Introducing Firm Heterogeneity into the GTAP Model

Introduction
by Isaac Wohl

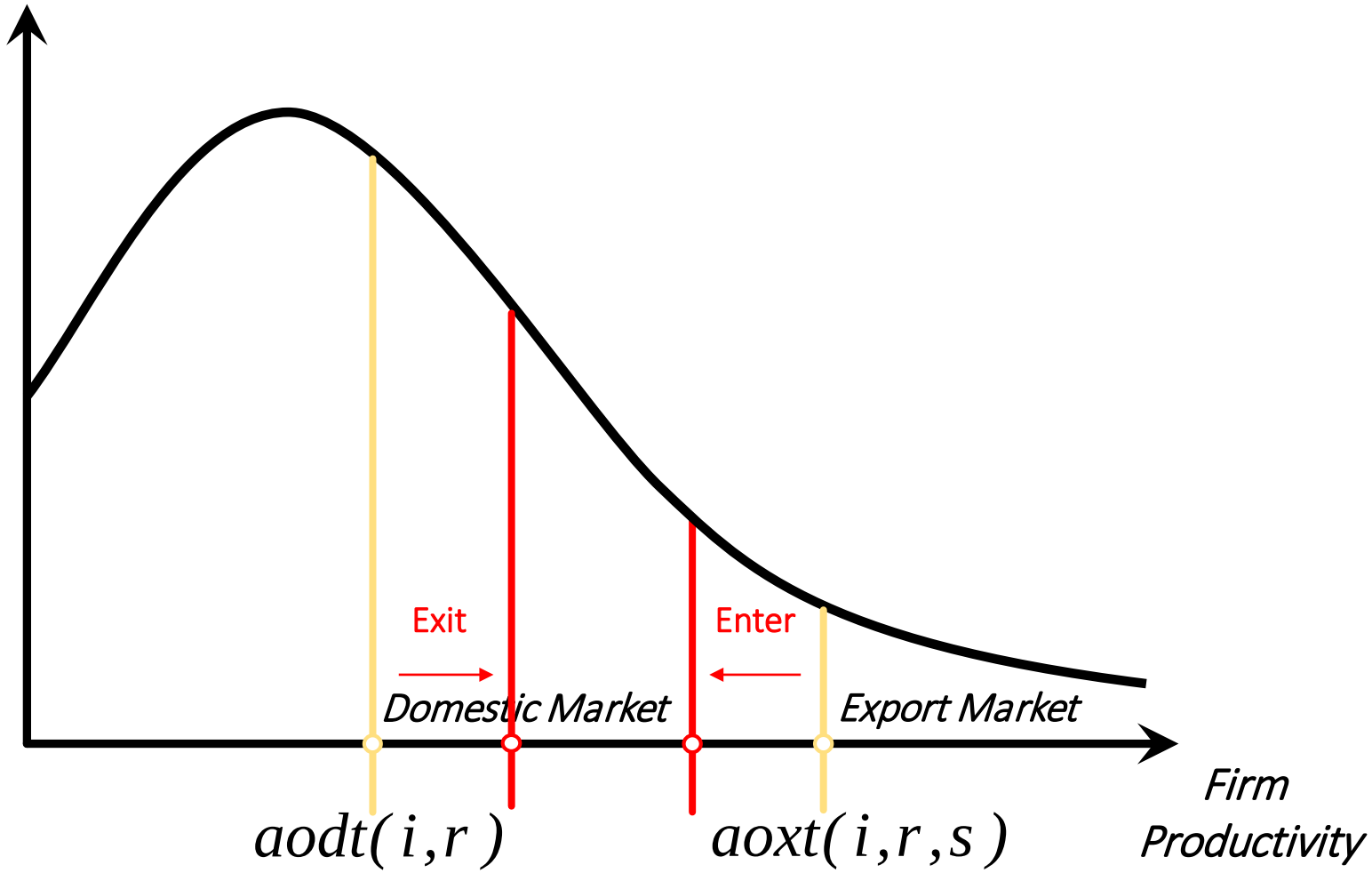
Firm heterogeneity is consistent with micro-level findings:

- Only some firms engage in exporting
- Exporters are larger and more productive than non-exporters (Roberts & Tybout, 1997; Bernard & Jensen, 1999; Bernard et al, 2003)
- Within-industry reallocation of market share is an important mechanism in determining the outcome of trade policies (Trefler, 2004; Bernard et al, 2006).

Melitz (2003)

- Product differentiation at the firm level
- Monopolistic competition, increasing returns to scale
- Heterogeneity at the firm level
- Bilateral fixed entry costs in export markets

Probability density of firm productivity



Source: Adapted from Greenaway and Kneller (2007)

Introducing firm heterogeneity in GTAP

- Love of variety
- Scale economies (increasing returns to scale)
- Markup pricing (relax perfect competition condition)
- Endogenous productivity
- Entry and exit of firms in the domestic and export markets
- Welfare decomposition with productivity (technology), variety, and scale effects

Experimental design

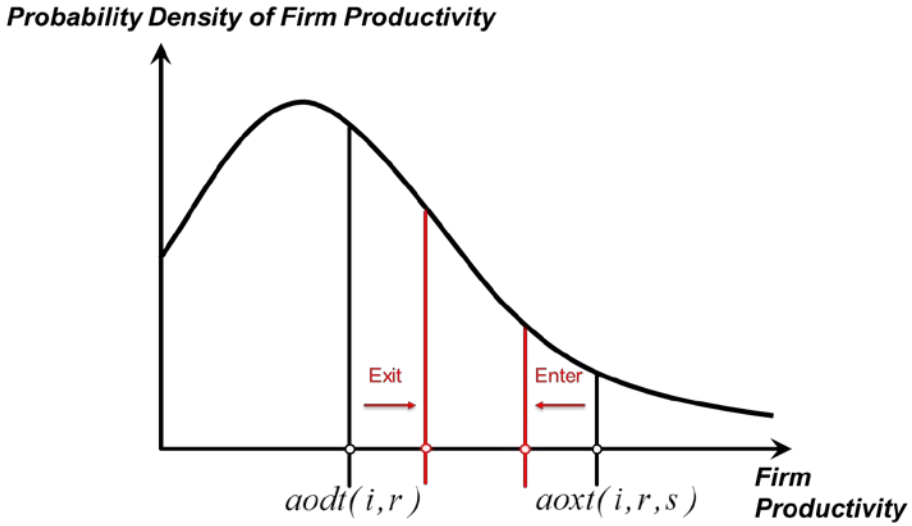
2 sectors

- Manufacturing
  - Monopolistic competition
  - Heterogeneous firms
- Non-manufacturing
  - Perfect competition
  - Armington assumption

3 regions: USA, JPN, ROW

Policy shock: Eliminate all tariffs on Japanese imports of U.S. manufactures

Productivity and firm entry/exit in the U.S.



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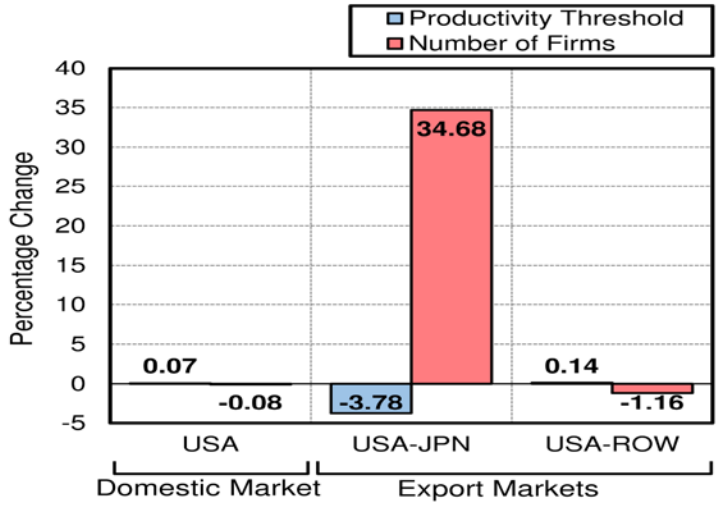

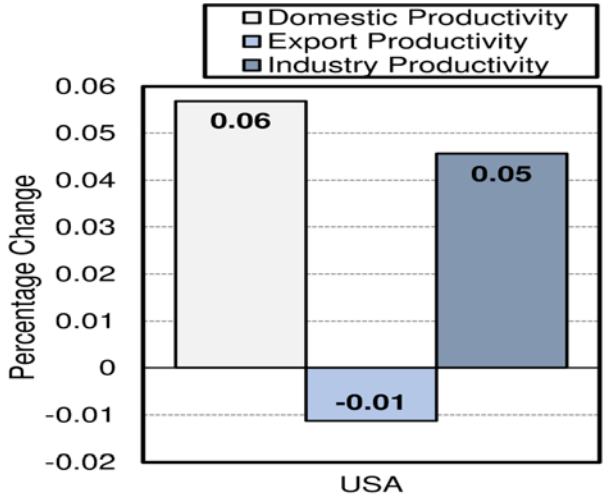

- Productivity threshold for the US-JPN trade declines.
- More firms engage in US-JPN export.
- Industry productivity increases due to the rise in average productivity in the domestic market.

