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Formal and informal gender wage gaps: The impact of trade liberalization in Brazil

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João Pessoa-PB, 18 de Dezembro de 2020

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Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Economia da UFPB (área de concentração: Economia do Trabalho), como parte dos requisitos necessários para a obtenção do Título de Mestre em Economia.

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"Quem elegeu a busca,
não pode recusar
a travessia..."
(Guimarães Rosa)

Resumo

A liberalização do comércio está intimamente associada aos choques competitivos que geram efeitos diferenciados nos setores formal e informal, especialmente nos países em desenvolvimento. Nós usamos o episódio de liberalização comercial do Brasil no início de 1990 como um experimento natural para testar a teoria de Becker sobre a discriminação, mas incluindo o setor informal. Em nosso modelo, a heterogeneidade na produtividade da empresa e a discriminação explicam os efeitos da liberalização do comércio sobre a disparidade salarial de gênero no setor formal e informal. O modelo estabelece um vínculo causal entre reforma comercial, mudança de produtividade das empresas e realocação de empresas discriminatórias entre setores, o que implica em efeitos variados da liberalização do comércio sobre a diferença salarial média de gênero e discriminação. Os resultados gerais indicam que uma redução de 1% na tarifa diminui a diferença salarial de gênero entre 3% a 8% no setor formal e aumenta a diferença salarial de gênero entre 5% a 8% no setor informal.

Palavras-chaves: Liberalização do comércio. Heterogeneidade da firma; Informalidade; Desigualdade salarial de gênero.

Abstract

Trade liberalization is closely associated with competitive shocks which generate differentiated effects in the formal and informal sectors, especially in developing countries. We use the Brazilian trade liberalization episode in early 1990 as a natural experiment to test Becker's theory on discrimination, but including the informal sector. In our model, heterogeneity on the firm's productivity and discrimination explain the effects of trade liberalization on the gender wage gap in the formal and informal sector. The model establishes a causal link between trade reform, firm productivity change, and reallocation of discriminatory firms between sectors, which implicate in varied effects of trade liberalization on the average gender wage gap and discrimination. Overall results indicate that a reduction in 1 % in tariff decreases the gender wage gap between 3% to 8% in the formal sector and increases the gender wage gap between 5% to 8% in the informal sector.

Keywords: Trade liberalization; Firm heterogeneity; Informality; Gender Wage Gap.

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Lista de abreviaturas e siglas

AMC	Áreas Minimamente Comparáveis
BNT	Barreiras Não-Tarifárias
CBO	Classificação Brasileira de Ocupações
CNAE	Classificação Nacional de Atividades Econômicas
IBGE	Instituto Brasileiro de Geografia e Estatística
INPC	Índice Nacional de Preços ao Consumidor
H-O	Hecksher-Ohlin
NAFTA	Tratado Norte-Americano de Livre Comércio
OBD	Oaxaca-Blinder Decomposition
RAIS	Relação Anual de Informações Sociais
RTC	Mudança de Tarifas Regionais
SIC	Classificação Industrial Padrão
TEC	Tarifa Externa Comum

Sumário

Introduction

The informal sector in developing countries has been a topic of discussion for a long time. In these locations, informality represents a large share of the economy, ranging from 20% to 40% in Latin America (Goldberg and Pavcnik (2003); Ponczek and Ulyssea (2017)). The informal sector is often associated with a lack of labor regulation and rights (Perry et al. (2007)), but it is also viewed as a complementary sector that serves as the counter-cyclical buffer of labor market shocks (Ponczek and Ulyssea (2017)). This is particularly important because if one looks through the lens of the traditional economical view, an increased portion of the informal sector in the economy, especially after an exogenous shock, seems to represent a loss in welfare, given the lower productivity of informal firms relative to formal firms, and their inability to grow within the informal sector (Paula and Scheinkman (2011)). However, newly found evidence appears to show quite the contrary. Dix-Carneiro et al. (2019) demonstrate that following a trade liberalization episode, which can be compared as a negative labor demand shock, the informal sector worked as a buffer in the labor markets and the productivity and welfare loss were greater in an economy without an informal sector, even though the eradication of the informality presented much larger positive effects.

There is a fair amount of evidence regarding the employment adjustment of labor markets following trade liberalization (Goldberg and Pavcnik (2003); Bosch, Goni and Maloney (2007); Menezes-Filho and Muendler (2011); Bosch, Goñi-Pacchioni and Maloney (2012); Paz (2014); Dix-Carneiro and Kovak (2017); Cruces, Porto and Viollaz (2018); Yahmed and Bombarda (2020)). Although we do not stray far from the literature, we examine a different perspective that receives less attention, which is wage inequality and, more specifically, the gender wage gap within each sector.

Becker's theory on taste-based discrimination arises, besides preferences, from the existence of economic rent and imperfect competition in labor and product markets[1], which provide discriminatory firms a leeway to remunerate differently equally productive and perfectly substitutable workers or have the sub-optimum share of minority workers. Therefore, sectors with high levels of economic rent are more able - not necessarily willing - to exercise employer taste-based discrimination relative to competitive markets.

Our paper seeks to emphasize a particular trade-off within the formal sector that involves discrimination and profit, and also seeks to provide a theoretical model of how a competitive shock may indirectly induce discriminatory firms to enter informality and thus increase discrimination in the informal sector. Within the framework of firm heterogeneity

[1] Although Becker (2010) presents cases where discrimination exists in competitive markets.

literature, firms differ in their productivity levels and make their decisions of which sector to enter by analyzing their profits, and thereby must have a certain productivity level to be profitable in the formal sector (Becker (2018)). In the formal sector, employers face a plurality of fiscal burdens and work-related expenses, which creates a restriction to enter formality. In addition, Becker (2010) emphasizes that practicing discrimination is costly for the employer, as he must bear the cost of discrimination in terms of profit, but sheltered from competition, discriminatory firms can persist within the formal sector. A competitive shock, such as a sudden trade liberalization policy, should reduce economic rent and put cost-pressure on the formal firms, but more extensively on discriminatory formal firms, which result in forcing them to either change their posture or exit the formal market (Black and Brainerd (2004); Yahmed (2017); Hirata and Soares (2020)). Therefore, formal firms may choose to become informal in this more competitive state, and since discrimination can not survive among low productivity firms with close-to-zero economic profits (Morchio, Moser et al. (2019)), which the informal sector is mostly represented by[2], in the short-run the gender wage gap should increase in the informal sector, but our long-run predictions come in line with Becker (2010), where discrimination should reduce in the formal and informal sectors.

