Trade, Technology Adoption and the Rise of the Skill Premium in Mexico

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The Trade vs. Technology Debate

- Earlier attempts to explain the rise of wage inequality in the US offered two competing alternatives:
  1. Increase in international trade
  2. Skill-biased technical change (SBTC)
- This literature finds that SBTC is quantitatively more important.
- But what if both SBTC and increased openness complement each other in explaining the rise of the skill premium?

The Acemoglu(2002)–Yeaple(2005) Hypothesis

Reductions in trade barriers increases market size for potential exporters

$\Downarrow$

Changes in production technologies (adoption of more skill-intensive production processes)

$\Downarrow$

Increasing relative demand for skilled workers

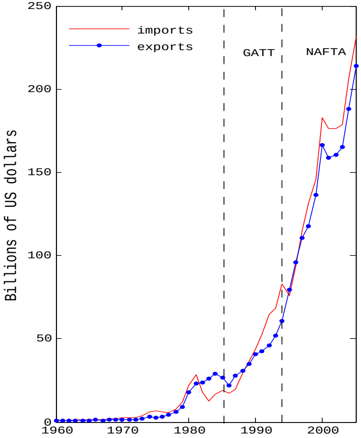
$\Downarrow$

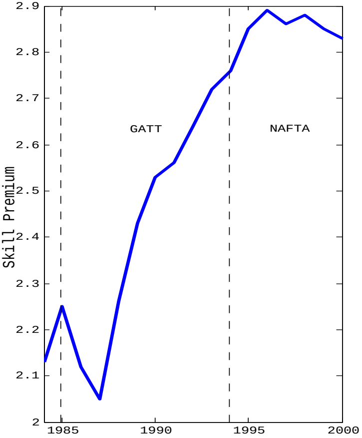
Resulting in a higher Skill premium

I estimate a structural model that incorporates this potential source of complementarity between trade openness and SBTC

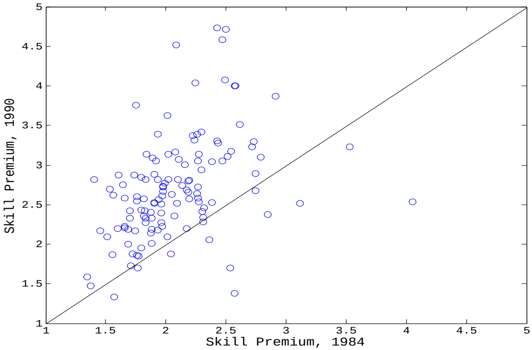
My estimates allow me to appraise how important is this mechanism in explaining the rise of the skill premium in Mexico

Trade and Skill Premium in Mexico



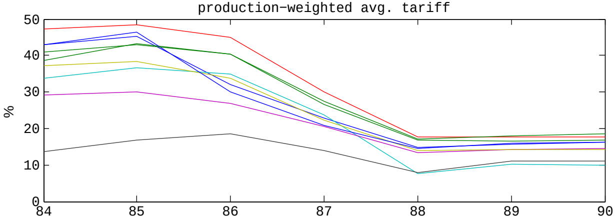


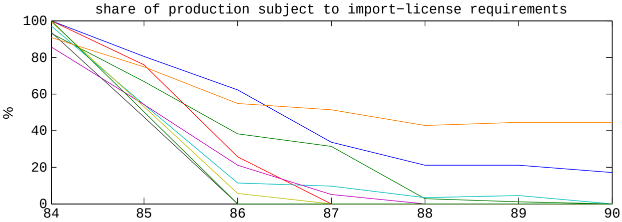
The increase in the skill premium has occurred all across the board



The skill premium increases for 115 out 127 4-digit industries between 1984 and 1990

Trade Liberalization in Mexico





Patterns of Exporting and Technology Use

Year	No Imported Tech. No Exporting	Only Imported Tech.	Only Exporting	Imported Tech. & Exporting
1986	1,157 (65.52)	201 (11.38)	210 (11.89)	198 (11.21)
1987	1,070 (60.59)	199 (11.27)	273 (15.46)	224 (12.68)
1988	967 (54.76)	243 (13.76)	250 (14.16)	306 (17.33)
1989	859 (48.64)	309 (17.50)	231 (13.08)	367 (20.78)
1990	757 (42.87)	375 (21.23)	226 (12.80)	408 (23.10)

