Romer or Ricardo?

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Romer or Ricardo?

- Benchmark growth models
  - Quality ladders (Aghion-Howitt, Grossman-Helpman)
  - New varieties (Romer, Rivera-Batiz and Romer)
- Benchmark trade models
  - Quality-based comparative advantage (Ricardo, Eaton-Kortum)
  - Trade in distinct varieties (Krugman, Melitz)
- Importance of horizontal varieties (Romer) vs. quality ladders (Ricardo)?

Why do we care?

- Gains from trade
  - Larger if trade facilitates idea inflows (e.g., creative destruction of imports)
  - Buera and Oberfield (2020), Hsieh, Klenow and Nath (2021)
- Optimal growth
  - Business stealing effects from creative destruction (Atkeson and Burstein, 2019)
  - Countries may not internalize the benefits of their own innovation on growth abroad
- Labor market effects of growth and trade
  - New varieties are less disruptive (require less employment reallocation)
  - Creative destruction is more disruptive (e.g. Dix-Carneiro and Kovak, 2017)

Most closely related predecessors

- Eaton and Kortum (2001 EER) "Technology, trade and growth: A unified framework"
  - We add new varieties and do accounting
  - Because we do accounting, our arrival rates are exogenous
- Hsieh, Klenow and Nath (2021) "A global view of creative destruction"
  - We add new varieties and own innovation, and do accounting
  - We have 20 countries rather than 2
- Garcia-Macia, Hsieh and Klenow (2019) "How destructive is innovation?"
  - We add trade and overhead costs (the latter leading to obsolescence)
  - We do indirect inference on trade flows rather than on domestic employment flows

Romer+Ricardo Model

- Three familiar ingredients
  - Trade due to Romerian new varieties and Ricardian comparative advantage
  - Growth due to new varieties and quality improvements
  - Quality ladder growth on imported products (knowledge spillovers across countries)
- Properties of the model
  - Romerian vs. Ricardian trade is endogenous to new product creation vs. innovation on imports
  - All countries grow at the same rate, but differ in TFP levels on the BGP
- Sources of growth affect the *distribution* of import and export growth rates
  - New varieties or innovation on imports $\rightarrow$ new exports (or large increases)
  - Innovation on imports $\rightarrow$ exit of imports (or large declines)

Preview of our findings

- Growth accounting
  - 43% of growth comes from new products
  - 44% of growth comes from foreign innovation
    - more important in smaller countries (up to 90%)
  - U.S. is an outlier: 64% from new products, 26% from foreign
- Trade accounting
  - Romerian share: 32% for the World, 87% for the U.S., 1% for China
- Global product life cycle
  - As a product ages, the U.S. share falls and "other rich" share rises

Static portion of the model

- Technology
  - CES demand and monopolistic competition for each variety in each country
  - Labor is a fixed factor in each country (size L_k differs by country)
  - Linear production in labor for each variety (same for each country)
  - Fixed labor cost f to sell into each market (including the domestic market)
  - Variable trade costs τ_k to sell into foreign market k
  - Romerian vs. Ricardian products
- Trade
  - Romerian products are sold in those countries where profits cover the fixed cost
  - Ricardian products are lowest quality-adjusted price in a country (and cover fixed cost)
  - Balanced multilateral trade
- Endogenous distribution of TFP across countries at a point in time
  - Based on varieties, qualities, and labor endowments

Cutoff quality and sets of products exported from country j to country k

$$q_j^k \equiv \frac{\sigma}{\sigma-1}\frac{w_j\,\tau_k^{\frac{\sigma}{\sigma-1}}}{P_k}\left[\frac{f(\sigma-1)\left(1-\frac{\tau_k-1}{\tau_k}x_k\right)}{L_k}\right]^{\frac{1}{\sigma-1}} \quad \text{for } k \neq j$$

$$K_{ij}^{Rm} \equiv \{k \in W \,|\, q_{ij} > q_j^k\}$$

$$K_{ij}^{Rd} \equiv \left\{k \in W \,\middle|\, j = \arg\min_{\ell \in W \,|\, q_{i\ell} > q_j^k} \left\{\frac{\tau_k\, w_\ell}{q_{i\ell}}\right\}\right\}$$

$$J_{jk} \equiv \{i \in P_j^{Rm} \,|\, k \in K_{ij}^{Rm}\} \;\cup\; \{i \in P_j^{Rd} \,|\, k \in K_{ij}^{Rd}\}$$