Extensions

- Tariff liberalization: Welfare decomposition
  - Damla and Isaac
- Reductions in non-tariff barriers to trade as opposed to tariff liberalization
  - Jooyoung and Zornitsa
- Reductions in fixed export costs
  - Michael and Takashi
- Changing the shape parameter
  - Alissa and Lin

Welfare decomposition with firm heterogeneity

Damla Haciibrahimoglu

Isaac Wohl

Japan eliminates tariffs on U.S. mnfg exports

WELFARE	Allocative efficiency	Endowment	Technology	Population	Terms of trade	IS	Preferences	Scale	Variety	Total
USA	600.18	0	1,851.84	0	2,304.37	1,007.03	0	-1,065.52	1,224.17	5,922.07
JPN	62.71	0	1,747.61	0	-1,544.39	-0.92	0	-1,571.80	624.86	-681.93
ROW	44.52	0	-104.59	0	-762.38	-1,007.01	0	-74.97	-567.10	-2,471.53
Total	707.41	0	3,494.87	0	-2.39	-0.91	0	-2,712.29	1,281.93	2,768.62

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What we've seen before

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What's new with firm heterogeneity

Allocative Efficiency

All. Efficiency	pfacttax	prodtax	inputtax	contax	govtax	xtax	mtax	Total
USA	0.594	-38.5	0.985	248	0	97.3	292	600
JPN	0.045	-231	27.2	39.8	0.006	0	226	62.7
ROW	0.882	-0.487	-195	-73.7	-0.516	56	257	44.5
Total	1.52	-270	-167	214	-0.51	153	775	707

- Allocative Efficiency refers to the improvements arising from the elimination of pre-existing distortions to the economy.
- There are significant welfare gains from the mtax part. US consumers also enjoy cheaper products.
- Same export tax rate but more exports—xtax is welfare enhancing

Scale

Scale Effect	Domestic	Exporting	Total
USA	663	-1729	-1066
JPN	537	-2109	-1572
ROW	-213	139	-75
Total	987	-3699	-2712

- The firm heterogeneity model assumes increasing returns to scale meaning the larger a firm's scale is, the more it will be producing (hence exporting).
- Once the tariffs are reduced we observe that the total number of USA firms exporting to Japan increases while the output for firm declines meaning the 'scale' gets smaller!!
- That is why we see a negative scale effect for the US export firms. That is true for the Japanese firms as well.
- But not for the ROW firms!!there is ENTRY

Scale

Scale Effect	Domestic	Exporting	Total
USA	663	-1729	-1066
JPN	537	-2109	-1572
ROW	-213	139	-75
Total	987	-3699	-2712

- As for the domestic firms, output increases faster than the per firm output meaning the scale of domestic firms gets bigger (some firms exit) hence there is a positive scale effect. (ROW—just the reverse)
- ROW exports more to US and the domestic market but loses the Japanese market.

Terms of Trade

TOT (Total)	USA	JPN	ROW	Total
MNFG	0.084	-0.19	0.009	-0.096
NonMNFG	0.066	-0.004	-0.039	0.023
Total	0.151	-0.194	-0.03	-0.073

tot(r) = psw(r) - pdw(r)

	psw(r)	pdw(r)	psw(r)-pdw(r)
USA	0.074	-0.0766	0.1506
JPN	-0.2357	-0.042	-0.1937
ROW	-0.0644	-0.0311	-0.0333
Total	-0.2261	-0.1497	-0.0764

TOT is the difference between the prices received for tradeable i produced in r (psw) and the prices paid for tradeable i used in region r (pdw).

- *Psw depends on pfob → FOB price of goods exported from US to Japan increases whereas they decline vice versa.*
- *Pdw depends on pcif → CIF price of goods imported from US to Japan increases whereas they decline vice versa.*
- *The relative increase in pfob is greater than the increase in pcif for US hence US benefits in terms of TOT.*

Variety effect

Variety effect	USA	JPN	ROW
USA	-756.17	3,751.31	-2,006.78
JPN	436.74	-1,489.85	1,137.55
ROW	1,543.59	-1,636.60	302.12
Total	1,224.17	624.86	-567.10

- People like having different varieties.
- Japan likes having more varieties from the U.S., but doesn't like having fewer domestic varieties (its firms are displaced by U.S. exporters).
- The U.S. doesn't like having fewer domestic varieties (U.S. non-exporting firms exit the market because of higher fixed costs), but likes having more imported varieties from Japan (whose exporters benefit from cheap new inputs from the U.S.).

Variety effect

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- What about imports from the rest of the world?
  - ROW firms that export to Japan are crowded out by U.S. exporters.
  - There's a slight increase in the number of ROW firms that export to the U.S. (caused by a slight decrease in the productivity threshold for ROW exporters to the U.S.). But this slight increase is multiplied by a very large level of U.S. private and firm consumption sourced from ROW.

Technology effect

	Technology effect
USA	1,851.84
JPN	1,747.61
ROW	-104.59
Total	3,494.87

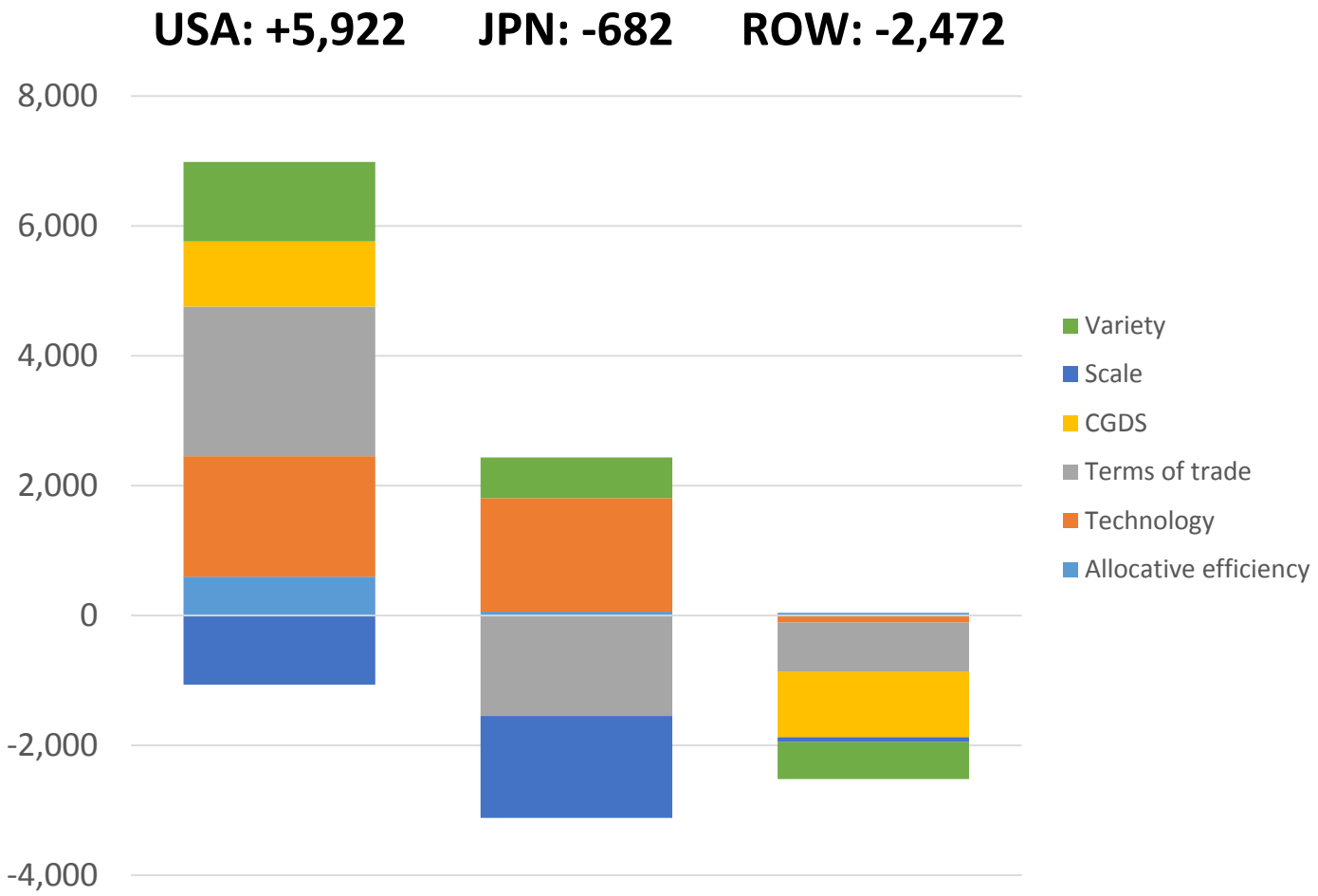
- Here, average domestic market productivity (*aod*) and average export market productivity (*aox*) are endogenous.
  - In the U.S., *aox* decreases (less-productive firms can enter the export-to-Japan market) and *aod* increases (the rise in fixed costs drives less-productive firms out of the U.S. domestic market).
  - In Japan, *aox* decreases (prices of Japanese exports decrease which attracts less-productive firms) and *aod* increases (domestic sales decrease which drives out less-productive firms).
- (Output-augmenting technical change, *ao*, is just a share-weighted addition of *aod* and *aox*.)

