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Trade, Firms, and Wages: Theory and Evidence

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How does trade liberalization affect wages? This is the first paper to consider in theory and data how the impact of final and intermediate input tariff cuts on workers' wages varies with the global engagement of their firm. Our model predicts that a fall in output tariffs lowers wages at import-competing firms but boosts wages at exporting firms. Similarly, a fall in input tariffs raises wages at import-using firms relative to those at firms that only source inputs locally. Using highly detailed Indonesian manufacturing census data for the period 1991–2000, we find considerable support for the model's predictions.

Key words: Input tariffs, Output tariffs, Firm heterogeneity, Trade liberalization

JEL Codes: F10, F12, F13, F14

1. INTRODUCTION

How does trade liberalization affect wages? This is one of the most important questions in international economics, one that has generated a vast theoretical and empirical literature.[1] Yet no contribution to this literature has simultaneously addressed the two most salient facts to emerge in the last decade about international production. The first fact is the role of firm-level heterogeneity in export and import behaviour. As emphasized in Bernard *et al*. (2007), exporting and importing are concentrated in a small number of firms that are larger, more productive, and pay higher wages. The second fact is the large and growing importance of trade in intermediates, as documented by Yi (2003). A distinct role for intermediates is of considerable importance, as well, because of the contrasting protective and anti-protective effects of final and intermediate tariffs, respectively.

The contribution of this paper is to examine, theoretically and empirically, the impact of trade liberalization on wages while taking explicit account of both of these facts. We develop a general equilibrium model that features firm heterogeneity, trade in final and intermediate products, and firm-specific wages. In doing so, it builds on the work on heterogeneous firms of Melitz (2003) as amended to allow trade in intermediate goods by Kasahara and Lapham (2007). Both of these

1. For recent contributions, see the papers in Harrison (2007) and the surveys by Goldberg and Pavcnik (2007) and Feenstra and Hanson (2003).

models maintain the assumption of homogeneous labour and a perfect labour market, so that the wages paid by a firm are disconnected from that firm's performance. We continue to focus on homogeneous labour but introduce a variant of fair wages most closely related to that of Grossman and Helpman (2007).

The key theoretical result is that the wage consequence of a particular tariff change depends on the mode of globalization of the firm at which a worker is employed. A decline in output tariffs reduces wages of workers at firms that sell only in the domestic market, but raises wages of workers at firms that export. A decline in input tariffs raises the wages of workers at firms using imported inputs, but reduces wages at firms that do not import inputs. And there is a synergy in these effects so that exporting or importing magnifies the effect of the other.

We test our model's hypotheses with a rich data set covering the Indonesian trade liberalization of 1991–2000. The trade liberalization provides us with over 500 price changes per period, covering both input and output tariffs. A distinctive feature of the Indonesian data set is the availability of firm-level data on individual inputs, making it possible to construct highly disaggregated input tariffs. This, in turn, enables us to disentangle the effects of output and input tariffs. The data cover a period with a very substantial liberalization of both types of tariffs, with important variation across and within industries. From 1991 to 2000, average output tariffs fell from 21% to 8%, while average input tariffs fell from 14% to 6%. Further, the data include information on firm-level importing and exporting behaviour, allowing us to identify the differential effects of trade liberalization on exporters, importers, and domestically oriented firms.

The results of our study are striking. First, heterogeneity matters. Not only are firms affected in a heterogeneous way by trade liberalization, but so are the wages of their workers. Second, modes of globalization matter. Liberalization in final and intermediate goods trade have distinct impacts on the fate of workers according to the modes of globalization of the firms at which they work. A 10% point fall in output tariffs decreases wages by 3% in firms oriented exclusively toward the domestic economy. But the same fall in the output tariff *increases* wages by up to 3% in firms that export. A 10% point fall in input tariffs has an insignificant effect on firms that do not import but *increases* wages by up to 12% in firms that do import. In short, liberalization along each dimension raises wages for workers at firms that are most globalized and lowers wages at firms oriented to the domestic economy or which are marginal globalizers. Ours is the first paper to show an empirical link between input tariffs and wages, and the first to show differential effects from reducing output tariffs on exporters and non-exporters.

Our results both parallel, and diverge from, findings in previous studies. The literature has found inconsistent results of the effect of output tariff cuts on wages. For example, both the industry-level study on Colombia by Goldberg and Pavcnik (2005) and the firm-level study on Mexico by Revenga (1997) associate a cut in output tariffs with a decline in industry and firm wages, respectively. However, the industry-level study on Brazil by Pavcnik *et al*. (2004) and the firm-level study of North American Free Trade Agreement by Trefler (2004) find insignificant or near zero effects of a decline in output tariffs on wages. None of the prior studies has found that cuts in output tariffs *raise* the wages of workers at some firms. Our approach, which allows the effect of output tariffs on firm wages to depend on the firm's export orientation, may explain the prior mixed results due to the pooling of groups of firms with disparate responses.

Differential firm-level wage responses between exporters and non-exporters arise in Verhoogen (2008). However, the experiment he considers is not a trade liberalization but rather an exchange rate depreciation. Implicitly, this is a movement in a single price. But the same devaluation that makes exporting more attractive also makes importing intermediates less attractive, and one can hope at best to ascertain the net of the two effects. The first study to place imported intermediates at the heart of a discussion of wage evolution is Feenstra and Hanson (1999). But their study only considers economy-wide wage changes and their empirical exercise includes no explicit measures of changes in the costs of importing intermediates (tariff reductions or otherwise). Indeed, no prior study has used explicit measures of liberalization in intermediate tariffs to estimate wage effects.

Our empirical results directly address the effect of tariff liberalization on firm-level wages, but the results have broader implications. The theoretical results encompass any element of globalization in which there is a change in the relative marginal cost of serving final goods markets or sourcing inputs from foreign vs. domestic markets. This includes changes in transport costs, regulation, or other barriers that affect these relative marginal costs. From this perspective, the advantage of our experiment in understanding the broader process of globalization is that tariff liberalization allows these changes in relative marginal costs to be measured precisely and so give us greater ability to identify the consequences for firm-level wages.

2. THEORY

Our theory draws on three key elements. The first is heterogeneous firms, as in Melitz (2003). The second is costly trade in intermediates, as in Kasahara and Lapham (2007). The third is imperfect factor markets that feature some form of rent sharing between firm and workers, as, *e.g.*, in Helpman, Itskhoki and Redding (2010).[2]

2.1. *Consumption of final goods*

Final demand is directly from Dixit and Stiglitz (1977). Consumers allocate expenditures E across a continuum of available final good varieties to

$$\text{Min } E = \int p(\nu)q(\nu)d\nu \text{ s.t. } \left[\int q(\nu)^{\frac{\sigma-1}{\sigma}} d\nu\right]^{\frac{\sigma}{\sigma-1}} = U. \tag{1}$$

Here, $\sigma > 1$ is the elasticity of substitution between final goods varieties. These deliver demand curves for final product ν of the form $q(\nu) = \left[\frac{p(\nu)}{P}\right]^{-\sigma} Q$ and revenue of the form $r(\nu) = R\left[\frac{p(\nu)}{P}\right]^{1-\sigma}$, where $Q \equiv U$, and P is an aggregate price index given by $P = \left[\int_{\nu\in V} p(\nu)^{1-\sigma} d\nu\right]^{\frac{1}{1-\sigma}}$ with $PQ = R$.

2.2. *The fair-wage constraint and the labour market*

Our data exercise focuses on the evolution of firm specific wages, and so our theory must provide for these. We do this with two elements. The first is firm heterogeneity, both in productivity and in firm-specific costs of penetrating international markets. The second is to tie firm wages to firm performance. We introduce this via a fair-wage constraint.

Our model will feature firms, some of whose operating profits are zero and others for which these are positive. Firms earning zero profits are either in a competitive intermediates sector or marginal firms in an imperfectly competitive final goods sector in which all other firms have positive operating profits.

Workers have fair-wage demands. All workers at zero-profit firms earn the same wage, whether in the intermediate or final goods sectors. We take this wage as our numéraire. Letting the wage on offer at any other firm ν be given as W_ν. We assume that other firms pay a wage

2. Imperfect factor markets that feature firm-worker rent sharing is key. The precise form this takes is not essential to our story and, at this stage and with this data, we do not aim to distinguish them. The literature has considered search models with *ex post* bargaining, as in Felbermayr *et al*. (2011) or Helpman, Itskhoki and Redding (2010); efficiency wage models, as in Davis and Harrigan (2011); and fair-wage models, as in Egger and Kreickemeier (2009) and the present paper.

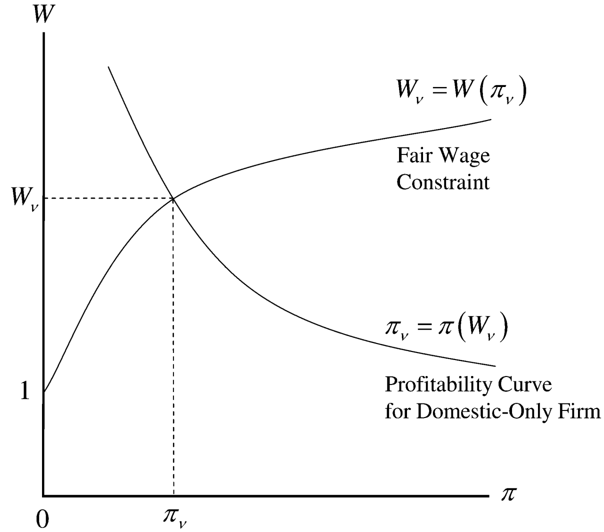

FIGURE 1

Determination of firm wage and profit for given mode of globalization

that is increasing in the profitability of the firm. Workers demand these wage premia as a condition of exerting effort because it is considered fair that a more profitable firm pay a higher wage (Akerlof, 1982). Firms are willing to pay these wages because it is necessary to elicit effort. The wages are not bid down because all workers are identical and once hired any other worker will likewise demand the fair wage. We assume that workers need not queue for these jobs, but instead accept any job offered so long as they are not currently employed at a job paying more. In sum, we have that

$$W(0) = 1, W_\nu = W(\pi_\nu), 0 < W'(\pi_\nu) < \infty, W_\nu \leq \overline{W}. \tag{2}$$

The fair-wage constraint determines that the nominal wage on offer at any zero-profit firm is unity while that at any other firm ν is an increasing function of the profitability of that firm, represented by $W_\nu = W(\pi_\nu)$. We assume that this is a stable behavioural relation, with $0 < W'(\pi) < \infty$, and that there are limits to the demands of fairness, so wages have a finite-upper bound. This relationship is illustrated in Figure 1.

2.2.1. Firm production, profits, and modes of globalization. We are now in a position to take a more detailed look at firm choices. The fair-wage constraint provided us with one relation in which firm wages depend on profits. To establish firm equilibrium, we need to develop the reverse relation, how the profitability of a firm depends on the wages that it pays. We will see that this relation varies according to the firm choice of a mode of globalization. Naturally, the firm chooses the mode of globalization that maximizes profits.

There are two sectors of production, intermediate, and final goods, each produced with a single homogeneous factor, labour. Intermediates are available in each country in a fixed measure of varieties on the unit interval, $m(j)$ for $j \in [0, 1]$. They are produced with free entry under constant returns to scale and priced at marginal cost. Units are chosen so that one unit of labour produces a unit of intermediates. Since labour employed in the intermediates sector is the numéraire, this implies that both the wage in this sector and the local price of intermediates are unity. At this price, intermediate suppliers stand ready to meet any demand arising in the final goods sector.[3]

In the final goods sector, the sequence of decision problems is based on Melitz (2003). From an unbounded mass of potential firms, a mass M_e pays a fixed cost f_e in units of labour. Having paid this fixed cost, the firm receives a random draw that reveals a triplet of information $\lambda_\nu = (\phi_\nu, t_{M\nu}, t_{X\nu})$ that is distributed with the joint probability density function $g(\lambda_\nu)$. The respective elements are the firm's productivity in marginal cost activities ϕ_ν as well as the idiosyncratic components of marginal trade costs in imports $t_{M\nu}$ and exports $t_{X\nu}$.

We add these additional dimensions of firm heterogeneity to match cross-sectional features of the data. If, as in Melitz, the marginal physical productivity parameter φ were the only dimension of firm heterogeneity, then we could have at most three of the four types of firms active (either all exporters would also import or all importers would also export rather than allowing each separately). Introduction of one additional dimension of firm heterogeneity would suffice to solve this issue. The reason for adding two additional dimensions of heterogeneity (export and import costs) is because, otherwise, all firms that export would export the same share of their output or all firms that import would import the same share of their inputs. The cross-sectional data instead strongly show large variation in export and import shares, hence motivate our assumptions. While we characterize $t_{X\nu}$ and $t_{M\nu}$ as trade costs, they can also be looked on as firm-specific marginal efficiencies, respectively, of penetrating foreign markets or using foreign inputs. All experiments considered in this paper consist of varying only common components of trade costs, τ_X and τ_M.

