Notes about Pavcnik (Restud 2002): "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants"

Seminario Avanzado de Comercio

José Pulido

Universidad del Rosario

2018 Term 2

Overview

- Objective: To investigate the effects of trade liberalization on plant productivity in the case of Chile
- Pavcnik shows that productivity increases because of:
  - reshuffling of market shares between low and high productivity firms
  - exit of low productivity firms
- Period 1974-79 in Chile: removal of NTB's and tariffs lowered to 10% (from 100% in some industries)
- Data 1979-1986 on manufacturing plants
- ISIC 4-digit industries

Approach and main results

- Difference-in-differences approach: compares import-competing vs export-oriented and non-traded sectors, before and after
- First paper in trade to use Olley and Pakes (1996) methodology to estimate plant TFP
- Main results:
  - Average increase in productivity of 3-10% in import-competing relative to nontraded goods
  - Exiting plants are 8% less productive than stayers

Caution... Next slides are dense!

- Caution:

  Olley and Pakes (1996), hereafter OP, is a highly technical method to estimate productivity. In the next slides I describe OP, but the non-interested student can drop the following slides and continue in slide 15!

Olley and Pakes (1996) - OP (I)

- Estimate production function:

$$
\begin{aligned}
y_{it} &= \beta_0 + \beta x_{it} + \beta_k k_{it} + e_{it} \\
e_{it} &= \omega_{it} + \mu_{it}
\end{aligned}
$$

- where x_{it} is labor and materials, k_{it} is capital
  - ω_{it} is productivity shock that is observed by plant/firm but not econometrician
  - μ_{it} is unexpected shock given all inputs have been chosen
  - both ω and μ are Markov processes (e.g. AR(1))
- Rewrite estimating equation:

$$
y_{it} = \beta_0 + \beta x_{it} + \beta_k k_{it} + \omega_{it} + \mu_{it}
$$

Olley and Pakes (1996) - OP (II)

- Drop firm i subscript
- Capital accumulation:

$$k_{t+1} = (1 - \delta)\, k_t + i_t$$

- Ericson and Pakes (1995) show that:
  - Markov Perfect Equilibrium: firms exit if ω_{it}below cutoff $\underline{\omega}_t(k_t)$
  - firms optimally invest

$$i_t = i_t\,(\omega_t, k_t)$$

- Three sources of bias:
  - simultaneity 1: correlation between ω_{it} and x_{it}
  - simultaneity 2: correlation between ω_{it} and k_{it+1}
  - endogenous exit: we don't observe firms that draw very low productivity shock and this may be correlated with factors of production

OP first step: β on variable inputs

- Solve simultaneity problem 1
- Goal of OP first step is to estimate β for variable inputs
- Estimate:

$$y_t = \beta_0 + \beta x_t + \beta_k k_t + \omega_t + \mu_t \tag{1}$$

- Invert investment function:

$$\omega_t = i_t^{-1}(i_t, k_t) = \theta_t(i_t, k_t) \tag{2}$$

- Replace 2 in 1:

$$y_t = \beta x_t + \lambda_t(k_t, i_t) + \mu_t \tag{3}$$

- where

$$\lambda_t(k_t, i_t) = \beta_0 + \beta_k k_t + \theta_t(i_t, k_t) \tag{4}$$

- Estimate β using (3) approximating λ_t with polynomial in i_t and k_t

OP second step: $\beta_k$on capital

- Goal of second stage: estimate β_k
- Two problems:
  - simultaneity 2: i_t and therefore k_{t+1} affected by expectation of ω_{t+1} which is serially correlated with ω_t
  - selection: if some firms exit the sample the expected productivity of remaining ones may be correlated with capital

OP second step: simultaneity 2 (I)

- Future productivity has expected and unexpected component: $\omega_{t+1} = E\left(\omega_{t+1} | \omega_t, k_t\right) + \xi_{t+1}$
- We now have to estimate:

$$y_{t+1} - \beta x_{t+1} = \beta_k k_{t+1} + E\left(\omega_{t+1} | \omega_t, k_t\right) + \xi_{t+1} + \mu_{t+1} \qquad (5)$$