Investment / savings effect

IS effect	pcgds	psave
1 USA	0.081	0.099
2 JPN	-0.157	-0.139
3 ROW	-0.064	-0.046
Total	-0.141	-0.085

- National account: X – M = S – I
- Investment sales are “like exports.” Savings are “like imports.”
  - Regional households like to save; it’s part of their utility function. So if the price of savings rises, that’s bad for regional welfare (as though the price of “imported savings” has risen).
  - Regions “sell their capital goods to the global bank” in exchange for savings. It’s good for the world to have inexpensive capital goods, but individual regions benefit when the price of their capital goods increases.

Japan eliminates tariffs on U.S. mnfg exports



Technological change at the border versus a tariff cut in a firm heterogeneity model

GTAP short course, 8 August 2014

Jooyoung Yang and

Zornitsa Kutlina-Dimitrova

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Theoretical background

- Tariff cuts reduce the relative price of imports in the destination country.
- The effect of NTBs can cause supply- and demand shifting effects.
- For example shocks to SPS and TBT affect the supply side whereas demand shift effects may occur due to increased information availability to consumers.

Simulation design

- Scenario 1: Tariff elimination on US exports to Japan in the manufacturing sector.
- Scenario 2: Mimicking the tariff elimination effect by a reduction in the technological change at the border at agent level in the manufacturing sector.
- Systematic Sensitivity Analysis (SSA) of the shape parameter determining the firm distribution.

Simulation results

Variables		Scenario 1 (tms shock)		Scenario 2 (ams shock)	
		USA	JPN	USA	JPN
Export sales (%)	USA	-0.347	69.670	-0.251	57.621
	JPN	3.601	-0.996	1.886	-0.518
Industry output (%)		0.016	-0.161	0.054	-0.128
Supply price (%)		0.041	-0.271	0.029	-0.148
Average Variable Cost (%)		0.041	-0.271	0.029	-0.148
Average Total Cost (%)		0.055	-0.240	0.040	-0.135
Terms of Trade (%)		0.151	-0.194	0.114	-0.097
Welfare ($US millions)		5922	-682	4684	2133
Number of Varieties (%)		-0.081	-0.373	-0.027	-0.220
Number of Exporting firms	USA	-0.081	34.678	-0.027	29.233
	JPN	1.691	-0.373	0.894	-0.220
Productivity Threshold for Domestic Markets (%)		0.067	0.153	0.056	0.071
Productivity Threshold for Export Markets (%)	USA	0.000	-3.779	0.000	-3.258
	JPN	-0.264	0.000	-0.143	0.000
Average Productivity (%)		0.035	0.072	0.029	0.034

Source: GTAP-Het model simulations

Model mechanics

- TMS shock affects the price of imports of i from r into s in a direct way (price linkages).

$$pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s)$$
$$pgs(i,r,s) = tgs(i,r,s) + pms(i,r,s)$$

- AMS shock affect the price of imports of i from r into s at agent level in an indirect way.

$$qgmc(i,r,s) = - \mathbf{ams}(i,r,s) + qg(i,s) + vg(i,r,s) - SIGMA(i) * [pgs(i,r,s) - \mathbf{ams}(i,r,s) - pg(i,s)]$$

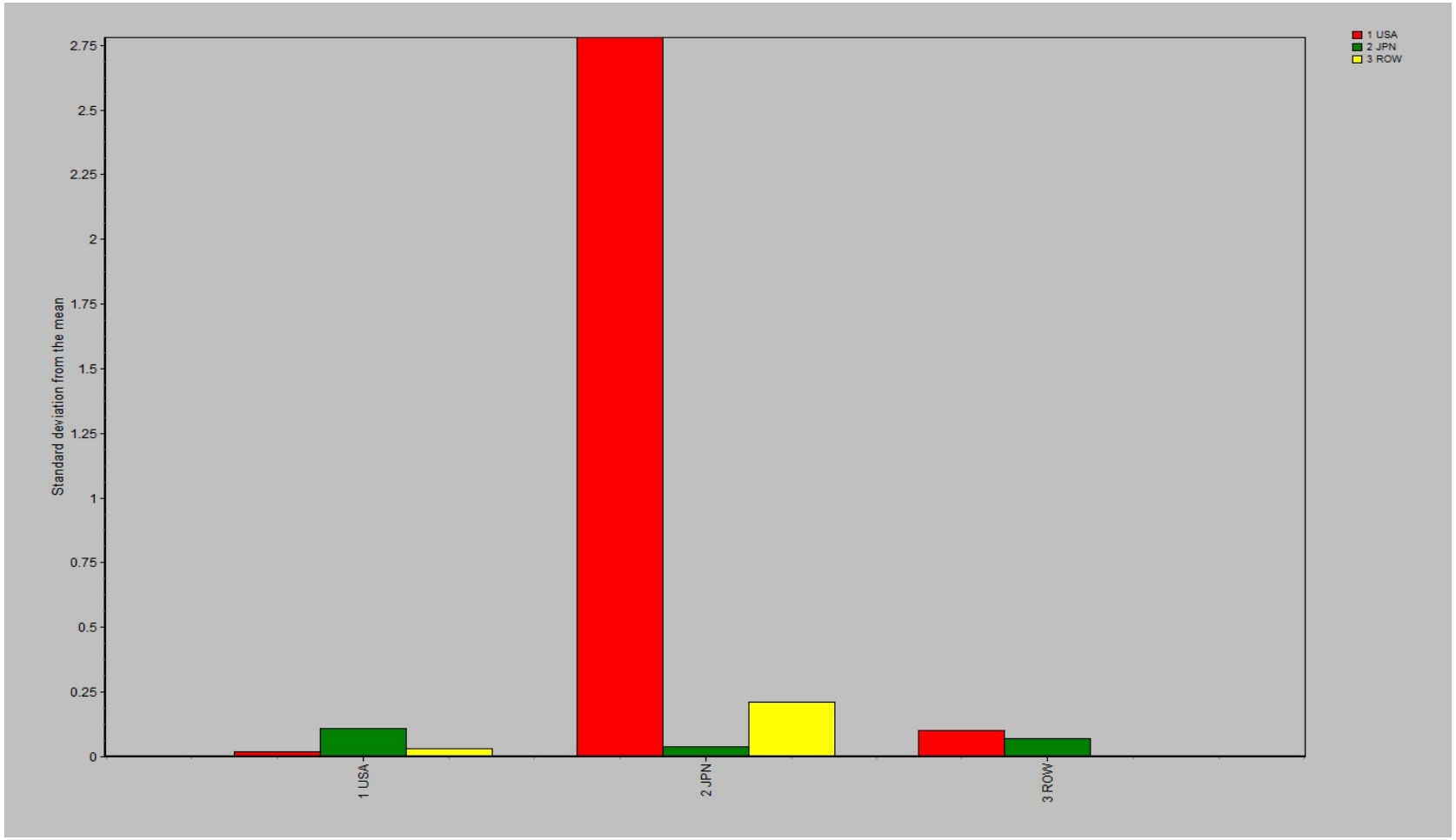
Welfare decomposition

Sc/Country	Allocation	Endow	Tech change	pop	ToT	IS	Pref	Scale effects	Variety	Total
Scenario (1) tms shock										
1 USA	600	0	1852	0	2304.4	1007	0	-1065	1224	5922
2 JPN	63	0	1748	0	-1544.4	-0.9	0	-1572	625	-682
Scenario (2) ams shock										
1 USA	415	0	1553	0	1785.5	724.9	0	-980	1186	4684
2 JPN	1343	0	818	0	-773.4	-14.4	0	-768	1525	2130