Transitions

	Tech = 1 Export = 0	Tech = 2 Export = 0	Tech = 1 Export = 1	Tech = 2 Export = 1
Tech = 1 & Export = 0	0.8796	0.0614	0.0422	0.0168
Tech = 2 & Export = 0	0.0357	0.8750	0.0032	0.0861
Tech = 1 & Export = 1	0.0550	0.0073	0.8071	0.1307
Tech = 2 & Export = 1	0.0009	0.0338	0.0256	0.9397

Relation to the Literature

- Empirical studies on the rise of the skill premium in Mexico:
  - HOS &'Mandated Wage' Equations:
    - Hanson and Harrison (1999)
    - Esquível and Rodríguez-López (2003)
    - Robertson (2004)
  - FDI:
    - Feenstra and Hanson (1997)
  - Quality improvements:
    - Verhoogen (2008)
- Complementarities between investment and the decision to export:
  - Calibrated:
    - Atkenson and Burnstein (2007)
    - Costantini and Melitz (2007)
  - Reduced-form estimation:
    - Bustos(2005)
    - Aw et. al. (2007)
    - Lileeva and Trefler (2007)
    - Iacovone and Javorcik (2008)

Model Assumptions

- Monopolistically competitive firms producing differentiated consumption goods
- Small open economy; one foreign good available at a price τ_f
- Two types of labor, skilled and unskilled
- Competitive labor market.

Technology

- Labor is the only input
- Firms choose between two technologies $k \in \{1, 2\}$
- Production technology:

$$q = \left[l^{\alpha} + (zh)^{\alpha}\right]^{\frac{1}{\alpha}}, \quad \sigma_p \equiv \frac{1}{1-\alpha} > 0$$

- z is idiosyncratic and evolves according to the following AR(1) process:

$$\log(z_{t+1}) = \overline{z}_k + \phi \log(z_t) + \varepsilon_{t+1}, \quad \varepsilon_{t+1} \sim \mathcal{N}(0, \sigma_{\varepsilon}^2),$$
$$\overline{z}_1 < \overline{z}_2$$

- Using technology 2 requires to pay a higher per-period fixed cost
- A firm that adopts a new technology has to pay a sunk cost

Technology (cont'd)

- Exporting is costly. Firms need to pay a fixed per-period cost when they sell abroad
- Iceberg transportation costs when exporting $\tau_x > 1$, and $\tau_x \neq \tau_f$
- All fixed and sunk costs are denominated in units of output

Preferences & Demand

- Individuals are risk-neutral and have CES preferences over a continuum of domestically-produced goods $q_d(\omega)$ and one imported good q_f:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t C_t,$$

$$C = \left(q_f^{\frac{\sigma_c - 1}{\sigma_c}} + \int_{\omega \in \Omega} q_d(\omega)^{\frac{\sigma_c - 1}{\sigma_c}} d\omega \right)^{\frac{\sigma_c}{\sigma_c - 1}}, \quad \sigma_c > 1,$$

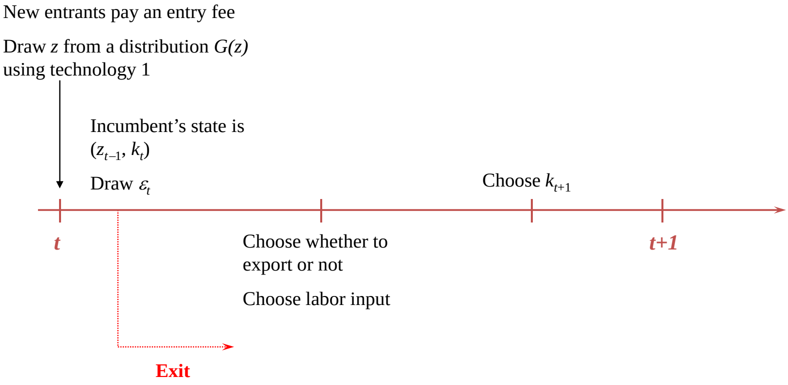
- Total income is labor income plus profits of domestic firms.
- Domestic demand:

$$q_d(\omega) = Y P^{\sigma_c - 1} (p_d(\omega))^{-\sigma_c},$$

- Foreign demand:

$$q_x(\omega) = A_x (p_x(\omega))^{-\sigma_c}$$

Sequence of Actions



Stationary Equilibrium Definition

A stationary equilibrium for the model is:

