

# Capital Goods Trade and Economic Development

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December 2014  
NYU-FRBATL Conference

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# Introduction

## Economic development

- ▶ Cross-country differences in income per worker are large.
  - ▶ For 2005, the countries in the top decile of the income distribution are roughly 40 times as rich as the countries in the bottom decile.
- ▶ Income per worker:  $y = Ak^\alpha$ 
  - ▶ Development accounting: roughly 50 percent due to factor differences and 50 percent due to aggregate TFP differences.

# Introduction

## Motivating facts

- ▶ World production of capital goods – concentrated among a few countries.
  - ▶ 10 countries account for almost 80 percent of the world production.
- ▶ Trade in capital goods – poor countries rely on imports.
  - ▶ Poor countries have a higher capital goods import to production ratio, relative to rich countries.
  - ▶ Malawi imports 47 times as much as it produces, U.S. imports only half as much as it produces.

# Introduction

## What we do

- ▶ A quantitative trade theory of factor differences and TFP differences.
- ▶ Embed a multi-country, multi-sector, Ricardian model of trade into a neoclassical growth model.
  - ▶ Endogenous capital formation.
  - ▶ Endogenous TFP.
- ▶ Examine the quantitative implications for cross-country income differences.

## Preview of results

- ▶ Without trade distortions the income gap between rich and poor countries shrinks in half.
- ▶ About 80 percent of the change stems from change in capital.
- ▶ Eliminating trade in capital goods leads to income losses for all countries. Almost all of the losses stem from decreased capital.

# Multi-country model

- ▶ Dornbusch, Fischer and Samuelson (1977), Eaton and Kortum (2002), Alvarez and Lucas (2007), Waugh (2010).
- ▶ Each country is endowed with labor, not mobile internationally.
- ▶ Each country has technologies for producing a final consumption good, structures, a continuum of capital goods, a continuum of intermediate goods and an aggregate intermediate good.
- ▶ All of the capital goods and intermediate goods can be traded. Final consumption good and structures cannot be traded.
- ▶ Barriers to trade: sector-specific bilateral iceberg costs.
- ▶ Steady state.

# Multi-country model

## Technologies

- ▶ Capital stock composite:  $k = (k^e)^\mu (k^s)^{1-\mu}$
- ▶ Final consumption good

$$F = A_f [k^\alpha \ell^{1-\alpha}]^{\nu_f} M^{1-\nu_f}$$

$A_f$  – domestic distortion.

- ▶ Structures

$$S = [k^\alpha \ell^{1-\alpha}]^{\nu_s} M^{1-\nu_s}$$

- ▶ Aggregate intermediate good

$$M = \left[ \int q_m(u) \frac{\eta-1}{\eta} \varphi_m(u) du \right]^{\frac{\eta}{\eta-1}}$$

# Multi-country model

## Technologies

- ▶ Capital accumulation

$$k^{e'} = (1 - \delta_e)k^e + x^e$$

$$k^{s'} = (1 - \delta_s)k^s + x^s$$

- ▶ Investment: producer durables and structures

$$x^e = E = \left[ \int q_e(v)^{\frac{\eta-1}{\eta}} \varphi_e(v) dv \right]^{\frac{\eta}{\eta-1}}$$
$$x^s = S$$



# Multi-country model

## Technologies

- ▶ A continuum of intermediate goods –  $u$

$$m(u) = u^{-\theta} [k^\alpha \ell^{1-\alpha}]^{\nu_m} M^{1-\nu_m}$$

- ▶ A continuum of producer durables –  $v$

$$e(v) = v^{-\theta} [k^\alpha \ell^{1-\alpha}]^{\nu_e} M^{1-\nu_e}$$

# Multi-country model

## Technologies

- ▶ A continuum of intermediate goods –  $u$ .
  - ▶ Country  $i$ 's productivity distribution in the intermediate goods sector is Fréchet with mean  $\lambda_{mi}^\theta$ .
- ▶ A continuum of producer durables.
  - ▶ Fréchet distribution with mean  $\lambda_{ei}^\theta$ .
  - ▶ If  $\lambda_{ei}/\lambda_{mi} > \lambda_{ej}/\lambda_{mj}$  (comparative advantage in capital goods), then country  $i$  will tend to be a net exporter of producer durables.