For future reference, we also introduce the marginal probability density $g_\Phi(\phi) \equiv \int_{t_M} \int_{t_X} g(\lambda)\, dt_X dt_M$ and the associated cumulative density $G_\Phi(\phi) \equiv \int_0^\phi g_\Phi(u)du$. After learning their characteristics, some firms exit without producing, and the remaining mass of firms M will choose labour and intermediate inputs as well as final outputs destined for each market to maximize profits. There is a constant hazard rate δ of firm death. Steady state requires that new entry matches firm exits.

At any point in time, the individual final goods producer maximizes profits, taking the demand curve as given. We assume that all fixed cost activities pay a wage in constant proportion to that available in the competitive intermediates sector, which we set at unity for convenience.[4] However, we will focus on firm-specific wages W_ν in variable cost activities that arise in equilibrium, as developed below. In order to produce in any period, a final goods firm is required to employ f units of labour in fixed costs. With the fixed costs incurred, production is Cobb–Douglas in labour and intermediates.

We show in the electronic appendix that firms behave as if marginal costs are constant at their equilibrium level. Thus, we must derive a functional relation between profits at the firm and the wages paid there for each mode of globalization. For given macro variables, this will allow the firm to choose the mode of globalization that maximizes profits, determining also wages and all other firm variables.

Profits for a firm in the isoelastic setting with constant marginal costs are generically given as

$$\pi_\nu = \mathrm{Max}\left[0, \frac{r_\nu}{\sigma} - F_\nu\right]. \tag{3}$$

3. We allow for love of variety in intermediates but fix the measure of varieties per market exogenously. This allows us to introduce the desired cost-saving aspect of intermediate trade without the complications, including multiple equilibria, familiar from economic geography models such as Venables (1996).

4. Our assumption that fixed costs are invariant here to changes in firm wages for variable cost labour is for simplicity and parallels the assumption in Helpman, Itskhoki and Redding (2010), where firm-fixed costs are paid in a competitive outside good.

The fixed cost F_ν for a firm is a function of the mode of globalization. Let n be the number of foreign markets, f_X be the fixed cost of penetrating an export market, and f_M be the fixed cost of importing intermediates from each foreign market, then

$$F_\nu = \begin{cases} f & \text{if domestic only,} \\ f + nf_M & \text{if import intermediates,} \\ f + nf_X & \text{if export final goods,} \\ f + n(f_X + f_M) & \text{if export final goods and import intermediates.} \end{cases} \tag{4}$$

In each of the $n+1$countries, a unit measure of intermediates is produced with labour only under free entry and constant returns to scale. From above, the price of any domestic intermediate is unity, as is the free on board price of exported intermediates. The common landed cost, insurance and freight price for imported intermediates is $\tau_M > 1$, but we assume there is also a firm-specific iceberg component, $t_{M\nu} \in [1, \bar{t}_M]$, that reflects a firm's own capability in using imported intermediates. Hence, the total effective price to a firm ν is $\tau_{M\nu} = \tau_M t_{M\nu} > 1$. Liberalization is assumed to affect only the common marginal import cost term τ_M. A firm with lower-idiosyncratic intermediate trade costs can more easily cover the common fixed import cost, so it will begin to import at a lower level of idiosyncratic output productivity. Because low-idiosyncratic import costs reduce the relative price of imported inputs, when such a firm imports it will also use a higher share of imported (relative to locally produced) intermediates, have higher profits and higher wages, *ceteris paribus*, than a firm with higher-idiosyncratic import costs.

Final good firms' choices about importing intermediates will affect their costs. Marginal costs c_ν are Cobb–Douglas in the input prices:

$$c_\nu = \frac{1}{\phi_\nu}\left(\frac{W_\nu}{\alpha}\right)^{\alpha}\left(\frac{P_{M\nu}}{1-\alpha}\right)^{1-\alpha} = \frac{\kappa W_\nu^\alpha P_{M\nu}^{1-\alpha}}{\phi_\nu}, \text{ where } \kappa \equiv \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}. \tag{5}$$

Costs feature two endogenous variables from the firm's perspective. The first is the wage. It must be kept in mind that firm costs, revenues, and profits in this section are determined *conditional on the firm wage*, which is itself determined only at the end of this section. The second is the price of the composite intermediate, which depends on whether intermediates are imported or not due to love of variety in available intermediates. A firm that imports has, in addition to a unit interval of local intermediates, access to n additional unit intervals of intermediates. Let $\gamma > 1$ be the elasticity of substitution between any two varieties of intermediates. Then the price of intermediates $P_{M\nu}$ varies according to input behaviour. A firm that uses domestic inputs only has $P_{M\nu} = 1$, while a firm that imports intermediates has $P_{M\nu} = [1 + n\tau_{M\nu}^{1-\gamma}]^{\frac{1}{1-\gamma}} < 1$.[5]

Hence, marginal costs depend on the choice of globalization, which affects $P_{M\nu}$ and the equilibrium firm wage W_ν (determined below). For a firm that does not import intermediates, marginal cost is $c_\nu = \frac{\kappa W_\nu^\alpha}{\phi_\nu}$ and for a firm that does import intermediates, there is a lower marginal cost at any given wage of $c_\nu = \frac{\kappa W_\nu^\alpha}{\phi_\nu}\left(1 + n\tau_{M\nu}^{1-\gamma}\right)^{\frac{1-\alpha}{1-\gamma}}$. Given isoelastic demand and monopolistic competition, as we saw earlier, the domestic price of a final good variety is the standard mark-up on marginal costs, $p_{\nu d} = \frac{\sigma}{\sigma-1}c_\nu$.[6]

5. Here we abstract from the issue of whether increased imports are due to an intensive or extensive margin, since in both cases a tariff reduction reduces costs, raising profits and wages. Evidence on these margins may be found, *inter alia*, in Goldberg *et al*. (2009), Klenow and Rodriguez-Clare (1997) and Arkolakis *et al*. (2008).

6. In an electronic appendix, we show that constant markup pricing remains optimal for the firm in spite of its knowledge that its choices affect the wage. Intuitively, since the wage depends *positively* on profitability, the firm has no incentive to manipulate the wage, so treats it as parametric at the equilibrium level.

Revenue in the domestic market depends on the price there, as in $r_{\nu d} = RP^{\sigma-1} p_{\nu d}^{1-\sigma}$. Since importing intermediates affects cost, and so price, it also affects revenues. For a firm that does not import intermediates, revenues are given as $r_{\nu d} = RP^{\sigma-1}\left(\frac{\kappa W_\nu^\alpha}{\rho\phi_\nu}\right)^{1-\sigma}$, while they are the higher $r_{\nu d} = \Gamma_{M\nu} RP^{\sigma-1}\left(\frac{\kappa W_\nu^\alpha}{\rho\phi_\nu}\right)^{1-\sigma}$ at a given wage for a firm that does import intermediates. Here, $\Gamma_{M\nu} \equiv \left(1+n\tau_{M\nu}^{1-\gamma}\right)^{\frac{(1-\alpha)(1-\sigma)}{1-\gamma}} > 1$ is an "import globalization" factor, reflecting the reduced marginal costs due to the use of imported intermediates, which lowers prices and raises revenues. The markup is $\frac{1}{\rho}$, where $\sigma = \frac{1}{1-\rho}$.

Total revenues r_ν depend not only on the degree of penetration of any one market but also on the effective number of markets served and the firm's efficiency in serving those markets. We assume that there are idiosyncratic iceberg costs for a firm to serve a foreign market, given by $\tau_{X\nu}$. These can be decomposed into a common export cost $\tau_X > 1$ and an idiosyncratic component $t_{X\nu} \in [1, \bar{t}_{X\nu}]$, where $\tau_{X\nu} = \tau_X t_{X\nu}$. Revenues in a foreign market are reduced proportionally to those in the domestic market, reflecting the higher price faced by consumers in that market due to iceberg costs $\tau_{X\nu}$ on final goods exports. All else equal, a firm with idiosyncratically low-export costs will enter exporting at a lower level of productivity than other firms and will export a higher share of its total output.

Letting $r_{\nu d}$ be the revenues of a firm that serves the domestic market only, a firm that exports will have revenues $\Gamma_{X\nu} r_{\nu d}$. Here, $\Gamma_{X\nu} \equiv (1+n\tau_{X\nu}^{1-\sigma}) > 1$ is an "export globalization" factor, reflecting the fact that in addition to the domestic market, exporting gives access to n additional markets, each of which is $\tau_{X\nu}^{1-\sigma} < 1$ times the size of the domestic market.

This gives us the complete set of dimensions of globalization, depending on whether intermediates are imported or final goods exported. Note that so long as profits are non-negative, these are related to revenues by $\pi_\nu = \frac{r_\nu}{\sigma} - F_\nu$. Let variable profits for a firm that is purely domestic be $\pi_{\nu d \mathrm{Var}} = \left(\frac{RP^{\sigma-1}}{\sigma}\right)\left(\frac{\kappa W_\nu^\alpha}{\rho\phi_\nu}\right)^{1-\sigma}$. Then the profits, conditional on wages, are

$$\pi_\nu(W_\nu) = \begin{cases} 0 & \text{if a firm exits without producing,} \\ \pi_{\nu d \mathrm{Var}} - f & \text{domestic only,} \\ \Gamma_{M\nu}\pi_{\nu d \mathrm{Var}} - (f + nf_M) & \text{imported intermediates,} \\ \Gamma_{X\nu}\pi_{\nu d \mathrm{Var}} - (f + nf_X) & \text{exported final goods,} \\ \Gamma_{X\nu}\Gamma_{M\nu}\pi_{\nu d \mathrm{Var}} - [f + n(f_X + f_M)] & \text{imp'd interm's \& exp'd final goods.} \end{cases} \tag{6}$$

Here, we emphasize the dependence, for each mode of globalization, of profits on wages, which we can label $\pi_\nu(W_\nu)$, where $\pi_\nu'(W_\nu) < 0$. The negative slope reflects the simple point that, all else equal, higher wages reduce profits. We can refer to these as profitability curves (see Figure 1 for a profitability curve if a firm serves only the domestic market).

For given macro variables (determined in the next section), we are now in a position to determine the firm wage. The fair-wage constraint provides one relation in which wages and profits are positively related. If we fix a mode of globalization, we now also have a second, decreasing, relation between profits and wages. Combining these two relations, as we do in Figure 1 for a purely domestic firm, determines the wage and profit *for that mode of globalization*. The firm then chooses the mode of globalization that maximizes profits (or exits if this maximum is negative). Notably, among these choices and due to the fair-wage constraint, the firm chooses the mode of globalization that also maximizes equilibrium wages. Thus, we have determined wages, profits, and all other firm level variables conditional on macro variables.

2.3. *Market equilibrium*

To determine the full general equilibrium, we make two simplifying assumptions.

Assumptions 1.

A. $f_X \geq f$. *This insures that zero-profit firms do not export because with strictly positive costs of trade* $\tau_X > 1$, *the variable profits earned in each foreign market are smaller than in the domestic market, hence cannot cover the fixed costs of exporting.*

B. $f_M > \frac{f}{n}(\Gamma_{M\max} - 1)$, *where* $\Gamma_{M\max} \equiv \left(1 + n\tau_M^{1-\gamma}\right)^{\frac{(1-\alpha)(1-\sigma)}{1-\gamma}}$, *i.e.* $t_{M\nu} = 1$. *This condition insures that a firm earning zero profits when it fails to import intermediates will not find it advantageous to import intermediates. To see this, note that, the net gains from importing intermediates are* $(\Gamma_{M\upsilon} - 1)\pi_{\nu d\mathrm{Var}} - nf_M$; *that for a zero-profit firm,* $\pi_{\nu d\mathrm{Var}} = f$; *set* $t_{M\nu} = 1$, *which raises* $\Gamma_{M\upsilon}$ *to its maximum; and then impose the condition that the net gain from importing intermediates is such that* $(\Gamma_{M\max} - 1) f - nf_M < 0$.

Together these two assumptions insure that zero-profit firms neither export nor import. Given that more than 70% of the firms neither export nor import, these assumptions seem reasonable. Together they imply that the equilibrium cutoff will have the characteristic that a firm survives if and only if $\phi \geq \phi*$.