Brazil occupies a prominent position in the discussion o the labor market effects of trade liberalization[3] Although relatively a smaller literature, recent work has explored the effects of globalization on labor market outcomes for women. For Mexico, Juhn, Ujhelyi and Villegas-Sanchez (2013) found that the country's entry into the North American Free Trade Agreement (NAFTA), which reduced the level of Mexican tariffs, increased the participation of women in occupations associated with the production process (blue collar) and increased female participation in the payroll of the analyzed companies. Ederington, Minier and Troske (2009) analyzed the episode of trade liberalization in Colombia and found support for the theory of discrimination à la Becker, showing that the increased competition encouraged firms (employers) - who previously paid the cost of discrimination - to hire more women. For Brazil, Gaddis and Pieters (2017) evaluated the results of the 1990 trade policy on local labor markets and found that the liberalization process contributed to the convergence of labor force participation between genders, but that the impacts are strictly concentrated on the population with incomplete high school and lower educational levels.

We argue that the results on the effects of trade liberalization on the gender wage gap that focus primarily on the formal sector often and disregard the reallocation of labor, especially of low skilled men and women and low productivity firms out of formality in

[2] The overall view of the literature is that informal firms are on average smaller, less productive, and are owned by less talented managers (Rauch (1991); Perry et al. (2007); Paula and Scheinkman (2011); Porta and Shleifer (2014); Ulyssea (2020)) We will follow up this discussion in the following sections.

[3] Pavcnik et al. (2004); Pavcnik et al. (2004), Ferreira, Leite and Wai-Poi (2007), Dix-Carneiro and Kovak (2015) and references therein.

the short run. Particularly in Brazil, the constitutional reform in 1988 drastically changed labor regulation, which in turn compounded the effects of trade liberalization on the formal labor market (Paz (2014)). This is particularly important in light of the results of Menezes-Filho and Muendler (2011), who provide some evidence of the reallocation of labor out of the manufacturing sector to services and informal sector, particularly in the short run, and additionally, Dix-Carneiro and Kovak (2017) and Ulyssea and Ponczek (2018) results show that in the long run, recovery in employment is entirely driven by the rise in the informal sector, whereas formal sector employment never fully recovers. Recent work in this direction has been made by Yahmed (2018), who evaluates the gender wage inequality across formal and informal jobs in Brazil and Yahmed and Bombarda (2020), that studies how Mexico's trade liberalization episode impacted formal employment across genders, focusing on the rise of the informal sector.

Our theoretical model is related to that of Becker (2018), who introduces the informal sector to the firm heterogeneity framework of Melitz (2003) by allowing for in formalization of firms. Empirically, this paper uses the model developed by Kovak (2013), who calculates a weighted sum of the change in industry relative prices (reduction in tariffs) with the allocation of workers across industries within a region as a representative of trade shock on local labor markets. In his model, it is assumed that labor is mobile across industries, but not across regions. This assumption is justified in our empirical strategy because Goldberg and Pavcnik (2003) find approximately 88% of the aggregate share of informal workers happens within industries across our period of study. Additionally, this approach allows us to control the non-observable and time-invariant regional effects, such as geographic composition and natural effects, as well as emphasizes the short and medium run effects of trade policy on the gendered earnings distribution on the formal and informal sector. Additionally, it relates to the literature that investigates the effect of trade on local labor market outcomes, which is extensive (Dix-Carneiro (2014); Gaddis and Pieters (2017); Dix-Carneiro and Kovak (2017); and references therein). More notably, Ulyssea and Ponczek (2018) have studied the effect of trade liberalization on informality in Brazil, but through the lens of enforcement intensity. Their findings reveal an important dimension on the margins of adjustment in local labor markets, especially for small formal firms and low-skill workers.

The model is designed to study the effects of trade liberalization on economies with a large informal sector and a substantial share of small-sized firms. Meghir, Narita and Robin (2015) estimate that around 40% of the salaried labor force in Brazil is informal. Additionally, across our period of study, approximately 64% of firms have less than 5 salaried workers[4]. The main source of data is the Brazilian *Censo Demográfico*, which is an extensive survey that has information about workers in the formal and informal

[4] Estimate based on Establishment data provided by the Relação Anual de Informações Sociais.

sector. We also supplement our analysis, especially regarding the formal sector workers and firms, by using the *Relação Anual de Informações Sociais* (RAIS), which is a matching employer-employee administrative data set with high-quality information about the formal labor market.

The general scope of our results indicates that microregions facing a larger effect of trade liberalization through tariff reduction presented a larger decrease in the formal gender wage gap and a larger increase in the informal gender wage gap. Controlling for observable characteristics such as an average change in skill earnings, we continue to find significant differences between the gender wage among formal and informal workers across microregions relative to tariff reductions. According to the predictions of the taste-based discrimination model, local labor markets with initially high levels of concentration should present a larger decrease in the gender wage gap following trade liberalization. We find support for this prediction for the formal sector in the specifications without the additional controls, while in the informal sector the results are not significant. An additional prediction of Becker (2010) model states that the gender wage gap should be higher in labor markets with initially high levels of female participation. Our work focus on the tradable industries, therefore, when we control for female participation in tradable industries, the results suggest an increase in the gender wage gap in the informal sector in microregions in higher levels of female participation in 1991. The results on the effect of the initial share of small firms in changes of the wage differential between gender show that tariff reduction policy had a greater impact in reducing the gender wage gap among formal workers on microregions with a higher share of small firms in 1991, but the estimates are not strongly robust. For the informal sector, we find the opposite evidence, however with the same robustness problem.

The results from the Oaxaca-Blinder regressions find some evidence in increased discrimination in the informal sector when measured by the unexplained component of the OB decomposition. Using the theoretical model developed in this paper, this effect can be explained by the entry of discriminatory firms in the informal sector. While it is empirically challenging to evaluate the existence of discriminatory firm and the flow of firms across sectors, especially once they enter the informal sector, Dix-Carneiro and Kovak (2017) provide evidence for Brazil on the effects of trade liberalization the reallocation of capital between local labor markets. In their findings, larger tariff declines increased exit rates throughout the establishment size distribution, and the decline in the number of formal firms was compounded by the reduction in the average size of remaining establishments. Muendler et al. (2004) also find evidence of the competitive effect of trade liberalization on the elimination of the least efficient firms. With some assumptions in our model, it is possible to establish a link between firm entry in the informal sector and discrimination, supported by previous results and our estimations. Controlling the Oaxaca-Blinder regressions for selection bias into job status, we find that the reduction in

gender wage gap remains significant among formal and informal workers in the majority of our specifications. When accounting for selection bias, the measure of discrimination is not significant in both sectors. However, more notably, microregions facing larger tariff reductions showed a reduction in the difference between male and female earning on observable characteristics in the formal sector, while the gender difference for informal employees increased. This is the most consistent evidence from our results.

