PhD Course: Development Economics (Micro)
Trade Liberalization & Firm Performance

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1 Introduction

In this lecture I will discuss a strand of the literature that is concerned with the effects of trade liberalization on firm or plant level performance. Recall that one of the main ideas underlying trade liberalization is that this should lead to efficiency gains, partly because resources get allocated more efficiently (in line with comparative advantages) and partly because existing firms are forced to improve their performance in response to international competition.

Has this actually happened? This is an empirical question.

The references for this lecture are the following:

Amiti, Mary, and J. Konings (2007), "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia," American Economic Review 97(5), 1611-38.

Bigsten, Arne, Mulu Gebreeyesus and Måns Söderbom (2009). "Trade Liberalization and Productivity amongst Ethiopian Manufacturing Firms," mimeo.

Pavcnik, Nina (2002). "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants," Review of Economic Studies 69, 245-276.

I will be focusing on the first two. The paper by Pavcnik is interesting too however.

2 Amiti and Konings (2007): Intermediate Inputs and Productivity

- The effects of trade reform on firm-level productivity have been widely studied. This paper focuses on a **gap** in the literature: while we know a lot about the efects of reducing tariffs on final goods, we don't know much about the effects lower tariffs on **inputs** on firm productivity. The basic idea:

- Reducing final goods tariffs is thought to lead to higher productivity because of tougher import competition.

- Reducing input tariffs can raise productivity via learning and quality effects. For example, if foreign inputs become cheaper, domestic producers get better access to foreign technology embodied in those inputs.

- The main contribution of the paper is to estimate both of these effects, using a very large panel dataset (census) on Indonesian manufacturing firms, for the years 1991-2000.

- The largest tariff reductions began in 1995 with the WTO commitment to reduce all bound tariffs to 40% or less (bound tariff = upper bound allowed under WTO agreement).

- Average final goods tariffs fell from 21% to 8% in 2001, with large variations across and within industries.

2.1 Model and estimation strategy

- The plant produces output (Y) by means of a three-factor Cobb-Douglas production function

$$Y_{it} = A_{it}(\tau) L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m},$$

where L, K, M denote labour, capital and materials, respectively, $A_{it}(\tau)$ is total factor productivity (TFP) which depends on trade policy (τ). The panel dimension of the data is reflected by the i, t subscripts.

- Two-step procedure. In the first step, plant level TFP is estimated; in the second step, the impact of trade policy on TFP is estimated.

2.1.1 Estimating productivity

- Begin by expressing the production function in logs (denoted in small letters):

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + e_{it},$$

where e_{it} is defined as TFP. This equation is estimated separately for each industry k (more on how in a moment) and TFP is then estimated as

$$tfp_{it}^{k} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it},$$

where ^ indicates that the parameter is estimated. Output and inputs are deflated by appropriate price indices.

- As discussed in Lecture 4, estimating production functions is not straightforward since factor inputs are possibly endogenous (e.g. because they are choosen by the manager in response to productivity shocks observed by the manager and not by the econometrician).

- To deal with this problem, Amiti and Konings draw on an approach proposed by Olley and Pakes in an Econometrica paper from 1996. This procedure supposedly takes account of the simultaneity between input choices and productivity shocks (as well as sample selection bias).

The Olley-Pakes approach.

- The Olley-Pakes (OP) approach has become very popular as a way of tackling the endogeneity problem alluded to above. To illustrate how it works, consider a two-factor production function as follows

$$y_{jt} = \beta_0 + \beta_k k_{jt} + \beta_l l_{jt} + \left(\omega_{jt} + \eta_{jt}\right).$$

  (the original OP model also allows for an effect of firm age, but I ignore that here; I also ignore the possibility acknowledged by OP that endogenous exit - attrition - may cause bias). The key term here is ω_{jt} denoting time varying unobserved productivity.

- **Labour** is a flexible input chosen in period t, after observing productivity ω_{jt}.

- **Capital** is a "quasi-fixed" input chosen in period $t-1$ and evolves according to the equation

$$K_{jt} = (1 - \delta) K_{j,t-1} + I_{j,t-1},$$

where $I_{j,t-1}$ denotes investment.

- Unobserved **productivity** ω_{it} exhibits first-order serial correlation, so that firms with a relatively high productivity today are likely to have a relatively high productivity tomorrow.* For example, unobserved productivity may

*Strictly speaking, it assumed that unobserved productivity follows a first order Markov process,

$$p\left(\omega_{j,t+1} | \{\omega_{j\tau}\}_{\tau=0}^{t}, I_{jt}\right) = p\left(\omega_{j,t+1} | \omega_{jt}\right),$$

where I_{jt} is the firm's information set in period t. This means that, given the present information, future states are independent of the past states - lags of the productivity variable do not provide additional information as to what might happen to productivity in the future.

follow a first order autoregressive process:

$$\omega_{jt} = \rho\omega_{j,t-1} + \xi_{jt}.$$

- The OP approach is innovative because it draws on behavioural mechanisms in a dynamic neoclassical model of the firm. In particular, the key contribution is to write down a model in which labour and capital solve a dynamic optimization problem. Key for the OP approach is the firm's **investment**. The firm is **forward looking** when choosing investment, in the sense that it tries to anticipate future levels of productivity when deciding how much to invest today.

- Investment in period t will depend on

  – the existing capital stock; and

- expectations about the future profitability of capital - i.e. expected future productivity.

- Because of the assumption that unobserved productivity is positively serially correlated, expected future productivity depends on current productivity. (recall: high productivity today $\rightarrow$ high expected productivity tomorrow).

- OP hence write down an investment demand function of the following form:

$$I_{jt} = I_t \left(k_{jt}, \omega_{jt} \right).$$

- It is assumed that this function is **strictly increasing** in unobserved productivity - a firm with a high value of ω_{jt} will invest strictly more than a firm with a low value of ω_{jt}, conditional on k_{jt}.

- **The key "trick" in OP.** Recall that investment is assumed to be a strictly monotonic in ω_{jt}. This implies that the investment demand function can be **inverted** so that productivity is expressed as a function of investment and capital:

$$\omega_{jt} = h_t\left(k_{jt}, I_{jt}\right).$$

- Intuitively, capital k_{jt} and investment I_{jt} "tell" us what ω_{jt} must be! This is the one-sentence summary of the OP approach.

- With this insight we return to the production function and simply replace ω_{jt} by $h_t\left(k_{jt}, I_{jt}\right)$:

$$y_{jt} = \beta_k k_{jt} + \beta_l l_{jt} + h_t\left(k_{jt}, I_{jt}\right) + \eta_{jt}.$$

By including the function $h_t\left(k_{jt}, I_{jt}\right)$ as an additional term on the right-hand side, we have effectively "controlled" for unobserved productivity.

- Building on this, OP proposed a **two stage procedure** to estimate the parameters β_l and β_k

- **First stage**: Define

$$\phi_t\left(k_{jt}, I_{jt}\right) = \beta_k k_{jt} + h_t\left(k_{jt}, I_{jt}\right),$$

and rewrite the production function as

$$y_{jt} = \beta_l l_{jt} + \phi_t\left(k_{jt}, I_{jt}\right) + \eta_{jt}.$$

- Approximate ϕ_t using a polynomial, e.g.

$$\phi_t\left(k_{jt}, I_{jt}\right) = \lambda_0 + \lambda_1 I_{jt} + \lambda_2 k_{jt} + \lambda_3\left(I_{jt} \times k_{jt}\right) + \lambda_4 I_{jt}^2 + \lambda_5 k_{jt}^2,$$

or using kernel methods (nonparametric). Indeed, if we use the polynomial above, all we have to do is to estimate the following regression

$$y_{jt} = \lambda_0 + \beta_l l_{jt} + \lambda_1 I_{jt} + \lambda_2 k_{jt} + \lambda_3\left(I_{jt} \times k_{jt}\right) + \lambda_4 I_{jt}^2 + \lambda_5 k_{jt}^2 + \eta_{jt}$$

using OLS - this identifies β_l.

