Global Trade Analysis Project

GTAP-HET: Introducing Firm Heterogeneity into the GTAP Model

Presented by
Team Heterogeneity

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Outline

- Firm heterogeneity theory of Melitz (2003)
- Stylized Results
- Group Presentations
  - Tariff Cuts and Trade Facilitation (Ross & David M.)
  - Tariff Cuts and Learning by Doing Exporting (Fernando & Arthur)
  - Tariff Cuts and Sluggish Labor (Jeff & Fay)
  - Tariff Cuts and Sensitivity Analysis with Shape Parameter (Vitaliy & David)

Evolution of trade theories

- **Hecksher-Ohlin**
  - Identical products
  - Perfect competition, CRTS
- **Armington insight (1969)**
  - Product differentiation at the national level
  - Perfect competition, CRTS
- **Krugman (1980)**
  - Product differentiation at the firm level
  - Monopolistic competition, IRTS
- **Melitz (2003)**
  - Product differentiation at the firm level
  - Monopolistic competition, IRTS
  - Productivity heterogeneity across firms
  - Bilateral fixed entry costs in export markets

Empirical findings motivate firm heterogeneity

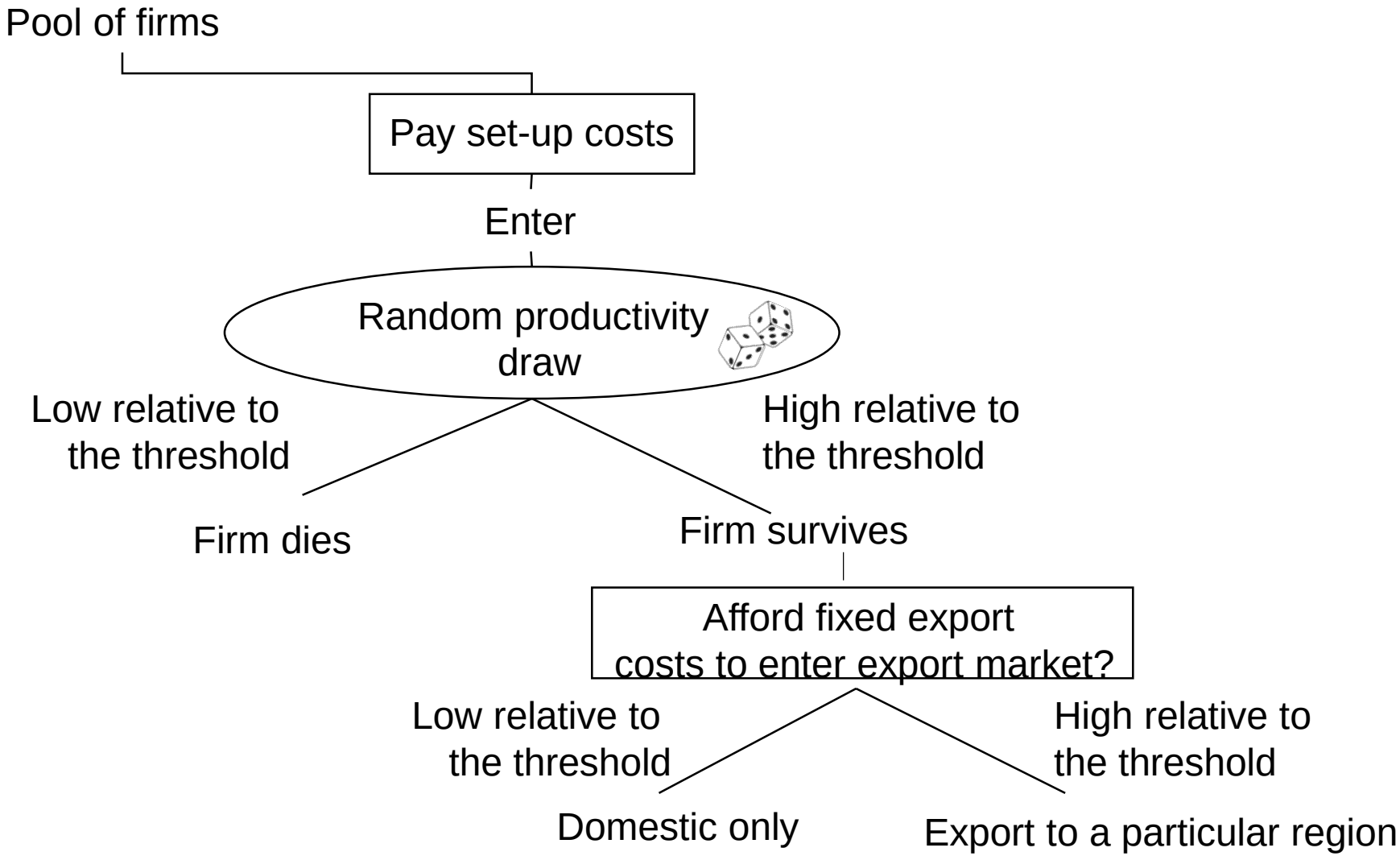
Exporting By U.S. Manufacturing Firms, 2002

NAICS Industry	*Percent of firms*	*Percent of firms that export*	*Mean exports as a percent of total shipments*
311 Food Manufacturing	6.8	12	15
312 Beverage and Tobacco Product	0.7	23	7
313 Textile Mills	1	25	13
314 Textile Product Mills	1.9	12	12
315 Apparel Manufacturing	3.2	8	14
316 Leather and Allied Product	0.4	24	13
321 Wood Product Manufacturing	5.5	8	19
322 Paper Manufacturing	1.4	24	9
323 Printing and Related Support	11.9	5	14
324 Petroleum and Coal Products	0.4	18	12
325 Chemical Manufacturing	3.1	36	14
326 Plastics and Rubber Products	4.4	28	10
327 Nonmetallic Mineral Product	4	9	12
331 Primary Metal Manufacturing	1.5	30	10
332 Fabricated Metal Product	19.9	14	12
333 Machninery Manufacturing	9	33	16
334 Computer and Electronic Product	4.5	38	21
335 Electrical Equipment, Appliance	1.7	38	13
336 Transportation Equipment	3.4	28	13
337 Furniture and Related Product	6.4	7	10
339 Miscellaneous Manufacturing	9.1	2	15
Aggregate Manufacturing	**100**	**18**	**14**

