GTAP-HET
Exploring Firm Heterogeneity Effects

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Evolution of trade theories

1817	Ricardo (1772-1823)	*On the Principles of Political Economy and Taxation* the theory of **comparative advantage**
1933	Heckscher- (1879-1952) Olin (1899-1979)	**GE mathematical model** of international trade
1969	Armington (b.1940)	*A theory of demand for products **differentiated by place of production***, **IMF Staff Paper**
1980	Krugman (b.1953)	***Scale economies, product differentiation** and the Pattern of Trade*, **AER**
2003	Melitz (b.1968)	*The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity*, **Econometrica**
2016	GTAP: Akgul, Villoria & Hertel	*GTAP-HET: Introducing **Firm Heterogeneity** into the GTAP Model*, **JGEA**

Overview of GTAP-HET

In standard GTAP

- **All firms in industry** i **have equal productivity**

- **Modelled as the 'Representative Firm'**

- **In GTAP-HET there is a Pareto distribution of firms' productivity,** Φ

- **Scale, fixed costs to export and consumers' love of variety are also modelled**

Effects of tariff cut on the exporter

Probability Density of Firm Productivity

DT0
DT1
XT1
XT0

Firm Exit
Firm Entry
Domestic Market
Export Market

Domestic Threshold (DT)
Export Threshold (XT)
Firm Productivity
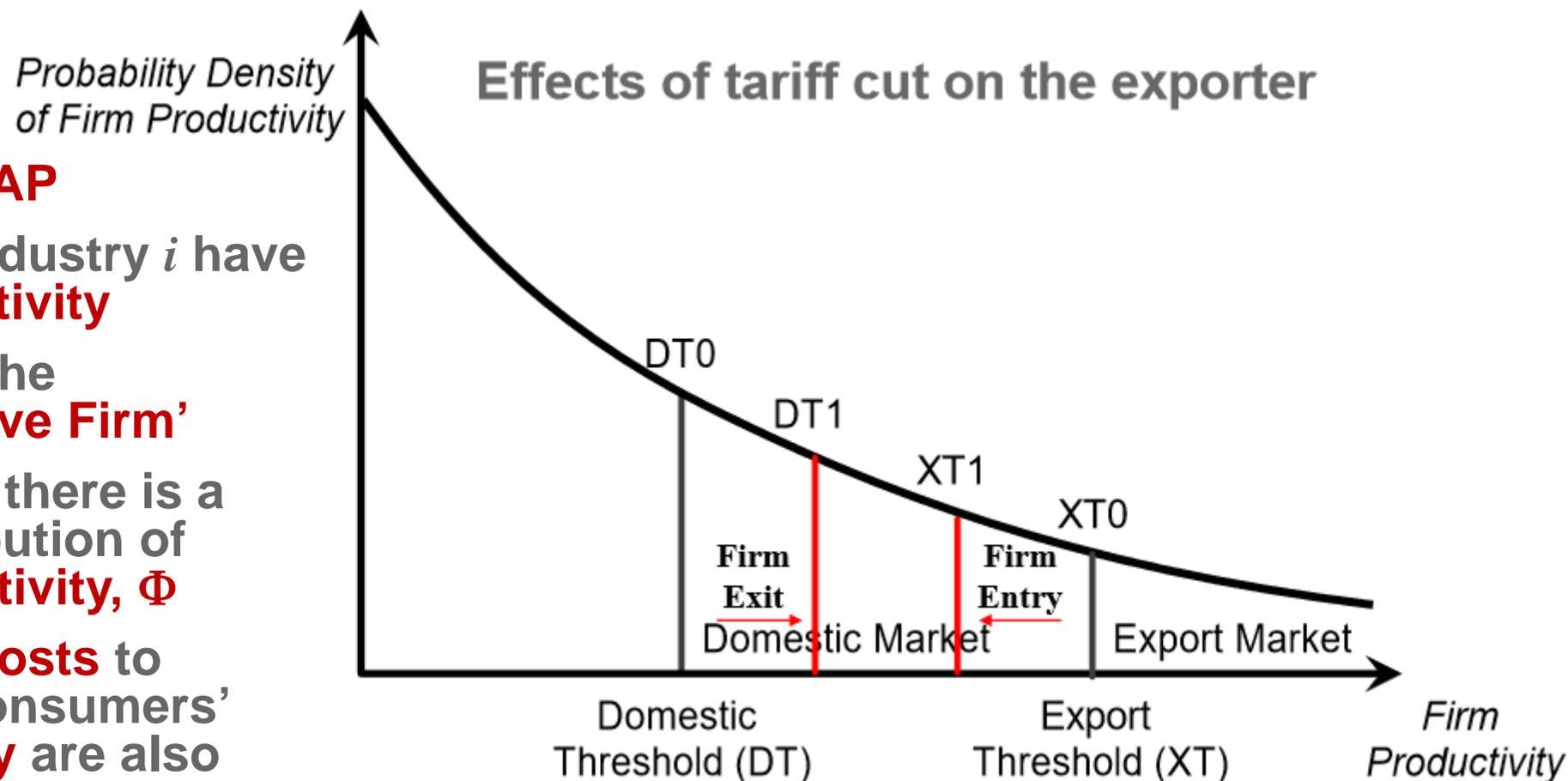
Adapted from Greenaway and Kneller (2007)

Closure swaps allow backward compatibility checks to Armington

GTAP-HET   **CLOSURE explanation**

Closure SWAPS	Productivity	Scale	Variety
Experiment	`aost`	`qof`	`vp, vg, vf`
`Melitz.exp`	endogenous	endogenous	endogenous
`Krugman.exp`	exogenous	endogenous	endogenous
`Armingtn.exp`	exogenous	exogenous	exogenous

Product and productivity differentiation at firm level, increasing returns to scale, entry-exit dynamics within industries and between exporting and non-export firms

	Products	Competition	Productivity	Bilateral
Ricardo	=	**CRTS**	=	—
Heckscher-Olin	=	CRTS	=	—
Armington	**region**	CRTS	=	—
Krugman	**firm**	**IRTS**	=	—
Melitz	firm	IRTS	**HET**	**Fixed costs**

How does GTAP-HET change the Welfare picture from our unilateral tariff shock?

