Simulating Heterogeneous Multinational Firms

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Presentation Outline

1. Facts on Multinational Production
2. Related Literature
3. Theoretical and Simulation Frameworks
4. Data and Empirical Regularities
5. Estimation and Model Validation
6. Counterfactual Analysis

Facts on Multinationals

- Growing multinational production
  - 11.7 percent per year for 1991-2005

- Worldwide investment liberalization
  - Falling barriers to foreign direct investment

- Firm-level response in domestic industry
  - Small and medium firms contract and exit
  - Large firms grow and invest abroad

Facts on Multinationals

◆ Declining FDI barriers

  ■ Gormsen (2011, mimeo)

    • Bilateral barriers for 28 OECD countries

    • 1985-2008

  ■ Average FDI barriers halved every **4.8** years

  ■ FDI barriers explain **75**% of FDI stock growth

    • Falling trade cost explain **33**% of trade growth (Jack, Novy, and Meissner, 2008)

Table 1. Firm Entry and Exit by Initial Size in 1996 and 2006

Initial Size Interval (percentile)	# All Firms			# Multinationals		
	Year		Change from	Year		Change
	1996	2006	1996	1996	2006	from 1996
0 to 10	1,411	1,376	-35	0	3	3
10 to 20	1,410	1,276	-134	5	13	8
20 to 30	1,411	1,178	-233	3	20	17
30 to 40	1,412	1,229	-183	11	40	29
40 to 50	1,412	1,202	-210	16	36	20
50 to 60	1,414	1,191	-223	27	73	46
60 to 70	1,411	1,299	-112	51	113	62
70 to 80	1,413	1,229	-184	75	185	110
80 to 90	1,412	1,409	-3	184	359	175
90 to 99	1,270	1,309	39	464	677	213
99 to 100	141	157	16	124	137	13
Total	14,117	12,855	-1,262	960	1,656	696

Notes: Percentile bins are determined by parent firms' global sales in 1996; all firms include domestic and multinational firms in manufacturing; we drop firms with *missing* domestic sales.

Source: Basic Survey of Japanese Business Structure and Activities, and Basic Survey of Overseas Business Activities from Japanese METI.

Table 2. Firm Growth by Initial Size in 1996 and 2006

Initial Size Interval (percentile)	Non-Multinational Sales			Multinational Sales			Global Sales		
	Year		Change from	Year		Change from	Year		Change from
	1996	2006	1996	1996	2006	1996	1996	2006	1996
0 to 10	1.21	1.17	-0.04	0.0	0.0003	0.0003	1.21	1.17	-0.04
10 to 20	2.07	1.87	-0.20	0.001	0.003	0.002	2.07	1.87	-0.20
20 to 30	2.84	2.36	-0.48	0.001	0.01	0.005	2.84	2.37	-0.47
30 to 40	3.73	3.23	-0.50	0.003	0.02	0.02	3.73	3.25	-0.48
40 to 50	4.93	4.15	-0.78	0.01	0.03	0.02	4.94	4.18	-0.76
50 to 60	6.61	5.48	-1.13	0.02	0.07	0.05	6.62	5.55	-1.07
60 to 70	9.23	8.45	-0.78	0.06	0.15	0.09	9.29	8.60	-0.69
70 to 80	14.2	12.2	-2.06	0.11	0.32	0.21	14.4	12.5	-1.85
80 to 90	26.9	26.0	-0.90	0.54	1.31	0.77	27.5	27.3	-0.13
90 to 99	110.4	110.1	-0.30	8.89	16.5	7.66	119.3	126.6	7.30
99 to 100	234.6	212.1	-22.5	38.0	76.5	38.4	272.7	288.6	15.9
Total	416.8	387.1	-29.7	47.7	94.9	47.2	464.5	482.0	17.5

Notes: Percentile bins are determined by parent firms' global sales in 1996; sales are in trillions of 2006 Japanese Yen; domestic sales include purely domestic and export sales of all firms; multinational sales include only sales of foreign affiliates by multinational firms.

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Source: Basic Survey of Japanese Business Structure and Activities, and Basic Survey of Overseas Business Activities from METI.

Introduction

- ◆ Globalization may unevenly impact firms
  - ■ Critical policy concern for small and medium firms in Japan

- ◆ Linkage between aggregate shocks and firms
  - ■ FDI barriers in foreign markets and domestic firm activity
  - ■ Standard econometric approach is not appropriate

- ◆ Develop a simulation framework
  - ■ Apply the model by Eaton, Kortum, and Kramarz (2010)
  - ■ Simulate multinational activities across countries

- ◆ Counterfactual analysis for declining FDI barriers
  - ■ Firm-level response to invest abroad

Related Literature

◆ Firm Heterogeneity and international markets
 ■ What firms export/invest abroad?
  • Helpman, Melitz, and Yeaple (2004)
  • Head and Ries (2003)
  • Hayakawa, Kimura, and Machikita (2011)

◆ Location of heterogeneous firms
 ■ Where and how much hetero-firms invest abroad?
  • Aw and Lee (2008)
  • Yeaple (2009)
  • Chen and Moore (2010)

Related Literature

- Structural econometric work on trade
  - Explicit theoretical structure
  - Able to perform counterfactual analysis

- Firm- and plant-level analysis
  - Bernard, Eaton, Jensen, and Kortum (2003)
    - US plant-level exporting behavior
  - Eaton, Kortum, and Kramarz (2010)
    - French firm with export by destination
  - Arkolakis and Muendler (2010)
    - Brazilian firm with product-level export

- Aggregate gains from multinational production
  - Burstein and Monge-Naranjo (2009)
  - Ramondo (2010)

Contributions

◆ Micro-data on Japanese multinationals
  ■ Key empirical regularities of JP multinational activities

◆ To apply EKK model to multinational production
  ■ Simulating heterogeneous multinationals
  ■ Extensive model validation

◆ Counterfactual analysis for FDI barriers
  ■ Reallocation effects on production structure
  ■ Reallocation effects on aggregate productivity

Model Setup

Multi-country world — N markets with technology T_i, size X_n, factor costs w_n,

Firm Heterogeneity: Each country has an unlimited continuum of potential firms each producing its own good with efficiency $z_i(j)$

- where $\mu_i^Z(Z \geq z) = T_i z^{-\theta}$ is a measure of firms producing its own good with efficiency at least z:

Serving Markets: A firm (j) headquartered in country i can setup a plant in host country n but faces

1. Fixed entry cost when entering a market: $E_n(j) = E_n * \varepsilon_n(j)$

2. Costly technology transfer/management that rises in proportion to d_{ni}

Where unit costs for firm (j) to supply market n is then: $c_n(j) = \frac{w_n d_{ni}}{z_i(j)}$

Market Structure: Dixit-Stiglitz preferences and monopolistic competition:

- Aggregate demand: $X_n(j) = \alpha_n(j) \left(\frac{p}{P_n}\right)^{-(\sigma-1)} X_n$
- constant markups: $p_n(j) = \bar{m} \frac{w_n d_{ni}}{z_i(j)} = \bar{m} c_n(j)$

Random Elements: We treat $\alpha_n(j)$, and $\varepsilon_n(j)$ as the realization of producer-specific shocks that are

Affiliate Entry/Sale Conditions

A firm will enter market n iff its operating profits is sufficient to overcome the cost of entry:

$$\pi_{ni} = \alpha_n(j)\left(\frac{\overline{m}c_n(j)}{P_n}\right)^{1-\sigma} X_n - E_n * \varepsilon_n(j) \geq 0$$

This leads to the following two conditions

i.   Foreign affiliate hurdle Condition:

$$c_n(j) \leq \bar{c}_{ni}(j) = \left(\frac{\alpha_n(j)}{\varepsilon_n(j)}\frac{X_n}{\sigma E_{ni}(j)}\right)^{1/(\sigma-1)}\frac{P_n}{\overline{m}}$$

ii.   Latent Sales Condition:

$$X_n^*(j) = \alpha_n(j)\left(\frac{\overline{m}c_n(j)}{P_n}\right)^{1-\sigma} X_n$$

The Price Index and Entry Cutoffs:

– A firm decides whether to enter a given market depending on how much competition they expect to face in that market. The toughness in competition in turn depends on which firms enter.

   Market Profitability → Increased firm entry → tougher competition→ lower profits →Lowers Market Profitability

– price index adjusts to balance entry and profitability

Theoretical Implications

◆ More productive firms tend to be multinational

◆ More productive firms tend to
  ■ Invest in a larger set of markets
  ■ Generate more sales per each market
  ■ Penetrate less attractive markets

◆ Weak pecking order
  ■ Strict pecking order
    • Productivity dictates sorting of firms into international markets
  ■ Entry and market shocks allow for deviations from strict form

Simulation Procedures

1. Re-specify model conditions for simulation

2. Set particular parameters $\Theta = (\theta', \sigma_\alpha, \eta_\sigma, \rho)$
   - Simulate artificial firms according to entry/sales conditions
   - Some efficient firms invest abroad and generate sales

3. Calculate moments of artificial firms
   - Moments describe features of their activities
   - Match moments of real and simulated firms

4. Search for optimal parameters Θ
   - Repeat until best fit between artificial and real moments

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Simulate Artificial Multinationals

◆ Fix parameters Θ of stochastic distributions:
- ■ Generate artificial firms for s = 1,…, S, with unit cost draw $u(s)$
- ■ Generate entry/sales shocks in each market, n, for each firm, s:
  - For **each firm s × market n**
    - Entry shock draw: $\eta_n(s)$
    - Sales shock draw: $\alpha_n(s)$
- ■ Construct entry hurdle condition for **each firm s × market n**
  - $\bar{U}_n(s) = \kappa_2 \times N_{nJ} \times \eta_n(s)^{\theta'}$
    - N_{nJ} is actual number of JP affiliates in market n
  - Firm s enter market n if firm's unit cost is lower (efficient)
    - $u(s) \leq \bar{U}_n(s)$
- ■ Conditional upon entry, compute affiliate sales
  - $X_{nJ}{}^*(s) = (\kappa_2/\kappa_1) \times (X_{nJ}/N_{nJ}) \times (\alpha_n(s)/\eta_n(s)) \times (u(s)/\bar{U}_n(s))^{-1/\theta'}$
    - X_{nJ} is actual total sales of JP affiliates in market n

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Simulated Method of Moments

- A vector of deviations between artificial and real moments

$$y(\Theta) = m - m'(\Theta)$$

- Under true Θ, $E[y(\Theta)] = 0$ should hold.
- We search Θ that minimizes the distance between simulated and actual moments

$$\widehat{\Theta} = \arg\min_{\Theta}\{y(\Theta)'W\,y(\Theta)\}$$

- Computation
  - Estimation by Nelder-Mead simplex search
  - Standard errors by bootstrapping for 1000 times

Data and Empirical Regularities

1. Kigyou Katsudou Kihon Chousa
   - All firms with over 50 employees or 30 mil. Yen of capital

2. Kaigai Jigyo Katsudo Kihon Chousa
   - Foreign affiliates owned by Japanese parent firms

Sample for 2006
- 2032 multinational parents in original data
  - 1656 parent firms have both sales at home and abroad

- 7626 manufacturing foreign affiliates across 70 countries

- Average Multinational Parent:
  - 4.6 foreign affiliates
  - 5.7 billion (yen) sales abroad per an affiliate

Market Entry

- **More entry of MNCs into larger markets**

- **Higher average affiliate sales in larger markets**

Figure 1. Entry and Sales by Market Size

Panel A: Entry of Firms

Panel B: Average Affiliate Sales

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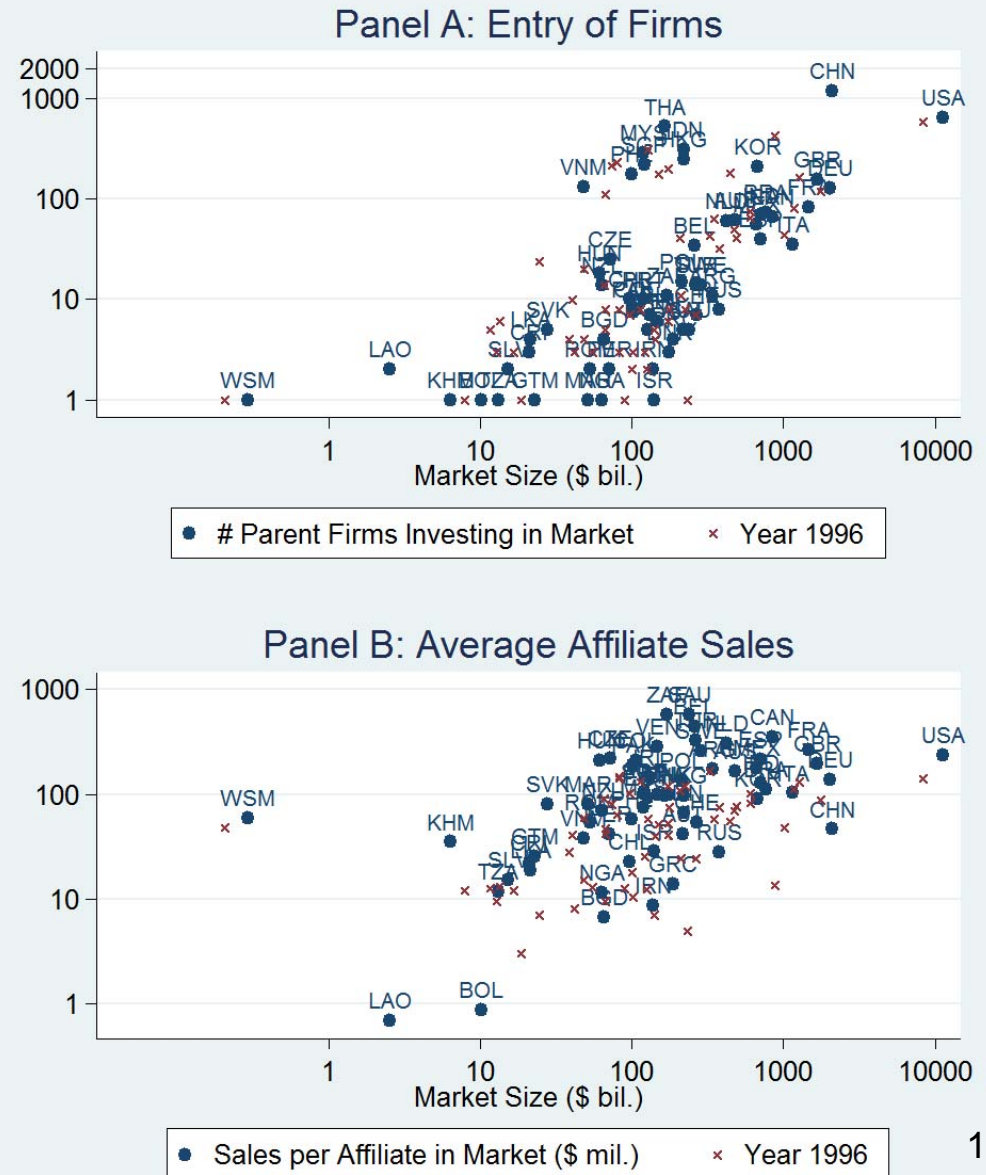
Weak Pecking Order