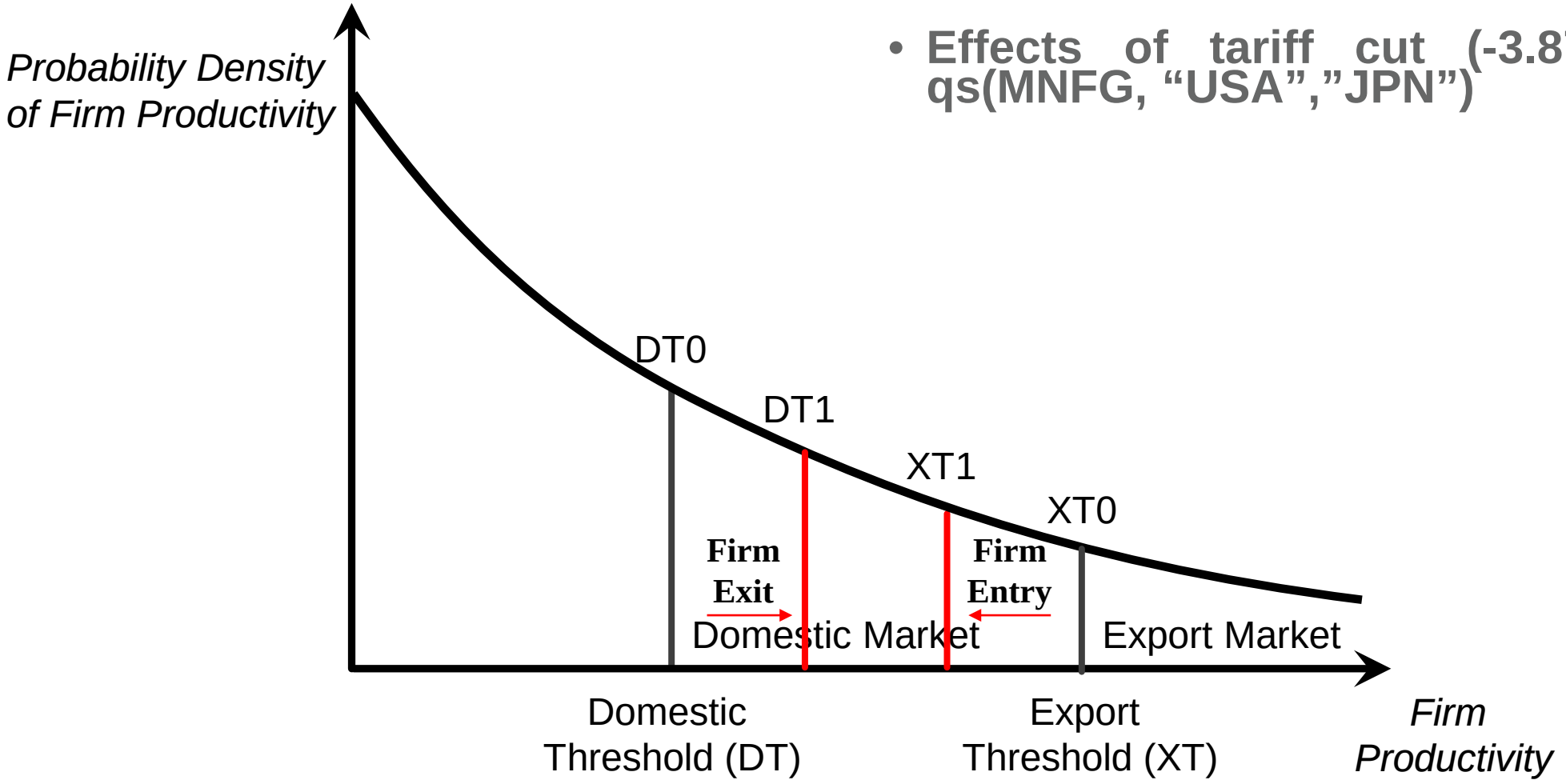
Source: Bernard, Jensen, Redding, and Schott (2007)

- Exporting is rare
- Exporting occurs in all manufacturing industries
- The share of firms that export varies within each industry category
- Exporters sell most of their output domestically
- Exporters are larger, more productive, pay higher wages and are relatively more capital- and skill-intensive than non-exporters

Production under firm heterogeneity



Endogenous productivity change



- **Effects of tariff cut (-3.87%) on qs(MNFG, "USA","JPN")**

Source: Adapted from Greenaway and Kneller (2007)

Global Trade Analysis Project

Tariff Cuts and Trade Facilitation (Ross & David M.)

Reciprocal Trade Facilitation

- U.S. negotiations a reduction (3.87%) in Japanese tariffs on U.S. manufactured goods.
- Japanese negotiators demand reciprocal reduction in U.S. NTMs on Japanese manufacturing exports to U.S.
- Trade Facilitation: fixed trade costs of cross a border
- Shock fixed cost technical change (avafsall(j,r,s)) by 5%
  - ➔ Decreases required fixed inputs to export manufactures to U.S.
- Sensitivity avafsall$\sim U[0,10]$

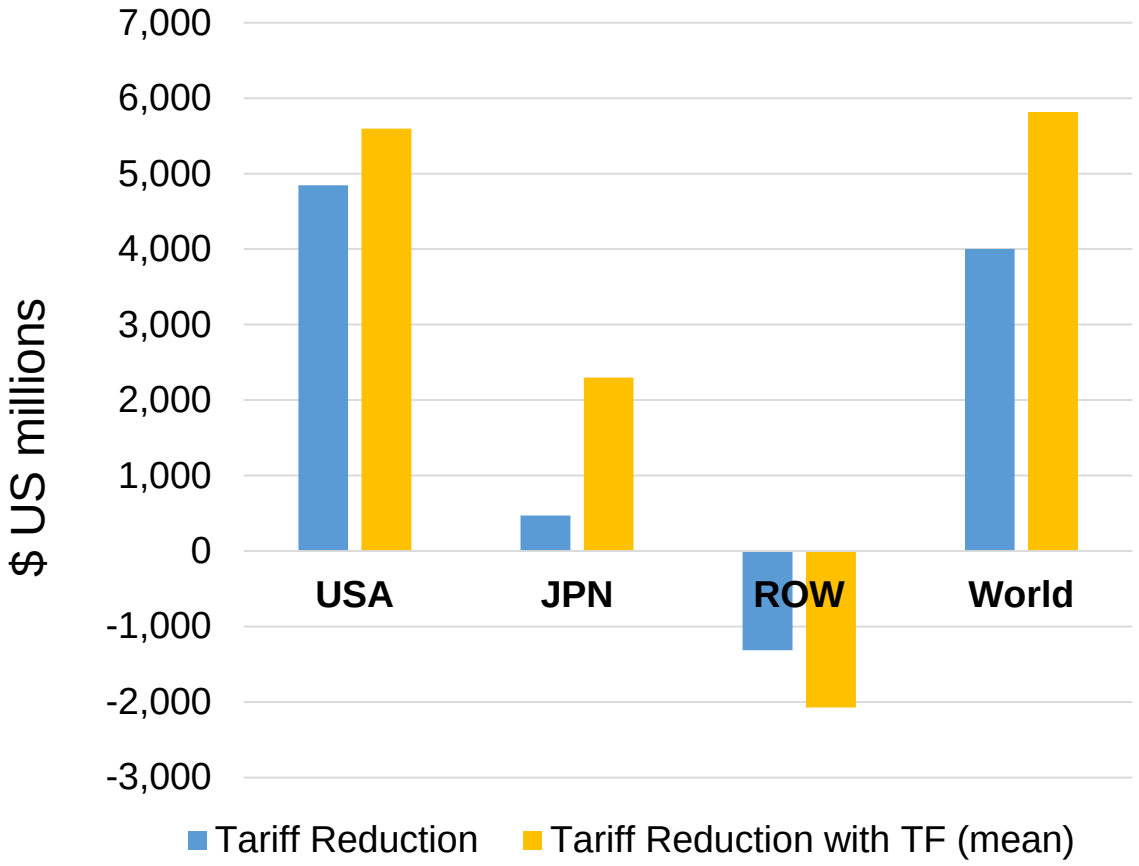
Results

Firm Heterogeneity Melitz Model
Incremental Impact of Trade Facilitation

			USA	JPN
Domestic and Export Sales (%)	qs(j,r,s)	USA	0.0	1.0
		JPN	4.4	0.0
Number of Active Firms (%)	ns(j,r,s)	USA	-0.1	0.4
		JPN	4.6	-0.2
Output per Firm (%)	qof(j,r)		0.1	0.2
Productivity Threshold for Market Entry (%)	aost(j,r,s)	USA	0.0	-0.1
		JPN	-1.6	0.1

- Unsurpringly: Trade Facilitation increased Japanese exports to U.S.
- Surprisingly: TF increased U.S. exports to Japan
  - Japanese imports reduce the price of intermediate inputs in the U.S.