- Expected component is increasing function of ω_t: $E\left(\omega_{t+1} | \omega_t, k_t\right) = g\left(\omega_t\right)$
- Simultaneity problem: correlation between $g\left(\omega_t\right)$ and i_t and therefore k_{t+1}

OP second step: simultaneity 2 (II)

- Replace (4) in $g(\cdot)$: ignoring β_0

$$g(\omega_t) = g(\theta(i_t, k_t)) = g(\lambda_t - \beta_k k_t)$$

- Because we have estimated λ_t in first step we can consider it as "data" and rewrite (5):

$$y_{t+1} - \beta x_{t+1} = \beta_k k_{t+1} + g(\lambda_t - \beta_k k_t) + \xi_{t+1} + \mu_{t+1}$$

- Notice how β_k shows up in two places: in particular cannot estimate component inside g by OLS
  - estimate with non-linear least squares

OP second step: selection (I)

- If firms with $\omega_{t+1} < \underline{\omega}_{t+1}(k_{t+1})$ exit, then $E(\omega_{t+1} | \omega_{t+1} > \underline{\omega}_{t+1}(k_{t+1}), \omega_t)$ depends on k_{t+1}
- In particular: since $\underline{\omega}_{t+1} \downarrow \text{with } k_{t+1}$
  - then negative correlation between error term and k_{t+1}
  - firms that have higher k_{t+1}can afford to stay in the market with relatively worse productivity shocks $\Rightarrow$ negative bias in β_k
- Define: $\Phi(\omega_t, \underline{\omega}_{t+1}) = E(\omega_{t+1} | \omega_{t+1} > \underline{\omega}_{t+1}(k_{t+1}), k_t, \omega_t)$

OP second step: selection (II)

- Control for selection:

$$Pr\left[\omega_{t+1} > \underline{\omega}_{t+1}\left(k_{t+1}\right), \omega_t\right] = p_t\left(\underline{\omega}_{t+1}\left(k_{t+1}\right), \omega_t\right) = P_t$$

- We can invert the $p_t$function:

$$\underline{\omega}_{t+1}\left(k_{t+1}\right) = p_t^{-1}\left(P_t, \omega_t\right)$$

- Rewrite estimating equation as:

$$y_{t+1} - \beta x_{t+1} = \beta_k k_{t+1} + \Phi\left(\lambda_t - \beta_k k_t, P_t\right) + \xi_{t+1} + \mu_{t+1}$$

OP second step: selection (III)

- Standard selection correction can rely on:
- Functional form (excluded variable: variable that affects P_t but does not affect output y_{t+1})
- In practice: run probit $P_t = p_t(i_t, k_t)$, take predicted value and include it in a (fourth-order) polynomial approximation of Φ:

$$\Phi(\omega_t, P_t) = \beta_{00} + \beta_{10}\left(\hat{\lambda}_t - \beta_k k_t\right) + \beta_{01}\hat{P}_t + \beta_{11}\left(\hat{\lambda}_t - \beta_k k_t\right)\hat{P}_t + \ldots$$

- Estimate again by non-linear least squares

Levinsohn and Petrin (2003) - LP

- Problem with investment: often zero
- Investment is very lumpy (firms don't invest for years and then make large investments)
- So Levinsohn and Petrin (2003) methodology is the same as OP, but instead relies on material inputs as a proxy for the productivity shock

Data

- Chile's trade liberalization:
  - Began in 1974, nished by 1979. (Tariffs actually rose a bit in 1982 and 1983 before falling again).
  - As usual with these trade liberalization episodes, there were a lot of other things going on at the same time.
- Pavcnik has plant-level panel data from 1979-1986
  - All plants (in all years open) with more than 10 workers
  - Unfortunately, no ability to link plants to their own trading behavior (though one could do that now).
  - Closest link is to the industry, for which we know (from other sources) how much trade is going on.
  - On this basis, Pavcnik characterizes firms (i.e. four-digit industries) as import competing (imports exceed 15% of domestic output), export-oriented (export over 15% of output) or non-tradable (neither of above).
  - One would really want to use tariffs at the industry level and exploit time variation in these (as some other studies have done).