Under these assumptions, the profits of a firm conditional on the cutoff can be written as $\pi_\nu = \pi(\lambda_\nu, \hat{\phi}*)$, where $\hat{\phi}*$ is the notional cutoff productivity. This is easily demonstrated as follows. Zero-profit firms have wages equal to unity by the fair-wage constraint. Hence,

$$\pi(\hat{\phi}*, W(0)) = \left(\frac{RP^{\sigma-1}}{\sigma}\right)\left(\frac{\kappa}{\rho\hat{\phi}*}\right)^{1-\sigma} - f = 0. \tag{7}$$

This yields precisely the macro values consistent with the notional cutoff $\hat{\phi}*$.

$$RP^{\sigma-1} = \sigma f \left(\frac{\kappa}{\rho\hat{\phi}*}\right)^{\sigma-1}. \tag{8}$$

With these macro values in hand, we need only return to the firm's problem in the last section to determine the profits $\pi_\nu = \pi(\lambda_\nu, \hat{\phi}*)$ consistent with this notional cutoff. This allows us to develop five propositions. The proofs are in an electronic appendix.

Proposition 1. *An autarky fair-wage equilibrium exists and is unique.*

Proposition 2. *The fair-wage equilibrium with trade in final and intermediate goods exists and is unique.*

Proposition 3. *A move to costly trade from autarky raises the equilibrium cutoff, i.e.,* $\phi^* > \phi^{*A}$.

Proposition 4. *A move to costly trade from autarky leads to*

A. Exit of the least productive firms, $\phi_\nu \in (\phi^{*A}, \phi^*)$.
B. A decline in wages at all firms that serve only the domestic market.
C. A decline in wages at marginal importers and marginal exporters.
D. A rise in wages for sufficiently large exporters or importers.

Proposition 5. *All else equal, a firm that exports a larger share of its output or imports a higher share of its inputs will have higher profits and wages.*

3. INDONESIA: LABOUR MARKETS AND DATA DESCRIPTION

We will apply our theory to the case of Indonesia, so it is important that our posited labour market institutions make sense in that context. For much of the period that we examine (through mid-1998), Indonesia was ruled by the authoritarian President Suharto. Independent unions were proscribed, which would be problematic for a simple union bargaining model (see Hadiz, 1997). The Stole–Zweibel bargaining approach focuses on bargaining in light of individual workers' potential defection from an agreement, which seems more relevant for a case in which workers are highly differentiated rather than the Indonesian case that is dominated by very low-skilled labour. Even non-production workers in Indonesia are not highly skilled, with only 10% having attained education above high school. The role of government is important, both because it provides an official sanction for labour organizations and it provides avenues for appeals if workers feel a firm's offer is unfair. Yildiz (2011) provides an example of how third-party (here, government) influences may matter even when not directly involved. For this reason, it is important to consider closely the government approach to labour relations. The official ideology was summarized in so-called "Pancasila labour relations," that emphasized collaborative relations among employers, workers, and the government, as discussed in Shamad (1997). The perspective of Shamad is helpful, as he spent several decades in the Indonesian bureacracy, including stints as the Director for Wages and Social Security (1988–1992) and the Chairman of Central Committee for Industrial Disputes Settlement (1992 to at least 1997). In a section titled "The Principles Used to Achieve the Aim [of Pancasila labour Relations]," he writes:

> The workers and employers are partners in enjoying the proceeds of the company; this means that *the proceeds of the company have to be mutually enjoyed, fairly and harmoniously*. (p. 8) [emphasis added]

Of course, one should not take this entirely at face value. But it does provide a foundation for believing in a norm such that workers share in the success of the firm, so have higher wages where there are higher profits. Notably, it is consistent with the observation by government critic Dan la Botz (2001, p. 137) that worker appeals to government councils about wage offers have a much better chance of an outcome attractive to workers when the workers group is large and the associated firm likely more profitable.

3.1. *Data description*

To take the theory to the data, we need three key ingredients. First, to establish a link between tariff cuts and firm-level wages, we need firm-level data. For this, we rely on the manufacturing survey of large and medium-sized firms (Survei Industri, SI) for 1991–2000 in 290 five-digit ISIC industry categories.[7] The data set has wide coverage, including all firms with 20 or more employees, and accounting for 60% of manufacturing employment.[8]

Second, we highlight that the effect of tariff cuts on wages depends on whether employment is at a firm that is domestically or internationally oriented. To establish this, we draw on the

7. Data are at the plant level and it is not possible to identify multiple plants pertaining to a common firm. For convenience in referring to the theory, we will use the terms "plant" and "firm" interchangeably. We begin our analysis in 1991 to avoid the reclassification of industry codes between 1990 and 1991.

8. The data were cleaned by dropping the top and bottom one percentiles of the firm average wage level, and the top and bottom one percentiles of the year-to-year growth in firm average wages. We are left with a total of 185,866 observations. Summary statistics are provided in the appendix.

firm-level information provided in the census on importers and exporters. For each plant in each year, the data set reports on the value of a firm's exports and the value of imported and domestically purchased intermediate inputs.[9]

Third, we identify separate effects on wages from cutting input tariffs to those from cutting output tariffs. This requires that the tariff data are sufficiently disaggregated to disentangle the two effects. A key ingredient in calculating disaggregated input tariffs is information on the type of inputs that firms use. A unique feature of this data is that the SI questionnaire asks each firm to list all its individual intermediate inputs and the amount spent on each input. This information was coded up and made available to us by the Indonesian Statistical Agency (Badan Pusat Statistic, BPS) for the year 1998.

Before going to the estimation, we preview the data and highlight some stylized facts on wages, importers, and exporters that are consistent with features of our model. Next, we explain how the tariff data are constructed, show the large variation in tariffs across industries and within industries and, most importantly, that input and output tariffs move differently.

3.2. *Importers, exporters and wages*

Consistent with our model and patterns in other countries, only a small fraction of firms in Indonesia are engaged internationally. Only 5% of all firms both export and import; an additional 10% of firms export some of their output but do not import; and only 14% of firms import some of their inputs but do not export. While the globally engaged firms account for less than 30% of all firms, they are powerhouses, accounting for more than 60% of manufacturing employment and nearly 80% of the value added in the sample. Similar patterns are evident in advanced countries, such as France (Eaton, Kortum and Kramarz, 2008) and the U.S. (Bernard *et al*. 2007) as well as in developing countries such as Mexico (Verhoogen, 2008).[10]

Most striking is the large variation in the wages paid by firms within the same industry. Looking at the data on a firm's wage relative to the industry average in 1991, we find there is considerable wage heterogeneity across firms, with a standard deviation equal to 0.73. Around 14% of firms pay more than 50% of the industry mean and 16% pay less than 50% of the industry mean.

Our theory implies that firm wages increase with firm profits. Unfortunately, reliable measures of profits are not available. However, theory also suggests that profits increase in revenues. So, a rough gauge of the plausibility of the link between wages and profits is to look at the corresponding link between wages and revenues, both in levels and in changes. Using 1991 data, we find there is a positive and significant relationship between the log of firm wages and log of firm revenues, with a coefficient equal to 0.2. This positive relationship also holds over time, between the change in log wages and the change in log revenues over the sample period, with a significant coefficient of 0.14.

Closer inspection of the data reveals that wages vary greatly by type of firm. Comparing internationally engaged firms to domestically oriented firms in Table 1A, we see from Column 1 that exporters pay 28% higher wages, importers pay 47% higher wages and firms that both import and export pay 66% higher wages. These wage differentials persist when we include industry fixed effects and control for the share of non-production workers and total employment, although the magnitudes fall. With these controls, and compared to domestically oriented firms, exporters pay 8% higher wages, importers pay 15% higher wages, and firms that import and

9. These imported inputs include inputs that are directly imported by the firm as well as imported inputs purchased from local distributors.

10. See electronic Appendix B for graphs of the information in this section.

TABLE 1A
Importers, exporters and wages

Dependent variable	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
Exporters	0·275***	0·176***	0·251***	0·161***	0·133***	0·076***
	(0·005)	(0·005)	(0·005)	(0·005)	(0·005)	(0·005)
Importers	0·468***	0·245***	0·381***	0·214***	0·287***	0·146***
	(0·005)	(0·005)	(0·004)	(0·004)	(0·004)	(0·004)
Importers and exporters	0·664***	0·445***	0·618***	0·422***	0·389***	0·254***
	(0·007)	(0·006)	(0·006)	(0·006)	(0·007)	(0·007)
skillshare			1·367***	0·897***	1·279***	0·833***
			(0·013)	(0·012)	(0·013)	(0·012)
ln(labour)					0·111***	0·097***
					(0·001)	(0·001)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	No	Yes	No	Yes	No	Yes
Firm effects	No	No	No	No	No	No
Observations	185,866	185,866	185,866	185,866	185,866	185,866
Adjusted R^2	0·30	0·52	0·37	0·54	0·39	0·55

TABLE 1B
Importers, exporters and size

Dependent variable	$\ln(\text{labour})_{f,i,t}$	$\ln(\text{labour})_{f,i,t}$	$\ln(\text{VA})_{f,i,t}$	$\ln(\text{VA})_{f,i,t}$	$\ln(\text{TFP})_{f,i,t}$	$\ln(\text{TFP})_{f,i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
Exporters	1·074***	0·889***	1·604***	1·297***	0·120***	0·107***
	(0·009)	(0·009)	(0·014)	(0·014)	(0·005)	(0·005)
Importers	0·893***	0·731***	1·746***	1·261***	0·107***	0·116***
	(0·009)	(0·009)	(0·015)	(0·014)	(0·005)	(0·004)
Importers and exporters	2·085***	1·749***	3·318***	2·692***	0·203***	0·202***
	(0·013)	(0·012)	(0·018)	(0·018)	(0·008)	(0·006)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	No	Yes	No	Yes	No	Yes
Firm effects	No	No	No	No	No	No
Observations	185,866	185,866	172,235	172,235	153,018	153,018
Adjusted R^2	0·24	0·39	0·27	0·45	0·02	0·47

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

export pay 25% higher wages. In short, even with these controls, wages vary systematically and substantially by the mode of firms' global engagement.

As per theory, the larger and more efficient firms are globally engaged. As can be seen from Table 1B, domestically oriented firms rank lowest in terms of employment (Columns 1 and 2), value added (Columns 3 and 4), and total factor productivity (Columns 5 and 6). The ranking between firms that import or export only is not tied down by theory and indeed varies by metric. However, in line with theory, in each case, those firms that both import and export are the largest and most productive. For example, from the last two columns, we see that firms that import and export are on average 20% more productive than domestically oriented firms.[11]

3.3. *Tariffs*

To construct the *output* tariffs, we map harmonized system (HS) nine-digit tariffs from the Indonesia Industry and Trade Department into production data at the five-digit ISIC level from the BPS based on an unpublished concordance.[12] Our five-digit output tariff, then, is the simple average of the tariffs in the HS nine-digit codes within each five-digit industry code.[13]

To compute a five-digit *input* tariff, we use an input-cost weighted average of these five-digit *output* tariffs, where

$$\begin{aligned} \text{input tariff}_{\text{it}} &= \textstyle\sum_j w_{ij,1998} * \text{output tariff}_{j,t} \\ \text{and } w_{ij,1998} &= \frac{\sum_f \text{input}_{f,ij,1998}}{\sum_{f,j} \text{input}_{f,ij,1998}}. \end{aligned} \tag{9}$$

The weights,$w_{ij,1998}$, are computed by aggregating the firm-level 1998 input data within 5-digit industry categories to create a 290 manufacturing input/output table. Thus, if industry i incurs 70% of its cost in steel and 30% in rubber, steel tariffs receive a 70% weight, while rubber tariffs receive a 30% weight. We assume that the distribution of spending across inputs by industry is fixed in our sample period, hence assume a Cobb–Douglas technology.

Importantly, these input tariffs are constructed at the industry level and not at the firm level. Further, the cost shares are based on total input purchases, both domestic and imported. If the weights only included a firm's own input choices or only imported inputs, this would introduce an endogeneity bias.[14] Conditional on these concerns, we assign the most relevant input tariff to each industry. Thus, if an industry is intensive in rubber usage, the relevant tariff is that on rubber irrespective of whether the rubber is imported. There may be concern that the weights are based on a year during the Asian crisis. To address this, we also construct input tariffs using cost shares from the 1995 input/output table, but these are at a more aggregate level.

There is considerable variation in both input tariffs and output tariffs. In general, output tariffs exceed input tariffs. Output tariffs were as high as 80% for the five-digit motorcycle and motor vehicle industries, while the highest input tariff was 36% in the footwear industry in 1991. The correlation between output tariffs and input tariffs in 1991 is only 0.41.[15]

11. Interestingly, all three sources of heterogeneity we highlight in the model contribute to the variation in the size of firms. After controlling for plant-level productivity and year effects, we found that adding in export status increases the R-squared by 10 percentage points, and then adding in import status increases the R-squared by a further 10 percentage points. The increments are smaller when we also add in industry effects but they remain significant.

