Trade Liberalization and the Wage Skill Premium: Evidence from Indonesia*

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Abstract: In this paper, we analyze the effect of reducing import tariffs on intermediate inputs and final goods on the wage skill premium within firms in Indonesia – a country with a high share of unskilled workers. We present a new finding that reducing input tariffs reduces the wage skill premium within firms that import their intermediate inputs. However, we do not find significant effects from reducing tariffs on final goods on the wage skill premium within firms.

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1. Introduction

A surprising result in the empirical trade literature is that globalization increased the wage skill premium in developing countries (Goldberg and Pavcnik (2007)). This result appears puzzling as it seems to be at odds with traditional trade theory that predicts that trade liberalization should increase the relative returns to the abundant factor: skilled workers in developed countries and unskilled workers in developing countries (Stolper and Samuelson, 1941). In this paper, we analyze the effect of reducing import tariffs on intermediate inputs and final goods on the wage skill premium within firms in Indonesia – a country with a high share of unskilled workers. We present a new finding that reducing input tariffs reduces the wage skill premium within firms that import their intermediate inputs. However, we find no significant effect from reducing tariffs on final goods on the wage skill premium within firms.

A key feature that differentiates this study is our focus on one of the most unskilled labor abundant countries in the world, Indonesia, whereas the previous literature on developing economies focused on middle-income countries such as Brazil and Columbia.[1] This is an important difference as the standard Heckscher-Ohlin theory does not directly apply to middle-income countries. In a Heckscher-Ohlin world with more than one cone of diversification, so that there are three groups of countries (high, medium, and low), trade liberalization can increase or decrease the skill premium in the middle-income countries, but is still expected to reduce the skill premium in the least skilled-labor abundant country (Davis and Mishra (2007)).[2] Indonesia's relative lack of skilled labor can easily be seen in aggregate statistics. According to the Barro and Lee (2010) data set, only 4 percent of Indonesia's population had attained tertiary qualifications in 1995, whereas more than double this number had attained tertiary qualifications in countries like Brazil and Columbia.[3] Similarly, 44 percent of the Indonesian population over the age of 25 had no schooling, compared to around 22 percent in Brazil and Colombia.

Another important difference from the previous literature is that we consider the separate role of intermediate input tariffs from that of output tariffs on the wage skill premium. Other studies only consider the role of output tariffs or trade shares. We show that

[1] See survey in Goldberg and Pavcnik (2007).
[2] Extensions to the simple HO model have generated a higher skill premium following trade liberalization in both developed and developing countries. See, for example Zhu and Trefler (2005), Burstein and Vogel (2010).
[3] See http://www.cid.harvard.edu/ciddata/ciddata.html. Based on Barro and Lee 1995 schooling data, with skilled workers defined as the percentage of higher schooling attained in the population.

once we control for input tariffs, the effect of final goods tariffs on the wage skill premium becomes insignificant. However, the effect of lower input tariffs remains positive and significant in all of the specifications. The intuition for these results is as follows. Lower input tariffs reduce the wage skill premium by shifting down the relative demand for skilled workers within firms. The direction of the effect will critically depend on the skill intensities of imported inputs relative to the skill intensities of the final goods production. We show that in Indonesia, intermediate inputs are produced with a higher skilled intensive technology than final goods, and that lower input tariffs reduce the relative demand for skilled workers. This is essentially the same mechanism as the Stolper-Samuelson effect, as demonstrated in an industry model of outsourcing in Feenstra and Hanson (2003), but reinterpreted through a firm-level lens. The insignificant effect from reducing tariffs on final goods may appear surprising. However, the likely mechanism that would drive a within firm effect from cutting output tariffs is if firms were to shift production between multiple products with different factor intensities. Our data set only lists the main product the firm produces thus making it difficult to discern this type of effect.

The only other studies to find that the wage skill premium falls with trade liberalization is Robertson (2005) on Mexico and Gonzaga et al (2006) on Brazil. These papers adopt the mandated wage approach, which essentially tries to link changes in output tariffs to an economy-wide wage under the assumption that price equals unit costs. One of the difficulties of establishing a link between tariffs and an economy-wide wage is that many other macro-wide factors are occurring simultaneously. For example, more disaggregated studies found an increase in the skill premium within industries in Mexico following a large currency depreciation (see Verhoogen (2008)), and no association between skill premiums and trade policy in Brazil (see Pavcnik et al (2004)). To overcome the problem of separating multiple economy-wide factors from tariffs that affect the average wage, Goldberg and Pavcnik (2005) use the variation in industry level tariffs in Colombia as their identifying assumption, recognizing that this approach cannot identify the economy-wide effect which is captured by the year dummies. We follow Goldberg and Pavcnik (2005) in relying on the variation in industry level tariffs to identify the effects of tariff cuts on the wage skill premium; however, we do this at the firm level instead of the industry level. This has the advantage of allowing us to control for firm characteristics such as firm size, foreign ownership and skill shares that could also affect wages. Another benefit of conducting the analysis at the firm level is that we can allow for differential effects between domestically-oriented firms and globalized firms. Studies by Bernard and Jensen (1997) and Verhoogen (2008) show that there are significant

differences in the wage skill premium paid by exporters and nonexporters. Following this line of research, we also allow for changes in tariffs to affect globalized firms differentially from domestically-oriented firms. We find that the effects on the wage skill premium are mostly concentrated among firms that import their intermediate inputs.

We draw on a rich data set from Indonesia that provides firm-level data for a census of manufacturing firms that employ at least 20 employees for the period 1991 to 2000. These data include information on wages and employment of production and nonproduction workers, our measure of skilled and unskilled workers, respectively. They also provide employment details by education attainment for the years 1995 to 1997 and we use these to show that the production/nonproduction breakdown is a good proxy for skill, and to show that compositional shifts in education are not driving our results. The data also include information on firm-level exports and imports.

Our sample period is one of extensive tariff reform. In 1995, Indonesia became a member of the World Trade Organization (WTO), which involved giving various commitments to liberalize trade over a 10 year period. Output tariffs in Indonesia fell from an average of 22 percent in 1991 to 8 percent in 2000, and over this same period input tariffs fell from an average of 14 percent to 6 percent (see table 1). There is also large variation in both input and output tariffs across industries, with output tariffs higher than 100 percent in some industries, for example on motor vehicles. The variation in tariffs across industries and over time allow us to identify the effect of tariff cuts on the wage skill premium. We regress the log of the firm-level ratio of the wage of skilled to unskilled workers on 5-digit ISIC industry level input tariffs and output tariffs. All the equations include year effects, so if trade liberalization only affects the economy-wide wage then this would be absorbed in the year fixed effects and the coefficients on the tariff variables would be insignificant.