- **Second stage**: We have now estimated β_l. In the second stage we shall estimate the capital coefficient β_k - this cannot be estimated in the first stage. Note that the first-stage estimation will give us an estimate of the function ϕ_t, e.g.

$$\hat{\phi}_t\left(k_{jt}, I_{jt}\right) = \hat{\lambda}_0 + \hat{\lambda}_1 I_{jt} + \hat{\lambda}_2 k_{jt} + \hat{\lambda}_3\left(I_{jt} \times k_{jt}\right) + \hat{\lambda}_4 I_{jt}^2 + \hat{\lambda}_5 k_{jt}^2,$$

if we are using the polynomial above.

- It follows that

$$\hat{\omega}_{jt} = \hat{h}_t\left(k_{jt}, I_{jt}\right) = \hat{\phi}_{jt} - \beta_k k_{jt}.$$

- Now, recall that unobserved productivity follows a first-order Markov process; this means we can decompose ω_{jt} as follows:

$$\begin{aligned} \omega_{jt} &= E_{t-1}\left(\omega_{jt}\right) + \xi_{jt} \\ \omega_{jt} &= g\left(\omega_{j,t-1}\right) + \xi_{jt}, \end{aligned}$$

  where ξ_{jt} is the innovation (shock) to productivity.

- The production function, again:

$$y_{jt} = \beta_k k_{jt} + \beta_l l_{jt} + \omega_{jt} + \eta_{jt},$$

which given the insights above can be written

$$y_{jt} - \beta_l l_{jt} = \beta_k k_{jt} + g\left(\omega_{j,t-1}\right) + \xi_{jt} + \eta_{jt},$$

or

$$y_{jt} - \beta_l l_{jt} = \beta_k k_{jt} + g\left(\hat{\phi}_{j,t-1} - \beta_0 - \beta_k k_{j,t-1}\right) + \left(\xi_{jt} + \eta_{jt}\right). \quad (1)$$

Now, because capital is chosen one period in advance, the residual $\xi_{jt}+\eta_{jt}$ will be **uncorrelated** with all the right-hand side variables (remember we have already estimated β_l, which is why I have moved $\beta_l l_{jt}$ to the left-hand side here).

- Depending on how flexible you want to be, (1) can be estimated using either NLLS (if g is a polynomial); or kernel methods (if g is treated nonparametrically).

- We are done! We have the estimates $\hat{\beta}_l$ and $\hat{\beta}_k$, and we can therefore compute TFP as the residual in the production function.

Discussion Whilst theoretically elegant, the OP approach won't always work. Theoretical reasons as to why the OP estimator may not work are carefully discussed in the following paper:

Ackerberg, D., L. Benkard, S. Berry, and A. Pakes (2006), "Production Functions," Section 2 of "Econometric Tools for Analyzing Market Outcomes" forthcoming in Handbook of Econometrics, Volume 6.

The details of this discussion, however, are clearly beyond the scope of the course. I simply list the main points here.

- There may be more than one productivity factor. Recall the OP model assumes unobserved productivity is equal to ω_{jt}. However, if there are **two** unobserved productivity factors, say ω_{jt}^1 and ω_{jt}^2, the OP approach won't work, because there is no way of fully characterizing unobserved productivity by investment and capital. Recall we said that capital k_{jt} and investment I_{jt} "tell" us what ω_{jt} must be - but they cannot tell us what ω^1_{jt} and ω^2_{jt} are separately, if they are both relevant.

- Zero investment levels potentially problematic. Investment needs to be a **strictly** monotonic function of unobserved productivity. The presence of lots of zero investments in the data strongly indicates that this is not the case - it's unrealistic to assume that all firms that invest nothing have precisely the same level of unobserved productivity (conditional on capital). Again, in this case, k_{jt} and investment I_{jt} will not tells us what ω_{jt} is - as zero investment may be associated with different values of ω_{jt}.

- Labour really flexible? The OP approach just described is really **only** appropriate if labour is a flexible input. If not, e.g. because firms can't easily hire and fire workers from one day to another, then OP approach won't work.

- Awkward assumptions. Wages need to vary across firms, and be serially uncorrelated; yet there must be **no** variation across firms in the **cost of capital**. Do you really believe this?

Extensions of the OP model. Amiti and Konings modify the original OP procedure to incorporate the firms's decision to enter the international market via importing or exporting. This means that the investment demand function becomes a function of capital, productivity, import status and export status - i.e. these become control variables in the first stage of the modified OP approach. The basic estimation principles are the same as in the original OP model though.

Estimates of the production function parameters - OLS and modified OP - are shown in Table 2.

[Table 2 here]

TABLE 2—COEFFICIENTS OF THE PRODUCTION FUNCTION

Industry	Labor		Materials		Capital	
	OLS	OP	OLS	OP	OLS	OP
Food products (311)	0.304	0.273	0.747	0.708	0.058	0.067
Food products, nes[a] (312)	0.421	0.335	0.494	0.467	0.172	0.132
Beverages (313)	0.965	0.818	0.353	0.346	0.166	0.175
Tobacco (314)	0.159	0.105	0.875	0.875	0.036	0.000
Textiles (321)	0.249	0.212	0.728	0.708	0.058	0.064
Clothing (322)	0.277	0.253	0.743	0.724	0.039	0.070
Leather goods, nes[a] (323)	0.334	0.321	0.718	0.702	0.026	0.003
Leather footwear (324)	0.392	0.351	0.643	0.619	0.017	0.002
Wood and cork, except furniture (331)	0.296	0.276	0.698	0.677	0.046	0.061
Furniture (332)	0.303	0.285	0.690	0.677	0.052	0.046
Paper and paper products (341)	0.281	0.230	0.739	0.730	0.044	0.018
Printing, publishing, and allied industries (342)	0.419	0.292	0.645	0.657	0.053	0.063
Industrial chemicals (351)	0.312	0.173	0.561	0.497	0.150	0.178
Other chemical products (352)	0.409	0.376	0.641	0.607	0.094	0.121
Rubber products (355)	0.221	0.223	0.717	0.694	0.049	0.045
Plastic products, nes[a] (356)	0.247	0.203	0.745	0.717	0.049	0.056
Pottery, china, and earthware (361)	0.353	0.377	0.583	0.498	0.145	0.196
Glass and glass products (362)	0.381	0.278	0.668	0.640	0.059	0.120
Cement (363)	0.358	0.251	0.713	0.706	0.062	0.128
Clay products (364)	0.544	0.517	0.422	0.367	0.137	0.115
Other nonmetallic mineral products (369)	0.448	0.364	0.578	0.518	0.164	0.222
Iron and steel industries (371)	0.259	0.248	0.787	0.755	0.015	0.045
Nonferrous metal basic industries (372)	0.364	0.182	0.691	0.664	0.124	0.174
Fabricated metal products, except machinery (381)	0.315	0.285	0.714	0.701	0.040	0.031
Nonelectrical machinery (382)	0.327	0.268	0.693	0.677	0.080	0.044
Electrical machinery (383)	0.289	0.293	0.737	0.713	0.044	0.096
Transport equipment (384)	0.384	0.312	0.671	0.639	0.051	0.143
Professional, scientific, and equipment (385)	0.384	0.312	0.671	0.639	0.051	0.143
Miscellaneous manufacturing (390)	0.390	0.346	0.620	0.589	0.074	0.133

[a] "nes" refers to "not elsewhere classified."