Production function estimation

TABLE 2

Estimates of production functions

		Balanced panel				Full sample					
		OLS		Fixed effects		OLS		Fixed effects		Series	
		(1)		(2)		(3)		(4)		(5)	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Food processing	Unskilled labour	0·152	0·007	0·185	0·012	0·178	0·006	0·210	0·010	0·153	0·007
	Skilled labour	0·127	0·006	0·027	0·008	0·131	0·006	0·029	0·007	0·098	0·009
	Materials	0·790	0·004	0·668	0·008	0·763	0·004	0·646	0·007	0·735	0·008
	Capital	0·046	0·003	0·011	0·007	0·052	0·003	0·014	0·006	0·079	0·034
	N	6432				8464				7085	
Textiles	Unskilled labour	0·187	0·011	0·240	0·017	0·229	0·009	0·245	0·015	0·215	0·012
	Skilled labour	0·184	0·010	0·088	0·014	0·183	0·009	0·088	0·012	0·177	0·011
	Materials	0·667	0·007	0·564	0·011	0·638	0·006	0·558	0·009	0·637	0·097
	Capital	0·056	0·005	0·015	0·012	0·059	0·004	0·019	0·011	0·052	0·034
	N	3689				5191				4265	
Wood	Unskilled labour	0·233	0·016	0·268	0·026	0·247	0·013	0·273	0·022	0·195	0·015
	Skilled labour	0·121	0·015	0·040	0·021	0·146	0·012	0·047	0·018	0·130	0·014
	Materials	0·685	0·010	0·522	0·014	0·689	0·008	0·554	0·011	0·679	0·010
	Capital	0·055	0·007	0·023	0·018	0·050	0·006	−0·002	0·016	0·101	0·051
	N	1649				2705				2154	
Paper	Unskilled labour	0·218	0·024	0·258	0·033	0·246	0·021	0·262	0·029	0·193	0·024
	Skilled labour	0·190	0·018	0·022	0·027	0·180	0·016	0·050	0·023	0·203	0·018
	Materials	0·624	0·013	0·515	0·025	0·597	0·011	0·514	0·021	0·601	0·014
	Capital	0·074	0·010	0·031	0·025	0·085	0·009	0·031	0·023	0·068	0·018
	N	1039				1398				1145	
Chemicals	Unskilled labour	0·033	0·014	0·239	0·022	0·067	0·013	0·246	0·020	0·031	0·014
	Skilled labour	0·211	0·013	0·079	0·018	0·213	0·012	0·090	0·017	0·194	0·016
	Materials	0·691	0·009	0·483	0·013	0·698	0·008	0·473	0·013	0·673	0·012
	Capital	0·108	0·008	0·032	0·014	0·089	0·007	0·036	0·013	0·129	0·052
	N	2145				2540				2087	
Glass	Unskilled labour	0·353	0·032	0·405	0·045	0·406	0·030	0·435	0·043	0·426	0·035
	Skilled labour	0·285	0·035	0·068	0·042	0·226	0·031	0·056	0·038	0·183	0·036
	Materials	0·523	0·022	0·360	0·026	0·544	0·019	0·403	0·024	0·522	0·024
	Capital	0·092	0·041	−0·015	0·036	0·093	0·011	−0·013	0·030	0·142	0·053
	N	623				816				666	
Basic metals	Unskilled labour	0·080	0·037	0·137	0·070	0·105	0·037	0·174	0·072	0·121	0·041
	Skilled labour	0·158	0·034	0·008	0·070	0·156	0·034	0·006	0·072	0·117	0·043
	Materials	0·789	0·017	0·572	0·040	0·771	0·016	0·567	0·039	0·727	0·032
	Capital	0·030	0·014	0·033	0·030	0·025	0·013	0·034	0·032	0·110	0·051
	N	306				362				255	
Machinery	Unskilled labour	0·186	0·013	0·225	0·018	0·199	0·012	0·238	0·016	0·178	0·015
	Skilled labour	0·238	0·011	0·130	0·016	0·222	0·010	0·112	0·014	0·202	0·012
	Materials	0·611	0·008	0·530	0·012	0·619	0·007	0·548	0·010	0·617	0·009
	Capital	0·078	0·006	0·057	0·013	0·078	0·005	0·047	0·013	0·051	0·013
	N	3025				4015				3268	