Our results provide evidence of a strong link between lower input tariffs and a fall in the wage skill premium. First, the most robust and strongest effects are within firms that import their inputs. A 10 percentage point fall in input tariffs reduces the wage skill premium by 10 percent for the average importing firm, with the effects larger the higher the share of imported inputs. This is consistent with importing firms substituting imported inputs for in-house production of skill-intensive intermediate inputs. Given that importers account for 50 percent of total employment in the sample, these findings suggest that there could be pronounced economy-wide effects of trade liberalization on the relative wage of unskilled workers.

Second, there are no statistically significant within-firm effects from reducing output tariffs.[4] These results have parallels with the empirical literature on developed countries that mostly found no effect of globalization on the wage skill premium (see, for examples, Krueger (1993), Lawrence and Slaughter (1993), and Berman, Bound, and Griliches (1994)). However, Feenstra and Hanson (1999) show that outsourcing of intermediate inputs – the less-skill intensive production stages in U.S. manufacturing – significantly contributed to the increased wage skill premium in the U.S. in the 1980s. Our findings on input tariffs, though at the firm rather than economy-wide level, can be viewed as the flip-side of the Feenstra and Hanson result.[5]

The rest of the paper is organized as follows. Section 2 provides an overview of wage movements in Indonesia. Section 3 describes the estimation strategy. Section 4 describes the data, and measurement of key variables. Section 5 presents the results and section 6 concludes.

2. Wages in Indonesia

Wages in Indonesia are largely determined by the market, with the exception of minimum wages which are set by provincial governments but in many places not strictly enforced.[6] The 1990s were a period of sustained high growth in both nominal and real wages in Indonesia. Prior to the 1997 Asian crisis, nominal wages grew on average 15 percent per annum and real wages 7 percent. This was mirrored in manufacturing with rates of 17 percent (nominal) and 8 percent (real) (Dhanani and Islam, 2004).[7] Table 2 shows the evolution of the skill premium over the decade. It presents the skill premium calculated as the ratio of the nonproduction wage to the production wage for each year calculated from our main data source, the *SI* data.[8] The data show a downward trend in the skill premium over the sample period, with a spike in 1997 during the Asian crisis. Over the sample period, the wage skill

[4] As noted above, this within-firm effect may be difficult to detect without multi-product firm level data. Further, we cannot rule out industry or economy-wide effects from cutting output tariffs. In Indonesia, as in many other countries, there is more variation in factor intensities between firms within industries than between industries, with 78 percent of the variance in a firm's share of skilled workers present within industries. Thus, it is difficult to identify the type of between-industry effects that are highlighted in an H-O model.

[5] Feenstra and Hanson consider the US case where intermediate inputs are more unskilled-labor intensive than final production so that the fall in the price of that input increases the wage skill premium. Note that when they allow for capital shares to differ across the production of different inputs and allow capital mobility between countries, the model predicts that the skill premium increases in both the skilled-labor abundant and unskilled-labor abundant countries. We do not consider the case of international capital flows. Instead, our focus is on tariff reform.

[6] We consider the role of minimum wages in determining the skill premium in Section 5B below.

[7] These numbers are for the period between 1989 and 1997.

[8] We calculate the simple average of the firm's wage skill premium by year.

premium fell 13 percent, with production workers earning 250 percent of the nonproduction wage in 1991, which fell to 220 percent by 2000.

To check that the changes the *SI* data reveal in the skill premium are representative of the wider economy, table 2 also shows the returns to skill calculated using the Indonesian Labor Force Survey (*Sakernas*). The *Sakernas* is an annual nationally representative household survey which covers approximately 250,000 individuals across all of Indonesia's provinces. Wage data is collected for all individuals who are employees, regardless of the size of the firm in which they work. The *Sakernas* does not identify workers as being "production" or nonproduction" but provides information on individual's educational attainment. Thus skill is defined here as educational attainment.[9] The comparison of the change in the skill premium calculated from the *Sakernas* thus is also a check on the validity of using the production/nonproduction breakdown to proxy for skill. Table 2 presents the ratio of the average hourly wage for tertiary, upper secondary, lower secondary and primary educated workers relative to workers with less than a primary school education. These series show the same basic pattern as the *SI* data – a decline between 1991 and the 1996, an increase in 1997 during the Asian crisis and then further declines by 2000.

Although the aggregate trend of a decreasing wage skill premium coincides with falling tariffs, we cannot conclude a causal relationship from this as there were many other factors that may have contributed to this decline. Most notably there was an increase in the supply of education. This followed from the Indonesian government's large-scale school building program and education campaigns. School enrolments grew rapidly in the late 1970s and early 1980s, translating into large increases in the supply of skilled labor in the 1990s. In our estimations below, these economy-wide effects will be swept up in the year fixed effects. Our focus instead will be on how the industry-level tariffs affect firm-level wages.[10]

The *SI* data also reveal large variance in firm-level wages. Wage variation within industries accounts for 76 percent of the total wage variation. As in many other countries, only a small fraction of firms in Indonesia are globally engaged. Only 19 percent of firms import some of their intermediate inputs, 15 percent of all firms export some of their output, and of these firms 5 percent both import and export. Although globally engaged firms account for less than 30 percent of all firms, they account for more than 60 percent of

[9] The Sakernas however does not provide the detailed information on the industry of employment that is required to assign a disaggregated tariff, which is a key element for the analysis in this paper. This is provided in the SI data.

[10] It would be difficult to separate out the impact of this increase in the supply of skill on the economy-wide wage from that of tariffs. This is another reason we do not pursue the mandated wage approach.

manufacturing employment in our sample, with importing firms accounting for nearly 50 percent of manufacturing employment.[11] In general, globalized firms pay higher wages than domestically-oriented firms. Regressing the average wage of production workers and nonproduction workers on an importer and export dummy in columns 1 and 2 of table 4, we see that importers and exporters pay higher wages than domestically-oriented firms within industries, even after controlling for the firm's skill share and employment size. These findings underscore the importance of focusing on firm-level wages, and allowing for heterogeneity in effects between globalized and domestically-oriented firms.[12]

