14.582: International Trade II
— Lecture 5: Firm-level Heterogeneity (Empirics II) —

Firm- and Industry-level Responses to Trade Liberalization

- An enormous literature has used firm-level panel datasets to explore how firms (and, hence, entire industries) respond to trade liberalization episodes.
- This has been important for policy, as well as for the development of theory.
- Interestingly, the first available data (and the largest and most plausibly exogenous trade liberalization episodes) was from developing countries. So this has been important for the field of Development Economics as well.

Measuring Aggregate Industry Productivity: Some Caveats

- Most of these studies have been concerned with the effects of trade liberalization on aggregate industry productivity, defined in quite a naive way as some weighted sum of each firm's physical productivity.
- Unfortunately, one often cares about much more than this.
  - Within industries, consumers may care about some firms' varieties more than others'.
  - Trade liberalization will also change the set of imported varieties, and this effect is obviously not counted at all in measures of an industry's (purely domestic) productivity.
- Data limitations have presented a full and integrated assessment of all of these channels.
- Bottom line: when there are multiple goods (as there obviously are within differentiated product industries), average/total productivity is not necessarily a good proxy for welfare.

Aggregate Industry Productivity: A Decomposition I

- Tybout and Westbrook (1995), among others, provide a helpful way of thinking about the effects of trade liberalization on aggregate industry productivity.
- Notation:
  - Output of firm i in year t is: $q_{it} = A_{it} f(v_{it})$, where A_{it} is firm-level TFP and v_{it} is a vector of inputs.
  - Let $f(v_{it}) = \gamma(g(v_{it}))$, where the function $g(.)$ is CRTS. Then all economies of scale are in $\gamma(.)$.
  - Let $B_{it} = q_{it}/g(v_{it})$ be measured productivity.
  - And let $S_{it} = g(v_{it})/\sum_i g(v_{it})$ be the firm's market share in its industry, but where market shares are calculated on the basis of inputs used.
  - And let $\mu_{it} = \frac{d\ln(q_{it})}{d\ln(g_{it})}$.

Aggregate Industry Productivity: A Decomposition II

- Then industry-wide average productivity (*defined* as $B_t \equiv \sum_i S_{it} B_{it}$) will change according to:

$$\frac{dB_t}{B_t} = \underbrace{\sum_i \left(\frac{dg_{it}}{g_{it}}\right)(\mu_{it} - 1)\left(\frac{q_{it}}{q_t}\right)}_{\text{Scale effects}} + \underbrace{\sum_i dS_{it}\left(\frac{B_{it}}{B_t}\right)}_{\text{Between-firm reallocation effects}} + \underbrace{\sum_i \left(\frac{dA_{it}}{A_{it}}\right)\left(\frac{q_{it}}{q_t}\right)}_{\text{Within-firm TFP effects}}$$

- The literature here has looked at the extent to which each of these terms responds to a liberalization of trade policy.

Trade Liberalization: Scale Effects

- Not much work on this.
- But Tybout (2001, Handbook chapter) argues that since exporting plants are already big it is unlikely that there is a large potential for trade to expand underexploited scale economies.
- Likewise, since the bulk of production in any industry is concentrated on already-large firms, the scope for the 'scale effects' term to matter in terms of changes is small.

Trade Liberalization: Within- and Between-Firm Effects

- This is where the bulk of work has been done.
- Indeed, the finding of apparently substantial aggregate productivity gains from between-firm reallocations was an important impetus for work on heterogeneous firm models in trade.
  - The finding that reallocations of factors (and market share) from low-B_{it} to high-B_{it} firms can be empirically significant was taken by some as evidence for an 'additional' source of *welfare* gains from trade. (But, again, important to keep in mind that this "aggregate productivity" term is not necessarily a clean measure of welfare.)

Trade Liberalization: Pavcnik (REStud, 2002)

- Pavcnik (2002) recognized that a good measure of $\frac{dB_t}{B_t}$ and each of its two decomposition terms $\sum_i dS_{it}\left(\frac{B_{it}}{B_t}\right)$ and $\sum_i \left(\frac{dA_{it}}{A_{it}}\right)\left(\frac{q_{it}}{q_t}\right)$ required a good measure of B_{it}.
- It is hard to measure these TFP terms B_{it} because of:
  - Simultaneity: Firms probably observe B_{it} and take actions (eg how much factor inputs to use) based on it. The econometrician doesn't observe B_{it}, but can infer it by comparing outputs to factor inputs used. But this only works if one is careful to invert the firm's decisions about factor input choices that were based on B_{it}.
  - Selection: Firms with low B_{it} might drop out of the sample and thus not be observed to the same extent as high B_{it} firms.
- Pavcnik (2002) was the first to apply to trade liberalization Olley and Pakes (1996)'s techniques for dealing with simultaneity and selection.
  - We discuss this briefly first before returning to the decomposition.

