Global Value Chains: Spiders and Snakes

First Annual Workshop of ECSB Research Cluster 2

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November 17, 2017

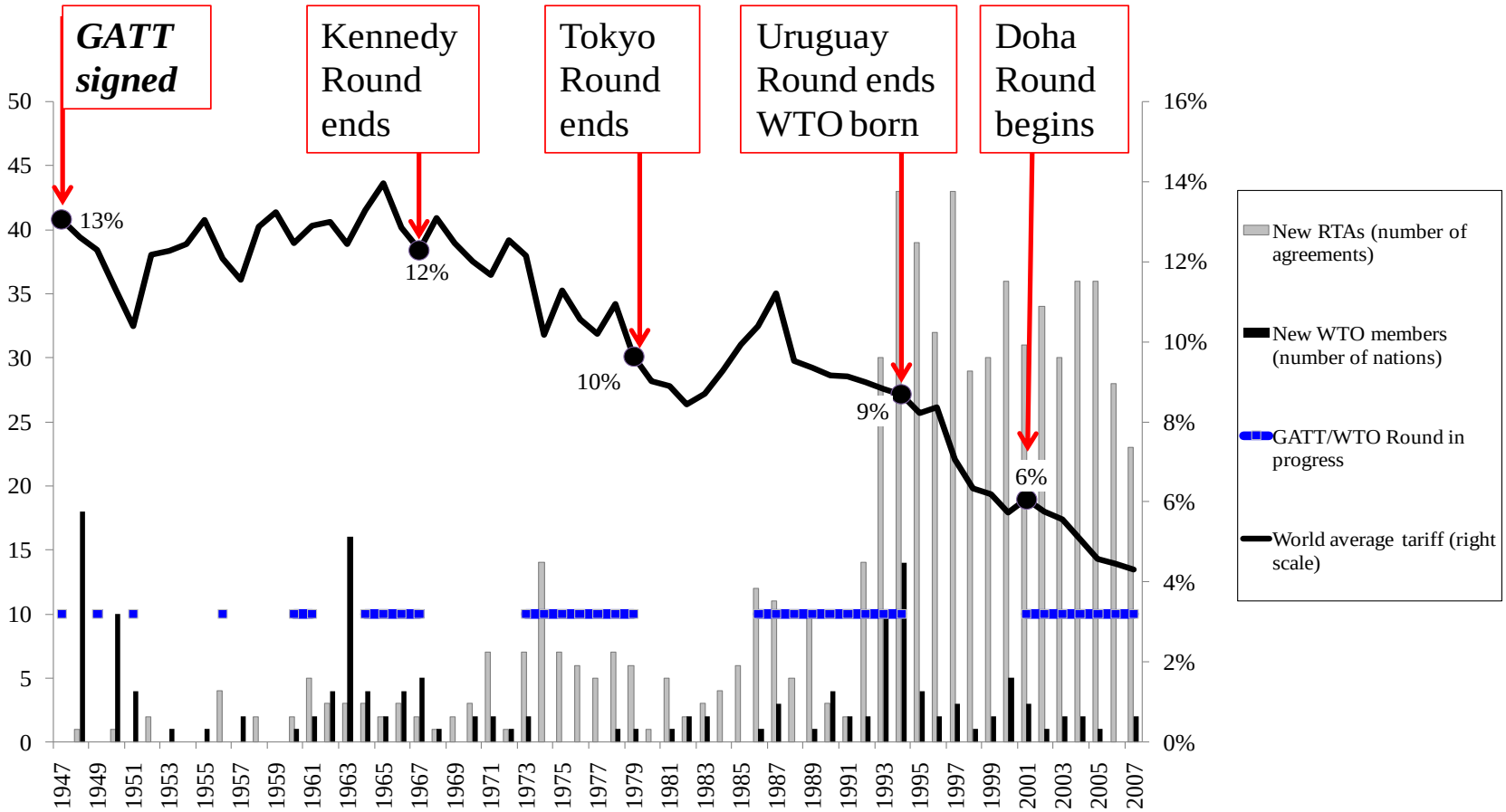
Three Major Developments

ICT Revolution

1. Information and communication technology (ICT) revolution
   - Processing power and memory capacity of computers
   - Cost of transmitting information over an optical network

Falling Trade Costs

2. Deepening trade liberalization and falling transportation costs
   - EU, NAFTA, Mercosur, ASEAN FTA, China's WTO accession, etc.