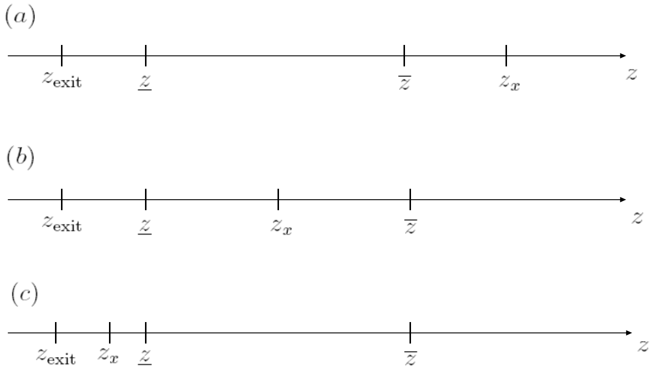
- A set of decision rules for exiting, technology adoption, pricing, exporting, labor demand
- Post entry/exit distribution of firms across technologies and productivity
- Mass of entrants and incumbents
- Aggregate income, aggregate price index and wages

such that:

1. Decision rules are optimal
2. Labor demand equals labor supply for both types of workers
3. The flow of entrants balances the flow of exiting firms
4. Equilibrium good prices are consistent with the aggregate price index P
5. Aggregate income Y equals aggregate profits plus total labor income
6. Free entry
7. Trade is balanced in every period

Firm's Discrete Decisions

The model produces a series of cutoffs that determine the decision to exit, adoption of technology and exporting



Data

- Balanced panel of 1,913 large Mexican manufacturing plants for the period 1984-1990 from INEGI
- Data on entry/exit patterns comes from Pages et. al. (2004)

Variable	**1984**	**1990**
Number of workers		
Blue-collar	201.81	228.90
	(304.92)	(361.75)
White-collar	86.71	98.35
	(135.13)	(157.00)
Hourly wages		
Blue-collar	28.65	26.70
	(14.62)	(14.09)
White-collar	56.15	67.54
	(41.80)	(42.03)
% Exporting plants	0.228*	0.359
	(0.419)	(0.479)
Exports/sales	0.247*	0.268
	(0.639)	(2.297)

Proxy for Technology Adoption

Statistic	Value
Mean investment rate	0.0832
Fraction of investment spikes $[I/K > 0.25]$	0.0635
Inaction rate investment $[I/K \leq 0.01]$	0.5246
Mean share of foreign investment	0.2288
Fraction of investment spikes in which foreign capital is purchased	0.7751

- As found by other studies, investment is very lumpy: a lot inaction accompanied by periods of large adjustments in the capital stock
- A substantial number of investment spikes involve the purchase of imported capital goods $\Rightarrow$ I assume that plants that start importing capital start are using technology 2 in my model

Calibrated Parameters

- $\beta = 0.939$, to match the annual average real interest rate for the period 1982-2006, of 6.46%
- $\sigma_c = 3.451$, to match the mean of the ratio of total revenues to total variable costs in 1984, 1.407
- $\tau_f = 1.55$, pre-liberalization level of variable trade cost for imports
- $\tau_x = 1.05$, variable trade cost for exports
- $\lambda = 0.301$, to match the mean share of non-production employment in 1984
- Normalize $L = 1,000$

Parameters to be Estimated

The parameters of the model are estimated using simulated method of moments. The vector of unknown parameters θ includes

$$\theta \equiv \{\overline{z}_1, \overline{z}_2, \phi, \sigma_\varepsilon^2, f_1, f_2, S, A_x, f_x, \mu_E, S_E, \sigma_p\}$$

The estimated vector of parameters $\hat{\theta}$ minimizes the distance between a set of simulated and sample moments

$$\hat{\theta} = \arg\min_{\theta \in \Theta} \Psi = (\hat{\mathbf{m}}(\theta) - \mathbf{m})' W (\hat{\mathbf{m}}(\theta) - \mathbf{m})$$

where W is a positive definite weighting matrix

Identification

- Exporting parameters (A_x, f_x):
  - Frequency of exporting
  - Share of exports in total revenues
  - Relative size of exporters
  - Entry rate into exporting
- Technology parameters $(\overline{z}_1, \overline{z}_2, f_1, f_2, \phi, \sigma_\varepsilon^2, S, \sigma_p)$:
  - Relative skill intensity of exporters, non-exporters
  - Persistence of skill intensity
  - Persistence of exporting status
  - Frequency of use of foreign technology
  - Rate of adoption of foreign technology
  - Size distribution
- Entry parameters (μ_E, S_E):
  - Mean entry rate
  - Relative size of entrant and exiting plants
  - Size distribution

Estimates

Parameter	Point Estimate
$\overline{z}_1$	-0.010
$\overline{z}_2$	0.031
ϕ	0.914
σ_ε^2	0.244
f_1	12.233
f_2	86.910
S	75.452
A_x	0.455
f_x	44.727
μ_E	1.218
S_E	19.743
σ_p	1.400
Ψ	1.766