Market String*	Number of Multinationals
CHN	479
CHN-USA	60
CHN-USA-THAI	29
CHN-USA-THAI-TWN	6
CHN-USA-THAI-TWN-IND	4
Total	(a) 578
Total (that invested in top five)	(b) 1972
Multinationals in Pecking Order	(a)/(b) = 29.3%

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Sales Distribution by Market

- **Similar shapes across markets**

- **Close to Pareto distribution at least in upper tails**

- **Consistent with Pareto assumption of efficiency shocks**

Figure 2. Sales Distribution of Japanese Firms

Japan   China

USA   Thailand

Sales in Market Relative to Mean

Fraction of Firms Selling at Least That Much
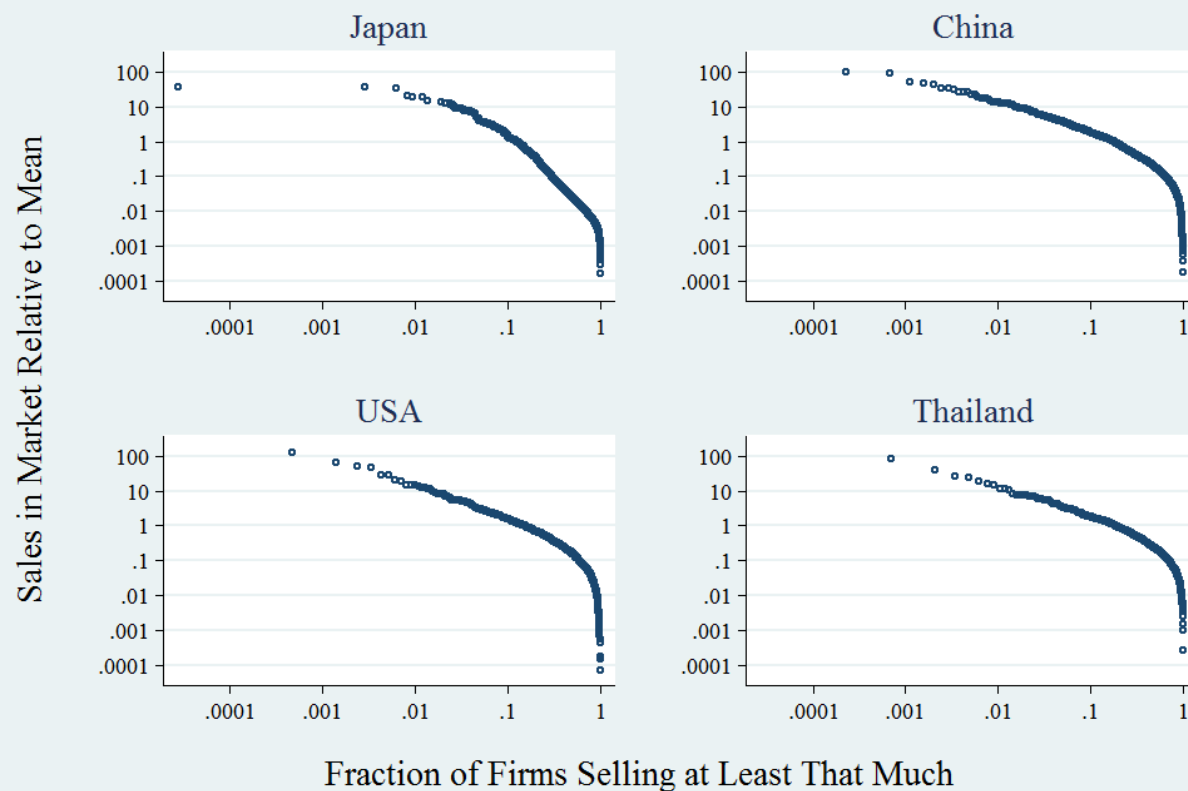
Sales at Home and Market Entry

- Sales in Japan rises for # markets invested

- Over 1000 firms investing in a single market have relatively lower sales in Japan