2.1.2 Trade liberalization

We've now got all the ingredients we need to estimate the effect of trade liberalization on plant level productivity. The baseline model is as follows:

$$\begin{aligned} tfp_{it}^{k} &= \gamma_0 + \alpha_i + \alpha_{lt} + \gamma_1 \left(\text{output tariff}\right)_t^k + \gamma_2 \left(\text{input tariff}\right)_t^k \\ &\quad + \gamma_3 \left(\text{input tariff}\right)_t^k \times FM_{it} + \gamma_4 FM_{it} + \varepsilon_{it} \end{aligned}$$

using OLS with firm fixed effects (α_i) to control for unobserved firm-level productivity (interestingly, if there really are fixed effects in the productivity equation, then the OP procedure will not in general work - recall that OP breaks down if there are two unobserved productivity terms). The term α_{lt} is an island-year fixed effect; FM is an variable measuring imports (in some specifications FM equals one if the firm imports any of its intermediate inputs; in some specifications, it is equal to the actual share of imported inputs to total inputs).

- Output tariff = average constructed at the five-digit ISIC industry k. Hypothesis: a fall in output tariffs will increase productivity ($\gamma_1 < 0$), as the increase in import competition is likely to force firms to search for ways to improve their efficiency.

- Input tariff = a **weighted average** of all output tariffs, where the weights are based on the cost shares of each input used. For example, if an industry uses 70% steel and 30% rubber, the input tariff for that industry is 0.7*(steel tariff) + 0.3*(rubber tariff). Hypothesis: Reducing input tariffs improves the access to foreign technology embodied in the inputs. This raises efficiency.

- Related: the importing firms should reap the largest benefits from these direct effects. We therefore expect a negative and significant coefficient on the interaction term, $\gamma_3 < 0$ - this would imply that importing firms reap higher benefits from lower input tariffs than nonimporting firms.

- These are the key mechanisms looked for (and indeed found) in the data.

2.2 Trade policy in Indonesia

- WTO member in 1995. Committment to reduce all bound tariffs to 40% or less over a 10-year period.

- [Figure 2: The change in tariffs 1991-2001 against initial tariffs.]

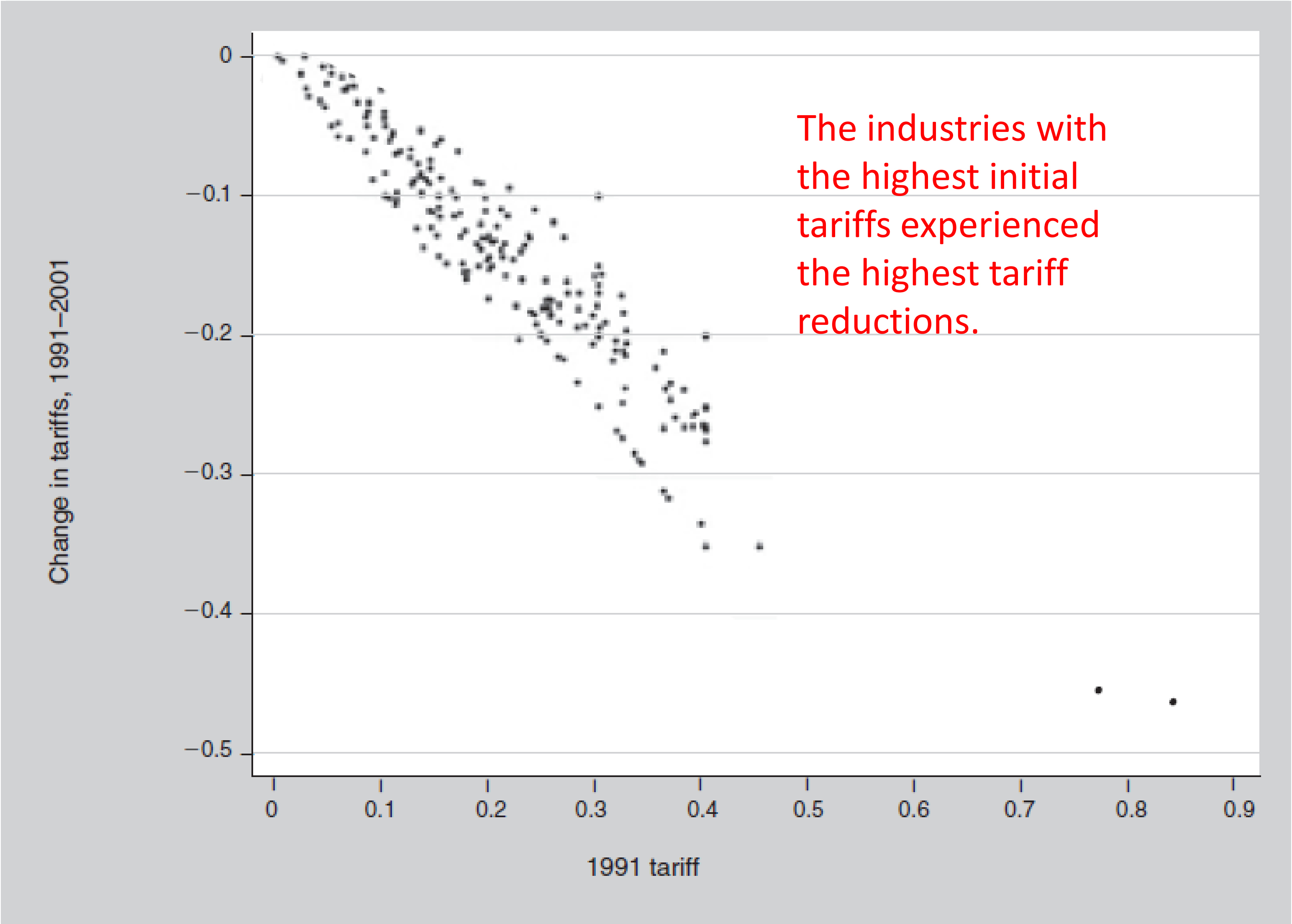


Figure 2. Change in Tariffs, 1991–2001, Relative to Initial Levels

Note: Industries that experienced an increase in their tariff over the sample period are excluded from the figure. These are industries 31161, 31169, 31310, and 31320.

- The usual worry: Is the trade reform worry **endogenous**? For example: political economy type reasons - industries lobby for protection. Tackles this issue in several ways:
  - Theoretical / institutional arguments: analysis done by other author indicates that political connections don't affect tariffs.
  - Instrumental variables: use (for example) lagged tariff levels as an IV for the change in tariffs, appealing to the WTO agreement in order to support exogeneity (i.e. tariffs of varying levels were inherited; WTO required a reduction across the board; hence you'd see high tariff cuts in sectors with high initial levels).
  - Controls for plant-level fixed effects - if political economy factors are time invariant this will not pose a problem.

2.3 Data

- Main source: Manufacturing Survey of Large and Medium-Sized Firms, 1991-2001. Annual census of firms with $>$20 employees (i.e. all such firms covered). Provides plant-level data on output, intermediate inputs, labor, capital, imports, exports and ownership.

- Construct a five-digit output tariff by taking a simple average of the HS nine-digit codes within each five-digit industry code.

- Construct the input tariff for industry k at time t by computing a weighted average of the output tariffs - where the weights are based on the cost share for the relevant imput as noted above (see paper for details).

- Unsurprisingly, input and output tariffs are fairly strongly correlated ($\rho = 0.47$ at the industry level).

- Final dataset: Unbalanced panel with around 15,000 firms per year with a total of 170,741 observations.