Source: GTAP-Het model simulations

- TARIFF REVENUE LOSSES DO MATTER A LOT!

Sensitivity analysis: Variation to the shape parameter of the Pareto productivity distribution in respect to US export sales to Japan



Source: GTAP-Het, SAS analysis

Conclusions and policy implications (1)

- Effect of tariff cuts/elimination can be mimicked to a large extent through shocks to the technological change at the border variable (ams).
- The ams variable in the GTAP model materialize on the demand side of the model similarly to the way tariff cuts affect the model equilibrium.

Conclusions and policy implications (2)

- Technological efficiency effects generate positive welfare effects in all concern regions whereas a one side liberalization creates a welfare loss for the importing country.
- This is an argument for multilateral liberalization of non-tariff barriers.
- There is a need for a thorough understanding of the nature of the technological shock and especially its magnitude.

Thank you for your attention!

Reduction of fixed export costs from USA to Japan with Firm heterogeneity

Trade and productivity implications

Michael Jerie
Takashi Hanagaki

Calibrating the shock

- Shock is given as technological change in fixed export costs of MNFG from USA to Japan.
- Calibrated to meet export sales target of from “NTB” subgroup: Zornista and Jooyoung.

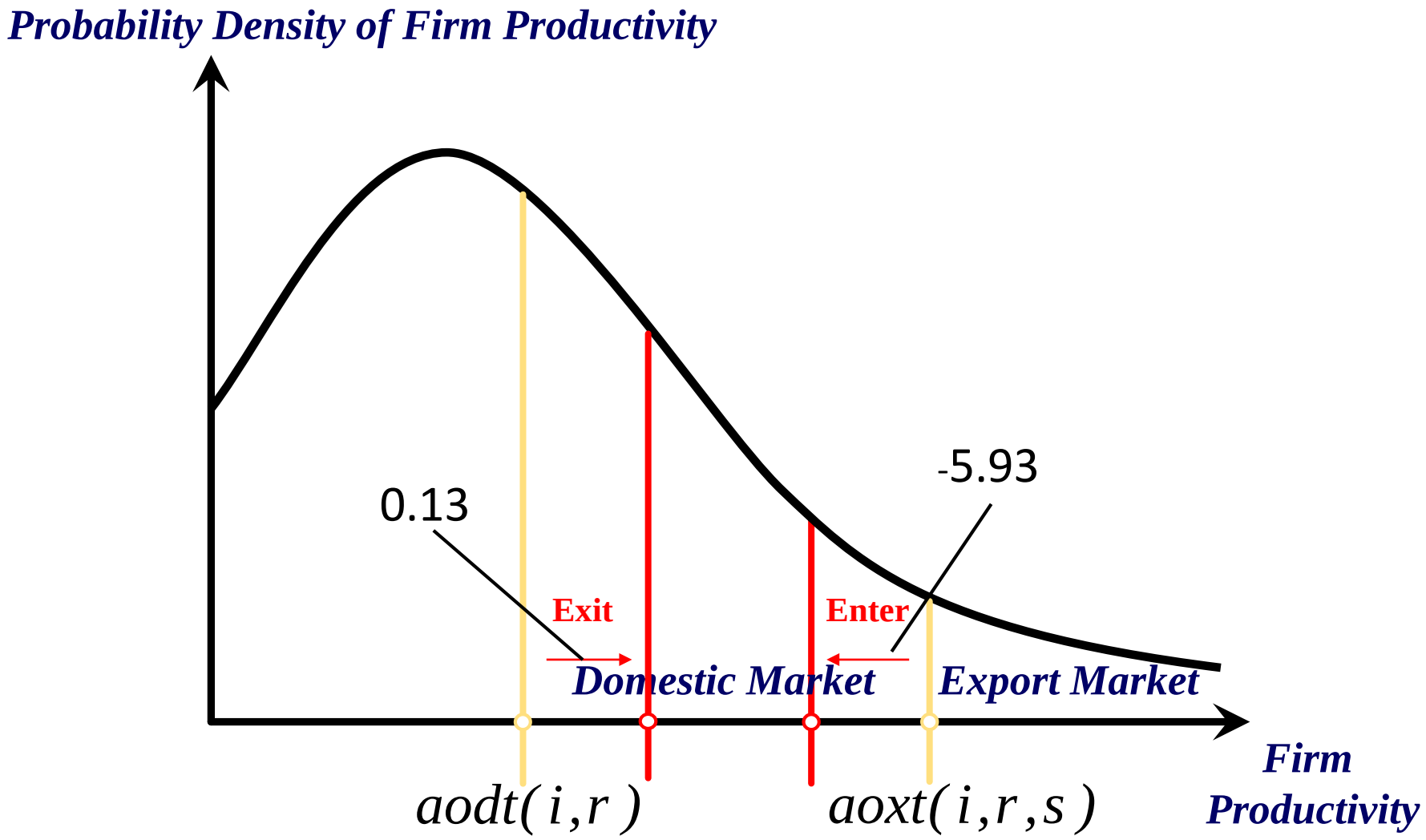
  qs(“MNFG”,USA,JPN) = 56.6.
- Technology change shock in fixed export costs.

  avafxall(“MNFG”,USA,JPN) = 47.6%

Simulation Results

	j=MNFG	USA	JPN	ROW
Export Sales	qs(j,r,s)	-0.34	56.6	-1.64
Industry Output	qo(j,r)	-0.06	-0.24	0.01
Supply Price	ps(j,r)	0.06	-0.21	-0.04
Average Variable Cost	avc(j,r)	0.06	-0.21	-0.04
Terms of Trade	tot(r)	0.12	-0.16	-0.02
Welfare (m$US)	EV(r)	9511.74	2181.51	-1323.92
Output per Firm	qof(j,r)	0.04	0.18	0
Number of Varieties (Firms)	n(j,r)	-0.1	-0.41	0.02
Number of exporting firms	nx(j,r,s)	-0.1	60.5	-0.99
Output per Exporting Firm	qox(j,r,s)	0.04	-37.73	0.94
Prod Threshold for Dom Market	aodt(j,r)	0.05	0.13	0
Prod Threshold for Export Market	aoxt(j,r)	0	-5.93	0.12
Aggregate Productivity	ao(j,r)	-0.01	0.06	0
fixed costs for exporting firms	qvafx(j,r,s)	-0.1	8.71	-0.99

