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Importing Inequality: Trade Liberalization, Technology, and Women's Employment

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Abstract

In this paper, we investigate the impact of trade liberalization on the demand for female workers using Indonesia's tariff reduction in the 1990s and 2000s as a natural experiment. This paper utilizes variation in output and input tariffs to examine two different channels through which trade liberalization affects female employment: import competition and imported technology. We find that a 10%-point reduction in output and input tariffs hurt women's employment by 0.5% point and 4.5% point, respectively, in light industries in the 1990s. We show that output tariffs affect women's employment in a competitive industry, while input tariffs increase firms' utilization of foreign inputs instead of domestic inputs. We also find that output tariffs encourage women's employment in heavy industry, while input tariffs have hurt women's employment in heavy industry since 2000. Our results suggest that there exists a race between gender inequality in education and imported technology in developing countries.

Keywords: trade liberalization; gender inequality; skill-biased technological change
JEL Classification Codes: F14, F66, J16, J24,

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1. Introduction

The rapid globalization over the last three decades has motivated a rich body of literature investigating the distributional impacts of international trade in labor markets. Although many recent studies have focused on the differential impact of international trade across male and female workers, there is currently no consensus regarding this impact in the empirical or theoretical literature. Becker (1957) argued that heightened competition increases the demand for female workers because it drives out costly discrimination towards minority workers, including females. On the other hand, Standing (1999) and Goldberg and Pavcnik (2003) claimed that through growing cost-cutting competition, globalization has made firms seek female workers, who earn low wages and engage in irregular employment.

Trade is also an important channel of technological adoption for developing countries. Wood (19995) and Acemoglu (2003) showed that trade liberalization creates incentives for firms to adopt new technologies through imported machinery from technologically advanced countries. Galor and Weil (1996) and Juhn et al. (2014) suggested that new capital is more complementary to female blue-collar workers because

new technologies embedded in physical capital involve computerized production processes and weaken the relative advantage of male workers.

On the other hand, Acemoglu (2003) noted that the transfer of new technology may encourage skill-biased technological change in developing countries. Technological change in many countries is found to favor skilled workers and to raise their wage premium. Katz and Murphy (1992) and Berman et al. (1998) also showed that technological change is pervasive among developed countries because of international trade. If most female workers are unskilled, the transfer of new technology driven by trade liberalization will decrease the demand for female workers.

In this paper, we employ both output tariffs and input tariffs calculated at the four-digit industry level in Indonesia's manufacturing sector to disentangle the effect of import competition and the effect of imported input induced by trade liberalization. A reduction in output tariffs increases domestic competition as the price of imported goods becomes cheaper. At the same time, a reduction in input tariffs encourages firms to employ more imported intermediate goods. We use firm-level data from Indonesia's manufacturing sector from 1993 to 2008, when Indonesia implemented comprehensive and gradual reductions in tariff rates mainly because of pressure from foreign countries.

Our empirical evidence shows that trade tends to hurt women employment especially through imported inputs. Further investigation shows that the impact of trade liberalization in Indonesia coincides with the story of skill-biased technological changes especially in light industry traditionally hired more women. On average, a 10%-point decline in output tariffs decreases women's employment share by 0.8% point, while a 10%-point decrease in input tariffs decreases this share by approximately 3.6% point in our baseline estimation. Then, we show that the impact of input tariffs is salient among production workers in light industry. The direction of the impact of output tariff changes when we restrict our sample to firms in previously male-dominated heavy industry.

Then, we further explore the mechanism of output and input tariffs. This exercise shows that the impact of output tariffs appears only in competitive industries, as measured by the Herfindahl index. An industry that experiences higher-than-average firm exits could avoid the impact of output tariffs. The impact of output tariffs through non-production workers' employment and skill premium is estimated to be limited. However, we find that a reduction in input tariffs significantly decreases a firm's utilization of domestic inputs and increases its utilization of foreign inputs. This implies that foreign advanced technology embedded in imported inputs favors male workers over female workers.

Our presented evidence is different from empirical findings in previous literature as we examine different context of trade liberalization. Black and Brainerd (2004) and Ederington et al. (2009) examined the impact of increased competition on women's employment in the United States and Colombia. Both articles found that increased competition driven by trade liberalization improves the gender wage gap in the United States, and leads Colombian firms to hire more female workers. Gaddis and Pieters (2012) examined regional variation in tariff reductions in Brazil and found that trade liberalization increases female employment in the trade and service sectors. Juhn et al. (2014) examined export and input tariffs at the disaggregated industry level in Mexico and provided empirical evidence that a reduction in export tariffs leads firms to enter export markets. These exporter firms update their technology and replace male blue-collar workers with female blue-collar workers.

We conjecture that difference between previous literature and our findings comes from difference in the measure of trade liberalization and the context of trade liberalization. The measure of trade liberalization employed in this paper is import tariff on final goods and intermediate goods, thereby all the evidence should be interpreted as the impact of increased importation. Also, empirical investigation shows that Indonesia's trade liberalization enlarged country's import of foreign final goods and intermediate

inputs without encouraging country's export activity. Second, we examine Indonesia, which has the 4th largest population in the world and a relatively large educational gap between women and men. This gap was especially large in the 1990s. Thus, Indonesia provides an appropriate context for us to examine how trade liberalization affects female workers due to their skill level as well as labor market discrimination.

