Importing Skill-Biased Technology

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Motivation

Observations

- Capital equipment (e.g. computers and industrial machinery):
  - embodies skill-biased technology
    - At firm, sector, plant level, surveyed in Katz & Autor '99
  - is highly traded and world production is highly concentrated
    - Eaton and Kortum '01

Implication

- Countries import skill-biased technology with equipment

This paper

- To what extent does trade in equipment raise demand for skilled labor and increase skill premia in many countries?

Framework

- Introduce capital-skill complementarity into a multi-country, multi-sector Ricardian model of trade
- Capital-skill complementarity:
  - $\uparrow$ in capital $\uparrow$ demand for skilled relative to unskilled labor
- With trade, capital stock depends on
  - domestic productivities and factor supplies,
  - foreign productivities and factor supplies,
  - and trade costs

Preview of analytic results

- *All* changes in
  - trade costs
  - foreign technologies
  - foreign factor supplies

  affect domestic skill premium *only* through changes in
  - domestic sectoral expenditure shares, $\pi_{ii}(j)$

- Analytic 1^{st}-order approx for SS change in skill premium
  - highlights intuition
  - facilitates sensitivity analysis

Preview of quantitative results

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- Counterfactual 1: Move to autarky
  - Effect varies widely across countries in our sample
  - Large in countries with comparative disadvantage in equipment
  - Skill Premium falls:
    - e.g., 16% in median country, 5% in US, 20% in Chile

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  - Skill Premium falls:
    - e.g., 16% in median country, 5% in US, 20% in Chile
- Counterfactual 2: Feed observed changes in trade shares
  - Moving from 2000 to 1963 trade shares, skill premium falls:
    - e.g., 13% in UK, 19% in Canada
  - Numbers significant relative to observed changes in skill premia

Related literature

- Evidence on trade and technology change:
  - Pavcnik ('02), De Loecker ('10), Lileeva & Trefler ('10), Bustos ('11a)
- Evidence on trade and skill intensity:
  - Verhoogen ('08), Bloom et. al. ('11), Bustos ('11b), Koren & Csillag ('11)
- Trade and SBTC:
  - Acemoglu (2003), Yeaple ('05), Thoenig and Verdier (2003)
- Capital skill complementarity and skill premium
  - Krusell et. al. ('00), Polgreen & Silos ('08)
- Quantitative trade models and inequality:
  - Parro ('10), Burstein & Vogel ('10)

Model

Model: Overview

- I countries, 3 sectors (Manufacturing, Equipment and Services)
  - M used for consumption and intermediate inputs
  - S used for consumption, intermediate inputs and structures
  - E used for capital equipment
- Production uses
  - skilled and unskilled labor, H_i and L_i
  - capital structures and equipment, $K_i(S)$ and $K_i(E)$
  - intermediate inputs, $X_i(S)$ and $X_i(M)$
- Countries endowed with labor, capital is accumulated
- Factors and goods markets are perfectly competitive
- Iceberg trade costs

Model: Preferences and final output

- Preferences:

$$\sum_{t=0}^{\infty} \beta^t u \left[C_{i,t} (M)^{\phi} C_{i,t} (S)^{1-\phi} \right]$$

- Sectorial output is an aggregate of intermediates:

$$Y_i (j) = \left[\int_0^1 q_i (\omega, j)^{(\eta-1)/\eta} d\omega \right]^{\eta/(\eta-1)}$$

- Market clearing in final goods:

$$\begin{aligned} Y_i(M) &= C_i(M) + X_i(M) \\ Y_i(S) &= C_i(S) + X_i(S) + I_i(S) \\ Y_i(E) &= I_i(E) \end{aligned}$$

Production of intermediate goods

- KORV production function—nested CES using H_i, L_i, $K_i(S)$, $K_i(E)$—w/ intermediate inputs & heterogeneous productivity