Source: R. Baldwin

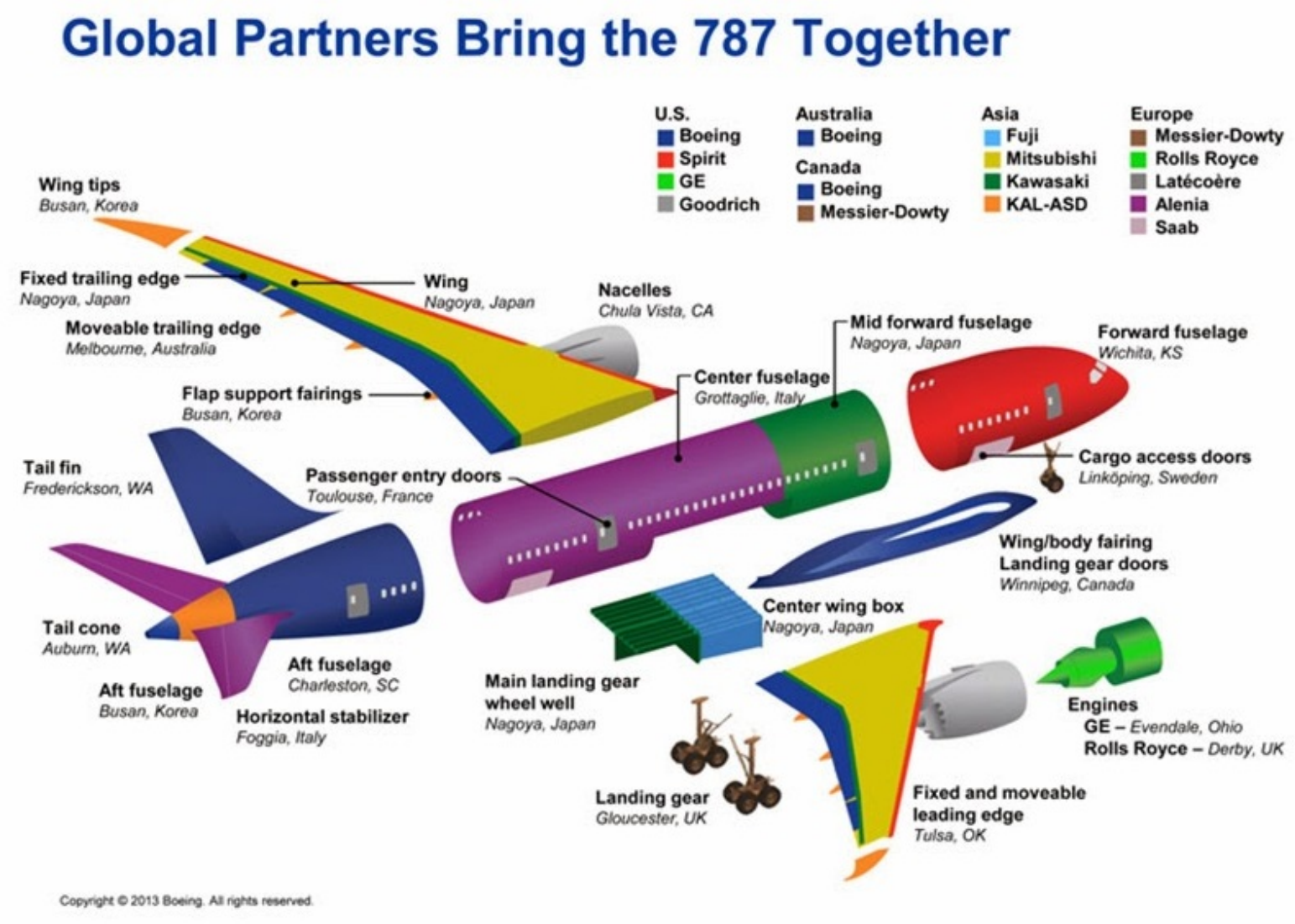
Sources: RTAs: WTO online databases & Hufbauer-Schott RTA database; tariffs: Clemson and Williamson (2004) up to 1988, then World DataBank (weighted tariffs all products)

Political Developments

3. Political developments expanding the reach of globalization
    - Fall of communism, worldwide ideological shift to the right in large parts of the globe

Spiders and Snakes

A Spider: Boeing's Dreamliner



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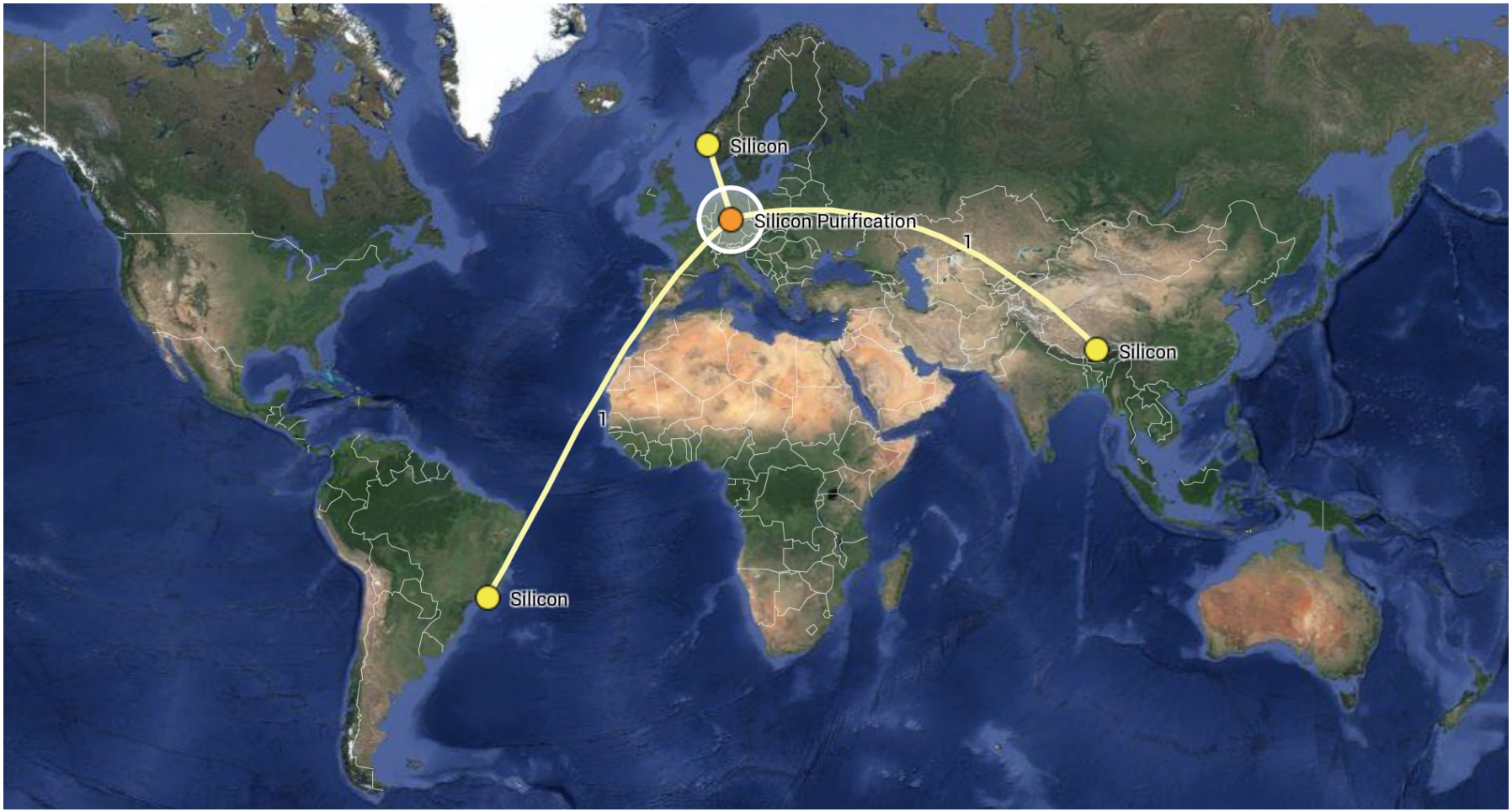

