

Trade and Technology

Asian Miracles and WTO Anti-Miracles

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March 6, 2007

Motivation

- Trade is considered an important source of technology diffusion
- ...but trade also shapes the incentives to adopt technology
- How did WTO policies affect both diffusion and adoption?
- In particular, how does WTO pressures against tariff escalation matter for technology diffusion and adoption?
- I will argue that WTO efforts in de-escalating tariffs at the time of trade liberalization may have been harmful to countries.

What this paper **IS** about

- Empirical Contribution
 - We show that, ironically enough, the positive effects of trade on TFP decreased dramatically (and even became negative) after WTO started to be actively involved in liberalization processes.
- Theoretical Contribution
 - We introduce complementarities, vertical linkages and technology adoption decisions in a trade model.
- Quantitative Contribution
 - We argue non de-escalating efforts would have increased TFP by around 17% for countries that liberalized the last decade.

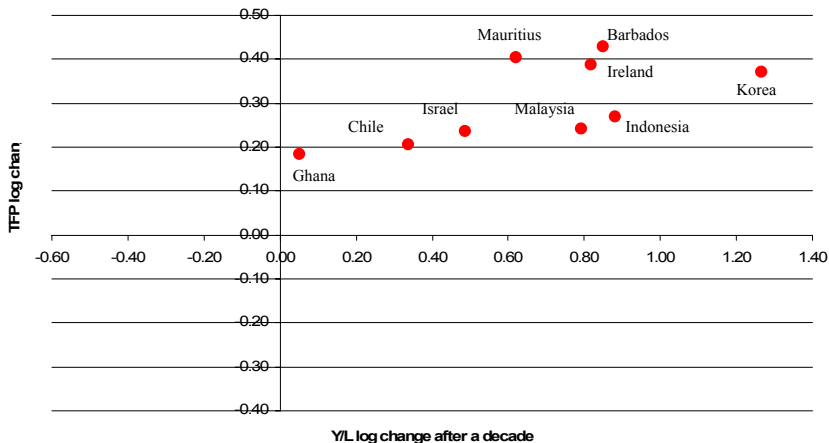
What this paper **IS NOT** about

- This is NOT about the welfare effects of trade.
- This is NOT an argument in favor of protectionism.
- This is NOT an argument against ALL WTO recommendations.

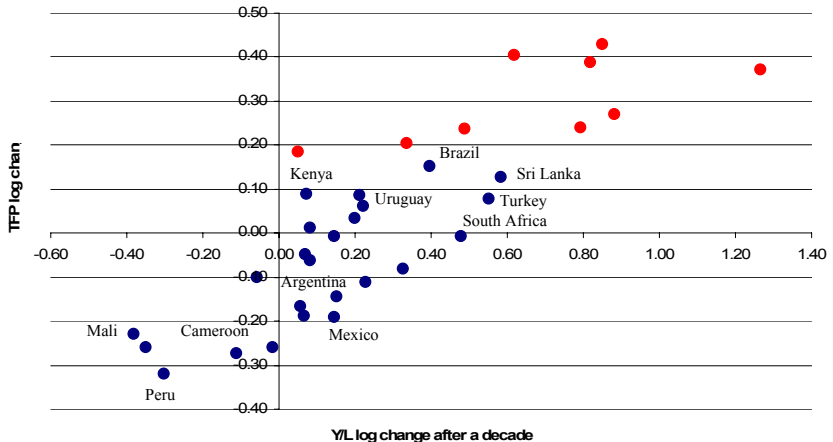
What is the WTO?

- The WTO (former GATT) is an international organization that establishes rules for international trade and guide liberalization processes through consensus among its member states.
- The WTO was created after the Uruguay Round (1986).
- Unlike GATT, the WTO has a substantial institutional structure.

Trade liberalization before 1986 (Uruguay Rounds)



Trade liberalization after 1986 (Uruguay Rounds)



WTO - Tariff escalation

- An important WTO guiding principle for tariff reform after the Uruguay Round has been the "concertina theorem".
- This idea is very related with tariffs de-escalation.
- A very important point in negotiations in the last decade has been the application of lower and more uniform tariffs.