3. Estimation Strategy

Our estimation strategy is to use the industry variation in tariffs over time to identify how reductions in the 5-digit industry level input tariff and in the output tariff affect the wage skill premium paid by firms. The dependent variable, the wage skill premium, is measured by the log of the ratio of the average wage of nonproduction workers to the average wage of production workers. We estimate the following reduced form equation with firm fixed effects (α_f) using OLS,

$$(1)\quad \boldsymbol{ln(w_s/w_u)_{f,i,t} = \alpha_f + \alpha_{l,t} + \beta_1 * input\ tariff_{i,t} + \beta_2 * input\ tariff_{i,t} * impshare_{f,i,t} + \beta_3 * output\ tariff_{i,t} + \beta_4 * output\ tariff * exshare_{f,i,t} + Z_{f,i,t}\Gamma + \epsilon_{f,i,t}.}$$

First, consider the effect of reducing input tariffs. A reduction in input tariffs makes the production of domestically produced inputs less profitable leading to a reallocation of resources away from domestically produced inputs. Because intermediate inputs are more skill-intensive than manufacturing in Indonesia, as we show below, this reduces the relative demand for skilled labor. If this were an economy-wide effect it would be picked up by the year fixed effects and β_1 and β_2 would be insignificantly different from zero. However, if wages are set at the firm or industry level, we would expect these coefficients to be positive via three potential channels. One, if importing firms are substituting in-house production of

[11] The SI data covers firms with more than 20 employees which constitute the formal sector. The formal sector accounts for approximately 41 percent of all manufacturing sector employment (Departemen Perindustrian dan Perdagangan RI, 2002, p59).

[12] Recent theories have incorporated firm-level wage heterogeneity due to search and wage frictions, efficiency wages or fair wages in models of complete labor mobility. See, for example, Helpman, Itskhoki and Redding (2010), Davis and Harrigan (2011), and Amiti and Davis (2011).

skill-intensive inputs for imported inputs, expanding their less-skill intensive production stages, the relative demand for skilled workers would fall within those importing firms and the skill premium would decline, and so $\beta_2>0$. Note that the lower input tariffs could also lead to higher productivity and profits for importers increasing their overall demand for both types of labor.[13] Two, importing firms may be substituting away from locally sourced inputs, which would lead to a decline in relative demand for skilled workers in nonimporting firms, and thus $\beta_1 >0$.[14] Three, lower input tariffs would affect all firms within an industry if wages were set at the industry level, which also implies $\beta_1 >0$.

Second, consider the effects from reducing output tariffs on the wage skill premium. A model with multi-product firms could generate within firm wage effects if different final goods were produced with different factor intensities. However, our data only contains information on the firm's main product thus it is difficult to detect these effects. Nevertheless, for completeness and to clearly identify the channel, we include both the input tariff and the output tariff in the specifications. We also interact output tariffs with export share as any output tariff effect may affect exporting firms differentially.

The vector Z in equation (1) controls for the firm's import and export status. In some robustness specifications it will also include measures of government ownership, foreign ownership, firm size and the skill share. To take account of shifts in the relative supply of skilled labor, as well as other differential shocks across different parts of Indonesia, all specifications will also include island-year effects, $\alpha_{l,t}$.[15]

4. Data and Measurement

The main data source we use to estimate equation (1) is the Annual Survey of Manufacturing Firms (Survei Tahunan Perusahaan Industri, SI) for the years 1991 to 2000. The data are collected by the Indonesian Statistical Agency (*Badan Pusat Statistik*, BPS) and constitute a census of all manufacturing establishments in the country that have twenty or more employees. There are roughly 14,000 manufacturing establishments in 1991 and this number increases to around 20,000 establishments in 2000. See table 1 for summary statistics.

[13] Indeed, Amiti and Davis (2011) show that lower input tariffs increased revenues and wages in importing firms, and Amiti and Konings (2007) show that lower input tariffs increased productivity in importing firms.
[14] Note that our estimation strategy would only detect this effect if the domestically sourced inputs were produced within the same industry as the importing firm.
[15] There are five island dummies: Sumatra, Java, Kalimantan, Sulawesi, and the outer islands; and a Jakarta dummy.

The data provide detailed information on the establishments. This includes 5-digit industry codes for 290 manufacturing industries, which enables a matching of industries with the tariff data. For each establishment, there is also information on the number of production and nonproduction employees, the wage bill (broken down by production and nonproduction workers), the proportion of output that is exported, the value of imported and domestically produced inputs, and the percentage of foreign ownership.

4A. Measure of Tariffs

Our raw tariff data is is at the 9-digit HS code level.[16] To merge the tariff data with the firm-level data we construct the tariffs on final goods at the 5-digit ISIC codes by taking the simple average of the 9-digit HS codes within 5-digit categories. To construct the input tariffs, we weight the output tariffs by their input cost shares, as follows:

$$input\ tariff_i = \sum_j w_{ij,1998} * output\ tariff_{j,t} \text{ and } w_{ij,1998} = \frac{\sum_f input_{f,ij,1998}}{\sum_{f,j} input_{f,ij,1998}}$$

Comprehensive information on the cost shares, w_{ij} for each input j used by industry i are only available for 1998. Although the SI questionnaire asks each firm to list all of their individual intermediate inputs and the amount spent on each in rupiah for other years, this information is not routinely prepared, and was only fully coded up by BPS for the year 1998. We aggregate the 1998 data up within the 5-digit industry categories to provide a 290 manufacturing input/output table.[17] At our request BPS also coded firm-level input information for the year 2000 but these data are less complete, covering around 60 percent of firms. Thus, we use the 2000 input data only as a robustness check.

Both input and output tariffs were on a downward trend over the sample period. The largest tariff cuts were on the highest level tariffs (see Figure 1), consistent with Indonesia's WTO commitment to reduce all of its bound tariffs to 40 percent over a 10 year period on most of its imported products.[18] This feature will prove useful when we construct our instrument set to address the potential endogeneity of the tariff reform. Though tariffs on intermediate inputs are generally lower than those on final goods, this sector also experienced

[16] The tariff data are from Amiti and Konings (2007). We experiment with using weighted averages of the 9-digit tariffs in Section 5B below.

[17] We assume that the mix of inputs used by industries does not change over our sample period.

[18] However, there was an exclusion list, which contained a list of imported products that were not subject to this commitment. Although there were as many as 73 5-digit ISIC codes that contained at least one HS code that was on the exclusion list, there are only nine 5-digit codes that contained 10 or more HS codes that were excluded from the commitment. These were in motor vehicles and components and iron and steel industries. See http://www.wto.org/english/tratop_e/goods_schedules_e.html for the exclusion list.

substantial declines over this period. And, similarly, it was the highest input tariffs that experienced the largest declines over the sample period. Most importantly, there is independent variation in the two types of tariffs as can be seen in Figure 2. The correlation between the changes in input tariffs and output tariffs over the sample period is only 0.38. It is this variation that will help identify the separate effects of these two types of trade liberalization on the wage skill premium.

