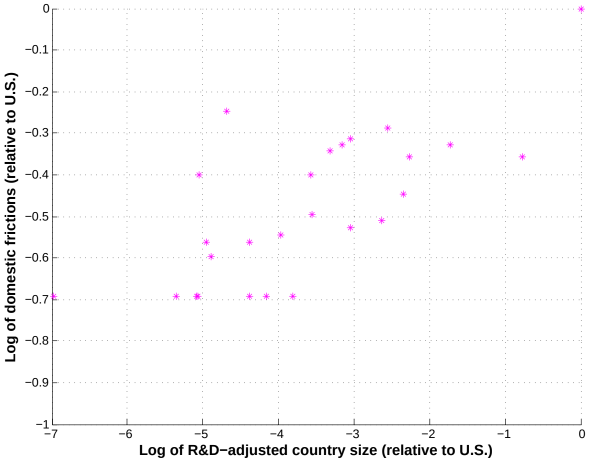
  - $dist_{mk}$: distance btw region m and k computed from longitude and latitude data for each metropolitan area in our sample
  - I_{mk}: dummy variable that equals one if m and k belong to the same country
- Calibrate:
  - β_0 to match the share of intra-regional trade, in total domestic trade, for the United States, from the CFS, for 2007 $= 0.40$
  - β_1 to match the avg int' bil trade sh, STAN, avg 96-01 $= 0.0156$
  - $\beta_2 = \beta_3 = 0.27$ from gravity evidence

Fit of Calibrated Model

- $R^2 = 1 - \frac{\sum_{n,i}(\lambda_{ni}^{data} - \lambda_{ni}^{model})^2}{\sum_{n,i}(\lambda_{ni}^{data})^2} = 0.96$
- OLS elasticity of simulated int' trade shares on (with source & dest. FE)
  - calibrated int' bil trade costs $= 3.96$ (s.e. 0.079)
  - int' bil distance $= -1.07$ (s.e. 0.021)

Calibrated Domestic Trade Costs and Country Size

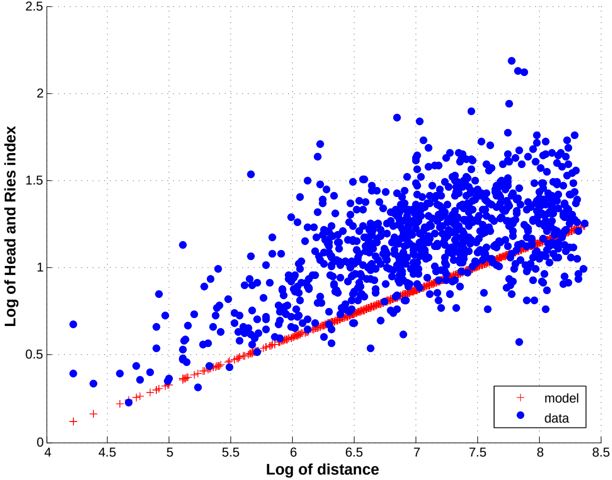
- Country-level index (AAY, 13): $\tau_{nn} = \sum_{m \in \Omega_n} \pi_m \left(\sum_{k \neq m, k \in \Omega_n} \pi_k \boldsymbol{d}_{mk}^{-\theta} \right)^{-1/\theta}$



$$M_{DNK} = 1 \ \& \ \frac{\tau_{DNK,DNK}}{\tau_{US,US}} = 0.50 \qquad M_{JPN} = 36 \ \& \ \frac{\tau_{JPN,JPN}}{\tau_{US,US}} = 0.70$$

Calibrated vs Head-Ries Domestic U.S. Trade Costs

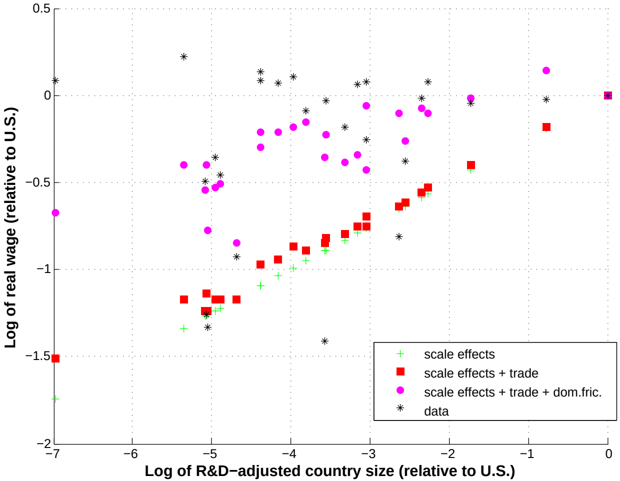
- Region-level Head-Ries index: $d_{mk}^{hr} \equiv \left(\frac{X_{mk}}{X_{kk}} \frac{X_{km}}{X_{mm}} \right)^{-\frac{1}{2\theta}}$