- Firms investing in more popular markets (CHN) have lower sales in Japan

Figure 3. Sales in Japan and Market Entry

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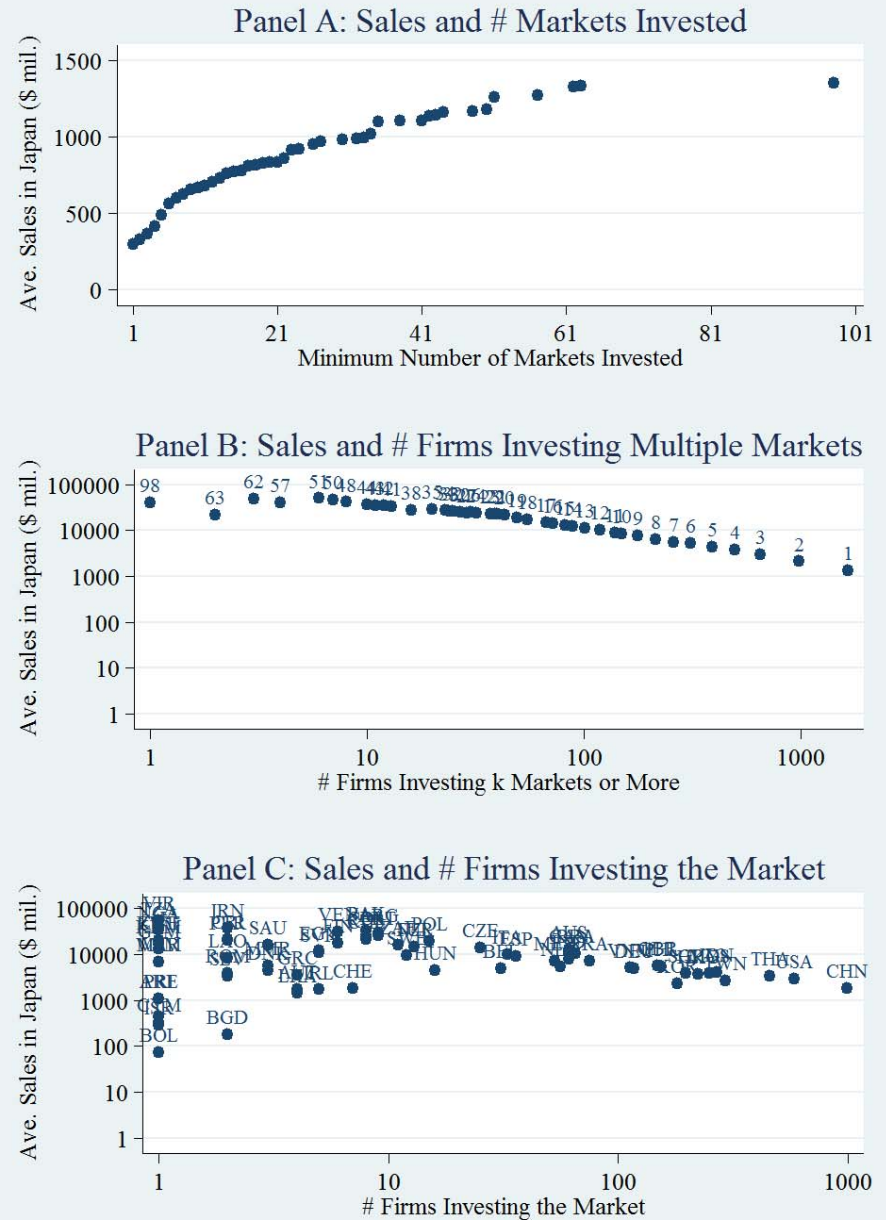
Multinational Production Intensity

- **Normalized affiliate sales / normalized domestic sales**

$$(X_n(j)/\overline{X}_n)/(X_J(j)/\overline{X}_J)$$

- **Noisy patterns in markets with less than 10 firms**

- **If more then 10 firms, affiliate sales rise for market popularity**

Figure 4. Multinational Production Intensity
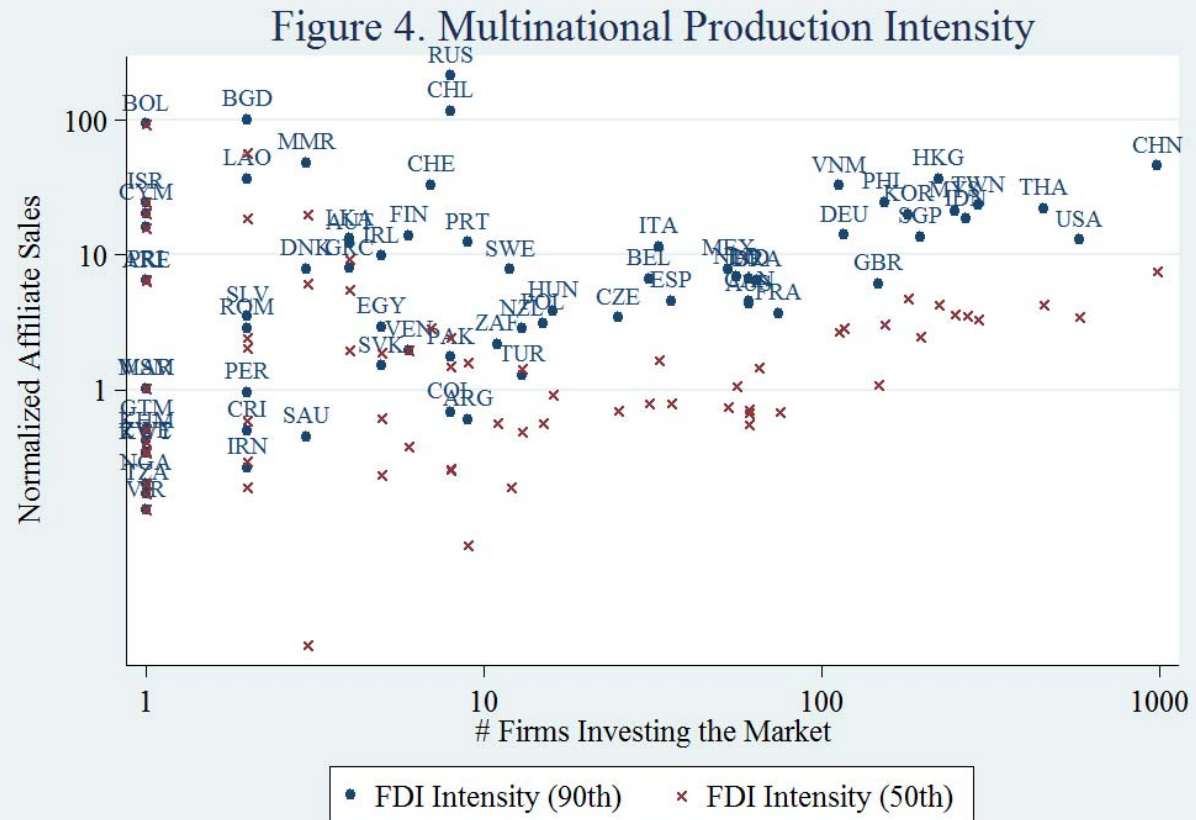
Patterns of Japanese Multinationals

- Market entry and market size
  - Larger markets attract more entry of MNCs

- Market entry and pecking order
  - Entry patterns weakly follow pecking order

- Sales distributions of Japanese firms
  - Similar shape across markets, close to Pareto

- Market entry and sales in Japan
  - Large sales firms invest in more markets/less attractive markets

- Multinational production intensity
  - Higher normalized affiliate sales in more popular markets, but noisy