4B. Measure of Skill

We use the average nonproduction and production wages as our measures of the skilled and non-skilled wage, respectively, as in many previous papers (see Goldberg and Pavcnik, 2007). Although the production/nonproduction categorization does not map perfectly into skill levels, we show that the average level of education attainment is much higher for production than nonproduction workers. Fortunately the *SI* collected information on the number of workers by education category for a subsample of years, 1995 to 1997.[19] We are thus able to establish that the production/nonproduction split is highly correlated with education attainment as shown in table 3. Of production workers, 52 percent have a primary school or lower education, compared to only 16 percent of nonproduction workers. Similarly, 66 percent of nonproduction workers are educated at or beyond upper secondary level, compared to only 24 of production workers. The most striking difference is at tertiary level where slightly more than 11 percent of nonproduction workers are tertiary educated compared to only 1 percent of production workers.

4C. Skill Intensity

The skill share of labor varies across different production stages. The data show that the skilled labor intensity of intermediate inputs is higher than in overall manufacturing. To calculate this, we used the 1998 data on input usage by firm. This enables us to identify which industries supply intermediate inputs, calculate their average skill intensity and compare it with the average for all manufacturing firms. The skill content of intermediate inputs is higher than manufacturing for all years in our sample. For example, in 1996 using the ratio of nonproduction workers to total employment as a measure of the skill share, the skill intensity for intermediate inputs is 23 percent compared to 15 percent for all manufacturing. Similarly, using the ratio of educated workers (defined as workers with at

[19] It does not however disaggregate wages by educational categories.

least an upper secondary school education) relative to total employment as a measure of skill intensity, the skill content of inputs is 46 percent compared to 28 percent for manufacturing. The skill intensity of the imported input is a key factor in understanding the effects of reducing input tariffs. As the price of these skill-intensive inputs falls with lower input tariffs, firms are likely to reallocate resources to less-skill intensive production. For firms producing both intermediate inputs and final goods, this is likely to lead to a within-firm downward shift in relative demand for skilled workers. Consistent with this, table 4 shows that although importers are more skill intensive than domestically-oriented firms (see column 3), importers have become less skill intensive relative to domestic-oriented firms over the sample period (see column 4).[20] Note that there could also be a downward shift in the relative demand for skilled workers in those domestic firms that were supplying these high skill intensive inputs. And lower relative demand for skilled workers puts downward pressure on the wage skill premium.

5. Results

We present the baseline results in table 5. First, we include output tariffs in column 1 and input tariffs in column 2 separately. We see that in each case, the coefficient is positive and significant indicating that a fall in tariffs is associated with a decline in the within-firm wage skill premium. However, in column 3 where we include both input tariffs and output tariffs in the same specification, we see that although both coefficients remain positive, the coefficient on output tariffs becomes insignificant. This suggests that leaving out the input tariff could lead to an omitted variable bias. When both variables are included it becomes clear that the main channel by which globalization is affecting the within-firm skill premium is via the cut in input tariffs, not output tariffs. In all subsequent specifications, we will include both output and input tariffs.

Next, we explore whether the effect from cutting input tariffs is industry-wide or one that only affects importers. We do this in column 4, by interacting input tariffs with the firm's input share (the ratio of imported inputs to total output). We also interact output tariffs with the firm's export share (the ratio of exports to total output). Indeed, we see that the effect is strongest among importers, with the importer interaction term positive and significant at the 1 percent level. Evaluating this effect at the mean import share of importers, equal to 0.25, we

[20] This implies that the skill share of the average importing firms decreased by 3 percent relative to domestic-oriented firms. Note that the mean skill share of importing firms is 0.2.

see that a 10 percentage point cut in input tariffs reduces the wage skill premium by 4.5 percent in importing firms. This effect is stronger for importers with a larger import share. For importers with an import share in the 90th percentile (an import share equal to 0.6), a 10 percentage point cut in input tariffs results in an 8.4 percent fall in the skill premium.

The linear input tariff term is now only marginally significant (at the 10 percent level). Thus there may be some spillovers to firms within the same industry – either through reduced demand for their skill-intensive outputs by firms in their own industry or through a general bidding down of the relative skilled wage within the industry. In further robustness tests below we will see that the effect on nonimporting firms is not robust across all specifications. The within firm effect on the skill premium following cuts in output tariffs remains insignificant even after we include an interaction term with the export share.

In column 5 of table 5, we include time varying firm-level characteristics to ensure that our results are not being driven by these omitted variables. In addition to the firm-level import and export shares we already included, we now also control for the share of foreign ownership, government ownership and the size of the firm, measured by the log of the firm's total labor force. We see that the average skill premium is higher in foreign-owned firms and large firms, and it is lower in firms with some government ownership. The inclusion of these variables does not, however, affect the statistical significance of the point estimates on the input tariff variables. It causes the coefficient on input tariffs interacted with import share to increase slightly. In column 6, we include the skill share, measured as the ratio of production to total number of workers. The negative coefficient on the skill share indicates that an increase in the share of skilled workers within a firm is associated with a lower skill premium. But, more importantly, the inclusion of the skill share hardly affects the point estimates on the tariff variables. The coefficients on the output tariff variables remain insignificant.

5A. Compositional Effects

We have argued that the downward shift in the relative demand for skilled workers is the underlying mechanism that has reduced the wage skill premium in importing firms in Indonesia. However, our measure of the wage skill premium - the average wage of nonproduction workers relative to production workers – means that it is possible that the relative wage measure is being driven by compositional shifts in the education of workers within these categories. For example, trade liberalization may cause importing firms to hire more educated production workers than other firms, which would cause the average wage of

production workers relative to nonproduction workers to rise. To investigate this possibility, we define a measure of relative educational intensity as:

$$Relative\ education\ intensity_{f,i,t} = \frac{educated\ production_{f,i,t}/total\ production_{f,i,t}}{educated\ nonproduction_{f,i,t}/total\ nonproduction_{f,i,t}},$$

where *educated production* is defined as the number of production workers that have completed at least upper high school level, and similarly for *educated nonproduction*. In column 1 of table 6, we show that between 1995 and 1997 (spanning the period in our sample for which we have data on educational attainment of workers), the changes in the relative education intensity of exporting and importing firms relative to domestically-oriented firms were insignificantly different from one another. This may, however, be too short a period in which to detect any differences. The only other year for which the *SI* collected education data is 2006. Although this is outside our sample period, we use these data to examine the longer term trend in relative educational intensity. Column 2 shows that relative education intensity of production workers actually declined between 1996 and 2006 in importing and exporting firms relative to domestically-oriented firms. That is, the share of educated workers among production workers fell for importers and exporters relative to domestically oriented firms, which should work against finding a decrease in the wage skill premium at globalized firms. This suggests that compositional shifts in education are unlikely to be driving our result.