Olley and Pakes (Ecma, 1996)

- Drop the firm subscript i (but everything below is at the firm level).
- Let x_t be variable inputs that can be adjusted freely, and let k_t be capital which takes a period to adjust and is costly to do so (usual convex costs).
- So output is: $y_t = \beta_0 + \beta x_t + \beta_k k_t + \omega_t + \mu_t$, where ω_t is TFP that the firm knows and μ_t is the TFP that the firm does not know. (The econometrician knows neither.) Both are Markov random variables (which is not innocuous actually, since we are trying to estimate TFP in order to relate it to trade policy; is trade policy Markovian?)
- Ericsson and Pakes (1995) show that:
  - It is a Markov Perfect Equilibrium for firms to exit unless ω_t exceeds some cutoff $\underline{\omega}_t(k_t)$.
  - Investment behaves as: $i_t = i_t(\omega_t, k_t)$, where $i_t(.)$ is strictly increasing in both arguments.

Olley and Pakes (1996)

- First step: estimate β.
- Estimating β (the coefficient on variable inputs) is easier since we're assuming that any firm in the sample in year t woke up in t, observed its ω_t, and chose exactly as many variable inputs x_t as it wanted.
  - Invert $i_t = i_t(\omega_t, k_t)$: $\omega_t = \theta_t(i_t, k_t)$. Note that we have no idea what the function $\theta(.)$ looks like.
  - Then we have $y_t = \beta x_t + \lambda_t(k_t, i_t) + \mu_t$, where $\lambda_t(k_t, i_t) \equiv \beta_0 + \beta_k k_t + \theta_t(k_t, i_t)$.
  - Estimate this function y_t and control for $\lambda(.)$ non-parametrically.
  - This is typically done with a 'series/polynomial estimator': some high-order (Pavcnik uses 3rd-order) polynomial in k_t and i_t.
  - With $\lambda_t(.)$ controlled for, the coefficient on x_t is just β.

Olley and Pakes (1996)

- Second step: estimate β_k.
- This is more complicated, as the firm makes an investment decision i_t in year t that is forward-looking, and this decision determines k_{t+1}. The firms know more about ω_{t+1} than we do, so we need to worry about this.
  - Let the firm's expectation about ω_{t+1} be: $E\left[\omega_{t+1}|\omega_t, k_t\right] = g(\omega_t) - \beta_0$. We have no idea what $g(.)$ is, but it should be strictly upward-sloping.
  - Note that $g(\omega_t) = g(\theta_t(i_t, k_t)) = g(\lambda_t - \beta_k k_t)$. We already have estimates of λ_t from Step 1 so think of λ_t as observed.
  - So we have: $y_{t+1} - \beta x_{t+1} = \beta_k k_{t+1} + g(\lambda_t - \beta_k k_t) + \xi_{t+1} + \mu_{t+1}$. ($\xi_{t+1}$ is defined by: $\xi_{t+1} = \omega_{t+1} - E\left[\omega_{t+1}|\omega_t, k_t\right]$.)
  - The goal is to estimate β_k, which we can do here with non-parametric functions $g(.)$ and non-linear estimation (β_k appears inside $g(.)$).

Olley and Pakes (1996)

- However, the above procedure (in Step 2) is invalid if some firms will exit the sample.
  - That is, we only observe the firms whose expectations about ω_{t+1} exceed the continuation cut-off $\underline{\omega}_t(k_t)$.
- OP (1996) derive another correction for this:
  - let $P_t = \Pr(\text{continuing in } t+1) =$ $\Pr\left[\omega_{t+1} > \underline{\omega}_{t+1}(k_{t+1}) | \underline{\omega}_{t+1}(k_{t+1}), \omega_t\right] = p_t(\omega_t, \underline{\omega}_{t+1}(k_{t+1}))$.
  - And let $\Phi(\omega_t, \underline{\omega}_{t+1}(k_{t+1})) = E\left[\omega_{t+1} | \omega_t, \omega_{t+1} > \underline{\omega}_{t+1}(k_{t+1})\right] + \beta_0$.
  - So $\Phi(\omega_t, \underline{\omega}_{t+1}(k_{t+1})) = \Phi(\omega_t, p_t^{-1}(P_t, \omega_t)) = \Phi(\omega_t, P_t)$.
  - Hence we should really estimate $y_{t+1} - \beta x_{t+1} = \beta_k k_{t+1} + \Phi(\lambda_t - \beta_k k_t, P_t) + \xi_{t+1} + \mu_{t+1}$
  - This requires an estimate of P_t, the probability of survival. OP show that $P_t = p_t(i_t, k_t)$ so we can estimate P_t from a series polynomial probit regression of a survival dummy on polynomials in i_t and k_t.

