14.581 MIT PhD International Trade —Lecture 13: Firm-Level Trade (Empirics Part I)—

Dave Donaldson

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Plan for 2 Lectures on Firm-Level Trade

1. First lecture:
   - Introduction: Firm-Level evidence on trade
   - Stylized facts about exporting firms
   - The response of firms and industries to trade liberalization

2. Second lecture:
   - Trade flows: intensive and extensive margins
   - Exporting across multiple destinations
   - Producing and exporting multiple products.

Plan for Today's Lecture

1. **Introduction**
2. Stylized facts about exporting at firm level:
   2.1 Exporting is rare
   2.2 Exporters are different
3. Firm-level responses to trade liberalization
   3.1 Pavcnik (2002)
   3.2 Trefler (2004)
   3.3 de Loecker (2011)

Introduction I

- Hallak and Levinsohn (2005): "Countries don't trade. Firms trade."
- Since around 1990, trade economists have increasingly used data from individual firms in order to better understand:
  - Why countries trade.
  - The mechanisms of adjustment to trade liberalization: mark-ups, entry, exit, productivity changes, factor price changes.
  - How important trade liberalization is for economic welfare.
  - Who are the winners and losers of trade liberalization?

Introduction II

- This has been an extremely influential development for the field.
  - Micro-level heterogeneity seems so important that industry-level data is now often thought to provide insights that are far too ‘coarse’ to be learned from.
  - And clearly this micro-level heterogeneity is often the object of interest for many studies, so micro-data is the only option.

Introduction III

- However, for many important questions that are aggregate in nature, exactly what is lost by using models and data that have been aggregated is not always clear.
  - For example, Arkolakis, Costinot and Rodriguez-Clare (2010) and Atkeson and Burstein (2009) point out how the presence of intra-industry heterogeneity *does not* change the welfare implications (conditional on trade costs) of a wide class of trade models.

Introduction IV

- A final point is that much of the empirical work using micro-data has forsaken the usual interest in GE
  - The models used to shape empirical work are often not truly GE.
  - And the empirical approaches often don't worry about GE interactions and spillovers.
  - This is typically not discussed or dealt with—but nor is there compelling evidence that these GE forces are strong enough to introduce serious bias.
  - Of course, the issues depend heavily on context.

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   2.1 **Exporting is rare**
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Stylized Facts about Trade at the Firm-Level

- Exporting is extremely rare.
- Exporters are different:
  - They are larger.
  - They are more productive.
  - They use factors differently.
  - They pay higher wages.
- We will go through some of these findings first.

Exporting is Rare

- Two papers provide a clear characterization of just how rare exporting activity is among firms:
  1. Bernard, Jensen, Redding and Schott (JEP, 2007) on US manufacturing.
  2. Eaton, Kortum and Kramarz (2008) on French manufacturing. (We will have more to say about this paper in the next lecture, when we discuss how exporting varies across firms and partner countries.)

- It has been difficult to match firm-level datasets (which typically contain data on total output/sales, but not sales by destination) to shipment-level trade datasets (that contain firm-level identifiers), but fortunately this has been achieved recently (by the above authors, among others).

BJRS (2007)

Table 2

Exporting By U.S. Manufacturing Firms, 2002

NAICS industry	*Percent of firms*	*Percent of firms that export*	*Mean exports as a percent of total shipments*
311 Food Manufacturing	6.8	12	15
312 Beverage and Tobacco Product	0.7	23	7
313 Textile Mills	1.0	25	13
314 Textile Product Mills	1.9	12	12
315 Apparel Manufacturing	3.2	8	14
316 Leather and Allied Product	0.4	24	13
321 Wood Product Manufacturing	5.5	8	19
322 Paper Manufacturing	1.4	24	9
323 Printing and Related Support	11.9	5	14
324 Petroleum and Coal Products	0.4	18	12
325 Chemical Manufacturing	3.1	36	14
326 Plastics and Rubber Products	4.4	28	10
327 Nonmetallic Mineral Product	4.0	9	12
331 Primary Metal Manufacturing	1.5	30	10
332 Fabricated Metal Product	19.9	14	12
333 Machinery Manufacturing	9.0	33	16
334 Computer and Electronic Product	4.5	38	21
335 Electrical Equipment, Appliance	1.7	38	13
336 Transportation Equipment	3.4	28	13
337 Furniture and Related Product	6.4	7	10
339 Miscellaneous Manufacturing	9.1	2	15
Aggregate manufacturing	**100**	**18**	**14**

