
Outsourcing and Volatility

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I. Background

- Outsourcing especially significant in the trade relationship between the U.S. and Mexico - 'maquiladoras' in Mexican border cities.
- Significance: Outsourcing represents 20% of value added in manufacturing in Mexico and over half of Mexican exports.
- Rapid growth: Tenfold increase in employment from 0.12 mil in 1980 to 1.3 mil in 2000.
- Hailed in Mexico as useful engine of growth. But regarded as 'fickle' due to excessive volatility.

Motivation

- While large literature studies other implications of outsourcing (trade volume, wages, environment), little work to date on second moment implications.
- Contribution #1: document a new stylized fact: value added in Maquilas is more volatile than corresponding U.S. industries or rest of Mexican manufac.

Use Mexican national data on Maquila plants; show statistical significance using dif-in-dif regressions adapted for second moments.
- Contribution #2: Develop a theoretical model of outsourcing with two novel features that can explain this stylized fact.

II. Empirical: New stylized fact

- Data: from Mexican government on earnings of production workers in 4 Maquila industries, monthly frequency.
- Study data 1996.1-2005:12: after implementation of NAFTA, and after passing of Peso Crisis.
- For U.S., earnings of production workers in corresponding US 3-digit industry.
- Also compare to aggregates for manufacturing earnings in each country.
- All variables in real terms, using national CPI. Logged and HP filtered to compute standard deviations.