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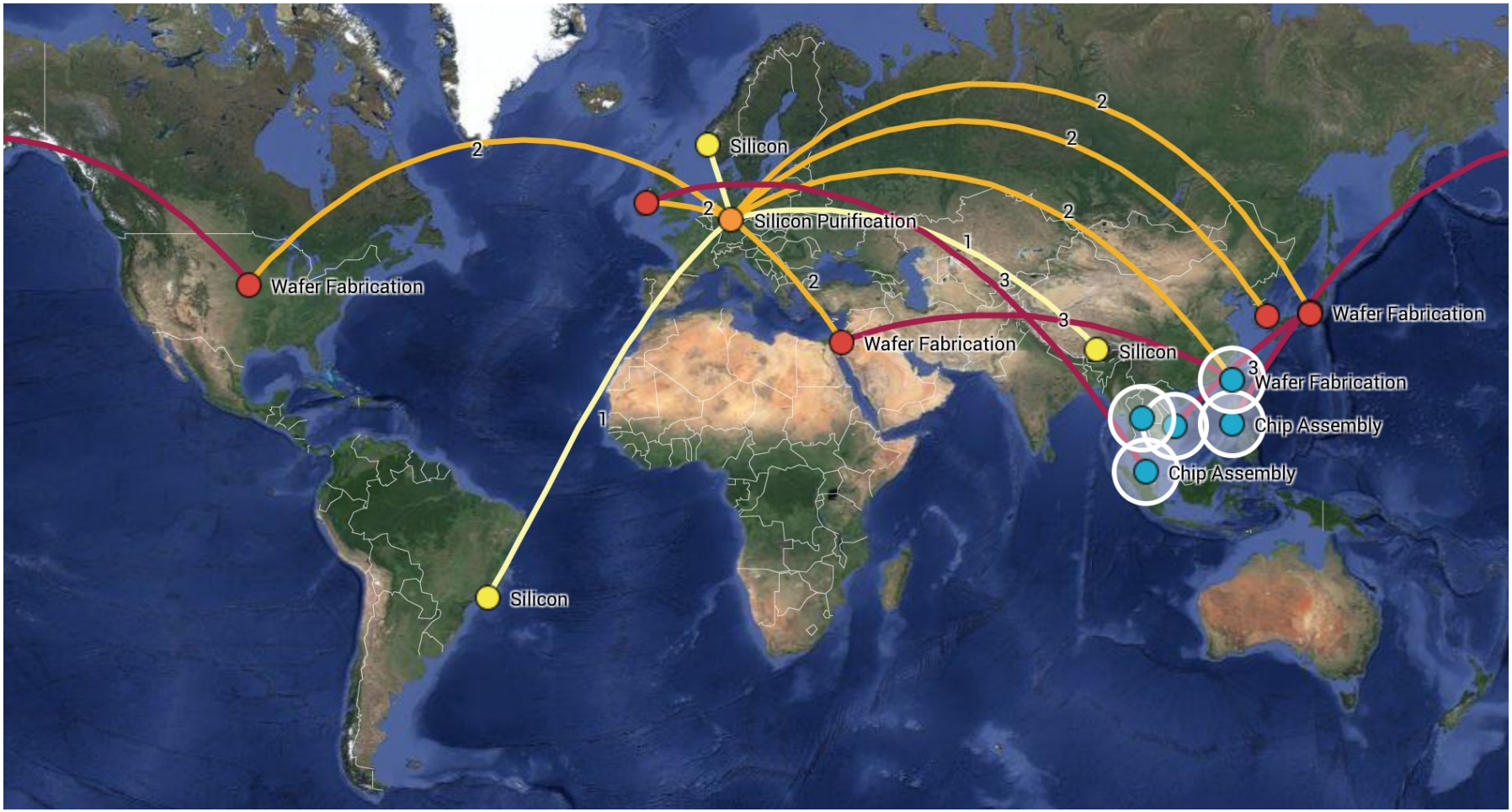

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- Does it matter that trade relationships are often initiated by importers seeking to procure inputs from foreign suppliers?
- Does it matter that trade within global value chains (GVCs) is often sequential in nature?
- Do we need new models?

Road Map

- Today I want to highlight some novel features that arise when analyzing and estimating multi-country global sourcing models

1. **Spiders:** Overview of Antràs, Fort and Tintelnot (2017)
2. **Snakes:** Overview of Antràs and de Gortari (2017)

Spiders: Antràs, Fort and Tintelnot (2017)

The Margins of Trade

- Suppose you interpret world trade flows (or U.S. imports more narrowly) as the legs of spiders
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- **Fact:** Superior performance (size, labor productivity, TFP) of importers
- Similar facts on the export side motivated today's workhorse models of trade

Challenges for a Multi-Country Global Sourcing Model

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  - Easy to handle various margins of trade
- But importing inputs naturally affects the marginal cost of the firm!
- Import entry decisions are thus interdependent across markets
- Interdependencies across markets complicate the firm's decision
  - Which countries should a firm invest in importing from?
  - From which particular country should each input be bought?
  - How much of each input should be purchased?