- The elasticity of substitution between skilled and unskilled workers is estimated to be 1.40; estimates for the US range between 1 and 2.2
- The mean fixed cost of operation accounts for 25% of total labor cost
- The mean fixed cost of exporting represents 12% of exporting revenues for exporting plants
- Plants that switch from technology 1 to 2 pay a sunk cost equivalent to 48% of their current yearly revenues on average

Goodness of Fit

Moment	Data	Simulated
Mean fraction of exporting firms	0.2313	0.2571
Mean exports/sales ratio	0.2188	0.2328
Corr(export$_t$, export$_{t-1}$)	0.8623	0.7580
St. dev. skill share of employment	0.1678	0.0746
Mean skill share, exporters	0.3538	0.3498
Mean skill share, non-exporters	0.2944	0.1913
Corr (skill share$_t$, skill share$_{t-1}$)	0.9395	0.8923
Mean entry rate	0.1100	0.0831
Mean log(total employment)	4.7914	4.6175
St. dev. log(total employment)	1.2357	1.1954
Mean log(total employment), entrants	2.8683	2.8468
St. dev. log(total employment), entrants	0.8668	0.4372
Mean log(total employment), exiters	2.2708	2.5084
St. dev. log(total employment), exiters	0.8662	0.5551
Mean fraction of firms using foreign technology	0.2259	0.2796
Mean adoption rate imported technology	0.0726	0.0401
St. dev. log(non-production employment)	1.3947	1.5744
St. dev. log(production employment)	1.2363	1.1000
Mean log(total employment), exporters	5.3040	5.5502
St. dev. log(total employment), exporters	1.1984	0.7234
Mean entry rate into exporting	0.0338	0.0808
Fraction of plants with 0-30 employees	0.7130	0.6558
Fraction of plants with 30-100 employees	0.2098	0.2428
Fraction of plants with 100-500 employees	0.0514	0.0785

Experiments

Statistic	Benchmark	35% reduction in τ_f	35% reduction in τ_f, affecting S
Aggregate income (Y)	100	85.09	85.21
Price index (P)	100	84.07	89.69
Price of foreign consumption good (τ_f)	155	105	105
Mass of incumbent firms (M)	100	98.62	99.37
Skill premium (w_h/w_l)	2.525	2.612	2.635
Fraction of plants using foreign tech.	0.279	0.246	0.283
Fraction of exporting plants	0.257	0.308	0.332

- Skill premium rises by 3.44% after a unilateral trade liberalization
- When we let the sunk cost of technology adoption depend on the import tariff, the skill premium increases by 4.6% relative to the pre-liberalization level
- The negative effect of trade liberalization on the adoption of foreign technology is reversed if we allow the cost of adoption to be affected by τ_f

Conclusions

- The estimates suggest that a unilateral trade liberalization has a small negative effect on the number of plants using "advanced technology", however, the associated increase in exports results in the skill premium increasing
- When the cost of adopting advanced technology falls after trade liberalization, the effect of trade liberalization on the skill premium becomes stronger
- Skill-biased technology adoption doesn't explain a large share of the rise of the skill premium in Mexico

Firm's Static Problem

An incumbent firm using technology k with productivity z solves:

$$\max_{h,l,q_d,q_x,p_d,p_x,\gamma\in\{0,1\}} p_d q_d + \gamma[p_x q_x - f_x mc] - w_h h - w_l l,$$

s.t.:

$$q_d = Y P^{\sigma_c - 1}(p_d)^{-\sigma_c},$$

$$q_x = A_x (p_x)^{-\sigma_c},$$

$$q = q_d + \gamma \tau_x q_x,$$

taking as given Y, P, A_x, w_l, w_h.

Firm's Dynamic Problem

At the beginning of each period, incumbent firms choose whether to remain in the market or exit:

$$V(k,z) = \max\{V^c(k,z), 0\}$$

A firm that stays in the market needs to choose what technology to operate next period:

$$V^c(k,z) = \max\{V^A(k,z), V^N(k,z)\},$$

$$V^A(k,z) = \pi(k,z) - [f_k + S_{\tilde{k}}]mc(k,z) + \beta \int_{z'} Q_{\tilde{k}}(z'|z) V(\tilde{k}, z'),$$

$$V^N(k,z) = \pi(k,z) - f_k mc(k,z) + \beta \int_{z'} Q_k(z'|z) V(k, z')$$