Our findings are consistent with findings from previous literature on Indonesia and its trade liberalization. Studies have examined Indonesia's trade liberalization and the demand for skilled workers. Amiti and Konnings (2007) found, using plant-level data from Indonesia in the 1990s, that imported technology driven by a reduction in input tariffs increases productivity. Amiti and Cameron (2012) also found that reducing import tariffs on intermediate goods decreases the wage premium of non-production workers. Lee and Wie (2015) examined Indonesia in the 2000s and provided empirical evidence that technology-embedded imported material increases the demand for skilled workers.

The paper is organized as follows. In section 2, we describe the background of Indonesia's trade liberalization and provide a detailed explanation of our data construction. In section 3, we present our data, our empirical specification and our baseline estimation. In section 4, we explore possible channels through which trade liberalization affects the demand for female workers. In section 5, we examine the

robustness of our results and use alternative specifications and tariff measures. We conclude in section 5.

2. Trade Liberalization in Indonesia

2.1. Changes in Trade Policy in Indonesia

Benefitting from an increase in the oil price during the 1970s, the Indonesian government implemented an import substitution strategy to support domestic industries (Soesastro and Basri 2005). In the early 1980s, the price of oil started to fall, and the government initiated comprehensive trade liberalization to improve the competitiveness of domestic firms and the marketability of their exports. However, these efforts to promote trade liberalization slowed in the late 1980s due to resistance from the agriculture, motor vehicles, plastic, and cement sectors (Feridhanusetyawan and Pangestu, 2003).

In the 1990s, trade liberalization gained momentum under pressures mostly from foreign countries. In January 1992, members of the Association of Southeast Asian Nations (ASEAN) agreed to the establishment of the ASEAN Free Trade Area (AFTA) and chose 15 commodities for fast-track tariff reduction.[4] In 1995, Indonesia joined the

[4] For fast-track products with tariffs higher than 20%, the tariff on the commodities would be immediately reduced to 20%. They promised that the upper bar would be further

World Trade Organization (WTO), and the government announced a comprehensive tariff reduction target of 10% by 2003 for all industries except motor vehicles. In 1995, Ministry of Trade also announced the commitment to removing non-tariff barriers on 12 commodities, including iron and steel products, within ten years.

After the 1997 Asian financial crisis, Indonesia agreed to the IMF's structural adjustment program. The January 1998 reform package included a gradual 5-10% point reduction in import tariffs on chemical, iron, steel, and fishery products (Soesastro and Basri, 1998). In addition to that structural reform program, the government announced a reduction in tariffs on motor vehicles and their components in July 1999 (Feridhanusetyawan and Pangestu 2003). Indonesia also removed other trade barriers such as non-tariff barriers. Most of the IMF program was implemented at the beginning. However, the government backtracked for a few sensitive sectors, such as rice, sugar, steel and logs (WTO 2003).

In the 2000s, Indonesia continued to reduce trade constraints (WTO 2013). The average Most Favored Nation (MFN) tariff declined from 9.9% in 2004 to 9.5% in 2006.

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decreased to below 5% within ten years. For commodities with tariff rates of 20% or less, tariffs should be reduced to 0-5% within seven years.

Additionally, more than 93% of the tariff lines were bound, which reduced uncertainty regarding the tariff change in the short run. More than 75% of tariff rates were in the range of zero to 10% in 2006.

2.2. Construction of Output and Input Tariffs

To construct the data on output and input tariffs, we utilized the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS), the Commodity Trade (UN Comtrade) Database, and Indonesia's Input-Output Table in three different years: 1995, 2000, and 2005. TRAINS provides detailed tariff rates within the 9-digit HS code during our sample period. We used only MFN tariff rates, which countries promise to impose on imports from other members of the WTO unless the country is part of other preferential trade agreements, such as in free trade areas or customs unions. Then, we calculated the simple average of tariffs within the 6-digit HS code, which is matched to the volume of imports from UN Comtrade, to calculate the weighted average tariffs within the 4-digit ISIC code. The weighted tariffs within the 4-digit ISIC code serve as our output tariffs for each firm. We utilized several concordances across the generation of HS codes and between HS codes and ISIC codes. The utilization

of such concordances[5] may decrease the accuracy of the output and input tariffs and cause attenuation bias in our estimation.

We employed three waves of input-output (IO) tables in 1995, 2000, and 2005 provided by BPS (Statistics Indonesia) to calculate input tariffs. The most detailed IO table is disaggregated by 172 sectors. We created concordance between sector codes within IO tables and 4-digit ISIC codes. Then, we matched tariff rates in 1990-1997 to the IO table in 1995, tariff rates in 1998-2003 to the IO table in 2000, and tariff rates in 2004-2009 to the IO table in 2005. Then, we calculated the input tariff within the 4-digit ISIC code weighted by input shares. We provide a detailed description of the tariff data construction in the appendix.

<Table 1 to be inserted here>

Table 1 shows the evolution of output and input tariffs aggregated at the two-digit industry level. It shows significant variations in both tariffs across industries and over time. Both output tariffs and input tariffs sharply decreased in the 1990s. In the 2000s,

[5] Annual Manufacturing Survey Indonesia employs industry codes based on ISIC rev2 and rev3. However, this industry code cannot be perfectly matched with ISIC codes. Approximately 30% of firms are dropped from our analyzed sample due to this problem.

most output tariffs gradually declined, while most input tariffs bounced back in the early 2000s and gradually increased until 2008.