Recent tariff escalation in countries pre WTO

Income Group	Country	Year Liberalization	Tariffs Industrial goods (2000, in %)		Ratio of tariffs final goods to tariffs intermediate goods	
			Intermediates	Final	Industrial	Agriculture
1	Ghana	1985	12.9	18.4	1.43	1.03
2	Barbados	1966	6.2	14.9	2.40	2.97
2	Chile	1976	6.0	5.9	0.98	1.00
2	Indonesia	1970	6.1	8.0	1.31	2.24
2	Malaysia	1963	7.6	3.2	0.42	1.32
2	Mauritius	1968	6.2	27.3	4.40	1.72
3	Israel	1966	2.7	6.1	2.26	5.32
4	Korea, Rep.	1968	6.1	7.0	1.15	0.34
Average countries liberalized before 1986 (8)			6.7	11.4	1.69	1.99

Recent tariff escalation in countries post WTO

Income Group	Country	Year Liberalization	Tariffs Industrial goods (2000, in %)		Ratio of tariffs final goods to tariffs intermediate goods	
			Intermediates	Final	Industrial	Agriculture
1	Cameroon	1993	14.2	19.6	1.38	1.09
1	Kenya	1993	16.0	17.5	1.09	1.02
1	Mali	1988	7.4	12.8	1.73	1.18
1	Nepal	1991	12.3	15.4	1.25	1.53
1	Uganda	1988	8.5	8.2	0.96	1.01
1	Zambia	1993	8.9	15.9	1.79	1.09
2	Argentina	1991	10.1	13.3	1.32	1.12
2	Brazil	1991	8.7	13.2	1.52	1.13
2	Colombia	1986	9.8	11.9	1.21	1.38
2	Costa Rica	1986	4.3	6.5	1.51	1.80
2	Ecuador	1991	9.4	12.0	1.28	1.28
2	El Salvador	1989	5.6	7.7	1.38	1.38
2	Guatemala	1988	4.5	7.0	1.56	1.77
2	Honduras	1991	4.3	6.3	1.47	1.61
2	Jamaica	1989	1.2	9.0	7.50	1.88
2	Mexico	1986	12.2	16.7	1.37	1.42
2	Paraguay	1986	8.6	9.6	1.12	1.07
2	Peru	1991	9.2	9.3	1.01	1.23
2	Philippines	1988	5.2	8.0	1.54	1.03
2	South Africa	1991	5.0	7.3	1.46	2.07
2	Sri Lanka	1991	3.2	9.8	3.06	1.17
2	Turkey	1989	6.3	4.5	0.71	2.03
2	Uruguay	1990	10.3	12.7	1.23	1.09
4	New Zealand	1986	2.1	5.4	2.57	1.04
Average countries liberalized after 1986 (24)			7.8	10.8	1.39	1.35

BUT..This is now. How it was before?

- Asian tariffs to final goods were **400%** higher than tariffs to intermediate goods in the 70's and 80's (IMF)
- Korean liberalization was characterized by very low and strategic tariffs to inputs and high protection to final goods (Panagariya, 04).
- Non-tariff barriers decreased in Asia from **30%** before 1986 to **3%** after the formation of WTO. (WTO Trade Policy Review).
- An alternative way to measure protection is import composition at the time of liberalization.
 - **10%** of asian imports were final goods (IMF - WB).
 - **60%** of latin american imports were final goods (IADB).

Model: Preliminaries

- Trade model
- Heterogeneous firms in two production sectors:
 - Final goods
 - Intermediate inputs
- What's Technology in this paper?
 - A more advanced technology in the production of final goods is characterized by a greater range of intermediate goods and, hence, a higher degree of specialization.

Model: Relation with the literature

- This paper is related to two strands of the literature
- The effects of trade on productivity,
 - Melitz (03), BEJK (03), Ghironi and Melitz (05)
 - My model introduces vertical linkages, complementarities and decisions on technology adoption.
- The determinants of firm-level technology (as specialization).
 - Ethier (82), Romer (90), Acemoglu et al.(06),
 - My model introduces this technology decision in an open economy.