Selected Moments of Simulated Firms

1. Pecking order
   - Share of simulated firms in combinations of five most popular markets
   - 2^5 (=32) moments

2. Sales distributions across markets
   - Share of simulated firms in 3 percentile groups
   - # markets × 3 moments

3. Sales distributions in Japan
   - Share of simulated firms that sell in market n and fall in three percentile groups of sales in Japan
   - # markets × 3 moments

4. Multinational production intensity
   - Share of simulated firms that sell in market n, whose ratio of sales in n to sales in Japan is below or above 50th percentile
   - # markets × 2 moments

Parameter Estimates

	(1)	(2)	(3)	(4)
Markets	Markets with over 10 affiliates	All Markets	Markets with over 10 affiliates	Markets with over 10 affiliates
Year	2006	2006	2006	1996
Moments	All	All	No Pecking Order String	All
Variable				
size dispersion	1.99	2.12	1.95	2.13
	(0.43)	(0.95)	(0.64)	(0.53)
variance of sales shock	1.64	1.64	1.66	1.36
	(0.07)	(0.10)	(0.08)	(0.11)
variance of entry shock	0.39	0.52	0.34	0.45
	(0.31)	(0.16)	(0.42)	(0.43)
correlation of sales and entry shocks	-0.62	-0.55	-0.64	-0.99
	(0.34)	(0.25)	(0.51)	(0.56)

Parameter Estimates

- Heterogeneity in size for JP MNCs
  - More dispersion than France exporters

- Variance of market sales shock
  - Similar between Japan and France

- Variance of entry shock
  - Larger variance for JP MNCs than French exporters
    - Investment decision is more uncertain than exporting

- Entry versus market shocks
  - Lower variance of entry shock
  - Predict affiliate entry with more precision than sales

Toward Credible Policy Evaluation

- Worldwide investment liberalization
    - Impact on multinational and domestic firms?

- Quantitative policy evaluation
    - Goal is to quantify policy effects at firm-level

- Experimentalist school: ex-post evaluation
    - What happens *after* policy changes?
    - Credible evidence of causality, but may apply only in original settings
    - Policy may actually affect original environments

- Structural counterfactual approach: ex-ante evaluation
    - What happens *before* policy changes?
    - Simulate and compare firm activities in counterfactual scenarios

Model Validation Tests

◆ Predictive accuracy of the model
  - ■ Can model replicate firm activities in various environments?

◆ Internal model validation
  - ■ Simulate a new set of firms and compare with JP MNCs in 2006
  - ■ Samples are identical in estimation and validation
    - Useful, but policy may change an environment

◆ External model validation
  - ■ Use year 2006 parameters to simulate JP MNCs in 1996
    - Entry/sale conditions use X_{nJ} and N_{nJ} in 1996
  - ■ Match simulated firms with actual firms
    - Simulate MNCs in significantly different environments

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In-Sample Predictions

Figure 5a. In-Sample Predictions

Panel A: Pecking Order

Panel B: Affiliate Sales by Market

Figure 5b. In-Sample Predictions

Panel C: Domestic Sales in Japan by Market Penetrated
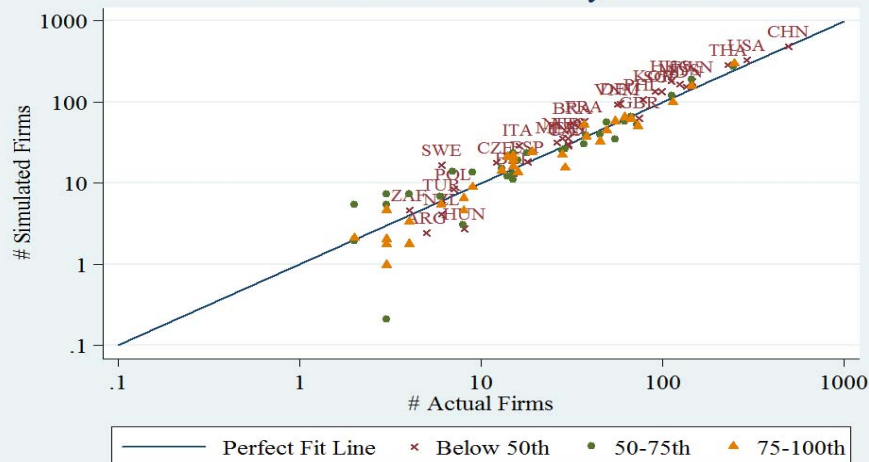
Panel D: Multinational Production Intensity

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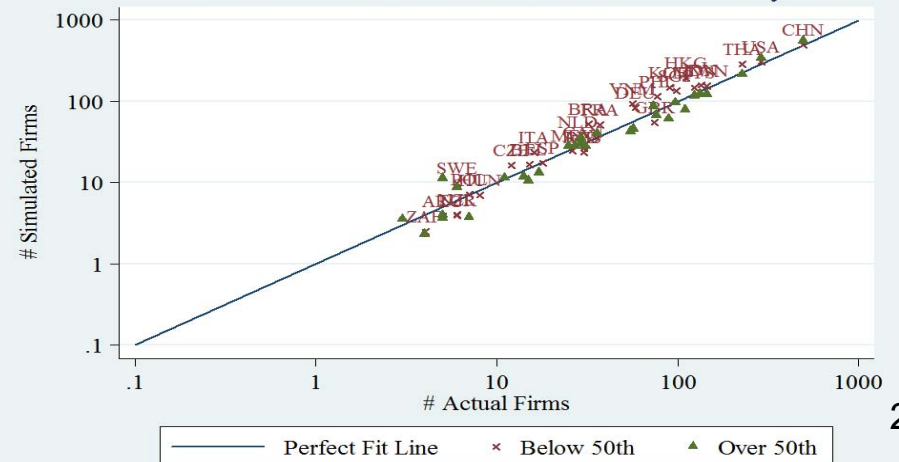
Out-of-Moments Predictions