Δ Welfare US$ M	WORLD	USA	Japan *Eliminates tariffs on US imports*	RoW
Armington	**425**	2 354	-1 191	-739
Melitz	**4 461**	5 430	501	-1 469

WORLD total: Melitz GTAP-HET

WORLD total

Increase ■ Decrease ■ Total

6,386 — Productivity
10,763 — Scale
-7,661 — Variety
-6,374 — Fixed Cost
-2 — ToT
1,350 — Alloc Eff
-1 — Inv-Savings
4,461 — Total

Global gains 10x

~ $ 4.5 Billion

Lots of moving parts
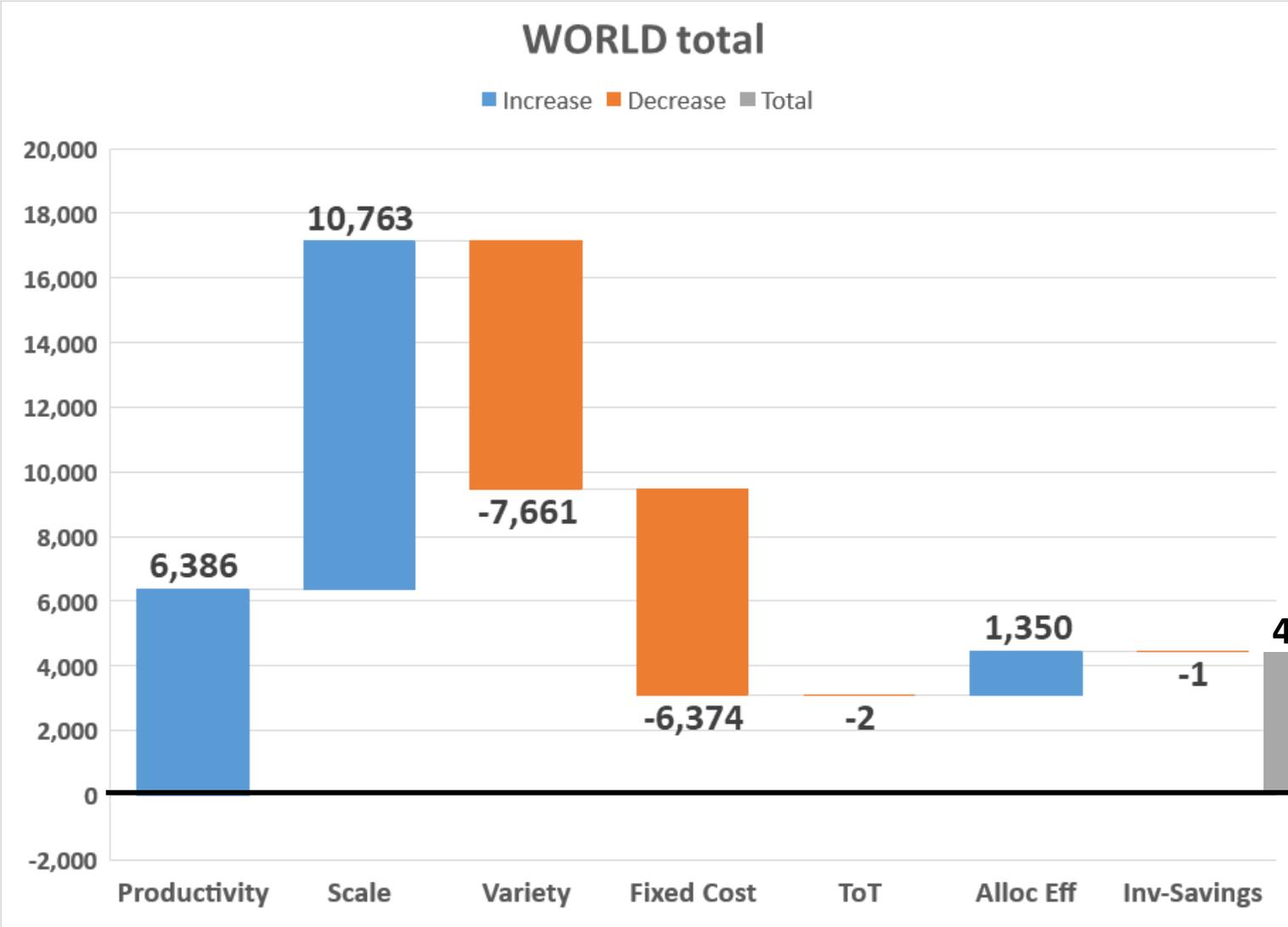
United States GTAP-HET
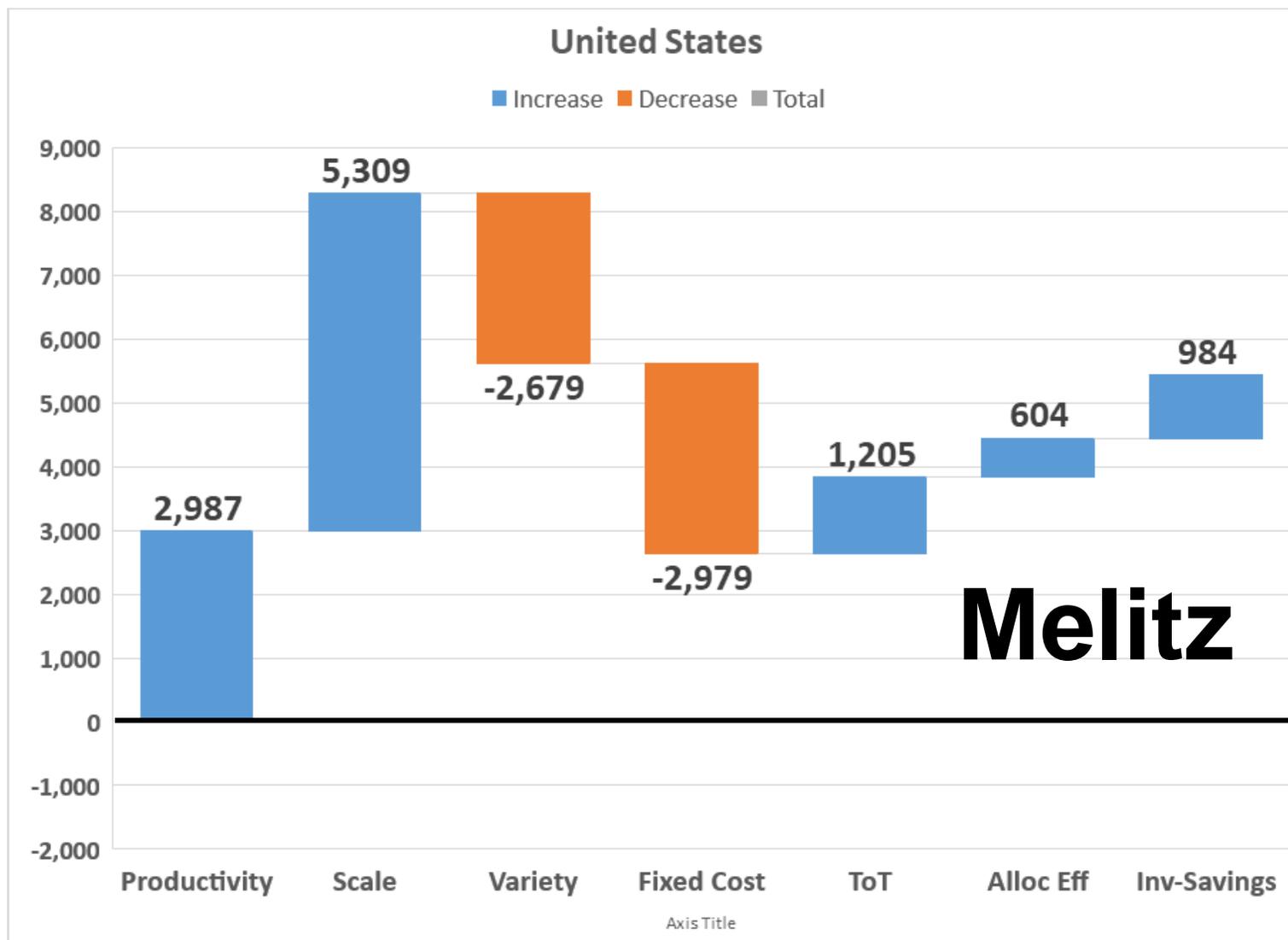
US gains 2x under Melitz