Households

- Inelastic supply of 1 unit of labor
- Utility (love for variety)

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \quad (1)$$

- hence

$$q(\omega) = Q \left(\frac{p_F(\omega)}{P_F} \right)^{-\sigma}$$
$$P_F = \left[\int_{\omega \in \Omega} p_F(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$$

Final good producers

- Continuum of firms (mass N), each one producing a different variety

$$q(\omega) = z_F \left[\int_0^J x_j^{\frac{\gamma-1}{\gamma}} dj \right]^{\frac{\gamma}{\gamma-1}} \quad (2)$$

where

- x_j denotes the input j and z_F is the firm efficiency in the use of inputs, distributed $g(z_F)$ over $(0, \infty)$
- $\gamma > 1$ is the elasticity of substitution between any two inputs
- J is the level of technology. It requires a payment of $C(J)$ to coordinate inputs and deal with many suppliers, where $C(J)$ is twice continuously differentiable, $C'(J) > 0$ and $C''(J) \geq 0$ for all $J > 0$

Final good producers

- Pricing Rule: $p_F = \frac{\sigma}{\sigma-1} MC(z_F, J)$
- A more productive firm (higher z_F) will be bigger, charge a lower price and earn higher profits than a less productive one
- Firms die each period with a probability δ . Entrants pay f_{EF} up front and then they learn their productivity z_F (Hopenhayn, 92)

Intermediate good producers

- Continuum of firms (mass M), each one producing a different variety
- Production only requires labor

$$x_j : \ell = f_l + \frac{x_j}{z_l} \quad (3)$$

where f_l is the same for all firms but z_l vary and is distributed $g(z_l)$ over $(0, \infty)$

- Pricing Rule: $p_l(z_l) = \frac{\gamma}{z_l(\gamma-1)}$. (we will assume hereafter $w = 1$)
- A more productive firm (higher z_l) will be bigger, charge a lower price and earn higher profits than a less productive one
- The process of entry and exit of firms is the same than for final producers.

Technology Adoption

- Each final firm maximizes profits

$$\max_{x_j, J} = p_F(z_F, J)q(z_F, J) - \int_0^J x_j p_{lj}(z_{lj}) dj - C(J) - f_F$$

- Demand for each intermediate is standard.

$$x(z_I) = X \left(\frac{p(z_I)}{P_I} \right)^{-\gamma} \quad (4)$$

where

$$P_I = \left[\int p_{lj}^{1-\gamma} dj \right]^{\frac{1}{1-\gamma}} = M^{\frac{1}{1-\gamma}} p_I(\tilde{z}_I)$$

Technology Adoption

- FOC for J is

$$\frac{\gamma}{\gamma-1} z_F P_F Q^{\frac{1}{\sigma}} x(\tilde{z}_I) J^{\frac{1}{\gamma-1}} = x(\tilde{z}_I) p_I(\tilde{z}_I) + C'(J) \quad (5)$$

Assumption

The elasticity of the marginal cost curve is big enough: $\frac{JC''(J)}{C'(J)} > \frac{1}{\gamma-1} > 0$

- FOC can also be expressed as

$$\frac{\gamma}{\gamma-1} z_F P_F Q^{\frac{1}{\sigma}} J^{\frac{1}{\gamma-1}} = P_I M^{\frac{1}{\gamma-1}} + \frac{C'(J) M^{\frac{\gamma}{\gamma-1}}}{X}$$

Technology Adoption

- Given these assumptions, under partial equilibrium
- Technology depends positively on
 - The firm's productivity ($\frac{\partial J}{\partial z_F} > 0$)
 - The price index of final goods ($\frac{\partial J}{\partial P_F} > 0$)
 - The size of the market ($\frac{\partial J}{\partial Q} > 0$)
- Technology depends negatively on
 - The price index of intermediate goods ($\frac{\partial J}{\partial P_I} < 0$)
 - The average productivity of intermediaries ($\frac{\partial J}{\partial \bar{z}_I} < 0$)

Technology Adoption

- Given these assumptions, under partial equilibrium
- Technology depends positively on
 - The firm's productivity ($\frac{\partial J}{\partial z_F} > 0$)
 - **The price index of final goods** ($\frac{\partial J}{\partial P_F} > 0$)
 - The size of the market ($\frac{\partial J}{\partial Q} > 0$)
- Technology depends negatively on
 - **The price index of intermediate goods** ($\frac{\partial J}{\partial P_I} < 0$)
 - The average productivity of intermediaries ($\frac{\partial J}{\partial \bar{z}_I} < 0$)

Measure of TFP in this economy

- Intermediate goods

$$TFP_I = \tilde{z}_I \quad (6)$$

- Final goods

$$TFP_F = \tilde{z}_F J(\tilde{z}_F)^{\frac{1}{\gamma-1}} \quad (7)$$

- The increase in technology of the average firm $J(\tilde{z}_F)$, increases the TFP in final goods.