Sources: Data are from the 2002 U.S. Census of Manufactures.
Notes: The first column of numbers summarizes the distribution of manufacturing firms across three-digit NAICS manufacturing industries. The second reports the share of firms in each industry that export. The final column reports mean exports as a percent of total shipments across all firms that export in the noted industry.

BJRS (2007)

Table 7

Exporting and Importing by U.S. Manufacturing Firms, 1997

NAICS industry	*Percent of all firms*	*Percent of firms that export*	*Percent of firms that import*	*Percent of firms that import & export*
311 Food Manufacturing	7	17	10	7
312 Beverage and Tobacco Product	1	28	19	13
313 Textile Mills	1	47	31	24
314 Textile Product Mills	2	19	13	9
315 Apparel Manufacturing	6	16	15	9
316 Leather and Allied Product	0	43	43	30
321 Wood Product Manufacturing	5	15	5	3
322 Paper Manufacturing	1	42	18	15
323 Printing and Related Support	13	10	3	2
324 Petroleum and Coal Products	0	32	17	14
325 Chemical Manufacturing	3	56	30	26
326 Plastics and Rubber Products	5	42	20	16
327 Nonmetallic Mineral Product	4	16	11	7
331 Primary Metal Manufacturing	1	51	23	21
332 Fabricated Metal Product	20	21	8	6
333 Machinery Manufacturing	9	47	22	19
334 Computer and Electronic Product	4	65	40	37
335 Electrical Equipment, Appliance	2	58	35	30
336 Transportation Equipment	3	40	22	18
337 Furniture and Related Product	6	13	8	5
339 Miscellaneous Manufacturing	7	31	19	15
Aggregate manufacturing	**100**	**27**	**14**	**11**

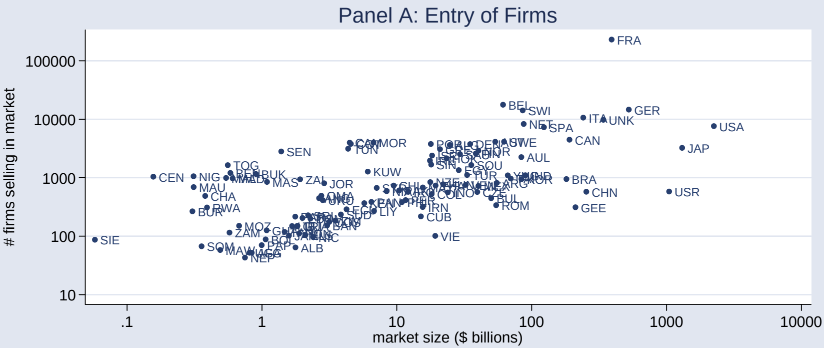
Sources: Data are for 1997 and are for firms that appear in both the U.S. Census of Manufactures and the Linked-Longitudinal Firm Trade Transaction Database (LFTTD).
Notes: The first column of numbers summarizes the distribution of manufacturing firms across three-digit NAICS industries. Remaining columns report the percent of firms in each industry that export, import, and do both.

From Bernard, Andrew B., J. Bradford Jensen, et al. *Journal of Economic Perspectives* 21, no. 3 (2007): 105-30.

EKK (2008)

Out of 229,9000 French manufacturing firms, only 34,035 sell abroad

Figure 1: Entry and Sales by Market Size



Exporters are Different

- The most influential findings about exporting and intra-industry heterogeneity have related to:
  - Exporters being larger.
  - Exporters being more productive.
- But there are other ‘exporter premia’ too.
- Clearly there is an issue of selection versus causation here that is of fundamental importance (for policy and for testing theory).
  - This difficult issue has been best tackled with respect to ‘exporting and productivity’, and we will discuss this shortly.
  - For now, we focus on the stylized fact that concerns the association between exporting and some phenomenon (like higher wages).