12. These tariffs are from Amiti and Konings (2007).

13. We also present results with import-weighted average tariffs as a robustness check.

14. It is possible to construct firm-level input tariffs only for those firms that exist in 1998, but this would cause problems relating to sample selection bias and introduce an endogeneity problem. The shares used to weight the firm input tariffs would differ due to price difference provided the elasticity of substitution were not equal to one. For example, if importers pay different prices for their inputs than domestic-oriented firm (*e.g.*, Kugler and Verhoogen, 2009 show imported input prices are higher than domestic inputs), their weighted tariff would differ from firms that purchase domestic inputs even if they used the same type of inputs. This could cause a bias on the input tariff coefficient, with the direction of the bias depending on whether input tariffs were higher or lower on the inputs with a higher input share. To avoid this potential pitfall, all tariffs are constructed at the industry level, however, we also present a robustness check using firm-level tariffs.

15. Over the whole period, the correlation is equal to 0.46. Note that this is the correlation at the industry level. However, once the tariff data has been merged with the firm data, the correlation increases to 0.67 since each industry tariff is repeated for every firm in that industry.

The highly detailed nature of the tariff data is also critical. For example, the three-digit transport equipment industry (ISIC 384) comprises ten five-digit ISIC codes, where the output tariffs within this grouping ranged from 77% on motor vehicles and 32% for motor vehicle components to only 3% on railroad equipment in 1991. Prior studies often rely on the more aggregate three-digit industry-level tariffs, which mask this heterogeneity.

Both input and output tariffs decline over the sample period, with the biggest reductions after 1995. Large reductions took place in most tariffs, with only four industries (in the rice milling and liquor industries) experiencing an increase in output tariffs. There are independent movements between changes in the two types of tariffs, with a correlation between the changes in input tariffs and output tariffs at 0.38. It is this independent variation that helps to identify the separate effects of the input and output tariff on wages over this period.

4. ESTIMATION

The model generates a number of hypotheses on how tariff cuts will affect wages. In particular, reducing output tariffs has differential effects on exporters and non-exporters, and reducing input tariffs has differential effects on importers and non-importers. To test these predictions, we estimate the following reduced form equation using ordinary least squares (OLS) with firm-fixed effects, α_f, to control for unobserved firm-level heterogeneity and interactive location-year fixed effects, $\alpha_{l,t}$, to control for shocks over time that affect wages across all sectors but may vary across different parts of Indonesia.[16]

$$\begin{aligned}\ln(\text{wage})_{f,i,t} = \alpha_f + \alpha_{l,t} + \beta_1{*}\text{ output tariff}_{i,t} + \beta_2{*}\text{ output tariff}_{i,t}{*}\, FX_{f,i,t} + \\ + \beta_3{*}\text{ input tariff}_{i,t} + \beta_4{*}\text{ input tariff}_{i,t}{*}\, FM_{f,i,t} + \mathbf{Z}_{f,i,t}\boldsymbol{\Gamma} + \varepsilon_{f,i,t}. \quad (10)\end{aligned}$$

The dependent variable is the log of the average firm-level wage, defined as the total wage bill divided by the number of workers.[17] The key variables of interest are the five-digit industry-level *output tariff* and the five-digit industry-level *input tariff*. To allow for the differential effects of tariff cuts on wages predicted by the model, we interact output tariffs with an export dummy, FX=1, for firms that export any of their output. And we interact the input tariff with an import dummy, FM=1, for firms that import any of their intermediate inputs.

We hypothesize that a fall in output tariffs reduces wages of non-exporters, $\beta_1>0$ and will increase wages of exporting firms, $\beta_2<0$. The coefficient on the interactive term gives the differential effect between exporters and other firms. Thus, the net effect for exporters is equal to $\beta_1 + \beta_2$. Recall that the theory predicts that some marginal firms that switch from domestic orientation to exporting following tariff cuts will experience a loss in profits and hence lower wages. These marginal firms will need to export a sufficiently large share of their output for the benefits of exporting to outweigh the loss in profits due to increased import competition. To capture this effect, we interact output tariffs with the export share rather than an export dummy in some of the specifications, enabling us to calculate the critical export share that makes $\beta_1 + \beta_2$ * export share negative, indicating a rise in wages following tariff cuts.

Similarly, the theory predicts that a cut in input tariffs reduces wages of non-importers, $\beta_3>0$ and increases wages of sufficiently large importers, $\beta_4<0$, with the net effect on importers equal

16. There are five island dummies: Sumatra, Java, Kalimantan, Sulawesi, and the outer islands; and a Jakarta dummy.

17. We exclude overtime and bonus payments from the total wage bill so that variations in average wages reflect changes in the standard hourly wages rather than changes in the hours worked. As a robustness check, we include all the wage components and find the results are robust. Further, all the equations are robust to redefining the dependent variable as the average production wage.

to $\beta_3 + \beta_4$. Again, marginal firms that switch from domestic orientation to importing following tariff cuts may experience a loss in profits and lower wages if the gains from importing do not outweigh the loss due to heightened competition from importing firms that experience a cut in their input costs. We expect that $\beta_3 + \beta_4 *$ import share is negative for firms that import a sufficiently large share of inputs, indicating a rise in their wages following tariff cuts.

The vector $\mathbf{Z}_{f,i,t}$ includes a firm's export orientation and import orientation. In some robustness specifications, we will include additional firm-specific characteristics. These will include ownership variables such as foreign ownership (the share of capital owned by foreigners) and government ownership (the share of capital owned by local or central government), skill share (the ratio of non-production workers to total employment), and the firm size (the number of employees).

In order to identify the effects of tariff reductions on wages, an important question is whether the trade reform pattern is endogenous, as this would lead to biased estimates. It could be argued that firms in low-wage growth industries lobby for protection, which would lead to reverse causality and a negative bias on the output tariff coefficient.[18] In panel estimation, the potential bias due to the endogeneity of tariffs is reduced because all the estimates include firm fixed effects, so if political economy factors are time invariant, this is already accounted for (see Goldberg and Pavcnik, 2005). However, time-varying industry characteristics could simultaneously influence wages and tariffs. To address this, Trefler (2004) proposes using initial industry-level characteristics as instruments in a differenced equation. We follow his approach. Given that it is easier to find instruments for changes in tariffs rather than levels, we first take five-period differences of equation (10) and then estimate using instrumental variables (IV).

$$
\begin{aligned}
\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5} &= \alpha_{l,t} - \alpha_{l,t-1} + \delta_1 * (\text{output tariff}_{i,t} - \text{output tariff}_{i,t-5}) \\
&+ \delta_2 * (\text{output tariff}_{i,t} * \text{FX}_{f,i,t} - \text{output tariff}_{i,t-5} * \text{FX}_{f,i,t-5}) \\
&+ \delta_3 * (\text{input tariff}_{i,t} - \text{input tariff}_{i,t-5}) \\
&+ \delta_4 * (\text{input tariff}_{i,t} * FM_{f,i,t} - \text{input tariff}_{i,t-5} * FM_{f,i,t-5}) \\
&+ (\mathbf{Z}_{f,i,t} - \mathbf{Z}_{f,i,t-5})\mathbf{\Lambda} + \eta_{f,i,t}. \qquad (11)
\end{aligned}
$$

The long differencing helps wash out measurement error and any concern of unit roots that may be prevalent in a levels equation. After differencing equation (10), any time-invariant controls, such as the firm-fixed effects, drop out, thus, the only fixed effects that remain are the differenced location-year fixed effects, $\alpha_{l,t}$-$\alpha_{l,t-1}$.

Following Trefler (2004), the instrument set includes initial industry-level characteristics, as these are unlikely to be correlated with the five-period differenced residuals. In addition, the instruments must be correlated with tariff changes. For output tariffs, likely candidates include the 1991 share of production workers in total industry employment to reflect an industry's propensity to get organized, and this variable interacted with the five-period lagged export status dummy indicator. We add an exclusion dummy that equals one if a five-digit industry contained ten or more HS nine-digit products that were excluded from Indonesia's World Trade Organization (WTO) commitment to reduce all bound tariffs to 40% or less; and we include a non-tariff

18. The political economy literature argues that certain industries have more political power to lobby governments for protection (see Grossman and Helpman, 1994).Interestingly, Mobarak and Purbasari (2006) find that political connections in Indonesia do not affect tariff rates.

barrier dummy.[19] The political economy of reducing output tariffs may differ from that of reducing input tariffs. For example, car workers may have lobbying power to reduce tariffs on motor vehicles but limited power to affect tariffs on intermediate inputs like steel. Thus, we include the 1991 input tariff level and its interaction with the five-period lagged import status indicator.

5. RESULTS

We estimate equation (11) as an unbalanced panel in five-period differences for the years 1991–2000 using IV estimation. We then perform a number of robustness checks, showing the results also hold using OLS in changes as well as in levels equation with plant fixed effects (as in equation (10)). The errors have been clustered at the industry-year level.[20]

5.1. *Tariff cuts and wages*

The data support the model's predictions. In Table 2A, we estimate equation (11) in five-period differences using IV estimation. To highlight the importance of the differential qualitative effects predicted for exporters and non-exporters, first, we regress the change in the log of average firm wage only on the change in output tariffs and find an insignificant positive coefficient in Column 1. When we interact the output tariff with the export dummy in Column 2, we find that the coefficient on output tariffs remains positive, but now we see the coefficient on the output tariff interacted with exporter status is negative and significant. Thus, the wage in exporting firms increases relative to non-exporting firms following cuts in output tariffs since $\delta_1 + \delta_2 < 0$.

Next, we consider the effects of reducing input tariffs. When we include the input tariff on its own (Column 3 of Table 2A), we see that the coefficient is negative and significant. Yet when we interact input tariffs with an import dummy in Column 4, the coefficient on the interaction term is negative and significant, and the coefficient on input tariffs becomes insignificant. This indicates that a cut in input tariffs leads to higher wages for importing firms relative to non-importers, as predicted by our model. However, although the coefficient on input tariffs becomes insignificant, it remains negative, which contrasts with the model's prediction that non-importers become less profitable following a cut in input tariffs because of the relative advantage importers derive from access to a greater variety of inputs. Of course, there are other possible offsetting effects beyond the purview of the present model that might explain the negative coefficient. For example, sharper competition from imports following a cut in tariffs might force domestic intermediate producers to cut prices. This would then also reduce the costs for firms that purchase their inputs domestically.

The same conclusions emerge when we include both input and output tariffs within one specification in Column 5, with the magnitudes and significance levels close to the specification where the input and output tariffs were included individually. This is reassuring, as it indicates that there is sufficient variation in each tariff type to enable us to disentangle the two effects.

19. The WTO commitment was made at the beginning of 1995 to reduce bound tariffs over a ten-year period. The tariff lines are at the HS nine-digit level, comprising thousands of product codes. For the exclusion list, see http://www.wto.org/english/tratop_e/schedules_e/goods_schedules_e.htm. There were nine industries that contained ten or more excluded HS nine-digit codes. The industries with the highest number of exclusions were motor vehicles and components, and iron and steel basic industries. For the non-tariff barrier dummy, there were 36 five-digit industries that contained ten or more HS nine-digit codes subject to non-tariff barriers.

20. We cluster the errors at the industry/year level to take account of the tariffs being at the industry level and the dependent variable at the plant level (Moulton, 1990). Alternatively, we could cluster at the plant level to take account of heteroskedasticity. The plant-level clustering produces the same conclusions with smaller standard errors.

Further, the instruments provide a good fit in the first stage and pass the overidentifiction tests with p-values greater than 0.05.[21]

Our theory does not address the issue of foreign ownership, so we want to ensure that the coefficients on tariffs are being driven by importers and exporters rather than just foreign firms. Thus, in Column 1 of Table 2B, we drop all firms with any foreign ownership. The coefficients on all the tariff terms are quite close to those in Column 5 of Table 2A except the coefficient on output tariffs is now a little higher and significant, indicating a stronger negative effect on

TABLE 2A
Tariffs and wages—baseline regressions

Dependent variable: $\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5}$					
	Instrumental variables estimation				
	Output tariff (1)	With exporters (2)	Input tariffs (3)	With importers (4)	Both tariffs (5)
ΔOutput tariff$_{i,t}$	0·158	0·271			0·244
	(0·184)	(0·186)			(0·187)
Δ(Output tariff$_{i,t}$ x FX$_{f,i,t}$)		–0·583***			–0·482***
		(0·098)			(0·096)
ΔInput tariff$_{i,t}$			–0·333*	–0·209	–0·227
			(0·190)	(0·188)	(0·196)
Δ(Input tariff$_{i,t}$ x FM$_{f,i,t}$)				–0·694***	–0·520***
				(0·131)	(0·124)
ΔFX$_{f,i,t}$	0·019***	0·129***	0·019***	0·022***	0·112***
	(0·007)	(0·019)	(0·007)	(0·007)	(0·018)
ΔFM$_{f,i,t}$	0·033***	0·031***	0·033***	0·112***	0·090***
	(0·008)	(0·008)	(0·008)	(0·016)	(0·015)
Joint Significance tests Ho: sum of coefficients on tariff variables equals zero					
Output tariffs		–0·312**			–0·238
		(0·154)			(0·168)
Input tariffs				–0·903***	–0·748***
				(0·217)	(0·222)
Weak instruments (F-stat)	2,501	1,818	22,000	8,515	1,273
Overidentification					
Hansen J statistic	5·97	5·51	0·28	5·82	4·90
p-value	0·05	0·06	0·60	0·12	0·09
Observations	55,393	55,393	55,393	55,393	55,393

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments include 1991 industry skill share, 1991 industry skill share interacted with five-period lagged export dummy, 1991 input tariff level, 1991 input tariff level interacted with five-period lagged import dummy, exclusion dummy = 1 if ten or more HS nine-digit products excluded within a five-digit industry code from commitment to reduce bound tariffs to 40%, and non-tariff dummy = 1 if ten or more HS nine-digit product codes were subject to non-tariff barriers. All of the estimations include location x year fixed effects.