Earnings by workers: Maquila and US counterpart

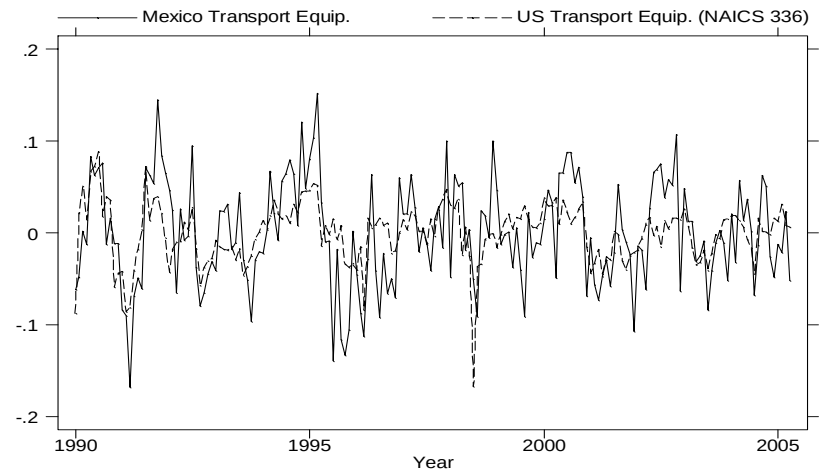
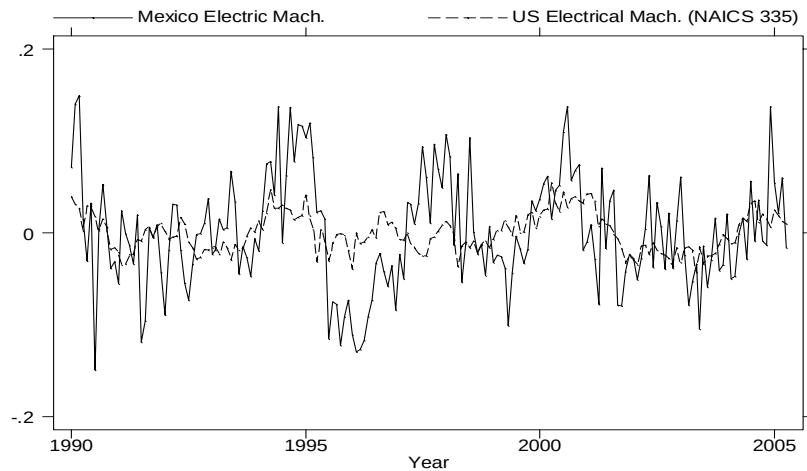
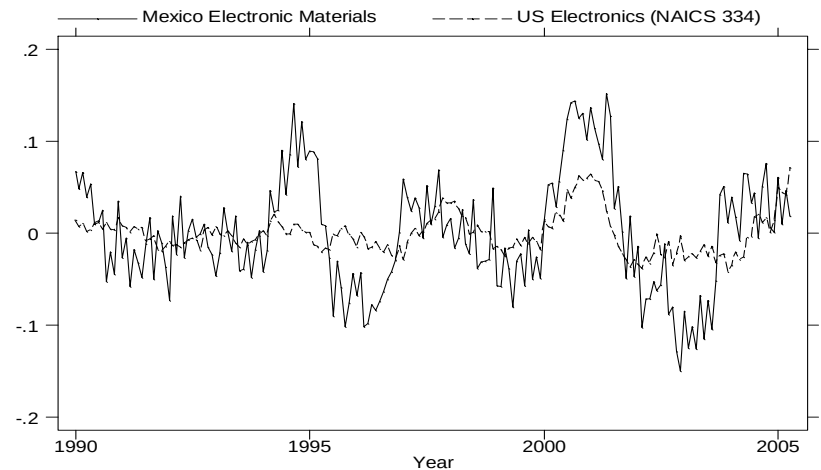
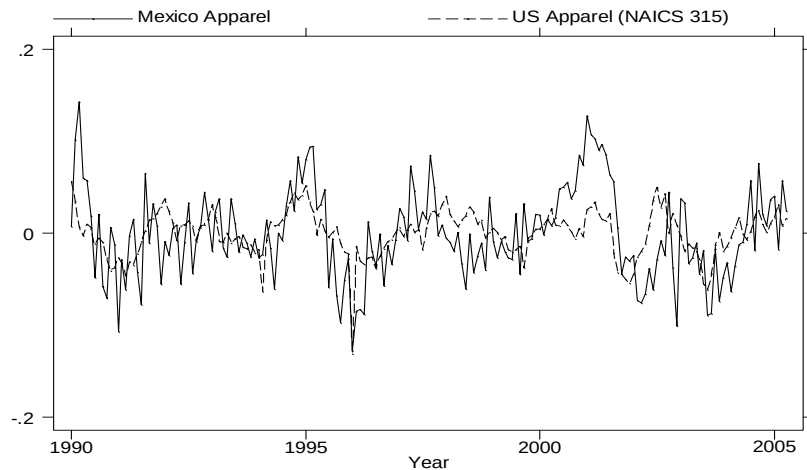


Table 1A: Data on Volatilities (earnings)

	apparel	electronic	elec. mach.	Transport	avg. over industries
<u>standard devs. (%):</u>					
$\sigma(Y_{os}^{Mex})$	4.83	6.21	4.41	4.20	4.91
$\sigma(Y_{os}^{US})$	2.31	2.79	2.01	2.63	2.44
$\sigma(Y^{Mex})$	1.94	"	"	"	1.94
$\sigma(Y^{US})$	1.27	"	"	"	1.27
$\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})$	2.09	2.23	2.19	1.60	2.03
$\sigma(Y^{Mex})/\sigma(Y^{US})$	1.53	"	"	"	1.53
$\frac{\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})}{\sigma(Y^{Mex})/\sigma(Y^{US})}$	1.37	1.46	1.44	1.05	1.33

Conclude: volatility in Mexican outsourcing sector, $\sigma(Y_{os}^{Mex})$ is much higher (x2) than corresponding US industry, $\sigma(Y_{os}^{US})$ and in rest of Mexican manufacturing, $\sigma(Y^{Mex})$.

