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Trading discrimination: an unexpected side effect of intra-industry trade on the gender wage gap

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Abstract

This paper develops a novel intra-industry trade model to illustrate what happens to the gender wage gap when two otherwise identical countries, that differ in the intensity of their labor market gender discrimination, trade. In this model, trade liberalization increases average firm productivity more for the discriminatory country, causing the gender wage gap to widen as men's wages rise disproportionately. Conversely, the gender wage gap decreases for the less-discriminatory country. Cross-sectional analysis for the OECD gives suggestive results in favor of the model. Contrasting results are found, however, when employing a difference-in-differences methodology to estimate the effects of KORUS FTA on the wage gap in several US industries.

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Chapter 1

Introduction

Recent decades have seen a remarkable convergence between male and female wages. However, progress has been achingly slow; at its current speed, gender parity is expected to be achieved in the year 2154 (World Economic Forum, 2023, p. 15). It is of clear political and societal importance to speed up this process. Nonetheless, the exact mechanisms behind this slow wage convergence remain poorly understood. Most of the preceding literature has focused on a variety of micro level explanations, such as discrimination and gender roles. However, in an increasingly globalized world, it is likely that some variables affecting the wage gap may originate from outside of country borders. In this light, this paper analyzes the effect of international trade on the gender wage gap. Specifically, it analyzes what happens to the gender wage gap when a more discriminatory country conducts intra-industry trade with a less discriminatory one.

The theoretical literature on the effect of international trade on the gender wage gap is seemingly consensual: trade liberalization should unambiguously narrow the gender wage gap. Usually, three main arguments are given. First, since discrimination is inefficient (Becker, 1972), increased competition from abroad will push out discriminatory firms in favor of less-discriminatory ones. Second, international trade may induce firms to upgrade their technology in a way that favors women, thus increasing women's relative returns and narrowing the wage gap (Juhn et al., 2012). Third, Heckscher-Ohlin theory predicts a narrowing effect of trade liberalization if export sectors are relatively female labor-intensive (which they are in developed countries). As the export sector expands, Stolper-Samuelson logic requires that the real relative returns of female labor rise correspondingly, thus narrowing the wage gap.

Empirically, however, the effect of trade liberalization on gender wage disparities is unclear. This highlights two things: 1. that the simple theories highlighted above are insufficient to explain current trade and wage gap patterns, and 2. that more empirical work is necessary to understand this relationship. This paper aims to contribute (modestly) to both of these two points by conducting new empirical analysis and by constructing a new intra-industry trade model that accounts for the effects of trade on gender discrimination. In essence, this paper combines Melitz (2003) with Becker (1972). It investigates a previously unexplored side effect of globalization: *what happens to the gender wage gap when two otherwise identical countries, that differ in the intensity of their labor market gender discrimination, trade?*

This study is one of the few that explicitly link productivity gains from intra-industry trade with labor market discrimination. This relationship may seem surprising, since classic Melitz (2003) theory does not have any direct implications for relative wages. Thus, this paper deviates from Meltiz (2003) in two major ways. It assumes 1. that there are two types of labor, male and female, and 2. that there are two types of firms: discriminatory and non-discriminatory ones. All firms employ more men than women. However, discriminatory firms are less productive on average and prefer to employ men in larger proportions than non-discriminatory firms. Countries are identical and only differ in their firm-type: foreign firms are discriminatory, while home firms are not. In this setting, trade liberalization leads to a larger decline in the number of foreign firms than domestic firms. Consequently, the productivity gains from intra-industry trade are larger for the foreign country. As a result, the home country partly loses its 'discrimination-induced' technological advantage and, similarly to Heckscher-Ohlin, this is reflected by a decrease in men's real relative wages. Conversely, the foreign country's relative productivity increase is reflected in a wage increase for both men and women, but this rise is stronger for men.

The second part of this paper tests the theoretical model's predictions using real world data. First, using regressions, it is shown that OECD countries with intense gender discrimination exhibit a positive relationship between intra-industry trade and the gender wage gap, while those countries with less intense discrimination exhibit a (less strong) negative relationship. This result is almost entirely driven by labor market discrimination. Thus, these (suggestive) findings are supportive of the theoretical model. Second, a difference-in-differences approach is used to estimate the effects of the 2012 FTA between the United States and South-Korea (KORUS) on the gender wage gap in US manufacturing industries that exhibit intensive intra-industry trade. Based on discrimination data and this paper's predictions, the gender wage gap should narrow in the US. However, a positive widening effect of KORUS is found, which is driven by a stronger rise in men's absolute wages. Taken together, there is weak support that the predictions of the model generally hold, but that its reliability remains context-dependent.

The paper is structured as follows. Section 2 provides a literature review that functions as the foundation of the theoretical model. Section 3 builds the theoretical model from scratch. Then, Section 4 justifies data usage and discusses this paper's empirical methodology. Consequently, Section 5 will analyze and interpret the results. Final remarks are made in Section 6.

Chapter 2

Literature review

Generally, international trade can be decomposed into a 'Heckscher-Ohlin' and an 'intra-industry trade' component. Hence, before constructing the formal model in section 3, which utilizes both types of trade, this section provides a foundational overview of the related academic research.

2.1 Heckscher-Ohlin trade

The first theoretical underpinning for the effect of international trade on gender labor market inequalities comes from directly applying Heckscher-Ohlin (H-O) trade theory. In short, the H-O theorem predicts that two heterogeneous countries that differ in their relative production factor endowments export the product that uses that country's relatively abundant production factor most intensively. That is, a country exports the product in which they have a comparative advantage. From the perspective of the home country, trade liberalization will increase the relative price of the export good, leading to an expansion of the export sector and an increase in the relative returns to the relatively abundant production factor. Conversely, trade liberalization will push down the relative price of the import good, causing the import-competing sector to shrink and the relative returns to the production factor used intensively in this sector to decline. Assuming male and female labor are different factors of production, trade will thus narrow the gender wage gap if the export sector is relatively female labor intensive.

The assumption that male and female labor are distinct factors of production is supported by the data. For instance, Acemoglu et al. (2004) use exogenous state-level variation in World War II mobilization rates to assess the different effects of female labor force participation on male and female postwar wages. They find that a 10% increase in relative midcentury female labor supply decreased relative female/male wages by 3-4%, implying imperfect substitution between both genders (their estimates of the elasticity of substitution range between 3.4 and 4.2). Furthermore, Sauré and Zoabi (2014) argue that female labor exhibits a relatively higher degree of complementary with capital as compared to male labor. This is, inter alia, because women are often assumed to have a comparative advantage in 'brain'-intensive tasks as opposed to 'brawn'-intensive work. This is also illustrated by Rendall (2017), who argues that increased returns to skill and 'brain'-biased technical change and in the US can help explain over half of the narrowing gender wage and employment gap since the 1960s.

Women's synergy with capital and 'brain'-intensive tasks is a non-trivial assumption. For developed countries, whose exports are relatively skilled-labor and capital intensive, it is then straightforward to predict that international trade will expand those sectors that employ relatively many women, thus narrowing the gender pay gap. Indeed, a narrowing effect of trade on the gender wage gap is exactly what some studies find. Notably, Besedeš et al. (2021) find that US trade liberalization with China decreased the gender wage gap by pushing out low-skilled male workers in male-intensive manufacturing industries and inducing higher-skilled women to enter the labor force - partly to compensate their male partner's loss of income. Similarly, Brussevich (2018) finds that increased US trade narrowed the gender wage gap by negatively impacting male-intensive import-competing sectors. This result is a consequence of male labor's limited sector mobility, which partly prevents migration to the expanding export industries.

It is important to note, however, that there is no empirical consensus with regard to the relationship between H-O dynamics and gender labor market inequalities. In direct contrast to the previous papers, Sauré and Zoabi (2014) show that trade liberalization is likely to increase the gender wage gap as it induces men in negatively affected import-competing sectors to migrate to women- and capital-intensive export sectors. Given women's synergy with capital, this influx of male workers increases the gender wage gap by decreasing women's marginal productivity more than that of their male colleagues.

The inconclusiveness of the preceding empirical research may reflect that the effect of trade on gender labor market disparities is highly context dependent. As this paper will argue, one possible confounding variable in this relationship is a country's share of intra-industry trade and the intensity of its gender discrimination. Nonetheless, it is empirically difficult to isolate intra-industry and Heckscher-Ohlin trade.

2.2 Intra-industry trade

Melitz's (2003) intra-industry trade framework provides the second theoretical foundation for the relationship between international trade and gender labor market inequalities. Building on Krugman (1980), Melitz (2003) deviates from classic Heckscher-Ohlin trade models by assuming that the home and foreign countries are identical in their relative productivity and factor endowments. Furthermore, there is assumed to be only one sector in which each firm produces its own distinct variety of a good. In this model, trade between these countries is driven by consumers' 'love of variety' preferences combined with increasing returns to scale (rather than driven by differences in relative factor endowments). International trade occurs because firms settle in one country to maximize economies of scale. Meanwhile, consumers aim to increase their utility by importing (new) foreign varieties - thus prompting intra-industry trade. Melitz (2004) extends Krugman (1980) by additionally assuming that firms differ in their randomly drawn productivity. In his model, trade liberalization increases expected profits of market entry through firms' possibility of higher export profits. Consequently, this induces new market entry, pushing out any incumbent firms that are relatively less productive. As a result, aggregate country productivity rises.

Melitz (2003) uses only one type of labor. Hence, this original model does not say anything about the effects of intra-industry trade on wage inequalities. However, the result that intra-industry trade increases firm productivity can easily be linked to the gender wage gap in the following two ways. The aim of the formal model in Section 3 is to extend the Melitz (2003) framework by incorporating one of these channels - gender discrimination - into the model.

2.2.1 Labor market discrimination

The link between firm productivity and gender labor market inequalities has already been documented by the seminal work of Becker (1972). In his model, Becker argues that increases in firm competition may discourage 'costly' discrimination by either pushing discriminatory firms out of business or by prompting them to hire relatively more (cheaper) women. Discrimination is deemed 'costly' as employers of discriminatory firms are willing to pay a wage premium to hire men in favor of (similarly productive) women to indulge in their discriminatory preferences. Trade will thus discourage discrimination if it induces the entry of firms that are less discriminatory and, as a result, more productive.

This theory has found broad empirical support. Notably, Black and Brainerd (2004) explicitly test Becker's hypothesis and find that international trade decreased US firms' ability to discriminate in concentrated industries, thus narrowing the gender wage gap. This anti-discriminatory effect of trade is likely to be strongest in industries that enjoy little ex ante competitive pressures. Similar results found by Artecona and Cunningham (2002) and Ederington et al. (2009) for South America imply that these results extend to developing countries as well.

An interesting situation arises when a more discriminatory country opens up to trade with a less discriminatory one. Such a situation is, however, largely ignored by the economic literature. One notable exception is Chisik and Emami Namini (2019), whose theoretical model illustrates that relative differences in the intensity of countries' labor market discrimination may affect international trade flows if a technological comparative advantage is overshadowed by discrimination-induced country productivity differences. In their model, trade liberalization decreases the wage gap in the more-discriminatory country, while expanding it in the less-discriminatory country. This is a result from H-O dynamics: since discriminatory countries have a discrimination-induced comparative disadvantage in sectors that are prone to discrimination, trade will expand 'non-discriminatory' sectors. Conversely, less-discriminatory countries will expand those sectors that are more susceptible to discrimination. Hence, the wage share of male workers will decline in the more-discriminatory country and increase in the less-discriminatory one. This theory is closely related to this paper's theoretical model. However, where Chisik and Emami Namini (2019) focus on a two-sector model, the present study looks at the effects of one-sector intra-industry trade. As will be seen, when two countries with differing discriminatory intensities conduct intra-industry trade (rather than H-O trade), the results will be opposite of those proposed in the former. This discrepancy also reinforces the previously made point that the effects of trade on the gender wage gap are highly context-dependent.