[Results]

Results

Table 4—Basic Results

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)	(5)	(6)
Output $tariff^k_t$	−0.206***	−0.070*	−0.092**	−0.096**	−0.096**	−0.095**
	(0.033)	(0.042)	(0.043)	(0.043)	(0.043)	(0.043)
Input $tariff^k_t$		−0.441***	−0.318***	−0.315***	−0.315***	−0.325***
		(0.062)	(0.063)	(0.063)	(0.063)	(0.063)
Input $tariff^k_t \times FM_{it}$			−0.914***	−0.899***	−0.896***	
			(0.086)	(0.086)	(0.086)	
$FM_{it} = 1$ if import share > 0			0.092***	0.091***	0.089***	
			(0.012)	(0.012)	(0.012)	
Input $tariff^k_t \times$ import $share_{it}$						−1.908***
						(0.164)
Import $share_{it}$						0.233***
						(0.024)
$FX_{it} = 1$ if export share > 0					−0.010**	
					(0.005)	
Export $share_{it}$						−0.008
						(0.006)
$FF_{it} = 1$ if foreign share ≥ 0.1					0.070***	
					(0.017)	
Foreign $share_{it}$						0.079***
						(0.023)
$Exit_{it} = 1$ if firm exits in $t + 1$				−0.040***	−0.040***	−0.040***
				(0.004)	(0.004)	(0.004)
Island × year effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Observations	170,741	170,741	170,741	170,741	170,741	170,741
R-squared	0.80	0.80	0.80	0.80	0.80	0.80

- Col 1: benchmark
- Col 2: input tariffs domintate output tariffs
- Col 3: effect stronger for importers
- Col 4-6: Robustness checks (nothing changes)

Alternative Productivity Measures

TABLE 5—ALTERNATIVE PRODUCTIVITY MEASURES

Dependent variable:	ln(real value added per worker$_{it}$)			ln(real output$_{it}$) Cobb-Douglas technology		ln(TFP$_{it}$) Cobb-Douglas technology		ln(TFP$_{it}$) Translog technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output tariff$_t^k$	−0.553***	−0.533***	−0.267***	−0.212***	−0.158***	−0.162***	−0.058	−0.236***	−0.167***
	(0.065)	(0.065)	(0.073)	(0.032)	(0.043)	(0.030)	(0.040)	(0.031)	(0.040)
Input tariff$_t^k$			−0.793***		−0.168***		−0.302***		−0.186***
			(0.124)		(0.063)		(0.058)		(0.059)
Input tariff$_t^k \times$ FM$_{it}$			−1.186***		−0.775***		−0.743***		−0.787***
			(0.160)		(0.088)		(0.082)		(0.081)
FM$_{it}$ = 1 if import share > 0			0.233***		0.090***		0.066***		0.090***
			(0.022)		(0.012)		(0.011)		(0.011)
FX$_{it}$ = 1 if export share > 0			0.007		−0.003		−0.007		0.003
			(0.009)		(0.005)		(0.005)		(0.005)
FF$_{it}$ = 1 if foreign share ≥ 0.1			0.179***		0.072***		0.053***		0.081***
			(0.030)		(0.017)		(0.017)		(0.016)
Exit$_{it}$ = 1 if firm exits in $t+1$			−0.083***		−0.032***		−0.031***		−0.034***
			(0.009)		(0.005)		(0.004)		(0.004)
ln(K/L)$_{it}$		0.058***	0.060***						
		(0.003)	(0.003)						
ln(real inputs$_{it}$) × prod5d [a]				yes	yes				
Island × year effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	165,025	165,025	165,025	170,741	170,741	170,741	170,741	169,217	169,217
R-squared	0.81	0.81	0.81	0.74	0.75	0.80	0.80	0.98	0.98

- Col 1-3: look at labor productivity directly (why are the effects so much higher here?)
- Col 4-5: one-step FE estimates
- Col 6-9: silly, ignore (OLS in two stages??)

- Table 7 shows results for alternative tariff measures (higher level of aggregation; using import weights; etc.). Key findings are robust.

- There is some analysis of the impact of the Asian crisis on the results (Table 8). The bottom line of this is that the effect of the trade liberalization is somewhat lower after taking into account the Asian crisis.

- Table 9 shows the results for alternative specifications. Have a look - nothing much changes.

- Table 10 shows the results of treating tariffs as econometrically endogenous. Why endogenous? Government might pick winners (high productivity firms); or support losers (low productivity firms) - i.e. bias could go either way.

[Discuss table 10]

TABLE 10—ENDOGENEITY

Dependent variable: ln(TFP$_{i,t}$)−ln(TFP$_{i,t-5}$) All variables in 5 period difference	(1)	(2)	(3)	(4)	(5)	(6)
ΔOutput tariff$_t^k$	−0.754*** (0.067)	−0.657*** (0.071)	−0.644*** (0.071)	−0.629*** (0.071)	−0.638*** (0.072)	−0.668*** (0.082)
ΔInput tariff$_t^k$		−0.326*** (0.106)	−0.099 (0.123)	−0.106 (0.123)	−0.171 (0.115)	−0.159 (0.131)
ΔInput tariff$_t^k$ × FM$_{i,t-5}$			−1.274*** (0.415)	−1.324*** (0.413)		
ΔInput tariff$_t^k$ × import share$_{i,t-5}$					−1.942*** (0.724)	−2.211*** (0.814)
ΔFM$_{it}$			0.040*** (0.010)	0.038*** (0.010)		
ΔImport share$_{it}$					0.118*** (0.021)	0.097*** (0.025)
ΔFX$_{it}$				0.020** (0.009)		
ΔExport share$_{it}$					0.032*** (0.011)	0.033** (0.014)
ΔFF$_{it}$				0.070*** (0.024)		
ΔForeign share$_{it}$					0.001*** (0.000)	0.001 (0.000)
Δln(TWI$_t^k$) × FM$_{i,t-5}$	−0.078*** (0.007)	−0.076*** (0.007)	−0.025 (0.022)	−0.021 (0.022)		
Δln(TWI$_t^k$) × import share$_{i,t-5}$					−0.078** (0.039)	−0.029 (0.044)
Δln(TWI$_t^k$) × FX$_{i,t-5}$	−0.046*** (0.007)	−0.044*** (0.007)	−0.042*** (0.007)	−0.053*** (0.009)		
Δln(TWI$_t^k$) × export share$_{i,t-5}$					−0.069*** (0.011)	−0.070*** (0.014)
ΔHerfindahl index$_t^k$				−0.209*** (0.030)	−0.210*** (0.030)	−0.185*** (0.034)
Island x year effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Weak instruments	F(3)=5712.42	$\chi^2(4)$=6528.68	$\chi^2(6)$=2081.14	$\chi^2(6)$=2082.70	$\chi^2(6)$=2196.36	$\chi^2(6)$=1609.52
Overidentification	2.80	2.08	2.80	2.78	1.36	5.48
Hansen J statistic	0.25	0.35	0.43	0.43	0.72	0.14
Observations	56,320	56,320	56,320	56,320	56,320	41,676

- **Endogenous**: output & input tariffs; input tariff x imports.
- **Instruments**: 1991 values of endogenous variables; proportion of skilled workers at the 5-digit industry level; dummy for products exempt from the 40% bound commitment.
- First stage regressions are (allegedly) fine (no surprise given fig 2).
- Bottom line: 2SLS suggest OLS/FE **underestimate** the tariff effects!

2.4 Conclusions

"Our analysis has produced important new findings." Such as:

- Reducing input tariffs significantly increases productivity
- This effect is higher than reducing output tariffs
- The productivity gains were larger for importing firms compared to non-importers
- These results are robust to numerous mechanisms.

3 Bigsten, Gebreeyesus and Söderbom: Ethiopia

3.1 Background

Since the 1980s most countries in Sub-Saharan Africa (SSA) have moved away from inward-looking development strategies, as a reaction to the failure of previous import substitution policies. Reforming trade policy was an important component of the structural adjustment programs.