It is possible that certain industries are more powerful in demanding government trade protection. Governments also have incentives to provide political favors by means of trade policy. To prevent any endogeneity caused by this industry-government connection, we include 4-digit industry fixed effects in all of our analyses.

3. Annual Manufacturing Survey and Empirical Results

3.1 Annual Manufacturing Survey

Indonesia's Annual Manufacturing Survey contains detailed information on all manufacturing firms in Indonesia with twenty or more employees. Each survey contains around 20,000 observations and provides information on each firm's wage bills, import and export status, main product, amount of fixed capital, and imported and domestic input materials. Information on employees' gender and worker class (production/non-production worker) is only available from the survey after 1993. Additionally, the data in the 1990s have a panel structure, which allows researchers to keep track of each firm over the years; however, the data collected in the 2000s do not provide such a unique firm identifier.

<Table 2 to be inserted here>

Table 2 provides the share of women's employment across two-digit industries. Overall, women's employment share in the manufacturing sector was 39.6% in 1993, remained almost the same until 2000, and slightly increased in the 2000s, reaching 41.6% in 2009. The disaggregated trends in Table 2 show that women are mostly hired in the food and beverages or textile industries. However, there was little change within each industry and each industry's employment share in the whole manufacturing sector.

<Table 3 to be inserted here>

Table 3 shows summary statistics of firm characteristics in 1993, 2000, and 2008. It shows that the share of non-production workers' wage bill slightly decreased from 0.245 in 1993 to 0.195 in 2008, while the share of non-production workers remained at a similar level during the same period. Firm size, measured as the number of employees, decreased from 247.13 in 1993 to 177.98, while firms' output and value added per worker both increased. The usage of both domestic and imported material per worker

slightly increased over our sample period. However, the share of importers[6] sharply declined from 19.05% in 1993 to 13.50% in 2008. The share of firms that exported their product also slightly declined from 19.88% in 1993 to 17.61% in 2008.

3.2 Empirical Strategy

We analyze the impact of trade liberalization on the firm-level female employment share using the following specification. For firm *i* in industry *k* in year *t,* the female employment share F_{it}^{k} is estimated as follows:

$$F_{it}^{k} = \alpha + \beta_1 OT_t^k + \beta_2 IT_t^k + \beta_3 (IT_t^k \times IM_{it}^k) + \delta_1 IM_{it}^k + \delta_2 EX_{it}^k + \xi Controls_{it}^k + \theta_k + \theta_t + \varepsilon_{it}^k \quad (1)$$

where OT_t^k and IT_t^k represent output tariffs and input tariffs, respectively, calculated at the 4-digit industry level. Both tariff rates are deflated by ten, so the estimated coefficient represents a 10%-point change in tariff rates on the demand for female workers. The

[6] A firm is categorized as an importing firm if imported material accounts for more than 10% of its total intermediate goods. A firm is categorized as an exporter if it was reported to export any positive share of its output.

coefficient for input tariffs is expected to capture any spillover effects of input tariffs on firms that do not import, while that for the interaction term between input tariffs and the importer dummy variable (IM_{it}^{k}) represents the direct impact of input tariffs on importing firms. Indicators for exporters (EX_{it}^{k}) and importers (IM_{it}^{k}) are included to identify differences between international and domestic firms. The set of control variables includes the number of employees, the real fixed capital per worker, the real value added per worker, and the real output per worker.

3.3 Baseline Estimation Results

Table 4 demonstrates our baseline results from the estimation of equation (1). In regression (1), output tariffs show a moderate positive impact on female employment: a 10%-point decrease in output tariffs decreases the female employment share by 0.8% point. The magnitude of the impact is moderate; however, the results are consistent across different specifications in regressions (1)-(4). The positive relationship between output tariffs and the female employment share suggests that higher import competition may cause de-feminization in the manufacturing sector rather than driving out costly discrimination against women.

<Table 4 to be inserted here>

The impact of input tariffs on importing firms shows a consistent and stronger impact of trade liberalization: a 10%-point decrease in input tariffs is associated with a 3.6%-point decline in the share of women's employment in importing firms in regressions (1) and (2) in Table 4. The impact of the input tariff is consistent across regressions (3) and (4) when we control for firm characteristics and the post-crisis period indicator. The coefficient of input tariffs is estimated to be insignificant, implying that there was no meaningful spillover effect on non-importing firms.

In regression (5), we employ non-weighted tariffs[7] as our alternative measure of trade liberalization. The coefficient on output tariffs becomes insignificant; however, the impact of input tariffs remains significant with a slightly reduced magnitude. In this specification, we can also see that non-importing firms were affected by changes in the input tariff, as well.

Table 4 also shows that exporting firms hired 5.4%-5.9% point more female workers. These results are consistent with findings from earlier studies that export-oriented firms in developing countries tend to hire more female workers due to their low wages and labor-intensive but low skills in those exporting industries (Berik, 2000; Ozler, 2000, and Standing 1999).

[7] Please see the appendix for the construction of the non-weighted tariff measure.

<Table 5 to be inserted here>

In Table 5, we re-estimated equation (1) by the type of worker (non-production and production workers) and type of industry (light and heavy industry). The reason for this exercise is to examine whether the impact of trade liberalization differs by the skill level of workers, the preference for female workers, and the capital intensity of firms. In previous literature, non-production workers hired in manufacturing sectors are considered to be highly skilled and work at the management level rather than in production operations. Light industry tends to produce final goods rather than intermediate goods such as food and textiles. Such industries are also the main source of demand for less skilled female workers in developing countries.