Note: Under full sample, the number of observations is lower in the series than in the OLS column because the series estimation requires lagged variables. I have also estimated OLS and fixed effects regressions excluding these observations. The coefficients do not change much. All standard errors in column 5 are bootstrapped using 1000 replications.

Decomposition

- Decompose productivity in industry in year t

$$W_t = \sum_i s_{it} pr_{it} = \overline{pr}_t + \sum_i (s_{it} - \bar{s}_t)(pr_{it} - \overline{pr}_t)$$

  where $\overline{pr}_t$ is (unweighted) average productivity in sector in year t and s_{it} is market share of firm i in the sector in year t

- covariance $\sum_i (s_{it} - \bar{s}_t)(pr_{it} - \overline{pr}_t)$ measures whether more productive plants have higher shares
- Table 3 shows growth of two terms $\overline{pr}_t$ and covariance relative to year 1979

TABLE 3

Decomposition of aggregate productivity growth

Industry	Year	Aggregate Productivity	Unweighted Productivity	Covariance	Industry	Year	Aggregate Productivity	Unweighted Productivity	Covariance
Food	79	0·000	0·000	0·000	Chemicals	79	0·000	0·000	0·000
	80	0·005	0·008	−0·003		80	0·014	0·046	−0·032
	81	0·008	0·058	−0·049		81	0·126	0·076	0·050
	82	0·209	0·099	0·110		82	0·312	0·039	0·274
	83	0·144	0·049	0·095		83	0·238	−0·050	0·288
	84	0·116	0·044	0·072		84	0·156	−0·040	0·196
	85	0·092	0·014	0·078		85	0·229	−0·033	0·262
	86	0·179	0·129	0·050		86	0·432	−0·056	0·488
Textiles	79	0·000	0·000	0·000	Glass	79	0·000	0·000	0·000
	80	0·064	0·063	0·001		80	0·137	−0·036	0·174
	81	0·148	0·119	0·029		81	0·109	−0·073	0·182
	82	0·147	0·090	0·057		82	0·155	−0·044	0·200
	83	0·075	0·063	0·012		83	0·231	−0·052	0·283
	84	0·130	0·082	0·048		84	0·257	−0·071	0·328
	85	0·136	0·095	0·041		85	0·193	−0·095	0·287
	86	0·184	0·171	0·013		86	0·329	−0·011	0·340
Wood	79	0·000	0·000	0·000	Basic metals	79	0·000	0·000	0·000
	80	−0·052	−0·030	−0·022		80	−0·136	−0·022	−0·114
	81	−0·125	−0·071	−0·054		81	−0·002	0·050	−0·052
	82	0·070	−0·076	0·145		82	0·711	0·215	0·496
	83	0·148	−0·051	0·198		83	0·343	0·030	0·312
	84	0·169	0·038	0·131		84	0·153	−0·037	0·190
	85	0·019	−0·038	0·058		85	0·228	−0·153	0·380
	86	−0·035	0·045	−0·081		86	0·183	−0·076	0·259