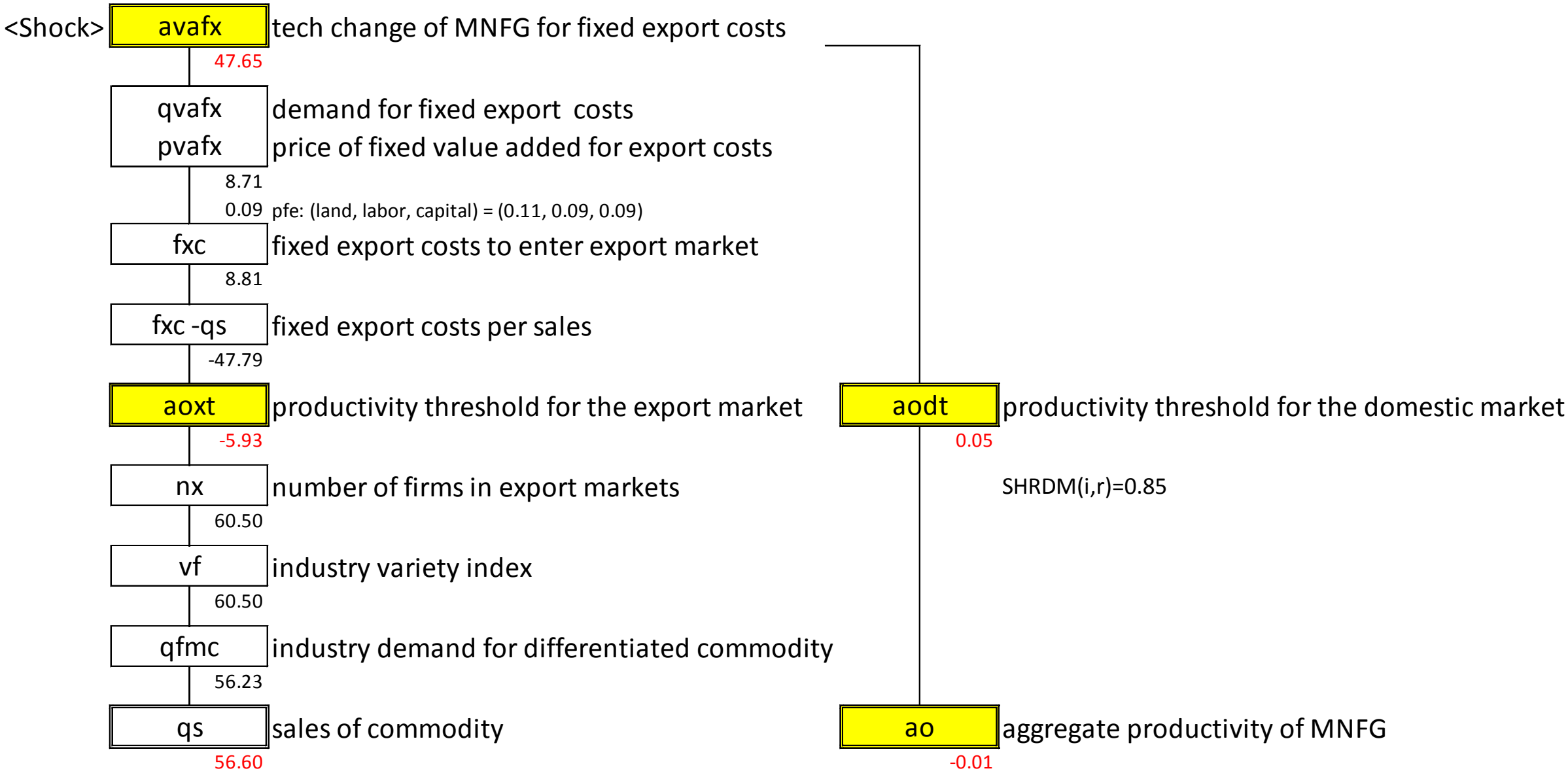
Trade Liberalization Effects on Industry Productivity



Source: Adapted from Greenaway and Kneller (2007)

Influence channel of tech. shock on fixed export costs

i=MNFG, r=USA, s=JPN



(Reference) Key equations

```
i=MNFG, r=USA, s=JPN

# generates flow-specific average rate of tech change for fixed export costs #
    avafx(j,r,s) = avafxsec(j) + avafxregr(r) + avafxregs(s) + avafxall(j,r,s);

# value added demand by the monop. comp. industry for fixed export costs #
    qvafx(j,r,s) = nx(j,r,s) - avafx(j,r,s);

# fixed export costs in industry i to enter the export market s  #
    fxc(i,r,s) = pvafx(i,r,s) + qvafx(i,r,s);

# eq'n links domestic and firm demand prices (HT 16) #
    pfe(i,j,r) = tf(i,j,r) + pm(i,r);

# price of fixed value added for export costs in the monop comp industry #
    pvafx(j,r,s) = sum(i,ENDW_COMM, SFCX(i,j,r,s) * [pfe(i,j,r)- afe(i,j,r)]);

# productivity threshold for the export market #
    aoxt(i,r,s) = [1 - DELTA(r,s)]
                  * {avc(i,r)
                     + [MARKUP(i,r)-1] * [fxc(i,r,s)-qs(i,r,s)]
                     - MARKUP(i,r) * pfob(i,r,s)}
                  + xthreshslack(i,r,s);

# number of active firms in export markets #
    nx(i,r,s) = n(i,r) - SHAPE(i) * aoxt(i,r,s) + entryslack(i,r,s);
```

(Reference) Key equations (ctd.)

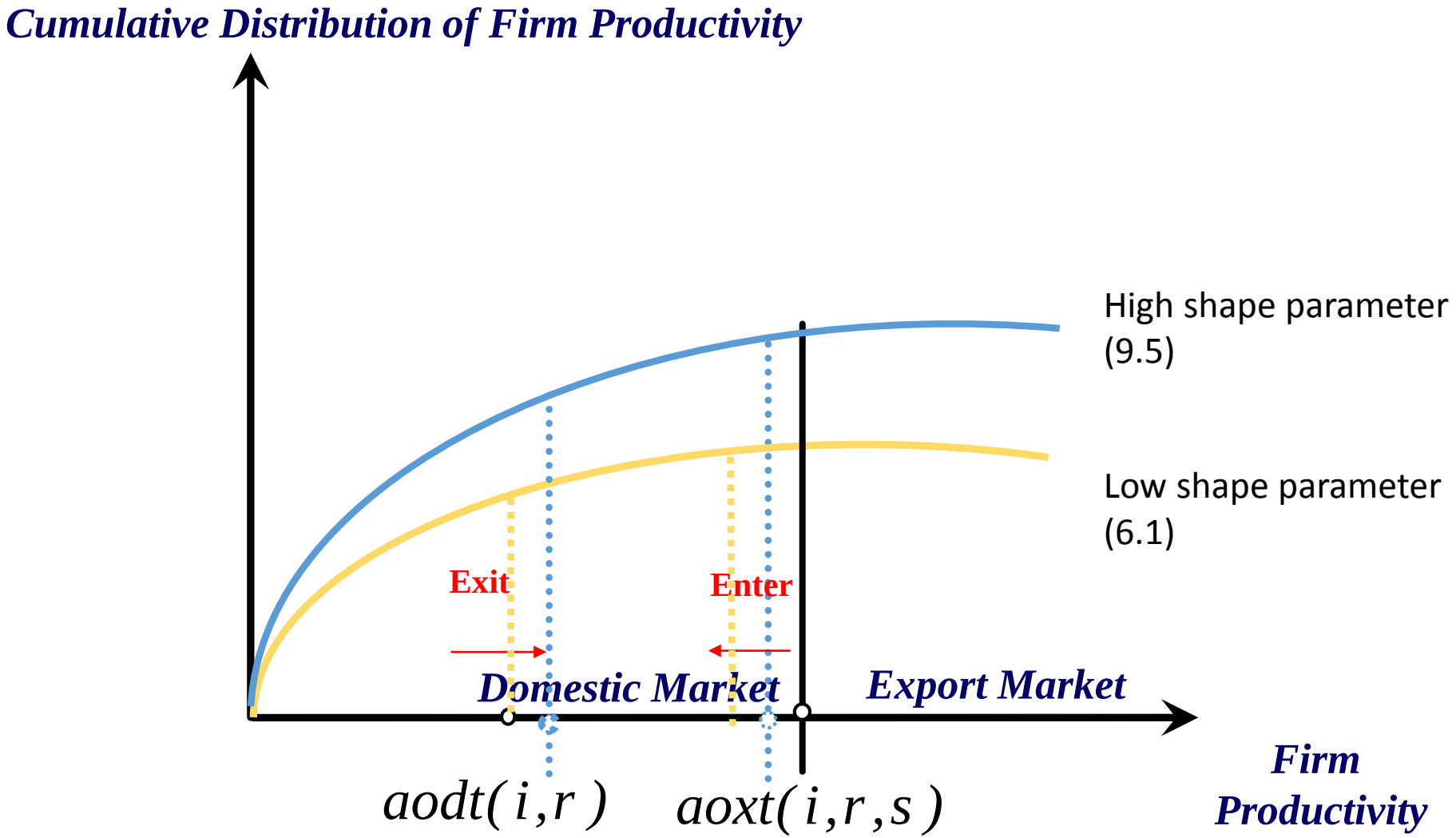
```
# industry variety index #
    vf(i,r,s) = nx(i,r,s) + vfslack(i,r,s);

# industry demand for sourced differentiated commodity #
    qfmc(i,r,j,s) = - ams(i,r,s) + qf(i,j,s) + vf(i,r,s)
                    - SIGMA(i) * [pfs(i,r,j,s) - ams(i,r,s) - pf(i,j,s)];

# market clearing in the sale of monopolistically competitive commodities #
    qs(i,r,s) = SHRSPM(i,r,s) * qpmc(i,r,s)
              + SHRSGM(i,r,s) * qgmc(i,r,s)
              + sum{j,PROD_COMM, SHRSFM(i,r,j,s) * qfmc(i,r,j,s)}
              + saleslack(i,r,s);

# productivity threshold for the domestic market #
    aodt(i,r) =  avc(i,r)
              + [MARKUP(i,r)-1] * [fdc(i,r)-qs(i,r,r)]
              - MARKUP(i,r) * ps(i,r)
              + dthreshslack(i,r);

# computes aggregate productivity of the monop. comp. industry with het. firms #
    ao(i,r) = SHRDM(i,r) * aod(i,r)
            + sum(s,REG, SHRSMD(i,r,s) * aox(i,r,s))
            + prodslack(i,r);
```