Aggregate consumption, quality, and wages

$$C_k = \left(\sum_{j \in W} \sum_{i \in J_{jk}} \left(q_{ij} \, C_{ijk} \right)^{1 - \frac{1}{\sigma}} \right)^{\frac{\sigma}{\sigma - 1}}$$

$$\widetilde{Q}_k \equiv \left[\frac{1}{M_k} \sum_{j \in W} \sum_{i \in J_{jk}} \left(\frac{w_k}{w_j \, \tau_k} \, q_{ij} \right)^{\sigma - 1} \right]^{\frac{1}{\sigma - 1}}$$

$$\frac{w_k}{P_k} = \frac{\sigma - 1}{\sigma} M_k^{\frac{1}{\sigma - 1}} \, \widetilde{Q}_k$$

Innovations originating in country j

- Creation of new varieties: κ_j
  - Random draw over quality of country j's existing products $\times \rho \leq 1$
- Quality ladder growth on domestic products: λ_j
  - Quality improvement over existing product $\sim$ Pareto $(1, \theta)$
  - Always replaces lower quality version
- Quality ladder growth on imported products: δ_j
  - Quality improvement over foreign incumbent $\sim$ Pareto $\left(\min\left[\frac{\alpha_j}{\alpha_k}, 1\right], \theta\right)$
    - ★ Conditional on $\alpha_j / \alpha_k < 1$, quality is increasing in α_j / α_k
  - Probability of success is decreasing in a country's relative wage
  - Probability replace import in domestic market is *increasing* in τ_j
  - Probability replace incumbent in foreign market is *decreasing* in τ_k

Innovations impacting products consumed in country j

To ease notation suppose for the moment that k stands in for all other economies

- Existing products in country j:
  - Exported product: $\lambda_j + \delta_k \left(\min\left[\frac{\alpha_k}{\alpha_j}, 1\right] \frac{w_j}{w_k \tau_j}\right)^\theta$
  - Imported product: $\delta_j \left(\min\left[\frac{\alpha_j}{\alpha_k}, 1\right] \frac{w_k \tau_j}{w_j}\right)^\theta + \lambda_k$
- New products:
  - New to world: $\kappa_j + \kappa_k$
  - New to country j: $\delta_k \left(\min\left[\frac{\alpha_k}{\alpha_l}, 1\right] \frac{w_l}{w_k}\right)^\theta$ if $\frac{w_k}{w_l}$ sufficiently low

Growth decomposition

	Domestic Innovation	Foreign Innovation
Existing products in j		
Exported	λ_j	$\delta_k \left(\min\left[\frac{\alpha_k}{\alpha_j}, 1\right] \frac{w_j}{w_k \tau_j} \right)^\theta$
Non-traded	λ_j	$\lambda_k \left(\frac{w_j}{w_k \tau_j} \frac{A_{ik}}{A_{ij}} \right)^\theta$
Imported	$\delta_j \left(\min\left[\frac{\alpha_j}{\alpha_k}, 1\right] \frac{w_k \tau_j}{w_j} \right)^\theta$	λ_k
New products in j		
New to World	κ_j	κ_k
New to country j	–	$\delta_k \left(\min\left[\frac{\alpha_k}{\alpha_l}, 1\right] \frac{w_l}{w_k} \right)^\theta$