5B. Robustness

In table 7, we show that the results are robust across different specifications. In column 1, we see that the results are similar using an alternative method of weighting the final goods tariffs. In our baseline specifications, each HS 9-digit tariff is given equal weight within a 5-digit ISIC industry. An alternative is to weight each tariff by its import share, though an issue with using import weights is that high tariffs may receive very small weights (as a result of low demand for imports in highly protected industries). Further, the average tariff could change in a year due to changing weights even though the actual tariff may have remained unchanged. To avoid this problem, we fix the weights as an average of the first and the last year in the sample. The input tariffs are then calculated as the input cost-weighted average of the import-weighted output tariffs. The results with the import-weighted tariffs are very similar to the ones with simple averages used in the baseline specification, except that the input tariff variable (not interacted with import share) is now insignificant. This variable

remains either insignificant or is only marginally significant (at the 10 percent level) in all of the robustness tests.

The input tariffs are constructed using cost shares from firm-level data in 1998. However, there may be concern that 1998 may not be representative of the whole sample, given it was a year in the middle of the Asian crisis, which began in August 1997. To check this, we recalculated the input tariffs with input cost shares from 2000, which is the only other year the data were available. Because these data were only available for about 60 percent of the firms, we use this information only as a robustness check, in column 2 of table 7, where we see that the coefficient on the input tariff variable interacted with import share remains positive and significant but smaller in magnitude. In the subsequent columns, we continue to use the more comprehensive 1998 cost share weighted input tariff.

Another potential concern is that during the Asian crisis, Indonesia experienced large exchange rate depreciations and high inflation, which could affect the results. Although the island-year dummies would control for the average of these effects, it could be argued that exporters and importers may be affected differentially. Thus in column 3 of table 7, we include interactions between the trade weighted exchange rate and the import share and the export share. We see that both of these coefficients are insignificant.[21] Of course, there may be other effects arising during the Asian crisis that are not picked up by changes in the exchange rate, which might bias our results. For example, the crisis made it difficult for firms to get bank loans and hence this might affect exporting and importing behavior, which in turn may shift the relative demand for labor and hence the wage skill premium. To ensure that these effects are not biasing the coefficients on tariffs, we re-estimate equation (1) for the pre-crisis subsample from 1991 to 1996 and we see from column 4 that the point estimate on the input tariff interacted with import share is very similar to the baseline specification in column 6 of table 5.

It should also be noted that during the sample period, minimum wages in Indonesia increased sharply, which could affect the wage skill premium. Chun and Khor (2010) show that higher minimum wages led to lower wage inequality in the 1990s. The government's stated aim in setting minimum wages is to cover the cost of a defined consumption bundle which reflects individuals' minimum physical needs and the cost of living, which varies across Indonesia's provinces (Rama, 2001). If the regions that experienced higher minimum wages also have a concentration of industries that experienced larger tariff cuts, this

[21] The results are the same if we include the real trade weighted exchange rate instead of the nominal exchange rate.

correlation could bias our results. To check for this, in column 5 of table 7 we include a measure of minimum wages.[22] We see that higher minimum wages reduce the wage skill premium, but they hardly change the coefficient on the input tariff for importing firms.

So far our estimations have controlled for the differential average wage skill premium in foreign firms by including the share of foreign capital in each firm. However, the mechanisms driving relative demand for labor in foreign firms may differ from domestic firms because of the relationship with the parent firm. This may be of particular concern for the effect of input tariffs on importers, given that the share of imported inputs is quite large for foreign firms. In column 6, we exclude all firms that have any foreign capital and find that the coefficient on input tariffs for importers remains positive, significant and similar in magnitude.

As mentioned above, Indonesia experienced a large increase in the supply of skilled workers in the 1990s. The economy-wide effect of this increase in skill is captured by the island-year effects included in all of the specifications. As a further check, column 7 presents results with industry-year effects in addition to the island-year effects. This controls for the possibility that the relative supply of skill increased differentially across industries. For example, the relative supply of skilled labor may have increased more in car manufacturing than in food processing. The estimate of the coefficient on input tariffs interacted with import share however remains significant and its magnitude is not greatly affected by these additional controls. Thus, relative supply shifts do not appear to be driving our results.[23]

Another important issue to consider is whether the trade reform process in Indonesia is endogenous. This would be the case if, say, politically powerful industries are able to successfully lobby government for trade protection. Mobarak and Purbasari (2006) argue that this is difficult in developing countries where trade reform is closely overseen by international organizations such as the International Monetary Fund (IMF). This argument is supported by their empirical results using Indonesian data which show no relationship between a political connection indicator and tariffs. Furthermore, all the estimations we present include firm fixed effects thus the potential bias is reduced if the political economy factors are time-invariant (see Golberg and Pavcnik, 2005). But time varying factors could affect both the tariffs and the wage skill premium. To address this concern, in table 8 we explore whether the effect of input tariffs on the wage skill premium might be biased due to a

[22] We thank Ann Harrison for providing us with these data. The minimum wage data vary across provinces over time, and in some cases there is also variation across districts within a province.

[23] Note that the input tariff and output tariff variables are dropped in this specification as they do not vary within industry and year.

potential endogeneity bias. We follow Trefler (2004) by using the initial share of unskilled workers at the industry level as an instrument, as well as using initial tariff levels, as in Goldberg and Pavcnik (2005), to instrument for changes in tariffs. We instrument in the equation estimated in five year differences since it is easier to find valid instruments for changes in tariffs than for levels.

Before using instrumental variables estimation, we first show that our results hold in a 5-period differenced equation using OLS. In column 1, we see that the magnitude of the coefficient on the change in input tariff interacted with import share is of a similar magnitude to the OLS estimation in levels shown in column 6 of table 5. In column 2, we estimate the 5-period differenced equation using instrumental variables, where the instruments comprise the 1991 input and output tariff levels, with the input tariff variable interacted with an initial importer status dummy equal to one if the firm imported any of its inputs at entry, and the output tariff interacted with an initial exporter status dummy, as well as the exclusion dummy.[24] We see that the coefficient on the change in input tariff interacted with import share is almost twice as large using instrumental variables than with OLS.