Unlike other regions, there exists very little empirical evidence on how trade reforms have impacted firm performance in SSA. This is a significant information gap - without direct evidence one should remain agnostic about the effects of the trade liberalization in Africa, because:

- There is evidence that the gains from trade are contingent on the state of other variables, such that the efficiency of the labour market or the quality of the infrastructure.

- There is also some evidence that trade does not stimulate growth in economies with excessive regulations, and that the effect of openness to trade is declining in initial income.

SSA has a low level of income and generally a poor investment climate. Gains from trade may therefore be modest. Empirical research based on African data therefore has an important role to play.

- This paper: firm-level panel data are matched with commodity-level disaggregated data on imports and tariffs to investigate how trade reforms have affected manufacturing firms in Ethiopia.

- The period covered by the data is one of relative political stability, and the effects of the trade liberalization can be identified whilst controlling for the effects of general policy changes (e.g. by allowing for general time effects in our regressions).

- Our estimation sample consists of more than 6,000 observations, which, by the standards of African firm-level datasets, is exceptionally large.

4 Context: Trade Reform in Ethiopia

- Between 1950s & early 1970s: Import-substituting industrial strategy based on private ownership. Generous tax incentives, high levels of tariff protection, and easy access to domestic credit for domestic production of manufactured goods.

- 1974-1991: Military regime (the Derg); nationalized all private large and medium scale manufacturing firms. Import-substituting strategy combined with a command economic system. The manufacturing sector was weakened and the private sector was intentionally stifled.

- 1991: New government, which has since then undertaken extensive policy reforms to transform the economy into a market oriented one. Structural adjustment program in 1992/1993 involving trade liberalization. Six successive, gradual custom tariff reforms were implemented between 1993 and 2003.

- [Table 1 here]

Table 1: Tariff reform steps in Ethiopia (1993-2003)

Rounds of reforms	Year	Maximum tariff	Average tariff	Number of tariff bands
Before reform	Before 1993	230	41.6	23
1st round	August 1993	80		
2nd round	January 1996	60		
3rd round	______ 1997	60		
4th round	January 1998	50	21.5	
5th round	December 1998	40	19.5	
6th round	January 2003	35	17.5	6

Source: MoFED (Study on Ethiopia's Industrial sector Effective Rate of Protection, December, 2006 – MoFED mimeo)

4.1 Data and Descriptive Statistics

- Match census panel data on manufacturing firms (with emp>=10) with annual data on tariffs on final goods and imports, for the period 1997-2005. There is information in the census data on output, inputs (local and imported), sales (local and export), employment, location, ownership type, and a variety of costs.

- The estimation sample contains firms from 39 different manufacturing subsectors at the 4-digit ISIC level, in 94 locations. With 9 years of data, there is thus plenty of variation in the data in the tariff variable.

[Basic characteristics of the formal manufacturing sector are shown in Table 2. Figures 1 and 2 show averages and standard deviations of nominal tariffs and import penetration rates, respectively, over the sampling period.]

Table 2: Plants and employment in Ethiopia's manufacturing sector

Sector	Plants			Employment									
	Number of plants		Growth	Total Employment		Growth	Sector share		Average firm size		Median firm size		
	1997	2004	1997-04	1997	2004	1997-04	1997	2004	1997	2004	1997	2004	
Food	179	294	64%	26,926	31,238	16%	28%	30%	150	106	21	24.5	
Textile	59	73	24%	31,839	26,677	-16%	33%	25%	540	365	51	58	
Leather	61	62	2%	8,226	7,575	-8%	9%	7%	135	122	27	49.5	
Wood	132	185	40%	5,680	6,822	20%	6%	7%	43	37	20.5	16	
Paper	46	73	59%	5,122	6,929	35%	5%	7%	111	95	24.5	35	
chemical	64	87	36%	6,124	9,306	52%	6%	9%	96	107	36	59	
Non-metallic	89	119	34%	6,745	9,170	36%	7%	9%	76	77	17	19	
Fabricated metal	72	103	43%	4,377	6,594	51%	5%	6%	61	64	20.5	30	
Total	703	997	42%	95,992	105,095	10%			137	105	23	26	

Figure 1: Trends in the Mean and Standard Deviation of Tariffs

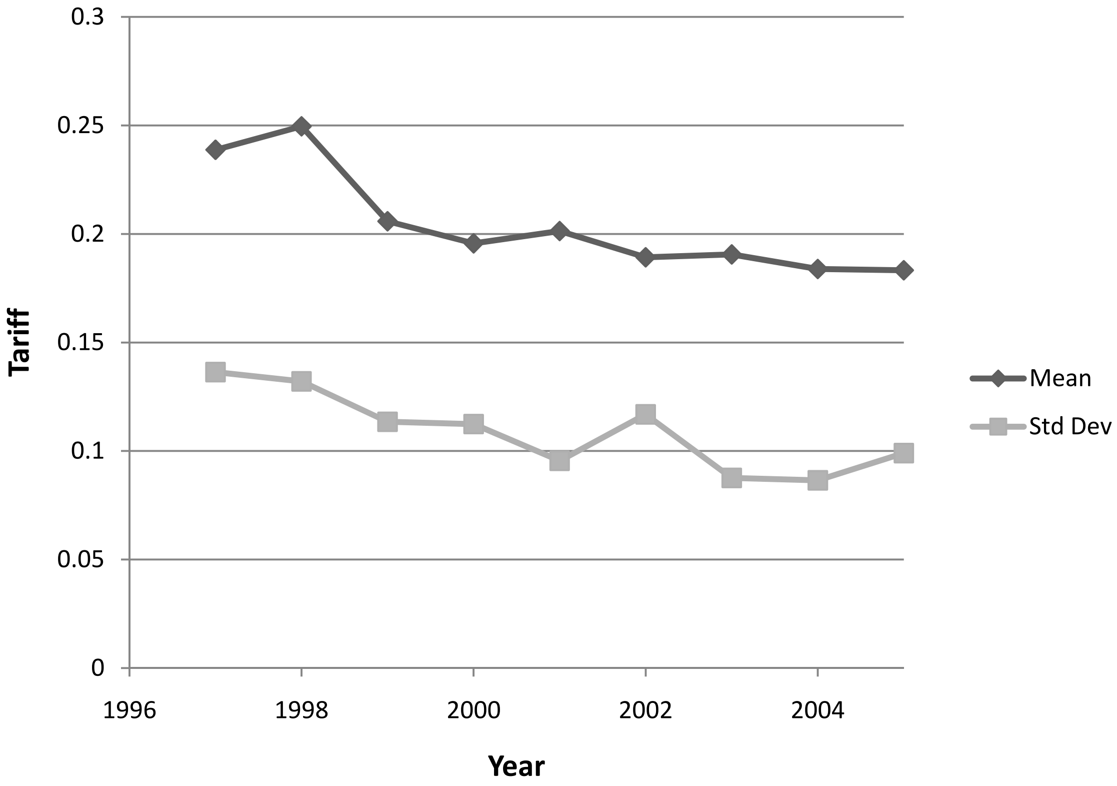
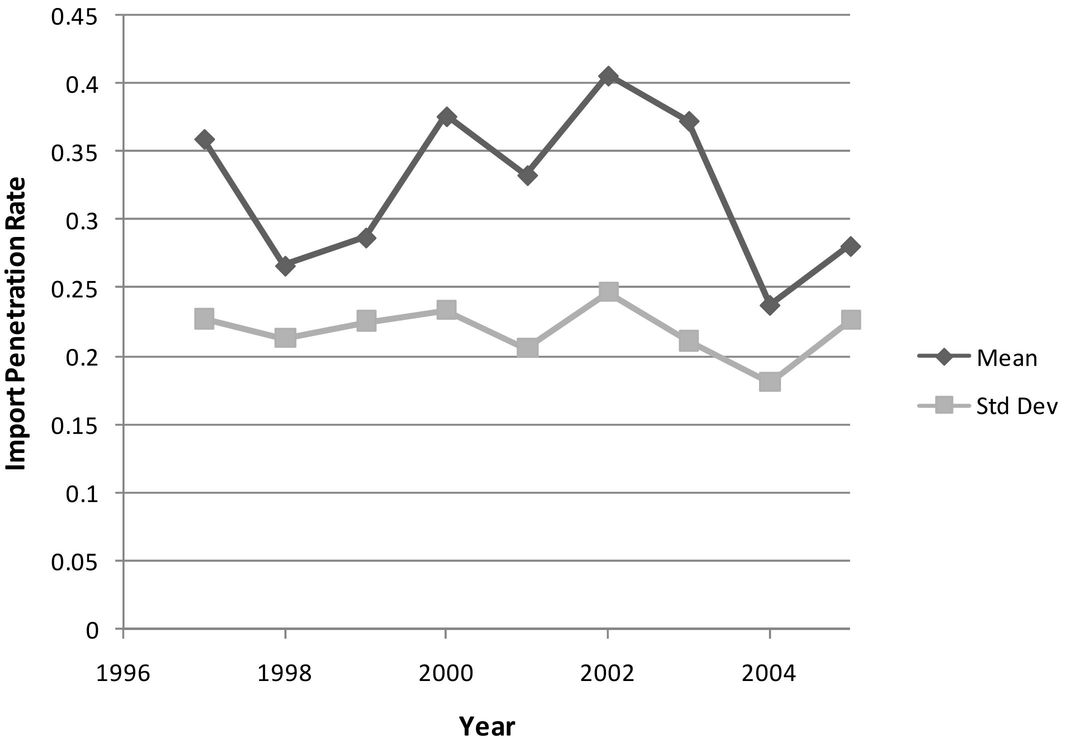