Domestic vs. Foreign Innovation: column 1 vs. column 2

Quality Upgrading vs. New Products: Rows 1, 2, 3 vs. Row 4, 5

Product shares in each country j

- x_j^x exported products
- x_j^n non-traded products
- x_j^m imported products
- x_j^o non-consumed products
- χ_j exiting domestically-produced products
- χ_j^* exiting imported products

Step sizes in each country j

- S_{λ_j} domestic own innovation
- $S_{\delta_j^*}$ creative destruction of exported products
- $S_{\lambda_j^*}$ nontraded products that are taken over by foreign own innovators
- $S_{\widetilde{\delta}_j}$ imported products that are improved by domestic creative destruction
- $S_{\widetilde{\lambda}_j^*}$ imported products that are improved by foreign own innovation
- S_{κ_j} new domestic varieties
- $S_{\kappa_j^*}$ new imported varieties
- $S_{\widetilde{\delta}_j^*}$ newly-imported varieties
- S_{χ_j} exiting domestically-produced products
- $S_{\chi_j^*}$ exiting imported products

Decomposing growth into quality improvements versus new varieties

$$\mathbb{E}\left[(1+g_j)^{\sigma-1}\right] = 1 + \underbrace{\left(x_j^x + x_j^n\right)\,\lambda_j\,S_{\lambda_j} + x_j^x\delta_j^*\,S_{\delta_j^*} + x_j^n\lambda_j^*\,S_{\lambda_j^*}}_{\text{quality improvement on domestic products}}$$

$$+\;\underbrace{x_j^m\left[\widetilde{\delta}_j\,S_{\widetilde{\delta}_j} + \widetilde{\lambda}_j^*\,S_{\widetilde{\lambda}_j^*}\right]}_{\text{quality improvement on imports}} \;+\; \underbrace{\left(x_j^x + x_j^n\right)\left[\kappa_j\,S_{\kappa_j} + \kappa_j^*\,S_{\kappa_j^*}\right] + x_j^o\,\widetilde{\delta}_j^*\,S_{\widetilde{\delta}_j^*}}_{\text{new varieties}}$$

$$-\,\chi_j\,S_{\chi_j} - \chi_j^*\,S_{\chi_j^*}$$

Decomposing growth into domestic and foreign sources

$$\mathbb{E}\left[(1+g_j)^{\sigma-1}\right] = 1 + \underbrace{\left(x_j^x + x_j^n\right)\lambda_j\, S_{\lambda_j} + x_j^m\,\widetilde{\delta}_j\, S_{\widetilde{\delta}_j} + \left(x_j^x + x_j^n\right)\kappa_j\, S_{\kappa_j}}_{\text{domestic innovation}}$$

$$+ \underbrace{x_j^x\,\delta_j^*\, S_{\delta_j^*} + x_j^n\,\lambda_j^*\, S_{\lambda_j^*} + x_j^m\,\widetilde{\lambda}_j^*\, S_{\widetilde{\lambda}_j^*} + \left(x_j^x + x_j^n\right)\kappa_j^*\, S_{\kappa_j^*} + \widetilde{\delta}_j^*\, S_{\widetilde{\delta}_j^*}}_{\text{foreign innovation}}$$

$$- \chi_j\, S_{\chi_j} - \chi_j^*\, S_{\chi_j^*}$$

Trade in Romerian vs. Ricardian products

- Assume two countries j and k and no trade costs ($\tau = 1$)

- Net arrival rate of Romerian exported products:

$$\kappa_j - \text{Romer Share}_j \, \delta_k \left(\frac{w_j}{w_k}\right)^{\theta}$$

- Net arrival rate of Ricardian exported products:

$$\delta_j \left(\frac{w_k}{w_j}\right)^{\theta} - \text{Ricardo Share}_j \, \delta_k \left(\frac{w_j}{w_k}\right)^{\theta}$$

- Share of Romerian vs. Ricardian exported products in steady state:

$$\frac{\text{Romer Share}_j}{\text{Ricardo Share}_j} = \frac{\kappa_j}{\delta_j \left(\frac{w_k}{w_j}\right)^{\theta}}$$