This paper is structured as follows. This section introduces. Section 1 gives a brief take on the history of the trade liberalization episode in Brazil. Section 2 provides an extensive summary of the defining characteristics of the informal sector, with overall and gender-specific facts. Section 3 present the theoretical model followed by a group of propositions. Section 4 refers to our methodological approach to the problem, explaining the data, empirical strategy, and estimation procedures. Section 5 presents the main results. Finally, section 6 concludes.

1 Trade liberalization in Brazil

The history of Brazil's trade policy until the late 1980s can be summed up as a history of restrictions. Industrialization based on the import substitution strategy reached its lowest point in the early 1980s, after the second oil shock and the external debt crisis. In the mid-1990s, Brazil was undergoing its third trade policy reform, finalizing the main changes in the tariff structure and the process of trade liberalization.

Prior to 1988, there were a series of restrictions on trade in Brazil, covering high tariff loads and qualitative and quantitative specifications for importing products. The average nominal tariff between industries was 54.9%, with the lowest industrial tariff - gas, coal, and oil sector - at 15.6% and the highest industrial tariff - clothing sector - at 102.7%. In June 1988, Brazil began the first round of trade liberalization reforms, reducing tariffs across industries and extinguishing taxes on inputs. However, non-tariff barriers (BNTs) did not change, which allowed industries to relatively enjoy the same level of protection as before (Kume, Piani and Souza (1990)).

Trade liberalization in Brazil effectively took place in the early 1990s, with the second round of trade policy reforms. In the 6-month interval, starting in March, the country's new administration adopted policies to make the exchange rate regime more flexible, redefined tariff levels for various product categories, reduced nominal and effective tariffs for capital goods and intermediaries, and eliminated non-tariff barriers to import. In relation to the nominal values of the tariffs of 1987 and 1990, the Brazilian tariff structure presented a reduction of 50.4% in the weighted average by added value. The agricultural sector presented the biggest reduction among the sectors, with a decrease of 99.5% of its average sectorial tariff. In contrast, the automotive sector remained one of the most protected sectors by the Brazilian commercial policy - a fact that would be highlighted during the period between 1987 and 1998[1], reducing its average tariff by 15% .

In 1992, the government adopted a position of greater trade liberalization, using the tariff instrument as an incentive to external competition, with the objective of guiding the domestic prices of the economy. Thus, Brazilian trade policy, during the years 1990 to 1993, was based largely on the control of customs tariffs due to the acceleration of the process of reducing nominal tariffs[2].

During 1994, two factors marked the Brazilian economic position in the face of the process of trade liberalization: First, the Real Plan was in its first phase and there was a need to keep domestic prices stable. To this end, the government decided to reduce import

[1] See Kume, Piani and Souza (1990).
[2] This process is known as *tarificação*.

tax rates on consumer goods and inputs to help control inflation. The second relevant factor was the establishment of the common external tariff (TEC) among Mercosur members. In this case, the Brazilian tariff structure had to take a contrary position in relation to previous years; however, the increase in tariffs was not significant.

During the months that followed the Real Plan, the tariff instrument was used as a policy to control domestic prices via international competition. However, the growth in the level of imports, as well as the exchange rate appreciation of the new currency came at the expense of the trade balance, producing trade deficits even in 1994. The Mexican crisis at the end of the year accelerated the process of capital flight from the country, reigniting protectionist debates about the most unprotected sectors. The 1995-1998 period ends the cycle of liberalization policies initiated at the end of 1987.

Figure 1 shows the trajectory of the average nominal tariff among all sectors over the period from 1987 to 1998. Additionally, figures 6 and 7 in appendix A show the sectorial dimension of change in tariffs. This period comprises the three phases of the Brazilian liberalization process. The accumulated result of the Brazilian tariff policy is a notable commercial opening over the years, with an increase in exporting and importing activities. Not only was the reduction in the tariff structure significant, as in figure 1, but the elimination of non-tariff barriers was an important milestone in Brazilian trade policy.

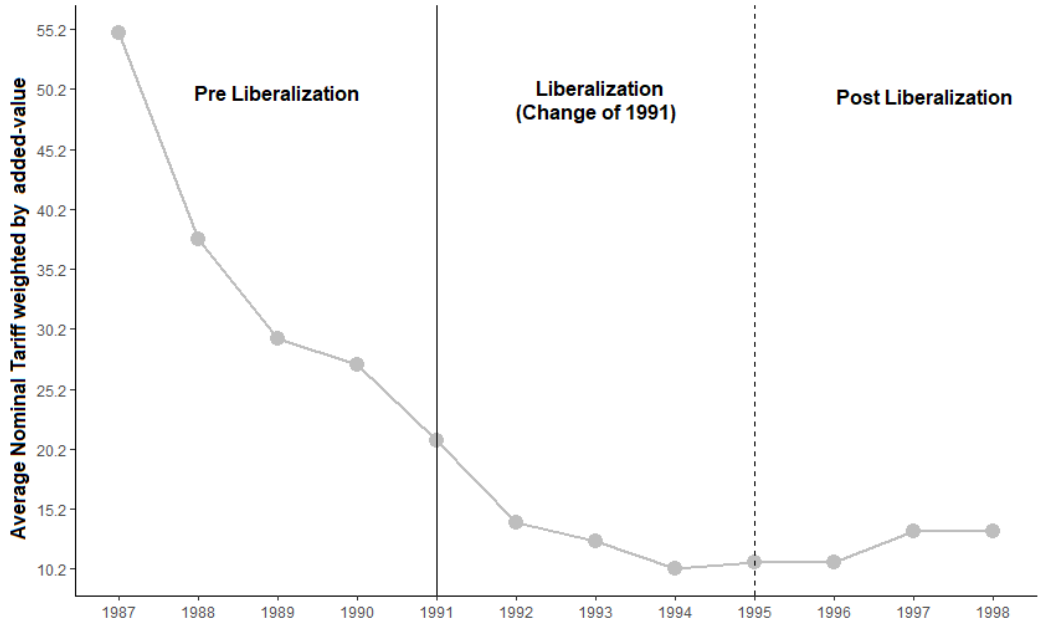

Figure 1 – Average Nominal Tariff - 1987-1995

Observation: Data about average nominal tariff from Kume, Piani and Souza (1990)

In general, there was a simplification of the tariff system and elimination of goods specifications, reducing the costs of conducting trade with Brazil. Protection has been reduced considerably across all sectors and consistently over the years, which, in theory,

reduces the possibility of endogenous influences on the selective protection of any particular sector.