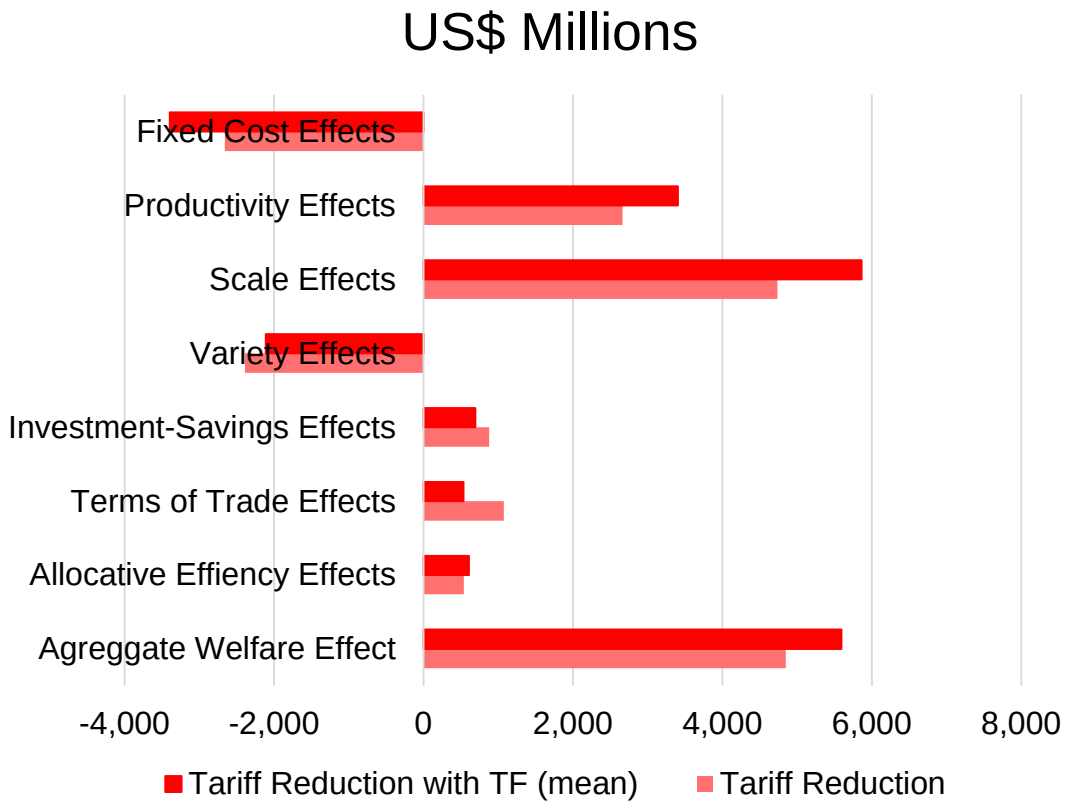
Welfare decomposition

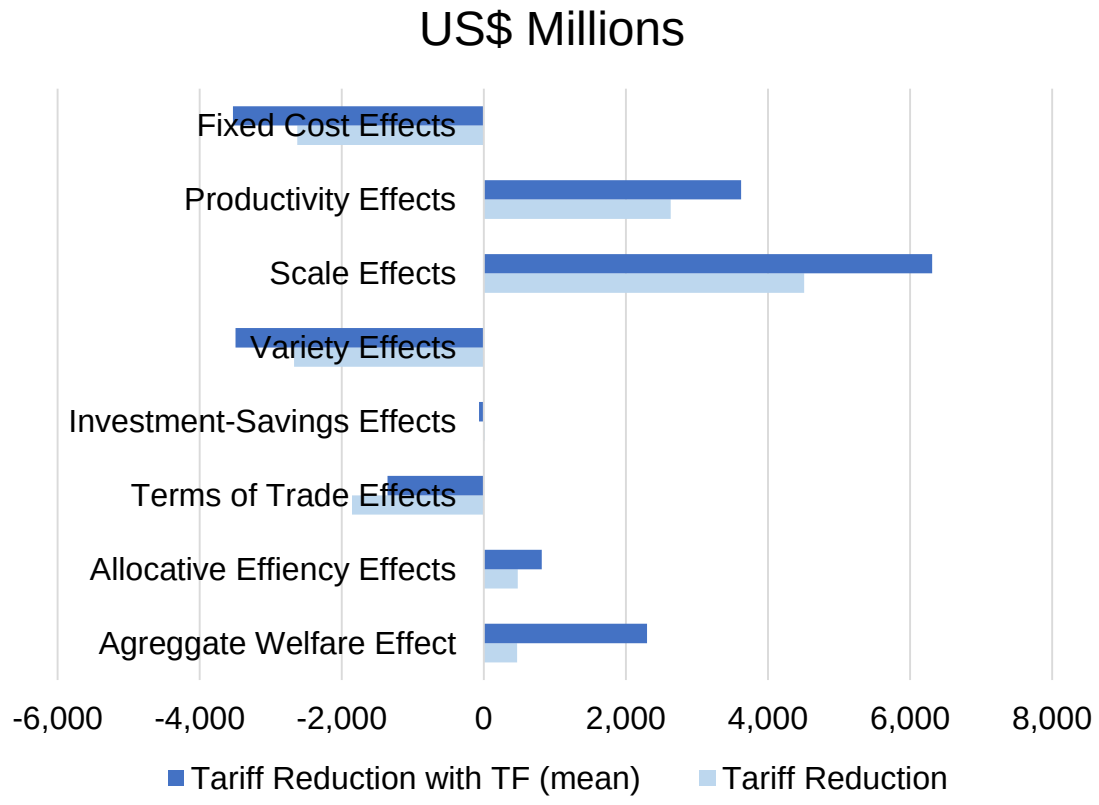


- New effects:
  - Endogenous productivity
  - Firm scale
  - Love-of-variety
  - Fixed costs

	Armington	Melitz
Allocative Efficiency Effect	•	•
Terms of Trade Effect	•	•
Productivity Effect		•
Scale Effect		•
Variety Effect		•
Fixed Cost Effect		•

Welfare comparison





US **JPN**

- Significant differences on productivity and scale effects

Productivity welfare effects

- The augmenting technical change for fixed trading cost (AVAFS) affects directly the productivity of the firms.
- An increase in this variable imply an improvement in the efficiency of inputs employed in covering associated costs.
- AVAFS also have an indirect effect through the change in the output augmenting technical change -ao(j,r)-.