Levinsohn and Petrin (REStud, 2003)

- A limitation of the OP procedure is that it requires investment to be non-zero (recall that $i_t(.)$ is strictly increasing).
- In the OP model this will never happen, but in the data it does.
  - Caballero and Engel and others have done work on models that do include this 'lumpy investment'.
  - Clearly the extent of the problem depends on the length of a 'period' t in the data.
  - Long periods can mask (i.e. smooth over) the lumpy nature of investment but it is probably still a constraint on investment that firms have to worry about).
- Levinsohn and Petrin (2003) introduce a procedure for dealing with this (but Pavcnik doesn't use it).

Pavcnik (2002): Data and Setting

- Chile's trade liberalization:
  - Began in 1974, finished 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).

Pavcnik (2002): Results

Exit is important

TABLE 1

Plants active in 1979 *but not in* 1986

Trade orientation	Share of plants	Share of labour	Share of capital	Share of investment	Share of value added	Share of output
Exiting plants of a given trade orientation as a share of all plants active in 1979						
All trade orientations	0·352	0·252	0·078	0·135	0·155	0·156
Export-oriented	0·045	0·049	0·009	0·039	0·023	0·023
Import-competing	0·141	0·108	0·029	0·047	0·068	0·065
Nontraded	0·165	0·095	0·040	0·049	0·064	0·067
Exiting plants of a given trade orientation as a share of all exiting plants						
Export-oriented	0·129	0·194	0·117	0·289	0·149	0·148
Import-competing	0·401	0·429	0·369	0·350	0·436	0·419
Nontraded	0·470	0·377	0·513	0·361	0·415	0·432
Exiting plants of a given trade orientation as a share of all plants active in 1979 in the corresponding trade sector						
Export-oriented	0·416	0·298	0·030	0·172	0·121	0·128
Import-competing	0·383	0·263	0·093	0·149	0·183	0·211
Nontraded	0·316	0·224	0·104	0·107	0·147	0·132

Note: This figure also includes plants that exited after the end of 1979, but before the end of 1980 and were excluded in the estimation because of missing capital variable.

Pavcnik (2002): Results

Production function estimation ('series' is the OP method)

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.

Pavcnik (2002): Results

Industry aggregate productivity growth, and its decomposition

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.

Pavcnik (2002): Results on Trade Liberalization

$TFP_{it} = \alpha_t + \alpha_i + \alpha_3(Trade \times Time)_{it} + \nu_{it}$

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.

Trefler (AER, 2004)

- Trefler evaluates how Canadian industries and plants responded to Canada's trade agreement with the United States in 1989.
- This is a particularly 'clean' trade liberalization (not a lot of other components of some broader 'liberalization package' as was often the case in developing country episodes).
- Further, this is a rare example in the literature of a *reciprocal* trade agreement:
    - Canada lowered its tariffs on imports from the US, so Canadian firms in import-competing industries face more competition.
    - And the US lowered its tariffs on Canadian imports, so Canadian firms in export-oriented industries face lower costs of penetrating US markets.
- So this is a great 'experiment'. Unfortunately the data aren't as rich as Pavcnik's so Trefler can't look at everything we'd like.

Trefler (2004): The Reciprocal Trade Liberalization

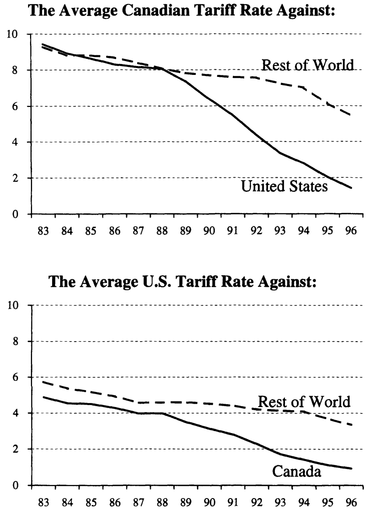

FIGURE 1. CANADIAN AND U.S. BILATERAL TARIFFS IN MANUFACTURING
(In Percents)