Exporter Premia in the United States

BJRS (JEP, 2007)

Table 3

Exporter Premia in U.S. Manufacturing, 2002

	Exporter premia		
	(1)	*(2)*	*(3)*
Log employment	1.19	0.97	
Log shipments	1.48	1.08	0.08
Log value-added per worker	0.26	0.11	0.10
Log TFP	0.02	0.03	0.05
Log wage	0.17	0.06	0.06
Log capital per worker	0.32	0.12	0.04
Log skill per worker	0.19	0.11	0.19
Additional covariates	None	Industry fixed effects	Industry fixed effects, log employment

Sources: Data are for 2002 and are from the U.S. Census of Manufactures.
Notes: All results are from bivariate ordinary least squares regressions of the firm characteristic in the first column on a dummy variable indicating firm's export status. Regressions in column 2 include industry fixed effects. Regressions in column 3 include industry fixed effects and log firm employment as controls. Total factor productivity (TFP) is computed as in Caves, Christensen, and Diewert (1982). "Capital per worker" refers to capital stock per worker. "Skill per worker" is nonproduction workers per total employment. All results are significant at the 1 percent level.

Exporter Premia in the United States

BJRS (JEP, 2007)

Table 8

Trading Premia in U.S. Manufacturing, 1997

	(1) Exporter premia	*(2) Importer premia*	*(3) Exporter & importer premia*
Log employment	1.50	1.40	1.75
Log shipments	0.29	0.26	0.31
Log value-added per worker	0.23	0.23	0.25
Log TFP	0.07	0.12	0.07
Log wage	0.29	0.23	0.33
Log capital per worker	0.17	0.13	0.20
Log skill per worker	0.04	0.06	0.03

Sources: Data are for 1997 and are for firms that appear in both the U.S. Census of Manufacturers and the Linked-Longitudinal Firm Trade Transaction Database (LFTTD).
Notes: All results are from bivariate ordinary least squares regressions of the firm characteristic listed on the left on a dummy variable noted at the top of each column as well as industry fixed effects and firm employment as additional controls. Employment regressions omit firm employment as a covariate. Total factor productivity (TFP) is computed as in Caves, Christensen, and Diewert (1982).

The Exporter Premium: Productivity

Bernard, Eaton, Jensen and Kortum (AER, 2003) on USA

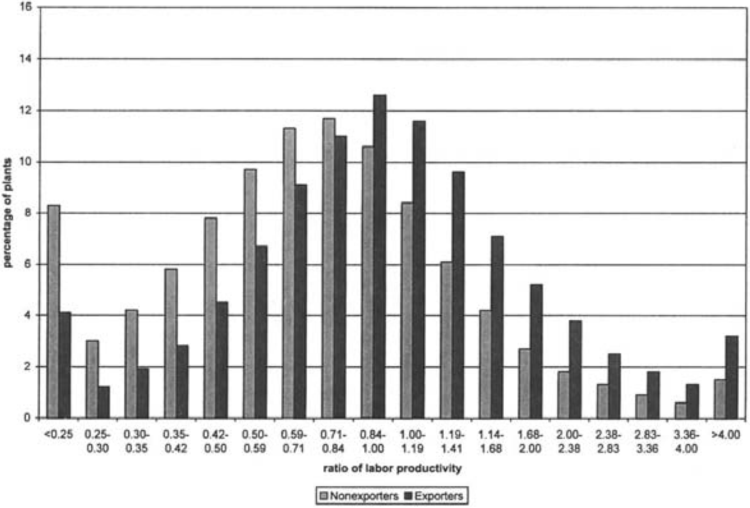
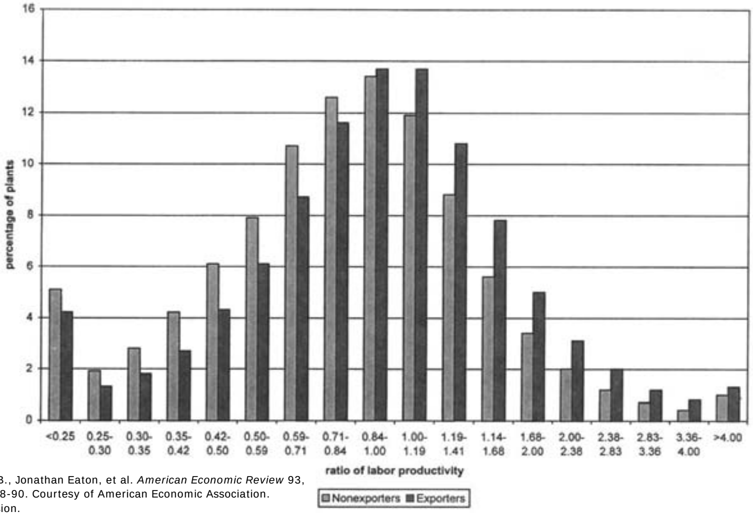