Paper	79	0·000	0·000	0·000	Machinery	79	0·000	0·000	0·000
	80	−0·111	−0·035	−0·076		80	0·031	−0·025	0·005
	81	−0·127	0·038	−0·165		81	0·125	0·070	0·055
	82	−0·127	−0·079	−0·048		82	0·131	0·027	0·105
	83	−0·084	−0·221	0·137		83	0·077	0·025	0·053
	84	−0·073	−0·266	0·192		84	0·137	0·072	0·064
	85	−0·252	−0·362	0·110		85	0·083	0·032	0·051
	86	−0·131	−0·326	0·195		86	0·076	0·040	0·036
All	79	0·000	0·000	0·000	Import competing	79	0·000	0·000	0·000
	80	−0·010	0·018	−0·027		80	−0·063	0·027	−0·090
	81	0·051	0·054	−0·003		81	0·032	0·092	−0·061
	82	0·329	0·048	0·281		82	0·088	0·066	0·022
	83	0·174	0·010	0·164		83	0·077	0·034	0·043
	84	0·117	0·025	0·092		84	0·089	0·059	0·030
	85	0·120	−0·003	0·123		85	0·095	0·061	0·034
	86	0·193	0·066	0·127		86	0·319	0·107	0·213
Export oriented	79	0·000	0·000	0·000	Nontraded	79	0·000	0·000	0·000
	80	−0·059	−0·038	−0·021		80	0·044	0·021	0·024
	81	−0·048	−0·054	0·006		81	0·101	0·047	0·054
	82	0·591	0·040	0·551		82	0·228	0·038	0·190
	83	0·326	0·015	0·311		83	0·127	−0·004	0·131
	84	0·178	0·049	0·129		84	0·114	0·000	0·114
	85	0·203	−0·011	0·214		85	0·101	−0·040	0·142
	86	0·254	0·087	0·166		86	0·062	0·038	0·024

Note: The reported growth figures are relative to 1979.

Comments

- Overall productivity in manufacturing goes up by 19.3%:
  - 6.6% due to within plant
  - 12.7% due to reallocation (growth in covariance)
- Effect is stronger in import-competing sectors (more than 15% import/domestic output)

Effect on individual plant productivity

- Specification where k is plant:

$$pr_{ikt} = \alpha_0 + \alpha_1 Time_{it} + \alpha_2 Trade_{it} + \alpha_3 Trade_{it} \times Time_{it} + u_{it}$$

  where $Trade_{it}$ is an indicator for trade status (export-oriented, import-oriented, non-traded) notice this is at the sector level

- $Time_{it}$ is a time dummy, so no adjustment for industry-specific trend
- Difference-in-difference

TABLE 4

Estimates of equation 12

	(1) Coef.	(1) S.E.	(2) Coef.	(2) S.E.	(3) Coef.	(3) S.E.	(4) Coef.	(4) S.E.	(5) Coef.	(5) S.E.	(6) Coef.	(6) S.E.
Export-oriented	0·106	0·030**	0·106	0·030**	0·112	0·031**	0·098	0·048**	0·095	0·048**	0·100	0·046**
Import-competing	0·105	0·021**	0·105	0·021**	0·103	0·021**	−0·024	0·040	−0·025	0·040	−0·007	0·039
ex_80	−0·054	0·025**	−0·053	0·025**	−0·055	0·025**	−0·071	0·026**	−0·068	0·026**	−0·071	0·026**
ex_81	−0·099	0·028**	−0·097	0·028**	−0·100	0·028**	−0·117	0·027**	−0·110	0·027**	−0·119	0·027**
ex_82	0·005	0·032	0·007	0·032	0·003	0·032	−0·054	0·028*	−0·042	0·028	−0·055	0·028*
ex_83	0·021	0·032	0·023	0·032	0·021	0·032	−0·036	0·029	−0·025	0·030	−0·038	0·029
ex_84	0·050	0·031	0·051	0·031	0·050	0·031	0·007	0·028	0·017	0·028	0·007	0·028
ex_85	0·030	0·030	0·032	0·031	0·028	0·030	−0·001	0·029	0·013	0·030	−0·003	0·029
ex_86					0·043	0·036					−0·008	0·034
im_80	0·011	0·014	0·011	0·014	0·010	0·014	0·013	0·014	0·013	0·014	0·013	0·014
im_81	0·047	0·015**	0·047	0·015**	0·046	0·015**	0·044	0·014**	0·044	0·014**	0·044	0·014**
im_82	0·033	0·016**	0·034	0·017**	0·030	0·016*	0·024	0·015*	0·024	0·015*	0·025	0·015*
im_83	0·042	0·017**	0·043	0·017**	0·043	0·017**	0·040	0·015**	0·041	0·015**	0·042	0·015**
im_84	0·062	0·017**	0·062	0·017**	0·063	0·017**	0·059	0·015**	0·059	0·015**	0·061	0·015**
im_85	0·103	0·017**	0·104	0·017**	0·104	0·017**	0·101	0·015**	0·102	0·016**	0·101	0·015**
im_86					0·071	0·019**					0·073	0·017**
Exit indicator	−0·081	0·011**	−0·076	0·014**			−0·019	0·010**	−0·010	0·013		
Exit_export indicator			−0·021	0·036					−0·069	0·035*		
Exit_import indicator			−0·007	0·023					−0·005	0·021		
Industry indicators	yes		yes		yes		yes		yes		yes	
Plant indicators	no		no		no		yes		yes		yes	
Year indicators	yes		yes		yes		yes		yes		yes	
R^2 (adjusted)	0·057		0·058		0·062		0·498		0·498		0·488	
N	22983		22983		25491		22983		22983		25491	