Table 1B: Data on Total Employment

	apparel	electronic	elec. mach.	Transport	avg. over industries
<u>standard devs. (%):</u>					
$\sigma(Y_{os}^{Mex})$	4.52	5.95	4.34	2.96	4.44
$\sigma(Y_{os}^{US})$	1.89	3.06	1.79	1.42	2.04
$\sigma(Y^{Mex})$	0.89	"	"	"	0.89
$\sigma(Y^{US})$	1.15	"	"	"	1.15
$\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})$	2.39	1.94	2.42	2.08	2.21
$\sigma(Y^{Mex})/\sigma(Y^{US})$	0.77	"	"	"	0.77
$\frac{\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})}{\sigma(Y^{Mex})/\sigma(Y^{US})}$	3.09	2.51	3.13	2.69	2.86

Conclude: Robustness: confirms previous conclusion for worker earnings.

Overall Mexican Volatility

Question:

Is volatility higher in Mexican outsourcing just because Mexico in general is more volatile?

Answer:

No. While overall manufacturing is somewhat more volatile in Mexico, the gap in outsourcing volatilities is larger.

Labor Market Regulations

Question:

Is Mexico more volatile because of laxer labor regulations, and U.S. firms move to take advantage?

Answer:

No. Botero et al. (2004) find that in terms of employment security regulations, Mexico is most restrictive out of 85 countries; U.S. is the fifth least restrictive.

This conclusion is reflected in table above, showing that employment volatility in overall manufacturing is even lower in Mexico than U.S.

Size

Question: Could higher volatility in Mexico be due just to the fact that the Mexican industries are smaller in size?

Table: Thousands of Employees (mean, 2000-2005)

	apparel	electronic	elec. mach.	Transport	Overall Manufac.
Mexico	230.8	265.6	100.2	240.7	1151.0
U.S.	356.9	1512.3	497.5	1855.8	15,336.7
California	97.4	366.6	38.5	137.5	1649.0
Texas		132.9	20.0	85.2	955.5

Answer: To check, we can compare Mexico to US border states rather than comparing to whole of US...

Table 1C: Data on California (Employment)

	apparel	electronic	elec. mach.	Transport	avg. over industries
<u>standard devs. (%):</u>					
$\sigma(Y_{os}^{Mex})$	4.48	4.11	5.50	2.73	4.21
$\sigma(Y_{os}^{US})$	2.25	2.35	2.62	1.31	2.13
$\sigma(Y^{Mex})$	0.77	"	"	"	0.77
$\sigma(Y^{US})$	1.40	"	"	"	1.40
$\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})$	1.99	1.75	2.10	2.08	1.98
$\sigma(Y^{Mex})/\sigma(Y^{US})$	0.55	"	"	"	0.55
$\frac{\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})}{\sigma(Y^{Mex})/\sigma(Y^{US})}$	3.62	3.18	3.82	3.79	3.60

Conclude: Higher Mexican volatility not due just to smaller size.

Table 1D: Data on Texas (Employment)

	apparel	electronic	elec. mach.	Transport	avg. over industries
<u>standard devs. (%):</u>					
$\sigma(Y_{os}^{Mex})$	4.48	4.11	5.50	2.73	4.21
$\sigma(Y_{os}^{US})$		2.48	3.12	1.66	2.42
$\sigma(Y^{Mex})$	0.77	"	"	"	0.77
$\sigma(Y^{US})$	1.16	"	"	"	1.16
$\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})$		1.66	1.76	1.64	1.69
$\sigma(Y^{Mex})/\sigma(Y^{US})$	0.66	"	"	"	0.66
$\frac{\sigma(Y_{os}^{Mex})/\sigma(Y_{os}^{US})}{\sigma(Y^{Mex})/\sigma(Y^{US})}$		2.51	2.67	2.49	2.56

Conclude: Higher Mexican volatility not due just to smaller size.