Figure 2: Trends in the Mean and Standard Deviation of Import Penetration Ratios



Correlations between tariff rates and some variables of interest. Table 4 shows OLS estimates based on regressions of the form

$$X_{jt} = \varphi_1^x T_{jt} + \lambda_t + \epsilon_{jt},$$

where X_{jt} is an outcome variable of interest, T_{jt} is the sector-year tariff rate on final goods, λ_t is a time effect, φ_1^x is a parameter to be estimated and ϵ_{jt} is an error term. All regressions are estimated at the year and sector (4-digit) level. Time dummies are included in all specifications, and standard errors are robust to heteroscedasticity.

[Discuss Table 4 here]

Table 4: Tariffs and Outcome Variables of Interest

		Tariff		
	Dependent variable	Coefficient	t-value	R-squared
(1)	Import penetration ratio	-0.598	(4.20)**	0.07
(2)	Herfindahl index	-0.267	(2.28)*	0.02
(3)	log Value-added per employee	-1.313	(2.98)**	0.03
(4)	Share of imported inputs	-0.391	(2.76)**	0.02
(5)	Entry rate	-0.081	(1.09)	0.10
(6)	Exit rate	0.071	(0.94)	0.10

Note: The estimation method is OLS. The regressions are estimated at the (4-digit) sector-year level. Year dummies and a constant are included in all regressions. t-values are based on standard errors robust to heteroskedsticity. * significant at 5% level; ** significant at 1% level. The number of observations is 342 in all specifications except in (6), for which it is 303 (data on exit for the last wave of the panel are not available).

4.2 Econometric Analysis

4.2.1 Tariffs and Productivity

Production function:

$$y_{ijt} = \beta^m m_{ijt} + \beta^k k_{ijt} + \beta^l l_{ijt} + \omega_{ijt} + \eta_{ijt}, \tag{2}$$

where y_{ijt} denotes the log of real output, m_{ijt} is log raw materials, k_{ijt} is log physical capital, l_{ijt} is log employment, ω_{ijt} is total factor productivity (TFP), η_{ijt} is a measurement error in output, $\beta^m, \beta^k, \beta^l$ are input elasticities, and i, j, t denote firm, sector and time, respectively.

- Assume here that β^m, β^k and β^l are constant across firms in all sectors, and check if this is restrictive.

- In the special case where the share of raw materials in output is **constant**, the output production function reduces to a value-added specification. We focus primarily on the output specification as this is less restrictive.

- Write TFP $\left(\omega_{ijt}\right)$ as follows:

$$\omega_{ijt} = \theta T_{jt} + \tau_t + \gamma_j + \alpha_{ij} + \epsilon_{ijt}, \tag{3}$$

  where τ_t is a time effect common to all firms, γ_j is a sector-level fixed effect, α_{ij} is a firm-level fixed effect, and ϵ_{ijt} is unobserved time varying productivity. Variation across sectors in the growth rates of tariff rates crucial for identification - why?

- Concern I: factor inputs may be endogenous. Even if this is the case, it may not lead to bias in the estimate of the tariff coefficient (θ) But we will check.

- Concern II: tariffs may be endogenous if these are set in response to productivity changes at the sectoral level (sign ambiguous: pick winners - protect losers). Will check.

- Empirical model:

$$y_{ijt} = \beta^m m_{ijt} + \beta^k k_{ijt} + \beta^l l_{ijt} + \theta T_{jt} + \tau_t + \gamma_j + \alpha_{ij} + \epsilon_{ijt} + \eta_{ijt}.$$

- We rely mostly on OLS and Fixed Effects regressions to estimate this type of model.

- To investigate whether endogeneity is a problem, we use IV. One objective of the reforms was to reduce the dispersion of tariff rates across sectors. Sectors with high initial tariff rates will have had relatively large tariff cuts.

Combined with the gradual process by which tariffs were reduced: initial tariffs interacted with time will be an informative instrument for subsequent tariff levels,

$$T_{jt} = \boldsymbol{X}_{ijt}^{1}\boldsymbol{\delta}_{x}^{1} + \delta_{T}^{1}\left(t \times T_{j0}\right) + e_{ijt}^{1},$$

and that lagged tariffs will be an informative instrument for subsequent growth in tariffs,

$$\Delta T_{jt} = \boldsymbol{X}_{ijt}^{2}\boldsymbol{\delta}_{x}^{2} + \delta_{T}^{2} \times T_{j,t-2} + e_{ijt}^{2},$$

where $\boldsymbol{X}_{ijt}^{1}$, $\boldsymbol{X}_{ijt}^{1}$ are vectors containing all non-instrumented explanatory variables in the main equation, $\boldsymbol{\delta}_{x}^{1}$, $\boldsymbol{\delta}_{x}^{2}$ are the associated vectors of coefficients, T_{j0} measures the tariff rate in sector j in the initial period, δ_{T}^{1}, δ_{T}^{2} are scalars (expected to be negative), and e_{ijt}^{1}, e_{ijt}^{2} are error terms.

- Key assumption: the policy objective of greater uniformity of tariffs was not meant to favour specific sectors that were expected to have unusually high (or low) subsequent growth rates.

- Still, it seems likely tariffs are exogenous (as were changed as part of SAP, guided by the World Bank).

[Baseline results in Table 5.]