Scale welfare effects

- The presence of fixed cost and imported intermediate inputs creates a wedge between a scale constant average total cost an average total cost.
- Technical change in fixed trade costs reduces the average cost.
- It induces in a expansion in firm scale spreads fixed costs across more output, it generating significant additional gains from trade

SLUGGISH LABOR IN GTAP

JEFF HOROWITZ AND FAY JOHNSON

ARMINGTON MODEL

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	254	0	0	0	1490	611	0	0	0	0	2354
2 JPN	25	0	0	0	-1296	80	0	0	0	0	-1191
3 ROW	146	0	0	0	-195	-690	0	0	0	0	-739
Total	425	0	0	0	-2	0	0	0	0	0	423

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	246	0	0	0	1466	585	0	0	0	0	2297
2 JPN	44	0	0	0	-1292	75	0	0	0	0	-1173
3 ROW	156	0	0	0	-175	-660	0	0	0	0	-679
Total	446	0	0	0	-1	0	0	0	0	0	445

KRUGMAN MODEL

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	287	0	0	0	1527	657	0	303	-16	0	2758
2 JPN	44	0	0	0	-1424	86	0	125	-341	0	-1509
3 ROW	150	0	0	0	-105	-744	0	-35	-123	0	-856
Total	481	0	0	0	-2	0	0	393	-479	0	393

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	283	0	0	0	1493	635	0	341	-73	0	2679
2 JPN	53	0	0	0	-1396	80	0	71	-272	0	-1462
3 ROW	155	0	0	0	-99	-715	0	-44	-110	0	-814
Total	491	0	0	0	-2	0	0	368	-454	0	403

KRUGMAN MODEL

USA/mnfg	No Slug	Slug
Variety		
vp (USA) (ns here)	0.0009	-0.0058
pfe (price of labor)	0.0983	0.1054
qfe (demand for labor)	0.0198	0.0117
Scale		
qof (output per firm)	0.0337	0.0380
qo (output)	0.0346	0.0322

Variety is determined by the number of firms, which decrease as we make labor sluggish. As wages become higher profits decline and, since firm entry/exit is driven by profits in this model, firms exit.

Demand for labor is lower.

Remaining firms are larger (scale effect) and produce more on a per firm basis, however total output is lower as the reduction in firms outweighs the scale effect.

MELITZ MODEL

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	539	0	2665	0	1076	878	0	4738	-2391	-2659	4846
2 JPN	476	0	2632	0	-1858	11	0	4508	-2671	-2629	469
3 ROW	217	0	400	0	780	-889	0	356	-1779	-400	-1314
Total	1232	0	5698	0	-1	-1	0	9603	-6841	-5688	4002

WELFARE	1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	8 scale_H1	9 var_I1	10 fixed_J1	Total
1 USA	538	0	2660	0	1128	887	0	4617	-2260	-2654	4917
2 JPN	471	0	2657	0	-1776	-6	0	4277	-2427	-2654	544
3 ROW	189	0	398	0	647	-882	0	294	-1719	-397	-1470
Total	1199	0	5715	0	-1	-1	0	9189	-6406	-5705	3990

MELITZ MODEL

USA/mnfg	No Slug	Slug
Variety		
vp (USA) (ns)	-0.1956	-0.1902
pfe (price of labor)	0.1137	0.1013
qfe (demand for labor)	-0.0235	-0.0148
Productivity		
aost (Domestic Threshold)	0.0567	0.0566
aost (Firms entering Japan)	-4.0912	-4.0898
Scale		
qo (output)	0.0886	0.0867
qof (output per firm)	0.2847	0.2774

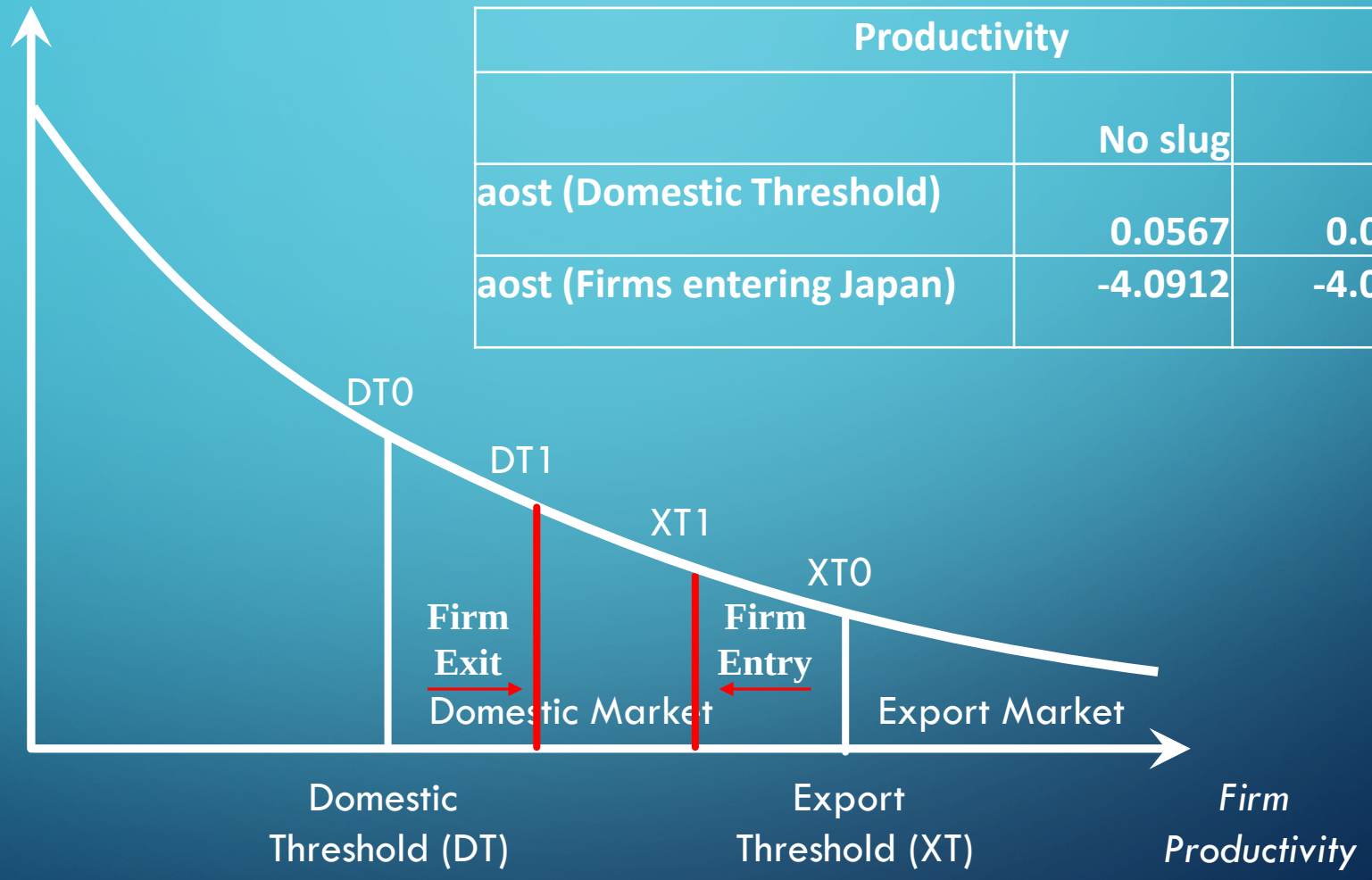
Variety decreases by less when labor is sluggish

The cost of labor is increasing by less, which lowers the domestic productivity threshold and more firms are able to stay in the domestic market.