Although we have corrected for the potential endogeneity of the tariff levels, there may still be some concern about the endogeneity of the decision to import or export. To address this, we interact input tariffs with the firm's import share fixed at entry into the sample and interact the output tariff with the export share fixed at the firm's entry into the sample. In column 3, we see that fixing the import and export shares results in a lower coefficient than in column 2, but it is still higher than the non-instrumented coefficient in column 1. In column 4, we continue to fix the import and export shares but experiment with an alternative instrument set that replaces the initial level of output tariffs with the initial proportion of unskilled workers in each industry. We find that this produces the same results as the previous instrument set. In each case, the instrumental variables estimation produces larger coefficients on the input tariff interacted with import share than the OLS results and in each case this coefficient is strongly statistically significant. The results from column 4 of table 8 imply that a 10 percentage point decline in input tariffs results in a 10 percent decline in the wage skill premium for the average importer.

[24] The exclusion dummy equal to one if at least 10 HS codes within a 5-digit industry were excluded from the WTO commitment in 1995.

5. Conclusions

There is an emerging view in the literature that trade liberalization increases the wage skill premium in both developed and developing countries. In this paper, we have presented contrary evidence for Indonesia, a country with a very high share of unskilled labor. We find that a 10 percentage point cut in tariffs on intermediate inputs reduces the wage skill premium by 10 percent in the average importing firm. By using industry-level tariff data with firm level wages we have been able to identify a causal effect from cutting import tariffs on the wage skill premium, after controlling for confounding factors such as shifts in the relative supply of skilled labor and changes in the minimum wages. Although we are unable to identify an economy-wide effect with this methodology, the fact that importers account for half of the employment in our sample suggests they could be large.

Our study differs from the previous literature in two fundamental ways. First, we focus on a very low skill economy rather than middle-income countries that have been the focus of previous studies. Given that less than 4 percent of Indonesia's population has attained tertiary education, it should not be surprising that its comparative advantage is in low-skill labor intensive activities and thus that unskilled labor is likely to benefit relatively more than skilled labor following trade liberalization.

Second, this is the first study to allow separate effects from reducing input tariffs and output tariffs. Previous studies have only considered the effects from reducing final goods tariffs or changing trade shares. As the mechanisms affecting the wage skill premium differ for cutting input tariffs from those of cutting output tariffs, it is important to allow for separate effects. Our results suggest that reducing input tariffs produces a large significant within-firm effect on the wage skill premium for importers while changes in output tariffs have an insignificant effect.

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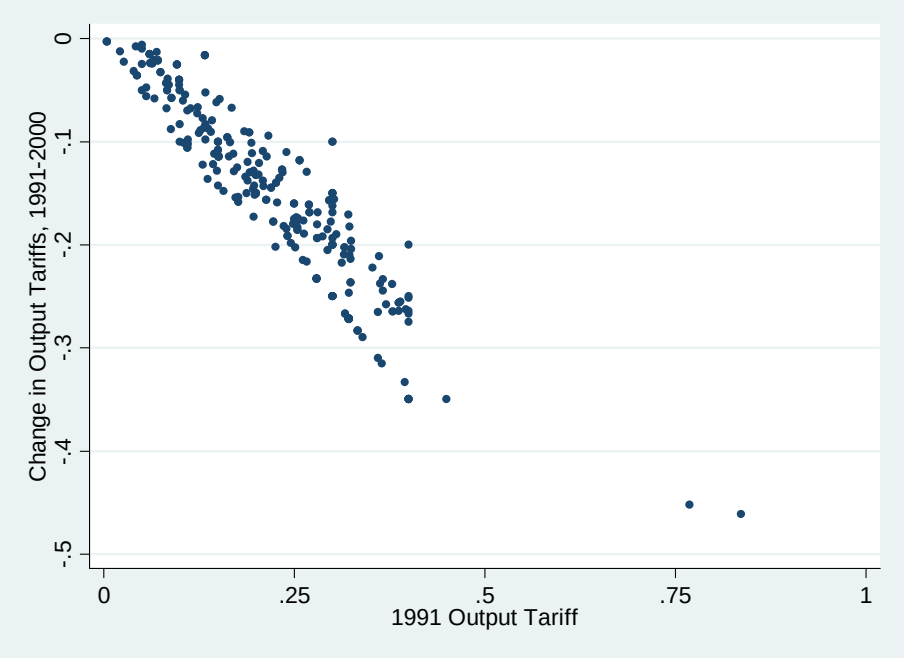
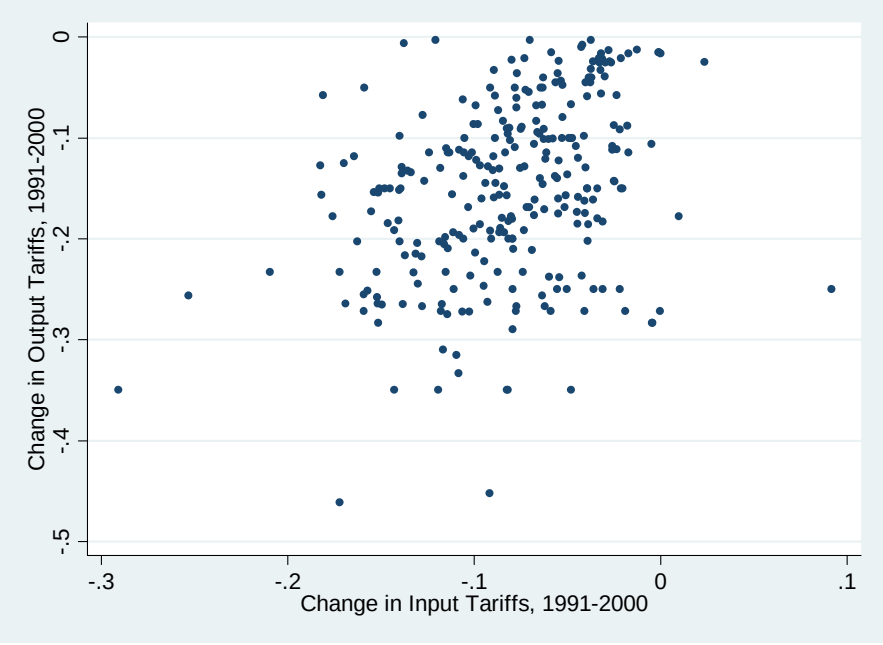
Figure 1: Higher Output Tariffs experience the largest declines



Note: Industries that experienced an increase in their tariff over the sample period are excluded from the figure. These are in the grain and liquor industries (ISIC codes: 31161, 31162, 31169, 31310, and 31320).