The discussion regarding the exogeneity of the liberalization process is an important element of the literature. Because trade policy is the result of a *policy marker's* decision-making process, it may be subject to its political interests and contrary to the liberalization process. Abreu (2011) argues that the political economy of protection focuses on the conflict of interests between the winners and losers of trade and that the mobility of factors plays an important role in the emergence of that conflict, followed by a process of liberalization.

Some authors raised the question of the exogeneity of the policy of commercial opening in Brazil. Pavcnik et al. (2004) state that not only Brazil, but developing countries have implemented tariff reforms in order to standardize the tariff structure between sectors so that industries with a high degree of protection were the ones that saw the most reductions tariffs. This is evidenced by Kovak (2013) and Dix-Carneiro and Kovak (2017), who found that tariff cuts are almost perfectly correlated - correlation coefficient of -0.9 - with pre-liberalization tariff levels. As the pattern of sectoral tariff reductions during the liberalization phase was consistent, in terms of magnitude, with the levels of pre-liberalization tariffs and with the government's own commercial policy objectives, we found no evidence to suggest the existence of endogenous effects in tariff changes.

2 An overview of the informal sector

2.1 Stylized facts about the informal sector

While the definition of informality tends to differ due to distinct governmental regulations, the informal sector has some remarkable resemblance across countries in a few fundamental aspects. Porta and Shleifer (2014) and Paz (2014) provide an extensive summary of the defining characteristics of the informal sector. The following sections will draw some insight from the stylized facts.

Fact 1: Informal firms are small and have lower productivity.

Following Rauch (1991), firms are managed by individuals with different levels of entrepreneurial ability. Formal firms are managed by individuals with higher levels of managerial ability and firm size is positively correlated with entrepreneurial talent (Paula and Scheinkman (2011)). Informal firms are managed by less talented managers. Using college degree as a proxy for managerial ability, Porta and Shleifer (2014) find for Brazil that 7% of managers of informal firms have a degree, while 76% of formal firm managers have it. Moreover, a majority of salaried informal workers are low skilled workers and informal firms are likely to have a harder time attracting more educated workers and engaging them in a longer-term relationship (Perry et al. (2007)), due to the lack of labor regulations, which maintains lower levels of productivity.

Fact 2: Informal firms cannot grow without drawing attention from fiscal authorities.

Given that informal firms do not fully comply with tax and labor regulations, being caught by regulatory agencies often means getting a fine and ultimately closing down its operations. Most models that incorporate informal firms attribute a probability of getting caught that induces a fine in the same amount as the profit (Paula and Scheinkman (2011); Dix-Carneiro et al. (2019)). The same models also assume that the probability of detection is monotonically increasing with firm size as a way to incorporate the difficulty of hiding operations to tax authorities. As a result, informality has the effect of limiting firm growth, both because smaller informal firms are less likely to be caught by government inspectors and because the uncertainty associated with informality discourages investments in illiquid assets (Perry et al. (2007)). Additionally, informal firms have a higher cost of capital and, therefore, have a lower capital-labor ratio than formal firms, which hinders growth (Paula and Scheinkman (2011)).

Fact 3: Small firms are more likely to hire informal workers.

Perry et al. (2007) argue that firms small firms have a disproportionately large share informal of workers relative to larger firms. Small firms benefit the least from the participation of the formal sector because they are often incapable to compete with larger firms within the same industries while satisfying all labor and tax regulations, due to their low productivity levels and limited growth prospects. Additionally, small firms choose to "informalize" some part of their formal activities in order to improve their economic performance, since they benefit less from formality relative to more efficient firms that produce at higher volumes for longer lengths of time. Paz (2014) find for Brazil that 37% of workers are formal in establishments with 5 or fewer employees, but the share increases to 58% for establishments with 10 or fewer employees. This is in line with the literature, which argues that formality provides more benefits as firms grow larger[1].

Fact 4: Informal salaried and self-employed workers are mainly low skilled.

The formal sector imposes strict labor and tax regulations and offers non-wage benefits such as minimum wages, unemployment benefits, maternity leave, social security, and job severance contribution, which are not available in the informal sector. These characteristics may provide some binding restrictions to less-educated workers to enter formality. Additionally, Perry et al. (2007) state that unskilled workers, who partially pay for social protection benefits directly, may find it disadvantageous to forgone greater flexibility and earnings in the informal sector to apply for jobs in the formal sector that would also deliver very low earnings. Galiani and Weinschelbaum (2012) support this claim, finding that the likelihood of a worker being employed in the informal sector is negatively correlated with educational level.

Fact 5: Informal workers partially self-select into informality.

One can look at the informal workers as low skilled individuals who are unable to achieve productivity levels needed in order to be hired in a formal occupation due to restriction of entry such as binding minimum wages, hiring cost, union bargaining and others, and resume to the informal salaried sector to escape unemployment while queuing for a job offer in the formal labor market. However, informality is also composed of a group of workers that self-select into the informal sector, given their preferences, skills, and social norms. According to Perry et al. (2007), independent workers (self-employed and micro firm owners) differ significantly, in terms of motivation and preferences, from informal salaried and many do not actively look for a formal occupational nor would accept a formal job offer, given their minimal human capital[2]. There is also the case where self-employed choose to work in the informal sector because their options in the formal

[1] For a more in-depth discussion about the benefits of formality, see Perry et al. (2007)

[2] When considering gender, male's and female's self-employment preferences in Brazil differ even more. Tables 9, 10, and 11 in the Appendix present additional information on this topic

sector are at least equally poor.