> $ 5 Billion

Lots of moving parts

Japan GTAP-HET
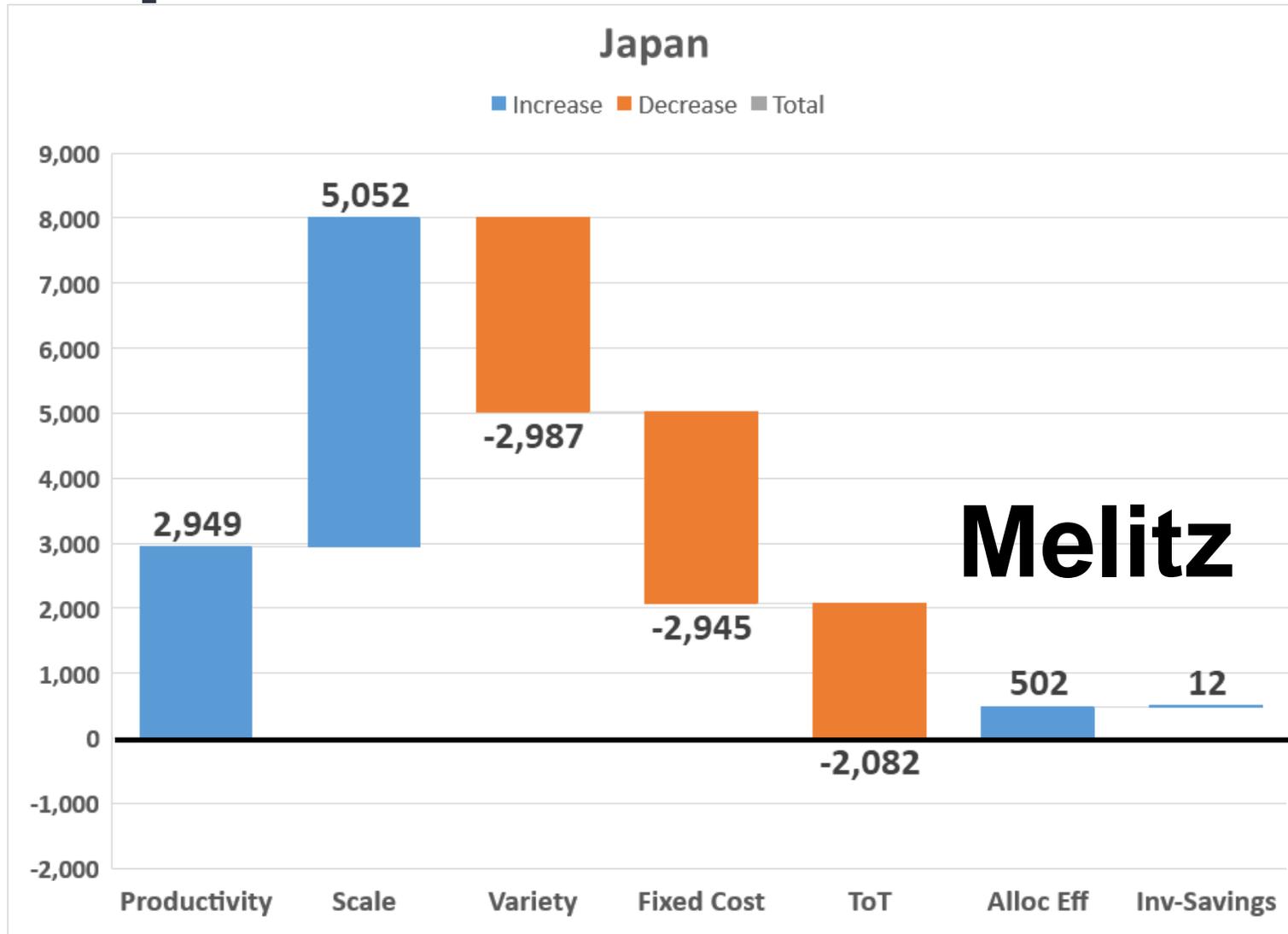
Japan loses under Armington