21. When the IV specification includes more than one endogenous variable, we include the Cragg–Donald statistic, to check for weak instruments. The Cragg–Donald statistic is well above the critical values listed in Table 1 of Stock and Yogo (2005).

TABLE 2B

Tariffs and wages—additional controls

Dependent variable: $\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5}$

	Instrumental variables						OLS
	Without foreign firms (1)	With ownership (2)	With skill share (3)	With size (4)	With trade shares (5)	With trade bins (6)	With trade shares (7)
ΔOutput tariff$_{i,t}$	0·411**	0·278	0·329*	0·336*	0·334*	0·341*	0·144*
	(0·185)	(0·187)	(0·185)	(0·186)	(0·187)	(0·186)	(0·082)
Δ(Output tariff$_{i,t}$ x FX$_{f,i,t}$)	–0·440***	–0·485***	–0·492***	–0·553***	–0·646***	–0·427***	–0·338***
	(0·102)	(0·096)	(0·096)	(0·097)	(0·138)	(0·113)	(0·080)
Δ(Output tariff$_{i,t}$ x highFX$_{f,i,t}$)						–0·250*	
						(0·128)	
ΔInput tariff$_{i,t}$	–0·261	–0·242	–0·244	–0·232	–0·254	–0·230	–0·074
	(0·197)	(0·197)	(0·194)	(0·196)	(0·196)	(0·196)	(0·137)
Δ(Input tariff$_{i,t}$ x FM$_{f,i,t}$)	–0·528***	–0·540***	–0·531***	–0·598***	–1·148***	–0·194	–0·790***
	(0·134)	(0·125)	(0·125)	(0·129)	(0·307)	(0·242)	(0·184)
Δ(Input tariff$_{i,t}$ x highFM$_{f,i,t}$)						–0·452*	
						(0·244)	
ΔFX$_{f,i,t}$	0·104***	0·110***	0·110***	0·127***	0·147***	0·107***	0·085***
	(0·020)	(0·019)	(0·018)	(0·018)	(0·027)	(0·021)	(0·017)
ΔFM$_{f,i,t}$	0·082***	0·092***	0·091***	0·104***	0·179***	0·053*	0·137***
	(0·016)	(0·015)	(0·015)	(0·016)	(0·041)	(0·029)	(0·025)
ΔSkill share$_{f,i,t}$			0·293***	0·284***	0·286***	0·285***	0·286***
			(0·029)	(0·028)	(0·028)	(0·028)	(0·028)
Δln(labour)$_{f,i,t}$				–0·065***	–0·064***	–0·065***	–0·062***
				(0·007)	(0·007)	(0·007)	(0·007)
Δforeign share$_{f,i,t}$		0·111***	0·116***	0·126***	0·127***	0·126***	0·130***
		(0·027)	(0·027)	(0·027)	(0·028)	(0·028)	(0·028)
ΔGovt share$_{f,i,t}$		0·067***	0·066***	0·065***	0·067***	0·066***	0·064***
		(0·014)	(0·014)	(0·014)	(0·014)	(0·014)	(0·014)

(*continued*)

TABLE 2B
Continued

Dependent variable: $\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5}$

	Instrumental variables						OLS
	Without foreign firms (1)	With ownership (2)	With skill share (3)	With size (4)	With trade shares (5)	With trade bins (6)	With trade shares (7)
Joint significance tests Ho: sum of coefficients on tariff variables equals zero							
Output tariffs	–0·029	–0·207	–0·163	–0·217	–0·312*	–0·336*	–0·194*
	(0·168)	(0·168)	(0·168)	(0·169)	(0·182)	(0·179)	(0·101)
Input tariffs	–0·789***	–0·783***	–0·775***	–0·830***	–1·402***	–0·877***	–0·864***
	(0·224)	(0·223)	(0·221)	(0·224)	(0·350)	(0·229)	(0·218)
Hansen J statistic	1·94	4·69	4·16	4·21	3·43	4·50	
p-value	0·38	0·10	0·12	0·12	0·18	0·11	
Observations	52,383	55,393	55,393	55,393	55,393	55,393	55,393
Adjusted R^2							0·04

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments include 1991 industry skill share, 1991 industry skill share interacted with five-period lagged export dummy, 1991 input tariff level, 1991 input tariff level interacted with five-period lagged import dummy, exclusion dummy = 1 if ten or more HS nine-digit products excluded within a five-digit industry code from commitment to reduce bound tariffs to 40%, and non-tariff dummy = 1 if ten or more HS nine-digit product codes were subject to non-tariff barriers. All specifications pass the weak instrument test with F-stats over 1,000; and Column 6 also includes $\Delta\text{highFX}_{f,i,t}$ and $\Delta\text{highFM}_{f,i,t}$ but are not reported to save space. All the estimations include location-year fixed effects.

non-exporting firms without foreign ownership. In Column 2, we return to the full sample and include controls for foreign ownership as well as government ownership, and we see that the coefficients on these ownership variables are positive and significant.

Table 2B shows that our results are robust to adding in more firm-level controls. Although the differencing has taken account of unchanging differences in skill composition, this leaves open the possibility that the results are driven by changes in the skill composition of the firms' work force. For example, if firms respond to changes in tariffs by upgrading their workforce quality, this could bias the coefficients on tariffs. To check this, we include the change in the firm-level skill share in Column 3 and see that its coefficient is positive and significant. Thus, firms that employ relatively more skilled workers do indeed, on average, pay higher wages. But, more importantly, the inclusion of the skill share leaves the coefficients on tariffs unchanged. We will address this issue in more detail below. Here, we also include the number of workers at the firm level in Column 4, and see that it has a negative effect on the average wage bill but does not affect the coefficients on the tariff variables.

So far, all the specifications include dummy variables to indicate global status, leaving aside variation among globalizers of each type. In these specifications, the sum of the main tariff effect and the interaction effect is always significantly different from zero for importers in both Tables 2A and 2B, but it is insignificantly different from zero for exporters, except in Column 2 in Table 2A where we had not controlled for input tariffs. These results imply that the total effect from cutting output tariffs for the average exporter is zero. This average includes marginal exporters, for whom theory says the wage effect should be negative as well as exporters sufficiently large that the total wage effect should be positive. This pattern continues throughout the rest of the robustness tests, where the effect from cutting input tariffs on importers is significantly different from zero in all but one specification; and the effect from cutting output tariffs is not significantly different from zero in almost all the specifications when we interact with a single dummy indicator for exporters but is significantly different from zero when we interact with export shares.

These joint significance tests suggest the value of looking to see whether we can in fact identify this within-exporter heterogeneity and determine a critical share of exports necessary for a firm to experience increasing wages following lower output tariffs. To do this, we re-estimate equation (11) with share variables. In Column 5, where we interact output tariffs with the export shares, the sum of the output tariff and output tariff interacted with export share is significantly different from zero at the 10% level. The results in Column 5 show that a 10 percentage point cut in output tariffs reduces wages in non-exporting firms by 3%. Firms that export at least 50% of their output experience a wage increase following tariff cuts, with a 3% wage increase in firms that export all their output.[22] Reducing input tariffs by 10 percentage points increases wages by 12% in firms that import all of their inputs. To calculate the average effect on wages in importing firms, the coefficient on the interactive input tariff in Column 5, equal to -1.1, must be multiplied by the mean import share for importers equal to 0.47 (see Appendix Table A1), indicating an average effect of around 0.5, which is very close to the result in Column 4 with the dummy variables.

An alternative way to approach this is to create bins comprising subgroups of "high" exporters and "high" importers. While theory does predict a difference for high and low, it does not tell us exactly where the threshold will be nor that the threshold should be the same for exporters and importers. Here, we define high exporters to be those whose export share exceeds that of the 40th percentile and high importers as those whose share exceeds the 10th percentile within each

22. This critical value is calculated as $\delta_1 / \delta_2 = 0.33/0.66 = 0.5$. Seventy-two percent of exporters export more than 50% of their output.

industry. In Column 6, we see that there is an additional differential effect between these high-globalized groups and the rest of the globalized firms. Note that the sum of these coefficients is significantly different from zero in this more flexible specification. Finally, in Column 7, we re-estimate equation (11) using OLS instead of IV estimation and see that the magnitudes on the tariff coefficients in the OLS specification in Column 7 are only slightly smaller than those in the IV specification in Column 5, indicating that the potential endogeneity of tariffs is only resulting in a slight under-estimation of the effects and is therefore not driving the key results.

These findings highlight the importance of firm heterogeneity in the choice of mode of globalization. If as in prior work we neglect export status we would be able to identify only the average effect of changes in output tariffs on wages rather than the distinct and opposite effects we actually find in the data.[23] Past research has neglected entirely the examination of input tariffs, which we remedy here. Moreover, it is again crucial to separate firms that import intermediates to see that there is a differential effect on wages of tariff cuts on inputs for workers at firms that import. The heterogeneous firm model provides a path from tariff cuts to profit gains for sufficiently large exporters and sufficiently large importers, while our hypothesis that firm wages are increasing in firm profits then links this to wages at the firm.

5.2. *Robustness*

5.2.1. Heterogeneity and selection. A potential concern with the results is that the firm's decision to globalize is endogenous, which could lead to biased coefficients. We address this concern in a number of different ways in Table 3A, where we estimate the equations in five-period differences using IV estimation, as in Table 2. First, we consider that changes in productivity could affect the decision to import and export and its omission could bias the estimates, thus, we include value added per worker in Column 1 of Table 3A. As expected, labour productivity has a significant positive effect on wages, but the coefficients on the tariff terms are very close to those in our baseline regressions (see Column 4 of Table 2B).

Next, we fix the set of firms used to calculate the interaction terms according to three different criteria and show the results are robust.[24] By fixing the set of exporters and importers, we ensure that the coefficient on the interactive terms are not driven by compositional changes into and out of exporting or importing. In Column 2, we define an exporter as a firm that exported at any time during the sample period, and an importer as a firm that imported at any time during the sample. In Column 3, we fix the global status as reported in 1991, and in Column 4, we fix the global status at the point the firm enters the sample. The results are robust to all of these alternative specifications. Although we keep the set of firms interacted with tariffs fixed, we need to control for the fact that all firms may actually have changes in import and export status over the sample period, otherwise, we would suffer omitted variable bias. In Column 5, as well as fixing the firm's global status at entry, we also drop any firm that changes its global status, so the change in FX and change in FM terms now drop out. Again, we see that the results are robust to this specification. In Column 6, we show that the results are also robust to fixing the import and export *shares* at entry.

Even after accounting for the changing global status, there is a potential concern that exit out of production could be biasing the results given that low-productivity firms are more likely to exit. To address this potential concern, we use a two-stage Heckman correction, which requires a variable to affect the exit decision but not the level of wages. Given that our model assumes an

23. For example, Revenga (1997) finds that on average, a fall in output tariffs reduced wages in Mexico but does not allow for an interaction effect for exporters.