Regressions (1) and (2) in Table 5 show that a decline in output tariffs moderately decreases women's employment share among both non-production workers and production workers. On the other hand, the input tariff only affects the share of women's employment among production workers of a much larger size.

In regression (3), we estimated equation (1) using a subsample of firms belonging to light industry, such as food, textile, and furniture. It shows that a 10%-point reduction in output tariffs and input tariffs would result in a decreases of 1.0% point and 2.1% point, respectively, in women's employment share. In regression (4), we employed firms

belonging to the metal, machine, transportation, chemical and electrical industries. The results show that a 10%-point reduction in output tariffs increases the demand for female workers in heavy industries by 1.0% point, while input tariffs have no impact on the share of female workers. In regression (5) and (6), we categorized firms by their capital intensity, and the results indicated that input tariff reductions reduce women's employment share only in labor-intensive firms; this finding is consistent with the results of firms in light industries.

Table 5 provides results indicating that a decrease in input tariffs also decreases the share of female production workers in light industry, which traditionally favors female workers. Indonesia import intermediate goods from developed countries, which are embedded with advanced foreign technology. Female workers in Indonesia are on average less educated than their male counterparts and tend to work in lower-skilled, repetitive and routine jobs (Lee and Wie 2015; Newhouse and Suryadarma 2009). Our empirical evidence implies that foreign technology hurts the employment of less-skilled female production workers in industries that used to provide a majority of jobs for women. We also have some empirical evidence that increased domestic competition hurts women's employment as well, but the estimated size of the impact is very small.

4. The Mechanism of Trade Liberalization

In this section, we further examine why trade liberalization negatively affects the female employment share, especially through input tariffs. The previous section provides some evidence suggesting that imported skills and imported competition favor male workers, who are on average more educated than female workers, especially in light industry. In subsection 4.1, we explore mechanisms through which output tariffs affect the relative demand for female workers: competition, firm exit, and industry-level output decline. In subsection 4.2, we further explore potential channels through which input tariffs hurt women's employment, such as skill upgrading and imported foreign inputs.

4.1 Competition, Firm Exit, and Output Decline

In this subsection, restrict our sample to firms in light industry because trade liberalization hurts female workers mostly in firms in light industry. In regression (1) of Table 6, we included the interaction term between output tariffs and the indicator for the Herfindahl index lower than 0.25 within 4-digit industries. The Herfindahl index is often employed in the literature as a measure of competition in an industry. The index ranges from 0 to 1, indicating a range from a huge number of small firms to a single monopolistic producer. Regression (1) shows that the impact of output tariffs is salient only among

firms in competitive industries. This result is intuitive, showing that the impact of import competition binds only when an industry is a competitive market.

In regression (2), we examine whether the mechanism of output tariffs occurs through firm exits from the market. An increased level of competition caused by a reduction in output tariffs may drive out firms that used to hire more female workers than their competitors. We constructed the indicator of whether the number of firms within 4-digit industries declined more than the average change in the overall manufacturing sector in each year. Regression (2) shows that the interaction term between output tariffs and industry-level firm exit is significantly negative with a similar magnitude in the coefficient of output tariffs. This implies that firms in industries with significant firm exit were not affected by output tariffs. Meanwhile, firms in other industries decreased the share of female workers to stay in the market in the face of increased competition.

<Table 6 to be Inserted Here>

In regressions (3), (4) and (5), we examined whether trade liberalization had any combined impact on the share of female workers during the industry-level recession. We constructed three indicators showing that employment, output and value added in a

specific industry declined more than those of other industries in the same year. Then, we controlled all of the indicators' main terms and their interaction term with output tariffs.

Regression (2) provides no convincing results that the industry-level decline in employment had any combined impact on women's employment at the plant level. Regressions (3) and (4) further show that firms that experienced an industry-level decline in output or value added did not experience the impact of a reduction in output tariffs. The evidence in this subsection implies that output tariffs hurt women in competitive industries without significant firm exit. It also suggests that a reduction in output tariffs induced individual firms to replace their female workers with male workers.

4.2 Skill Upgrading, Imported Intermediate Goods, and Exports

Skill upgrading is a key channel through which technology hurts unskilled workers in both developed and developing countries. In this subsection, we examine whether firms reacted to trade liberalization by having more non-production workers. On average, there are more men than women among non-production workers, and such a change in hiring patterns could decrease the relative employment of women. In previous literature, Amiti and Konings (2007) and Amiti and Cameron (2012) reported that trade

liberalization in Indonesia increased productivity but lowered non-production workers' wage premiums in the 1990s.

<Table 7 to be Inserted Here>

Regressions (1) and (2) in Table 7 show that a 10%-point reduction in output tariffs increased the share of non-production workers by 0.4% point The magnitude is moderate; however, it suggests that part of the reduction in women's employment found in previous empirical evidence is attributed to the hiring of more non-production workers, who are mostly men.

Another key mechanism suggested by the previous literature is foreign technology embedded in imported inputs. Lower input tariffs stimulate demand for imported intermediate goods, and higher technology embedded in those imported materials lead firms to favor male production workers who, on average, possess higher skill levels.