FIGURE 2A. RATIO OF PLANT LABOR PRODUCTIVITY TO OVERALL MEAN

The Exporter Premium: Productivity

Bernard, Eaton, Jensen and Kortum (AER, 2003) on USA. Note that while there is an exporter premium, there is hardly a sharp 'cut-off as in Melitz (2003). But perhaps industry categories are too coarse to see this properly.

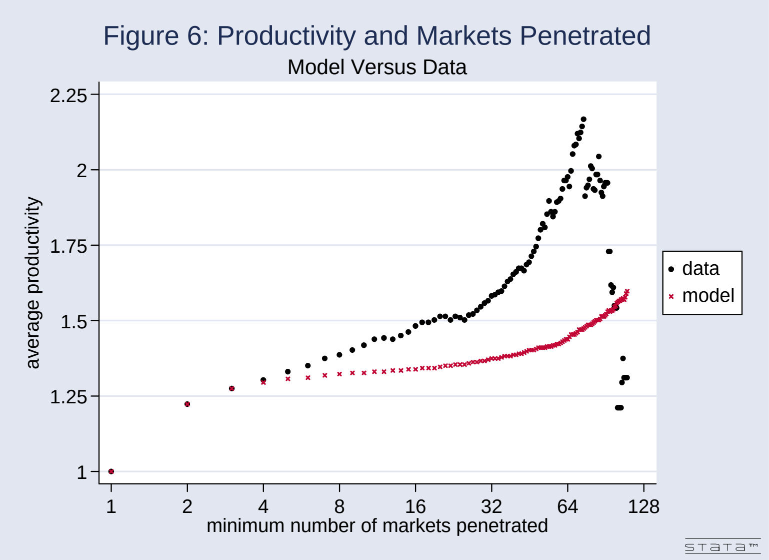


Bernard, Andrew B., Jonathan Eaton, et al. *American Economic Review* 93, no. 4 (2003): 1268-90. Courtesy of American Economic Association. Used with permission.

FIGURE 2B. RATIO OF PLANT LABOR PRODUCTIVITY TO 4-DIGIT INDUSTRY MEAN

The Exporter Premium: Productivity

EKK (2008) on France



The Exporter Premium: Domestic Sales

EKK (2008) on France

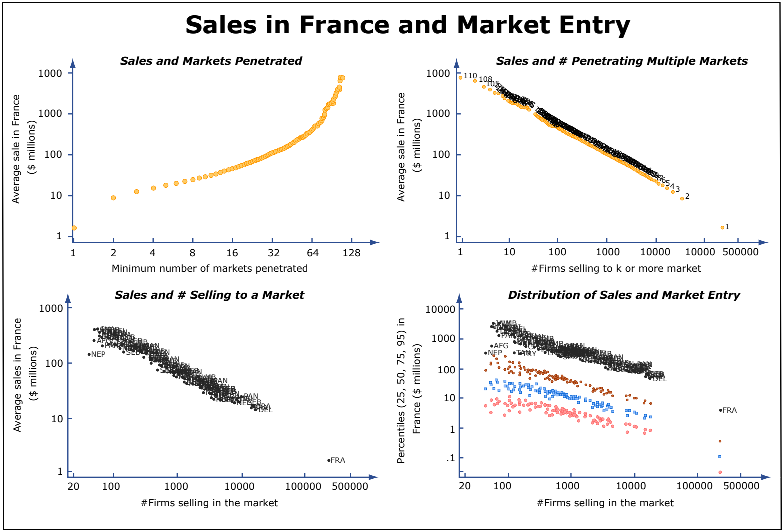


Image by MIT OpenCourseWare.