2.2 Informal sector: Overall and gender specific facts for Brazil

From the 1980 until the year 2000, Brazil had experienced macroeconomic turmoil, alternating periods of recession and high inflation with stabilization programs and other policies. Within the same period, the Brazilian economy faced two major policy and institutional events, namely the Constitutional reform of 1988 and the trade liberalization episode of 1990, which evidence shows that both structural changes produced labor reallocation towards the informal sector (Bosch, Goni and Maloney (2007)). In 1987, the size of the informal sector comprised 34% of the active labor market. By the end of the period, the share of informal labor force increased approximately 10%. Extending to 2002, the expansion in the informal sector accounted for 87% of the jobs created (Hoek (2007)).

Informality behaved differently across gender during the decade, especially when considering the skill extension of each sector. Table 1 compares the share of each skill level in formal and informal labor markets and overall representation by each gender. Across the period 1991-2000, female share on informality has increased approximately 8% but the educational attainment for women has also increased in both sectors, which may have a positive effect on wages. Both low skill (less than 11 years of education or incomplete high school) men and women are over-represented in the informal sector, consistent with the models of Rauch (1991), in which individuals with low managerial ability choose to become workers and those with productivity smaller than the formal threshold take informal jobs and Albrecht, Navarro and Vroman (2009) that assumes heterogeneity of productivity among workers, concluding that the decision to accept an informal salaried job is dependent on the worker's productivity type.

Table 1 – Share of Informal Labor by Gender and Skill Level - 1991-2000

	Men		Women	
	1991	2000	1991	2000
Work Status				
Informality	0.524	0.492	0.224	0.302
Skill Level				
High Skill	0.160	0.202	0.185	0.256
Skill Level and Work Status				
Low Skill Informal	0.876	0.807	0.767	0.711
High Skill Informal	0.124	0.193	0.233	0.289
Low Skill Formal	0.769	0.691	0.560	0.439
High Skill Formal	0.231	0.309	0.440	0.561

Observations: Individuals with 18 to 64 years old.
Brazilian Demographic Census.

The differentiated behavior of informality across gender had an important sectoral and occupational component. Recent work has been made to emphasize on occupational and sectoral choice as a major part of the reduction in the gender wage gap in Brazil. If trade liberalization generates labor reallocation, especially from young and low skill workers, from tradable industries to non-tradable industries and informality, as supported by Menezes-Filho and Muendler (2011), and these workers settle in very distinct occupations, then job polarization and segregation across gender become an important feature of the gender wage gap debate, especially when considering the informal sector. Gaddis and Pieters (2017) found that the trade liberalization episode had larger impacts on gender differences in industries that had larger gender segregation due to the higher requirement of physical strength. Previously, Madalozzo (2010) argued that across the period 1978-2007, women have entered, to some extent, in traditionally male occupations in the formal sector, but traditionally female occupations remained stable. This finding is corroborated by Benguria and Ederington (2017). The authors show that microregions more exposed to Chinese trade from 2000 to 2010 saw larger declines in the gender wage gap, and this was primarily because female workers shifted towards higher-paying occupations and increasing returns of traditionally female occupations.

The allocation of formal workers across sectors presented in table 12 (in the Appendix) indicates distinct intensities in the manufacturing industries in Brazil, as same as in Paz (2014). Nevertheless, informality is concentrated in Agriculture, Apparel and Leather Manufacturing and Non-Tradable industries in the period 1991-2000. In the same period, Non-Tradable industries experienced an 8% increase in informality share, while Agriculture formality rate increased in the same proportion. Following Kovak (2013), if local labor markets specialize in a set of industries that were largely affected by tariff reduction policy, informality may rise in these regions as a way to compensate for increasing competition, especially if these regions were composed of industries that are labor-intensive in low skill workers, such as wood and leather manufacturing industries (Gonzaga, Filho and Terra (2006)).

Female share[3] has varied substantially across all sectors. Sectors with initial high female participation, presented in table 2 outside of agriculture, experienced an increase in the share of female workers[4]. According to Do, Levchenko and Raddatz (2014), trade liberalization is expected to improve women's labor market outcomes relative to men's in a country where female-intensive sector have a comparative advantage, through decisions on fertility, and possibly women's human capital investments, occupational choice, and bargaining power within the household[5]. Moreover, the informality rate within the female

[3] Information on the female share in all sectors is present in table 2, located in the Appendix section.

[4] The correlation between initial female share in 1991 and decennial difference in female share across sectors is 0.574.

[5] However, Gaddis and Pieters (2017) point out that the theoretical model of Sauré and Zoabi (2014) finds opposite predictions, thus yielding an additional question mark to the literature.

labor force in sectors with initial high female participation rose in the period 1991-2000. Notably, the share of informal females workers in Textiles Manufacturing increased twofold in the period 1991-2000.

Table 2 – Sector with highest female share - outside of Agriculture - and female informality rate - 1991-2000

	Female Share		Informality Rate*	
Industry	1991	2000	1991	2000
Apparel and Apparel Accessories Manufacturing	81.5	85.9	67.7	66.5
Textiles Manufacturing	45.7	51.5	27.1	56.4
Footwear and Leather and Hide Products Manufacturing	41.3	44.7	17.5	29.7
Non tradables	40.3	44.7	58.5	66.2
Agriculture	13.0	12.7	91.1	85.3

Observations: Individuals with 18 to 64 years old. Brazilian Demographic Census outside of public and defense services. * Females only.

Focusing on the occupational component, table 3 presents the number of occupations whose sum of shares is equivalent to a threshold percentage value, which is 25%, 50%, 75%, 90%. In this sense, table 3 shows that the formal sector has a larger occupational heterogeneity for both genders relative to the informal sector. For males in the formal sector in 1991, 12 occupational levels represent half of the male labor force and, for women, 8 occupational levels constitute 50% of the female labor force. In the informal sector in 1991, 3 and 5 occupational levels represent half of the labor force for men and women, respectively. Additionally, men in both sectors are more disperse across occupations relative to women and this pattern remains the same in the period 1991-2000.

In particular, Perry et al. (2007) argue that the profile of informal salaried workers is largely comprised of domestic employees, which are almost exclusively women, unskilled workers such as salesperson, clerks, and beauticians in small enterprises and workers in larger firms who are under informal labor arrangements. The authors also list a group of characteristics that are more strongly correlated with informal employment which is firm size, education, industry, sector (construction, agriculture, retail, and transport), tenure (less than one year), age (youth predominantly informal salaried, self-employed mostly older workers), and women's household status (married women with children). We find support for this claim in table 15, located in the appendix section.