Changing the SHAPE Parameter

Alissa Tafti

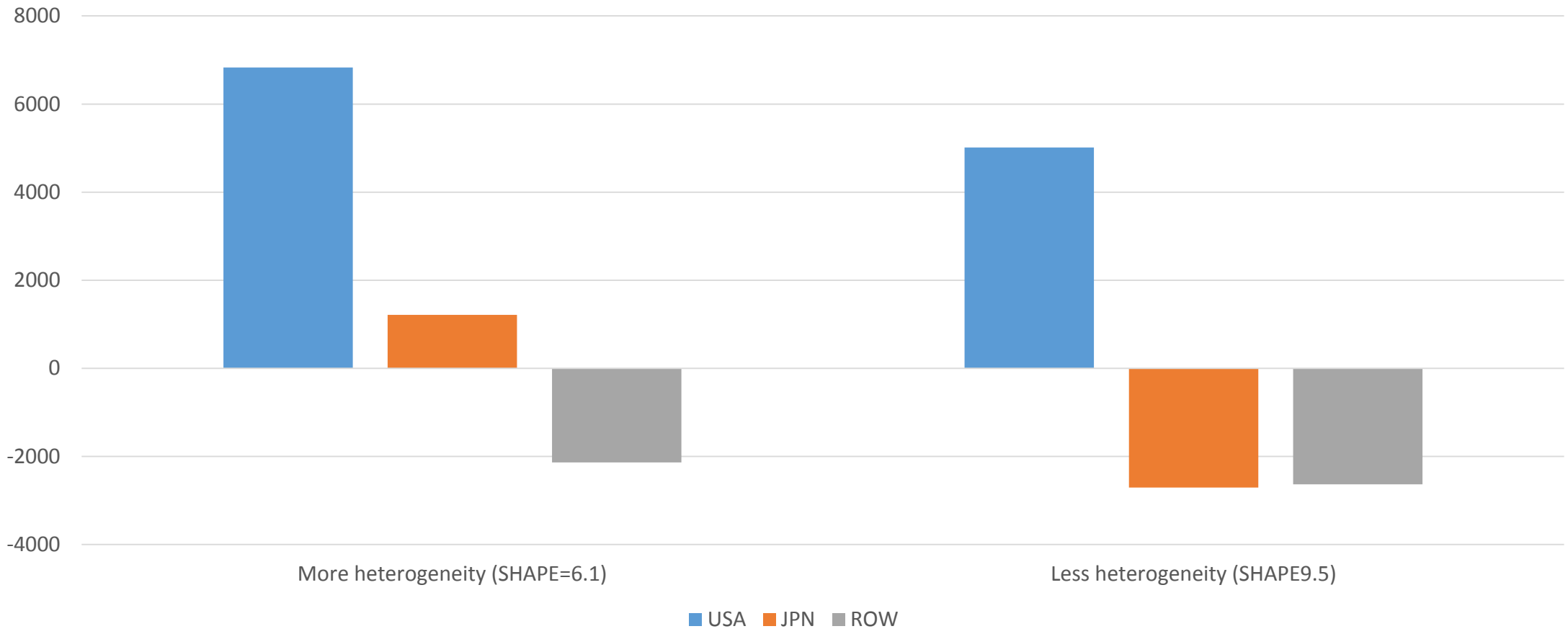
Lin Jones

SHAPE parameter



Source: Adapted from Greenaway and Kneller (2007)

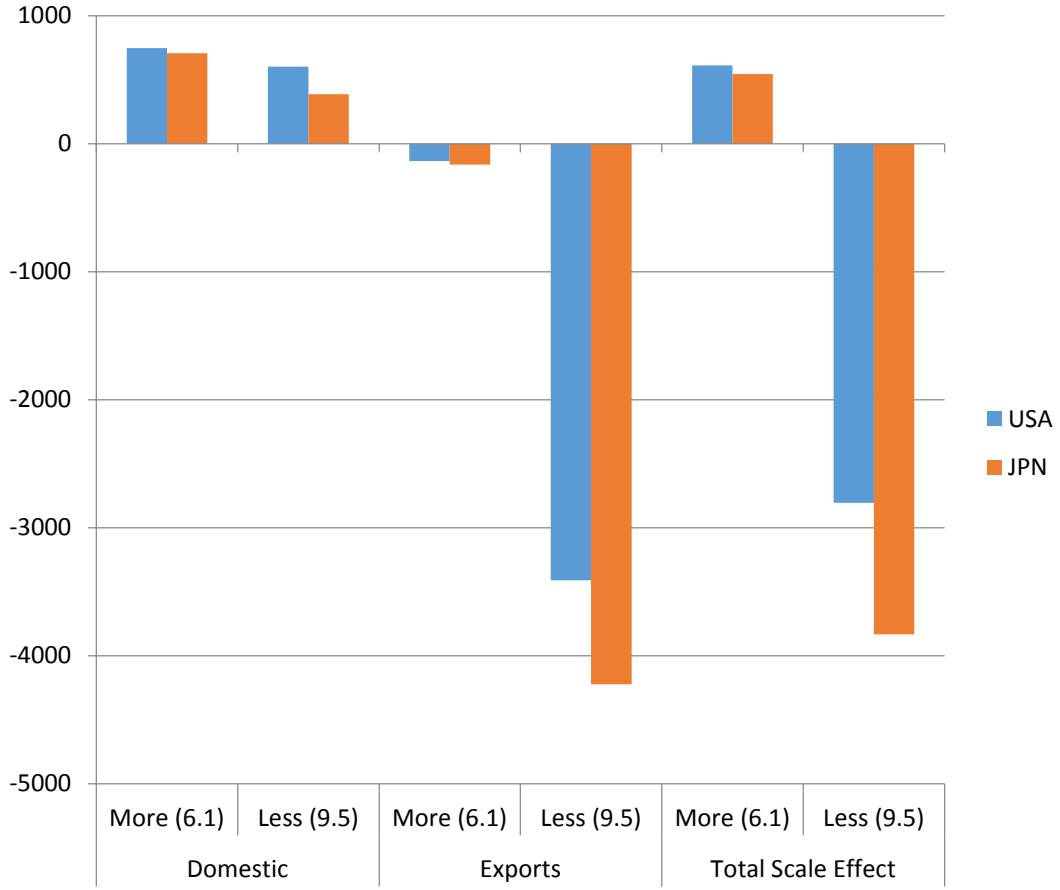
Welfare Effects (EV)



Welfare Decomposition

	Allocative Efficiency effect		Technical change effect		Terms of trade effect		Scale effect	
	More het.(6.1)	Less het. (9.5)	More het.(6.1)	Less het. (9.5)	More het.(6.1)	Less het. (9.5)	More het.(6.1)	Less het. (9.5)
USA	630	572	1462	2265	2142	2478	614	-2806
JPN	235	-123	1371	2150	-1519	-1571	547	-3833
ROW	88	11	-15	-237	-626	-910	-174	249