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- Develop a quantifiable multi-country sourcing model
  - Characterization of intensive and extensive margins of global sourcing
  - Eaton-Kortum (2002) and multi-country Melitz (2003) are special cases

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  - Apply theoretical insights and IO algorithm to estimate model
  - Counterfactual analysis of shock to China's sourcing potential
- Study effects of shocks to global sourcing
  - Distinguish net vs. gross changes in sourcing / employment
  - Reduced-form evidence consistent with these predictions

Environment

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- **Intermediate good** sector
  - Each firm uses a unit measure of intermediate inputs (next slide)
  - Each firm in i needs to pay fixed cost $w_i f_{ij}$ to activate source market j
  - Sourcing strategy: $\mathcal{J}_i(\varphi) \subseteq \{1, ..., J\}$
  - Iceberg trade cost τ_{ij} for firms in i to import from j
  - Perfect competition $\Longrightarrow$ Marginal-cost pricing of inputs

Production Technology

- Marginal cost of final good producer φ based in i is:

$$c_i\left(\left\{j\left(v\right)\right\}_{v=0}^{1},\varphi\right)=\frac{1}{\varphi}\left(\int_0^1\left(p_i\left(v,j(v)\right)\right)^{1-\rho}dv\right)^{1/(1-\rho)}$$

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- Instead assume that productivity $1/a_j(v)$ for a given location j is drawn from Fréchet distribution:

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  - Pros and Cons

Firm Behavior Conditional on Sourcing Strategy

- Share of intermediate input purchases sourced from any country j:

$$\chi_{ij}(\varphi) = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i(\varphi)} \quad \text{if } j \in \mathcal{J}_i(\varphi)$$

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- Marginal cost:

$$c_i(\varphi) = \frac{1}{\varphi} (\gamma \Theta_i(\varphi))^{-1/\theta}$$

Optimal Sourcing Strategy

- Profit Function:

$$\max_{I_{ij}\in\{0,1\}_{j=1}^{J}} \varphi^{\sigma-1}\left(\gamma\sum_{j=1}^{J} I_{ij}\,T_j\left(\tau_{ij}w_j\right)^{-\theta}\right)^{(\sigma-1)/\theta} B_i - w_i\sum_{j=1}^{J} I_{ij}\,f_{ij}$$

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- Proposition 1. The solution $I_{ij}(\varphi)\in\{0,1\}_{j=1}^{J}$ to the optimal sourcing problem is such that:

  (a) a firm's sourcing capability $\Theta_i(\varphi)=\sum_{j=1}^{J} I_{ij}(\varphi)\,T_j\left(\tau_{ij}w_j\right)^{-\theta}$ is nondecreasing in φ;

  (b) if $(\sigma-1)/\theta\geq 1$, then $\mathcal{J}_i(\varphi_L)\subseteq\mathcal{J}_i(\varphi_H)$ *for* $\varphi_H\geq\varphi_L$, where $\mathcal{J}_i(\varphi)=\{j: I_{ij}(\varphi)=1\}$.

Interdependencies in Firm Sourcing Decisions

- Proposition 3. Holding constant the the market demand level B_i, whenever $(\sigma - 1)/\theta \geq 1$, an increase in the sourcing potential $T_j (\tau_{ij} w_j)^{-\theta}$ or a reduction in the fixed cost f_j of any country j, (weakly) increases the input purchases by firms in i not only from j, but also from all other countries.

- Corollary. There may exist complementarities between domestic and foreign sourcing

Structural Estimation

Data

- 2007 data from the U.S. Census Bureau
  - Economic Censuses
  - Import transactions data
- Sample is all manufacturing firms (around 250,000 firms)
  - Include firms with non-manufacturing activity
  - 23% of employment and 38% of sales
  - 65% of (non-mining) imports
  - A quarter of these firms imports
- Structural Estimation
  - Limit analysis to countries with 200+ U.S. importers
  - 66 countries and the U.S.
- Reduced form evidence on interdependencies
  - Balanced panel of manufacturing firms in 1997 and 2007
  - UN Comtrade data; 1997 BEA Input-Output tables