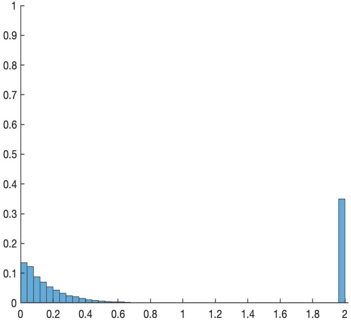
Inference: λ vs. δ vs. κ

- Small vs. large <u>export</u> growth
  - Innovation on imports δ and new products κ create *new* exported products
  - Innovation on domestic products λ results in small increases in *existing* exports
  - Does not distinguish between δ and κ
- Small vs. large <u>import</u> declines
  - Innovation on imports δ results in replacement of imported products
  - Creation of new products κ does not
  - Imported products also become obsolete (due to the fixed cost)

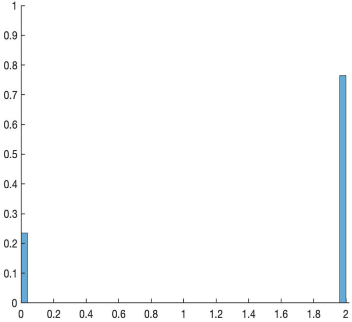
Innovation on domestic products λ vs. on imports δ

Distribution of growing exports across products

Innovate on domestic products



Innovate on imports



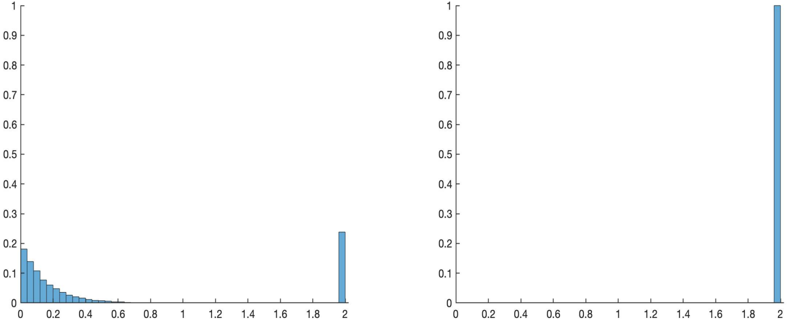
Export growth rate

$\lambda_j = .6$, $\delta_j = .01$, $\kappa_j = .04$ $\qquad$ $\lambda_k = 0$, $\delta_k = .9$, $\kappa_k = .04$

Innovation on domestic products λ vs. new varieties κ

Distribution of <u>growing</u> exports across products

Innovate on domestic products New varieties

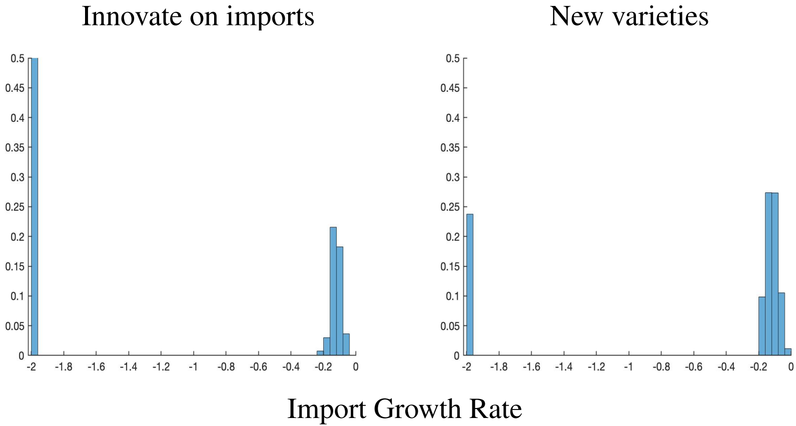


Export Growth Rate

$\lambda_j = .5125$, $\delta_j = .01$, $\kappa_j = .04$ $\lambda_k = 0$, $\delta_k = .01$, $\kappa_k = .2$