Difference in Difference Tests

- Adapt dif-in-dif approach for second moments.
- Dependent variable is the squared deviation of earnings from its mean (separate equation for each Maquila industry).
- Independent variables are indicators for outsourcing, Mexican variable, or interaction of the two.
- Interaction term measures the stylized fact above.
- Conclusion: higher volatility in Mexican outsourcing compared to US is statistically significant, even after controlling for volatility in overall Mexican manufac.

Table 2A: Dif-in-Dif: Earnings

	Apparel	Elec. Mach.	Electronics	Trans Equip
Constant	0.161 (0.021)	0.161 (0.020)	0.161 (0.020)	0.161 (0.021)
Outsourcing Industry	0.370 (0.126)	0.240 (0.049)	0.613 (0.105)	0.526 (0.201)
Mexico	0.211 (0.046)	0.211 (0.045)	0.211 (0.047)	0.211 (0.045)
Outsourcing *Mexico	1.574 (0.294)	1.315 (0.232)	2.841 (0.475)	0.852 (0.319)
R Squared	0.224	0.246	0.234	0.110

Table 2B: Dif-in-Dif: Total Employment

	Apparel	Elec. Mach.	Electronics	Trans Equip
Constant	0.101 (0.013)	0.101 (0.013)	0.101 (0.014)	0.101 (0.013)
Outsourcing Industry	0.161 (0.034)	0.127 (0.035)	0.505 (0.096)	0.013 (0.030)
Mexico	-0.043 (0.016)	-0.043 (0.016)	-0.043 (0.016)	-0.043 (0.016)
Outsourcing *Mexico	1.767 (0.237)	1.492 (0.205)	2.441 (0.505)	0.668 (0.150)
R Squared	0.282	0.261	0.164	0.108

Table 2C: Dif-in-Dif: California (Employment)

	Apparel	Elec. Mach.	Electronics	Trans Equip
Constant	0.195 (0.031)	0.195 (0.031)	0.195 (0.031)	0.195 (0.032)
Outsourcing Industry	0.307 (0.075)	0.353 (0.098)	0.484 (0.110)	-0.024 (0.041)
Mexico	-0.137 (0.032)	-0.137 (0.033)	-0.137 (0.032)	-0.137 (0.033)
Outsourcing *Mexico	1.620 (0.239)	1.266 (0.220)	2.462 (0.495)	0.705 (0.152)
R Squared	0.249	0.209	0.158	0.093

Table 2D: Dif-in-Dif: Texas (Employment)

	Apparel	Elec. Mach.	Electronics	Trans Equip
Constant		0.134 (0.015)	0.134 (0.014)	0.134 (0.015)
Outsourcing Industry		0.474 (0.090)	0.832 (0.120)	0.141 (0.053)
Mexico		-0.075 (0.017)	-0.075 (0.016)	-0.075 (0.017)
Outsourcing *Mexico		1.145 (0.226)	2.113 (0.504)	0.540 (0.155)
R Squared		0.219	0.157	0.090

III. Theory: Basic Approach

- Our approach in thinking about higher volatility:
 - Consistent with FDI literature, suppose that fixed costs (headquarters services) are done in U.S. and variable costs in Mexico (or shared)
 - Two distinctive features which will help generate volatility in the outsourcing sector:
 - 1) Endogenize the outsourcing decision
 - 2) Modulate firm entry with translog prefs.

Model feature 1

- Endogenize the extensive margin of outsourcing:
- Firms decide whether to outsource by comparing cross-country productivity to cross-country wage (like DFS, 1977, or Feenstra-Hanson).
- If home shock lead to rise in home relative wage, the margin of outsourcing will shift – some range of firms will switch status to become outsourcers.
- Can shift much of production fluctuations abroad: volatility depends not just on entry, but on the choice of outsourcing location.
- Role of size: In addition, since Mexican economy is smaller, a given relocation of production from US to Mexico has bigger percentage impact on Mexico.