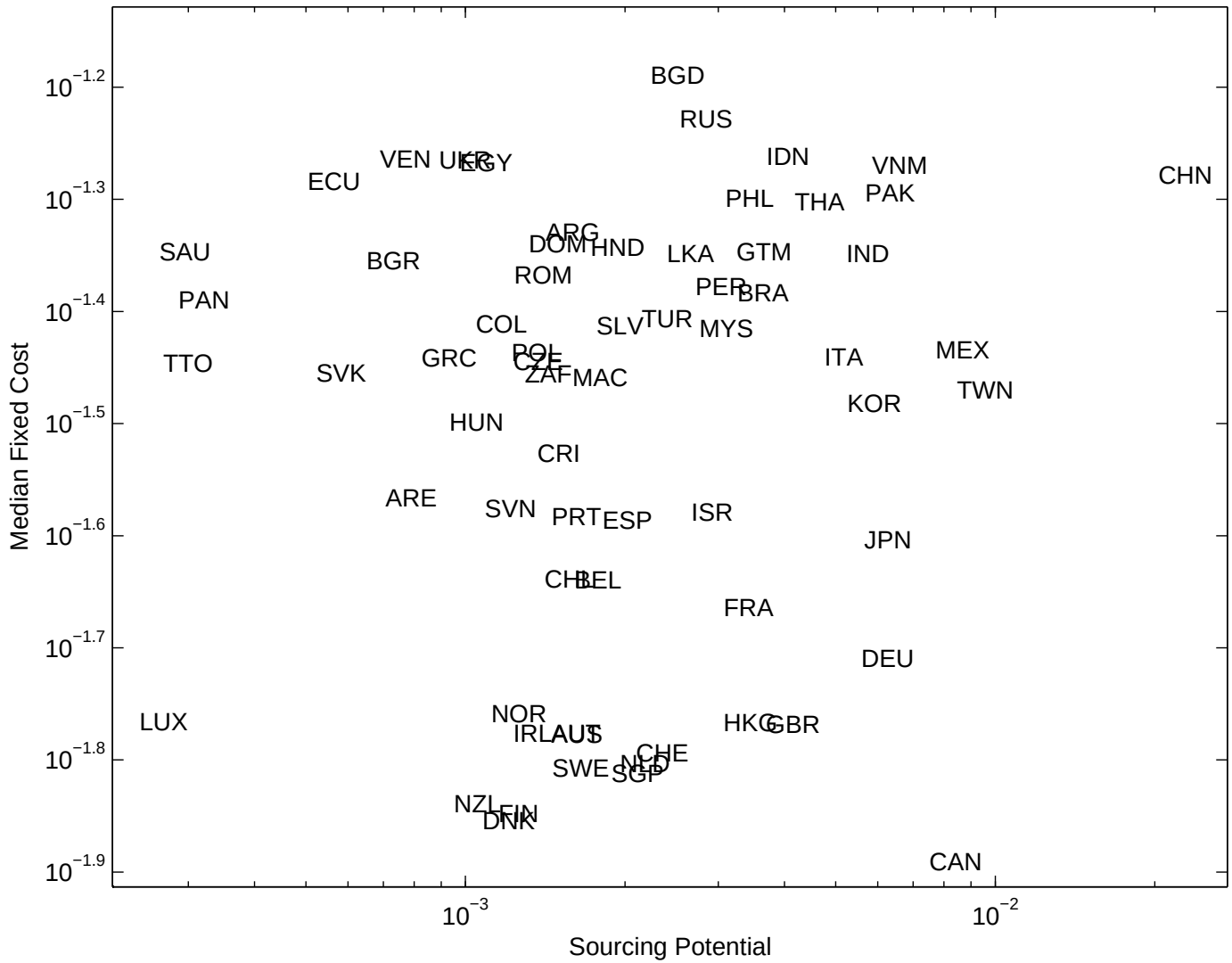
Overview of Estimation

- Step 1: Back out sourcing potential from firm-level input shares
  - Recovered from country fixed effects in normalized share regressions
- Step 2: Estimate demand elasticity and productivity dispersion
  - Project fixed effect on human-capital adjusted labor cost
- Step 3: Estimate fixed costs of sourcing and residual demand
  - Simulated method of moments + Jia's (2008) algorithm

$$\Pi(\mathcal{J},\varphi,f_{ij}^n) = \varphi^{\sigma-1}\left(\sum_{j=1}^{j\in\mathcal{J}} T_j(\tau_{ij}w_j)^{-\theta}\right)^{(\sigma-1)/\theta} \left(\widetilde{B} - \sum_{j\in\mathcal{J}} f_{ij}^n\right)$$

Step 1 Step 2 Step 3

Sourcing Potential vs. Fixed Cost Estimates



Counterfactual and Reduced-Form Evidence: China Shock

- Negative shock to China's sourcing potential to match 1997 share of China importers (38% of its 2007 level)
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- Calculate impact from going back to 2007 sourcing potential values
- We find evidence of heterogeneous effects
  - Some firms expand sourcing **everywhere**, others contract
- We also provide reduced-form evidence using plausibly exogenous variation in sourcing from China (as in Autor et al., 2013)
  - U.S. firms that started importing from China actually expanded their sourcing from U.S. and also from third countries

Snakes: Antràs and de Gortari (2017)

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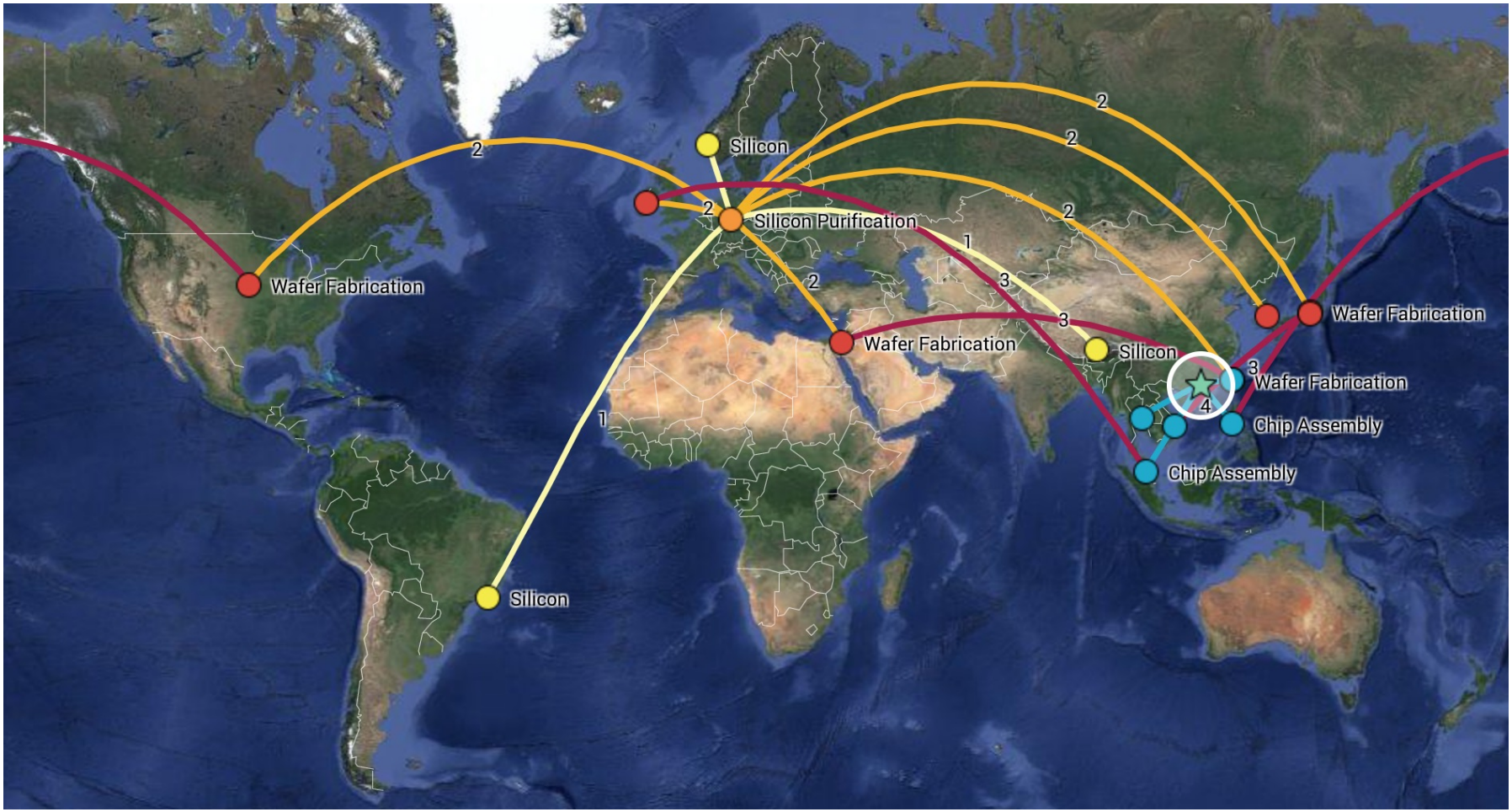