2.2.2 Technological upgrading

Secondly, intra-industry trade may narrow the gender wage gap if it prompts firms to invest in technologies that benefit women disproportionately. The effect of trade on firm productivity and technological investment has been extensively discussed within the trade literature. For instance, Bustos (2011) builds on Melitz (2003) to show that revenue increases following MERCOSUR led to technology upgrading by both incumbent and newly exporting Argentinean firms. This trade-induced technological upgrading can be expected to narrow the gender wage gap if it benefits women disproportionately. This is found by, inter alia, Juhn et al. (2012), who subsequently extend Bustos (2011) by showing that the reduction in tariffs following NAFTA induced newly exporting firms to invest in computerization that lowered the need of 'brawn'-intensive skills, replacing male blue-collar workers with female peers and decreasing the gender wage gap.

The way in which trade may benefit women through technical change is key in understanding the full effects of trade. However, the theoretical model in Section 3 does not include the possibility of technological upgrading, as this falls beyond the scope of this thesis. Nonetheless, it is important to be aware of the potential role of technological change, since it may counteract some of the propositions made by this paper's model. For instance, the theoretical model's result that intra-industry trade has a widening impact on the gender wage gap in more-discriminatory countries may be partly mitigated if is accompanied by technological change that favors women.

Chapter 3

Theoretical model

This section combines Becker (1972) and Melitz (2003) into a formal model. As a starting point, (Bernard et al., 2007) is used. Their model is a convenient benchmark as it combines intra-industry trade with classic Heckscher-Ohlin trade. Hence, this model readily includes the necessary tools to investigate trade-induced relative wage effects. The goal of this model is to illustrate how the gender wage gap widens (narrows) when a relatively more (less) discriminatory country conducts intra-industry trade with a relatively less (more) discriminatory one.

This study deviates from Bernard et al. (2007) in two major ways. First, the model assumes that there is only one sector - thus bringing the model partly back to the setting by Meltiz (2003). Second, there are now two types of firms: those that are discriminatory (d), and those that are non-discriminatory (nd). Discriminatory firms are assumed to draw their productivity from a less favorable productivity distribution; reflecting the notion of 'costly' discrimination. Important derivations of the model can be found in appendix A.

3.1 Demand

There are two countries: Home and Foreign. Consumers in both countries are characterized by Dixit-Stiglitz preferences. That is, their utility increases with the amount of varieties (indexed by $\omega \in \Omega_{\{nd,d\}}$) that they consume ($q(\omega)$). Consumers do not care about whether a variety is produced by a discriminatory firm (d) or a non-discriminatory one (nd). Thus, the utility U of a representative consumer equals the simple sum of utilities obtained from both types of firms:

$$U = \left[\int_{\omega \in \Omega_{nd}} q(\omega)^{\rho} d\omega + \int_{\omega \in \Omega_{d}} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}, \tag{1}$$

where $0 < \rho < 1$ is a preference parameter. The constant elasticity of substitution between varieties ($\sigma = \frac{1}{1-\rho}$) rises with ρ. The price per unit of utility (or price index) is then given by:

$$P = \left[\int_{\omega \in \Omega_{nd}} p(\omega)^{1-\sigma} d\omega + \int_{\omega \in \Omega_{d}} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{2}$$

where $p(\omega)$ is a firm's profit-maximizing price. Solving for a single variety ω's optimal consumption gives the aggregate demand and revenues for any variety, with aggregate income $I \equiv P \cdot U$:

$$q(\omega) = UP^{\sigma} p(\omega)^{-\sigma} \tag{3}$$

$$r(\omega) = I \left(\frac{p(\omega)}{P} \right)^{1-\sigma} \tag{4}$$

3.2 Production

Identically to Bernard et al. (2007), the goods market is occupied by a continuum of firms (now indexed by ϕ) that each produce idiosyncratic varieties within the same sector. There are two types of firm labor inputs: female labor l_f and male labor l_m. Note that a country n's total gender labor endowments are assumed to be equal ($L_f^n = L_m^n$). Both discriminatory and non-discriminatory firms are subject to the same production function but draw their productivity parameters (ϕ) from a different distribution $\mu_{\{nd,d\}}(\phi)$.[1] The Cobb-Douglas production functions for non-discriminatory and discriminatory firms have the following structure, respectively:

$$q_{nd}(\phi) = \phi_{nd} \cdot l_m^{\beta_{nd}} l_f^{1-\beta_{nd}} \cdot A \quad \text{and} \quad q_d(\phi) = \phi_d \cdot l_m^{\beta_d} l_f^{1-\beta_d} \cdot A \quad , \tag{5}$$

where $A > 0$ is a constant [2], $0 < \beta_{nd} \leq \beta_d < 1$, and $E[\phi_{nd}] > E[\phi_d]$. Here, $\beta_d > \beta_{nd} > 0.5$ is another key assumption driving the results of this model. All firms prefer to hire men. However, on top of drawing their productivity from less favorable productivity distribution, discriminatory firms are assumed to hire women in lesser proportions than non-discriminatory firms. Without this assumption, there would be no gender wage gap. Instead, both genders' wages would be proportionately lower compared to the situation without (less productive) discriminatory firms.

Fixed production costs f_c and per period fixed market entry costs f_e are assumed to be homogeneous across firms and are produced using the same labor inputs as variable costs. Thus, a given firm j of firm type i's cost function Γ_{ij} equals total labor inputs times marginal cost:

$$\Gamma_{ij} = \left(f_c + f_e + \frac{q_{ij}(\phi_{ij})}{\phi_{ij}} \right) \cdot w_m^{\beta_i} w_f^{1-\beta_i} \tag{6}$$

where w_m and w_f are male and female wages, respectively. As consumers do not distinguish between firm type and all firms are subject to the same cost structure, the profit-maximizing price ($p_{ij}(\phi_{ij})$) for any given firm j equals a constant markup $\frac{1}{\rho}$ above marginal cost. Consequently, firms have identically structured profit functions (π_{ij}):

$$p_{ij}(\phi_{ij}) = \frac{1}{\rho} \frac{w_m^{\beta_i} w_f^{1-\beta_i}}{\phi_{ij}} \tag{7}$$

$$\pi_{ij}(\phi_{ij}) = \frac{r_{ij}(\phi_{ij})}{\sigma} - f_c w_m^{\beta_i} w_f^{1-\beta_i} \tag{8}$$

[1] It can be easily illustrated that discriminatory tastes (as described in, e.g., Becker (1972)) translate into different productivity distributions. For illustration purposes, assume a production function $q_d(\phi) = \phi \cdot l_m^{\beta} \frac{l_f}{d}^{1-\beta}$, where $d > 0$ is a measure of discrimination. Rewriting then gives: $q_d(\phi) = \frac{\phi}{d^{1-\beta}} \cdot l_m^{\beta} l_f^{1-\beta} \equiv \phi_d \cdot l_m^{\beta} l_f^{1-\beta}$.

[2] $A = [\beta_i^{\beta_i}(1-\beta_i)^{1-\beta_i}]^{-1}$, and its sole purpose is for mathematical convenience when solving for factor inputs.

3.3 Firm entry in autarky

In equilibrium, only firms survive that earn positive (or zero) per period profits. Given that all firms' cost and revenue functions have the same structure, there is a country-wide threshold productivity ϕ^* from which market entry is successful. Mathematically, this threshold productivity parameter can be derived from the country-specific zero cutoff profit condition:

$$\pi_i(\phi^*) = \frac{r_i(\phi^*)}{\sigma} - f_c w_m^{\beta_i} w_f^{1-\beta_i} \geq 0 \qquad \leftrightarrow \qquad r_i(\phi^*) \geq \sigma f_c w_m^{\beta_i} w_f^{1-\beta_i} \tag{9}$$

Given this threshold, firms enter the market only when they expect to earn positive (or zero) profits. Firms know whether they are discriminatory or not. Hence, non-discriminatory and discriminatory firms' free market entry conditions take on the following form, respectively:

$$\begin{aligned} [1 - G_{nd}(\phi^*_{nd})]\pi(\tilde{\phi}_{nd}) &\geq \delta f_e w_m^{\beta_i} w_f^{1-\beta_i} \\ [1 - G_d(\phi^*_d)]\pi(\tilde{\phi}_d) &\geq \delta f_e w_m^{\beta_i} w_f^{1-\beta_i} \quad , \end{aligned} \tag{10}$$

where $1-G(\phi^*)$ is the probability of drawing a productivity parameter that exceeds the threshold given the cumulative distribution function $G(\phi)$. $\pi(\tilde{\phi})$ is the per period profits of the average firm $E[\phi] \equiv \tilde{\phi}$. δ is the per period firm death probability and f_e is the fixed entry labor cost.[3]

When assuming $\beta_{nd} = \beta_d$ and homogeneous productivity distributions, the implications of this model are identical to those of Melitz (2003) and Bernard et al. (2007). However, deviating from these assumptions has two contrasting consequences for a country's mass of firms in autarky. First, assuming $\beta_{nd} > \beta_d$ will lead to a lower mass of firms in the discriminatory country. This is because discriminatory firms demand a higher input share of male labor even though the total country endowments of male and female labor remain fixed (and equal). Consequently, discriminatory firms will take up a disproportionately large share of male labor. This drives up the relative price of male labor and prevents optimal labor allocation for other firms. Second, if discriminatory firms are less likely to be productive (that is, their productivity distribution is less favorable), the autarky mass of firms will be higher than in the situation without discrimination. This is the result of relatively little competitive pressure: fewer productive firms will be reflected in a lower productivity threshold ϕ^* and thus lower firm market exit. Which of these two effects dominates depends on their relatively strengths and is thus an empirical question. In either case, it can be shown that a higher share of discriminatory firms lowers the productivity threshold ϕ^* and thus leads to a lower average productivity $\tilde{\phi}$.

Proposition 1: *In autarky, discriminatory countries will have a lower threshold productivity parameter, implying a lower level of aggregate country productivity.* (proof)

[3]For more elaboration on firm entry and death probability, see Bernard et al. (2007, p. 38)

This is an important result because it suggests that opening up to trade will affect the mass of firms in the relatively more discriminatory country more than in the less discriminatory country. This, in turn, implies that the productivity gains resulting from intra-industry trade may be larger for the more discriminatory country. Furthermore, as with Chisik and Emami Namini (2019), this lower aggregate productivity also implies that discrimination can have negative effects on a country's long term growth.

3.4 Open economy equilibrium

For simplicity, this paper assumes that all firms in Home are non-discriminatory while all Foreign firms are discriminatory. In practice, this is comparable to a situation wherein a more culturally progressive country trades with one that is relatively more conservative.