Table 3 – Share of worker by number of occupations - 1991-2000

	Formal Sector				**Informal Sector**			
	Men		Women		Men		Women	
	1991	2000	1991	2000	1991	2000	1991	2000
p. 25	3	3	3	2	1	1	1	0*
p. 50	12	16	8	8	3	6	5	5
p. 75	43	53	22	22	16	36	18	17
p. 90	97	112	56	62	54	93	46	43
N**	342	373	338	365	372	372	370	358

Notes: Each cell represents the number of occupations
whose sum of shares is equivalent to threshold percentage value.
* Zero occupations means that the job with the highest share
has a larger percentage share than the threshold value.
** N represents the number of occupational levels. Occupation
codes from Demographic Census of 1991.

Concurrently with the rise of informal salaried and self-employed workers, the proportion of small-sized firms increased during this period. Figure 2 present the share of firms by firm size across our sample period with 9 categories, ranging from very small firms (less than 5 employees) to very large firms (more than 1000 employees).

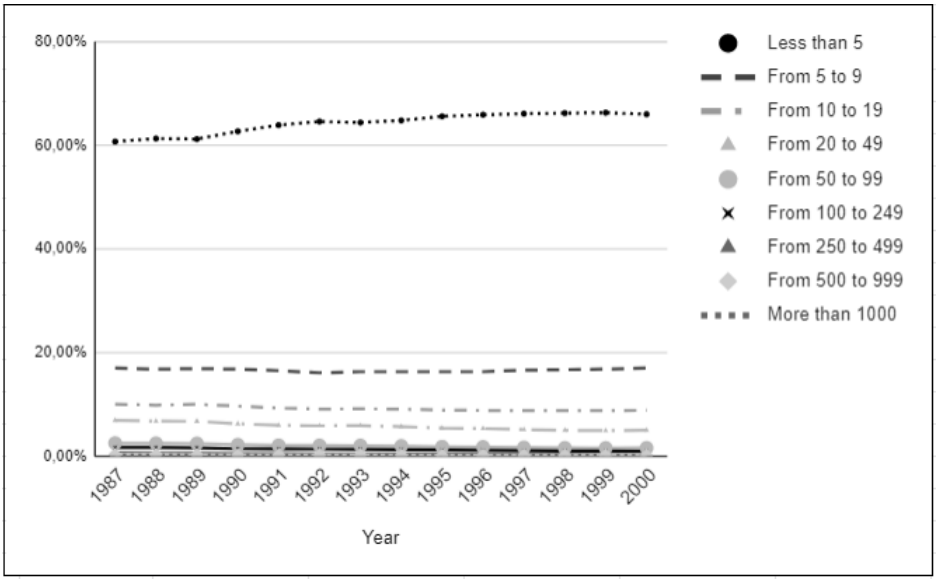

Figure 2 – Share of firms by each firm size cohort - 1987-2000

Observation: *Relação Anual de Informações Sociais* (RAIS) - Establishment Data

While firms with more than 5 employees remained relatively with the same share across the 1990s, firms with less than 5 employees experienced an increase in participation of 6% by the end of the period. Evidence from Dix-Carneiro and Kovak (2017) show that trade liberalization affected the establishment size distribution by slowly adjusting

capital between harder hit and lighter hit regions, reducing the average establishment size. Moreover, as discussed in section 2.1, small firms are closely related to informality[6] because, given their low productivity, they benefit the least from the advantages of formality. Furthermore, Ulyssea (2020) argues that formal firms with a larger number of employees should have a lower share of informal workers, otherwise they would become too visible for fiscal and labor authorities.

When we dissect the share of workers by gender across firm size in figure 3, we find that female participation in very large firms (+ 1000 employees) increased by almost two-fold in the decade. This gives some support to the theoretical model of Juhn, Ujhelyi and Villegas-Sanchez (2014), who predicts that very large (and exporting) firms[7] benefit from the trade liberalization by gaining access to cheaper new technology, which improves the production process and increases demand for female labor in blue-collar occupations.

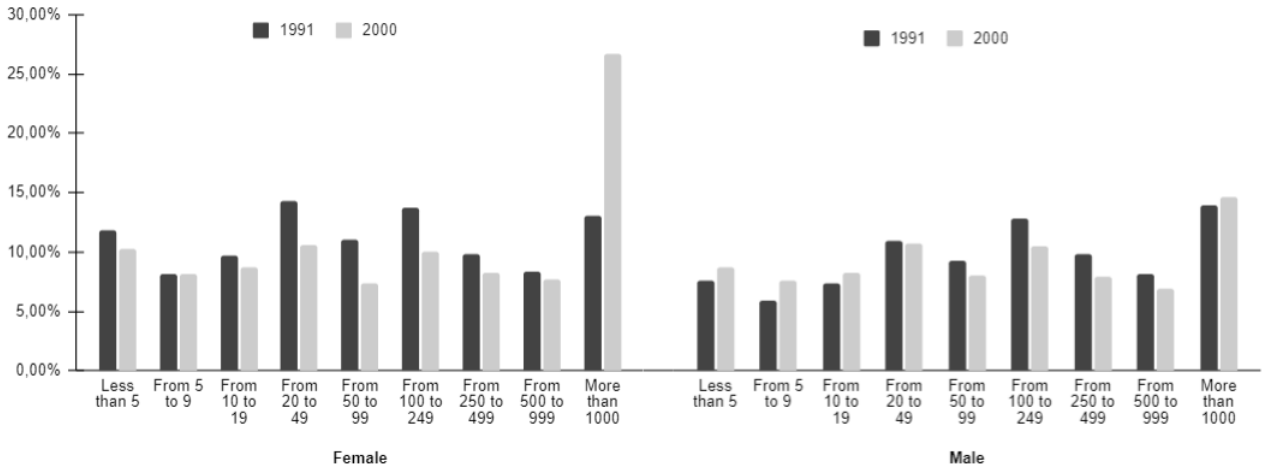

Figure 3 – Share of workers by gender at each firm size cohort - 1987-2000

Observation: *Relação Anual de Informações Sociais* (RAIS) - Establishment Data

In addition, larger firms employ more capital (Paula and Scheinkman (2011)) relative to smaller firms and, if trade liberalization provides access to more advanced (or cheaper) inputs[8], then more productive (larger) firms would invest in new technologies, as in Bustos (2011) for the case of Argentina, and under a high complementarity between capital and female labor, which is an assumption in the model of Sauré and Zoabi (2014), female employment share should increase in larger firms.