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- $Int.Inputs = x_S^{\varepsilon} x_M^{1-\varepsilon}$
- $VA = k_S^{\alpha} \chi_2^{1-\alpha}$
  - $\chi_2 = \left[\mu^{\frac{1}{\sigma}} I^{\frac{\sigma-1}{\sigma}} + (1-\mu)^{\frac{1}{\sigma}} \chi_1^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \rightarrow \varepsilon(I, \Upsilon_1) = \sigma$
  - $\chi_1 = \left[\lambda^{\frac{1}{\rho}} k_E^{\frac{\rho-1}{\rho}} + (1-\lambda)^{\frac{1}{\rho}} h^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \rightarrow \varepsilon(k_E, h) = \rho$

Capital skill complementarity if $\sigma > \rho$

Equilibrium

- Unit cost of producer (ω, j):

$$c_{in}(\omega, j) = \frac{c_i \tau_{in}(j)}{A_i(j) z_i(\omega, j)}$$

- Prices:

$$p_n(\omega, j) = \min_i \{c_{in}(\omega, j)\},$$

- Price indexes:

$$P_n(j) = \left[\int_0^1 p_n(\omega, j)^{1-\eta} d\omega\right]^{1/(1-\eta)}.$$

- Trade share:

$$\pi_{in}(j) = \frac{\int_0^1 p_n(\omega, j)^{1-\eta} \mathbb{1}_{in}(\omega, j) d\omega}{P_n(j)^{1-\eta}}$$

Analytic Results

Skill Premium

- Following KORV:

$$\frac{s_i}{w_i} = \kappa \left[\lambda^{\frac{1}{\rho}} \left(\frac{K_i(E)}{H_i} \right)^{\frac{\rho-1}{\rho}} + (1-\lambda)^{\frac{1}{\rho}} \right]^{\frac{\sigma-\rho}{(\rho-1)\sigma}} \left(\frac{L_i}{H_i} \right)^{\frac{1}{\sigma}}$$

- $\frac{s_i}{w_i}$ increasing in $\frac{L_i}{H_i}$ if $\sigma > 0$
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  - $K_i(E)$ determined in equilibrium

Result

Proposition

Given parameters, country i's steady state skill premium can be calculated using only

1. *Domestic expenditure shares, $\pi_{ii}(j)$'s*
2. *Domestic technologies, $A_i(j)$'s*
3. *Domestic endowments, H_i and L_i*

- **Implication**: $\pi_{ii}(j)$'s are sufficient statistics for all international forces
  - Only need data on the domestic country for each counterfactual

Broad Intuition

- In trade models with gravity, change in stock of consumption resulting from foreign shocks is a function of π_{ii}
  - Arkolakis, Costinot, Rodriguez-Clare (2011)
  - e.g., in EK (2002), $Q_i \propto A_i \pi_{ii}^{-\theta}$
- Here, changes in skill premium depend on changes in $K_i(E)$
  - And $K_i(E)$ depends on $A_i(j)$ and $\pi_{ii}(j)$ in a related manner...

First-order approximation for the change in SP

- Log linearizing, the change in s_i / w_i is given by

$$\widehat{s}_i - \widehat{w}_i = \sum_j \beta_{1,i}(j) \left[\widehat{A}_i(j) - \theta \widehat{\pi}_{ii}(j) \right] - \beta_{2,i} \left(\widehat{H}_i - \widehat{L}_i \right)$$

  $\beta_{1,i}(j)$, $\beta_{2,i}$ are functions of factor shares and parameters
- Two ways to increase stock of equipment:
  - produce more ($\widehat{A}_i(E) > 0$)
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- Parameters and factor shares $\Rightarrow$ elasticities

Quantitative results

Counterfactuals:

- Two counterfactuals taking changes in trade shares as given
- How would the skill premium change in each country if
  - it were moved to autarky?
  - trade shares return to base-year levels?
- From analytic results:
  - We conduct each counterfactual without solving for full multi-country general equilibrium
  - Only need data for domestic country
  - Value of elasticities ρ and σ key for results