Identically to Bernard et al. (2007), exporting firms pay per period fixed export costs f_X incurred on top of domestic market fixed costs f_c in equation 6. Furthermore, international trade is assumed to be costly: firms pay exogenous iceberg cost $\tau > 1$ per exported unit. That is, of $\tau \cdot q_{ij,X}(\phi_i)$ units exported, only $q_{ij,X}(\phi_{ij})$ units arrive abroad. Rewriting equation (7) gives country n firms' profit-maximizing export prices, accounting for these variable export costs:

$$p^n_{ij,X}(\phi_{ij}) = \frac{\tau}{\rho} \cdot \frac{(w^n_m)^{\beta_i}(w^n_f)^{1-\beta_i}}{\phi_{ij}} \tag{11}$$

If $f_X > f_c$, not every firm exports. This is because marginal export revenues decrease with τ; the slope of the export revenue curve is flatter than that of domestic sales. Thus, a firm will only export if it is productive enough to be able to cover fixed export costs despite these lower marginal revenues. Similar to equation (9), firms will only export if their productivity exceeds the threshold export productivity parameter $\phi_i \geq \phi^*_X > \phi^*$:

$$r^n_{i,X}(\phi^{*n}_X) \geq \sigma f_X (w^n_m)^{\beta_i}(w^n_f)^{1-\beta_i} \tag{12}$$

Trade liberalization changes firms' market entry decision. Opening up to trade increases expected profits from market entry as firms now have the added probability of becoming an exporter. Hence, the free entry conditions from equation (10) become:

$$\begin{aligned} [1 - G_{nd}(\phi^*_{nd})]\pi(\tilde{\phi}_{nd}) + [1 - G_{nd}(\phi^*_{nd,X})]\pi(\tilde{\phi}_{nd,X}) \geq \delta f_e w_m^{\beta_i} w_f^{1-\beta_i} \\ [1 - G_d(\phi^*_d)]\pi(\tilde{\phi}_d) + [1 - G_d(\phi^*_{d,X})]\pi(\tilde{\phi}_{d,X}) \geq \delta f_e w_m^{\beta_i} w_f^{1-\beta_i} \quad , \end{aligned} \tag{13}$$

where the second term on the left-hand side reflects the positive profit probability arising from trade liberalization. In equilibrium, equation (13) will hold as an equality. Thus, the addition of this positive export term in the firms' entry decision needs to be compensated by a higher threshold productivity parameter ϕ^* - and thus a lower $1 - G_{nd}(\phi^*_{nd})$ - to stay in equilibrium.

In other words, the classic Melitz (2003) result that intra-industry trade increases average firm productivity holds for both discriminatory and non-discriminatory firms.

This model differs from Melitz (2003), however, in the way that aggregate productivity in the discriminatory country and non-discriminatory country are impacted heterogeneously by trade. This follows from proposition 1. For Foreign, whose average firm productivity is lower, international trade will have a larger negative impact on the mass of firms. This intuitive result captures the notion of costly discrimination: if discriminatory firms are less productive, increased competition from abroad will push out discriminatory firms more than non-discriminatory ones.

Proposition 2: *Trade liberalization decreases the mass of firms more in the discriminatory country than in the non-discriminatory country.* (proof)

This result is key, since it also directly implies that the productivity gains from intra-industry trade are larger for Foreign than for (less-discriminatory) Home. This is a simple consequence of the fact trade liberalization pushes out more unproductive firms in Foreign than in Home. As such, Foreign becomes relatively more productive. Phrased differently, trade liberalization weakens Home's 'discrimination-induced' technological advantage over Foreign.

Proposition 3: *Trade liberalization increases average firm productivity more in the country that is more discriminatory.* (proof)

This latter proposition also implies that, from the perspective of the Foreign country, their average profit-maximizing price decreases relative to Home's average profit-maximizing price. In other words, this intra-industry trade-induced relative productivity improvement increases the relative price of the exported varieties from Foreign firms' perspective. It can easily be seen from domestic and export price functions for the average firm that a relative increase in average productivity directly implies a relative decrease in the profit-maximizing prices:

$$p^n(\tilde{\phi}^n) = \frac{1}{\rho}\frac{(w_m^n)^{\beta_i}(w_f^n)^{1-\beta_i}}{\tilde{\phi}^n} \quad \text{and} \quad p_X^n(\tilde{\phi}_X^n) = \frac{\tau}{\rho}\frac{(w_m^n)^{\beta_i}(w_f^n)^{1-\beta_i}}{\tilde{\phi}_X^n}$$

Together, these propositions imply that intra-industry trade has heterogeneous effects on countries that differ in their intensity of gender labor market discrimination. In essence, Stolper-Samuelson logic is at play here. Namely, as trade liberalization increases the relative price of Foreign varieties, the real returns to the production factor used most intensively in the production of that variety (male labor) increase relative to those used less intensively (female labor) Conversely, the less discriminatory country partly loses its 'discrimination-induced technological advantage' and the men's real wages decrease relative to those of women.

Proposition 4: *Intra-industry trade widens the gender wage gap in the country that is relatively more discriminatory, while narrowing it in the relatively less discriminatory one.*

This last proposition cannot be proven analytically, but using mathematical general equilibrium software to find numerical solutions confirms this theory: wages of both men and women increase in the more discriminatory country, but those of men rise more. Conversely, both wages of men and women decrease in the less discriminatory country, but those of men fall more. See appendix 2 for the full simplified general equilibrium equations that can be used to numerically solve the model using mathematical software.

Table 1: Descriptive statistics

	Mean	Std. Dev.	Min	Max	Obs.	Source
Panel A: Cross-sectional data						
Gender wage gap (%)	18.3	9.8	0.4	52.8	747	OECD
FLFP (%)	51.4	10.5	13.3	78.2	1,573	OECD
3-digit GL index	0.4	0.2	0.1	0.6	40	Brülhart (2009)
5-digit GL index	0.3	0.1	0.0	0.4	40	Brülhart (2009)
$SIGI_{\{aggregate\}}$	15.7	6.5	6.7	32.9	38	OECD
$SIGI_{\{familial\ discrimination\}}$	14.8	13.5	0	52	40	OECD
$SIGI_{\{physical\ integrity\}}$	18.5	6.0	10	32	38	OECD
$SIGI_{\{civil\ liberties\}}$	15.1	7.6	2	35	40	OECD
$SIGI_{\{access\ to\ resources\}}$	12.9	11.8	1	61	40	OECD
Panel B: Panel data						
Gender log wage gap (Δ)	78	82	-56	476	737	IPUM-CPS
Female log wages (USD)	45.8	49.2	1.7	264	740	IPUM-CPS
Male log wages (USD)	118.7	116.2	2.2	687.5	780	IPUM-CPS
Residual gender log wage gap (Δ)	11	13	-34	85	783	IPUM-CPS
Female residual log wages (USD)	1.0	4.4	-20.3	23.8	783	IPUM-CPS
Male residual log wages (USD)	11.5	14.3	-37.8	86.4	783	IPUM-CPS
Grubel-Lloyd index	0.5	0.2	0.0	1.0	1,101	US census bureau
Panel C: Quantitative data used to construct residual wages						
Age (years)	39.1	12.8	16	64	1,386,608	IPUM-CPS
Education (years)	14.0	2.8	0	23	1,386,608	IPUM-CPS
Potential experience (years)	19.1	12.7	0	58	1,386,608	IPUM-CPS

Note: Means and standard deviations are not clustered and computed across all industries/countries/groups. FLFP stands for female labor force participation. See section 4.2 for further elaboration on the construction and interpretation of the (residual) log gender wage gap.

Chapter 4

Methodology and data

4.1 Data sources

The first part of this empirical analysis uses cross-sectional regression analysis across the entire OECD and a few partner countries. Here, data on the gender wage gap and female labor force participation is taken from the OECD data warehouse. It is measured using full-time equivalent hourly wages (USD) at the median of the income distribution and computed as the difference between average male wages and female wages divided by average male wages. Countries' extent of intra-industry trade is proxied for using the aggregated Grubel-Lloyd indices as computed by Brülhart (2009). These country-level indices are constructed using weighted aggregation of industry-level Grubel-Lloyd indices, both at a 5-digit level of aggregation and at a broader 3-digit level (SITC). It measures what share of a country's total bilateral trade across all trade partners is intra-industry. Finally, as will be elaborated on in the next subsection, discrimination is measured using the Social Institutions and Gender Index constructed by the OECD.

In the second part of the analysis, this paper shifts its focus to the US and the effects of its free trade agreement with South-Korea (KORUS) on gender disparities in the US labor market. Here, the IPUM Current Population Survey (CPS) is the main source of data used. This dataset provides yearly individual-level US data on employment, wages, education, and other key personal information such as gender, maternity and education. Lastly, US bilateral trade data with South-Korea is taken from the US census bureau and courtesy of Peter K. Schott. The data covers the years 1989-2023 but it is limited to the year 2006-2018 to minimize noise.

4.2 Measuring discrimination

Although a central concept to this paper, reliably quantifying gender discrimination remains difficult. Nonetheless, this paper uses two different proxies: the Social Institutions and Gender Index (SIGI) from the OECD and the residual gender wage gap.

For the cross-sectional analysis, discrimination is proxied for using the SIGI. This index is a weighted aggregate of 25 variables that measure gender discrimination explicitly. It can be decomposed into four distinct sub-indices: (1) discrimination within the family, (2) restricted physical integrity, (3) restricted civil liberties, and (4) restricted access to productive and financial resources. Of these, the last component is of most interest, as it also explicitly captures labor market discrimination against women. The SIGI's main virtue is that it measures discrimination directly rather than measuring gender inequality as an outcome. This makes it preferred over other more general indices such as the well-known UN Gender Inequality Index (GII), which include the gender wage gap in their composition. Using such an index would lead to simultaneity issues, as running a regression of the gender wage gap on the GII would be equivalent to running a regression of the gender wage gap partly on itself. Using the SIGI circumvents this issue. A high SIGI indicates intense gender discrimination and it can range between 0 and 100, although the highest value in this study's sample is 32.9 (Japan) while the lowest is 6.7 (Norway).

Another proxy used by the preceding literature is the residual gender wage gap. This gender wage gap is 'residual' as it takes out the part of the gender wage gap that can be explained by any observable productivity-related differences between men and women. In theory, the residual wage gap is an explicit measure of wage discrimination, since it reflects the wage differential that cannot be explained by observable gender productivity differences. In practice, however, the residual wage gap is likely also composed of other unobserved (to the researcher) gender differences, such as real experience and occupational self-selection. Nonetheless, the residual wage gap remains the closest possible individual-level proxy for gender wage discrimination.

To construct the gender wage gap, an approach is used similar to that of Artecona and Cunningham (2002) and Berik et al. (2004). First, all non-working age individuals and individuals that are not participating in the labor market are removed from the sample. Second, individual (gross) wages are obtained using total yearly wage income and average weekly hours worked, assuming 49 yearly work weeks on average. Third, a Mincer earnings equation is estimated with hourly wages as the dependent variable and a variety of individual-level observable productivity-related characteristics as predictors:

$$ln(wage)_{it} = \alpha + \beta_1 \eta_{it} + \beta_2 \{education\}_{it} + \beta_3 \gamma_{it} + \beta_4 \gamma_{it}^2 + \epsilon \quad \text{(R1)}$$

where η_{it} is a vector of observed individual characteristics such as marital status, age, and worker status. In line with the preceding literature, γ denotes potential experience and is measured by age minus years of education minus six. Its square is included to capture the nonlinear returns to potential experience. Finally, educational attainment is added into the regression. Running regression (R1) gives an R-squared of around 0.28, indicating that most (72%) of the variation in individual's wages is explained by unobserved variables. As argued before, it is unlikely that this unexplained wage variation is fully (or mostly) explained by gender discrimination. Fourth, after running regression (R1), the residuals (ϵ) are kept as residual log wages. Lastly, the residual gender wage gap is computed as the difference between male and female residual log wages per industry at the 4-digit level (NAICS). Descriptive statistics are reported in table 1.