[Table 6: Robustness to endogeneity]

Table 5: Tariffs and Firm-Level Productivity: Baseline specifications

	(1) log Output	(2) log Output	(3) log Value-added	(4) log Value-added
log Raw Materials	0.827	0.791		
	(113.62)**	(53.70)**		
log Physical Capital	0.032	0.069	0.199	0.199
	(7.05)**	(4.52)**	(12.40)**	(4.34)**
log Employment	0.173	0.175	1.032	0.851
	(15.71)**	(8.47)**	(36.67)**	(13.93)**
Tariff (4-digit level)	-0.305	-0.317	-1.499	-1.702
	(2.84)**	(2.74)**	(4.11)**	(4.45)**
Time effects	Yes	Yes	Yes	Yes
Location effects	Yes	Redundant	Yes	Redundant
Firm fixed effects	No	Yes	No	Yes
Industry effects (4-digit level)	Yes	Redundant	Yes	Redundant
Observations	6096	6096	6096	6096
Firms	1,700	1,700	1,700	1,700
R-squared	0.98	0.81	0.80	0.16

Note: t-statistics based on robust standard errors clustered at the firm-level in parentheses. *significant at 5% level; ** significant at 1% level. Overall R-squared reported for models without firm fixed effects; within R-squared reported for models with firm fixed effects.

Table 6: Tariffs and Firm-Level Productivity: Two-Stage Least Squares Results

	First Differences			Levels (location & sector effects)	Within (firm fixed effects)
	(1)	(2)	(3)	(4)	(5)
log Raw Materials	0.757	0.821	0.710	0.833	0.800
	(46.33)**	(8.39)**	(22.71)**	(119.7)**	(51.85)**
log Physical Capital	0.036	0.036	0.114	0.030	0.051
	(1.67)	(0.62)	(2.98)**	(6.47)**	(2.75)**
log Employment	0.127	0.143	0.176	0.171	0.178
	(6.05)**	(1.38)	(4.49)	(16.10)**	(8.32)**
Tariff	-0.590	-0.543	-0.757	-0.536	-0.688
	(1.71)	(1.35)	(2.06)*	(1.77)$^{+}$	(1.51)
Tests (p-values)					
Tariff exogenous	0.28	0.42	0.20	0.14	0.21
Underidentification	0.00	0.00	0.00	0.00	0.00
Overid restrictions		0.17	0.08		
Constant returns	0.01			0.00	0.18
Autocorrelation, m1	0.00	0.00	0.00		
Autocorrelation, m2	0.64	0.64	0.65		
Inputs	Exogenous	Endogenous	Predetermined	Exogenous	Exogenous
CRS imposed	No	Yes	Yes	No	No
Exclusion restrictions	Tariff(t-2)	Tariff(t-2) Inputs(t-2)	Tariff(t-2) Inputs(t-1)	Initial tariff x time	Initial tariff x time
Observations	3031	3031	3031	5495	5495

Note: t-statistics based on robust standard errors clustered at the firm-level in parentheses. * significant at 5% level; ** significant at 1% level. The specification in (5) controls for location and industry effects. Time dummies are included in all specifications. m1 and m2 are the Arellano-Bond (1991) tests for first and second order serial correlation in the differenced residuals. The number of observations varies because of how the instruments are defined.

Market Concentration, Technology and Trade Patterns

- Main conclusion so far: tariffs negatively correlated with TFP and no strong evidence that the OLS or fixed effects estimates of the tariff effect are biased by endogeneity. Now extend the baseline specification in various ways.
  - Allow for heterogeneity in input coefficients across sectors (because technology may differ). Could be important if tariffs are set low in sectors with large firms and high returns to scale
  - Are these producitivy effects or disguised mark-up effects? Control for the Herfindahl index of industry concentration.
  - What about effects operating on the input side (Amiti and Konings)? We don't have data on input tariffs and therefore cannot document

the effects of input tariffs on productivity directly. However, we do have information about the share of imported inputs in total inputs. If the trade liberalization impacts performance primarily through better and/or cheaper inputs, and if (as seems likely) output tariffs and input tariffs are positively correlated, we would expect to find a larger tariff coefficient for firms with large shares of imported inputs. Add interaction term between imported inputs and the tariff variable.

– Does exporting play a role (should be related to trade liberalization; exporting might raise productivity - will come back to this next week).

[Results in Table 7]

Table 7: The Effects of Market Concentration, the Real Exchange Rate and the Firm's Trade Patterns on Productivity

	(1)	(2)	(3)	(4)	(5)
log Raw Materials	0.777	0.791	0.798	0.801	0.791
	(54.22)**	(53.67)**	(55.59)**	(65.51)**	(54.07)**
log Physical Capital	0.045	0.068	0.065	0.065	0.068
	(2.66)**	(4.49)**	(4.41)**	(4.39)**	(4.50)**
log Employment	0.170	0.174	0.177	0.163	0.175
	(8.85)**	(8.47)**	(8.70)**	(8.97)**	(8.49)**
Tariff (4-digit level)	-0.240	-0.349	-0.282	-0.290	-0.322
	(1.98)*	(3.01)**	(2.47)*	(2.40)*	(2.74)**
Herfindahl index (3-digit level)		-0.481			
		(2.50)*			
Real exchange rate (2000 = 1.00)			0.086		
			(1.84)+		
Tariff x Share imported inputs				0.127	
				(0.53)	
Share imported inputs				0.003	
				(0.07)	
Tariff x Any exports					0.120
					(0.479
Any exports					-0.025
					(0.30)
Time effects	Yes	Yes	No	Yes	Yes
Firm effects	Yes	Yes	Yes	Yes	Yes
Industry heterogeneity in input coefficients (4 digit level)	Yes	No	No	No	No
Observations	6,096	6,096	6,096	6,088	6,096
Firms	1,700	1,700	1,700	1,700	1,700
R-squared	0.82	0.81	0.81	0.81	0.81

Note: The dependent variable is log output. t-statistics based on robust standard errors clustered at the firm-level in parentheses. * significant at 5% level; ** significant at 1% level. Imported inputs and exports are centered on their sample means, so as to facilitate interpretation of the tariff coefficient.

Heterogeneous Productivity Gains: Firm Size and Non-Linearities

- Allow for heterogeneity in the tariff effect depending on firm size. Consider two size groups, small and large.

- Allow for nonlinear tariff effects. Two ways:

  - Add quadratic

$$\omega_{ijt} = \theta_1 T_{jt} + \theta_1 T_{jt}^2 + \tau_t + \gamma_j + \alpha_{ij} + \epsilon_{ijt}$$

  - Allow for a piecewise linear spline function:

$$\omega_{ijt} = \theta_1 T_{jt} + \sum_{k=2}^{K} \theta_k \max\Big(T_{jt} - c_k, 0\Big) + \tau_t + \gamma_j + \alpha_{ij} + \epsilon_{ijt},$$

where K denotes the number of nodes, $c_k > 0$ determines the position of the kth node, and $\theta_1, \theta_2, ..., \theta_K$ are parameters determining the productivity tariff profile. The coefficient θ_1 is interpretable as the slope of the profile in the range $0 \leq T \leq c_1$, while θ_k, $k = 2, 3, ..., K$, is interpretable as the change in the slope of the profile that results from moving from the interval $\{c_{k-2}, c_{k-1}\}$ to $\{c_{k-1}, c_k\}$, where $c_0 = 0$. The slope of the productivity function in the interval $\{c_{L-1}, c_L\}$ is thus given by $\theta_1 + \sum_{k=2}^{L} \theta_k$. Hence, if $\theta_2 = \theta_3 = ... = \theta_K = 0$ the productivity function is linear.