24. We would like to thank an anonymous referee for suggesting this approach.

TABLE 3A

Tariffs and wages—heterogeneity and selection

Dependent variable: $\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5}$						
Instrumental variables estimation						
	With productivity	Alternative definitions of global status				
		Any time in sample	As in 1991	At entry	At entry; drop switchers	At entry; with shares
	(1)	(2)	(3)	(4)	(5)	(6)
ΔOutput tariff$_{i,t}$	0·374**	0·405***	0·316*	0·401***	0·513***	0·400***
	(0·157)	(0·156)	(0·172)	(0·157)	(0·170)	(0·159)
Δ(Output tariff$_{i,t}$ x FX$_{f,i,t}$)	–0·435***	–0·424***	–0·407***	–0·574***	–0·509***	–0·691***
	(0·087)	(0·086)	(0·130)	(0·115)	(0·127)	(0·163)
ΔInput tariff$_{i,t}$	–0·141	–0·055	–0·025	–0·111	–0·185	–0·135
	(0·171)	(0·170)	(0·189)	(0·171)	(0·181)	(0·172)
Δ(Input tariff$_{i,t}$ x FM$_{f,i,t}$)	–0·514***	–0·448***	–0·613***	–0·563***	–0·354**	–1·039***
	(0·129)	(0·136)	(0·173)	(0·151)	(0·159)	(0·327)
ΔFX$_{f,i,t}$	0·039***	0·018**	0·019**	0·030***		0·037***
	(0·009)	(0·007)	(0·009)	(0·008)		(0·012)
ΔFM$_{f,i,t}$	0·032***	0·018**	0·019**	0·028***		0·032*
	(0·008)	(0·007)	(0·008)	(0·008)		(0·018)
ΔSkill share$_{f,i,t}$	0·281***	0·282***	0·253***	0·282***	0·257***	0·282***
	(0·025)	(0·025)	(0·028)	(0·025)	(0·029)	(0·025)
Δln(labour)$_{f,i,t}$	–0·042***	–0·044***	–0·059***	–0·042***	–0·046***	–0·042***
	(0·006)	(0·006)	(0·007)	(0·006)	(0·007)	(0·006)
Δforeign share$_{f,i,t}$	0·083***	0·082***	0·044	0·085***	0·010	0·086***
	(0·026)	(0·026)	(0·031)	(0·026)	(0·032)	(0·027)
ΔGovt share$_{f,i,t}$	0·080***	0·082***	0·076***	0·081***	0·084***	0·082***
	(0·014)	(0·014)	(0·015)	(0·014)	(0·017)	(0·014)
Δln(VA per worker)$_{f,i,t}$	0·179***	0·179***	0·172***	0·180***	0·190***	0·180***
	(0·005)	(0·005)	(0·006)	(0·005)	(0·006)	(0·005)

(*continued*)

TABLE 3A
Continued

Dependent variable: $\ln(\text{wage})_{f,i,t} - \ln(\text{wage})_{f,i,t-5}$

Instrumental variables estimation

	With productivity	Alternative definitions of global status				
		Any time in sample	As in 1991	At entry	At entry; drop switchers	At entry; with shares
	(1)	(2)	(3)	(4)	(5)	(6)
Joint Significance tests Ho: sum of coefficients on tariff variables equals zero						
Output tariffs	–0·060	–0·019	–0·092	–0·173	0·004	–0·292*
	(0·148)	(0·143)	(0·158)	(0·153)	(0·176)	(0·178)
Input tariffs	–0·655***	–0·504***	–0·637***	–0·674***	–0·539***	–1·175***
	(0·205)	(0·120)	(0·237)	(0·215)	(0·221)	(0·355)
Hansen J statistic	3·19	3·08	1·89	2·82	0·57	2·36
p-value	0·20	0·21	0·39	0·24	0·75	0·31
Observations	50,484	50,484	38,335	50,484	38,275	50,484

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments include 1991 industry skill share, 1991 industry skill share interacted with five-period lagged export dummy, 1991 input tariff level, 1991 input tariff level interacted with five-period lagged import dummy, exclusion dummy = 1 if ten or more HS nine-digit products excluded within a five-digit industry code from commitment to reduce bound tariffs to 40%, and non-tariff dummy = 1 if ten or more HS nine-digit product codes were subject to non-tariff barriers. All specifications pass the weak instrument test with F-stats over 800. All the estimations include location-year fixed effects.

TABLE 3B

Tariffs and wages—heterogeneity and selection

Dependent variable: ln(wage)$_{f,i,t}$							
	baseline	1^{st} stage probit	Heckman	heterogeneity	non-parametric		With exit
					1^{st} stage	2^{nd} stage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Output tariff$_{i,t}$	0·021	0·355**	0·011	0·006	0·462***	0·016	0·015
	(0·045)	(0·169)	(0·049)	(0·049)	(0·170)	(0·048)	(0·045)
Output tariff$_{i,t}$ x FX$_{f,i,t}$	–0·096***		–0·095**	–0·089**		–0·100**	–0·091**
	(0·043)		(0·044)	(0·043)		(0·049)	(0·043)
Input tariff$_{i,t}$	0·120	–1·332***	0·159	0·174	–1·372***	0·177	0·124
	(0·099)	(0·463)	(0·123)	(0·123)	(0·454)	(0·132)	(0·098)
Input tariff$_{i,t}$ x FM$_{f,i,t}$	–0·385***		–0·382***	–0·368***		–0·412***	–0·370***
	(0·083)		(0·081)	(0·082)		(0·010)	(0·083)
Skill share$_{f,i,t}$	0·297***	–0·202***	0·300***	0·301***	–0·139	0·304***	0·296***
	(0·021)	(0·044)	(0·022)	(0·022)	(0·102)	(0·021)	(0·021)
ln(labour)$_{f,i,t}$	–0·068***	0·125***	–0·072***	–0·074***		–0·076***	–0·070***
	(0·006)	(0·007)	(0·007)	(0·007)		(0·007)	(0·006)
ln(VA per worker)$_{f,i,t}$	0·143***	0·028***	0·142***	0·142***		0·142***	0·142***
	(0·004)	(0·006)	(0·004)	(0·004)		(0·004)	(0·004)
Age$_{f,i,t}$		0·004***	–0·0002	–0·0004		–0·0002	
		(0·001)	(0·0004)	(0·0004)		(0·0004)	
Age$_{f,i,t}$ x Finance dependence$_{i,t}$		–0·004***	0·0001	0·0003	–0·003**	–0·00004	
		(0·001)	(0·0007)	(0·0007)	(0·001)	(0·0008)	

(*continued*)

TABLE 3B
Continued

	Dependent variable: ln(wage)$_{f,i,t}$						
	baseline	1^{st} stage probit	Heckman	heterogeneity	nonparametric 1^{st} stage	nonparametric 2^{nd} stage	With exit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exit$_{f,i,t}$=1 if exit in t+1							–0·043*** (0·006)
IMR$_{f,i,t}$			–0·934*** (0·256)				
Series terms: *p*-values from *F*-tests							
zhat$_{f,i,t}$ (3^{rd} order)				0·000***			
Age$_{f,i,t}$ (4th order)					0·004***		
ln(VA per worker)$_{f,i,t}$ (3^{rd} order)					0·000***		
ln(labour)$_{f,i,t}$					0·000***		
Interaction terms					0·000***		
Propensity$_{f,i,t}$ (3^{rd} order)						0·000***	
Joint significance tests Ho: sum of coefficients on tariff variables equals zero							
Output tariff	–0·074 (0·056)		–0·084 (0·063)	–0·083 (0·062)		–0·084 (0·061)	–0·075 (0·056)
Input tariff	–0·264** (0·116)		–0·223* (0·132)	–0·194 (0·134)		–0·235* 0·142	–0·246** (0·115)
Observations	109,302	125,962	109,302	109,302	125,962	107,270	109,302
Adjusted R^2	0·86	0·03	0·86	0·86	0·05	0·85	0·86

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors in Columns 3, 4, and 6 have been bootstrapped with 200 repetitions. All the estimations also include FX, FM, foreign share, and government share but the coefficients are suppressed to save space. The top and bottom one percentiles of the propensity measure have been trimmed. All estimations have location-year effects and firm-fixed effects except the first-stage probits in Columns 2 and 5, which include year and industry effects.

exogenous rate of firm death, we draw on other related models to find an appropriate variable that meets the exclusion restriction. Hopenhayn (1992) shows that the rate of survival is higher for older firms. And Chaney (2005) shows how financial constraints can affect entry and exit into the export market. The model assumes that firms only face liquidity constraints for accessing foreign markets, but one could easily imagine that financial constraints also apply to entry and exit decisions in the domestic market. Building on this intuition, we use an industry measure of external financial dependence, defined as the share of capital expenditures not funded by cash flows for the median U.S. firm in the 1980's, from Rajan and Zingales (1998).[25] We use these two measures in the first-stage selection equation.

The Heckman correction is more straightforward in a levels equation where exit is more easily defined than in the long-difference specification where being in the sample would have to be defined as present in period t and $t-5$. Thus, in Column 1 of Table 3B, we first show that our five-period differenced results also hold in a levels equation. In Column 2, we present the first-stage probit results, where the dependent variable is equal to one if the firm is in the sample that year and equal to zero in the year the firm exits. We model the probability of being in the sample as a function of the variables used in the second stage, lagged one period, year-fixed effects and industry-fixed effects. The results show that the probability of being in the sample is increasing in output tariffs, as firms are protected from import competition; decreasing in input tariffs, as high input tariffs make it more costly to produce; and increasing in value added per worker. The financial dependence variable on its own would drop out because this measure is time invariant due to the industry-fixed effects. Thus, we interact it with the firm's age that is firm-specific and time-varying. That is, the age variable is constructed by subtracting the year that the firm started operations in a province from the sample year. As expected, the probability of being in the sample increases with the age of the firm but this is offset if the firm is in an industry that is relatively more dependent on external finance. We construct the inverse mills ratio (IMR) from this selection equation and include it in the second-stage Heckman correction in Column 3. As expected, the age variables are both insignificant in the second stage, thus meeting the exclusion restriction. Moreover, this Heckman correction leaves the results unchanged (compare Columns 1 and 3 of Table 3B), which implies that selection is not biasing our results.[26] As shown in Helpman, Melitz and Rubinstein (2008), even if there is no selection bias, there may be a heterogeneity bias, which could arise from the changing global status of firms. We address this potential concern following their methodology and include a third-order polynomial of $\widehat{\overline{z}}^* \equiv \widehat{z}^* +$ IMR, where $\widehat{z}^*$ is defined as the inverse cumulative distribution of the fitted values from the first-stage probit. Column 4 shows that while the z terms are significant, they leave the point estimates on the tariff terms unchanged, indicating that our results are not driven by heterogeneity bias.

In Columns 5 and 6, we re-estimate the two-stage Heckman correction using a non-parametric approach as in Das, Newey and Vella (2003) to allow for the functional form of regressions and the disturbance distributions to be unknown.[27] We use the Akaike information criterion to query the appropriate order of the polynomial expansion in the first stage as well as to determine the appropriate order of polynomial of the propensity score variable in the second stage. From Columns 5 and 6, we see that the results are robust to this non-parametric correction.

Finally, in Column 7, we control for exit and show this has no effect on our main results. The exit dummy variable equals one if the firm exits in period $t+1$. The coefficient on the

25. These data are at the three- and four-digit ISIC level and comprise 36 industries.

26. Note that we restrict the sample size in Columns 1 to be the same as the Heckman correction equation in order to assess the potential selection bias. The Heckman equation has fewer observations than the full sample because the selection equation includes firm specific one-period lagged regressors.

27. See also Becker and Muendler (2010) for an application.

exit indicator shows that, on average, firms that will exit shortly pay 4% lower wages, which is consistent with our model where the least efficient and lower-paying firms end up exiting.

5.2.2. Asian crisis. Our sample period includes the Asian crisis of 1997 and 1998, during which time Indonesia experienced large depreciations, high inflation and a banking crisis. To ensure that our results are not being driven by these factors, we include trade weighted real exchange rates interacted with importer and exporter status in Column 1 of Table 4.[28] We would expect exporters to gain from a currency depreciation as the relative price of their exports becomes cheaper, and importers to lose as imported intermediate inputs become more expensive. However, all firms with domestic sales should gain from a depreciation since competing imported goods become relatively more expensive. The results show that the coefficient on the interaction of the exchange rate with exporters is negative and significant as expected, but the coefficient on the interaction of the exchange rate with importers though has the expected positive sign is statistically insignificant. While our model would predict that the coefficient on the interactive importers variable should be significant and positive, relative price changes due to exchange rate movements are not as clean an experiment as changes in import tariffs. As Dominguez and Tesar (2006) show, the relationship between exchange rates and firm value varies considerably across countries and industries. Moreover, including the exchange rate interacted with importer and exporter status in Column 1 leaves our key results unaffected.

An alternative way to check that our results are not being driven by the Asian crisis is to re-estimate equation (10) for the pre-crisis period, 1991–1996. Column 2 of Table 4 shows that the coefficients are similar for this sub-sample to those for the full sample. Another potential influence of the Asian crisis on our results arises from constructing input tariffs with industry cost shares based on firm-level data in 1998, the only year such detailed data are available. If cost shares differed during the crisis years from other years this would affect the input tariff variable and could potentially affect our results. To address this issue, we re-calculate the input tariffs using 1995 weights from input/output tables in equation (9) instead of the 1998 weights. The disadvantage of using these 1995 weights is that the input tariffs are far more aggregated than our central measures. The 1995 weights from the input/output table only enable us to construct input tariffs when the 290 industries are grouped into a more aggregated set of 90 industries. As we showed in section 3B, there is tremendous heterogeneity of input tariffs across five-digit industries, thus aggregation is a serious concern.