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- Connection with logistics literature

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3. Show how to map our model to world Input-Output tables
4. Structurally estimate the model and perform counterfactuals

Model: Partial Equilibrium

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- The wage rate w_i varies across countries
- Countries also differ in their geography: $J \times J$ matrix of iceberg trade cost coefficients τ_{ij}
- Technology features constant returns to scale and market structure is perfectly competitive

Partial Equilibrium: Sequential Production Technology

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- Assume a Cobb-Douglas-Ricardian cost function

$$p^n_{\ell(n)}(\boldsymbol{\ell}) = \left(a^n_{\ell(n)} w_{\ell(n)}\right)^{\alpha_n} \left(p^{n-1}_{\ell(n-1)}(\boldsymbol{\ell})\, \tau_{\ell(n-1)\ell(n)}\right)^{1-\alpha_n}, \text{ for all } n,$$

with $\alpha_1 = 1$

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- A good assembled in $\ell(N)$ after following the path $\boldsymbol{\ell}$ is available in any country j at a cost $p^F_j(\boldsymbol{\ell}) = p^N_{\ell(N)}(\boldsymbol{\ell})\, \tau_{\ell(N)j}$

Some Results

- Iterating, the cost-minimization problem for a **lead firm** is:

$$\ell^j = \arg\min_{\ell \in \mathcal{J}^N} \left\{ \prod_{n=1}^{N} \left(a^n_{\ell(n)} w_{\ell(n)} \right)^{\alpha_n \beta_n} \times \prod_{n=1}^{N-1} \left(\tau_{\ell(n)\ell(n+1)} \right)^{\beta_n} \times \tau_{\ell(N)j} \right\}$$

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   - Turns a problem of dimensionality $N \times J$ into a J^N problem
   - But easy to reduce dimensionality with dynamic programming
2. Trade-cost elasticity of the unit cost of serving consumers in country j increases along the value chain ($\beta_1 < \beta_2 < ... < \beta_N = 1$)
   - Incentive to reduce trade costs increases as one moves downstream

General Equilibrium

A Multi-Stage Ricardian Model

- We next embed our framework into a general equilibrium model
- Framework accommodates:
  - Ricardian differences in technology across stages and countries
  - A continuum of final goods
  - Multiple GVCs producing each of these final goods
  - An arbitrary number of countries J and stages N

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  - A continuum of final goods
  - Multiple GVCs producing each of these final goods
  - An arbitrary number of countries J and stages N
- Model constitutes a multi-stage extension of the Eaton and Kortum (2002) framework
  - Characterize the relative prevalence of different possible GVCs
  - Study average positioning of countries in GVCs
  - Trace implications for the world distribution of income

Some Results

- Percentage of country j's spending produced following a path ℓ:

$$\pi_{\ell j} = \frac{\prod_{n=1}^{N-1} \left(\left(T_{\ell(n)} \right)^{\alpha_n} \left(\left(c_{\ell(n)} \right)^{\alpha_n} \tau_{\ell(n)\ell(n+1)} \right)^{-\theta} \right)^{\beta_n} \times \left(T_{\ell(N)} \right)^{\alpha_N} \left(\left(c_{\ell(N)} \right)^{\alpha_N} \tau_{\ell(N)j} \right)^{-\theta}}{\Theta_j}$$

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- Can compute final-good trade shares and intermediate input shares as explicit functions of T_j's, c_j's, and τ_{ij}'s (conditional probabilities)

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  where Θ_j is the sum of the numerator over all possible paths

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Estimation

Calibration to World-Input Output Database

- We next map our multi-country Ricardian framework to world Input-Output Tables
- Core dataset: World Input Output Database (2016 release)
  - 43 countries (86% of world GDP) + ROW; available yearly 2000-2014
  - Provides information on input and final output flows across countries
- Also Eora dataset: 190 countries (but consolidate to 101)