Figure 6a. Out-Of-Sample Predictions for Multiple Entries
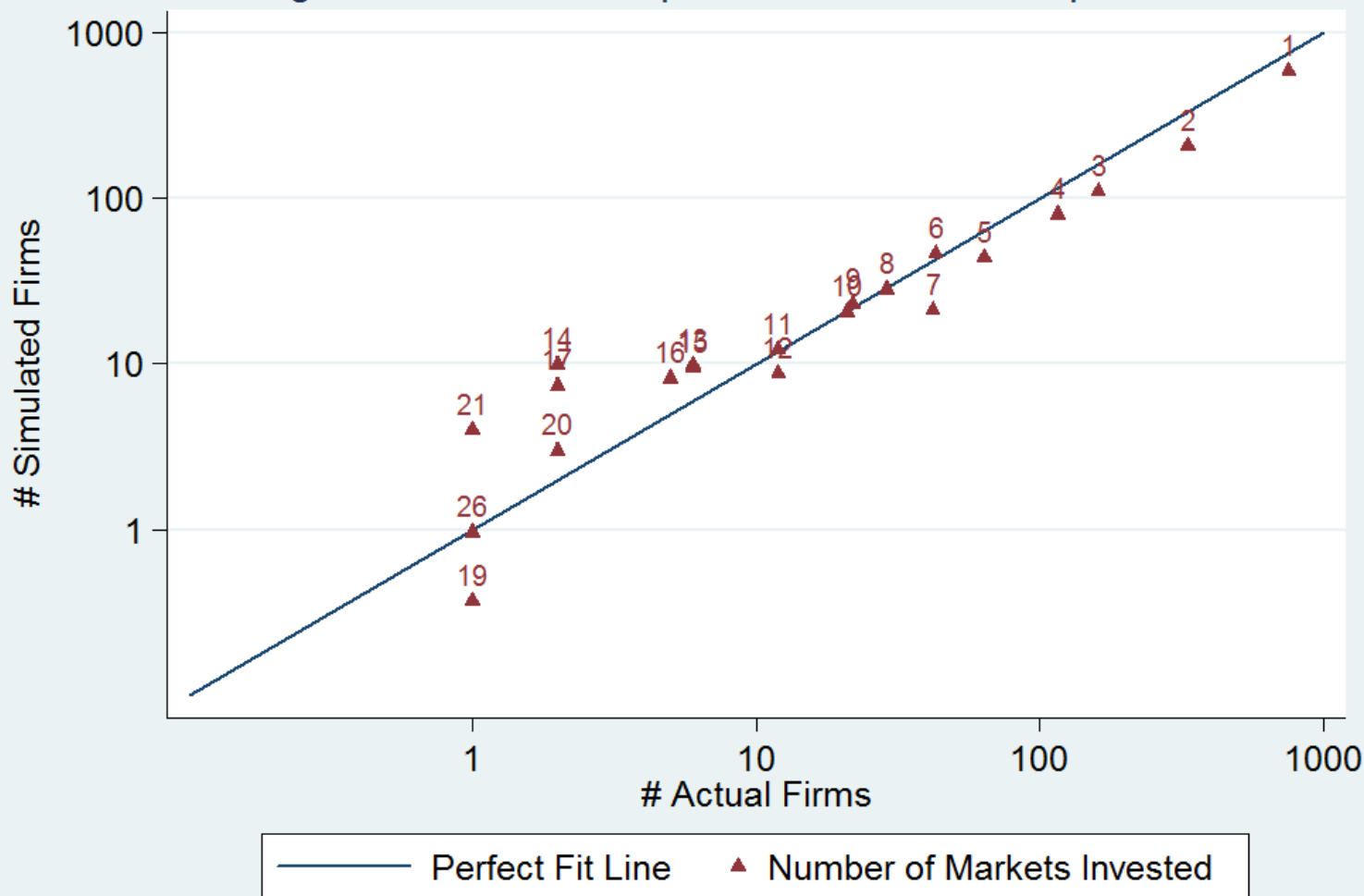
Out-of-Sample Predictions