> $ 1 Billion

Japan gains under Melitz

$0.5 Billion

501

Lots of moving parts

Introduction

Chris and Stephen

- Sensitivity of tariff reduction effects to Pareto Shape parameter of the **productivity distribution** of firms within an industry

Ilaria and Lily

- Technological change in **fixed trade costs**

Wai Kit and Liu

- Impact of reductions in bilateral **non-tariff barriers**

ABSTRACT

- *In what ways* and *to what extent* does **productivity heterogeneity among firms** **affect GTAP model results of the shock:** *unilateral removal by Japan of tariffs on US imports*

  - Experiment 1: flexing the distribution of productivity differences between firms using the shape parameter of the Pareto productivity distribution **`SHAPE(i)`**…

  - Experiment 2: a reduction in the technology change in fixed trade costs of industry j from region r to s: **`avafsall(j, r, s)`**

  - Experiment 3: Impact of reductions in bilateral non-tariff barriers **`atall(m, j, r, s)`**

Sensitivity of Tariff Reduction Effects to Shape of Firm Productivity Distribution

Chris Blaha & Stephen Wilson

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ABSTRACT

- **How does the impact of the elimination of Japanese manufacturing tariffs on U.S. exports change with declines in manufacturing productivity heterogeneity**
  - Lower productivity heterogeneity increases the magnitude of the tariff shock effects
  - Sensitivity of output to changes in shape parameter, vary across metrics; aggregate effects generally larger for Japan
  - Welfare fairly sensitive due to large contributions form Melitz-specific effects

Adjustment: Increase shape parameter to decrease heterogeneity of firm productivity

- **Increase shape parameter (SHAPE) by 25%, 50%, and 75% over the base value used in original simulation**

- **Applies to all regions**

- **Tariff shock not changed; elimination of Japanese tariffs on U.S. exports in the manufacturing sector**

— 2.89 — 3.61 — 4.34 — 5.06
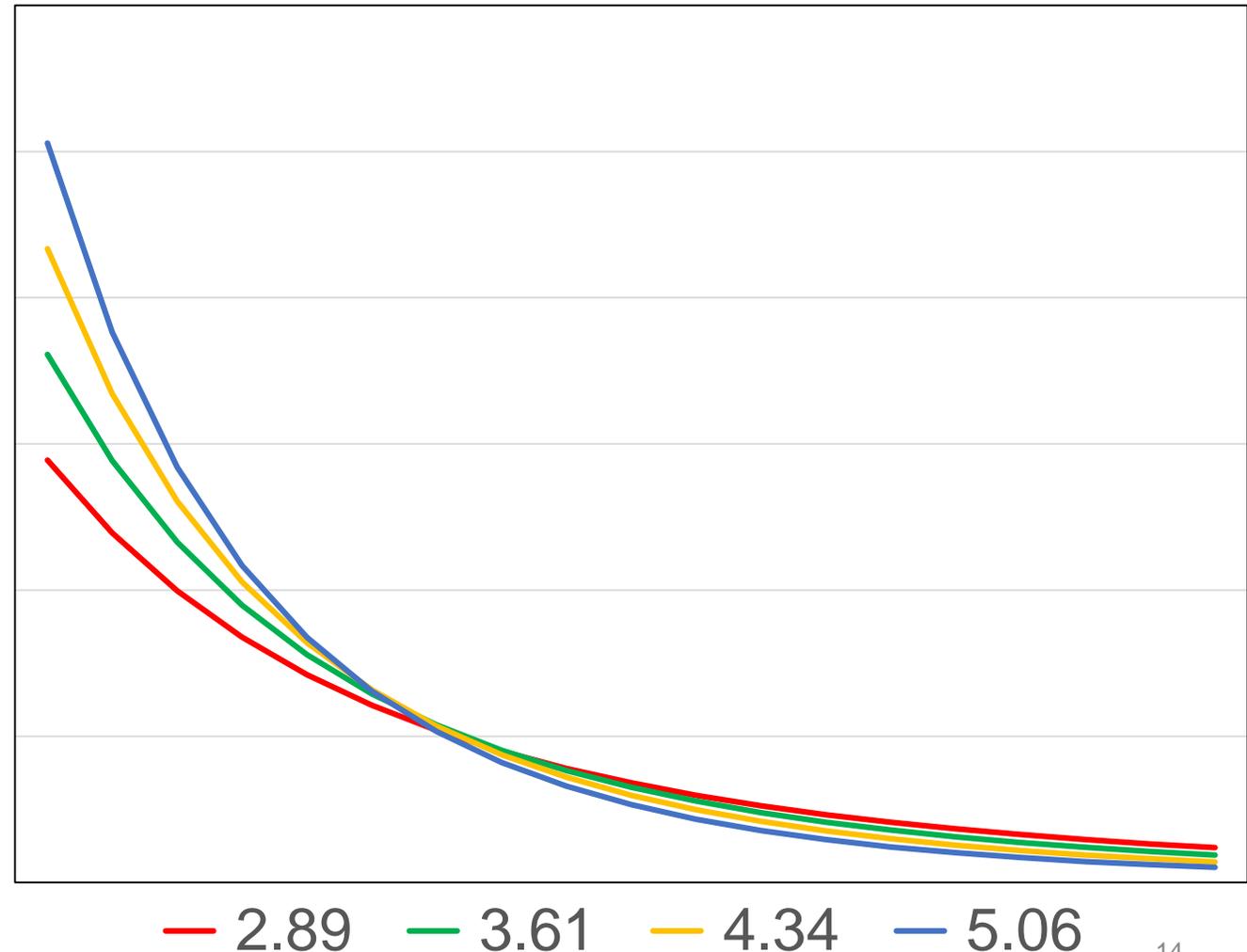
Magnitudes of the tariff shocks increase with the slope parameter