Trefler (2004): Empirical Approach

- Define the policy 'treatment' variables:
  - Let τ_{it}^{CA} be the FTA-mandated Canadian tariff on US imports in industry i and year t. This is the gap between the solid and dotted lines in the previous figure (top panel).
  - Let τ_{it}^{US} be the US equivalent.
- Trefler estimates the following 'diff-in-diff' regression (notation explained on next slide):

$$\begin{aligned}(\Delta y_{i1} - \Delta y_{i0}) &= \theta + \beta^{CA}(\Delta\tau_{i1}^{CA} - \Delta\tau_{i0}^{CA}) + \beta^{US}(\Delta\tau_{i1}^{US} - \Delta\tau_{i0}^{US}) \\ &+ \gamma(\Delta y_{i1}^{US} - \Delta y_{i0}^{US}) + \delta(\Delta b_{i1} - \Delta b_{i0}) + \nu_i\end{aligned}$$

Trefler (2004): Empirical Approach

- Trefler estimates the following 'diff-in-diff' regression:

$$(\Delta y_{i1} - \Delta y_{i0}) = \theta + \beta^{CA}(\Delta \tau_{i1}^{CA} - \Delta \tau_{i0}^{CA}) + \beta^{US}(\Delta \tau_{i1}^{US} - \Delta \tau_{i0}^{US}) + \gamma(\Delta y_{i1}^{US} - \Delta y_{i0}^{US}) + \delta(\Delta b_{i1} - \Delta b_{i0}) + \nu_i$$

- Notation:
  - ΔX_{is} is defined as the annualized log growth of a variable 'X_i' over all years in period s. Note that this means the specification is DD in growth rates of y.
  - There are two periods s: that before the FTA (1980-1986, $s = 0$), and that after the FTA (1988-1996, $s = 1$).
  - y is any outcome variable. Employment and output per worker are the two main outcomes of interest.
  - y^{US} is the same outcome variable but for industries in the US. This is meant to act as a control, but it is endogenous so needs an IV.
  - b is 'business conditions': measures based on GDP and real exchange rates.

Trefler (2004): Empirical Approach

- Trefler (2004) looks at this specification with both plant-level and industry-level data.
  - A caveat is that the paper focuses on plants that have good data, which is relatively large plants only.
  - Another caveat is that the above approach requires units of analysis to be observed in 1980, 1986, 1988 and 1996. So any exiting or newly entering firms are not part of the analysis.
- To do this he runs exactly the same regression as above on plants within industries, rather than on industries. Note however that the 'treatment' variable τ_{it}^{CA} does not differ across plants.
  - This is attractive here, as it means we can directly compare the tariff coefficient in the industry regression with that in the plant-level regression—if these coefficients differ, this is suggestive of reallocation effects across plants generating aggregate industry-level losses/gains.
  - NB: Trefler and Lileeva (QJE 2009), which focuses on a different question (and which we look at later in the course), does construct firm-specific tariffs by using tariffs on each of the 'products' (6-digit industries) that each firm produces.

Trefler (2004): Results on Employment

NB: 'β^{CA}' (etc) reported here is really $\widehat{\beta}^{CA}\Delta\tau^{CA}_{k1}$ where 'k' means 'an an average of the 1/3rd most affected industries'.