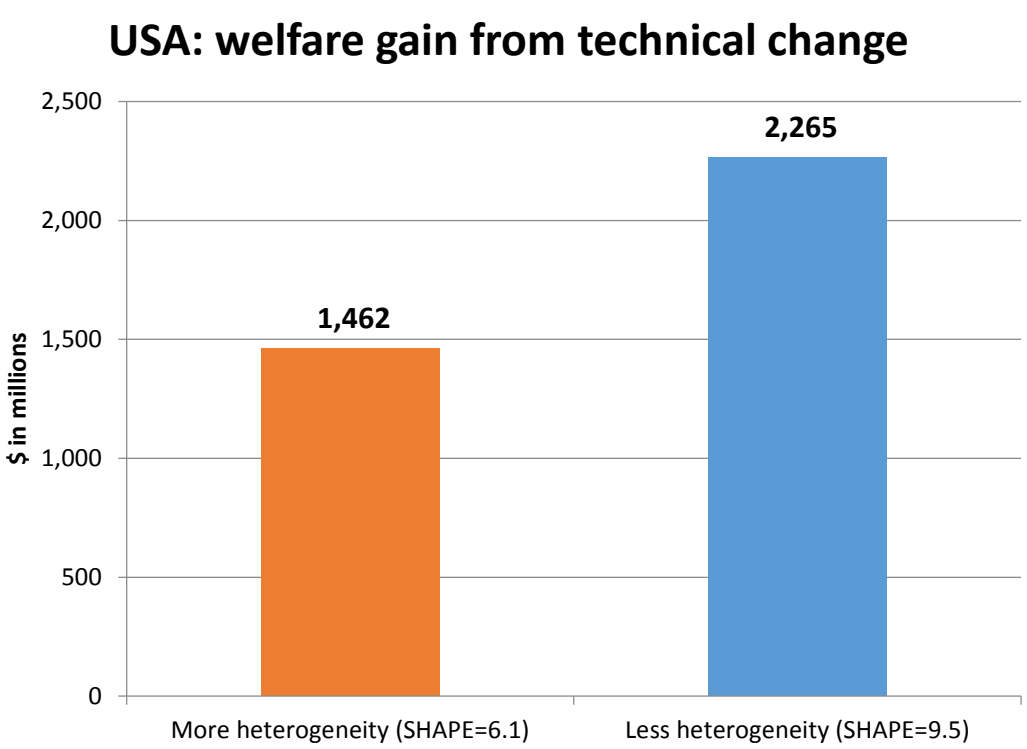
Scale Effect



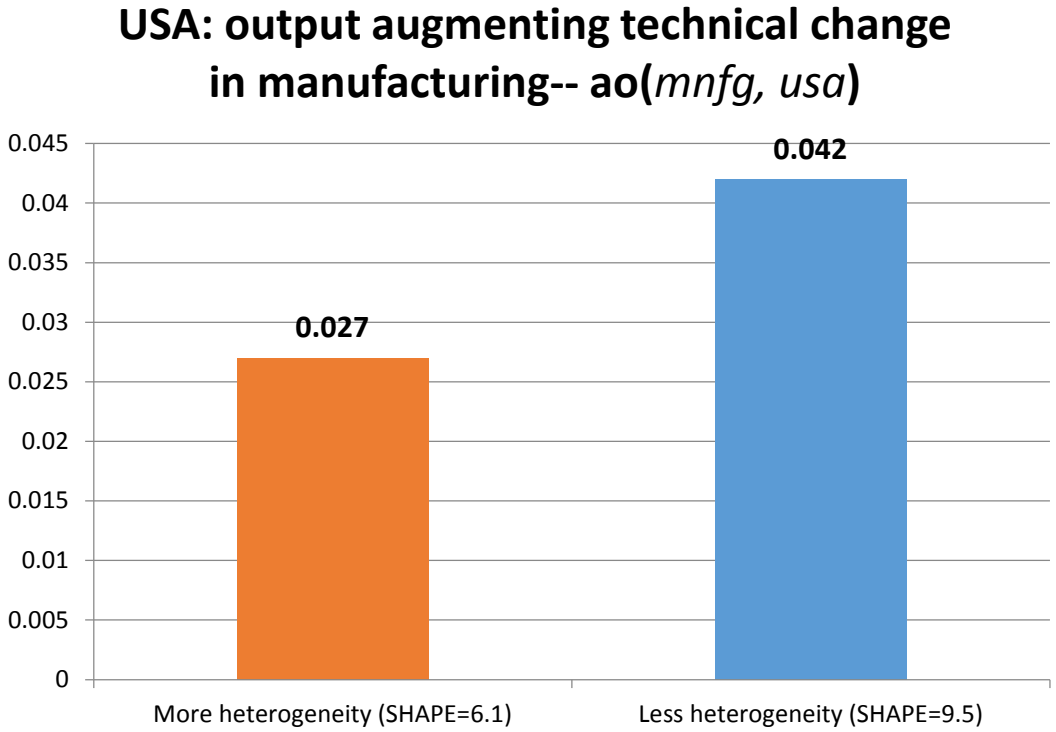
	Industry output (Manufacturing)	
	More het.(6.1)	Less het. (9.5)
USA	0.031	0.001
JPN	-0.096	-0.231

	Number of total firms		Number of exporting firms (bilateral trade)	
	More het. (6.1)	Less het. (9.5)	More het. (6.1)	Less het. (9.5)
USA	-0.054	-0.11	26.651	43.591
JPN	-0.276	-0.476	1.346	2.056

Technical change effect



100% technical welfare gain is from output augmenting technical change.

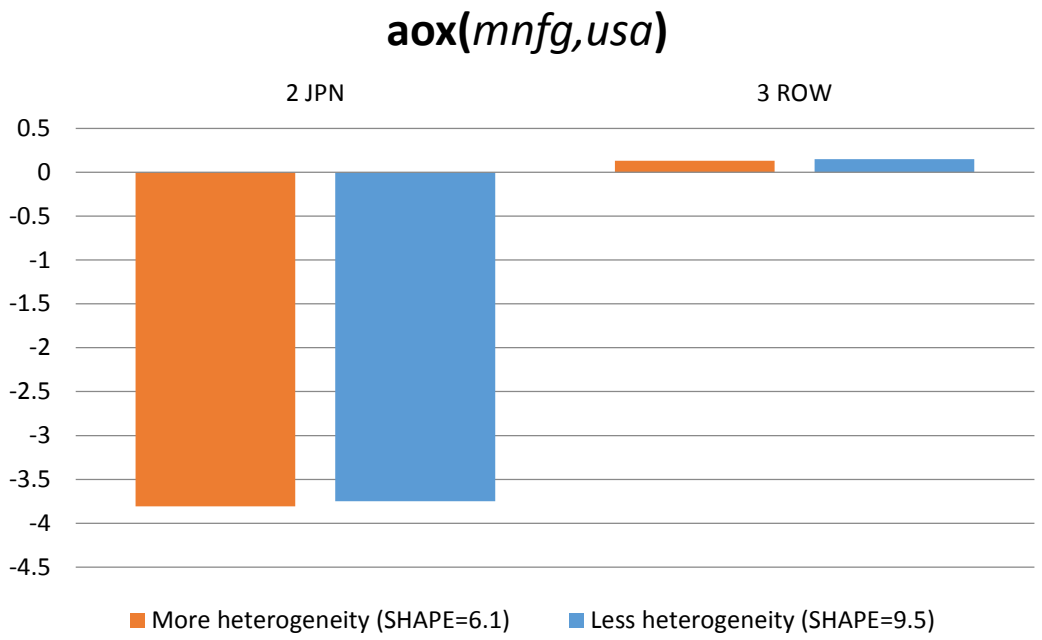


Industry with less heterogeneity gained more productivity improvement after trade liberalization. WHY?

ao(i,r) = SHRDM(i,r) * aod(i,r) + sum(s,REG, SHRSMD(i,r,s) * aox(i,r,s))+ prodslack(i,r);

- 85% went to domestic sales;
- 0.8% exported to Japan; and
- 14.2% exported to ROW.