Overall output and output per firm are both less relative to the non-sluggish case.

PRODUCTIVITY CHANGE

Productivity		
	No slug	Slug
aost (Domestic Threshold)	0.0567	0.0566
aost (Firms entering Japan)	-4.0912	-4.0898



Source: Adapted from Greenaway and Kneller (2007)

Learning by exporting and reversing engineering

Arthur Chambers & Fernando Izquierdo

Disclaimer

- We are practicing some of the tools that had been show to us during this course.
- As using an updated data for make new simulations from with a different starting point.
- We are concern about the lack on the investment transmission between stages, since we are working in sort of a dynamic simulation, that take into account past shocks and its effect in the following shocks.

Before all

- There is s a tariff reduction for USA manufactures exports (“Standard model”).
- One could argue that trade leads to “learning by exporting”.
- That’s why we think the productivity of the exporters in USA increase (we shock the productivity of the firms).
- Even if we can not only shock the productivity of exporters, we know that there could be a spillover effects, that flows through the other firms in the manufacture sector.
- Also we think, that would be a effect in the productivity of Japan because of the possibility of spillovers using reversing engineering.

Simulation

- We use the GTAP-HET model standard. Shock a tariff (**tms**) reduction as a STAGE 1
- Next we assume that eventually manufactures sector will gain some productivity by learning by exports. Shocking 0.1% of **aoall** MNFC as a STAGE 2
- Finally, as a increment of MNFC products in Japan, we expect that MNFC sector in that country could improve their productivity (**aoall**) as a result of certain reversal engineering of the products they get from USA.
- The reason be don't make the shock simultaneously its because we assume that could take some time to make the reversal engineering.

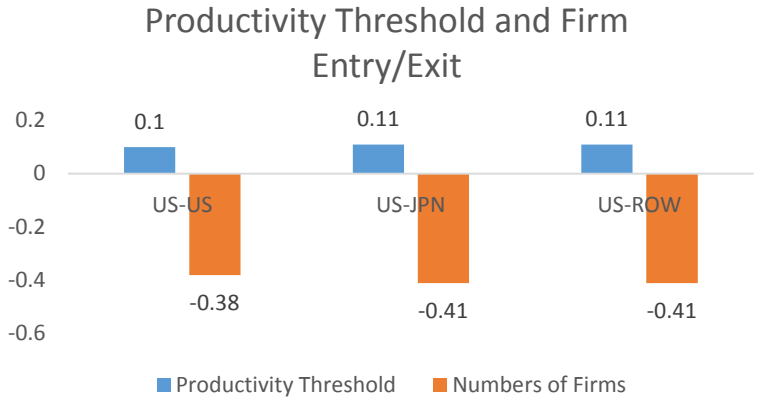
Updated Melitz model with tariff and productivity shock:

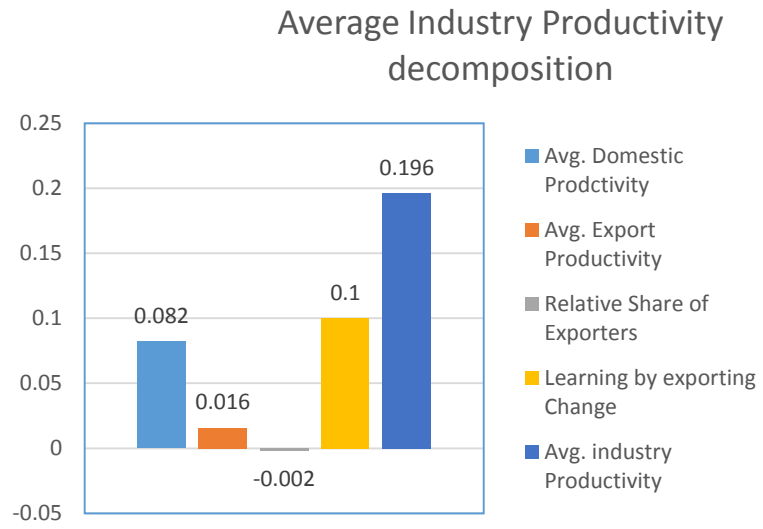
WELFARE	alloc_A1	endw_B1	tech_C1	pop_D1	tot_E1	IS_F1	pref_G1	scale_H1	var_I1	fixed_J1	Total
1 USA	766	0	9003	0	-1053	657	0	9294	-7439	-4413	6816
2 JPN	-23.4	0	19.4	0	64.0	-50.6	0	-13.7	-132	-19.4	-156
3 ROW	-38.1	0	159	0	989	-607	0	-17.9	-1702	-159	-1375
Total	704	0	9182	0	0.503	-0.32	0	9263	-9273	-4591	5285

Based on GTAP-HET: Introducing Firm Heterogeneity into the GTAP Model by Zeynep Akgul, Nelson Villoria and Thomas W. Hertel

USA effects

- Decreased variety and fixed costs, increasing US allocative efficiency
- Primary factor prices and output increasez in the US, but domestic and exports prices in mnfcs decline, US mnfcs sales increase
- Productivity actually increases more than the shock value due to firm exit
  - Number of US firms in both domestic and export markets declines
- Productivity threshold for exporting decreases for US export markets but increases for Japan
  - Due to declining prices and markups
  - Lower productivity firms can't survive