[6] International Labor Organization (ILO) defines informal employment as any job in a firm with 5 or fewer employees.

[7] Because we do not identify which firms are exporters or not, we assume that, on average, exporting firms have high productivity and are larger than non-exporting firms or, at least, have a higher capital-labor ratio than non-exporting firms.

[8] Evidence for Brazil (Lisboa, Filho and Schor (2010)) appear to agree with this point.

2.3 How trade impacts the informal sector

Trade produces ambiguous results regarding labor market outcomes in the informal sector. On one hand, trade liberalization produces differentiated effects based on where firms are on the productivity spectrum. In line with Melitz (2003), trade liberalization induces more productive firms to engage in exporting activities while least productive informal firms exit the market. This process increases the labor demand of new trading firms, increasing employment share and wages in the formal sector. Implications for the informal sector arise from the productivity differential for formal and informal firms. As formal firms become larger in industries with initially higher levels of productivity faced with larger tariff reduction, labor should shift toward these larger firms, increasing formal employment share and reducing informality rate[9]. Aleman-Castilla (2006) found evidence for Mexico's trade liberalization episode that industries with higher levels of import penetration after a reduction in import tariff presented lower informality rate and a reduction in US import tariff produced a larger decrease in informality rate in export-oriented industries.

On the other hand, the possibility to import cheaper input and final goods exercise some competitive pressure on domestic suppliers by either reducing prices or improving a variety of goods (Broda and Weinstein (2006); Perry et al. (2007); Loecker et al. (2016)). This process drives less productive firms out of business[10] or generates incentives to use less expensive factors of production. One way a formal firm can accomplish this is to incorporate an increasing amount of informal workers to reduce labor costs. Ulyssea and Ponczek (2018) entitle this as the intensive margin of informality. In this margin, formal firms respond to tariff cuts by firing costly formal workers and hiring informal workers, which provide more flexibility in the adjustment of the labor force. Cruces, Porto and Viollaz (2018) provide theoretical and empirical support for the intensive margin, finding evidence that Argentina's trade liberalization policy of tariff reduction produced an increase in labor informality, especially in industries with a larger share of small firms.

Early research did not seem to find evidence of the relationship between trade liberalization and informality for Brazil. Notably, Goldberg and Pavcnik (2003) argued that the competitive view, where foreign competition induces firms to hire informal workers to reduce labor cost, consequently increasing the firing rate of the formally employed, was a possible explanation in the case of Brazil. In their model, trade liberalization led to an increase in informality. Nonetheless, the authors did not find results that established a relationship between tariff reduction policy and informal employment. Menezes-Filho and Muendler (2011) discussed a mix of the views, where trade reform generates productivity

[9] McCaig and Pavcnik (2018) provide evidence for the effects of trade liberalization on labor reallocation across firm sizes.

[10] Ponczek and Ulyssea (2017) address this as the extensive margin of informality.

growth at firms that survived the foreign competition and also provide access to foreign inputs. However, their results indicate that exporters firing rate is considerably larger than the average employer, and labor transitioned out of formality. Finally, Dix-Carneiro and Kovak (2019) claimed that import competition could create a situation where firms must reduce labor costs in order to stay active. Empirically, the authors found that harder-hit regions by the tariff reduction policy faced larger increases in informal employment after a long period of non-employment. In sum, although the first view has some empirical support in other countries, in the case of Brazil, the view that foreign competitive pressure reallocated capital and labor towards informality seems more plausible.

3 The Model

The model draws ideas from Melitz (2003), but since we implement the informal sector dimension, we follow Becker (2018) more closely. And since the analysis focuses on the trade liberalization episode through the lens of a productivity shock, we draw some insight from the theoretical model of Bustos (2011) and empirical evidence of Lisboa, Filho and Schor (2010).

There are two sectors. The formal sector is assumed to be in monopolistic competition, which is traditional in the literature that follows Melitz (2003). Heterogeneity within the formal sector arises from differences in the productivity of firms. Nevertheless, every firm in the formal sector has a higher productivity level than any informal firm. The economy consists of L units of labor, which is inelastically supplied, where it divides into female labor l_w and male labor l_m, both in the formal sector and informal sector. Formal firms only employ formal workers[1] and informal firms employ exclusively informal workers. Additionally, firms are also one of two types: discriminatory and non-discriminatory. Yahmed (2017) uses an exogenous distribution of discrimination in which firms are more or less discriminatory. Here we treat discrimination as a binary component.

Becker (2010) argues if there are enough non-discriminatory firms, then discrimination is competed away from the labor market. For the sake of theoretical results, it is initially assumed that there is a sub-optimum number of non-discriminatory firms in the formal labor market, which consequently presume the existence of discrimination. Since firms are heterogeneous in productivity and binary in discrimination, discriminatory firms are, on average, less productive than non-discriminatory firms. This assumption, while it does not directly produce any results, states that any exogenous change in market conditions should have larger effects on discriminatory firms than on non-discriminatory firms along with the productivity distribution.

3.1 The Setup

Final output follows a constant elasticity of substitution (CES) production function:

$$Y = [M^{-(1-\rho)} \int_{v \in V} q(v)^{\rho} \, dv]^{\frac{1}{\rho}} \tag{1}$$

Good varieties are represented by v from the set V, which represent the mass of available goods M. $\sigma = \frac{1}{1-\rho}$, with $\rho \in (0, 1)$ is the elasticity of substitution between goods.

[1] Although Ulyssea and Ponczek (2018) found an important response of the intensive margin of informality following trade liberalization, our model is based primarily on the extensive margin.

In addition, $q(v)$ is the quantity of variety v.

The price index of the final output is:

$$P = [M^{-1} \int_{v \in V} p(v)^{1-\sigma} \, dv]^{\frac{1}{1-\sigma}} \tag{2}$$

Where $p(v)$ is the price of variety v. To simplify the model, we normalize the price index to 1 and assume perfect competition on the factor markets, so that wages reflect the marginal product of labor. The demand for variety v is given by:

$$q(v) = \frac{Y}{M} p(v)^{-\sigma} \tag{3}$$

Firms in the formal sector that are under monopolistic competition face the demand of their variety v as in equation 3.

3.2 The informal and formal sector

As stated in section 3.1, formal firms are under monopolistic competition in the product market. Based on previous discussions on the informal sector, informality more closely resembles a competitive than an oligopolistic market structure. It is mainly composed of small and low productive firms with little restriction of entry and exit, both in firms and labor sense, who produce fairly similar low-quality products to low-income customers (Porta and Shleifer (2014)). However, Becker (2018) assumes that the informal sector also is under monopolistic competition, and given that our model draws heavily from his, we also take on this assumption.