Figure 2: Low Correlation Between Changes in Output Tariffs and Input Tariffs



Note: Correlation is 0.38. Industries that experienced an increase in their final goods tariff over the sample period are excluded from the figure. These are in the grain and liquor industries (ISIC codes: 31161, 31162, 31169, 31310, and 31320).

Table 1: Summary Statistics

	Variable	N	mean	sd	min	max
Levels	$\ln(ws/wu)_{f,i,t}$	152,702	0.55	0.72	-1.89	2.93
	$\ln(ws)_{f,i,t}$	152,702	7.87	1.00	-0.38	17.04
	$\ln(ws)_{f,i,t}$	152,702	7.32	0.85	-0.80	15.76
	$FM_{f,i,t}$=1 if impshare>0	152,702	0.22	0.41	0.00	1.00
	$Impshare_{f,i,t}$ if FM=1	33,260	0.25	0.23	0.00	1.00
	$FX_{f,i,t}$=1 if exshare>0	152,702	0.18	0.38	0.00	1.00
	$Exshare_{f,i,t}$ if FX=1	27,213	0.70	0.33	0.00	1.00
	$foreign_{f,i,t}$	152,702	0.05	0.20	0.00	1.00
	$Gov_{f,i,t}$	152,702	0.10	0.30	0.00	1.00
	$\ln(size)_{f,i,t}$	152,702	4.37	1.22	2.08	10.66
	$Skillsh_{f,i,t}$	152,702	0.18	0.15	0.00	0.99
	$\ln(minwage)_{k,t}$	152,500	11.68	0.51	10.20	12.77
Changes	$\Delta\ln(ws/wu)_{f,i,t}$	44,610	-0.08	0.85	-4.75	4.21
	$\Delta impshare_{f,i,t}$	44,610	-0.01	0.13	-0.99	0.99
	$\Delta exshare_{f,i,t}$	44,610	-0.03	0.30	-1.00	1.00
	$\Delta foreign_{f,I,}$	44,610	0.01	0.13	-1.00	1.00
	$\Delta gov_{f,i,t}$	44,610	0.15	0.38	-1.00	1.00
	$\Delta\ln(size)_{f,i,t}$	44,610	0.03	0.56	-5.52	4.82
	$\Delta skillsh_{f,i,t}$	44,610	0.00	0.14	-0.91	0.98
tariffs	Δoutput $tariff_{i,t}$	44,610	-0.11	0.09	-0.87	1.30
	Δinput $tariff_{i,t}$	44,610	-0.06	0.05	-0.28	0.32
	output $tariff_{i,1991}$	266	0.22	0.12	0.00	0.84
	output tariff $_{i,2000}$	288	0.08	0.14	0.00	1.70
	input $tariff_{i,1991}$	266	0.14	0.06	0.00	0.36
	input $tariff_{i,2000}$	288	0.06	0.03	0.00	0.37

Note: The data was cleaned by dropping the top and bottom 1 percentiles of the firm's log skill premium in levels and year to year changes All of the differenced variables are in 5 period differences. All variables are logged except variables expressed in ratios or in percentages.

Table 2: Relative Wages of Skilled to Unskilled Workers

	SI Data	Sakernas Data			
Year	Non-Prod /Prod	Primary	Lower Secondary	Upper Secondary	University
1991	2.52	1.19	1.60	2.22	3.29
1993	2.36	1.25	1.72	2.43	3.71
1996	2.17	1.17	1.46	2.01	2.99
1997	2.35	1.18	1.51	2.08	3.13
1998	2.21	1.16	1.42	2.04	3.05
2000	2.20	1.13	1.43	2.05	3.08

Note: Relative Wages from Sakernas data are relative to workers with less than primary school education.

Table 3: Educational Attainment of Production/Nonproduction Workers

	Production Workers (%)	Non-Production Workers (%)
Highest Education level graduated from:		
Did not finish primary school	10.0	2.8
Primary	41.6	13.0
Lower secondary	24.6	18.0
Upper secondary	23.0	55.6
Tertiary	0.9	10.6

Source: 1995 Survei Industri

Table 4: Firm Heterogeneity

Dependent variable	$\ln(wu)_{f,i,t}$	$\ln(ws)_{f,i,t}$	$Skillsh_{f,i,t}$	$Skillsh_{f,i,t}$-$skillsh_{f,i,t-5}$
	(1)	(2)	(3)	(4)
$FM_{f,i,t}$=1 if import $share_{f,i,t}$>0	0.155***	0.266***	0.023***	-0.006***
	(0.004)	(0.006)	(0.001)	(0.002)
$FX_{f,i,t}$=1 if export $share_{f,i,t}$ >0	0.053***	0.116***	-0.006***	-0.001
	(0.005)	(0.006)	(0.001)	(0.002)
$\ln(labor)_{f,i,t}$	0.071***	0.189***		
	(0.002)	(0.002)		
Skill $share_{f,i,t}$	0.829***	-0.616***		
	(0.011)	(0.015)		
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	152,702	152,702	152,702	44,752
Adjusted R^2	0.49	0.40	0.20	0.01

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Wage Skill Premium and Tariffs

Dependent variable: $\ln(ws/wu)_{f,i,t}$						
	(1)	(2)	(3)	(4)	(5)	(6)
	with output tariffs	with input tariffs	With both tariffs	With globalized share interactions	With firm characteristics	With skill share
Input $\text{tariff}_{i,t}$		0.261***	0.206**	0.169*	0.164*	0.142*
		(0.074)	(0.095)	(0.095)	(0.095)	(0.087)
Input $\text{tariff}_{i,t}$ x $\text{impshare}_{f,i,t}$				1.118***	1.421***	1.369***
				(0.366	(0.374)	(0.363)
Output $\text{tariff}_{i,t}$	0.111***		0.053	0.065	0.068	0.036
	(0.041)		(0.049)	(0.049)	(0.049)	(0.047)
Output $\text{tariff}_{i,t}$ x $\text{exshare}_{f,i,t}$				-0.071	-0.031	-0.015
				(0.078)	(0.078)	(0.076)
$\text{impshare}_{f,i,t}$				-0.044	-0.092**	-0.074*
				(0.046)	(0.046)	(0.044)
$\text{exshare}_{f,i,t}$				0.060***	0.043***	0.037**
				(0.017)	(0.016)	(0.016)
Foreign $\text{share}_{f,i,t}$					0.074***	0.074***
					(0.027)	(0.025)
Government $\text{share}_{f,i,t}$					-0.022*	-0.011
					(0.013)	(0.013)
$\ln(\text{labor})_{f,i,t}$					0.103***	0.065***
					(0.006)	(0.006)
Skill $\text{share}_{f,i,t}$						-2.096***
						(0.035)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year x island effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	152,702	152,702	152,702	152,702	152,702	152,702
Adjusted R^2	0.43	0.43	0.43	0.43	0.43	0.50

Robust standard errors in parentheses are clustered at the 5-digit industry-year level. * significant at 10%; ** significant at 5%; *** significant at 1%. Impshare is the ratio of imports to output and exshare is the ratio of exports to output.