The Role of Domestic Frictions: Real Wages

- Data: real PPP-adjusted GDP (PWT 7.1) per unit of equipped labor
- Income-size elasticities:

  data (black) = -0.006; scale effects (green) = 0.25; RRS (pink)= 0.13



The Role of Domestic Frictions: Denmark

	TFP_{DNK} / TFP_{US}	
	no dom.fric	dom.fric.
Scale Effect	0.34	0.69
Trade	0.37	0.81
Data	0.94	0.94

Alternative Geographies: Symmetry

$$\frac{w_n/P_n}{w_{US}/P_{US}} = \underbrace{\left(\frac{\phi_n L_n}{\phi_{US} L_{US}}\right)^{1/\theta}}_{\text{R\&D-adjusted size}} \underbrace{\left(\frac{GT_n}{GT_{US}}\right)}_{\text{trade}} \underbrace{\left(\frac{\tau_{nn}}{\tau_{US,US}}\right)^{-1}}_{\text{domestic frictions}}$$

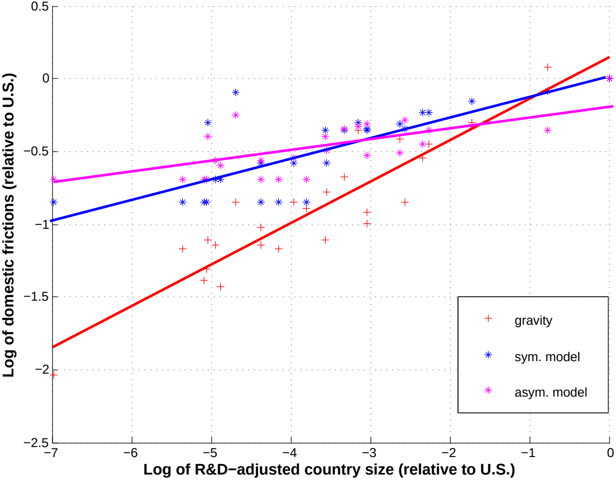
$$\tau_{nn} \equiv \left(\frac{1}{M_n} + \frac{M_n - 1}{M_n}\delta_n^{-\theta}\right)^{-1/\theta}$$

- Domestic trade costs: $\delta_n = \delta = 2.7$
  - model's eq relation: $\tau_{nn}^{\theta} = M_n \sum_{m \in \Omega_n} X_{mm} / \widetilde{X}_{nn}$
  - data on U.S. inter-regional trade data (CFS, 07) for 100 metro areas

- International trade costs
  - $\tau_{ni} = \beta_1 dist_{ni}^{\beta_3}$
  - β_1 matches avg int' bil trade sh and $\beta_3 = 0.27$

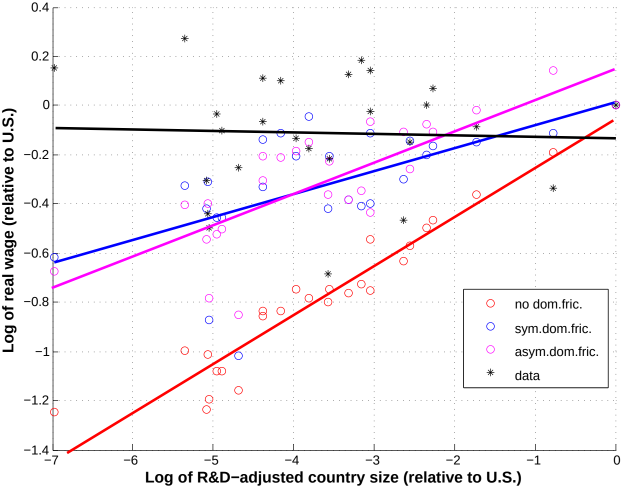
Implied Domestic Trade Costs

- "Gravity" domestic frictions refer to $\log \hat{\tau}_{nn} = \frac{1}{\theta}(\hat{S}_n - \hat{H}_n)$ where $\hat{S}_n$ and $\hat{H}_n$ are fixed effects from running gravity on normalized trade shares



Real Wages: Data vs Models

- Size elasticities: data (black) = -0.01; no dom.fric. (red) = 0.20; sym.dom.fric. = 0.09; asym.dom.fric. (pink)= 0.13



Other Variables: Data vs Models

Size elasticities	import share	nominal wage	prices
no dom.fric.	-0.39	0.10	-0.09
sym. dom.fric.	-0.15	0.06	-0.04
asym. dom.fric.	-0.27	0.06	-0.05
data	-0.23	0.07	0.07

Gains from Trade

- ACR formula vs general case
  - Denmark: 1.222 vs 1.222
  - Sweden: 1.186 vs 1.189
  - USA: 1.022 vs 1.021
  - Avg: 1.211 vs 1.211

Final Remarks

- Do small countries have better institutions?
  - R&D-adjusted scale is not correlated with measures of institutional quality, schooling, and measures of patents per (equipped) worker
- Multinational Production and Non-Traded Goods (working paper)
- Diffusion of ideas across and within countries