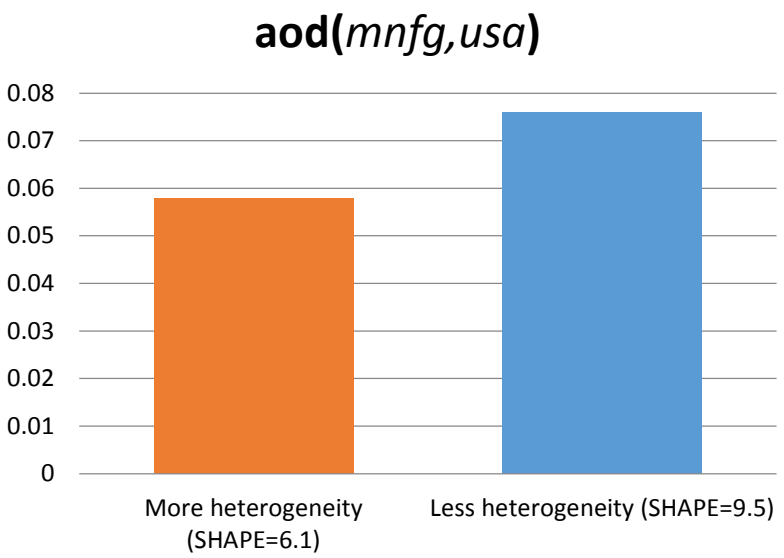
aox(i,r,s): average productivity of industry I in region r for export market s



ao(i,r) = SHRDM(i,r) * aod(i,r) + sum(s,REG, SHRSMD(i,r,s) * aox(i,r,s))+ prodslack(i,r);

aod(i,r): average productivity for domestic market

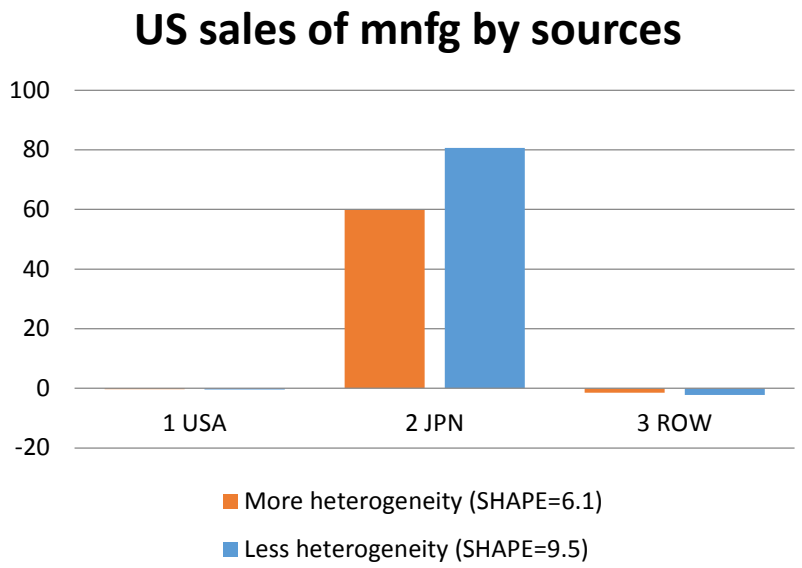
aod(i,r)= aodt(i,r)=avc(i,r) + [MARKUP(i,r)-1] * [fdc(i,r)-qs(i,r,r)] - MARKUP(i,r) * ps(i,r)+ dthreshslack(i,r);



	More heterogeneity (SHAPE=6.1)	Less heterogeneity (SHAPE=9.5)
fdc (*mnfg,usa*): fixed domestic cost	**0.103**	**0.081**
qs (*mnfg,usa,usa*):	**-0.289**	**-0.408**

Difference: 0.018

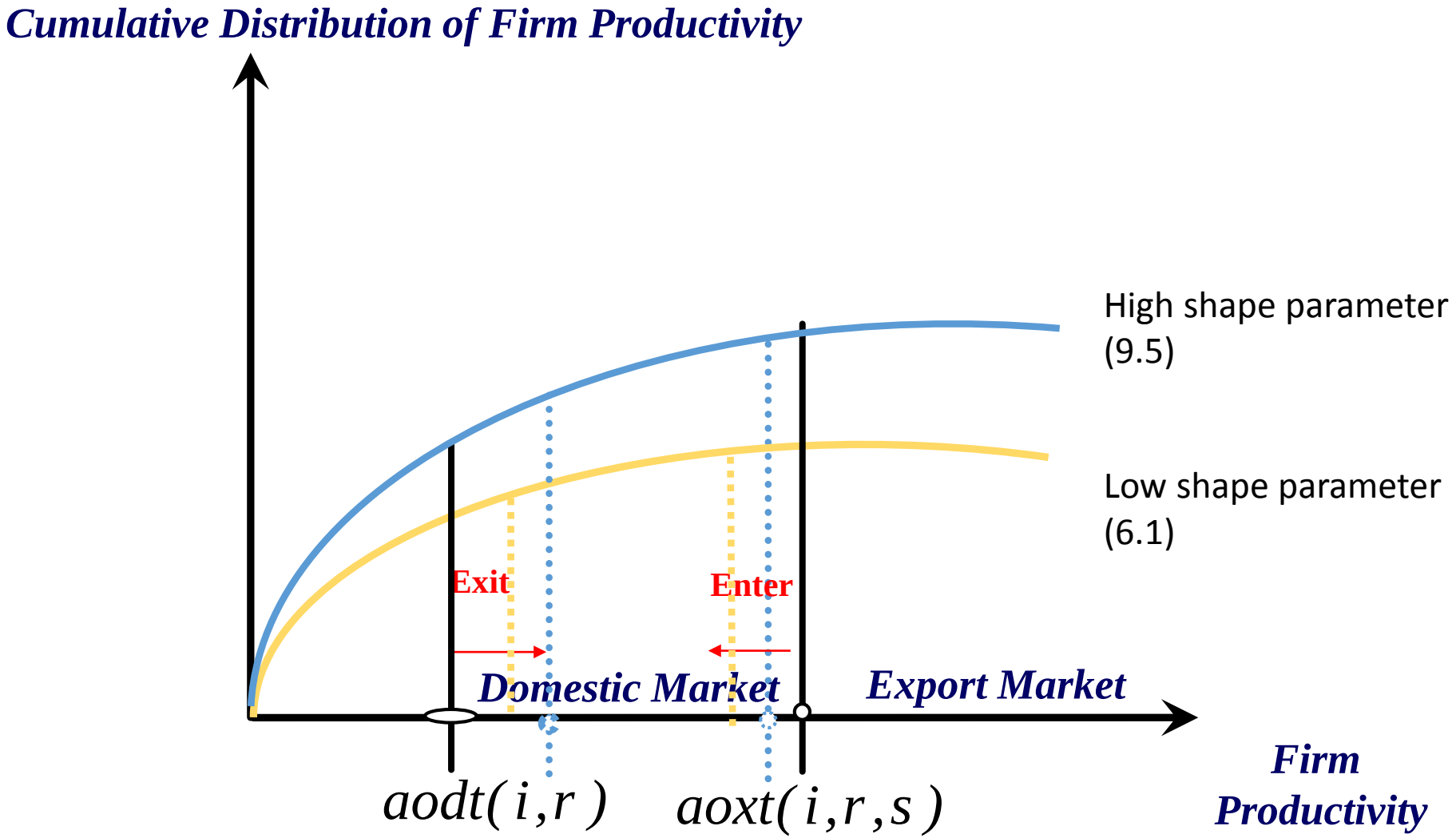
Increasing imports from Japan reduced the demand for US domestic mnfg commodities, particularly from US firm demand for domestic intermediate goods.



Firm heterogeneity: SimHET.exp, high bound 9.5			
pms from USA to all region		pms from Japan to all region	
R059	R059	R059	R059
1 USA	0.037	1 USA	-0.28
2 JPN	-3.623	2 JPN	-0.287

Firm heterogeneity: SimHET.exp, low bound 6.1			
pms from USA to all region		pms from Japan to all region	
R026	R026	R026	R026
1 USA	0.045	1 USA	-0.25
2 JPN	-3.616	2 JPN	-0.256

SHAPE parameter



Source: Adapted from Greenaway and Kneller (2007)

Thank you for your attention!