We see from Column 3 in Table 4, where we include the 1995 weighted input tariffs, that the signs of the coefficients are the same as before but the size of the coefficient on input tariffs interacted with importers falls by about half. This is likely the result of aggregation biases. We show this in Column 4 of Table 4, where we use the same level of aggregation as the 1995 input/output tables with the 1998 data. We see that the coefficients in Columns 3 and 4 are very similar. This strongly suggests that the differences are driven by aggregation and not by the Asian crisis.

5.2.3. Alternative tariffs. An additional robustness check is to include firm-level tariffs instead of industry-level tariffs for intermediate inputs. Using firm-level tariffs has the advantage of providing more variation but has a number of disadvantages: it restricts the sample to only those firms that exist in 1998 since that is the only year we have firm-level data on intermediate input use, it introduces a potential endogeneity problem, and also an asymmetry with the level of aggregation on output tariffs since only the input tariffs can be constructed at the

28. Real trade weighted exchange rates are annual averages of monthly data from JP Morgan.

TABLE 4

Asian crisis and alternative tariff measures

Dependent variable: $\ln(\text{wage})_{f,i,t}$							
	Asian crisis						
	With exchange rates (1)	1991–1996 (2)	Input tariffs (I/O 1995) (3)	Input tariffs (I/O1998) (4)	Firm level tariffs (5)	Weighted tariffs (6)	Drop firms in Duty-free zones (7)
Output tariff$_{i,t}$	0·090*	0·085	0·090**	0·099**	0·078**	0·055*	0·098**
	(0·051)	(0·063)	(0·039)	(0·040)	(0·035)	(0·033)	(0·051)
Output tariff$_{i,t}$ x FX$_{f,i,t}$	–0·116***	–0·132***	–0·219***	–0·204***	–0·165***	–0·111***	–0·203***
	(0·046)	(0·054)	(0·043)	(0·042)	(0·042)	(0·041)	(0·043)
Input tariff$_{i,t}$	–0·029	0·086	–0·069	–0·127*	0·180***	–0·071*	–0·034
	(0·095)	(0·154)	(0·054)	(0·072)	(0·062)	(0·041)	(0·096)
Input tariff$_{i,t}$ x FM$_{f,i,t}$	–0·492***	–0·434***	–0·159***	–0·238***	–0·302***	–0·427***	–0·454***
	(0·094)	(0·123)	(0·047)	(0·071)	(0·065)	(0·082)	(0·085)
FX$_{f,i,t}$	0·031***	0·066***	0·060***	0·057***	0·048***	0·039***	0·057***
	(0·011)	(0·014)	(0·009)	(0·009)	(0·009)	(0·008)	(0·009)
FM$_{f,i,t}$	0·097***	0·077***	0·055***	0·059***	0·074***	0·081***	0·090***
	(0·013)	(0·017)	(0·007)	(0·007)	(0·009)	(0·009)	(0·011)
Skill share$_{f,i,t}$	0·278***	0·260***	0·278***	0·278***	0·303***	0·279***	0·276***
	(0·020)	(0·024)	(0·020)	(0·020)	(0·022)	(0·020)	(0·020)
$\Delta\ln(\text{labour})_{f,i,t}$	0·072***	0·073***	0·071***	0·071***	0·068***	0·071***	0·073***
	(0·006)	(0·009)	(0·006)	(0·006)	(0·006)	(0·006)	(0·006)
Δforeign share$_{f,i,t}$	0·130***	0·111***	0·132***	0·132***	0·149***	0·129***	0·126***
	(0·018)	(0·026)	(0·018)	(0·018)	(0·019)	(0·018)	(0·018)

(*continued*)

TABLE 4
Continued

	Dependent variable: $\ln(\text{wage})_{f,i,t}$						
	Asian crisis						
	With exchange rates (1)	1991–1996 (2)	Input tariffs (I/O 1995) (3)	Input tariffs (I/O1998) (4)	Firm level tariffs (5)	Weighted tariffs (6)	Drop firms in Duty-free zones (7)
ΔGovt share$_{f,i,t}$	0·059***	0·034**	0·057***	0·057***	0·060***	0·057***	0·058***
	(0·010)	(0·018)	(0·010)	(0·010)	(0·010)	(0·010)	(0·010)
Exit$_{f,i,t}$ if exit in t+1	–0·047***	–0·039***	–0·048***	–0·048***	–0·049***	–0·048***	–0·048***
	(0·006)	(0·006)	(0·006)	(0·006)	(0·011)	(0·006)	(0·006)
TWRER$_t$ x FX$_{f,i,t}$	–0·096***						
	(0·021)						
TWRER$_t$ x FM$_{f,i,t}$	0·012						
	(0·019)						
Joint significance tests Ho: sum of coefficients on tariff variables equals zero							
Output tariffs	–0·025	–0·046	–0·129***	–0·105**	–0·087*	–0·056	–0·105*
	(0·059)	(0·073)	(0·049)	(0·049)	(0·052)	(0·045)	(0·058)
Input tariffs	–0·521***	–0·349**	–0·228***	–0·365***	–0·123*	–0·498***	–0·488***
	(0·117)	(0·166)	(0·055)	(0·088)	(0·070)	(0·090)	(0·113)
Observations	185,866	105,262	185,866	185,866	126,576	184,928	184,809
Adjusted R^2	0·82	0·82	0·82	0·82	0·80	0·82	0·82

Notes: Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. All the estimations include firm-fixed effects and location-year fixed effects.

firm level. Nevertheless, we check the robustness of our industry-level input tariffs by replacing it with firm-level tariffs in Column 5 of Table 4 and we see that main conclusions are unaffected.

Another concern is the choice of weights in constructing the five-digit industry tariffs from the underlying HS nine-digit tariff data. We use simple averages in our main estimations, but we present estimates of the effect of import weighted tariff cuts on wages using the Fisher index, as a robustness check in Column 6 of Table 4.[29] These results are similar to those with simple average tariffs except that the size of the coefficients on the output tariff variables is a bit smaller.

Finally, there may be a concern arising from Indonesia operating duty-free zones, which allows firms to import inputs without paying any tariffs if their output is for export. If a firm was already able to import duty-free inputs, then cuts in input tariffs should not be of benefit to them and in fact could hinder their performance due to the competition effect of other firms being able to access lower-cost imported inputs. To ensure that this does not bias our coefficients, we omit all firms that operate in a duty-free zone. Column 7 shows that the results are unaffected by dropping these observations.

5.3. *Mechanisms*

The empirics establish a robust relation between tariff changes, modes of globalization and average firm-level wages. We develop this within a theoretical framework in which tariff changes, mediated by modes of globalization, lead to changes in firm profitability, and these in turn affect wages. It is worth noting, though, that the link between tariff changes and wages could be viewed through the lenses of a variety of models. Our approach has focused on firm heterogeneity and abstracted from worker heterogeneity in wage formation and changes. However, it is possible that globalized firms attract a different type of worker; respond to tariff changes by adjusting the composition of workers or adjust product quality, and hence also change either their mix of workers or their demands on workers. Examples of these alternative models include Yeaple (2005) and Verhoogen (2008). Any data set will have limitations, as does ours, so we will go as far as we can in demonstrating the robustness of our results to controls for these alternative interpretations.

A first question concerns the role of worker vs. firm heterogeneity in wage determination. Early studies stressed the importance of individual worker heterogeneity; however, more recent results have underscored the role of firm heterogeneity, particularly concerning changes in wages. Abowd, Kramarz and Margolis (1999), shows that worker heterogeneity is more important than firm heterogeneity in determining wages in French data. However, a subsequent paper by Abowd, Creecy and Kramarz (2002) shows that using an exact solution, the correlation between worker and firm effects is negative, in contrast to the earlier finding of a positive correlation. In comparing the results for France and for the State of Washington, the study finds that the worker and firm components have equal importance. Recent work by Frias, Kaplan and Verhoogen (2009) uses matched employer–employee data for Mexico. They show that two-thirds of the higher level of wages can be explained by firm heterogeneity; that nearly all the within-industry wage changes can be explained by firm differences; and none of the changes reflect changes in skill composition. Since matched firm-worker data are unavailable for Indonesia, we are unable do this decomposition. Still, the literature does establish that there is potentially a

29. The results are the same using 1991 or 2000 weights. We were unable to get imports at the HS nine-digit level, so the import-weighted five-digit ISIC tariffs are constructed by first taking the simple mean of the HS nine-digit to HS six-digit, then weighting the HS six-digit tariffs by the import shares.

large role for the heterogeneous firm mechanism in our model to account for differential changes in wages between globalized firms and domestic-oriented firms.

The classic paper linking a trade shock, via a currency depreciation, to quality upgrading is Verhoogen (2008). However, Verhoogen's case concerns Mexico, and it is worth keeping in mind that the Mexican case is quite distinct from that of Indonesia. Mexico is a middle income country whose exports at the onset of the exchange rate shock were dedicated 80% to the U.S. alone,

TABLE 5
Mechanisms

Dependent variable	$\ln(\text{revenue})_{f,i,t}$	$\ln(\text{wu})_{f,i,t}$	$\ln(\text{ws})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,i,t}$	$\ln(\text{wage})_{f,I,t}$
				1995–1997	1995–1997	1995–1997
					With skill share	With education share
	(1)	(2)	(3)	(4)	(5)	(6)
Output tariff$_{i,t}$	–0·028 (0·076)	0·119** (0·051)	0·134*** (0·053)	0·452*** (0·132)	0·460*** (0·131)	0·463*** (0·130)
Output tariff$_{i,t}$ x FX$_{f,i,t}$	–0·399*** (0·072)	–0·202*** (0·045)	–0·147*** (0·057)	–0·277*** (0·099)	–0·272*** (0·098)	–0·264*** (0·094)
Input tariff$_{i,t}$	0·130 (0·168)	–0·085 (0·097)	–0·014 (0·099)	–0·529* (0·310)	–0·516* (0·306)	–0·524* (0·302)
Input tariff$_{i,t}$ x FM$_{f,i,t}$	–0·649*** (0·130)	–0·573*** (0·095)	–0·225** (0·100)	–0·600*** (0·215)	–0·613*** (0·215)	–0·600*** (0·203)
FX$_{f,i,t}$	0·148*** (0·015)	0·047*** (0·010)	0·072*** (0·011)	0·069*** (0·018)	0·068*** (0·018)	0·065*** (0·017)
FM$_{f,i,t}$	0·251*** (0·019)	0·092*** (0·012)	0·077*** (0·014)	0·100*** (0·027)	0·100*** (0·027)	0·098*** (0·026)
skillshare$_{f,i,t}$	0·050 (0·034)	0·570*** (0·020)	–1·595*** (0·033)		0·270*** (0·042)	
$\Delta\ln(\text{labour})_{f,i,t}$	0·794*** (0·016)	–0·062*** (0·006)	0·002*** (0·006)	–0·128*** (0·014)	–0·126*** (0·014)	–0·121*** (0·014)
Exit$_{f,i,t}$ if exit in t+1	–0·082*** (0·009)	–0·052*** (0·006)	–0·026*** (0·008)	–0·054*** (0·009)	–0·054*** (0·009)	–0·053*** (0·008)
Education shares$_{f,i,t}$						
Production_1						–0·938***
Production_2						–0·929***
Production_3						–0·890***
Production_4						–0·835***
Production_5						–0·599***
Non-production_1						–0·831***
Non-production_2						–0·926***
Non-production_3						–0·669***
Non-production_4						–0·446***

(*continued*)

TABLE 5
Continued

Dependent Variable	ln(revenue)$_{f,i,t}$	ln(wu)$_{f,i,t}$	ln(ws)$_{f,i,t}$	ln(wage)$_{f,i,t}$	ln(wage)$_{f,i,t}$	ln(wage)$_{f,I,t}$
					1995–1997	
					With skill share	With education share
	(1)	(2)	(3)	(4)	(5)	(6)
Joint significance tests Ho: sum of coefficients on tariff variables equals zero						
Output tariffs	–0·427***	–0·083	–0·013	0·175	0·188	0·199
	(0·095)	(0·060)	(0·070)	(0·142)	(0·141)	(0·140)
Input tariffs	–0·519***	–0·658***	–0·239*	–1·129***	–1·129***	–1·123***
	(0·192)	(0·118)	(0·132)	(0·311)	(0·308)	(0·304)
Observations	173,732	185,795	149,575	61,901	61,901	61,901
Adjusted R^2	0·93	0·79	0·71	0·85	0·85	0·85

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Education shares are defined as the number of workers in each category divided by total employment. The categories are 1–5: 1—“not finished primary school”; 2—primary school; 3—junior high school; 4—senior high school; 5—diploma or higher. All the estimations also include foreign share and government share, but the coefficients are suppressed to save space. All the estimations include firm-fixed effects and location-year effects.

rising to 88% in the course of the shock. Export growth was thus very highly quality biased. The case of Indonesia is quite distinct. Indonesia is one of the least skill-abundant countries in the world. According to the Barro and Lee (2000) data set, Indonesia ranked 79th out of 105 countries in the proportion of tertiary education completed—just 1.6% of the population.[30] These facts at least suggest that the scope for liberalization to affect quality choices may be considerably more limited in Indonesia compared to the Mexican case.