In regressions (3) and (4), we examined whether trade liberalization affected imported material per worker and domestic material per worker, respectively. The results show that output tariffs had no impact on imported materials; however, input tariffs among importers had significant and sizable impacts. Regression (3) implies that a 10%-point reduction in input tariffs increases imported material per worker by 0.283, which is

approximately 18 the average level[8]. In regression (4), a 10%-point reduction in input tariffs decreases domestic material per worker by 0.260, implying that firms replaced domestic material with imported material. The estimation provides us supporting evidence that trade liberalization encourages firms to utilize imported materials with foreign technology, which leads them to favor more skilled production workers who are more complementary to those intermediate goods. In regression (5), we examine whether trade liberalization further facilitates the globalization of manufacturing firms. Regression (5) shows that input tariffs have a limited impact on a firm's probability of being an exporter.

5 Robustness Tests

5.1. External Validity, Minimum Wage, Ownership, and Firm Size

Indonesia is a developing country that has experienced rapid change in educational attainment, macroeconomic trends, and labor market policies. In this

[8] Among importing firms, the average level of imported material per worker throughout the sample period is 1.585. The amount of imported material is deflated by the consumer price index and in 1,000 Indonesian Rupiah.

subsection, we examine whether our estimation results remain robust when we further test our results by sub-period, controlling for regional minimum wage and other firm characteristics.

<Table 8 to be inserted here>

In regressions (1) and (2) of Table 8, we estimate the impact of trade liberalization in two periods: the 1990s and the 2000s. In regression (1), all of our previous findings remain robust; however, regression (2) shows that our findings in light industry are restricted to the 1990s. Regression (3) shows another interesting result: a 10%-point reduction in output tariffs induced a 6.4%-point increase in women's employment in heavy industry in the 2000s. At the same time, a reduction in input tariffs had a similar impact as it had in light industry in the 1990s; a 10%-point reduction in input tariff was associated with a 2.3%-point decline in women's employment share.

These results show that the impact of trade liberalization changes as the economy develops. In the 1990s, light industry was a major industry that absorbed less-skilled female workers. Import competition and imported foreign technology induced by trade liberalization hurt female workers, whose average education is far lower than that of male workers. In the 2000s, those trends continued into heavy industry, showing that imported technology hurts female workers, while increased competition favors them. The empirical

evidence suggests that there exists a race between technology and education. When female workers in an industry are on average less skilled than male workers, trade liberalization hurts female workers. Then, the negative impact moves to more technology-oriented sectors as women workers catch up with men.

In regression (3), we test whether our previous findings remain robust when we control for provincial-level minimum wage. Indonesia's provincial government set its own minimum wage, and this wage sharply increased in both the 1990s and the 2000s. On average, its nominal term tripled and its real term doubled in both decades. Rama (2001) investigated this drastic change in minimum wage[9] in Indonesia and found that it increased in exchange for a decrease in employment. Our estimation results could have been driven by such policy changes if industries that experienced a greater reduction in tariffs are geographically concentrated in provinces that implemented greater increases in the minimum wage. Regression (3) of Table 8 shows the results controlling for the real

[9] To construct the provincial-level minimum wage, we acquired data before 1997 from the appendix of Rama (2001) and data after 1997 from the Ministry of Manpower in Indonesia.

minimum wage and confirms that our previous results are not driven by such omitted variable bias.

Trade liberalization is often involved in foreign direct investment. As firms owned by foreigners tend to have different employment patterns, we restricted our sample to domestic private firms in regression (4) of Table 8. Estimated coefficients are the same in their sign and similar in their magnitude to previous ones, showing that ownership does not affect our results in any direction.

In regressions (6) and (7), we examined whether the findings from section 4 differ across firms with different sizes. We group firms into two categories: small and medium firms with fewer than fifty employees and large firms with more than 130 employees. The results demonstrate that output tariffs led only small and medium firms to reduce female employment due to increased domestic competition. On the other hand, the effects of input tariffs exist only for large firms, showing that a 10%-point reduction in input tariffs decreases women's employment by 1.5% point.

5.2. Alternative Specifications, Tariff Measures, and Non-tariff Barriers

In this subsection, we further corroborate our results by using alternative specifications and tariff measures. In regressions (1) and (2) of Table 9, we test robustness

by controlling for province-specific linear time trends and non-tariff barriers that started to arise in Indonesia in the 2000s. To cross-check our results with the baseline results in Table 4, we employed all firms in all industries during the sample period.

<Table 9 to be inserted here>

Indonesia is an archipelago country, and each island has its own ethnicity, culture, and industry composition. To control for any time-varying characteristics of each province, we added province-specific linear time trends in regression (1) of Table 9, and our previous results remain robust. In regression (2), we controlled for variables indicating whether each industry has any non-tariff barriers (NTBs) reported in the UNCTAD TRAINS database. Regression (2) of Table 9 presents that the coefficients barely change when we control for NTBs.

Thus far, we have utilized weighted output tariffs, calculated at the 4-digit industry level, and input tariffs, derived from the 172-sector IO table. Our tariff measures are not ideal compared to measures employed in Amiti and Konnings (2007), which utilize firm-level information of inputs available in a 1998 survey and main products to accurately identify tariffs that directly affect each firm.

In regression (3), we employed Amiti and Konning's tariff measure with data from 1993 to 1999 only[10]. It shows that output tariffs have no impact on firms' demand for female workers, while input tariffs adversely affect female employment with a much smaller magnitude. In regression (4), we further controlled for firm fixed effects and acquired similar results to regression (3). The difference seems mostly driven by differences in the sample period, as our tariff measures also provide such estimation results when we restrict the sample period to the 1990s.