Equilibrium in a closed economy

- Intermediate goods

- Cutoff productivity z_I^* is determined by $\pi_I(z_I^*) = 0$

- Free entry: Average profits is $\tilde{\pi}_I = \pi(\tilde{z}_I) = \frac{\delta f_{EI}}{1-G(z_I^*)}$

- Final goods

- Cutoff productivity z_F^* is determined by $\pi_F(z_F^*) = 0$

- Free entry: Average productivity is $\tilde{\pi}_F = \pi(\tilde{z}_F) = \frac{\delta f_{FF}}{1-G(z_F^*)}$

Aggregation

- Key general equilibrium interaction comes from the competition of producers for the scarce resource, labor L
 - Each of M intermediate firms use
 - 1 unit of labor to produce
 - f_I units of labor to cover fixed costs
 - Each of N final firms use
 - $C(J)$ units of labor to manage the technology (coordinate inputs)
 - f_F units of labor to cover fixed costs
 - Each of δM intermediate entrants use f_{EI} units of labor
 - Each of δN final entrants use f_{EF} units of labor
- This determines N and $M = \tilde{N}\tilde{J}$

Open economy - Preliminaries

- Trade among n countries that are identical as the one described.
- Tariffs are introduced as iceberg per-unit trade costs, $\tau_I > 1$ and $\tau_F > 1$.
- Intermediate and final firms can export to all countries but paying a fixed per period investment cost of f_{xI} and f_{xF} respectively.

Open economy - Preliminaries

- Average productivity with trade for final and intermediate producers

$$\tilde{z}_{Ft} = \left[\frac{1}{N_t} \left[N \tilde{z}_F^{\sigma-1} + n N_x (\tau_F^{-1} \tilde{z}_{xF})^{\sigma-1} \right] \right]^{\frac{1}{\sigma-1}}$$

$$\tilde{z}_{It} = \left[\frac{1}{M_t} \left[M \tilde{z}_I^{\gamma-1} + n M_x (\tau_I^{-1} \tilde{z}_{xI})^{\gamma-1} \right] \right]^{\frac{1}{\gamma-1}}$$

where $N_t = N + N_x$ being $N_x = \frac{1-G(z_{xF}^*)}{1-G(z_F^*)} N$

and $M_t = M + M_x$ being $M_x = \frac{1-G(z_{xI}^*)}{1-G(z_I^*)} M$

- Export status
 - Final firms: z_{xF}^* is determined by $\pi_{xF}(z_{xF}^*) = 0$
 - Intermediate firms: z_{xI}^* is determined by $\pi_{xI}(z_{xI}^*) = 0$

Open economy - Technology Adoption

- Technology adoption by exporters

$$(1 + n\tau_F^{1-\sigma}) \frac{\gamma}{\gamma-1} z_F P_F Q^{\frac{1}{\sigma}} x(\tilde{z}_I) J^{\frac{1}{\gamma-1}} = x(\tilde{z}_I) p_I(\tilde{z}_I) + C'(J)$$

- Everything else constant, exporters will adopt a better technology since $(1 + n\tau_F^{1-\sigma}) > 1$

Decrease in τ_F

- Reduction of final goods Price Index P_F (caused by reduction of average prices $p_F(\tilde{z}_{Ft})$ and increase in the number of varieties N_t).
- The marginal benefit of the technology decreases.
- For a given z_F
 - Non exporters would adopt less technology
 - Exporters will adopt depending on the trade off between higher demand ($Qn\tau_F^{1-\sigma}$) and lower price index (P_F).

Decrease in τ_I

- Reduction of intermediates Price Index P_I (caused by reduction of average prices $p_I(\tilde{z}_{It})$ and increase in the number of varieties M_t).
- The marginal cost of the technology decreases.
- As a second round effect, the reduction in costs reduce the Price Index of final goods and may lead to a decrease in adoption benefits.

Calibration - Environment

- To solve the model we parameterize the distribution of productivity draws $G(z)$, assuming z_F is distributed Pareto with lower bound z_F^{min} and shape parameter $k_F > \sigma - 1$. We assume the same for z_I
- We assume the cost of technology adoption is given by $C(J) = \theta J^\phi$ with $\theta > 0$ and $\phi > 1$.
- L is normalized to 1.