Innovation on imports δ vs. new varieties κ

Distribution of shrinking imports across products



$\lambda_j = 0$, $\delta_j = .3$, $\kappa_j = .04$ $\qquad$ $\lambda_k = 0$, $\delta_k = .01$, $\kappa_k = .3$

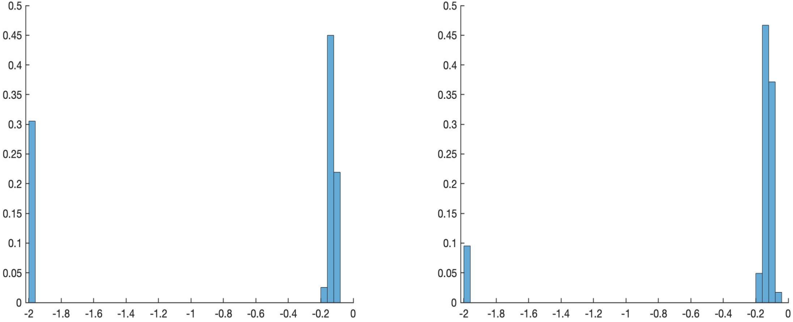
Inference: large vs. small α for poor countries

- Recall that creative destruction by j on import from k has a scale parameter of $\min(\frac{\alpha_j}{\alpha_k}, 1)$
- $\alpha_{poor}/\alpha_{rich} < 1$ makes it less likely that a poor country will replace import from rich country
- But no effect on probability of replacing import from another poor country (with the same α)
- Affects frequency of large import declines from poor countries vs. from rich countries

Distribution of shrinking imports from rich vs. poor countries

$$\alpha_{\text{poor}} / \alpha_{\text{rich}} = 1$$

Imports from rich country | Imports from poor country



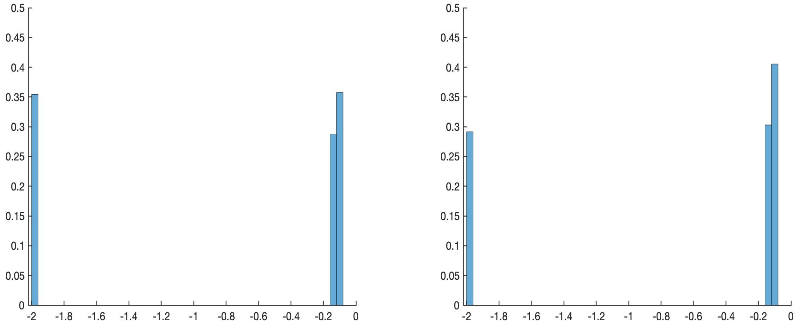
Import Growth Rate

Note: $\frac{\text{TFP}_{\text{poor}}}{\text{TFP}_{\text{rich}}} = 0.5, \delta_{\text{poor}} = 0.01, \kappa_{\text{rich}} = 0.325$

Distribution of shrinking imports from rich vs. poor countries

$$\alpha_{\text{poor}} / \alpha_{\text{rich}} = 0.5$$

Imports from rich country　　Import from poor country



Import Growth Rate

Note: $\frac{\text{TFP}_{\text{poor}}}{\text{TFP}_{\text{rich}}} = 0.5, \delta_{\text{poor}} = 0.1, \kappa_{\text{rich}} = 0.303$

Varieties vs. Categories

- So far we have focused on <u>varieties</u> (individual products)
  - Product arrivals have clear predictions for import declines and export increases
  - Can track varieties in the model but not so easily in the data
- Empirically we see <u>categories</u> (collections of varieties)
  - 4-digit SITCs
  - Though less sharp, product arrivals have similar predictions for categories