While we cannot directly test these alternative hypotheses, we are able to indirectly assess the plausibility of the profit channel we focus on. Our model predicts that firm performance should improve in globalized firms relative to domestic-oriented firms, following trade liberalization. To check this, we regress the log of firm revenue, as our measure of firm performance, on tariffs and their interactions in Column 1 of Table 5. As expected, we do indeed see that globalized firms enjoy an increase in their revenues following liberalization, and the joint significance tests indicate that the total effect is also significantly different from zero for exporters and importers.[31]

We also consider whether changes in skill patterns can account for our results. As a first pass, we reproduce our results separately for skilled and unskilled. In Table 5, we rerun the regressions with the log of unskilled wage (proxied by production workers) in Column 2 and the log of skilled wage (proxied by non-production workers) in Column 3, and find that the results hold for each of these two types of workers.

30. See http://www.cid.harvard.edu/ciddata/ciddata.html.

31. Another approach to assessing the relative importance of the profit channel is to include profits in the wage equation in Column 1 of Table 5 to see how much of the effect from tariffs works through profits. In Table B1 of the electronic appendix, we do this with total revenues as a proxy for profits. Although the magnitudes of the coefficients on the tariff variables decline, it is difficult to draw conclusions from this specification because total revenue misses key components of profits, such as firm-specific fixed costs, and due to potential endogeneity bias.

While encouraging, we would like to ensure that our results are not driven just by changes in skill composition at the firm level. Although we control for the share of non-production workers in our main specifications, there may still be changes in the share of educated workers *within* the broader production and non-production categories that could be driving the changes in wages. Information on worker education is not available for the full sample but does exist for three years, between 1995 and 1997. There are five different education levels for production workers, ranging from 1 to 5 with 5 being the highest level, and similarly for non-production workers.[32] In Column 4 of Table 5, we show that our results hold for these three years of data without any control for skill shares. In Column 5, we show that the results are unchanged if we control for the share of production workers. And in Column 6, we include controls by education level. This includes ten categories of education in total, with the omitted category being the most educated non-production workers. We see that all the coefficients on education shares are negative and significant, but most importantly they do not change the point estimates on the tariff variables at all. These findings suggest that compositional changes in skill are not driving our results. While the mechanisms identified in our model are not necessarily the whole story, they appear to be a robust component of the link between tariff liberalization and firm wages.

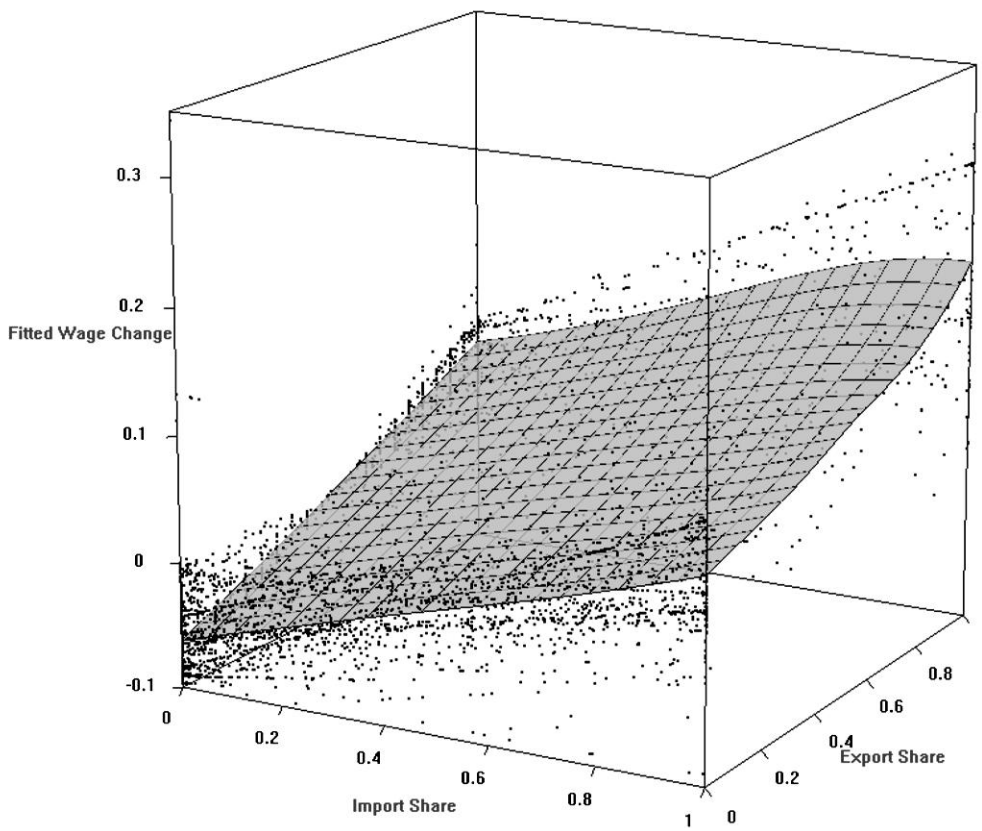

FIGURE 2

Modes of globalization and firm-wage changes. The predominance of negative values near the origin indicates that non-globalizers lose from liberalization, and vice versa for those who globalize via exports or imports

32. The categories are 1–5: 1—“not finished primary school”; 2—primary school; 3—junior high school; 4—senior high school; 5—diploma or higher.

5.4. *Discussion of results*

Since all our estimates include year fixed effects, these will capture an average effect of trade liberalization on wages. We cannot determine the total effect of trade liberalization on wages because we cannot separately identify the role of tariff cuts on the year effects. Still, relative to the average, exporters and importers pay higher wages following tariff cuts and domestic oriented firms pay lower wages. This can be seen clearly from Figure 2 where we plot the firm's predicted change in wage as a function of its import share and export share. We calculate the firm's fitted wage, resulting from the change in tariffs over the whole sample period using coefficients from Column 5 in Table 2B, for all firms in the sample in 2000 as follows:

$$\Delta\hat{w}_f = \widehat{\beta_1} * \Delta\text{output tariff}_i + \widehat{\beta_2} * \Delta\text{output tariff}_i * \text{export share}_f \\ + \widehat{\beta_3} * \Delta\text{input tariff} + \widehat{\beta_4} * \Delta\text{input tariff}_i * \text{import share}_f .$$

We see from Figure 2 that firms with negative predicted wages are those that are predominantly domestic oriented (close to the origin), and those with the large positive predicted wages are the industries that are large globalizers either with a high-export share or a high-import share (away from the origin). There is large heterogeneity in firm-level wage responses. For example, in the motor vehicle industry, which experienced one of the biggest declines in output tariffs of 45 percentage points, the fitted wage change for firms that sell all their output in the domestic market and buy all their inputs locally is a fall of 15%. Yet, within the same industry, firms that export large shares of their output and import their inputs have a positive fitted wage change of 4%. The largest predicted wage gains following tariff cuts were 29% in the toy industry, which experienced big cuts in both input and output tariffs, and these were for firms that export all of their output and import all of their inputs.

6. CONCLUSIONS

The effect of trade liberalization on wages has generated a vast literature in international economics. Yet, no prior study has simultaneously accounted for the two most salient empirical facts about international production to emerge in the last decade. The first fact is firm heterogeneity—large firms are more productive, more likely to export and import, and pay higher wages. The second fact is the prominent role of intermediate trade, distinct from final goods trade. Firm heterogeneity is the very foundation of our approach to firm-level wages. And theory tells us that reductions in final and intermediate goods tariffs tend to have opposite signs, so distinguishing their impacts is crucial. We incorporate both salient facts in our analysis.

Our theory combines elements of Melitz (2003) and Kasahara and Lapham (2007) with a specification of fair-wage setting closely related to that of Grossman and Helpman (2007) . This allows us to develop a general equilibrium model with firm heterogeneity, trade in final and intermediate goods, and firm-specific wages. The model predicts that the wage consequences of liberalization vary qualitatively and quantitatively with the nature and magnitude of firms' global engagement via exports and imports.

We examine the predictions of the model with highly detailed firm-level data for the Indonesian trade liberalization in the period 1991–2000. Of particular note is that our data allow us to construct highly detailed import tariffs on inputs, hence to separate the effects of cuts in input tariffs from cuts in output tariffs.

The results are strongly supportive of the predictions arising from the theory and stable across a wide variety of robustness checks. Introducing firm heterogeneity and a separate impact for input and output tariffs (and their interactions) is crucial to the results. Cuts in output tariffs reduce wages at firms oriented exclusively to the domestic market but raise wages at firms that export a sufficient share of their output. Cuts in input tariffs raise wages at firms that import inputs while having an insignificant effect on wages of workers at firms that fail to import.

We would like to highlight a few directions for future work. First, although the results are consistent with our fair-wage model, the data do not permit us to rule out some role for compositional shifts within education categories or changes in unobserved worker heterogeneity in the differential wage responses of globalized and domestically oriented firms. This remains an area for future research. Second, changes in final and intermediate output tariffs here function as international demand and cost shocks. It would be very interesting to investigate whether such shocks function differently based on domestic or international origin. Third, while we developed a specific mechanism, fair wages, through which the tariff shocks are transmitted to wages, it would be very interesting to have data with profit measures and more institutional detail that would permit a clear contrast between competing theories of the mechanism involved. Fourth, we have not modelled explicitly the role of foreign firms. Doing so and exploring in more detail any contrasts between domestic and foreign firms would be interesting.

TABLE A1
Summary statistics

	Levels		Five-period differences	
Variable	Mean	Standard deviation	Mean	Standard deviation
ln(wage)$_{f,i,t}$	7·35	0·80	0·70	0·54
ln(ws)$_{f,i,t}$	7·87	0·92		
ln(wu)$_{f,i,t}$	7·25	0·79		
ln(labour)$_{f,i,t}$	4·18	1·19	0·01	0·53
Skill share$_{f,i,t}$	0·14	0·15	0·00	0·14
Foreign share$_{f,i,t}$	0·04	0·18	0·00	0·11
Govt share$_{f,i,t}$	0·02	0·14	0·17	0·40
Export share$_{f,i,t}$	0·11	0·29	–0·02	0·28
Export share$_{f,i,t}$ if FX=1	0·71	0·33		
FX$_{f,i,t}$ =1 if exshare>0	0·15	0·36	–0·03	0·38
Import share$_{f,i,t}$	0·09	0·24	–0·01	0·20
Import share$_{f,i,t}$ if FM=1	0·47	0·36		
FM$_{f,i,t}$=1 if import share >0	0·19	0·39	–0·02	0·34
Exit$_{f,i,t}$=1 if exit next period	0·08	0·28		
Age$_{f,i,t}$	12·67	12·73		
Output tariff$_{i,t}$	0·17	0·11	–0·12	0·08
Input tariff$_{i,t}$	0·11	0·06	–0·03	0·08
ln(TFP)$_{f,i,t}$	1·63	0·66		
ln(VA per worker)$_{f,i,t}$	8·56	1·25	0·67	0·96
ln(revenue)$_{f,i,t}$	13·62	2·06		
Financial dependence	0·23	0·35		
Production_1$_{f,i,t}$	0·08	0·17		
Production_2$_{f,i,t}$	0·36	0·29		
Production_3$_{f,i,t}$	0·22	0·20		
Production_4$_{f,i,t}$	0·19	0·22		
Production_5$_{f,i,t}$	0·01	0·03		
Non-production_1$_{f,i,t}$	0·00	0·03		

(*continued*)

TABLE A1
Continued

	Levels		Five-period differences	
Variable	Mean	Standard deviation	Mean	Standard deviation
Non-production_2$_{f,i,t}$	0·02	0·06		
Non-production_3$_{f,i,t}$	0·02	0·05		
Non-production_4$_{f,i,t}$	0·07	0·09		
Non-production_5$_{f,i,t}$	0·02	0·04		
Observations	185,866		55,393	

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Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

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