Calibration - Intermediate Goods

	Value	Source
δ	0.1	Job destruction per year
γ	3.8	BEJK(03)
$z_I^{min}; f_{E,I}$	1	Normalization
k_I	3.4	$sd_{(US-logSales)} = 1.67 = \frac{1}{k_I - \gamma + 1}$
f_I	$\delta f_{E,I} \frac{k_I - \gamma + 1}{\gamma - 1}$	$z_I^* = z_I^{min}$ w/o Openness
$f_{x,I}$	$0.235 \frac{1 - \beta \delta}{\beta(1 - \delta)} f_{E,I} + f_I$	Match 21% Exports

Calibration - Final Goods

	Value	Source
δ	0.1	Job destruction per year
σ	3.8	BEJK(03)
$z_F^{min}; f_{E,F}$	1	Normalization
k_F	3.4	$sd_{(US-\log Sales)} = 1.67 = \frac{1}{k_F - \sigma + 1}$
f_F	$\delta f_{E,F} \frac{k_F - \sigma + 1}{\sigma - 1}$	$z_F^* = z_F^{min}$ w/o Openness
$f_{x,F}$	$0.7 \frac{1 - \beta \delta}{\beta(1 - \delta)} f_{E,I} + f_I$	Match 21% Exports
θ	0.4	Match M=N (Basu, 95 and Jones, 06)
ϕ	1.8	Match average TFP growth pre WTO









Trade liberalization before WTO

Tariffs		Ratio	Average Productivity Intermediates	Final Goods		TFP All economy
Intermediate	Final			Technology	TFP	
7.8	39	5.0	1.27	2.11	1.33	1.30
10	39	3.9	1.22	1.88	1.27	1.24
20	39	2.0	1.05	1.59	1.18	1.12
30	39	1.3	1.02	1.49	1.15	1.08
39	39	1.0	1.00	1.00	1.00	1.00

Trade liberalization before WTO

Tariffs		Ratio	Intermediate goods		Price Index	
Intermediate	Final		Varieties	Average Price	Final	Intermediate
7.8	39	5.0	1.40	0.91	0.94	0.80
10	39	3.9	1.38	0.91	0.94	0.82
20	39	2.0	1.26	0.95	0.96	0.88
30	39	1.3	1.19	0.98	1.00	0.92
39	39	1.0	1.00	1.00	1.00	1.00

What the model predicts after tariff de-escalation?

Tariffs		Ratio	Average Productivity Intermediates	Final Goods			TFP Total
Intermediate	Final			Average Productivity	Technology	TFP	
7.8	10.8	1.4	1.10 	1.05 	0.55 	0.84 	0.97 
10	17	1.7	1.09	1.04	0.63	0.88	0.99
20	25	1.3	1.05	1.02	0.81	0.94	1.00
30	33	1.1	1.02	1.00	1.00	1.00	1.01
39	39	1.0	1.00	1.00	1.00 	1.00 	1.00 

What would have happened without tariff de-escalation?

Tariffs		Ratio	Final Goods			TFP All economy
Intermediate	Final		Average Productivity	Technology	TFP	
7.8	10.8	1.4	1.00	1.00	1.00	1.00
7.8	15.6	2.0	0.99	1.15	1.04	1.02
7.8	23.4	3.0	0.97	1.35	1.08	1.04
7.8	31.2	4.0	0.96	2.02	1.24	1.12
7.8	39.0	5.0	0.96	2.53	1.33	1.17

What would have happened without tariff de-escalation?

Tariffs		Ratio	Final goods		Price Index	
Intermediate	Final		Varieties	Average price	Final	Intermediate
7.8	10.8	1.4	1.00	1.00	1.00	1.00
7.8	15.6	2.0	0.91	1.05	1.08	0.99
7.8	23.4	3.0	0.80	1.11	1.20	0.97
7.8	31.2	4.0	0.66	1.22	1.41	0.96
7.8	39.0	5.0	0.58	1.23	1.49	0.95

Conclusions

- After WTO started to set guidelines, the positive effects of trade liberalization on TFP seem to have disappeared.
- More than asian miracles we seem to have experienced WTO non-miracles.
- More focus should be placed on generating a more flexible trading system to less developed countries.
- Not surprisingly, timing matters.