- **Direction of effects same as in base Melitz case, no reversals**
- **With greater proportion of less-productive firms, Melitz impacts are magnified**
  - Threshold movements larger
  - Relatively more firms begin exporting
  - Relatively more leave market altogether
  - Welfare effects from larger, more productive firms

Φ_{dom} Φ_{exp}
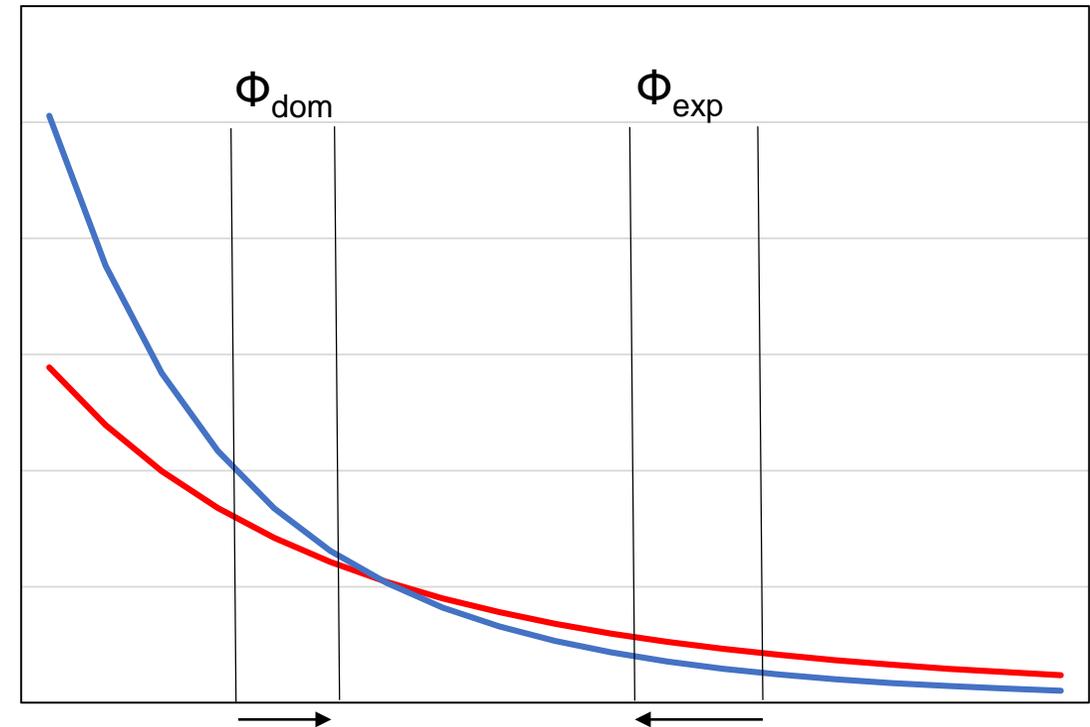
Changes to tariff shock flow-specific effects across regions

Sales

	usa-usa	usa-jpn	usa-row	jpn-usa	jpn-jpn	jpn-row
base	-0.08	30.13	-0.6	1.95	-0.29	1.28
125% base	-0.08	34.5	-0.69	2.14	-0.31	1.49
150% base	-0.09	39.06	-0.78	2.45	-0.33	1.71
175% base	-0.11	43.68	-0.88	2.76	-0.35	1.93

Productivity Threshold

	usa-usa	usa-jpn	usa-row	jpn-usa	jpn-jpn	jpn-row
base	0.06	-4.51	0.16	-0.24	0.14	-0.14
125% base	0.07	-4.49	0.17	-0.22	0.16	-0.12
150% base	0.08	-4.48	0.18	-0.2	0.18	-0.1
175% base	0.09	-4.46	0.19	-0.19	0.21	-0.08