Data

- Compute $\pi_{ii}(j)$ as $1 - \frac{\text{Imports}}{\text{Output+Imports-Exports}}$
- Trade data: Feenstra et.al. (2004)
- Gross Output Data: UNIDO Industrial Statistics Database
- Follow Eaton-Kortum (2001) to group goods into E and M
  - The major investment sectors in Germany, US, & Japan:
    - non-electrical equipment
    - electrical equipment
    - instruments
- 54 countries, 1963 (or 1^{st} available year) - 2000
  - period varies across countries b/c of data coverage

Data Summary

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	Median Level (2000)	Median Change
$\pi_{ii}(E)$	0.25	-30%
$\pi_{ii}(M)$	0.67	-15%

- Countries import a large share of their capital equipment
- Large increases in import shares over the period
- Import share is higher (π_{ii} lower) and change is larger in E

Baseline Parameterization

- Factor shares from NIPA and IO tables
- Calibrate:

$$\rho^{-1} = 1 + \frac{\widehat{\xi^H}}{\widehat{K(E)/H}} \text{ and } \sigma = \frac{(\rho-1)\widehat{(H/L)} + \rho\left(1+\widehat{1/\xi^H}\right)}{(1-\rho)\widehat{(s/w)} + \left(1+\widehat{1/\xi^H}\right)}$$

where $\xi^H = s_i H_i / (r_i K_i(E))$ & changes from 1963 to 2000

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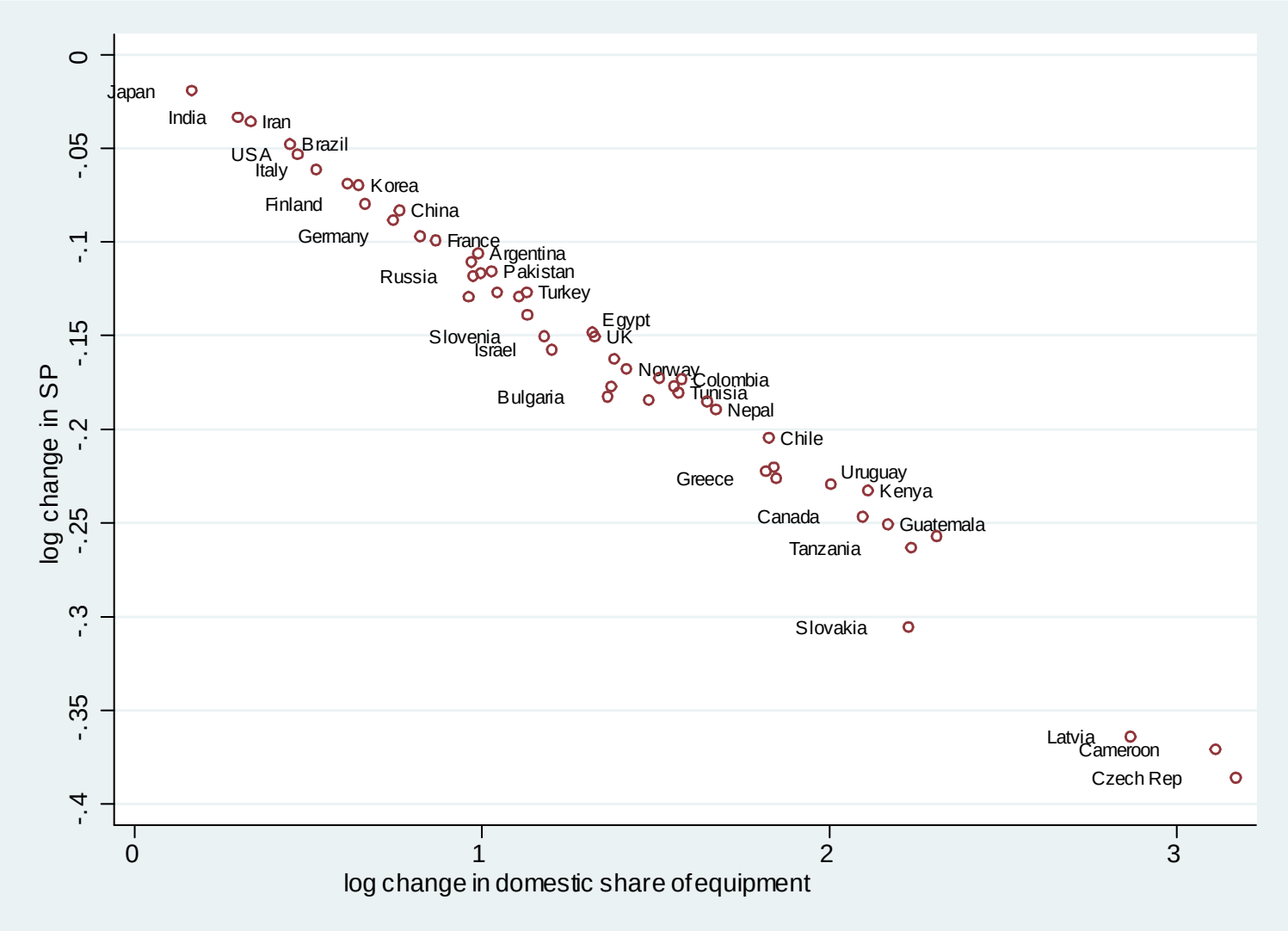
  where $\xi^H = s_i H_i / (r_i K_i(E))$ & changes from 1963 to 2000
- US 63-00: $\rho = 0.63$, $\sigma = 1.56$
- Implied elasticities: $\frac{d\log[s/w]}{d\log[\pi_{ii}(E)]} = -0.10$, $\frac{d\log[s/w]}{d\log[\pi_{ii}(M)]} = -0.04$