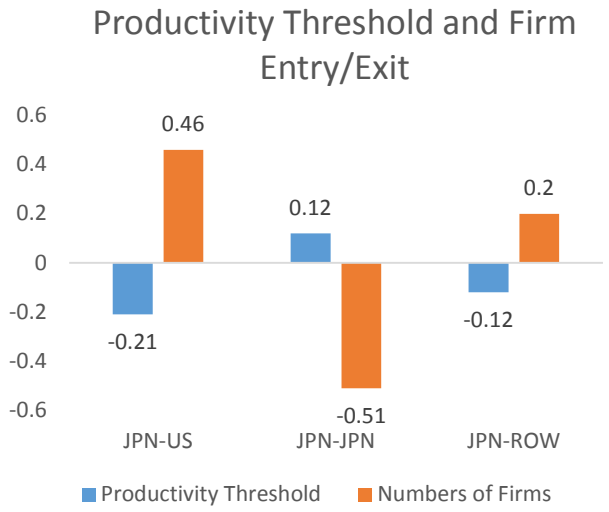


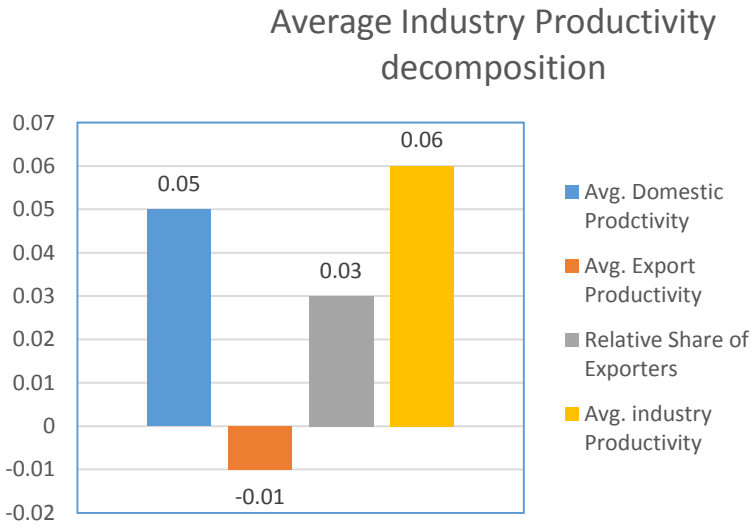


Based on GTAP-HET: Introducing Firm Heterogeneity into the GTAP Model by Zeynep Akgul, Nelson Villoria and Thomas W. Hertel

Japan effects

- From Stage 1. Japan imports more Manufactures about 26,9%.
- US varieties increases competition and crowds Japanese firms.
- Dropping the domestic sales 0.26%.
- Firms are replaced by US competitors but surviving firms from Japan benefit from the cheap US manufactures.
- Reducing the average cost of production in Japan by 0.30%
- Japan becomes more competitive in export markets, relative prices of primary factor decrease in Japan implying a real depreciation of 0,05%.
- Japan export increases by 1,6% and 1,1%.
- As they gain access a larger market their fixed cost per sale decline, leads the reduction in productivity of exporting to US (-0.21%) and ROW (-0.12%).
- The firms who exports increases in 0.46% and 0.2%.
- The productivity threshold of supplying the domestic market 0.12%, which reduces the number of firms in the domestic market -0.51%.
- Average industry productivity rises by 0.13%





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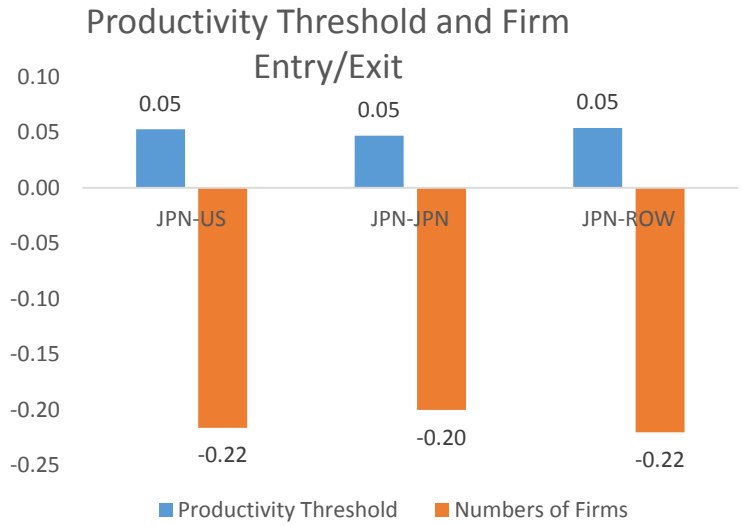
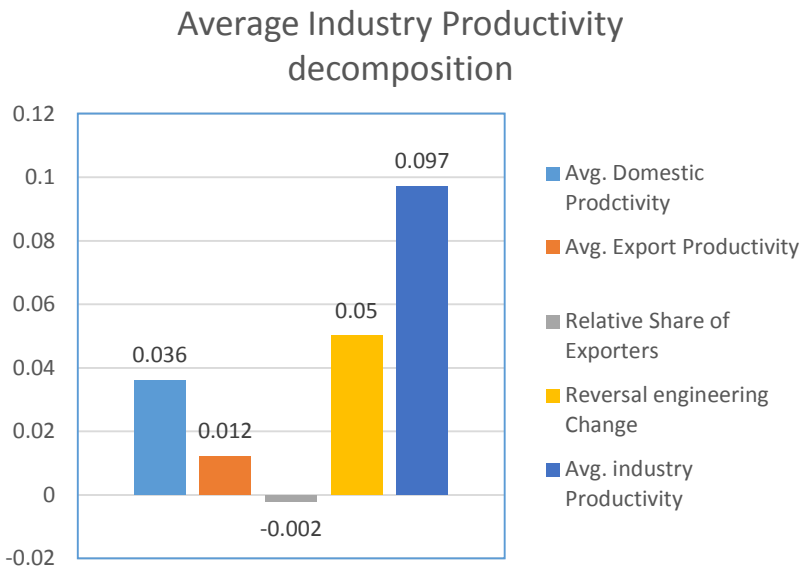
Japan effects

- After *shock aoall ("MNFG","JPN") = 0.05*
- Drives the effect to increase the average of industry productivity.
- We observe the productivity threshold increase. Firms that came out.
- Average cost of production is reduced by the increase of productivity in Japan by 0.08%
- Japan becomes more competitive in export markets, relative prices of primary factor decrease in Japan.
- Japan export increases by 0.07% and 0.06%.
- Their fixed cost per sale increase but their decrease of supply price, leads the increase in productivity of exporting to US (0.053%) and ROW (0.054%).
- The firms who exports decreases in 0.21% and 0.22%. Due their more fixed cost.





Based on GTAP-HET: Introducing Firm Heterogeneity into the GTAP Model by Zeynep Akgul, Nelson Villoria and Thomas W. Hertel

Introducing Firm Heterogeneity… with a twist ;-)