- **Vary in magnitude and direction, but scale of effects appear similar across region; both the United States and Japan are subject to reductions in heterogeneity of firm production**
- **Bilateral sales effects increase more than domestic sales effects; trade minority share of sales**

Changes to tariff shock effects scale differently for region-wide effects

Output

	usa	jpn	row
base	0.1	0.09	0
125% base	0.12	0.13	0
150% base	0.13	0.16	0
175% base	0.14	0.2	0

Average Manufacturing Productivity

	usa	jpn	row
base	0.07	0.14	0
125% base	0.08	0.18	0
150% base	0.1	0.22	0
175% base	0.11	0.27	0

- **Effects of changing shape (175% base) larger for Japan, roughly doubling the effect of the tariff shock**
- **Exports represent smaller share of U.S. manufactured goods production than that of Japan, (15% versus 22%), relatively larger bilateral impacts contribute more to overall effect**

Melitz-related welfare contributions large and increasing with shape parameter

U.S. Welfare

	Total	Allocation	Terms of Trade	Variety	Scale	Productivity	Fixed Costs
base	5,430	604	1,205	(2,679)	5,309	2,987	(2,979)
125% base	6,151	705	1,148	(3,379)	6,550	3,812	(3,765)
150% base	6,888	807	1,081	(4,062)	7,811	4,640	(4,566)
175% base	7,455	893	1,056	(4,611)	8,860	5,264	(5,270)

- **With higher shape parameter, relatively more "unproductive" U.S. firms - fewer producing for domestic market, more exporting**
  - Reallocation of resource from low-productivity to higher-productivity firms
  - Reduced number of firms/variety; loss of domestic varieties outweighs increased import varieties
  - IRTS
  - Increased share of revenue allocated to fixed costs; addition U.S. firms now exporting

Welfare, contd.

Japan Welfare

	Total	Allocation	Terms of Trade	Variety	Scale	Productivity	Fixed Costs
base	501	502	(2,082)	(2,987)	5,052	2,949	(2,945)
125% base	1,069	634	(2,291)	(3,670)	6,372	3,772	(3,742)
150% base	1,679	773	(2,511)	(4,382)	7,756	4,638	(4,570)
175% base	2,298	913	(2,730)	(5,103)	9,151	5,514	(5,402)

ABSTRACT

- **Question:** What is the impact of a reduction in fixed trade costs under Melitz assumptions?
- **Shock:** 50 percent increase in technological change in fixed trade costs for US firms (monopolistic) exporting to Japan
- **Primary findings**
  1. Bi-directional increase in export sales between the US and Japan
  2. Increase in aggregate productivity from inter-firm reallocation of resources in both the US and Japan
  3. Welfare gains for both US and Japan

UK to apply to stay in European standards system after Brexit

Move follows business warnings that creating UK benchmarks would increase costs

US: Sales, output and price

- **Significant expansion in sales of US manufactures in Japan**

- **Marginal increase in industry output (large domestic market share)**

- **Relative price of primary factors increase - raising the costs of US varieties in the domestic and world market**

- **Diverts sales from the domestic and ROW markets bringing the US economy back into external balance**

US	
Domestic sales	-0.1
Export sales (Japan)	47.3
Export sales (ROW)	-0.9
Industry output	0.2
Supply price	0

Japan: Sales, output and price

- Greater US variety on the Japanese market increases competition and crowds out Japanese firms

- Surviving Japanese firms benefit from cheaper US manufactures (intermediate inputs)

- Reduces average costs of production in Japan - Japanese exporters are more competitive in export markets

- Relative prices of primary factors decrease in Japan implying a real depreciation

- Restores external balance in Japan by stimulating exports – Japanese exports to the US and ROW increase

Japan	
Domestic sales	-0.7
Export sales (US)	2.9
Export sales (ROW)	2
Industry output	0
Supply price	-0.5

US: productivity and no. of firms

- **The productivity threshold to produce in US manufacturing industry increases – inefficient firms lose competitiveness against cheaper imports coming from Japan and ROW due to increased factor prices**

- **The number of active US firms in the domestic market (and exporting to the ROW) decreases.**

- **The reduction in fixed costs to export to Japan significantly lowers the productivity threshold for US manufacturing firms exporting to Japan**

- **Sales to Japan rise which lowers fixed export cost per sale – raises the potential for positive profits and induces a rise in the number of US firms exporting to Japan**

- **Two impacts on aggregate productivity:**
    1) Average domestic productivity rises due to increase in domestic productivity threshold (dominates)
    2) New exporters pull down the average productivity in export markets

- **Gain from inter-firm reallocation of resources within the manufacturing industry**