[Results in Table 8]

[Figure 3]

Table 8: Heterogeneous Productivity Gains: Firm Size and Nonlinear Effects

	(1)	(2)	(3)	(4)	(5)
log Raw Materials	0.791	0.789	0.789	0.786	0.789
	(53.80)**	(53.66)**	(53.70)**	(52.91)**	(53.66)**
log Physical Capital	0.068	0.071	0.069	0.068	0.071
	(4.46)**	(4.67)**	(4.59)**	(4.49)**	(4.71)**
log Employment	0.183	0.176	0.184	0.179	0.176
	(7.74)**	(8.50)**		(8.69)**	(8.46)**
Tariff		0.920		0.290	-0.027
		(2.70)**		(0.11)	(0.19)
Tariff x Small	-0.194		0.948		
	(1.39)		(1.74)		
Tariff x Large	-0.400		0.792		
	(3.09)**		(1.81)		
Tariff squared		-2.567			
		(3.77)**			
Tariff squared x Small			-2.380		
			(2.25)*		
Tariff squared x Large			-2.509		
			(2.99)**		
max(tariff-.05,0)				1.589	
				(0.56)	
max(tariff-.10,0)				-3.422	
				(2.99)**	
max(tariff-.15,0)				2.908	
				(2.89)**	
max(tariff-.20,0)				-2.594	
				(2.41)*	
max(tariff-.25,0)				1.266	
				(1.07)	
max(tariff-.30,0)				1.149	-1.108
				(0.96)	(3.43)**
max(tariff-.35,0)				-3.742	
				(2.44)*	
max(tariff-.40,0)				0.669	
				(0.44)	
max(tariff-.45,0)				2.133	
				(0.74)	
max(tariff-.50,0)				-6.022	
				(1.22)	
Large (emp > 26)	0.022		0.019		
	(0.62)		(0.30)		

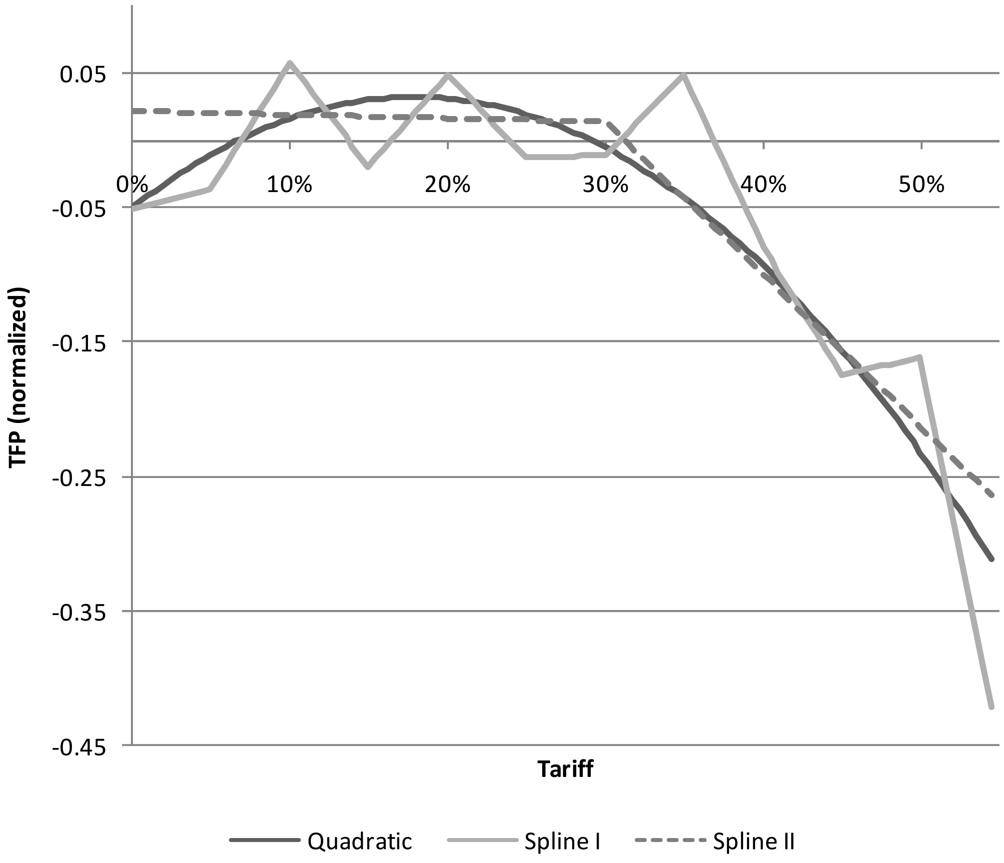
The table continues on the next page.

Table 8 Continued

	(1)	(2)	(3)	(4)	(5)
H_0: Quadratic, Small (p-value)			0.022		
H_0: Quadratic, Large (p-value)			0.000		
H_0: Quadratic common across size (p-value)			0.257		
Time effects	Yes	Yes	Yes	Yes	Yes
Firm effects	Yes	Yes	Yes	Yes	Yes
Observations	6,096	6,096	6,096	6,096	6,096
Firms	1,700	1,700	1,700	1,700	1,700
R-squared	0.81	0.81	0.81	0.81	0.81

Note: The dependent variable is log output. t-statistics based on robust standard errors clustered at the firm-level in parentheses. * significant at 5% level; ** significant at 1% level.

Figure 3: Predicted TFP based on Nonlinear Specifications in Table 8, col. (2), (4) & (5)



Note: Predicted TFP is normalized to zero at sample means of the explanatory variables.

4.2.2 Input Decisions

- Table 9 shows results from fixed effects regressions modelling employment, the capital-labour ratio (both in logs) and the share of imported inputs as dependent on tariffs.

- Column (1): some evidence (at the 10% significance level) that the reduction in tariffs has resulted in a *reduction* in employment. The result that firms are becoming smaller and more productive at the same time is consistent with the hypothesis that the trade liberalization has increased competition in the domestic market (entry: forces firms to become more productive; also leads to smaller market shares for the incumbents, disincentivizing growth).

[Table 9 here]

Table 9: Tariffs and Input Decisions

	(1) Log Employment	(2) Log Capital-Labor Ratio	(3) Share of imported inputs
Tariff	0.306	-0.504	0.006
	(1.74)+	(2.14)*	(0.09)
Time effects	Yes	Yes	Yes
Firm effects	Yes	Yes	Yes
Observations	6,096	6,096	6,096
Firms	1,700	1,700	1,700
R-squared			

Note: t-statistics based on robust standard errors clustered at the firm-level in parentheses. * significant at 5% level; ** significant at 1% level.

4.3 Conclusions

- Relatively large positive effects of tariff reductions on total factor productivity. This finding is robust to treating tariffs as an endogenous variable, and to various generalizations of the baseline model (e.g. models allowing for industry-specific input coefficients; industry concentration; the extent of imported inputs; and the extent of exporting).

- There is some evidence that the tariff effect is stronger for large than for small firms, although when tested formally we cannot reject the hypothesis that the effect is common across the two size groups.

- It is clear, however, that the negative relationship between tariffs and productivity is primarily driven by mechanisms operating at high tariff levels.

The results from a specification containing a simple piecewise linear spline function with a single kink at a tariff level of 30% indicate that the tariff effect below 30% is close to zero, while at tariffs above 30% the estimated partial effect is -1.14 and significant at the 1% level.

- Some evidence that lower tariffs are associated with a fall in average firm size. We tentatively interpret this result as suggesting that the trade liberalization has increased competition in the domestic market, resulting in higher productivity and lower market shares for domestic firms.

- No significant effect of tariffs on domestic entry or exit rates suggests that the trade liberalization has not affected the average profitability of firms (assuming that entry and exit decisions respond to profitability shocks).

- Relevance? For about 20% of the observations in our sample, and 11% in the final year of the panel, tariffs exceed 30%. Such firms will have benefitted from the trade liberalization, and would benefit from further cuts in cases where tariffs remain high.

- The very low effect estimated for tariffs less than 30% suggests that low and intermediate tariffs may not be overly distortionary. To the extent that moderate tariffs provide an important source of government revenue, and abstracting from consumer welfare implications (which with our data we cannot say anything about), our results thus suggest that low tariffs may be justifiable from an economic point of view.