Model feature 2

- Endogenize the markup using translog preferences:
- Implies that as new firms enter, the elasticity of substitution rises and markup falls.
- This dampens the entry of new firms in response to shocks, which is more realistic than the instantaneous full entry that the model otherwise would imply.
- Since the fixed cost activities located in the US vary only with new firm entry, dampening entry dampens volatility in US labor earnings.
- Translog has nice properties: (i) preferences are homothetic; (ii) with suitable choice of parameters, the elasticity of demand = number of products.

General model description

- Two countries: Home (U.S.) and Foreign (Mexico,*)
 - Home can outsource to foreign.
 - Scale home variables by size n , foreign $1-n$
- Two sectors:
 - Country-specific sector: one nondifferentiated good produced exclusively by each country (H, F)
 - Multinational sector (M): Where outsourcing can occur. Represents sum of the four industries from empirical section above.
- One factor of production: Labor.

Market structure in multinational sector

- Continuum of differentiated multinational goods
 - indexed by z on unit interval $(0,1)$
 - With aggregator: $\ln D_{Mt} = \int_0^1 \ln d_{Mt}(z)$
 - heterogeneous in terms of marginal costs.
- Each multinational good comes in multiple varieties produced by distinct firms,
 - indexed by integer $N(z)$
 - with free entry of new firms.
- Using “double-continuum” similar to Romalis (2004)

Production in multinational sector

Production involves two activities:

1) fixed cost activity (B) (not proportional to production)

- representing headquarters and management
- Assumed to take place in US due to higher productivity in this activity.
- Cost constant level across sectors (B).

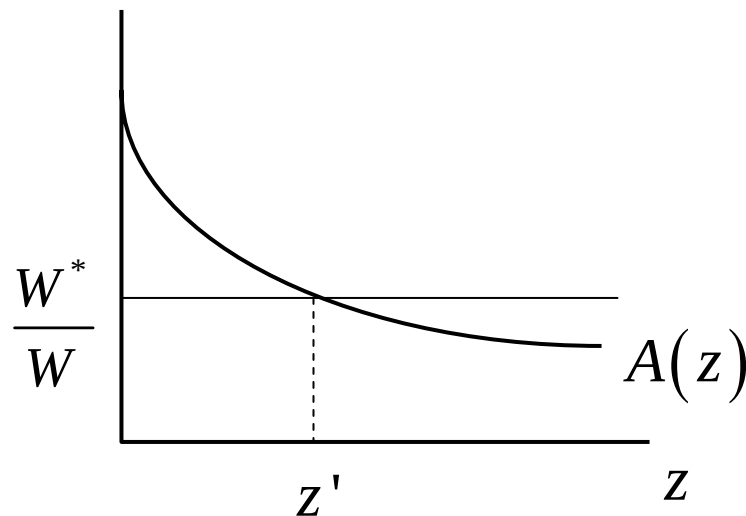
2) variable cost activity (proportional to production)

- representing assembly
- Can take place in either country.
- Unit labor cost of activity varies by good ($a(z)$)

- Whether production is outsourced depends on comparative advantage, along lines of DFS (1977) model of trade.
- Rank the traded goods in decreasing order of unit labor costs of production in US to that Mexico.
- Allow this ratio to follow some distribution

$$A(z) \equiv \frac{a_M(z)}{a_M^*(z)} = \frac{e^{az+b}}{e^{a^*z+b^*}} = e^{(a_d)z+(b_d)}$$

- Compare costs to relative wages across countries:
If $A(z) > W^*/W$ then outsource variable cost activity.
If $A(z) < W^*/W$ then do activity at home.
If $A(z) = W^*/W$ is marginal good (z'), which is the share of outsourced goods.



Entry of new firms into each product

Z:

Familiar CES case

σ

- demand elasticity =
- Equilibrium number of entrants:

$$N_{CES,t} = \frac{D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n} \right)}{\sigma B W_t}$$

So more firms enter as demand for traded goods rises, or if value of fixed cost falls.