Other Exporter Premia

- Examples of other exporter premia seen in the data:
    - Produce more products: BJRS 2007 and Bernard, Redding and Schott (2009).
    - Higher Wages: Frias, Kaplan and Verhoogen (2009) using employer-employee linked data from Mexico (ie, when a given worker moves from a purely domestic firm to an exporting firm, his/her wage rises).
    - More expensive ('higher quality') material inputs: Kugler and Verhoogen (2008) using very detailed data on inputs used by Colombian firms.
    - Innovate more: Aw, Roberts and Xu (2008).
    - Pollute less: Halladay (2008)

Premia: Selection or Treatment Effects?

- Consider the 'exporter productivity premium', which has been found in many, many datasets.
- A key question is obviously whether these patterns in the data are driven by:
  - Selection: Firms have exogenously different productivity levels. All firms have the opportunity to export, but only the more productive ones (on average) choose to do so. A fixed cost of exporting delivers this in Melitz (2003), and Bertrand competition delivers this in BEJK (2003).
  - Treatment: Somehow, the very act of exporting raises firm productivity. Why?
    - Intra-industry competition
    - Exporting to a foreign market (and hence larger total market) allows a firm to expand and exploit economies of scale.
    - Learning by exporting.
    - Some exporting occurs through multinational firms, who may have incentives to teach their foreign affiliates how to be more productive.
- Of course, both of these two effects could be at work.

Premia: Selection or Treatment Effects?

- An important literature has tried to distinguish between these 2 effects:
  - Clerides, Lach and Tybout (QJE, 1997)
  - Bernard and Jensen (JIE, 1998)
- The conclusion of these studies is that the effect is pure selection.
  - However, as we shall see below, there is evidence from trade liberalization studies of firms becoming more productive after trade liberalization.
  - And in more recent work, Trefler and Lileeva (QJE, 2009) and de Loecker (2010) improve upon the methods used in the above papers and find evidence for a treatment effect of exporting on productivity. (We will cover this work later in the course when we discuss trade and innovation/growth.)

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    3.1 **Pavcnik (2002)**
    3.2 **Trefler (2004)**
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Firm-level Responses to Trade Liberalization

- An enormous literature has used firm-level panel datasets to explore how firms 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 using firm-level panel data to study trade issues has become an important sub-field in Development Economics (indeed surprisingly, there aren't that many questions that firm-level data are used to look at in Development other than trade issues!)

Aggregate Industry Productivity

- Most of these studies have been concerned with the effects of trade liberalization on aggregate industry productivity.
- Unfortunately, one often cares about much more than this.
  - Consumers may care about some industries more than others.
  - 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 a (domestic) industry's productivity.
  - Not all inputs are fully measured, so what one observes as productivity in the data (eg Y/L or TFP) is not true productivity.
  - Relatedly, there are probably uncounted adjustment costs behind any liberalization episode.
- Data limitations have presented a full and integrated assessment of all of these channels.
  - But there might be ways to make progress here.
  - Theory can be particularly informative in shedding light on the magnitude of some of these effects.

Aggregate Industry Productivity: A Decomposition I

- A helpful way of thinking about the effects of trade liberalization on aggregate industry productivity is due to Tybout and Westbrook (1995) among others.
- 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 ($B_t = \sum_i S_{it} B_{it}$) 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 aggregate changes is small.

Trade Liberalization: Within- and Between-Firm Effects

- This is where the bulk of work has been done.
- Indeed, the finding of significant 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 'another' source of *welfare* gains from trade. (Though an alternative way of thinking about this is that these are really just Ricardian gains from trade at work within an industry rather than across industries.)