Effects of tariff cut on the exporter
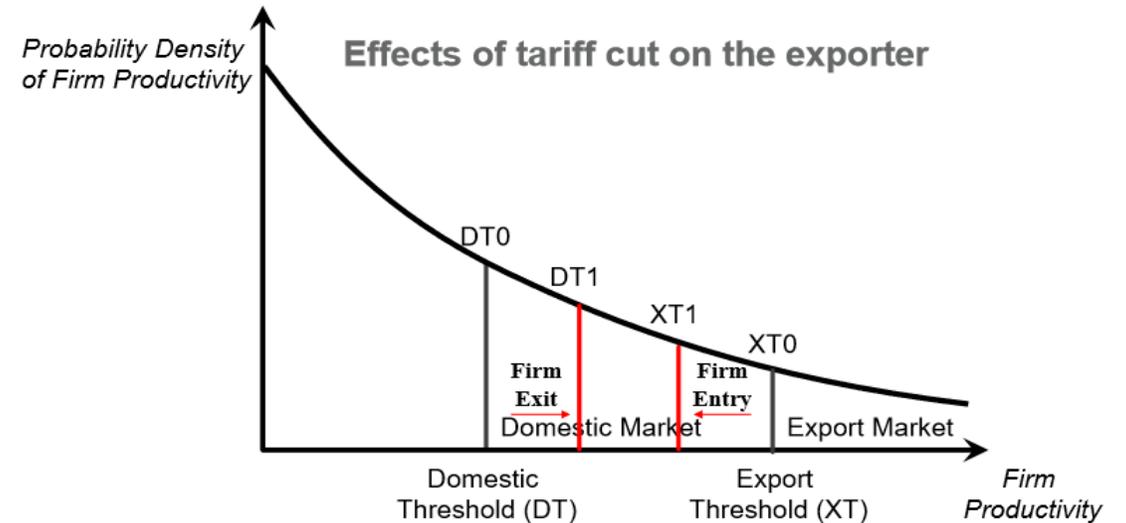
US	
Number of active firms selling to domestic market	-0.4
Number of active firms selling to Japan	49.6
Number of active firms selling to ROW	-0.8
Productivity threshold for domestic market	0.1
Productivity threshold for Japan market	-13
Productivity threshold for ROW market	0.3
Aggregate productivity	0.1

Japan: productivity and no. of firms

- **Reduction in the productivity thresholds of exporting to the US and ROW**
    1) Japanese exporters gain access to larger markets - fixed costs per sale decline
    2) Declining average variable costs (lower factor costs)
- **Number of Japanese exporters in the US and ROW markets increases**
- **Productivity threshold of supplying to the domestic market increases - reduces the number of firms in the domestic market**
- **Two impacts on aggregate productivity:**
    1) Average domestic productivity rises due to increase in domestic productivity threshold (dominates)
    2) New exporters pull down the average productivity in export markets
- **Same as US - resources shift towards more productive firms, generating efficiency gains from trade from within reallocation of firms**

Japan	
Number of active firms selling to domestic market	-1.1
Number of active firms selling to US	0.7
Number of active firms selling to ROW	0.2
Productivity threshold for domestic market	0.2
Productivity threshold for US market	-0.4
Productivity threshold for ROW market	-0.2
Aggregate productivity	0.2

Welfare Decomposition in GTAP-HET

	Allocative efficiency	Terms of trade	Investment/saving effect	Productivity effect	Scale effect	Variety effect	Fixed costs effect	Aggregate welfare effect
United States	995	1873	1612	5410	8761	-4560	-5088	9003
Japan	1035	-3430	24	4901	8242	-1183	-4894	4694
RoW	346	1553	-1638	592	426	-3238	-591	-2551
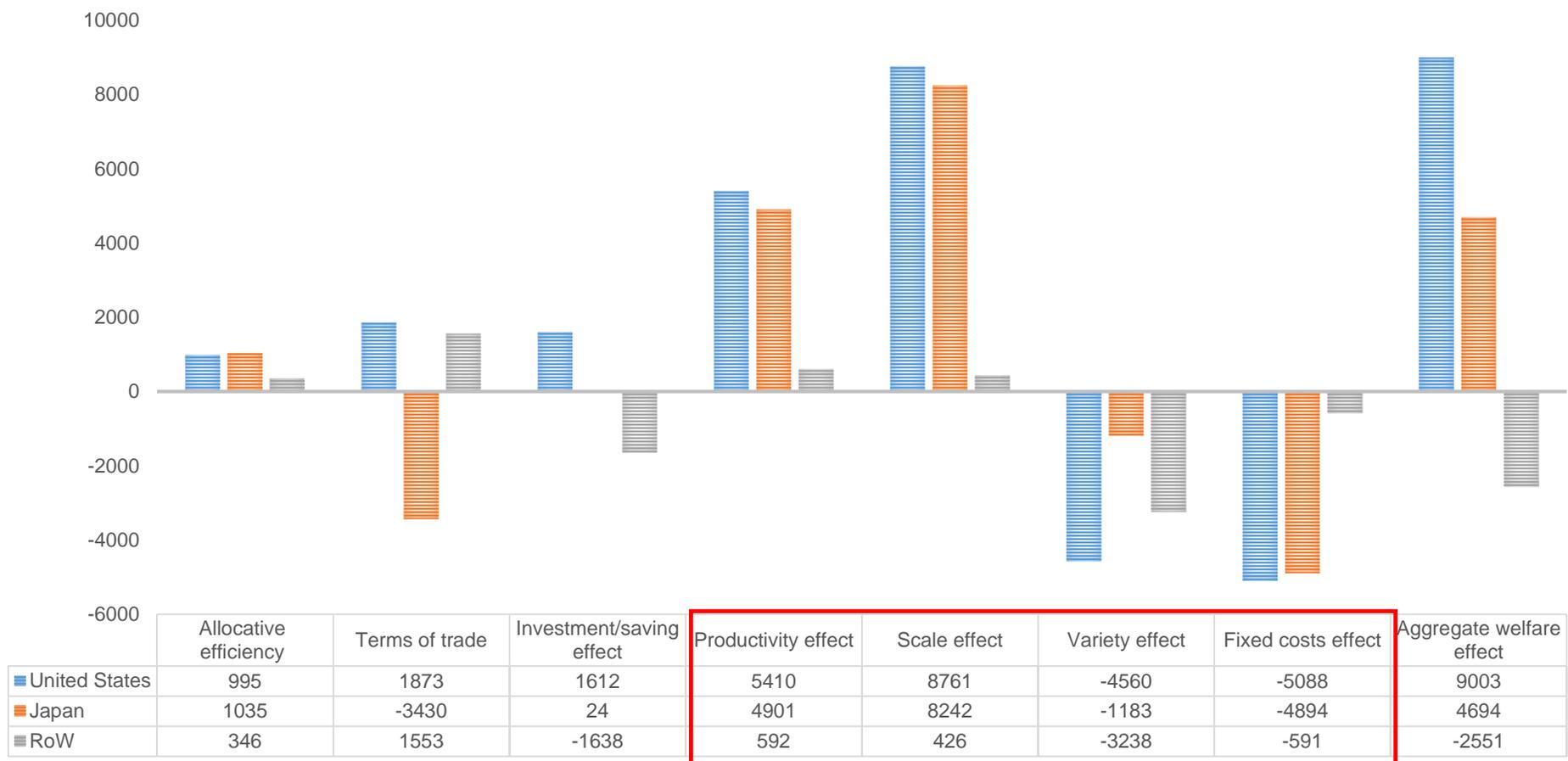
Additional gains from trade under Melitz (I)