4.3 Methodology

This paper's empirical analysis is divided into two parts. First, it tests the theoretical model's prediction that intra-industry trade (IIT) widens the gender wage gap in more-discriminatory countries while narrowing it in less-discriminatory ones. To do this, cross-sectional regression analysis is conducted. Included in the sample are the entire OECD and a few of their partner countries for the year 2006. In order to assess the mediating role of discrimination in the relationship between IIT and the gender wage gap, the following regression equation is estimated:

$$\text{GWG}_j = \alpha + \beta_1\{\text{SIGI}_j\} + \beta_2\{\text{IIT}_j\} + \beta_3\{\text{SIGI}_j \times \text{IIT}_j\} + \beta_4 X + \epsilon \qquad \text{(R2)}$$

where GWG_j reflects the gender wage gap at median income for country j. The variables of interest are SIGI_j, which proxies for gender discrimination, and intra-industry trade IIT_j, which is measured using the country-aggregated Grubel-Lloyd index. Both variables are demeaned. X is a vector of control variables and includes log of GDP, female unemployment rate, unionization rate, and services sector net output as a percentage of GDP. The main coefficient of interest is β_3 as it reflects the mediating role of (measured) discrimination on the effect between IIT and the gender wage gap. A positive estimate implies that more discriminatory countries are more likely to exhibit a widening effect of IIT on the gender wage gap, as predicted by the model. Note, however, that this coefficient does not measure the effect of intra-industry trade liberalization on the gender wage gap directly. Rather, it only estimates whether countries' relationship between IIT and the gender wage gap depends on a country's absolute level of gender discrimination.

Therefore, the second part of the empirical analysis focuses on the context of US trade liberalization with South-Korea. More specifically, it analyzes the effects of the 2012 KORUS free trade agreement (FTA) - the US' largest FTA signed after NAFTA. This context is chosen because it is a close real world example of a more gender liberal (US) and a more gender conservative (South-Korea) country conducting intensive bilateral intra-industry trade.[4] Furthermore, analyzing KORUS enables estimating the effects of an absolute increase in intra-industry trade

[4]At first glance, both the US and South Korea have similar SIGI scores of 19 and 20, respectively. However, further investigation reveals that this is largely driven by the US' abortion restrictions. The sub-index that covers labor market discrimination is almost twice as high for South-Korea (29 and 15, respectively).

rather than just the effect of an increase in the share of trade that is intra-industry. Lastly, focusing on the US enables the use of their extensive labor market and trade data.

Similar to Artecona and Cunningham (2002), a difference-in-differences (DiD) approach is used to assess whether US-South Korea trade liberalization led to a decrease in the gender wage gap in the US, as predicted by the model. DiD is a useful method as it helps isolate the effect of KORUS on the gender wage gap that is only the result of changes in intra-industry trade (as opposed to other trade-induced effects). Here, the treatment group consists of affected industries that conduct intensive intra-industry trade after KORUS (as measured by their post-KORUS industry-level Grubel-Lloyd index). Conversely, the control group includes those industries that are characterized by low intra-industry trade before and after KORUS. In this light, any heterogeneous effects of KORUS on these two types of firms should be a consequence of increased intra-industry trade. Indeed, industries with a Grubel-Lloyd index close to zero do not conduct intra-industry trade at all. Formally, the regression takes on the following form:

$$\Delta \text{GWG}_{it} = \alpha + \eta_i + \gamma_t + \sum_{k=0}^{3} \beta_4 \{\text{KORUS}_t \times \text{IIT}_i\} + \epsilon_{it} \qquad \text{(R3)}$$

where ΔGWG_{it} is the change in the average (residual) gender wage gap of industry i from year $t-1$ to t. γ_t are year dummies that capture yearly shocks to the gender wage gap that affect both types of firms homogeneously. In other words, γ_t captures the effect of KORUS on the gender wage gap that is *not* specifically through an increase in intra-industry trade. η_i are industry dummies that control for ex ante industry differences that do not differ over time. IIT_i is a dummy variable that equals one if an industry passes a certain minimum benchmark Grubel-Lloyd index. KORUS_t is a dummy variable that equals one for the years after 2011. Thus, β_4 is the coefficient for interest since it captures the effect of KORUS on the gender wage gap for those firms that exhibit intensive intra-industry trade. To check whether the parallel trends assumption holds, three-year leads are added to the model. A statistically significant 'placebo treatment' in the years before KORUS indicates that the trends between the treatment and control groups already deviated before KORUS. Lastly, ϵ_{it} is the error term.

Several robustness checks will be conducted to test this methodology's assumptions. To begin with, not every industry with a high Grubel-Lloyd index is by definition affected by KORUS. Hence, the regressions only include industries whose gross trade flows increase following KORUS. Furthermore, industries that exhibit a fall of more than 0.1 in the Grubel-Lloyd index after KORUS are removed from the sample. This is done to avoid capturing Heckscher-Ohlin trade effects, as international trade may push countries to (partially) specialize. Industries are left a limited scope of downward movement as the Grubel-Lloyd index may also drop if KORUS simply increases either country's industry's exports slightly more than their foreign counterpart.

Chapter 5

Results

The first part of this section will provide some suggestive cross-sectional results on the mediating role of discrimination on the effect of intra-industry trade on the gender wage gap using OLS regressions. The second part aims to concretise these results by analyzing the context of US trade liberalization with South-Korea with panel data.

5.1 Cross-sectional analysis

5.1.1 The mediating role of discrimination

Table 2 reports the cross-sectional results obtained from estimating equation R2 for the entire OECD and several partner countries using the aggregate SIGI. The regression is repeated for both the aggregated Grubel-Lloyd indices at the 3-digit and 5-digit level and both with and without controls. As expected, the coefficient of SIGI is positive and marginally significant throughout all specifications.[5] A one-point increase in the SIGI is associated with a 0,3-0.4 percentage point increase in the gender wage gap when the Grubel-Lloyd index is at its mean. This implies that, on average, a country with more intense gender discrimination has a wider gender wage gap.

The coefficients for the two measures of intra-industry trade are also positive in every column. Since both variables are demeaned, this implies that a higher share of IIT is associated with a higher gender wage gap for a country with an average level of discrimination. However, these coefficients are statistically insignificant and imprecisely estimated. As will be shown later, these coefficients' high standard errors likely reflect that the effect of IIT on the gender wage gap is highly dependent on a country's level of discrimination. Nonetheless, OECD countries with a higher share of IIT and more intense discrimination can be expected to have a higher wage gap.

[5] These regressions also illustrate the importance of having a direct measure of discrimination rather than a measure of gender outcome inequality. Using the UN Gender Inequality Index, for instance, leads to a negative coefficient for discrimination. This is due to selection bias: unequal countries tend to have a lower wage gap since lower female labor force participation implies self selection into the labor market by higher-earning women.

Most importantly, the interaction terms between SIGI and the Grubel-Lloyd indices are positive and largely significant throughout all specifications. The only exception is column (4), which is still positive and similar in magnitude, but lacks significance ($p = 0.16$). This implies that there is an interplay between IIT and gender discrimination: IIT and the gender wage gap are more negatively related for a country that exhibits more intense general gender discrimination. These coefficients are somewhat robust to the addition of controls in columns (2) and (4), although their decreasing coefficients may point toward overestimation of the coefficients in columns (1) and (3), respectively. Nonetheless, table 2 weakly supports this paper's prediction that IIT has a widening effect on the gender wage gap if that country is more discriminatory.

Table 2: The mediating role of aggregate discrimination

	Gender wage gap			
	(1)	(2)	(3)	(4)
$\text{SIGI}_{\{aggregate\}}$	0.40*	0.31*	0.42*	0.33*
	(0.21)	(0.17)	(0.21)	(0.17)
3-digit Grubel-Lloyd	8.71	4.27		
	(8.51)	(12.46)		
3-digit Grubel-Lloyd × SIGI	2.80**	2.70*		
	(1.28)	(1.41)		
5-digit Grubel-Lloyd			15.59	9.62
			(10.37)	(15.54)
5-digit Grubel-Lloyd × SIGI			2.77*	2.45
			(1.60)	(1.71)
Constant	16.57***	6.01	16.24***	7.35
	(1.51)	(22.51)	(1.50)	(23.31)
Controls	No	Yes	No	Yes
Observations	34	33	34	33
R^2	0.17	0.28	0.14	0.26

Note: This table shows the results of regressing the gender wage gap (at median income) on a measure of gender discrimination (SIGI) and country-aggregated Grubel-Lloyd indices. Both variables are demeaned, so their respective main effects can be interpreted as their conditional effects when holding the other variable constant at its sample average. Controls include log of GDP, female unemployment rate, unionization rate, and the importance of the services sector. Robust standard errors are given in parentheses.
*p<0.1; **p<0.05; ***p<0.01