6. Conclusions

In this paper, we examined how trade liberalization affects women's employment using Indonesia's Annual Manufacturing Survey from 1993 to 2008. Benefitting from a large data set over the long run, we examined two channels through which trade liberalization affects employment: import competition caused by a reduction in output tariffs and imported technology caused by a reduction in input tariffs.

[10] For more analyses using Amiti and Konnings' tariff measure in 1993 1995, 1997, and 1999, please refer to Oishi (2018).

We found that both output and input tariffs are associated with a reduction in the female employment share among production workers in light industry. Then, we found that the channel of output tariffs occurs through competition, where firms did not exit the market under heightened pressure. Input tariffs also increased firms' imported material, implying that advanced foreign technology embedded in imported inputs are the channel through which trade liberalization hurts female workers. Further robustness tests suggest that there exists a race between imported technology and education in Indonesia; a reduction in input tariffs disadvantaged female employees in light industry in the 1990s, and that effect can be found in heavy industry in 2000s.

We interpret the results as evidence showing that skill-biased technological bias driven by trade liberalization favors more-skilled male workers in developing countries. Advanced imported technology favors male workers because they are, on average, more complementary to new machine and intermediate goods than female workers. Additionally, it is known in the literature that Indonesia's men and women possess different skillsets. According to Newhouse and Suryadarma (2009), in 2007, 63.8% of male students in vocational school majored in technical or industrial subjects, but less than 5% of female students majored in such areas. Most female students in vocational school receive education in simple accounting and tourism.

To further investigate this, we will need firm-employee matched data with detailed information about their wages and educational attainment. We will leave this for future research agendas. Though incomplete, our findings suggest that technology intrinsically does not discriminate between male and female workers; however, technology clearly favors skilled workers.

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Tables and Figures

Table 1 Output Tariffs and Input Tariffs

Industry	Output tariffs				Input tariffs			
	1993	1998	2003	2008	1993	1998	2003	2008
Food and beverages	14.12	6.45	11.07	12.89	19.37	3.30	7.84	14.78
Textile	27.77	14.03	11.19	12.73	13.34	6.76	1.55	9.08
Wooden commodities	12.16	6.07	5.20	5.47	15.82	5.85	5.01	6.66
Paper, printing and publishing	13.78	5.81	3.76	4.11	18.90	4.21	5.44	4.61
Chemicals, petroleum, and rubber	16.19	10.46	9.33	10.24	10.36	4.41	5.39	7.31
Metal products, machinery, and transportation	20.31	10.46	8.32	8.41	19.81	5.04	4.63	7.01

The reported numbers are the average output tariffs and input tariffs within two-digit industries.

Table 2 Women's Employment Share by Industry

Industry	1993		2000		2008	
	Female employment share	Industry employment share	Female employment share	Industry employment share	Female employment share	Industry employment share
Food and beverages	0.493	0.228	0.520	0.212	0.526	0.263
Textile	0.645	0.320	0.661	0.327	0.684	0.269
Wooden commodities	0.388	0.124	0.359	0.099	0.359	0.060
Paper and publishing	0.249	0.040	0.249	0.042	0.243	0.046
Chemicals, petroleum, and rubber	0.419	0.105	0.382	0.106	0.395	0.116
Metal products machinery, and transportation	0.262	0.163	0.355	0.193	0.314	0.216

Table 3 Summary Statistics: Annual Survey of Manufacturers

Variables	1993	2000	2008
Relative wage bill of non-production workers	0.245 (0.202)	0.205 (0.198)	0.195 (0.193)
Share of non-production workers (%)	15.75 (15.43)	14.30 (15.57)	15.54 (16.09)
Number of workers	247.13 (734.54)	205.84 (730.36)	177.98 (701.23)
Real value added per worker (in 1,000 Rp)	0.853 (7.375)	0.898 (7.128)	1.010 (15.676)
Real fixed capital per worker (in 1,000 Rp)	2.124 (38.17)	1.643 (72.65)	0.900 (24.15)
Real output per worker (in 1,000 Rp)	0.002 (0.014)	0.002 (0.014)	0.003 (0.032)
Domestic material per worker (in 1,000 Rp)	1.069 (6.802)	0.901 (4.577)	1.274 (8.611)
Imported material per worker	0.303 (1.723)	0.347 (4.386)	0.340 (12.428)
Share of importing firms (%)	19.05	15.17	13.60
Share of exporting firms (%)	19.88	17.62	17.61
Observations	10,460	19,203	22,531

Note: The reported numbers are means. Standard deviations are in parentheses.