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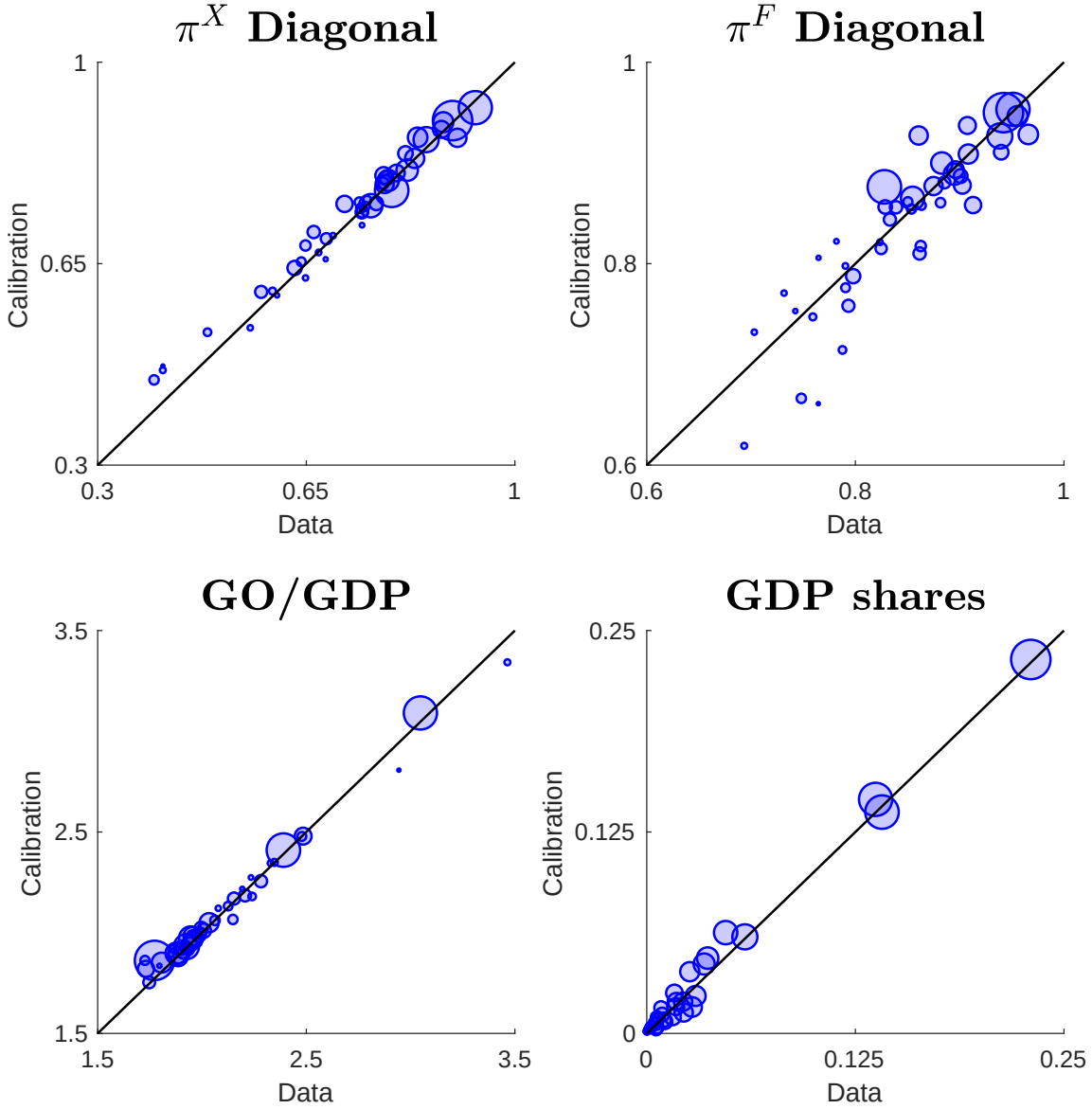
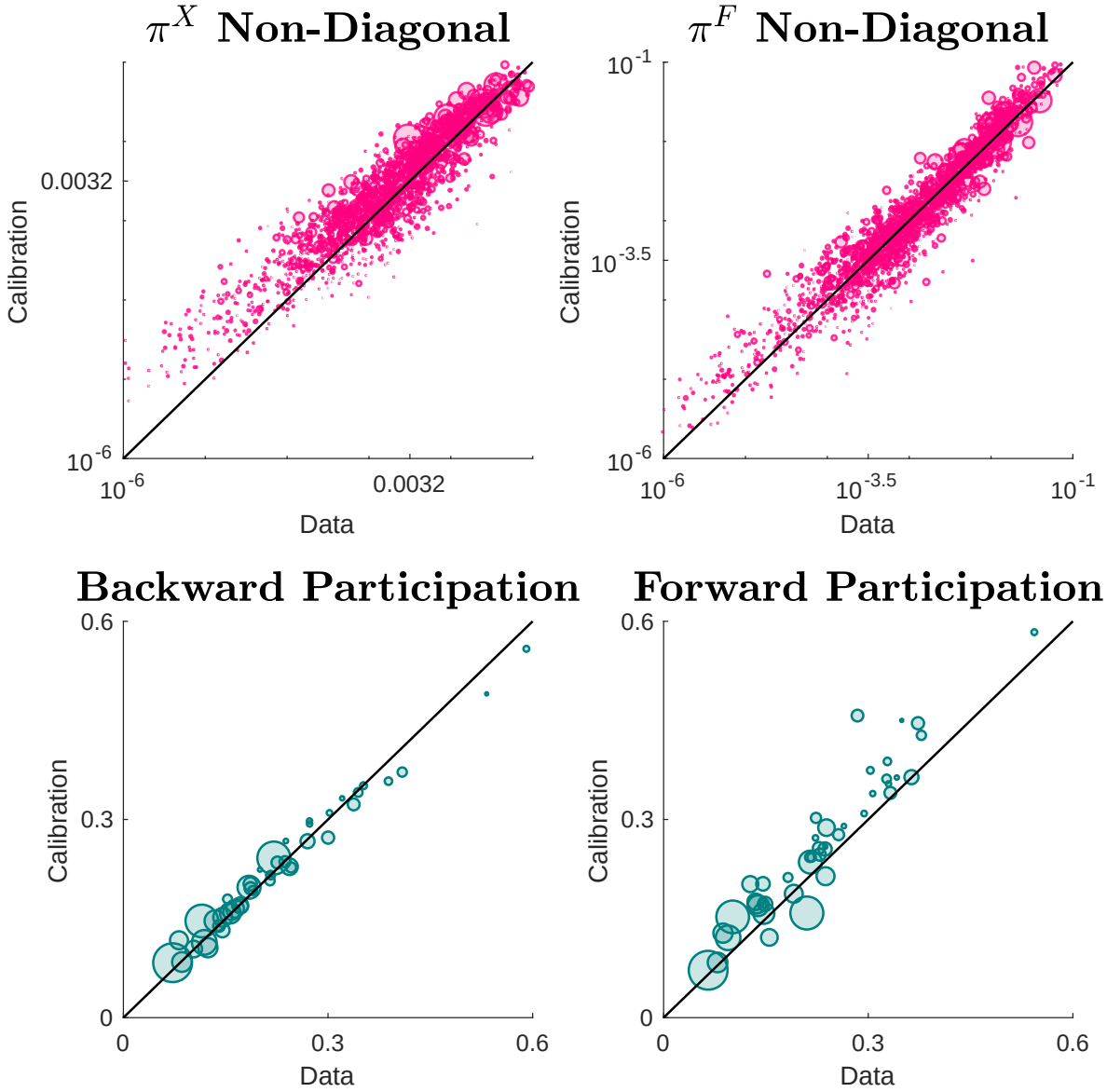
		Input use & value added			**Final use**			**Total use**
		Country 1	$\cdots$	Country J	Country 1	$\cdots$	Country J	
Intermediate inputs supplied	Country 1							
	$\cdots$							
	Country J							
Value added								
Gross output								