# Multi-country model

## Barriers to trade

- ▶ Iceberg costs: for 1 unit of the sector  $b$  good ( $b \in \{e, m\}$ ) to arrive in country  $i$  from country  $j$ , country  $j$  must ship  $\tau_{bij} > 1$  units of the good.  $\tau_{bij} - 1$  “melts away” in transit.
- ▶ There is no barrier for a country to import from itself:  $\tau_{bii} = 1$ .

# Multi-country model

## Preferences and budget constraint

- ▶ Preferences of the representative household in country  $i$ :

$$\sum_{t=0}^{\infty} \beta^t \ln(c_{it})$$

- ▶ Budget constraint in country  $i$ :

$$P_{fi}c_i + P_{ei}x_i^e + P_{si}x_i^s = w_i + r_{ei}k_i^e + r_{si}k_i^s$$

# Multi-country model

## Equilibrium

Steady state in country  $i$

- ▶ The representative household maximizes lifetime utility, taking prices as given.
- ▶ Firms maximize profits, taking factor prices as given.
- ▶ Domestic markets for factors and nontradable goods clear.
- ▶ Total trade is balanced.
  - ▶ Trade might be imbalanced at the sectoral level.

# Multi-country model

## Development accounting

- ▶ Income per worker in country  $i$

$$y_i \propto A_{fi} \left[ \left( \frac{\lambda_{mi}}{\pi_{mii}} \right)^\theta \right]^{\frac{1-\nu_f}{\nu_m}} k_i^\alpha,$$

# Multi-country model

## Development accounting

- ▶ Income per worker in country  $i$

$$y_i \propto A_{fi} \left[ \left( \frac{\lambda_{mi}}{\pi_{mii}} \right)^\theta \right]^{\frac{1-\nu_f}{\nu_m}} k_i^\alpha,$$

- ▶ Capital per worker in country  $i$

$$k_i = \kappa \left( \frac{\lambda_{ei}}{\pi_{eii}}, \frac{\lambda_{mi}}{\pi_{mii}} \right)$$

# Calibration

## Common parameters

Parameter	Description	Value
$\alpha$	$k$ 's share	0.33
$\nu_m$	$k$ and $l$ 's share in intermediate goods	0.31
$\nu_e$	$k$ and $l$ 's share in producer durables	0.31
$\nu_s$	$k$ and $l$ 's share in structures	0.39
$\nu_f$	$k$ and $l$ 's share in final goods	0.90
$\delta_e$	depreciation rate of producer durables	0.12
$\delta_s$	depreciation rate of structures	0.06
$\theta$	variation in productivity levels	0.25
$\mu$	share of producer durables in capital	0.56
$\beta$	discount factor	0.96
$\eta$	elasticity of subs in aggregator	2



# Calibration

## Country-specific parameters

- ▶ Endowment of labor,  $L_i$ .
- ▶ Domestic distortions to final goods production,  $A_{fi}$ .
- ▶ Average productivity in capital goods and intermediate goods,  $\lambda_{ei}^\theta$  and  $\lambda_{mi}^\theta$ .
- ▶ Trade barriers:  $\tau_{eij}$  and  $\tau_{mij}$ .
- ▶ Take  $L_i$  directly from the data. Calibrate  $\tau_{eij}$ ,  $\tau_{mij}$ ,  $\lambda_{ei}$ ,  $\lambda_{mi}$ , and  $A_{fi}$  to bilateral trade shares in capital goods and intermediate goods, relative price of capital goods, relative price of intermediate goods, and income per worker.
  - ▶ Use structural relationships from the model.