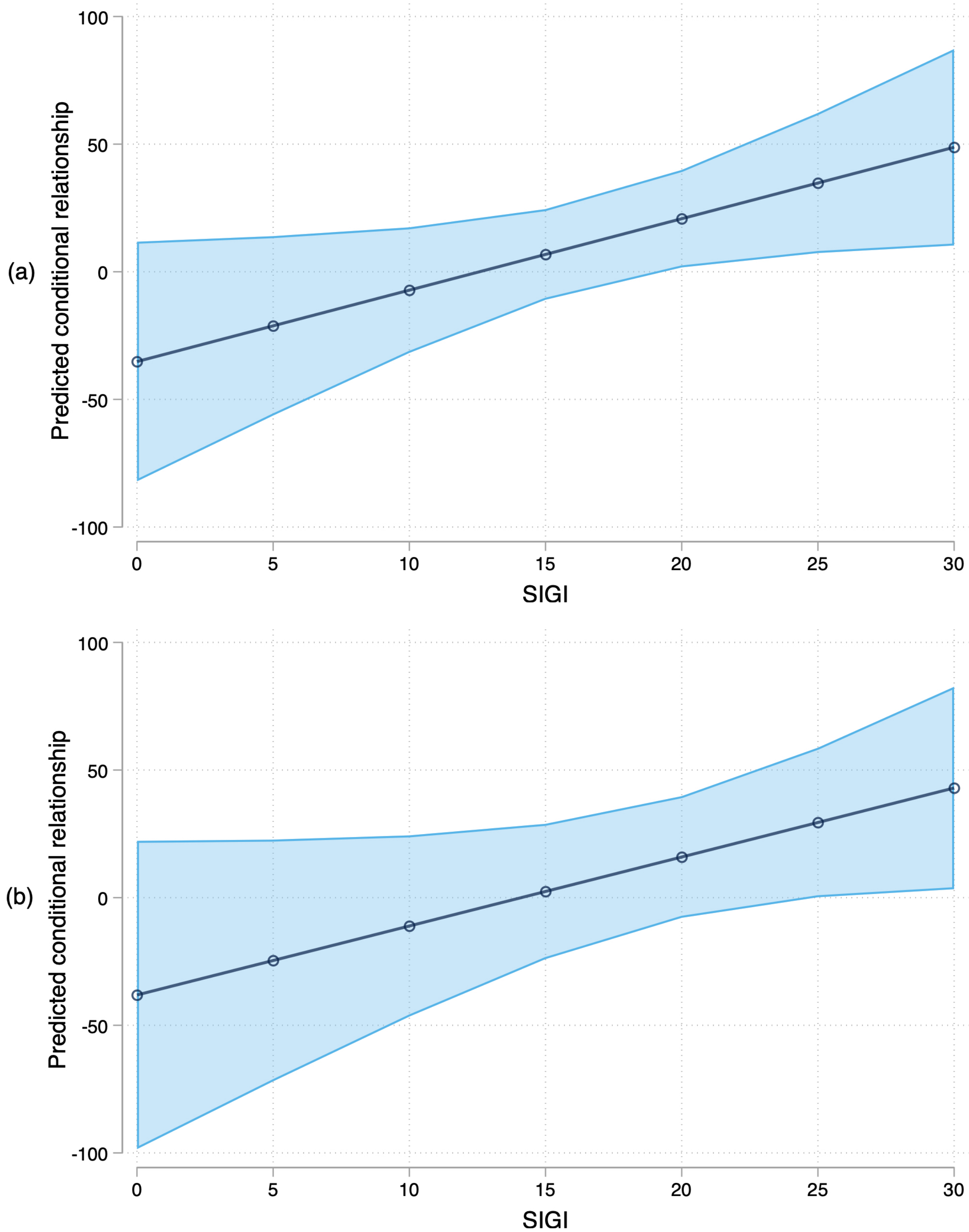
The coefficients of table 2 so far only suggest that the relationship between IIT and the gender wage gap is less positive for less-discriminatory countries. This does not necessarily support the theoretical model's inverse prediction: that IIT should narrow the wage gap for less-discriminatory countries. That is, the slope of the regression line should be negative for these countries. Hence, figure 1 shows what happens to the relationship between IIT and the gender wage gap when holding discrimination constant at increasing levels. Panel (a) is the equivalent of column (1), while panel (b) gives the conditional relationship when controlling for the same variables as in column (2). Using the 5-digit Grubel-Lloyd index rather than its 3-digit counterpart does not significantly alter these results. As can be seen in panel (a), the predicted coefficients for IIT clearly slope upward. Again, higher levels of discrimination are associated with a positive unconditional relationship between IIT and the gender wage gap. This relationship turns significant from a SIGI of 19 or higher. Conversely, it can now also be seen that this relationship is negative for countries whose levels of gender discrimination are low - exactly as predicted by the theoretical model. However, this negative relationship is not significant due to the large confidence intervals at the bottom of the SIGI distribution. Panel (b) shows that this latter relationship is somewhat robust to the inclusion of several macroeconomic controls, although the positive relationship now only becomes significant from a SIGI of 25 onward. Taken together, figure 1 weakly supports the inverse hypothesis that IIT may narrow the gender wage gap in less-discriminatory countries.

The fact that the widening role of IIT for more discriminatory countries is larger than its narrowing effect for less discriminatory ones is also reflected in the results of table 2. If both effects were of similar importance, the coefficient for the Grubel-Lloyd index would be close to zero. Given that the theoretical model predicts that IIT would narrow the wage gap in less-discriminatory countries by suppressing the wages of both female and (disproportionately) male labor, it may be wondered if the weak support for the narrowing effect of IIT is a predictable consequence of downward nominal wage rigidity, which can also prevent wage cuts in the OECD (Holden & Wulfsberg, 2008). In sum, these suggestive results weakly support the model's prediction that IIT widens the wage gap in more-discriminatory countries while narrowing it for less-discriminatory ones.

5.1.2 Mechanisms

The SIGI is constructed using four sub-indices: (1) discrimination within the family, (2) restricted physical integrity, (3) restricted civil liberties, and (4) restricted access to productive and financial resources. Of these, this paper's theoretical model predicts that it is the last channel, which includes explicit measures of labor market discrimination, that should drive the previous results. Insofar as the other channels are uncorrelated with labor market discrimina-

Figure 1: Conditional relationship between IIT and the gender wage gap



Note: This figure shows how the relationship between intra-industry trade and the gender wage gap across the OECD depends on a country's level of discrimination, measured by the Social Institutions and Gender Index (SIGI). A higher SIGI means a higher level of gender discrimination within a given country. The blue area is the 95% confidence interval surrounding each predicted marginal effect.

tion, they should have no significant impact on the relationship between intra-industry trade and the gender wage gap.

First, it can indeed be shown that the first three measures of discrimination do not drive the previously found results. To show this, table 3 reports the results obtained from replacing the total SIGI with its sub-indices as the independent variable. For the sake of brevity, only the 5-digit Grubel-Lloyd index is used. Using the more precise 3-digit index does not significantly change these results. Again, discrimination is positively related with the wage gap across all indices. It is marginally significant for familial discrimination and for restricted civil liberties.

It is interesting to note that these sub-indices are, at most, moderately correlated with the measure of labor market discrimination ($\rho = 0.28$ for familial discrimination and $\rho = 0.37$ for restricted physical integrity). Restricted civil liberties is practically uncorrelated to labor market discrimination ($\rho = 0.01$). This suggests that these positive coefficients reflect - at least in part - distinct mechanisms that affect the gender wage gap separately from labor market discrimination. Importantly, this also illustrates that observable labor market discrimination is insufficient to fully explain the gender wage gap and that the effects of trade and discrimination on the gender wage gap go far beyond this study's simple theory.

Importantly, none of the sub-indices' interactions terms with intra-industry trade are now statistically significant. Indeed, their sign has turned negative. Based on these coefficients, it can therefore not be inferred that there is any mediating effect of these discrimination sub types on the relationship between intra-industry trade and the gender wage gap. This foreshadows the upcoming key result that, indeed, it is labor market discrimination that is driving the results of table 2 - as predicted by the theoretical model.

Second, table 4 now repeats regression R2 again but using the SIGI's final sub-index: 'restricted access to productive and financial resources'. Note that this measure also includes non-labor market gender discrimination and that it is thus a rough proxy of labor market discrimination. It also includes other forms of economic discrimination against women, including restrictions in land ownership and access to financial assets. As such, it could be interpreted as a more broad measure of economic discrimination against women. Nonetheless, labor market discrimination is this index's largest component and is arguably most likely to affect female wages negatively. Furthermore, its variation within the OECD is mostly driven by differences in labor market discrimination rather than differences in access to land and financial institutions.

The results of table 4 largely mirror those of table 2, suggesting that it is indeed labor market discrimination that is driving the previous results. As expected, the coefficient for SIGI remains positive across all specifications. It has, however, lost significance and has decreased in magni-

Table 3: The mediating role of discrimination sub-indices

	Gender wage gap					
	(1)	(2)	(3)	(4)	(5)	(6)
$SIGI_{\{familial\ discrimination\}}$	0.22*	0.17*				
	(0.11)	(0.10)				
$SIGI_{\{restricted\ physical\ integrity\}}$			0.36	0.37		
			(0.24)	(0.23)		
$SIGI_{\{restricted\ civil\ liberties\}}$					0.31*	0.34*
					(0.17)	(0.17)
5-digit Grubel-Lloyd	7.74	7.08	3.41	-2.38	5.53	3.46
	(10.4)	(14.09)	(17.30)	(20.9)	(9.62)	(15.09)
5-digit Grubel-Lloyd × $SIGI_{fd}$	-0.07	-1.06				
	(0.95)	(1.48)				
5-digit Grubel-Lloyd × $SIGI_{rpi}$			-1.38	-2.42		
			(3.19)	(3.47)		
5-digit Grubel-Lloyd × $SIGI_{rcl}$					-2.20	-2.43
					(1.68)	(2.01)
Constant	15.83***	25.88	15.83***	5.93	15.15***	16.15
	(1.40)	(22.66)	(1.62)	(22.61)	(1.34)	(21.62)
Controls	No	Yes	No	Yes	No	Yes
Observations	36	35	34	33	36	35
R^2	0.11	0.25	0.08	0.26	0.09	0.25

Note: This table shows the results of regressing the gender wage gap (at median income) on several decomposed measures of gender discrimination (SIGI) and country-aggregated Grubel-Lloyd indix. All variables are demeaned, so their respective main effects can be interpreted as their conditional effects when holding the other variable constant at its sample average. Controls include log of GDP, female unemployment rate, unionization rate, and the importance of the services sector. Robust standard errors are given in parentheses. *p<0.1; **p<0.05; ***p<0.01

Table 4: The mediating role of labor market discrimination

	Gender wage gap			
	(1)	(2)	(3)	(4)
$\text{SIGI}_{\{restricted\ access\ to\ resources\}}$	0.29	0.15	0.28	0.14
	(0.22)	(0.21)	(0.22)	(0.20)
3-digit Grubel-Lloyd	1.74	-4.30		
	(7.71)	(11.20)		
3-digit Grubel-Lloyd × SIGI_{ratr}	1.79**	1.55**		
	(0.73)	(0.67)		
5-digit Grubel-Lloyd			5.03	-2.74
			(9.99)	(15.46)
5-digit Grubel-Lloyd × SIGI_{ratr}			2.26**	1.89**
			(0.96)	(0.86)
Constant	16.90***	13.07	16.87***	13.30
	(1.56)	(22.18)	(1.62)	(22.30)
Controls	No	Yes	No	Yes
Observations	36	35	36	35
R^2	0.20	0.30	0.17	0.27

Note: This table shows the results of regressing the gender wage gap (at median income) on a measure of gender discrimination (SIGI) and country-aggregated Grubel-Lloyd indices. Both variables are demeaned, so their respective main effects can be interpreted as their conditional effects when holding the other variable constant at its sample average. Controls include log of GDP, female unemployment rate, unionization rate, and the importance of the services sector. Robust standard errors are given in parentheses. *p<0.1; **p<0.05; ***p<0.01

tude. This reinforces the previously discussed idea that it is not only economic discrimination against women that contributes to gender wage disparities, but other non-economic forms of discrimination as well.

Now, the interactions between intra-industry trade and the labor market discrimination measure turn positive and statistically significant across all columns ($p < 0.05$). Again, this illustrates that there is likely an interaction between labor market discrimination and intra-industry trade: the more discriminatory a country, the more positive the relationship between intra-industry trade and the gender wage gap. Conversely, a country that conducts more intra-industry trade will have a larger positive relationship between labor market discrimination and the gender wage gap. Although not the focus of this paper, this latter result is undoubtedly interesting, as it suggests a stronger need for anti-discriminatory measures in countries that rely more heavily on intra-industry trade.

5.1.3 Female labor force participation

Before concluding this analysis, it is useful to assess whether changes in the gender wage gap as a result of intra-industry trade may correspond to changes in female labor force participation (FLFP). Indeed, any effect of IIT on the gender wage gap may be driven by (or mitigated by) changes in FLFP. If FLFP rises as a result of IIT, this increase in female labor supply is expected to, ceteris paribus, widen the gender wage gap by suppressing women's wages. To assess this probability, table 5 repeats regression R2 but using FLFP as its dependent variable.

Interestingly, the coefficients for the interaction between labor market discrimination and intra-industry trade are positive and marginally significant in columns (1) and (3). Their significance is not robust to the addition of controls, indicating that there is likely omitted variable bias affecting the base specifications. Nonetheless, although not causal, these coefficients suggest that IIT has a larger positive impact on countries that are more discriminatory. At face value, this paper's theoretical model does not conclude anything about FLFP. Indeed, there is no unemployment and full labor force participation is assumed. However, when combined with the theoretical framework highlighted in section 2, the following likely explanation for this result can be hypothesized.