Table 4. Trade Liberalization and Female Employment

	(1)	(2)	(3)	(4)	(5) Non-weighted tariff
Output tariff	0.008**	0.009**	0.008**	0.008**	-0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
Input tariff	0.009	0.009	0.009	0.009	0.010**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Input tariff × Importer indicator	0.036**	0.036**	0.035**	0.035**	0.023**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.009)
Importer	0.017	0.017	0.011	0.011	0.008
	(0.018)	(0.018)	(0.016)	(0.016)	(0.017)
Exporter	0.059***	0.059***	0.054***	0.054***	0.054***
	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)
Herfindahl index less than 0.25		-0.008	-0.008	-0.008	-0.004
		(0.013)	(0.013)	(0.013)	(0.013)
Number of workers			0.000**	0.000**	0.000**
			(0.000)	(0.000)	(0.000)
Real fixed capital			-0.000	-0.000	-0.000
			(0.000)	(0.000)	(0.000)
Real value added			0.001	0.001	0.001
			(0.000)	(0.000)	(0.000)
Real output			-0.671**	-0.671**	-0.671**
			(0.303)	(0.303)	(0.304)
Crisis period indicator				controlled	controlled
Observations	208,878	208,878	208,444	208,444	208,444
R-squared	0.333	0.333	0.335	0.335	0.335

Note: The sample period is from 1993 to 2009, excluding 1997 due to the reliability of the tariff data. All tariff measures are deflated by 10; thus, the estimated coefficients represent the impact of a 10% change in tariffs. Real fixed capital, real value added, and real output are per worker, deflated by 1,000 Rp. All regressions include 4-digit industry fixed effects, year fixed effects, and province fixed effects. Standard errors are clustered within four-digit industries. *** p<0.01, ** p<0.05, * p<0.1

Table 5. The Impact of Trade Liberalization by Type of Worker and Industry

	(1) Non-production worker	(2) Production worker	(3) Light industry	(4) Heavy industry	(5) Capital intensive	(6) Labor intensive
Output tariff	0.005**	0.007*	0.010***	-0.018***	0.006*	0.001
	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)	(0.006)
Input tariff	0.004	0.008	0.007*	0.004	0.008**	0.008*
	(0.003)	(0.005)	(0.003)	(0.012)	(0.003)	(0.004)
Input tariff × Importer indicator	0.000	0.020*	0.021**	-0.002	0.011	0.036***
	(0.005)	(0.011)	(0.010)	(0.005)	(0.009)	(0.013)
Importer	-0.001	0.010	0.042	-0.021**	-0.000	0.017
	(0.006)	(0.017)	(0.026)	(0.009)	(0.013)	(0.023)
Exporter	0.006	0.062***	0.057**	0.052*	0.061***	0.058***
	(0.009)	(0.017)	(0.022)	(0.027)	(0.015)	(0.019)
Observations	176,081	208,406	150,167	58,277	103,976	104,467
R-squared	0.070	0.339	0.285	0.244	0.325	0.310

Note: See the note for Table 4. Light industry includes food and beverages, textiles, wooden commodities, paper and printing, furniture and recycling. Heavy industry includes chemicals, petroleum and rubber, metal products, machinery, and transportation. Capital-intensive firms (labor-intensive firms) are defined as firms where real fixed capital per worker deflated by 1,000 is greater than 0.1 (less than 0.1). All regressions control for competitiveness (Herfindahl index), the number of workers, per capita level of real fixed capital, real value added, and real output.

Table 6. The Mechanisms: Industry-level Competition, Firm Exit, and Recession in Light Industry

Potential Mechanism	(1) Competition	(2) firm exit in industry	(3) employment decline in industry	(4) output decline in industry	(5) value added decline in industry
Output tariff	-0.003	0.013***	0.012***	0.013***	0.013***
	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
Output tariff × HH	0.015**				
	(0.006)				
Output tariff × recession variable		-0.011*	-0.004	-0.004	-0.004
		(0.005)	(0.005)	(0.003)	(0.003)
Input tariff	0.007**	0.007*	0.006*	0.007*	0.007*
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Input tariff × Importer indicator	0.022**	0.022**	0.022**	0.022**	0.022**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	150,167	150,167	150,167	150,167	150,167
R-squared	0.302	0.302	0.302	0.302	0.302

Note: The sample is restricted to firms in light industry. See the note for Table 5 regarding the definition of light industry. HH indicates that the Herfindahl index is lower than 0.25. All regressions include 4-digit industry fixed effects, year fixed effects, and province fixed effects. All regressions control for the number of workers, per capita level of real fixed capital, real value added, real output, and each industry-level recession (or competition) variable. Standard errors are clustered within four-digit industries. *** p<0.01, ** p<0.05, * p<0.1

Table 7. The Mechanisms: Skill upgrading, Imported goods, and Exports

Dependent variables	(1) non-production worker	(2) non-production workers' wage bill	(3) imported material/worker	(4) domestic material/worker	(5) exporter
Output tariff	-0.004***	-0.004**	0.008	-0.000	0.002
	(0.002)	(0.002)	(0.007)	(0.011)	(0.009)
Input tariff	-0.000	0.000	0.023**	-0.027**	-0.001
	(0.001)	(0.002)	(0.010)	(0.012)	(0.004)
Input tariff × Importer indicator	0.001	0.006*	-0.248**	0.256**	0.008
	(0.002)	(0.003)	(0.094)	(0.095)	(0.014)
Importer	0.010	0.038***	1.137***	-1.240***	0.193***
	(0.008)	(0.013)	(0.262)	(0.283)	(0.025)
Exporter	0.016***	0.047***	-0.016	-0.025	
	(0.004)	(0.006)	(0.038)	(0.033)	
Observations	150,167	150,142	150,151	150,151	150,167
R-squared	0.142	0.148	0.220	0.953	0.205

Note: See the note for Table 6.