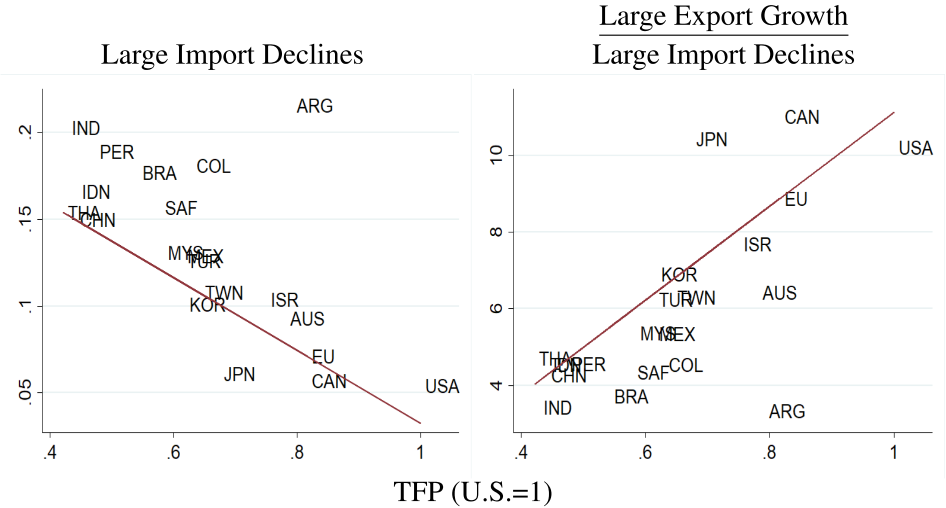
Dataset

- 4-digit SITCs in Feenstra's dataset (average of 1991-1996 through 2011-2016)
- 20 countries (EU is one country) accounting for 95% of world trade
- Normalize total growth of exports and imports of each country to zero
  - Growth rate of exports between t and $t + 5 = \Delta$ exports / average exports
  - New exports = +2, Exiting exports = –2
- Exports with strong positive growth
  - Share of growing export categories with growth rate > 1
- Imports with strongly negative growth
  - Share of shrinking import categories with growth rate < -1
- Imports with strongly negative growth from poor countries versus from rich countries

20 countries

Rich Countries		Poor Countries	
U.S.	South Korea	Thailand	Mexico
Canada	Colombia	Turkey	South Africa
EU	Israel	China	Indonesia
Japan	Australia	Malaysia	Peru
Argentina	Taiwan	India	Brazil

Import declines, export growth, and TFP levels



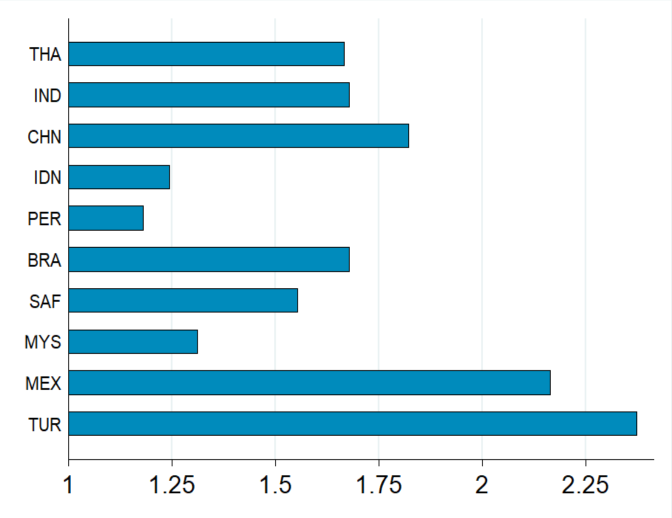
Identification

- Data on relative wages
  - Innovation rate (from all sources) relative to the U.S.
- Data on trade shares
  - Trade costs (fixed costs and variable costs)
- Data on the share of large export growth rates
  - New varieties and creative destruction of imports
- Data on the frequency of big import declines
  - Creative destruction of imports
- Data on the share of small export growth rates
  - Innovation on domestic varieties
- Aggregate growth rate
  - Quality step size