Fit of the Model: Targeted Moments

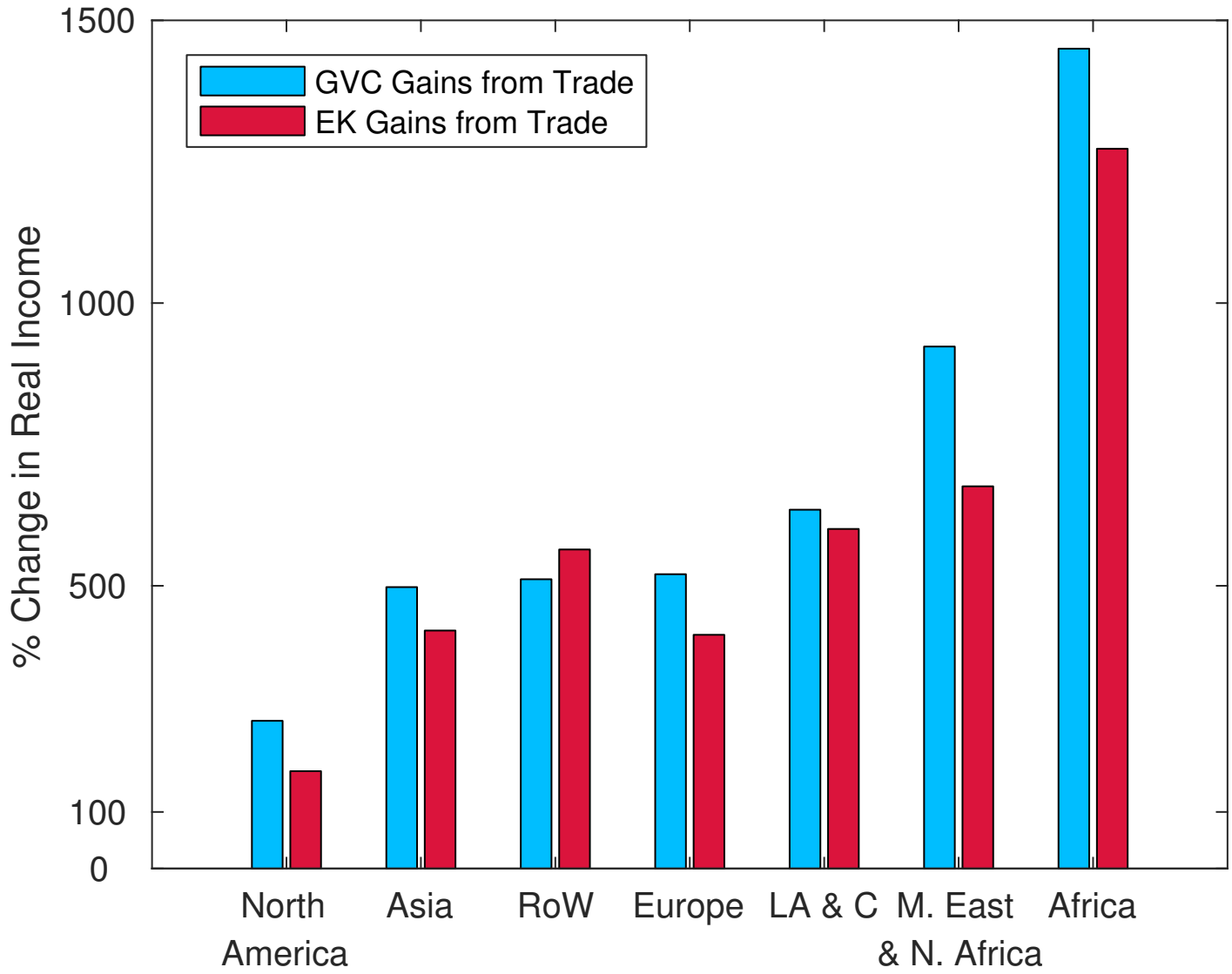


Fit of the Model: Untargeted Moments



Counterfactuals

Counterfactuals: Real Income Gains from Free Trade



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- Both for Spiders and for Snakes
- Frameworks deliver novel qualitative insights, but can also be used to quantitatively assess the implications of the rise of GVCs
- I view this work as a stepping stone for a future analysis of the role of **man-made** trade barriers in GVCs
  - Should countries use policies to place themselves in particularly appealing segments of global value chains?
  - What is the optimal shape of those policies?