Table 1—Detailed Results for Employment

	Construction of Δb	Canadian tariffs $\Delta\tau^{CA}$		U.S. tariffs $\Delta\tau^{US}$		Business conditions Δb		U.S. control Δy^{US}		Adjusted R^2	OverId/ Hausman	Total FTA impact	
		β^{CA}	t	β^{US}	t	δ	t	γ	t			*TFI*	t
Industry level, OLS													
1	*gdp*, *rer* (2)	−0.12	−2.35	−0.03	−0.67	0.29	6.96	0.15	2.21	0.24		−0.05	−2.66
2	*gdp*, *rer* (0)	−0.11	−2.03	−0.04	−0.91	0.30	3.66	0.21	2.75	0.12		−0.06	−2.58
3	*gdp* (2)	−0.11	−2.08	−0.03	−0.66	0.37	6.60	0.15	2.16	0.23		−0.05	−2.41
4	—	−0.14	−2.40	−0.02	−0.52			0.20	2.58	0.07		−0.06	−2.58
5	*gdp*, *rer* (2)	−0.13	−2.48	−0.02	−0.39	0.28	6.74	0.29	3.00	0.24		−0.05	−1.71
6	*gdp*, *rer* (2)	−0.14	−2.75	−0.03	−0.80	0.30	7.12			0.23		−0.06	−3.16
7	—	−0.17	−2.88	−0.03	−0.66					0.04		−0.07	−3.15
8	*gdp*, *rer* (2)	−0.14	−2.24	−0.02	−0.53	0.29	6.89	0.15	2.11	0.24		−0.06	−2.65
9	*gdp*, *rer* (2)	−0.12	−2.30	−0.06	−1.45	0.30	7.23	0.14	2.04	0.27		−0.06	−3.24
Plant level, OLS													
10	*gdp*, *rer* (2)	−0.12	−3.76	0.00	0.15	0.13	4.59	0.25	5.29	0.04		−0.04	−3.26
11	*gdp*, *rer* (2)	−0.12	−3.60	−0.01	−0.26	0.16	5.63	0.25	5.21	0.02		−0.04	−3.51
Industry level, IV													
12	*gdp*, *rer* (2)	−0.24	−1.45	0.09	0.66	0.29	6.68	0.15	2.06	0.22	0.60/0.65	−0.04	−1.26
13	*gdp*, *rer* (2)	−0.24	−1.43	0.04	0.29	0.31	6.37	−0.16	−0.50	0.20	0.67/0.57	−0.05	−1.57
Plant level, IV													
14	*gdp*, *rer* (2)	−0.19	−2.40	0.07	0.94	0.13	4.30	0.24	4.96	0.04	0.14/0.99	−0.04	−2.55
15	*gdp*, *rer* (2)	−0.19	−2.44	0.07	0.92	0.13	4.17	0.16	0.95	0.03	0.10/0.89	−0.04	−3.10

Notes: The dependent variable is the log of employment. The estimating equation is equation (6) for the industry-level regressions and equation (7) for the plant-level regressions. β^{CA} is scaled so that it gives the log-point impact of the Canadian tariff concessions on employment in the most impacted, import-competing industries. β^{US} is scaled so that it gives the log-point impact of the U.S. tariff concessions on employment in the most impacted, export-oriented industries. The "Total FTA impact" column gives the joint impact of the tariff concessions on employment in all 213 industries. The "OverId/Hausman" column reports p-values for the overidentification and Hausman tests. Rejection of the instrument set or exogeneity are indicated by p-values less than 0.01. The number of observations is 213 for the industry-level regressions and 3,801 for the plant-level regressions. In rows 4 and 7, the business conditions variable is omitted so that business conditions are controlled for implicitly by double-differencing $\Delta y_{i1} - \Delta y_{i0}$. In row 5 the U.S. control is replaced by the Japan-U.K. control discussed in the text. In row 8, the 2 "outlier" observations with the largest Canadian tariff cuts are omitted. In row 9, all 9 observations associated with the automotive sector are omitted. In row 11, the plant controls are omitted. In rows 12 and 14, only the Canadian and U.S. tariff variables are instrumented. In rows 13 and 15, the two tariff variables and the U.S. control are instrumented.

Trefler (2004): Results on Value Added per Hour

NB: 'β^{CA}' (etc) reported here is really $\widehat{\beta}^{CA}\Delta\tau_{k1}^{CA}$ where 'k' means 'an an average of the 1/3rd most affected industries'.