Empirical moments we target

	U.S.	Other Rich	China	Other Poor	World
TFP	1	0.751	0.441	0.507	0.678
Trade Share	18.4%	24.1%	16.2%	26.4%	20.9%
Export Growth > 1	55.2%	64.5%	63.9%	71.4%	63.3%
Import Growth < -1	5.4%	7.7%	15.0%	16.5%	10.5%

Imports from poor vs. rich countries with strongly negative growth



Counting parameters and moments

- 87 parameters
  - 80 from τ_k, κ_k, δ_k, and λ_k for each of 20 countries
  - 2 α imitation parameters for the 10 poorest countries
  - 5 parameters common to all countries: θ, f, ρ, κ_c, and σ (imposed to be 4)
- 87 moments
  - share of large export growth, share of large import decline, trade share, TFP for 20 countries
  - 3% annual TFP growth for U.S. manufacturing (assumed common to all 20 countries)
  - weighted share of large export growth, exit rate, share of export with positive growth
  - poor/rich large import decline ratio for 5 poorest and 5 next poorest countries
  - impose 1% annual population growth in all 20 countries

Inferred innovation rates

	U.S.	Other Rich	China	Other Poor
New Products κ	77.6%	23.0%	0.8%	22.0%
Imported Products δ	3.6%	7.1%	8.0%	6.7%
Success rate	0.4%	2.5%	4.3%	2.1%
Domestic Products λ	93.7%	80.1%	2.0%	51.0%

Parameters values common to all countries

	Value
Imitation parameter α for 5 lowest TFP countries	0.531
Imitation parameter α for 5 second-lowest TFP countries	0.449
Share of new products in new category κ_c	2%
Pareto shape θ	18.2
Fixed cost f	0.05
Quality of new varieties ρ	0.886

κ_c is the share of new products that are allocated to new export categories.
θ is the shape parameter of the distribution of the innovation step size.
f is the fixed cost in units of labor to sell in a market.

Growth decomposition: domestic vs. foreign innovation

	World	U.S.	Other Rich	China	Other Poor
Domestic Innovation	56.1%	74.2%	35.4%	78.1%	39.6%
Foreign Innovation	43.9%	25.8%	64.6%	21.9%	60.4%

Growth from new products vs. quality upgrading

	World	U.S.	Other Rich	China	Other Poor
Quality upgrading	57.2%	35.6%	48.1%	85.3%	53.6%
New products	42.7%	64.4%	51.9%	14.7%	46.4%

Growth from new varieties

$$\Delta \log \frac{w_k}{P_k} = \frac{1}{\sigma - 1} \cdot \Delta \log M_k + \Delta \log \widetilde{Q}_k$$

With population growth of 1% per year, $\Delta \log M_k = 1\%$ for all countries.

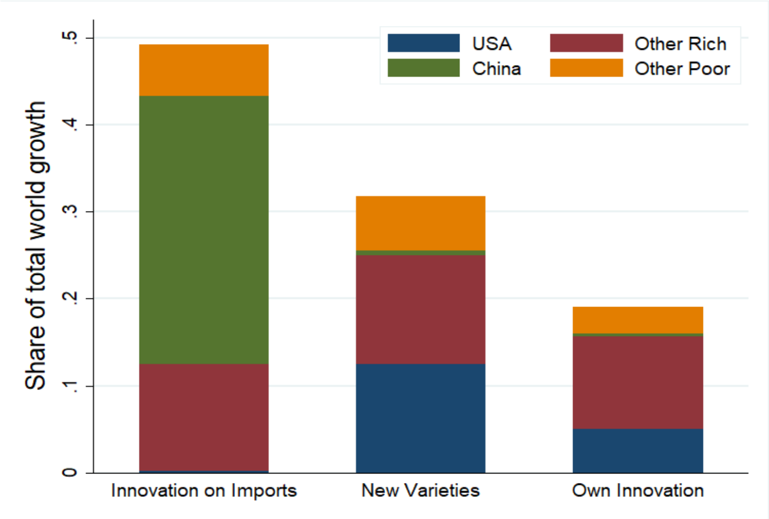
So with $\sigma = 4$ population growth leads to love-of-variety growth of 0.33% per year.