Table 8. Robustness Test: Pre-/Post-2003, Minimum Wage, Ownership, and Firm Size

	(1) Light industry 1990s	(2) Light industry 2000s	(3) Heavy industry 2000s	(4) minimum wage	(5) domestic private firms only	(6) small and medium firms: E<50	(7) large firms: E>130
Output tariff	0.005**	0.009	-0.064***	0.008**	0.007*	0.008*	-0.003
	(0.002)	(0.014)	(0.017)	(0.004)	(0.004)	(0.004)	(0.005)
Input tariff	0.010*	0.004	-0.015**	0.008*	0.009**	0.010	0.002
	(0.006)	(0.003)	(0.006)	(0.004)	(0.004)	(0.006)	(0.003)
Input tariff ×	0.045***	0.008	0.023**	0.019*	0.015*	0.004	0.015*
Importer indicator	(0.013)	(0.014)	(0.011)	(0.011)	(0.009)	(0.008)	(0.009)
Minimum wage				0.002	0.003		
				(0.005)	(0.006)		
Importer	0.021	0.052*	-0.029*	0.013	0.013	0.019	-0.008
	(0.020)	(0.026)	(0.014)	(0.016)	(0.017)	(0.027)	(0.012)
Exporter	0.072***	0.053**	0.044*	0.054***	0.057***	0.034***	0.019
	(0.019)	(0.022)	(0.025)	(0.016)	(0.014)	(0.012)	(0.012)
Observations	61,069	101,379	37,822	208,323	178,833	113,092	49,426
R-squared	0.302	0.307	0.289	0.335	0.324	0.313	0.522

See the note for Table 6. Minimum wage is province-level minimum wage deflated by the consumer price index. In regressions (4)-(7), we use firms in both light and heavy industry during the whole sample period.

Table 9. Robustness Test: Alternative Specifications and Tariff Measure

	Female employment share			
	(1)	(2)	(3)	(4)
			Tariff measure by Amiti and Konning	
Specification	province-specific linear trends	non-tariff barriers	1990s	firm fixed effects
Output tariff	0.007**	0.007**	-0.001	-0.002**
	(0.003)	(0.003)	(0.003)	(0.001)
Non-tariff barrier		0.007		
		(0.005)		
Input tariff	0.007	0.008*	-0.002	0.004*
	(0.004)	(0.005)	(0.007)	(0.002)
Input tariff × Importer indicator	0.016*	0.017*	0.094***	0.011***
	(0.009)	(0.009)	(0.018)	(0.004)
Importer	0.002	0.003	-0.073***	-0.012**
	(0.016)	(0.016)	(0.016)	(0.005)
Exporter	0.037**	0.037**	0.056***	0.005***
	(0.016)	(0.016)	(0.014)	(0.002)
Observations	195,591	195,591	80,795	76,167
R-squared	0.341	0.340	0.468	0.925

Note: See the note for Table 6 regarding controls in regressions (1), (2), and (3). Regressions (3) and (4) employed tariff rates as calculated by Amiti and Konnings (2007). Regression (4) further controlled for wage bills paid to production workers and non-production workers. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Construction of Tariff Measures

Output Tariff

We employed tariff data collected by the UNCTAD Trade Analysis Information System (TRAINS). TRAINS provides detailed tariff rates for the 9-digit HS code during our sample period. We excluded 1997 tariff data since we found some flaws in the raw data. We used only MFN tariff rates, which countries promise to impose on imports from other WTO members unless the country is part of other preferential trade agreements, such as in free trade areas or customs unions. If additional value-added tax and advance income tax were reported for an item, we calculated the sum of all tariff and tax rates.

Weighted output tariff used in most analyses

We calculated a simple average of tariffs within the 6-digit HS code, which is then matched to the volume of imports from US Comtrade to calculate weighted output tariffs within the 4-digit ISIC code. The weighted tariffs serve as our main output tariffs measure for analyses. The ISIC code from firm data is made by BPS based on ISIC rev.3 but is not entirely identical to it. Due to a lack of proper concordance between two codes, we could match only 77% of firms to output tariffs. Non-weighted output tariffs were also calculated to check the robustness.

Amiti and Konning's output tariff measure

Amiti and Konnings constructed a five-digit output tariff measure by taking a simple average of the HS 9-digit codes within each 5-digit industry code. They utilized unpublished concordance between the HS 9-digit classification and the 5-digit ISIC from the firm-level data.

Input Tariff

We employed three waves of IO tables in 1995, 2000, and 2005 provided by BPS (Statistics Indonesia) to calculate input tariffs. We created concordance between sector codes in IO tables and 4-digit ISIC codes. Using concordance, we created IO tables within 4-digit ISIC codes

calculated at buyer's prices. We used total inputs rather than imported inputs, as tariff rates can change the cost of domestic inputs, as well.

Then, we matched tariff rates in 1990-1997 to the IO table in 1995, tariff rates in 1998-2003 to the IO table in 2000, and tariff rates in 2004-2009 to the IO table in 2005. We excluded inputs from the public sector or domestic sector where there are no valid tariff rates. Then, we calculated the input tariff within the 4-digit ISIC code weighted by input shares. Various concordances between HS codes and ISIC codes were utilized, which might reduce the accuracy of input tariffs and output tariffs.

The main input tariff measure was constructed using a weighted output tariff. We also constructed another input tariff based on alternative output tariff and non-weighted output tariff.

We also checked the robustness of our results using Amiti and Konning's input tariff measure. The input tariff here is a weighted average of output tariffs, where the weights are the cost share of each industry producing each good. The cost share is derived based on detailed input information only provided in firm-level data in 1998.