As argued in the theoretical model, more discriminatory country see greater average firm productivity improvements as a result of intra-industry trade. Furthermore, as found by Juhn et al. (2012), these firm productivity increases may be translated into technological upgrading by firms that particularly favors women (such as computerization). As a result, increased female labor demand will push up women's wages, prompting increased FLFP. Note that in this paper's theoretical model, the gender wage gap should increase for more discriminatory countries. However, this follows from the result that men's wages rise more than women's - not that women's absolute wages decrease. Furthermore, at a micro decision-making level, FLFP is likely to rise as a result of absolute wage increases even if this coincides with a decrease in relative wages.

Table 5: The role of female labor force participation

	Gender wage gap			
	(1)	(2)	(3)	(4)
$SIGI_{\{aggregate\}}$	-0.30	-0.18	-0.33	-0.20
	(0.22)	(0.18)	(0.23)	(0.17)
3-digit Grubel-Lloyd	9.20	8.36		
	(10.08)	(8.86)		
3-digit Grubel-Lloyd × $SIGI_{rr}$	3.76*	2.73		
	(1.99)	(2.03)		
5-digit Grubel-Lloyd			2.53	3.53
			(12.18)	(12.03)
5-digit Grubel-Lloyd × $SIGI_{rr}$			4.51**	4.16
			(2.04)	(2.60)
Constant	53.36***	58.89***	53.54***	50.71***
	(1.38)	(16.82)	(1.41)	(16.69)
Controls	No	Yes	No	Yes
Observations	37	34	37	34
R^2	0.24	0.53	0.21	0.53

Note: This table shows the results of regressing female labor force participation on a measure of gender discrimination (SIGI) and country-aggregated Grubel-Lloyd indices. Both variables are demeaned, so their respective main effects can be interpreted as their conditional effects when holding the other variable constant at its sample average. Controls include log of GDP, unionization rate, and the importance of the services sector. Note that, in contrast to the previous regressions, the female unemployment rate as a control variable is omitted from the regression to prevent obvious simultaneity. Robust standard errors are given in parentheses.
*p<0.1; **p<0.05; ***p<0.01

Taken together, three things can cautiously be inferred from the preceding analysis. First, more discriminatory countries exhibit a widening relationship between intra-industry trade and the gender wage gap. Second, less discriminatory countries are more likely to exhibit a narrowing relationship between intra-industry trade and the gender wage gap. Both of the previous two results are solely driven by labor market discrimination. Lastly, the relationship between female labor force participation and intra-industry trade is expected to be more positive for more discriminatory countries. It can be hypothesized that this last result is a mechanism; more discriminatory countries see the biggest productivity gains. If these productivity improvements coincide with women-favoring computerization by firms, this creates new job entry opportunities for women. Consequently, as the relative demand of female labor increases, women's relative wages fall and the gender wage gap rises. Although suggestive, these (non-causal) results are unambiguously in support of this study's theoretical predictions.

5.2 Time series

The preceding cross-sectional analysis only supports a part of the theoretical model's main prediction. Namely, that a country's relationship between its reliance on intra-industry trade and the gender wage gap depends on its level of gender discrimination. However, this does not necessarily imply that the effect of intra-industry trade *liberalization* on the gender wage gap depends on a country's intensity of labor market gender discrimination *relative to its trade partner*. Hence, this section now aims to estimate the effect of an increase in intra-industry trade on the gender wage gap following a free trade agreement between the (relatively less discrminatory) US and (relatively more discriminatory) South-Korea.

Table 6 reports the results obtained from estimating regression R3. Column (1) gives the results when using the change in the simple wage gap as the dependent variable, while column (2) replaces it with the residual wage gap. To check for heterogeneous treatment effects across different intensities of IIT, every panel repeats the same regression but with an incremental increase in the minimum Grubel-Lloyd index at which an industry is considered to be part of the treatment group. Every industry that does not reach this benchmark and is not in the control group is removed from the sample. The control group consists of industries that have an average Grubel-Lloyd index below 0.3 across all sample years.

As can be seen, the coefficients of the treatment effect are positive throughout all specifications - contrary to the theoretical model's predictions. Interestingly, the coefficients in panels A and B are large and statistically significant. Specifically, the increase in the simple gender wage gap following KORUS is estimated to be between 9 and 15 log points. That is, intra-industry trade liberalization following KORUS is estimated to have widened the simple gender wage gap within US manufacturing industries. The estimates in panels C and D remain positive but are smaller in magnitude and statistically insignificant. This could indicate that KORUS' widening effect was stronger for those industries that exhibited moderate to high intra-industry trade. Finally, the treatment effects on the residual wage gap are all positive but insignificant. Hence, it cannot be concluded that KORUS had any effect on the residual wage gap of affected US industries. Assuming that the residual wage gap is a reliable measure of gender wage discrimination, it cannot be concluded that KORUS had any suppressing or exacerbating effect on gender labor market discrimination.

Table 6: Difference-in-differences results

	Treatment effects	
	Δ Simple wage gap	Δ Residual wage gap
	(1)	(2)
Panel A: Grubel-Lloyd ≥ 0.6		
$IIT_i \times KORUS_t$	15.12***	1.26
	(5.17)	(1.54)
Observations	189	205
Industries	15	15
Panel B: Grubel-Lloyd ≥ 0.7		
$IIT_i \times KORUS_t$	13.01**	0.22
	(5.45)	(1.20)
Observations	110	121
Industries	11	11
Panel C: Grubel-Lloyd ≥ 0.8		
$IIT_i \times KORUS_t$	9.77	0.67
	(6.19)	(1.44)
Observations	88	99
Industries	9	9
Panel D: Grubel-Lloyd ≥ 0.9		
$IIT_i \times KORUS_t$	9.18	0.77
	(7.25)	(1.70)
Observations	77	88
Industries	8	8

Note: Every panel repeats the same regression but with an incremental increase in the benchmark Grubel-Lloyd index from which an industry is considered to be in the treatment group (IIT_i). Standard errors are given between brackets. *p<0.1; **p<0.05; ***p<0.01

In the previous regression, allocation to the treatment group is based on an affected industry's Grubel-Lloyd index after implementation of KORUS. Doing so captures two types of industries into the treatment group. Firstly, industries are included that already had a high Grubel-Lloyd index before the implementation of KORUS and whose index remains above the benchmark after it was implemented. These affected industries have thus always been characterized by high IIT; their absolute levels of intra-industry trade have solely increased as a result of KORUS. Secondly, industries are included into the treatment group because intra-industry trade liberalization after KORUS pushed their Grubel-Lloyd indices above the benchmark. Both of these types of industries are expected to have an effect of KORUS on the gender wage gap by increasing their absolute levels of IIT and are thus of interest. However, allowing industries to be pushed into the treatment group by the treatment itself is likely to lead to selection bias if these self-selecting industries are different from those in the control group (which cannot self-select).

Furthermore, the previous result that the widening effect of KORUS is only significant for those industries with a Grubel-Lloyd index between 0.6 and 0.8 might also partially be driven by these self-selecting industries. Thus, to analyze this issue, table 7 repeats regression R3 but now only with industries that have a high Grubel-Lloyd index both before and after KORUS. Specifically, any industry whose Grubel-Lloyd index increases with more than 0.2 after the implementation of KORUS is removed from the sample. Column (1) shows that the treatment effects are larger in magnitude for industries that do not self-select. However, this is not translated into stronger statistical significance. Hence, it cannot be concluded that self-selecting firms have any heterogeneous treatment effects whose inclusion might cause selection bias. Lastly, the coefficients for the residual wage gap also remain close to zero and insignificant.

Table 7: Difference-in-differences without firm self-selection

	Treatment effects	
	Δ Simple wage gap	Δ Residual wage gap
	(1)	(2)
Panel A: Grubel-Lloyd ≥ 0.6		
$IIT_i \times KORUS_t$	17.73**	1.58
	(6.73)	(2.11)
Observations	138	150
Industries	14	14
Panel B: Grubel-Lloyd ≥ 0.7		
$IIT_i \times KORUS_t$	21.02*	−0.88
	(9.35)	(1.00)
Observations	59	66
Industries	6	6

Note: Both panels repeat the same regression but with an incremental increase in the benchmark Grubel-Lloyd index from which an industry is considered to be in the treatment group (IIT_i). Panels C and D are omitted since there are no industries omitted past this benchmark. That is, all industries with a post-KORUS average Grubel-Lloyd index above 0.8 already had a high index before KORUS as well. Standard errors are given between brackets. *p<0.1; **p<0.05; ***p<0.01

To assess the mechanism behind this increase in the simple gender wage gap, table 8 reports the results obtained from repeating regression R3 but with female and male (non-residual) wages as the dependent variables in columns (1) and (2), respectively. It becomes clear from column (2) that the previous result was driven by an absolute increase in male wages following KORUS. Where men's wages increase between 8-13.6 log points on average across industries, women's wages remain stagnant. Similarly to table 6, the treatment effect estimates loses significance as the treatment benchmark becomes incrementally higher, further indicating that the previous results were driven by a relative increase in men's wages.

Table 8: Difference-in-differences results wage levels

	Treatment effects	
	Δ ln(female wages)	Δ ln(male wages)
	(1)	(2)
Panel A: Grubel-Lloyd ≥ 0.6		
$IIT_i \times KORUS_t$	3.53	13.65**
	(3.59)	(6.09)
Observations	191	202
Panel B: Grubel-Lloyd ≥ 0.7		
$IIT_i \times KORUS_t$	-0.26	8.18*
	(1.65)	(4.26)
Observations	111	119
Panel C: Grubel-Lloyd ≥ 0.8		
$IIT_i \times KORUS_t$	-0.29	4.79
	(1.29)	(4.00)
Observations	89	97
Panel D: Grubel-Lloyd ≥ 0.9		
$IIT_i \times KORUS_t$	-0.83	3.81
	(1.09)	(4.68)
Observations	78	86

Note: Every panel repeats the same regression but with an incremental increase in the benchmark Grubel-Lloyd index from which an industry is considered to be in the treatment group (IIT_i). Standard errors are given between brackets. *p<0.1; **p<0.05; ***p<0.01

It is difficult to reconcile the results of table 6 with the predictions of this paper's theoretical model. However, the empirical literature (section 2) provides a few possible explanations. For instance, the result that men migrate to export sectors following trade liberalization, (Sauré & Zoabi, 2014), may also hold in the case of intra-industy trade liberalization. If women and capital exhibit particularly high complementary between them, this influx of male workers will decrease women's marginal productivity more than men's. This effect would, however, be partially mitigated if IIT also induces women-favoring technological upgrading (Juhn et al., 2012). Furthermore, if IIT increases female labor force participation, as suggested by section 5.1.3, any trade-induced increase in female wages would be suppressed by a simultaneous increase in female labor supply. Lastly, IIT may reduce women's bargaining power (Berik et al., 2004).

It may also be the case, however, that this section's results are biased. For instance, to assess whether the parallel trends assumption holds in the previous difference-in-differences regressions, three-year leads are added to the model. In the case of the significant estimates from panel A in tables 6-8, a 'placebo treatment' is significant one year before KORUS ($p < 0.1$). Leads of more than one year are never significant. In other words, one year before KORUS was implemented, the trends between the treatment and control industries were not exactly parallel. This possibly indicates anticipation effects: KORUS was ratified by the US in 2011 and industries were thus likely aware of the upcoming tariff cuts. The significant increase in male's wages before KORUS may then, e.g., be explained by a disproportionate increase in demand for male labor.