Table 6: Change in Relative Education Intensity

Dependent variable	ΔRelative education intensity$_{f,i,t}$	
	(1995-97)	(1996-2006)
	(1)	(2)
$FM_{f,i,t}$=1 if	-0.003	-0.086***
import share$_{f,i,t}$>0	(0.017)	(0.024)
$FX_{f,i,t}$=1 if	0.006	-0.069***
export share$_{f,i,t}$ >0	(0.019)	(0.027)
Firm effects	No	No
Industry effects	Yes	Yes
Year effects x island effects	No	No
Observations	10,176	6,704
Adjusted R^2	0.00	0.03

Notes: Robust standard errors in parentheses are clustered at the 5-digit industry-year level. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Skill Premium and Tariffs – Robustness

Dependent Variable: ln(ws/wu)	Import weighted tariffs	Input tariffs with 2000 cost shares	With exchange rates	Pre-crisis period (1991-1996)	With Minimum wages	Without foreign firms	Relative Supply of Skill Control
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Input $tariff_{i,t}$	-0.027	0.042	0.144*	-0.175	0.148*	0.140	
	(0.041)	(0.074)	(0.088)	(0.160)	(0.088)	(0.088)	
Input $tariff_{i,t}$ x $impshare_{f,it}$	1.385***	0.629**	1.456***	1.283**	1.306***	1.374***	1.052***
	(0.390)	(0.321)	(0.498)	(0.568)	(0.363)	(0.398)	(0.304)
Output $tariff_{i,t}$	0.038	0.062	0.031	0.048	0.034	0.024	
	(0.033)	(0.046)	(0.047)	(0.074)	(0.047)	(0.049)	
Output $tariff_{i,t}$ x $exshare_{f,i,t}$	-0.024	0.008	0.070	0.082	-0.018	0.009	-0.054
	(0.077)	(0.079)	(0.097)	(0.109)	(0.076)	(0.081)	(0.074)
Foreign $share_{f,i,t}$	0.075***	0.076***	0.073***	0.043	0.074***		0.072***
	(0.025)	(0.026)	(0.025)	(0.036)	(0.025)		(0.025)
$ln(labor)_{f,i,t}$	0.064***	0.065***	0.065***	0.059***	0.065***	0.065***	0.068***
	(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)	(0.006)
Skill $share_{f,i,t}$	-2.095***	-2.094***	-2.096***	-2.104***	-2.096***	-2.065***	-2.095***
	(0.035)	(0.036)	(0.035)	(0.055)	(0.035)	(0.036)	(0.026)
$ln(TWI)_t$ x $impshare_{f,i,t}$			-0.008				
			(0.033)				
$ln(TWI)_t$ x $exshare_{f,i,t}$			-0.023				
			(0.016)				
$ln(minimum\ wage)_{p,t}$					-0.110***	-0.119***	
					(0.031)	(0.031)	
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x island effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Industry Effects	No	No	No	No	No	No	Yes
Observations	151,970	149,613	152,702	87,978	152,500	141,521	152,702
Adjusted R^2	0.50	0.50	0.50	0.54	0.50	0.49	0.50

Robust standard errors in parentheses are clustered at the 5-digit industry-year level. * significant at 10%; ** significant at 5%; *** significant at 1%. The standard errors in column 7 are bootstrapped with 200 repetitions. The variables impshare, exshare and government share are included as controls but suppressed to save space.

Table 8: Tariffs and the Wage Skill Premium – Endogeneity

Dependent variable: $\ln(ws/wu)_{f,i,t} - \ln(ws/wu)_{f,i,t-5}$	All variables in 5 period differences			
	(1)	(2)	(3)	(4)
	OLS	Instrumental Variables		
		Fix import and export shares at entry		
				Alternative instrument set
ΔInput tariff$_{i,t}$	0.267**	0.362*	0.390*	0.291
	(0.123)	(0.210)	(0.208)	(0.214)
Δ(Input tariff$_{i,t}$ x impshare$_{f,it}$)	1.960***	3.699***	2.900***	2.893***
	(0.431)	(0.820)	(0.642)	(0.647)
ΔOutput tariff$_{i,t}$	0.066	0.141	0.115	0.293
	(0.064)	(0.103)	(0.101)	(0.189)
Δ(Output tariff$_{i,t}$ x exshare$_{f,i,t}$)	0.008	-0.183	-0.106	-0.035
	(0.097)	(0.173)	(0.127)	(0.138)
Δimpshare$_{f,i,t}$	-0.173***	-0.378***	-0.013	-0.012
	(0.061)	(0.102)	(0.037)	(0.037)
Δexshare$_{f,i,t}$	0.040*	0.073*	0.044***	0.040***
	(0.024)	(0.037)	(0.015)	(0.015)
ΔForeign share$_{f,i,t}$	0.075*	0.078**	0.075*	0.076*
	(0.040)	(0.040)	(0.040)	(0.040)
$\Delta\ln(\text{labor})_{f,i,t}$	0.054***	0.056***	0.055***	0.056***
	(0.008)	(0.008)	(0.008)	(0.008)
ΔSkill share$_{f,i,t}$	-2.076***	-2.075***	-2.074***	-2.073***
	(0.046)	(0.046)	(0.046)	(0.046)
Year x island	yes	yes	yes	yes
Weak instruments (F-stat)		2,280	3,692	1,116
Overidentification Hansen J Statistic		0.001	0.06	0.46
p-value		0.98	0.81	0.50
Observations	44,610	44,610	44,610	44,610
Adjusted R^2	0.12			

Notes: Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments in columns 2 and 3 include *output tariff$_{1991}$, output tariff$_{1991}$*FX$_{t0}$, input tariff$_{1991}$, input tariff$_{1991}$*FM$_{t0}$, exclusion dummy=1* if at least 10 HS codes within a 5-digit ISIC code are excluded from the commitment to reduce bound tariffs to 40 percent. Column 4: as in previous column with 1991 output tariffs replaced by the proportion of unskilled workers in a 5-digit industry in 1991. Govt share is suppressed to save space.