# Calibrating country-specific parameters

## Trade barriers

- ▶ Compute  $\tau_{eij}$  and  $\tau_{mij}$  using

$$\frac{\pi_{bij}}{\pi_{bjj}} = \left( \frac{P_{bj}}{P_{bi}} \right)^{-1/\theta} \tau_{bij}^{-1/\theta}.$$

- ▶  $\pi_{bij} = \frac{\text{Country } i \text{'s expenditure on sector } b \text{ goods from country } j}{\text{Country } i \text{'s total expenditure on sector } b \text{ goods}}.$

# Calibrating country-specific parameters

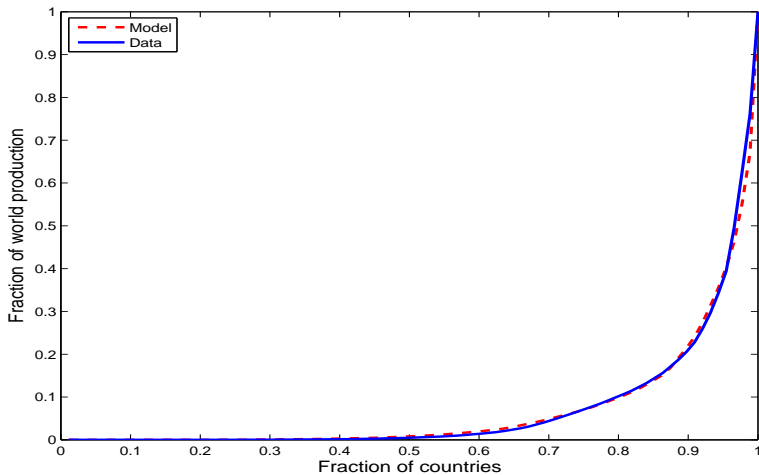
## Productivities

- ▶ Calibrate  $\lambda_{ei}$ ,  $\lambda_{mi}$ , and  $A_{fi}$  to match relative price of capital goods, relative price of intermediate goods, and income per worker, relative to U.S. (normalize  $\lambda_{eUS} = \lambda_{mUS} = A_{fUS} = 1$ ).

$$\frac{P_{ei}}{P_{fi}} \propto \frac{A_{fi}}{(\lambda_{ei}/\pi_{eii})^\theta} \left[ \left( \frac{\lambda_{mi}}{\pi_{mii}} \right)^\theta \right]^{\frac{(\nu_e - \nu_f)}{\nu_m}}$$
$$y_i \propto A_{fi} \left[ \left( \frac{\lambda_{mi}}{\pi_{mii}} \right)^\theta \right]^{\frac{1 - \nu_f}{\nu_m}} \underbrace{\kappa \left( \frac{\lambda_{ei}}{\pi_{eii}}, \frac{\lambda_{mi}}{\pi_{mii}} \right)^\alpha}_{k_i^\alpha}.$$

# Results

## World distribution of capital goods production



Correlation = 0.94

# Results

## Investment rates

- ▶ Observed investment rates measured at domestic prices are roughly constant across countries but investment rates measured at PPP prices vary positively with income (Hsieh and Kenow (2007) and Restuccia and Urrutia (2001)).
- ▶ Our model is consistent with both facts.

# Results

## Prices

- ▶ Observed price of capital goods relative to final goods covaries positively with development.
  - ▶ Most of the systematic variation is in the price of final goods (Hsieh and Klenow (2007)).

### Price elasticity w.r.t. income per worker

Sector	model	data
Producer durables	0.03	0.03
Final goods	0.57	0.52

## Counterfactual: No trade distortions

- ▶ Trade barriers distort the allocation of resources, both across sectors within a country and across countries.
- ▶ Compute the optimal allocation of resources in a world without trade distortions.
- ▶ The gap in income per worker between countries in the top and bottom deciles of the income distribution:
  - ▶ 22 in the benchmark.
  - ▶ 10 in the world without trade distortions.
  - ▶ 80 percent of the change is due to change in capital.

## Counterfactual: Autarky in capital goods

- ▶ Compute the steady state in a world without trade in capital goods
- ▶ Income losses for all countries
- ▶ Almost **all** of the losses stem from decreased capital.



# Conclusion

- ▶ Multi-country Ricardian model of trade in capital goods and other intermediate goods.
  - ▶ The model quantitatively replicates the observed capital goods production, capital per worker, prices, and investment rates.
- ▶ Elimination of barriers to trade results in
  - ▶ optimal allocation of factors, and
  - ▶ reduction of income gap by 50 percent, with 80 percent of the change in income coming from change in capital.
- ▶ Shutting down trade in capital goods implies income losses for all countries.
  - ▶ Almost all of the losses are due to decreased capital.