Furthermore, these regressions do not control for the fact that industry concentration may change heterogeneously over time in a way that is independent from an industry's Grubel-Lloyd index. Equation R3 only controls for time-invariant industry differences and time shocks that affect all industries homogeneously. Any heterogeneous effect of KORUS is then solely attributed to an industry's increase in intra-industry trade. Not controlling for industry concentration leads to bias, since, as suggested by Black and Brainerd (2004), gender discrimination is more negatively affected by trade in highly-concentrated industries. This is because these industries exhibit relatively little ex ante competitive pressures. Lastly, although little, the control industries do exhibit *some* IIT. A more robust IV approach using potentially exogenous industry tariff cuts may alleviate these concerns. However, this goes beyond the scope of this paper.

Note also that the estimated treatment effects do not reflect the full effect of KORUS on the gender wage gap. Rather, they only measure the effects of KORUS on the gender wage gap that is attributed to an increase in IIT. Thus, the full effects might have been different. For instance, assuming that the results Sauré and Zoabi (2014) hold, the simple gender wage gap would have widened even further when accounting for Heckscher-Ohlin trade effects.

Chapter 6

Concluding remarks

Although intuitive in theory, the effects of international trade of the gender wage gap remain empirically elusive. This paper builds a new intra-industy trade model that shows what happens to the gender wage gap when a discriminatory country trades with a less-discriminatory one. Namely, assuming 'costly discrimination', intra-industry trade will push out more (unproductive) firms in the discriminatory country than in the less-discriminatory one. As such, average firm productivity rises more in the discriminatory country. That is, the discriminatory country alleviates part of its discrimination-induced 'comparative disadvantage'. And, since firms are assumed to prefer hiring men in this industry, these productivity gains are reflected in a relative increase in male wages. Conversely, the wage gap narrows in the less-discriminatory country.

This paper finds suggestive results in favor of the model when conducting cross-sectional analysis for the OECD: more discriminatory countries that exhibit more intense labor market discrimination exhibit a widening relationship between intra-industry trade and the gender wage gap, while less discriminatory ones exhibit a narrowing relationship. In contrast, a difference-in-differences analysis focusing on the US-South Korea 2012 FTA finds a widening effect of trade liberalization on the simple gender wage gap in US manufacturing industries. This illustrates that the true extent of the effect of trade on the gender wage gaps remains difficult to capture in any simple model and that this relationship goes beyond the existing theoretical literature.

Thus, more theoretical and empirical work is needed to be able to fully understand the extent of this relationship. Future research can improve this paper by 1. incorporating technological upgrading into the theoretical model, and 2. applying a more robust IV approach using potentially exogenous variation in tariff cuts following KORUS. Furthermore, a general lack of gender-disaggregated employment data for settings outside of the US manufacturing industry remain difficult to acquire. This limits external validity, which is especially harmful since the effects of trade on the gender wage gap seem to be particularly context dependent.

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Appendix A

Important derivations

A.1 Proof for proposition 1

Firms' randomly drawn productivity parameters are assumed to follow a Pareto distribution, with the following CDF and PDF, respectively:

$$G_{\{nd,d\}}(\phi) = \begin{cases} 1 - \left(\frac{\phi_L}{\phi^*}\right)^k & \text{if } \phi \geq \phi_L \\ 0 & \text{if } \phi < \phi_L \end{cases} \quad \text{and} \quad g_{\{nd,d\}}(\phi) = \begin{cases} \frac{k\phi_L^k}{\phi^{k+1}} & \text{if } \phi \geq \phi_L \\ 0 & \text{if } \phi < \phi_L \end{cases}$$

where shape parameter $k = \{k_{nd} \ , \ k_d\}$ and lower productivity bound $\phi_L = \{\phi_{Lnd} \ , \ \phi_{Ld}\}$. It is assumed that discriminatory firms' distribution is either characterized by a higher shape parameter ($k_d > k_{nd}$) and/or a lower lower-bound productivity parameter ($\phi_{Lnd} > \phi_{Ld}$). Choosing either assumption does not change the results of the model. For the sake of clarity, firm type subscripts will mostly be omitted during the next steps.

The average productivity parameter in country $N = \{H, F\}$ can then be computed as:

$$\tilde{\phi} = \left(\int_{\phi^*}^{\infty} \phi^{\sigma-1} \frac{g(\phi)}{1 - G(\phi^*)} d\phi\right)^{\frac{1}{\sigma-1}} \quad \Rightarrow \quad \tilde{\phi} = \left(\int_{\phi^*}^{\infty} \phi^{\sigma-1} \frac{\frac{k\phi_L^k}{\phi^{k+1}}}{1 - \left[1 - \frac{\phi_L}{\phi^*}\right]^k} d\phi\right)^{\frac{1}{\sigma-1}}$$

$$\Rightarrow \tilde{\phi} = \phi^* \left(\frac{k}{k - \sigma + 1}\right)^{\frac{1}{\sigma-1}} \tag{A1}$$

which gives an expression for average firm productivity. Now, an expression for ϕ^* can be found using the autarky free entry conditions by substituting for $\pi(\tilde{\phi})$:

$$[1 - G(\phi^*)]\pi(\tilde{\phi}) = \delta f_e w_m^{\beta_i} w_f^{1-\beta_i}$$

$$\Rightarrow [1 - G(\phi^*)] \left[\frac{r(\tilde{\phi})}{\sigma} - f w_s^{\beta_i} w_f^{1-\beta_i}\right] = \delta f_e w_m^{\beta_i} w_f^{1-\beta_i}$$

This can be simplified further using the zero cutoff profit condition $r(\phi^*) = \sigma f_c w_m^{\beta_i} w_f^{1-\beta_i}$ and the fact that the ratio of any two firm revenues equals the ratio of their productivities:

$$\frac{r(\tilde{\phi})}{r(\phi^*)} = \frac{I \cdot P^{\sigma-1} \cdot p(\tilde{\phi})^{1-\sigma}}{I \cdot P^{\sigma-1} \cdot p(\phi^*)^{1-\sigma}} = \left(\frac{\tilde{\phi}}{\phi^*}\right)^{\sigma-1}$$

Then, the free entry condition can be rewritten into:

$$[1 - G(\phi^*)] \left[\left(\frac{\tilde{\phi}}{\phi^*}\right)^{\sigma-1} - 1\right] = \delta \frac{f_e}{f_c} \qquad \Rightarrow \qquad \left(\frac{\phi_L}{\phi^*}\right)^k \left[\left(\frac{\tilde{\phi}}{\phi^*}\right)^{\sigma-1} - 1\right] = \delta \frac{f_e}{f_c} \tag{A2}$$

using the fact that $[1 - G(\phi^*)] = 1 - \left[1 - \left(\frac{\phi_L}{\phi^*}\right)^k\right]$ during the last step. Lastly, this second expression can be rewritten into a function for the threshold productivity parameter:

$$(\phi^*)^n = \phi_{L\{nd,d\}} \left(\frac{f_c(\sigma - 1)}{\delta f_e(k_{\{nd,d\}} - \sigma + 1)}\right)^{\frac{1}{k\{nd,d\}}} \tag{A3}$$

From this expression, it can already be seen that the threshold productivity parameter is lower for the country n that has either a lower productivity lower-bound (ϕ_L) or a higher shape parameter k. A higher shape parameter implies that there are fewer productive firms and a more pronounced clustering of unproductive firms at the bottom of the productivity distribution. Thus, assuming that Home firms are non-discriminatory and Foreign firms are discriminatory, the threshold productivity will be higher in Home, as $\phi_{L,nd} > \phi_{L,d}$ and/or $k_{nd} < k_d$.

Finally, equation (A3) can be substituted back into equation (A1) to obtain a formal expression of country n's average firm productivity in autarky:

$$\tilde{\phi} = \phi_{L\{nd,d\}} \left(\frac{f_c(\sigma - 1)}{\delta f_e(k_{\{nd,d\}} - \sigma + 1)}\right)^{\frac{1}{k\{nd,d\}}} \left(\frac{k_{\{nd,d\}}}{k_{\{nd,d\}} - \sigma + 1}\right)^{\frac{1}{\sigma-1}} \tag{A4}$$

Again, the same logic applies as with equation (A3). A lower productivity lower-bound (ϕ_L) and/or a higher shape parameter k imply that average firm productivity will be lower in the discriminatory country. Since there is only one sector in this model, this also implies that aggregate country productivity is negatively impacted by gender discrimination. Back.

A.2 Proof for proposition 2

By definition, country n's mass of firms M is equal to total industry revenues R^n divided by average firm revenues. That is, $M = \frac{R^n}{r(\tilde{\phi}^n)}$. Furthermore, since there are only two production factors, all revenues are translated into female and male wage income: $R^n = w_m^n L_m^n + w_f^n L_f^n$. Assuming that wages are constant (like in the case without discrimination), the mass of firms decreases in the country where average revenues $r(\tilde{\phi}^n)$ increase the most.

$$\frac{r(\tilde{\phi}^n)}{r(\tilde{\phi}^m)} = \frac{I^n \cdot (P^n)^{\sigma-1} \cdot p(\tilde{\phi}^n)^{1-\sigma}}{I^m \cdot (P^m)^{\sigma-1} \cdot p(\tilde{\phi}^m)^{1-\sigma}} = \left(\frac{p(\tilde{\phi}^n)}{p(\tilde{\phi}^m)}\right)^{1-\sigma} = \left(\frac{\tilde{\phi}^m}{\tilde{\phi}^n}\right)^{\sigma-1}$$

As can be observed from the ratio between revenues of both countries, this is the case for the more discriminatory country. As argued in proposition 3, the average productivity increases the most in the more discriminatory country. Thus, the profit-maximizing price of its firms decreases relative to the less discriminatory country and its relative average output increases. In a sense, the more discriminatory country partly alleviates its 'comparative disadvantage' with the less discriminatory one. Consequently, average revenues increase the most and the mass of firms in the discriminatory country decreases disproportionately. Note that in the model, in contrast to this simple illustration, aggregate wages and price indices differ across countries - with ambiguous effects on their average revenues. However, solving the model numerically shows that the effect highlighted above dominates. Back.