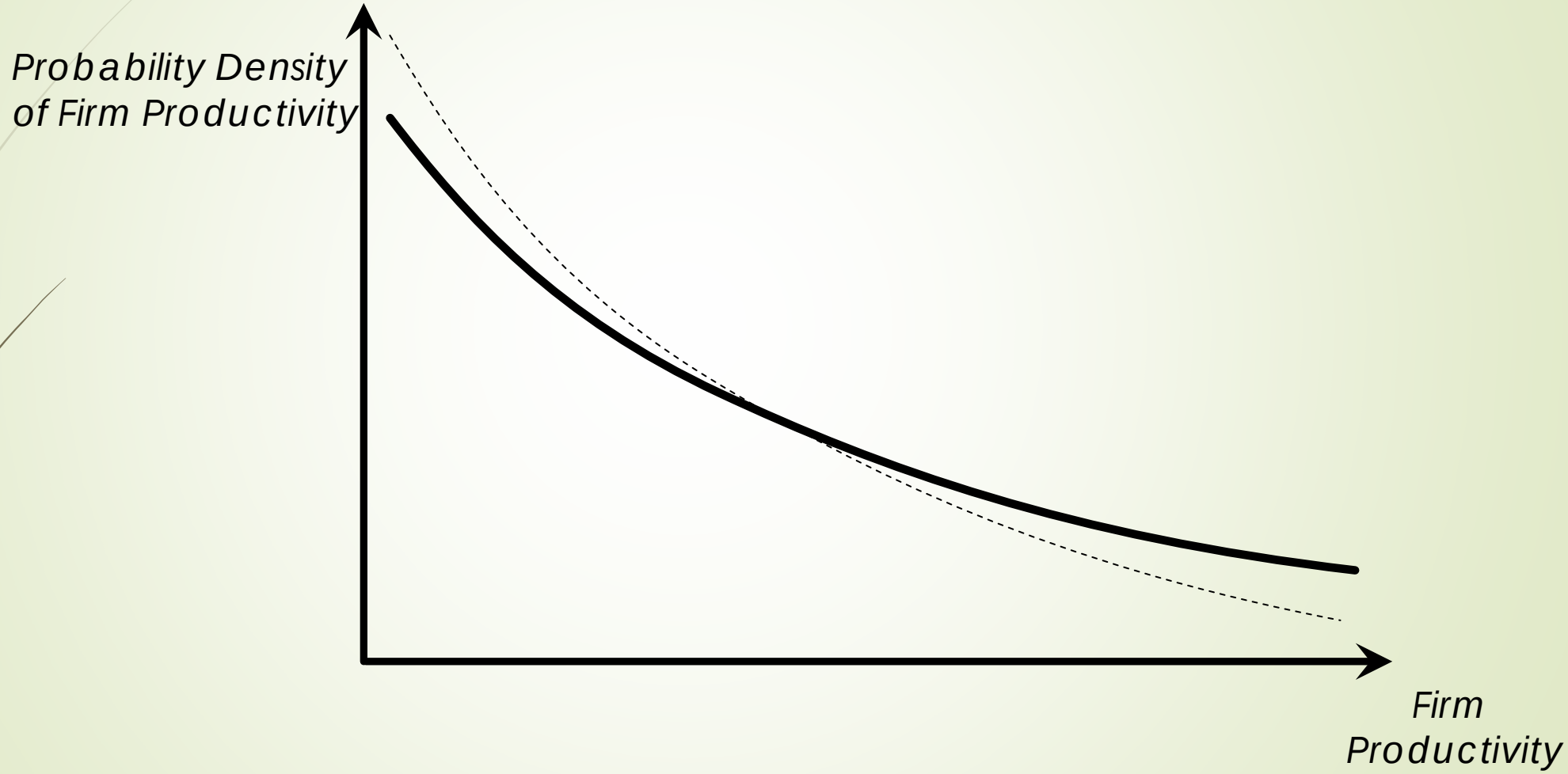
By Hao Cui & Vitaliy Krupin

The experiment consists of:

1. Melitz Simulation for manufacturing sector with the reduction of tariffs levied by Japan on US manufacturers (Shock tms("MNFG","USA","JPN") = -3.309607)

2. Alteration of Pareto Distribution Parameter (Shape) for Manufacturing (from initial of 2.89 to 5.00)

Pareto Distribution



Source: adapted from Zeynep Akgul and Angel H. Aguiar (2016) adaptation of Greenaway and Kneller (2007)

Industry output

qo[MNFG*]	melitz1	melitz2
1 USA	0.09	0.13
2 JPN	0.08	0.18
3 ROW	0	0

Equation INDOUTPUT

 # industry output in the monopolistically competitive industry #

(all,j,MCOMP_COMM)(all,r,REG)

qo(j,r) = qof(j,r) + ns(j,r,r);

Output per Firm

qof[MNFG*]	melitz1	melitz2
1 USA	0.28	0.47
2 JPN	0.6	1.07
3 ROW	0.01	0

ns[MNFG,r,r]	melitz1	melitz2
1 USA	-0.2	-0.34
2 JPN	-0.51	-0.88
3 ROW	-0.01	0

qof equation (implicit)

qof(j,r) = [VOA(j,r)/VAF(j,r)]*[scatc(j,r)-avc(j,r)]

Equation ZEROPROFITSMC

 # zero pure profits condition for firms in the monopolistically comp industry #

(all,j,MCOMP_COMM)(all,r,REG)

VOA(j,r) * ps(j,r)

= VOA(j,r) * scatc(j,r) - VAF(j,r) * qof(j,r)

+ VOA(j,r) * *profitslackmc*(j,r);

Equation MKUPRICE

 # markup pricing (with constant markup) in the monop. comp. ind. j in r #

(all,j,MCOMP_COMM)(all,r,REG)

ps(j,r) = avc(j,r) + *mkupslack*(j,r);

scatc[MNFG*]	melitz1	melitz2
1 USA	0.06	0.07
2 JPN	-0.14	-0.13
3 ROW	-0.04	-0.05

avc[MNFG*]	melitz1	melitz2
1 USA	-0.01	-0.06
2 JPN	-0.3	-0.41
3 ROW	-0.04	-0.05

Equation NSFIRM

 # number of active firms that sell from region r to market s #

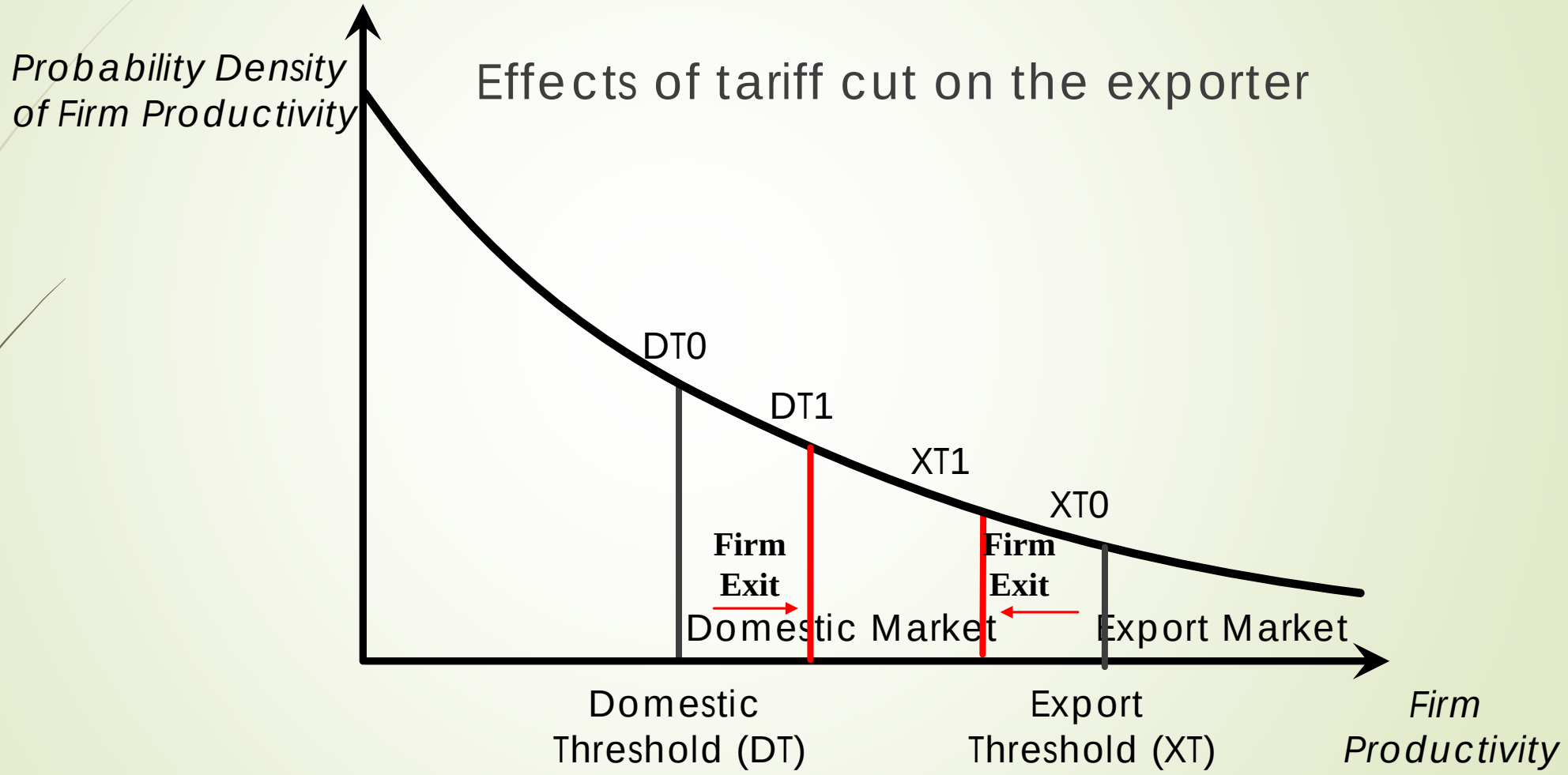
(all,i,MCOMP_COMM)(all,r,REG)(all,s,REG)