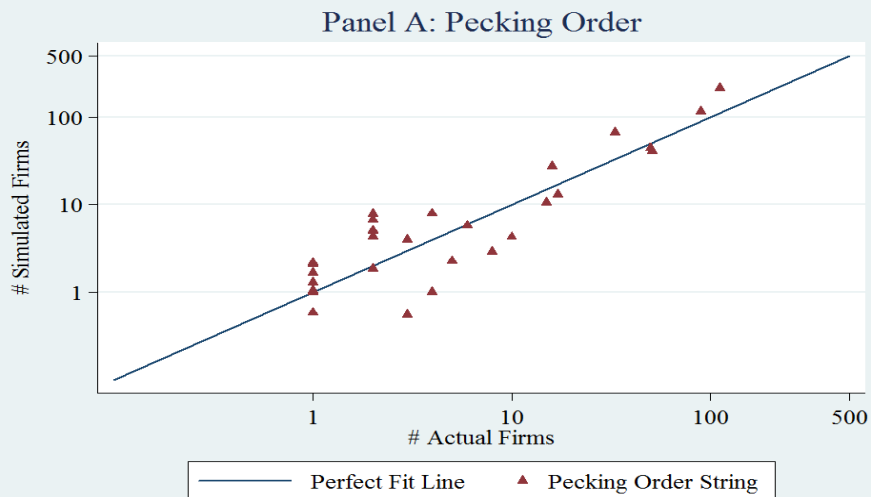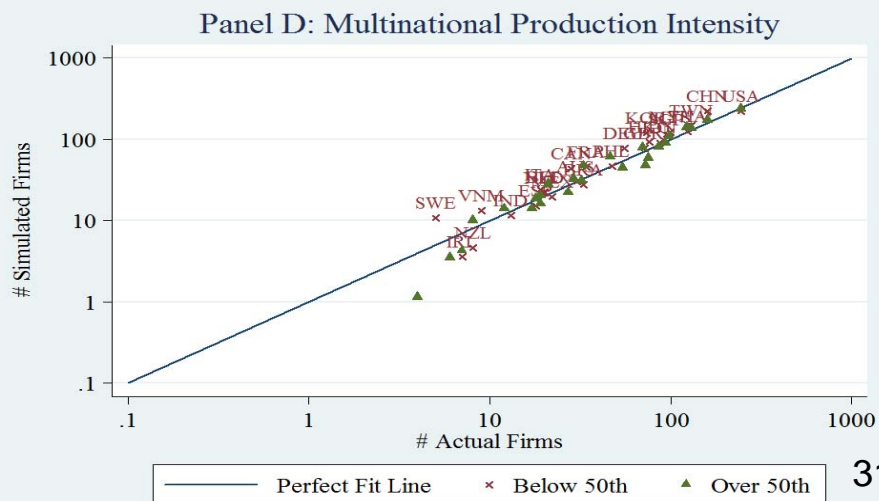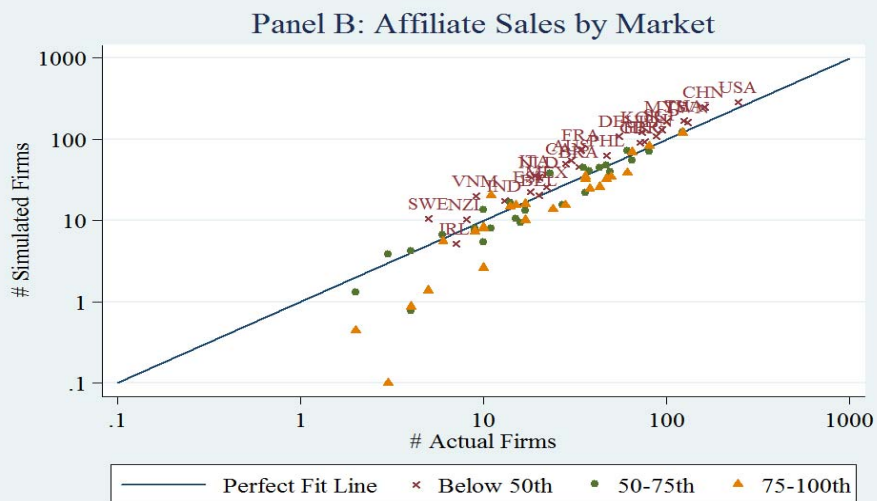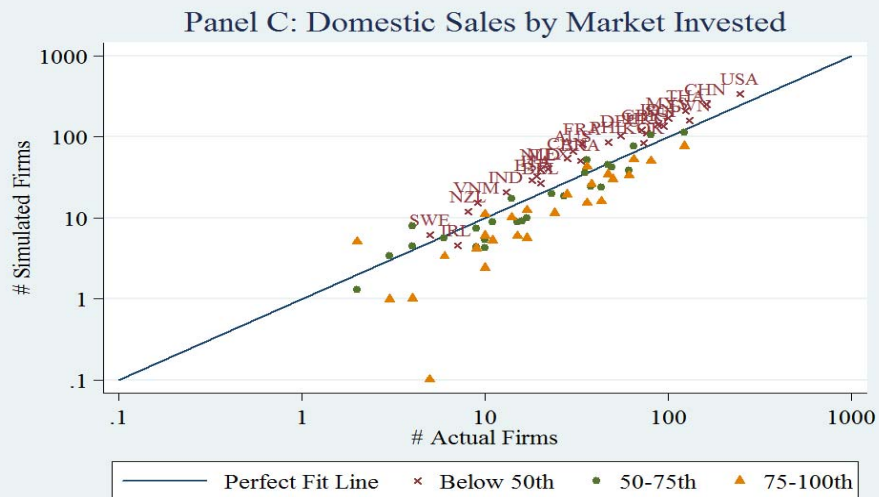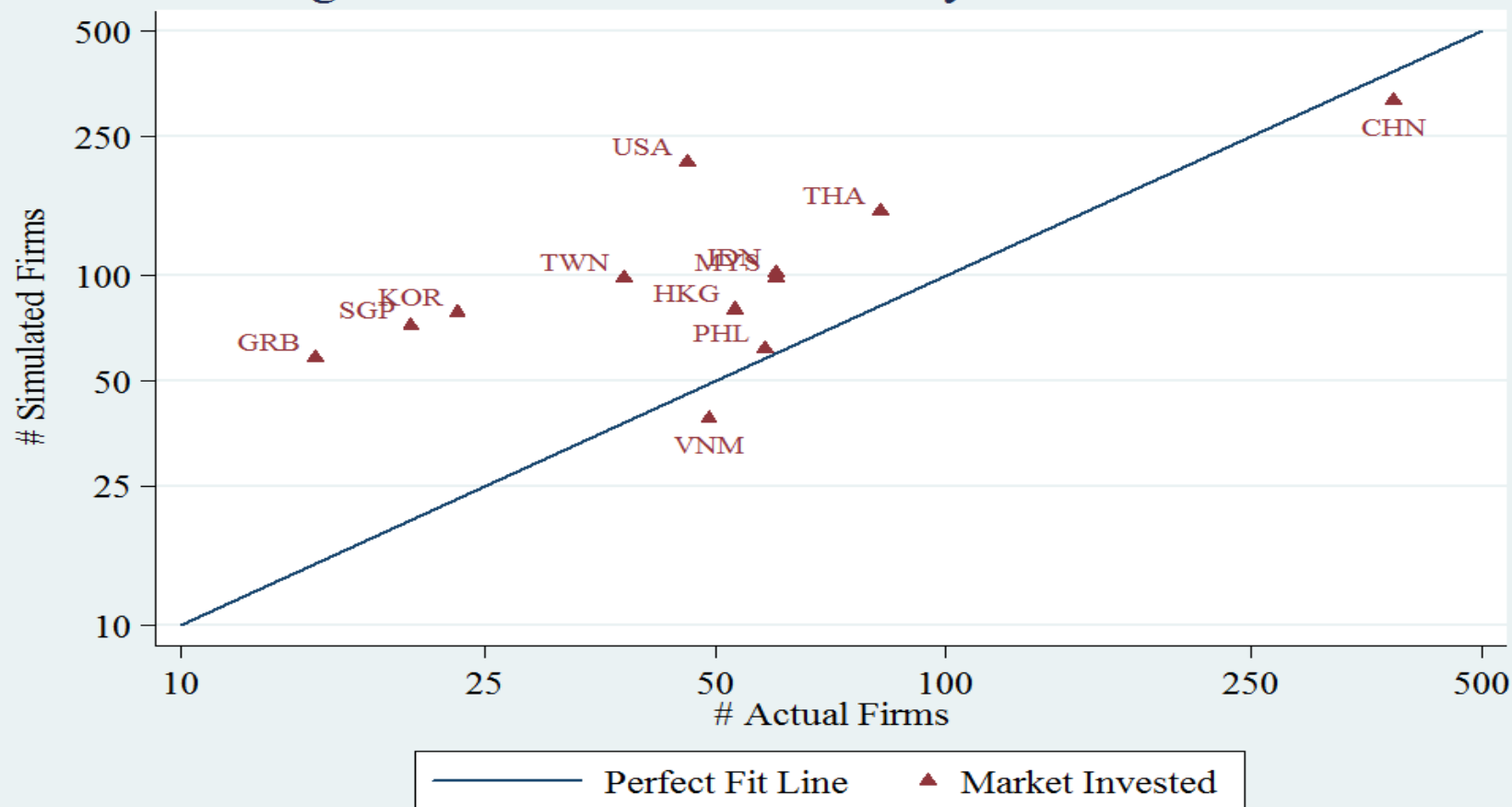Figure 6b. Out-Of-Sample Predictions for 1996

Figure 6c. Out-Of-Sample Predictions for 1996

Where Does the Model Fail?