Our translog case

- Specify price index:

$$\ln e_t(p_t, z_t) = \sum_{i=1}^{N(z_t)} \frac{\ln p_{it}(z_t)}{N(z_t)} + \frac{1}{2} \sum_{i=1}^{N(z_t)} \sum_{j=1}^{N(z_t)} \gamma_{ij} \ln p_{it}(z_t) \ln p_{jt}(z_t)$$

where

$$\gamma_{ij} = \begin{cases} -\gamma \frac{N(z) - 1}{N(z)}, & i = j \\ \frac{\gamma}{N(z)}, & i \neq j \end{cases} \quad \gamma > 0$$

- Convenient property: $\gamma = 1$ implies elasticity = N_t
So market becomes more competitive as more firms enter, raising elasticity and lowering markup.

- Equilibrium number of entrants: $N_{TLog,t} = \sqrt{\frac{D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n} \right)}{BW_t}}$
Note depends on sq root of demand

Remainder is standard int'l macro model

- Household problem:

$$\max U = \frac{1}{1-\phi} C_t^{1-\phi} - \frac{1}{1+\mu} L_t^{1+\mu}$$

$$st. \quad P_{Ht} C_{Ht} + P_{Ft} C_{Ft} + C_{Mt} + \sum_{s^{t+1}} v(s^{t+1} | s^t) X(s_{t+1}) = W_t L_t + X_t$$

$$where \quad C_t = \left(C_{Ht}^\theta C_{Ft}^{1-\theta} \right)^{1-\alpha} C_{Mt}^\alpha$$

- Additively separable preferences over consumption (C) and labor (L).
- Wage income (W); households receive no firm profit.
- Country-specific good sells for distinct price (P_{Ht}, P_{Ft}).
- Complete asset markets equate marginal utilities.

- Four shocks:
 - Additive shock to home and foreign demand (government).
 - and to Home and foreign productivity.
 - both pairs of stochastic terms are specified as joint auto-regressions in log deviations from steady state, with shocks log normally distributed.
- Compute value added in each sector as wage times labor (corresponds to data in empirical section)

Model calibration:

- Basic preference parameters taken from literature.
- Steady state mimics levels in 2003 in our data: cross-country relative wage and outsourcing share...
- Cross-sectional unit labor cost distribution parameters calibrated to satisfy (1) standard deviation estimated in Bernard et al. (2003), (2) be consistent with steady state wages and outsourcing share.
- The parameter determining the slope of the relative unit labor cost, $A'(\bar{z})$, is studied by sensitivity analysis.
- Supply shock parameters estimated from Solow residual implied by our monthly manufacturing earnings and employment data
- Demand shocks from monthly gov't spending data.

IV. Results: Analytical result

- Combining labor demand conditions produces:

$$\frac{Y_{Mt}^*}{Y_{Mt}} = \frac{W_t^* L_{CES,Mt}^*}{W_t L_{CES,Mt}} = \frac{(\sigma - 1) z'}{1 + (\sigma - 1)(1 - z')} \left(\frac{n}{1 - n} \right)$$

So if z' and σ are constant, so is ratio of value added.

- Then is impossible to generate higher volatility in the Mexican part of outsourcing sector than in US part.
- Intuition: extra demand is supplied fully by new entry not by increased firm size. So fixed cost activity in US and variable cost activity in Mexico rise together.
- Two approaches to break this linkage:
 - 1) let z' move: extensive margin shift (next slide)
 - 2) inhibit entry by endogenizing σ via translog

Simulation Experiments

- Draw sequence of 120 periods from distribution for each shock, solving model as nonlinear system.
- Compute standard deviations of simulated data on earnings.
- Deflate by national CPI and HP filtered, to mimic treatment of the data.
- Repeat 1000 times, and report average moments.