Note: ** and * indicate significance at a 5% and 10% level, respectively. Standard errors are corrected for heteroscedasticity. Standard errors in columns 1–3 are also adjusted for repeated observations on the same plant. Columns 1, 2, 4, and 5 do not include observations in 1986 because one cannot define exit for the last year of a panel.

Comments

- Plants that exit are on average 8.1% less productive than surviving ones
- Plants in import-competing sectors become more productive by 3-10.4%
- Plants in export-oriented sectors don't see their productivity change

TABLE 5—EARNINGS, WAGES, HOURS, INEQUALITY, AND OUTPUT

	Canadian tariffs		U.S. tariffs		Total FTA impact		Business conditions	U.S. control	
Variable	β^{CA}	t	β^{US}	t	TFI	t	δ	γ	Adjusted R^2
Earnings—All workers									
1 Industry	0.05	2.43	0.03	1.92	0.03	3.80	0.34*	0.25*	0.20
10 Plant	0.04	2.92	0.04	3.60	0.03	5.64	0.17*	0.19*	0.03
Earnings—Production workers									
1 Industry	0.04	2.12	0.00	−0.02	0.02	3.61	0.16*	0.11	0.07
10 Plant	0.05	3.25	0.03	2.57	0.03	4.74	0.12	0.21	0.02
Earnings—Nonproduction workers									
1 Industry	0.01	0.30	−0.01	−0.29	0.00	0.02	0.18*	0.12	0.08
10 Plant	0.04	1.48	0.06	2.87	0.03	3.67	0.11	0.11	0.01
Hourly wages of production workers									
1 Industry	0.05	3.15	0.03	1.84	0.03	4.37	0.60*	0.13	0.33
10 Plant	0.06	3.23	0.02	1.40	0.03	4.04	0.20	0.16*	0.01
Annual hours of production workers									
1 Industry	−0.01	−0.48	−0.02	−1.75	−0.01	−1.94	0.02	0.14	0.01
10 Plant	−0.02	−0.90	0.01	0.80	0.00	−0.12	0.03	0.07	0.00
Earnings inequality									
1 Industry	−0.04	−1.32	−0.01	−0.55	−0.02	−1.66	0.42*	0.05	0.21
10 Plant	−0.01	−0.46	0.02	0.97	0.00	0.41	0.13*	0.08	0.00
Gross output per plant in production activities									
1 Industry	−0.05	−0.65	0.03	0.54	0.00	−0.05	0.30*		0.18
10 Plant	−0.05	−1.36	0.06	2.01	0.01	0.72	0.16*		0.05