A.3 Proof for proposition 3

First, it must be shown that the cutoff productivity parameter for the export market is larger than that of the domestic market by dividing the zero cutoff profit conditions, where the right-hand side of equation (A5) is positive. Again, firm type subscripts are omitted for clarity.

$$\frac{r_X^n((\phi_X^*)^n)}{r^n((\phi^*)^n)} = \frac{\sigma f_X w_m^{\beta_i} w_f^{1-\beta_i}}{\sigma f_c w_m^{\beta_i} w_f^{1-\beta_i}} = \frac{I^m \left(\frac{\tau p^n(\tilde{\phi}^n)}{P^m}\right)^{1-\sigma}}{I^n \left(\frac{p^n(\tilde{\phi}^n)}{P^n}\right)^{1-\sigma}} \quad \Rightarrow \quad (\phi_X^*)^n = (\phi^*)^n \tau \frac{P^n}{P^m} \left(\frac{I^m}{I^n}\frac{f_c}{f_X}\right)^{\frac{1}{1-\sigma}} \tag{A5}$$

Country n's average firm productivity is also in the open equilibrium determined by equation (A1). Thus, to find the new average firm productivity, the same logic as with equation (A2) is applied but now with the open economy free entry condition and by using $\frac{\tilde{\phi}}{\phi^*} = \left(\frac{k}{k-\sigma+1}\right)^{\frac{1}{\sigma-1}}$:

$$\left(\frac{\phi_L}{(\phi^*)^n}\right)^k f_c \frac{\sigma-1}{k-\sigma-1} + \left(\frac{\phi_{L,X}}{(\phi_X^*)^n}\right)^k f_X \frac{\sigma-1}{k-\sigma-1} = \delta f_e$$

$$\Rightarrow \frac{f_c}{((\phi^*)^n)^k} + \frac{f_X}{((\phi_X^*)^n)^k} = \frac{\sigma-1}{k-\sigma-1}\frac{\sigma f_c}{\phi_L^k}$$

Then, using equation (A5), an expression for the average firm productivity in the open economy equilibrium can be derived:

$$(\phi^*)^n = \left\{\frac{\sigma-1}{k-\sigma-1}\frac{\sigma f_c}{\phi_L^k}\left[f_c + \left(\frac{P^m}{P^n}\right)^k \left(\frac{I^m}{I^n}\right)^{\frac{k}{\sigma-1}} \left(\frac{f_c^{\frac{k}{\sigma-1}}}{f_x^{\frac{k+1-\sigma}{\sigma-1}}\tau^k}\right)\right]\right\}^{1/k} \tag{A6}$$

Lastly, dividing equation (A6) by equation (A4) gives the ratio between the average productivity in the open economy and during autarky, respectively. Thus, it reflects the expected increase in average productivity when opening up to international trade:

$$(\phi^*)^n = \phi_L^{k-1}\left(\frac{P^m}{P^n}\right)^k \left(\frac{I^m}{I^n}\right)^{\frac{k}{\sigma-1}} \left(\frac{f_c^{\frac{k-1}{\sigma-1}}}{f_x^{\frac{k+1-\sigma}{\sigma-1}}\tau^k}\right) \tag{A7}$$

From this equation, it can be seen that it is rising in k with regards to the first three terms. That is, the more discriminatory a country, the more pronounced the trade-induced productivity increase will be with regard to these terms. To illustrate, if $\frac{I^m}{I^n} > 1$ (that is, if country n opens up to a relatively big foreign market m), productivity will increase more as a bigger export markets means larger expected exports profits - prompting even more firms to enter the market and increasing competitive pressures. This positive productivity effect will be larger for countries that are more discriminatory. That is, countries that have a larger shape parameter k. This reflects the intuitive idea that increased competition pushes out more (less productive) firms in countries that are more discriminatory.

The last term of this equation has an ambiguous effect of k. However, using mathematical modelling software to solve numerical applications of the model shows that the the effect of k on the productivity gains of intra-industry trade are indeed positive. The assumed parameter values used to obtain this paper's results are highlighted in appendix B.

This equation does not necessarily imply that it is *relative* discrimination that is causing the larger productivity gains for more discriminatory countries. This is because these relative discriminatory effects are contained within the ratio of price indices $\frac{P^m}{P^n}$. To see this, consider the general price index of country n:

$$P^n = \left[M^n p^n(\tilde{\phi}^n)^{1-\sigma} + M^m \left(\frac{(\phi_X^*)^m}{(\phi^*)^m}\right)^{k_d} [\tau p_X^m(\tilde{\phi}_X^m)]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

As discussed, the mass of firms M decreases more as a result of trade liberalization in the relatively more discriminatory country. At the same time, the profit-maximizing price decreases relative to the less discriminatory country. As a result, the price index of the discriminatory country decreases relative to that of the less discriminatory one. Thus, assuming that country m is relatively more discriminatory means that $\frac{P^m}{P^n}$ will decrease as a result of intra-industry trade. Thus, the second term of equation (A7) will be smaller, implying a smaller productivity gain from trade for the relatively less discriminatory country. Back.

Appendix B

Simplified model equations

Back. The following simplified model equations can be used to solve the general equilibrium numerically using mathematical modeling software like GAMS:

Zero cutoff profit conditions for country N, where $N = \{H, F\}$:

$$\frac{k_{nd}(\sigma-1)f_c}{k_{nd}-\sigma+1} \geq \frac{\tilde{q}^N_{nd}(\tilde{\phi}^N_{nd})}{\tilde{\phi}^N_{nd}} \qquad \frac{k_d(\sigma-1)f_c}{k_d-\sigma+1} \geq \frac{\tilde{q}^N_d(\tilde{\phi}^N_d)}{\tilde{\phi}^N_d} \tag{14}$$

Free entry conditions for country N, where $f_{ppe} = \delta f_e$ equals the per period-equivalent entry costs accounting for per period firm death probability δ:

$$\frac{\sigma-1}{k_{nd}-\sigma+1}\left[\left(\frac{\phi_{L,d}}{\left(\frac{k_d-\sigma+1}{k_d}\right)^{\frac{1}{\sigma-1}}\tilde{\phi}^N_d}\right)^{k_d} f_c + \left(\frac{\phi_{L,d}}{\left(\frac{k_d-\sigma+1}{k_d}\right)^{\frac{1}{\sigma-1}}\tilde{\phi}^N_{d,X}}\right)^{k_d} f_X\right] \geq f_{ppe}$$

$$\frac{\sigma-1}{k_{nd}-\sigma+1}\left[\left(\frac{\phi_{L,nd}}{\left(\frac{k_{nd}-\sigma+1}{k_{nd}}\right)^{\frac{1}{\sigma-1}}\tilde{\phi}^N_{nd}}\right)^{k_{nd}} f_c + \left(\frac{\phi_{L,nd}}{\left(\frac{k_{nd}-\sigma+1}{k_{nd}}\right)^{\frac{1}{\sigma-1}}\tilde{\phi}^N_{nd,X}}\right)^{k_{nd}} f_X\right] \geq f_{ppe}$$

Good market equilibrium conditions for domestic and export markets, respectively, where aggregate country income $I^N = L^N_f w^N_f + L^N_m w^N_m$:

$$q^N_{nd}(\tilde{\phi}^N_{nd}) = p^N_{nd}(\tilde{\phi}^N_{nd})^{-\sigma}(P^N)^{\sigma-1}I^N \qquad q^N_d(\tilde{\phi}^N_d) = p^N_d(\tilde{\phi}^N_d)^{-\sigma}(P^N)^{\sigma-1}I^N \tag{15}$$

$$\begin{aligned}
\frac{q^H_{nd,X}(\tilde{\phi}^H_{nd,X})}{\tau} &= (p^H_{nd,X}(\tilde{\phi}^H_{nd,X})\cdot\tau)^{-\sigma}(P^F)^{\sigma-1}(I^F)\\
\frac{q^H_{d,X}(\tilde{\phi}^H_{d,X})}{\tau} &= (p^H_{d,X}(\tilde{\phi}^H_{d,X})\cdot\tau)^{-\sigma}(P^F)^{\sigma-1}(I^F)\\
\frac{q^F_{nd,X}(\tilde{\phi}^F_{nd,X})}{\tau} &= (p^F_{nd,X}(\tilde{\phi}^F_{nd,X})\cdot\tau)^{-\sigma}(P^H)^{\sigma-1}(I^H)\\
\frac{q^F_{d,X}(\tilde{\phi}^F_{d,X})}{\tau} &= (p^F_{d,X}(\tilde{\phi}^F_{d,X})\cdot\tau)^{-\sigma}(P^H)^{\sigma-1}(I^H)
\end{aligned} \tag{16}$$

Labor market clearing conditions for male (L_m^N) and female (L_f^N) labor for country N, where $T_{nd} = \left(\frac{k_{nd}-\sigma+1}{k\phi_{L,nd}^{\sigma-1}}\right)^{\frac{1}{\sigma-1}} \cdot f_{ppe}$ and $T_d = \left(\frac{k-\sigma+1}{k_d\phi_{L,d}^{\sigma-1}}\right)^{\frac{1}{\sigma-1}} \cdot f_{ppe}$:

$$L_f^N \geq (1-\beta_{nd})\left(\frac{w_m^N}{w_f^N}\right)^{\beta_{nd}} M^N \left[\left(\frac{q_{nd}^N(\tilde{\phi}_{nd}^N}{\tilde{\phi}_{nd}^N}\right) + f_c + \left(\frac{\tilde{\phi}_{nd}^N}{\tilde{\phi}_{nd,X}^N}\right)^{k_{nd}} \left(\frac{q_{nd,X}^H(\tilde{\phi}_{nd,X}^N)}{\tilde{\phi}_{nd,X}^N} + f_X\right) + (\tilde{\phi}_{nd}^N)^{k_{nd}} \cdot T_{nd}\right]$$

$$L_m^N \geq \beta_{nd}\left(\frac{w_f^N}{w_m^N}\right)^{1-\beta_{nd}} M^N \left[\left(\frac{q_{nd}^N(\tilde{\phi}_{nd}^N}{\tilde{\phi}_{nd}^H}\right) + f_c + \left(\frac{\tilde{\phi}_{nd}^N}{\tilde{\phi}_{nd,X}^N}\right)^{k_{nd}} \left(\frac{q_{nd,X}^H(\tilde{\phi}_{nd,X}^N)}{\tilde{\phi}_{nd,X}^N} + f_X\right) + (\tilde{\phi}_{nd}^N)^{k_{nd}} \cdot T_{nd}\right]$$

The labor market clearing conditions for the discriminatory country are of identical structure, but with discriminatory d subscripts for all variables and country-specific parameters. Price indices country for country n where m refers to the other country:

$$P^n = \left[M^n p^n(\tilde{\phi}^n)^{1-\sigma} + M^m \left(\frac{(\phi_X^*)^m}{(\phi^*)^m}\right)^{k_d} [\tau p_X^m(\tilde{\phi}_X^m)]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Lastly, firms' profit-maximizing (export) prices in country N are determined using:

$$p_{nd}^N(\tilde{\phi}_{nd}^N) = \frac{\sigma}{\sigma-1}\frac{(w_m^N)^{\beta_{nd}}(w_f^N)^{1-\beta_{nd}}}{\tilde{\phi}_{nd}^N} \quad \text{and} \quad p_d^N(\tilde{\phi}_d^N) = \frac{\sigma}{\sigma-1}\frac{(w_m^N)^{\beta_d}(w_f^N)^{1-\beta_d}}{\tilde{\phi}_d^N}$$

$$p_{nd,X}^N(\tilde{\phi}_{nd}^N) = \frac{\sigma}{\sigma-1}\frac{(w_m^N)^{\beta_{nd}}(w_f^N)^{1-\beta_{nd}}}{\tilde{\phi}_{nd,X}^N} \quad \text{and} \quad p_{d,X}^N(\tilde{\phi}_d^N) = \frac{\sigma}{\sigma-1}\frac{(w_m^N)^{\beta_d}(w_f^N)^{1-\beta_d}}{\tilde{\phi}_{d,X}^N}$$

To solve the general equilibrium numerically, the following values are assumed for the parameters:

$\sigma = 5$ $\quad \tau = 1.1$ $\quad f_c = 5$ $\quad f_e = 6.7$ $\quad f_X = 5$ (free trade) $\quad f_X = 100$ (autarky) $\quad k_d = 9$ $\quad k_{nd} = 8$ $\quad \phi_{L,d} = 1$ $\quad \phi_{L,nd} = 1$

$\beta_d = 0.8$ $\quad \beta_{nd} = 0.6$ $\quad L_m^H = L_m^F = L_f^H = L_f^F = 100$