Table 3A: simulations, benchmark case

	Simulation	Data
<u>Standard devs. (%):</u>		
$\sigma(Y_{os}^*)$	4.08	4.91
$\sigma(Y_{os})$	2.29	2.44
$\sigma(Y^*)$	2.01	1.94
$\sigma(Y)$	1.77	1.27
$\sigma(Y_{os}^*)/\sigma(Y_{os})$	1.78	2.03
$\sigma(Y^*)/\sigma(Y)$	1.14	1.53
$\frac{\sigma(Y^*_{os})/\sigma(Y_{os})}{\sigma(Y^*)/\sigma(Y)}$	1.58	1.33

Note: Benchmark case (all four shocks, translog preferences and endogenous outsourcing) delivers substantial volatility.

Intuition for endogenous outsourcing case

- Consider home boom driven by home demand shock
- Real wage is procyclical in data and in simulation.
- Rise in wage costs in U.S. relative to Mexico.
- Leads to extensive margin shift: new range of goods shift from U.S. production to outsourcing assembly.
- Depending on slope of $A(z)$ distribution, this implies that a home demand shock has a bigger effect on foreign outsourcing sector than at home.

Table 3B: Sensitivity to calibration of slope of relative unit cost distribution:

$A'(z)$	-0.001	-0.1	-1
<u>Std. devs. (%):</u>			
$\sigma(Y^*_{os})$	4.08	3.57	3.08
$\sigma(Y_{os})$	2.29	2.30	2.36
$\sigma(Y^*)$	2.01	1.94	1.91
$\sigma(Y)$	1.77	1.78	1.80
$\sigma(Y^*_{os})/\sigma(Y_{os})$	1.78	1.56	1.31
$\sigma(Y^*)/\sigma(Y)$	1.14	1.10	1.06
$\frac{\sigma(Y^*_{os})/\sigma(Y_{os})}{\sigma(Y^*)/\sigma(Y)}$	1.58	1.42	1.23

Note: Flatter slope helps; results hold for range of calibrations of $A'(z)$

Table 3C: Role of the two key model features

Endogenous OS:	Yes	No	No
Translog:	No	Yes	No
<u>Std. devs. (%):</u>			
$\sigma(Y^*_{os})$	4.05	3.01	2.72
$\sigma(Y_{os})$	2.04	2.37	2.16
$\sigma(Y^*)$	1.97	1.89	1.84
$\sigma(Y)$	1.71	1.80	1.77
$\sigma(Y^*_{os})/\sigma(Y_{os})$	1.99	1.27	1.26
$\sigma(Y^*)/\sigma(Y)$	1.15	1.05	1.04
$\sigma(Y^*_{os})/\sigma(Y_{os})$	1.73	1.21	1.22
$\sigma(Y^*)/\sigma(Y)$			

Note: Endogenous outsourcing delivers most of the volatility here.

Table 3D: Extreme case: Preclude all new firm entry

Entry allowed:	No	No
Endogenous OS:	Endog OS	Exog OS
<u>Standard devs. (%):</u>		
$\sigma(Y_{os}^*)$	3.84	2.77
$\sigma(Y_{os})$	1.79	2.06
$\sigma(Y^*)$	1.92	1.83
$\sigma(Y)$	1.66	1.74
$\sigma(Y_{os}^*)/\sigma(Y_{os})$	2.15	1.35
$\sigma(Y^*)/\sigma(Y)$	1.16	1.05
$\frac{\sigma(Y_{os}^*)/\sigma(Y_{os})}{\sigma(Y^*)/\sigma(Y)}$	1.86	1.29

Note: Similar results to translog cases. So trying to model more realistic entry dynamics (in between the two extreme cases shown) will not improve result.

Conclusions

- Outsourcing has been transforming the trade relationship between Mexico and the U.S.

May be predictive for other regions in the future (Eastern Europe, China)

- Seems to be a channel that is good at transmitting shocks abroad; domestic shocks can be transmitted in amplified manner.
- Offers a tradeoff for countries engaging in outsourcing activities as an engine for growth.
- Future work: three country model. Study exchange rate pass-through.