But new varieties also drive out marginal quality varieties (gross $>$ net variety creation rate).

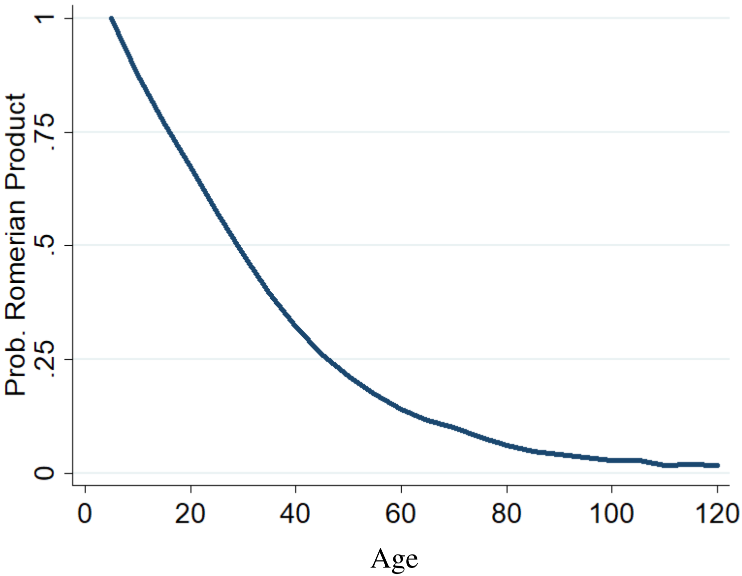
This indirect quality growth channel contributes another 0.85% per year to world growth.

In total, new varieties contribute 1.2 % points of the overall 3% world growth rate.

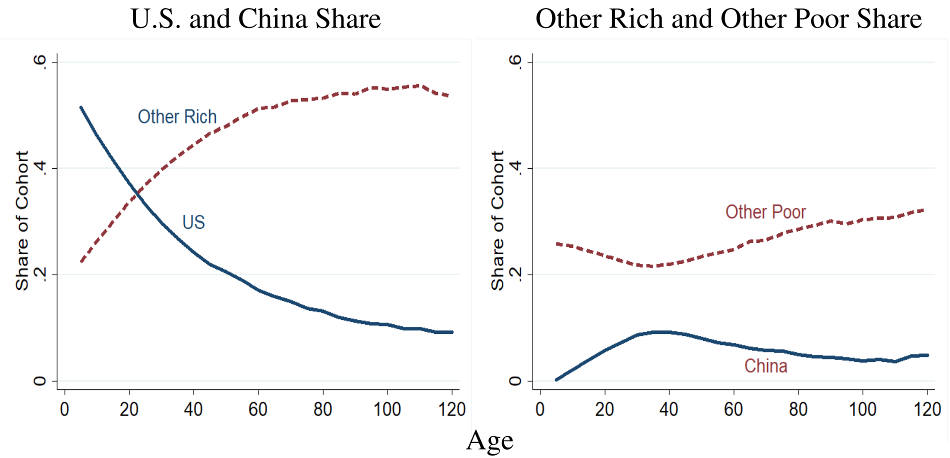
Sources of world growth



Global product cycle: share of Romerian products by age



Reallocation of products across countries



Recap of our findings

- Growth accounting
  - 43% of growth is Romerian
  - 44% of growth is from foreign innovation
  - U.S. is an outlier: 64% Romerian, 26% from foreign
- Trade accounting
  - Romerian share: 32% for the World, 87% for U.S., 1% for China
- Global product life cycle
  - U.S. share falls, and “other rich” share rises as products age