ns(i,r,s) = np(i,r) - SHAPE(i) * aost(i,r,s) + *entryslack*(i,r,s);

melitz1			
aost[MNFG**]	1 USA	2 JPN	3 ROW
1 USA	0.06	-4.09	0.14
2 JPN	-0.21	0.12	-0.12
3 ROW	-0.08	0.27	0

melitz2			
aost[MNF	1 USA	2 JPN	3 ROW
1 USA	0.08	-4.05	0.17
2 JPN	-0.17	0.18	-0.08
3 ROW	-0.08	0.29	0

Endogenous productivity change



Source: Zeynep Akgul and Angel H. Aguiar (2016) adaptation of Greenaway and Kneller (2007)

np[MNFG*]	melitz1	melitz2
1 USA	-0.03	0.06
2 JPN	-0.16	0.02
3 ROW	0	0

Thank you!

Comments? Questions?

Welfare Decomposition

Comparison of Simulations

Melitz1								
Regions	Allocative Efficiency Effects	Productivity Effects	Terms of Trade Effects	Investment-Savings Effects	Scale Effects	Variety Effects	Fixed Cost Effect	Aggregate Welfare Effect
1 USA	538.9	2665.2	1076.3	878	4738.3	-2390.8	-2659.4	4846.4
2 JPN	475.6	2632.3	-1857.7	10.9	4507.9	-2670.8	-2628.9	469.3
3 ROW	217.5	400.1	780.1	-889.4	356.5	-1779.1	-399.7	-1314.1
Total	1231.9	5697.6	-1.3	-0.5	9602.6	-6840.7	-5688	4001.6

Melitz2								
Regions	Allocative Efficiency Effects	Productivity Effects	Terms of Trade Effects	Investment-Savings Effects	Scale Effects	Variety Effects	Fixed Cost Effect	Aggregate Welfare Effect
1 USA	787	4638.7	938.2	1115.6	7805.5	-4064.8	-4638.8	6581.4
2 JPN	841	4833.1	-2407.6	-38	8023.9	-4486	-4737.2	2029.1
3 ROW	306.1	292.3	1468.6	-1078.5	206.3	-2653.2	-460.9	-1919.3
Total	1934.2	9764.1	-0.9	-0.8	16035.6	-11204.1	-9836.9	6691.2

Welfare Decomposition (Change in Melitz2 compared to Melitz1)

Regions	Allocative Efficiency Effects	Productivity Effects	Terms of Trade Effects	Investment-Savings Effects	Scale Effects	Variety Effects	Fixed Cost Effect	Aggregate Welfare Effect
1 USA	248.1	1973.5	-138.1	237.6	3067.2	-1674	-1979.4	1735
2 JPN	365.4	2200.8	-549.9	-48.9	3516	-1815.2	-2108.3	1559.8
3 ROW	88.6	-107.8	688.5	-189.1	-150.2	-874.1	-61.2	-605.2
Total	702.3	4066.5	0.4	-0.3	6433	-4363.4	-4148.9	2689.6

Welfare Decomposition explanation

- Reduction of the Variety Effects is caused by the decrease of firms on the domestic markets
- The Scale Effects have increased due to growth in the output
- The Fixed Costs' increase is derived from the proportion of fixed costs in sales

Simulation Results for the Manufacturing Sector

Parameters	Regions	Melitz1			Melitz2 (Shape Alteration)		
		USA	JPN	ROW	USA	JPN	ROW
Industry output (%), qo(j,r)		0.1	0.1	0.0	0.1	0.2	0.0
Domestic and Export Sales (%), qs(j,r,s)	USA	-0.1	26.9	-0.5	-0.1	38.5	-0.8
	JPN	1.6	-0.3	1.1	2.4	-0.3	1.7
	ROW	0.5	0.0	0.5	0.7	-2.2	-0.0
Supply price (%), ps(j,r)		-0.0	-0.3	-0.0	-0.1	-0.4	-0.1
Average Variable Cost (%), avc(j,r)		0.0	-0.3	0.0	-0.1	-0.4	-0.1
Scale Constant Average Total Cost (%), scatc(j,r)		0.1	-0.1	0.0	0.1	-0.1	-0.1
Number of Potential Firms (%), np(j,r)		0.0	-0.2	0.0	0.1	0.0	0.0
Number of Active Firms (%), ns(j,r,s)	USA	-0.2	12.8	-0.4	-0.3	23.0	-0.8
	JPN	0.5	-0.5	0.2	0.9	-0.9	0.4
	ROW	0.2	-0.8	0.0	0.4	-1.4	0.0
Output per Firm (%), qof(j,r)		0.3	0.6	0.0	0.5	1.1	0.0
Productivity Threshold for Market Entry (%), aost(j,r,s)	USA	0.1	-4.1	0.1	0.1	-4.0	0.2
	JPN	-0.2	0.1	-0.1	-0.2	0.2	-0.1
	ROW	-0.1	0.3	0.0	-0.1	0.3	0.0
Aggregate Productivity Terms of Trade (%), ao(j,r)		0.1	0.1	0.0	0.1	0.2	0.0
Real Exchange Rate (%), pfactor(r)		0.1	-0.1	0.0	0.1	0.0	-0.1

Number of Active Firms

melitz1			
ns[MNFG]**	**1 USA**	**2 JPN**	**3 ROW**
1 USA	-0.2	12.79	-0.43
2 JPN	0.46	-0.51	0.2
3 ROW	0.23	-0.79	-0.01

Melitz1			
ns[MNFG]**	**1 USA**	**2 JPN**	**3 ROW**
1 USA	-0.34	23.01	-0.78
2 JPN	0.87	-0.88	0.4
3 ROW	0.42	-1.45	-0.01