Trade Liberalization: Within- and Between-Firm Effects

- However, it is now better recognized that aggregate industry productivity is not equal to welfare and thus one needs to be careful.
  - A stark example of this is Arkolakis, Costinot and Rodriguez-Clare (2011), which shows that the Krugman (1980) and Melitz (2003, but with Pareto productivities added a la Chaney (2008)) models have exactly the same welfare implications.
  - Thus, while the two models seem identical except for the fact that Melitz's heterogeneous firms create the scope for (aggregate) productivity-enhancing reallocation effects, other welfare effects induced by trade liberalization go in the opposite direction.
- We will discuss some of the more recent papers in this area.

Trade Liberalization: Pavcnik (ReStud 2002)

- Pavcnik (2003) recognized that a clear 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 of each factor input 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 'reverse-engineer' 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 (Ecta, 1996)

- Drop the firm subscript i for simplicity (but bear in mind that 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 (as usual, adjustment costs are convex).
- Assuming Cobb-Douglas production, log 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?)
- Ericson 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 (the coefficient on variable inputs).
- Estimating β 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 (the coefficient on capital).
- 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 does the econometrician, 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 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 trading behavior.
  - 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 (ie four-digit industries) as 'import competing' (imports exceed 15% of domestic output), 'export-oriented' (export over 15% of output) or 'non-tradable'.
  - 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

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)

Estimates of Production Functions

		Balanced panel				Full sample					
		(1)		(2)		(3)		(4)		(5)	
		OLS		Fixed effects		OLS		Fixed effects		Series	
		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	0.012	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

Decomposition of Aggregate Productivity Growth

Industry	Year	Aggregate Productivity	Unweighted Productivity	Covariance
Food	79	0.000	0.000	0.000
	80	0.005	0.008	-0.003
	81	0.008	0.058	-0.049
	82	0.209	0.099	0.110
	83	0.144	0.049	0.095
	84	0.116	0.044	0.072
	85	0.092	0.014	0.078
	86	0.179	0.129	0.050
Textiles	79	0.000	0.000	0.000
	80	0.064	0.063	0.001
	81	0.148	0.119	0.029
	82	0.147	0.090	0.057
	83	0.075	0.063	0.012
	84	0.130	0.082	0.048
	85	0.136	0.095	0.041
	86	0.184	0.171	0.013
Wood	79	0.000	0.000	0.000
	80	-0.052	-0.030	-0.022
	81	-0.125	-0.071	-0.054
	82	0.070	-0.076	0.145
	83	0.148	-0.051	0.198
	84	0.169	0.038	0.131
	85	0.019	-0.038	0.058
	86	-0.035	0.045	-0.081
Paper	79	0.000	0.000	0.000
	80	-0.111	-0.035	-0.076
	81	-0.127	0.038	-0.165
	82	-0.127	-0.079	-0.048
	83	-0.084	-0.221	0.137
	84	-0.073	-0.266	0.192
	85	0.252	-0.362	0.110
	86	-0.131	-0.326	0.195
All	79	0.000	0.000	0.000
	80	-0.010	0.018	-0.027
	81	0.051	0.054	-0.003
	82	0.329	0.048	0.281
	83	0.174	0.010	0.164
	84	0.117	0.025	0.092
	85	0.120	-0.003	0.123
	86	0.193	0.066	0.127
Export oriented	79	0.000	0.000	0.000
	80	-0.059	-0.038	-0.021
	81	-0.048	-0.054	0.006
	82	0.591	0.040	0.551
	83	0.326	0.015	0.311
	84	0.178	0.049	0.129
	85	0.203	-0.011	0.214
	86	0.254	0.087	0.166