1. **Endogenous productivity**:

   - Productivity in US exports to Japan increases (due to the shock) **+**

   - Growth in the **aggregate industry productivity** arising from inter-firm reallocations:

 - Growth in the **aggregate industry productivity** arising from inter-firm reallocations:

   US: the greatest reallocation (big gains!)

   Japan: domestic firms displaced by US competition; less firms, but less costly inputs.

   RoW: trade diversion (to Japan) / creation (to US), but negligible effect.

2. **Firm scale**

   - The surviving firms in the domestic market operate on a larger scale to allow for expanding output in the US and Japan.

   - The increased imports of cheap intermediate inputs reduces average **variable cost** relative to scale constant average total cost and increases firm scale.

Additional gains from trade under Melitz (II)

3. **Love-of-variety**

Consumers suffer from a loss in domestic varieties (**negative variety effect**):

> The decreasing number of domestic varieties more than offsets the wider selection of foreign varieties (*home bias*).

4. **Fixed costs** (relative changes bring welfare losses)

- Potential/Producing firms:

> The increase in the number of firms that pay the fixed set-up costs but cannot produce reduces regional welfare.

- Producer/Exporter:

> As the number of exporters increases relative to producers, there is an increase in fixed trading costs (welfare loss).

Thank you!

Grazie!

GTAP-HET
Non-tariff barriers

LIU Yu

Wai Kit SI TOU

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Impact of reductions in bilateral non-tariff barriers?

Positive shock on the technological change of shipping
of **manufactured goods** from **USA** to **Japan**

- Compared to tariff reduction, the effect of lower shipping cost is much smaller as transportation cost only represents around 3 to 4% of the imports

- Japan would be better off from the reduction of non-tariff barriers

- Given a lower price of composite transportation services, ROW would relocate part of its resources to the production of manufactured goods

Welfare Decomposition

Shock tms("MNFG","USA","JPN") = -2

Region	Aggregate Welfare Effect	Allocative Efficiency Effects	Terms of Trade Effects	Investment-Savings Effects	Variety Effects	Scale Effects	Productivity Effects	Fixed Cost Effects
USA	2,778	309	618	503	-1,370	2,716	1,527	-1,525
JPN	317	331	-1,064	7	-1,541	2,582	1,509	-1,507
ROW	-759	123	446	-510	-1,015	198	225	-225
Total	2,336	763	0	0	-3,927	5,496	3,261	-3,257

Shock atall("NonMNFG","MNFG","USA","JPN") = 2

Region	Aggregate Welfare Effect	Allocative Efficiency Effects	Terms of Trade Effects	Investment-Savings Effects	Variety Effects	Scale Effects	Productivity Effects	Fixed Cost Effects
USA	90	10	20	16	-44	88	49	-49
JPN	43	12	-31	0	-51	75	83	-45
ROW	-15	5	11	-16	-27	12	9	-9
Total	118	27	0	0	-122	175	141	-103

Manufacturing Sector

		Shock tms("MNFG","USA","JPN") = -2				Shock atall("NonMNFG","MNFG","USA","JPN") = 2		
		1 USA	**2 JPN**	**3 ROW**		**1 USA**	**2 JPN**	**3 ROW**
Domestic and Export Sales (%)	**1 USA**	-0.04	15.47	-0.31	**1 USA**	0.00	0.54	-0.01
	2 JPN	0.94	-0.15	0.66	**2 JPN**	0.03	-0.01	0.02
	3 ROW	0.27	-0.88	**-0.00374**	**3 ROW**	0.01	-0.03	**0.00003**
Industry Output (%)		0.05	0.04	**-0.00057**		0.00	0.00	**0.00018**
Supply Price (%)		-0.01	-0.17	-0.02		0.00	-0.01	0.00
Average Variable Cost (%)		-0.01	-0.17	-0.02		0.00	-0.01	0.00
Scale Constant Average Total Cost (%)		0.04	-0.08	-0.02		0.00	0.00	0.00
Number of Potential Firms (%)		-0.02	-0.09	**-0.00009**		-0.0006	-0.0042	**0.00013**
Output per Firm (%)		0.16	0.34	0.00		0.01	0.01	0.00
		1 USA	**2 JPN**	**3 ROW**		**1 USA**	**2 JPN**	**3 ROW**
Productivity Threshold for Market Entry (%)	**1 USA**	0.034	-2.571	0.083	**1 USA**	0.001	-0.086	0.003
	2 JPN	-0.126	0.073	-0.074	**2 JPN**	-0.004	0.002	-0.002
	3 ROW	-0.048	0.163	0.001	**3 ROW**	-0.002	0.005	0.000

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