Alternative Parameterizations

1. Estimate ρ and σ via non-linear least squares using annual rather than cumulative changes
   - $\rho = 0.66$, $\sigma = 1.47$ (precisely estimated)
2. Allow exogenous SBT change similar to Katz & Murphy '92
   - If SBT annual growth is $\leq 5.2\%$, then $\sigma \geq \rho$
3. Estimate σ and ρ using Chilean data 74-00
   - $\rho = 0.53$, $\sigma = 1.54$

Recall baseline parameterization in US: $\rho = 0.63$, $\sigma = 1.56$

Counterfactual 1: Moving to Autarky



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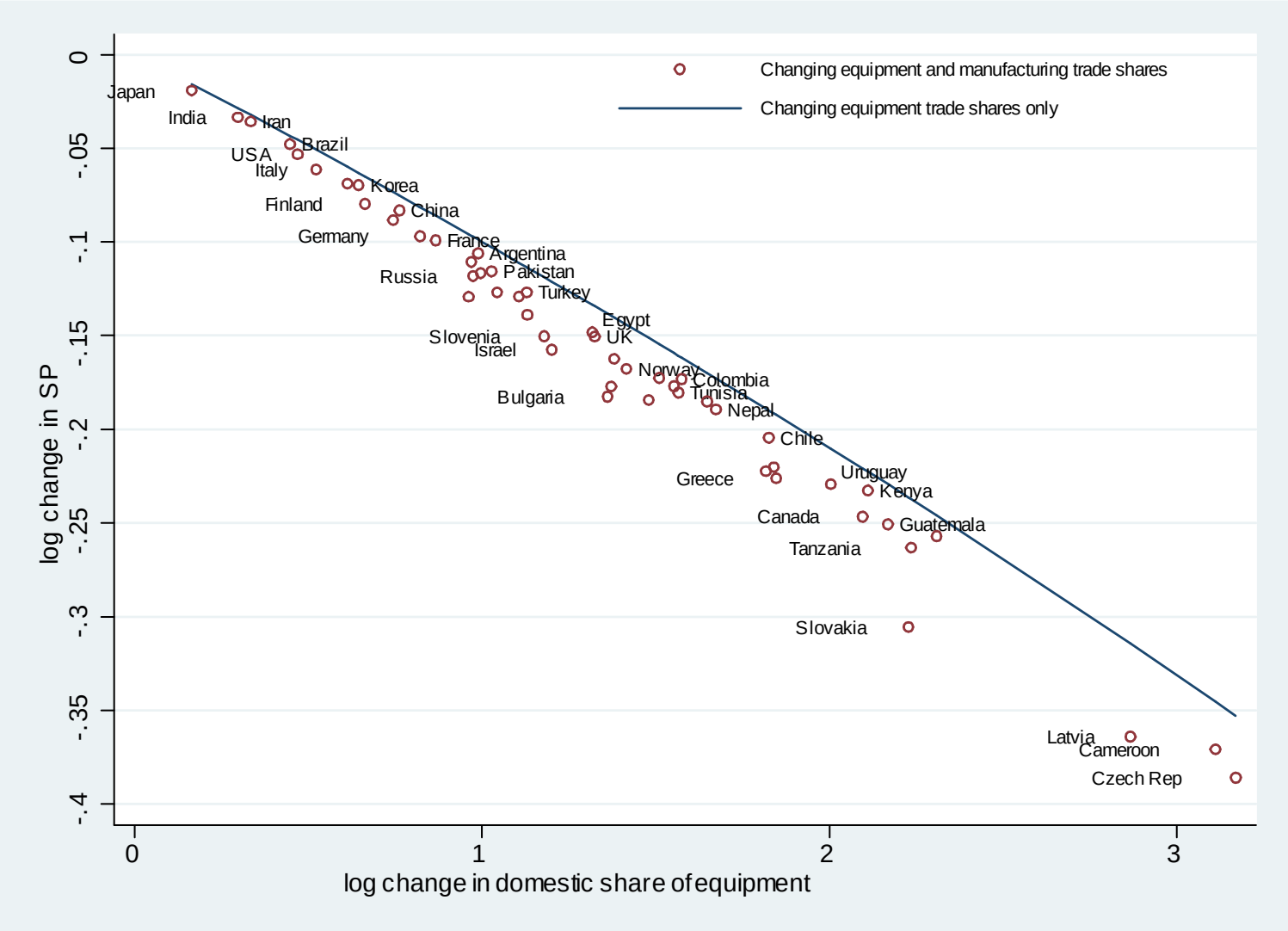
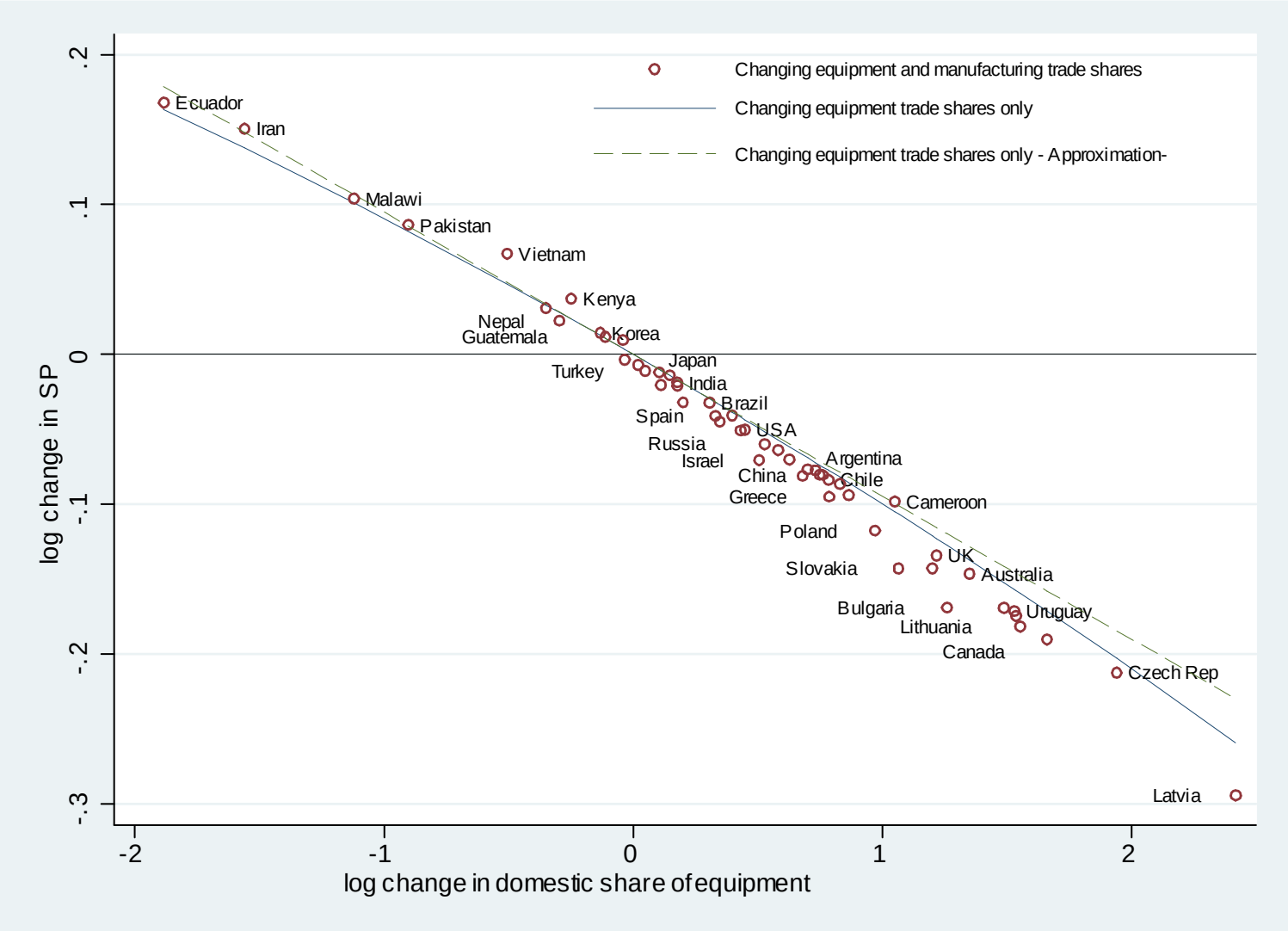


Counterfactual 1: Moving to Autarky

- Skill premium declines 16% in median country
- Wide variation across countries depending on comparative advantage rather than stage of development, e.g.
  - 2% decline in Japan,
  - 5% decline in US,
  - 11% decline in Argentina,
  - 25% decline in Canada,
  - 39% decline in Czech Republic
- Trade in manufactures important for some countries

Counterfactual 2: Observed changes in trade shares



Counterfactual 2: Observed changes in trade shares

- Median decline of 6%
- Wide variation depending on changing trade patterns
  - Significant in some developing countries (e.g. Argentina, Chile, Brazil, Greece, Uruguay)
  - Large in some developed countries, e.g. UK and Canada
  - Small in Japan and the US
  - Increase in the SP in some countries
- Most is coming from trade in equipment
- Get very similar results using the approximation

Conclusions

- Presented a theory of international trade and capital skill complementarity:
  - By importing equipment (and intermediates), countries import rise in skill premium
- Simple analytical expression summarizes all effects of trade
  - For quantitative work, only need data on domestic country
- Channel quantitatively important for various developing and developed countries