Industry	Year	Aggregate Productivity	Unweighted Productivity	Covariance
Chemicals	79	0.000	0.000	0.000
	80	0.014	0.046	-0.032
	81	0.126	0.076	0.050
	82	0.312	0.039	0.274
	83	0.238	-0.050	0.288
	84	0.156	-0.040	0.196
	85	0.229	-0.033	0.262
	86	0.432	-0.056	0.488
Glass	79	0.000	0.000	0.000
	80	0.137	-0.036	0.174
	81	0.109	-0.073	0.182
	82	0.155	-0.044	0.200
	83	0.231	-0.052	0.283
	84	0.257	-0.071	0.328
	85	0.193	-0.095	0.287
	86	0.329	-0.011	0.340
Basic metals	79	0.000	0.000	0.000
	80	-0.136	-0.022	-0.114
	81	-0.002	0.050	-0.052
	82	0.711	0.215	0.496
	83	0.343	0.030	0.312
	84	0.153	-0.037	0.190
	85	0.228	-0.153	0.380
	86	0.183	0.076	0.259
Machinery	79	0.000	0.000	0.000
	80	0.031	-0.025	0.005
	81	0.125	0.070	0.055
	82	0.131	0.027	0.105
	83	0.077	0.025	0.053
	84	0.137	0.072	0.064
	85	0.083	0.032	0.051
	86	0.076	0.040	0.036
Import competing	79	0.000	0.000	0.000
	80	-0.063	0.027	-0.090
	81	0.032	0.092	-0.061
	82	0.088	0.066	0.022
	83	0.077	0.034	0.043
	84	0.089	0.059	0.030
	85	0.095	0.061	0.034
	86	0.319	0.107	0.213
Nontraded	79	0.000	0.000	0.000
	80	0.044	0.021	0.024
	81	0.101	0.047	0.054
	82	0.228	0.038	0.190
	83	0.127	-0.004	0.131
	84	0.114	0.000	0.114
	85	0.101	0.040	0.142
	86	0.062	0.038	0.024

Note: The reported growth figures are relative to 1979.

Pavcnik (2002): Results on Trade Liberalization

$TFP_{it} \quad \alpha_0 + \alpha_1(Time)_{it} + \alpha_2(Trade)_{it} + \alpha_3(Trade \times Time)_{it} + \nu_{it}$

Estimates of Equation 12

	(1)		(2)		(3)		(4)		(5)		(6)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	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 to see.

Trefler (2004): The Reciprocal Trade Liberalization

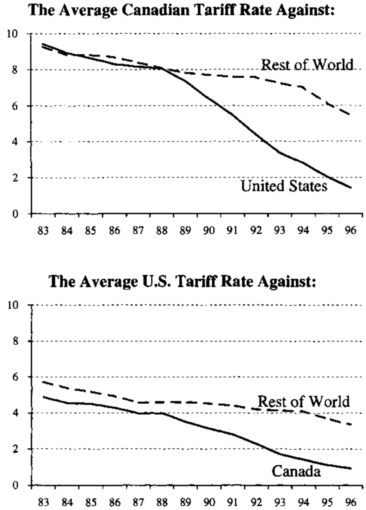

FIGURE 1. CANADIAN AND U.S. BILATERAL TARIFFS IN MANUFACTURING
(In Percents)

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:

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

Trefler (2004): Empirical Approach

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

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

- Notation:
  - ΔX_{is} is defined as the annualized log growth of a variable 'X_i' over all years in period s.
  - 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 needs an IV.
  - b is 'business conditions': measures based on GDP and real exchange rates.

Trefler (2004): Empirical Approach

- Trefler (2004) also looks at plant-level data.
  - A caveat is that the paper focuses on plants that have good data, which are only the relatively large plants.
  - 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.
  - Trefler and Lileeva (QJE 2009), which we will discuss 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	Overld/ 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 "Overld/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

Trefler (2004): Results on Value Added per Hour

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 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	Overld/ 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 (Ecta, 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. Typical assumption is $y_{it} = r_{it}/p_t$.
- 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.
  - Economic change (including trade liberalization) may 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.

de Loecker (2011): Methodology

- One natural solution would be to work in settings where we do observe good firm-level price data. But this is quite hard.
- de Loecker (2011) proposes a more model-driven solution to this problem:
  - He 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).
  - Scond, 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).

de Loecker (2011): Results

- de Loecker (2011) finds that the measured productivity effects of Belgium's textile industry reform fall by 50% if you use his method compared to the pure OP (as in, eg, Pavcnik(2002)).