Figure 7. Vertical FDI Firms by Market Penetrated

Counterfactual Analysis

Up to this point,

- Model validation tests
  - Multinational activities can be reasonably simulated under various environments

Next,

- Counterfactual simulations
  - Simulate baseline artificial multinationals
  - Simulate under counterfactual scenarios
    - Further investment liberalization
    - 25% drop in fixed and/or variable FDI costs
  - Compare baseline and counterfactuals

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Counterfactual Analysis

◆ Step 1: Global general equilibrium
- To apply EKK's model to bilateral FDI activity
- To use methodology by Dekle, Eaton, Kortum (2007)
- A set of equations determine wages and prices in the world in terms of exogenous variables

◆ Counterfactual aggregate outcomes
1. Falls in fixed/variable FDI costs
2. Changes in wages and prices
3. Changes in affiliate sales/ number of multinationals

Counterfactual Analysis

◆ Step 2: Counterfactual firm-level behavior

- Use original data and changes in multinational data
- Compute counterfactual values for each market:
  - Japanese affiliate sales
 - Number of Japanese firms investing

◆ Perform simulation procedures

- Maintain firm-specific shocks in baseline
- Use new aggregate values on JP multinationals
- Simulate individual firm response

IDE-JETRO

- Increased globalization scenario
  - 25% drop in FDI barriers
- Changes in sales by firm size
  - Measured in Trillion Yen
- Skewed impacts
  - Large increase in foreign sales for top
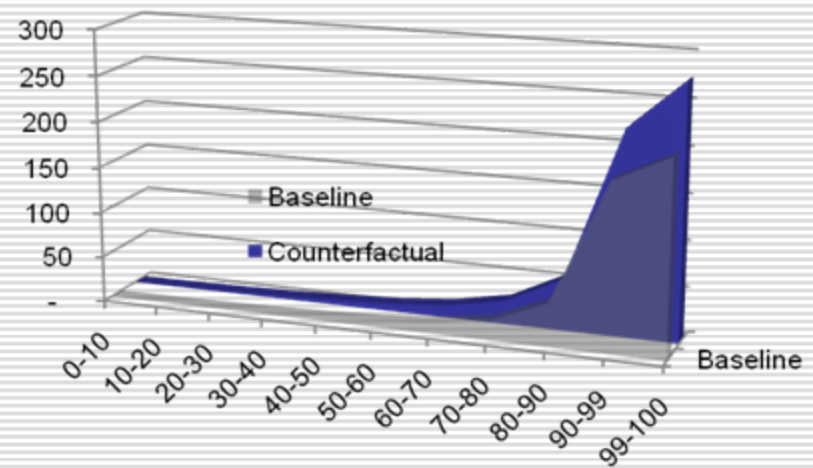 - 52% growth of total sales from top 1%
- Large reallocation effects

Changes in Domestic Sales
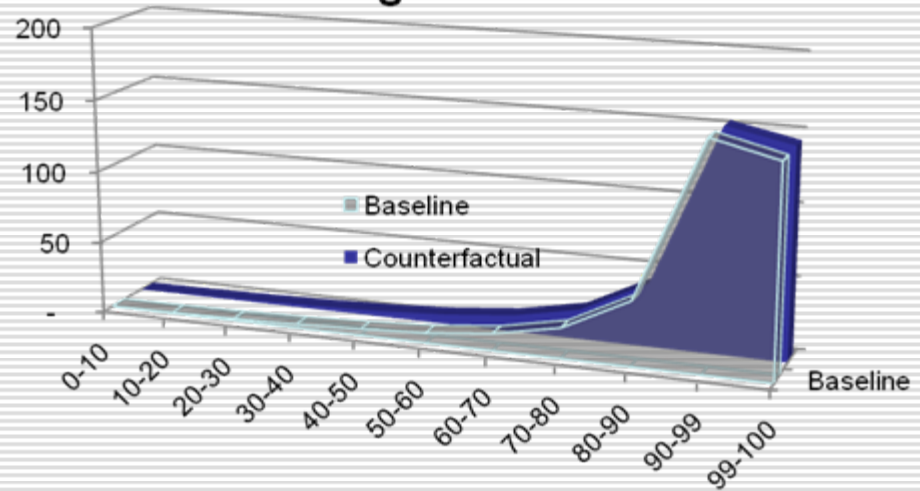
Changes in Multinational Sales
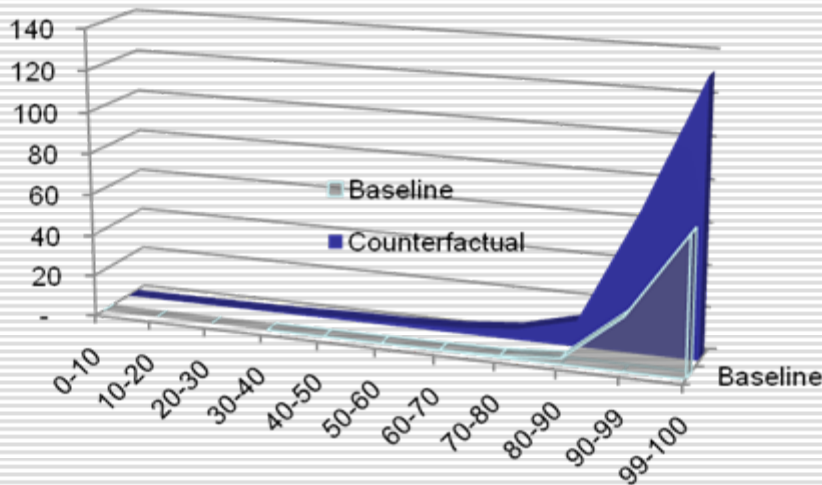
Changes in Total Sales

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Aggregate Productivity Growth

◆ Decomposition of aggregate productivity changes

1. **No** within-firm effects: firm-level efficiency is held constant
2. **No** entry effects: no firm enters the market
3. **Reallocation effects** in market share:
   - Expansion of high productive firms
   - Contraction of low productive firms
4. **Exit effects**
   - Exit of low productive firms

◆ Results

Total effects	35.6%
Reallocation effects	34.4%
Exit effects	1.2%

Implications for Japanese Firms

◆ **Comparison with Japanese firms in 1996-2006**
   ■ Counterfactual results are **quantitatively** comparable to data
   ■ Multinational production expansion is especially comparable

% Changes	Actual Japanese firms for 1996-2006	Counterfactual Results
Domestic Production	-7%	-1%
Multinational Production	99%	133%
Total Production	4%	26%
Number of Firms	-9%	-3%
Number of Multinationals	72%	79%
Contribution of top 1% firms	91%	52%

Implications for Japanese Firms

◆ Declining FDI barriers
- Potentially strong impact on domestic industry
- Intra-industry reallocation may be a key channel

◆ Why is actual fall in domestic production larger?
- Import competition

◆ Why is actual contribution of top firms larger?
- Technological advances biased to largest firms

Concluding Remarks

◆ Develop a simulation framework for multinationals
- Model validation supports predictive power of the model

◆ Counterfactual analysis of globalization scenario
- Falling FDI barriers cause large intra-industry reallocation
- Large gains for aggregate productivity
- Largest firms grow at the expense of small firms

◆ Policy implications
- Erosion of domestic production is inevitable
- Public support for small and medium firms

Concluding Remarks

◆ Ongoing projects for analysis
- Distinguish fixed and variable FDI costs
- Policy barriers specific to FDI
  - Additional corporate tax burden
  - Additional regulation procedures

◆ Future agenda
- Exporting and FDI
- Multinationals in service sector