TABLE 2—DETAILED RESULTS FOR LABOR PRODUCTIVITY

	Construction of Δb	Canadian tariffs $\Delta\tau^{CA}$ β^{CA}	t	U.S. tariffs $\Delta\tau^{US}$ β^{US}	t	Business conditions Δb δ	t	U.S. control Δy^{US} γ	t	Adjusted R^2	OverId/ Hausman	Total FTA impact *TFI*	t
Industry level, OLS													
1	*gdp*, *rer* (2)	0.15	3.11	0.04	1.14	0.25	8.30	0.16	1.99	0.31		0.058	3.79
2	*gdp*, *rer* (0)	0.15	2.77	0.02	0.40	0.13	1.79	0.28	3.05	0.09		0.050	2.87
3	*gdp* (2)	0.17	3.21	0.04	1.17	0.25	5.19	0.21	2.43	0.18		0.065	3.87
4	—	0.16	2.85	0.01	0.34			0.29	3.23	0.08		0.051	2.89
5	*gdp*, *rer* (2)	0.14	2.79	0.05	1.36	0.26	8.77	0.05	0.31	0.29		0.058	2.46
6	*gdp*, *rer* (2)	0.14	2.96	0.05	1.44	0.27	8.82			0.30		0.059	3.89
7	—	0.15	2.58	0.03	0.76					0.04		0.053	2.98
8	*gdp*, *rer* (2)	0.17	2.97	0.04	0.98	0.26	8.34	0.16	1.95	0.30		0.061	3.76
9	*gdp*, *rer* (2)	0.16	3.27	0.02	0.49	0.26	8.61	0.18	2.24	0.33		0.051	3.36
Plant level, OLS													
10	*gdp*, *rer* (2)	0.08	1.70	0.14	3.97	0.12	3.95	0.11	1.51	0.06		0.074	4.92
11	*gdp*, *rer* (2)	0.09	1.92	0.11	3.02	0.10	3.18	0.14	1.79	0.01		0.066	4.39
Industry level, IV													
12	*gdp*, *rer* (2)	0.15	1.10	0.10	0.86	0.26	8.09	0.14	1.53	0.30	0.86/0.43	0.081	3.41
13	*gdp*, *rer* (2)	0.13	0.89	0.13	1.01	0.28	6.99	−0.08	−0.28	0.28	0.87/0.51	0.083	3.40
Plant level, IV													
14	*gdp*, *rer* (2)	0.22	1.67	0.05	0.49	0.11	3.20	0.17	1.80	0.06	0.06/0.77	0.082	2.53
15	*gdp*, *rer* (2)	0.79	2.58	−0.49	−1.73	−0.19	−1.29	2.07	2.29	0.05	0.76/0.52	0.050	0.39

Notes: The dependent variable is the log of labor productivity. The estimating equation is equation (6) for the industry-level regressions and equation (7) for the plant-level regressions. The number of observations is 211 for the industry-level regressions and 3,726 for the plant-level regressions. See the notes to Table 1 for additional details. In rows 4 and 7, the business conditions variable is omitted so that business conditions are controlled for implicitly by double-differencing $\Delta y_{i1} - \Delta y_{i0}$. In row 5 the U.S. control is replaced by the Japan-U.K. control discussed in the text. In row 8, the two "outlier" observations with the largest Canadian tariff cuts are omitted. In row 9, all nine observations associated with the automotive sector are omitted. In row 11, the plant controls are omitted. In rows 12 and 14, only the Canadian and U.S. tariff variables are instrumented. In rows 13 and 15, the two tariff variables and the U.S. control are instrumented.

Subsequent Work: de Loecker (Ecma, 2011)

- A well-known (and probably severe) problem with measuring productivity is that we rarely observe output y_{it} properly.
  - Instead, in most settings, one sees revenues/sales r_{it} at the plant level but some price measure only at the industry level: p_t.

- Klette and Griliches (1995) show the consequences of this:
  - What we think is a measure of firm-level TFP (eg $y_{it}/g(v_{it})$) is really a mixture of firm-level TFP, firm-level mark-ups, and firm-level demand-shocks.
- This is bad for studies of productivity. But it is worse for studies like Pavcnik (2002) above that want to relate economic change (like trade liberalization) to changes in productivity.
  - Trade liberalization could change mark-ups and demand.
  - Indeed, theory such as BEJK (2003) and Melitz and Ottaviano (ReStud, 2008) suggests that mark-ups will change.
  - And Tybout (2000, Handbook chapter) reviews evidence of mark-ups (and profit margins) changing (see also de Loecker and Warzynski (AER, 2012) and deLGKP (Ecma, 2016)).

de Loecker (2010)

- de Loecker (2010) proposes a solution to this problem:
  - Specifies a demand system (CES across each firm's variety, plus firm-specific demand shifters).
  - This leads to an estimating equation like that used in OP (1996), but with two complications.
  - First, each firm's demand-shifter appears on the RHS. He effectively instruments for these using trade reform variables (quotas, in a setting of Belgian textiles).
  - Second, each coefficient (eg β_k on capital) is no longer the production function parameter, but rather the production function parameter times the markup. But there is a way to correct for this after estimating another coefficient (that on total industry quantity demanded) which is the CES taste parameter (from which one can infer the markup).
- This correction implies that the measured productivity effects of Belgium's textile industry are 50% than previously thought.
- See de Loecker and Goldberg (ARE, 2015) and de Loecker and van Biesebroeck (2016) for nice overviews of this literature.