Entry in each sector is a voluntary decision of the firm and generates a fixed cost on entry of f. Production in the informal sector requires taking on a fixed cost of f_i, and similarly, in the formal sector, fixed cost of production is f_f. A common assumption is that $f_f > f_i$ in order to illustrate the additional cost of formality.

Firms in each sector produce a unique variety of goods. Thus, the mass of available goods can be divided into $M = M_f + M_i$[2], which is the number of domestic firms. Additionally, firms differ in their productivity levels (φ) and, given that only input is labor l, firm's output is linear labor input and productivity level, therefore, $q = \varphi * Q(l_w, l_m)$, where $Q(l_w, l_m) = l_w + l_m$ is a production function that employs male and female labor. As mentioned in section 2.1, informal firms are, on average, less productive than formal firms. To illustrate this in the model, assume that only an exogenous share $\lambda \in (0, 1)$ of contracts in the formal sector are enforced. Therefore, the actual productivity of formal firms is given by $\frac{\varphi}{1-\lambda}$.

[2] The subscripts f and i are used to describe formal and informal sectors, respectively.

Additionally, firms in both sectors maximize profits by charging a constant markup $1/\rho$ over marginal cost. We assume that wages are associated with a firm's productivity, thus, salaried informal workers always earn less than their formal counterpart[3]. The profit-maximizing prices for informal and formal firms are, respectively:

$$p_i(\varphi) = \frac{w_i(\varphi)}{\rho\varphi} \tag{4}$$

$$p_f(\varphi) = \frac{w_f(\varphi)}{\rho\frac{\varphi}{1-\lambda}} \tag{5}$$

Given the profit-maximizing prices, the profit functions for informal and formal are, respectively:

$$\Pi_i(\varphi) = q(v)p_i(\varphi)^{1-\sigma} - f_i \tag{6}$$

$$\Pi_f(\varphi) = q(v)p_f(\varphi)^{1-\sigma} - f_f \tag{7}$$

As in Becker (2018), the number of firms operating in the domestic market M is negatively correlated with each firm's revenue. An increase in domestic competition through the increase in M reduces the demand for each variety produced by every individual firm. On the other hand, a productivity increase as a result of the access to new and better quality input has a positive effect on revenue. According to Paula and Scheinkman (2011), informal firms are smaller and are less productive than formal firms, therefore, trade liberalization should produce a heterogeneous effect on revenue, and consequently, on profits across establishments with different sizes, in which input improvement effect should dominate on large formal firms and competition effect on smaller firms. Additionally, Yahmed (2017) states that discriminatory firms are, on average, less productive than non-discriminatory firms. By comparing both types of firms, the competition effect should have a larger effect on discriminatory firms than in non-discriminatory firms, which is a common prediction of Becker (2010).

Discrimination in our model arises from the existence of discriminatory firms, which in turn is captured by assuming that employers get a disutility penalty from hiring female workers. Given the marginal cost of each firm, a discriminatory employer will hire women only if the difference between female and male wages compensates the loss in utility, same as in Yahmed (2017). Therefore, discriminatory firms will only practice taste-based discrimination if $w_m - w_w \leq z$. In this sense, if discriminatory firms have the same profit at a certain productivity level as non-discriminatory firms, the utility-maximization problem of the firms assumed by Becker (2010) differ due to the presence of a coefficient

[3] Although labor market segmentation literature states that informal workers should earn more given the lack of work-related amenities, however, there is evidence that this is not the case (Botelho and Ponczek (2011)).

of discrimination. The utility function[4] for discriminatory and non-discriminatory firms are, respectively:

$$U_f^d(\varphi, \delta) = \Pi_f^d(\varphi) - \delta(z) \qquad (8) \qquad\qquad U_f^{nd}(\varphi) = \Pi_f^{nd}(\varphi) \qquad (9)$$

The parameter z is the coefficient of discrimination, obtained from some function $\delta(z)$. To simplify the model, in autarky, discriminatory and non-discriminatory firms have the same profit functions. In terms of utility, discriminatory employers derive disutility from hiring female workers. In this case, wage differential will arise if the fraction of discriminatory firms is large enough so that the demand for female workers at equal wages is less than the supply. Consequently, there will be a large portion of women without an active occupation or making a relatively smaller wage. Within our framework, wages are a function of the firm's productivity[5], and therefore, given that discriminatory firms have, on average, lower productivity than non-discriminatory firms, an additional prediction states that wage differential should be smaller on larger firms[6] (Oi and Idson (1999)).

3.3 The effect on trade liberalization on productivity and formality status

In a closed economy, firms in both sectors operate within their productivity thresholds. However, following a trade liberalization episode, which in our model is represented by a reduction in nominal import tariff, formal productivity cut-off increases, given the competitive effect of trade and access to cheaper and better quality input[7]. Lisboa, Filho and Schor (2010) find supporting evidence from Brazil in the direction of the impact of trade liberalization on both the input market and competitive effect[8].

Figure 4 illustrates the effects of trade liberalization on the productivity cut-offs. Initially, overall productivity shifts positively along the productivity spectrum. As a result of this effect, the least productive informal firms exit the market. Additionally, formal firms face an increased number of foreign competing goods in the domestic market, which reduces profitability. As some formal firms informalize[9] their activities to stay active in the

[4] The superscript "d"and "nd"refer to discriminatory and non-discriminatory firms, respectively.
[5] Alvarez et al. (2018) shed some light on firm productivity and wages, with evidence from Brazil.
[6] Heinze and Wolf (2010) argue that larger firms are more likely to have market power than smaller firm, and relative to firm size, discrimination may have a larger effect on concentrated markets.
[7] Topalova and Khandelwal (2011), for India; Bustos (2011), for Argentina.
[8] Additionally, the authors found more pronounced effects of the reduction in input tariff in capital-intensive industries, which is an important margin given the discussion on section 2.2, where females workers have a higher complementary with capital.
[9] In the model, informalization is a binary decision. Either firms are formal, i.e, employ workers following all labor regulations, or informal. Therefore, we do not consider here the intensive margin of informality, defined in Ulyssea (2020).

domestic market, the informal sector also faces an increase in competition, which pushes the informal productivity cut-off.

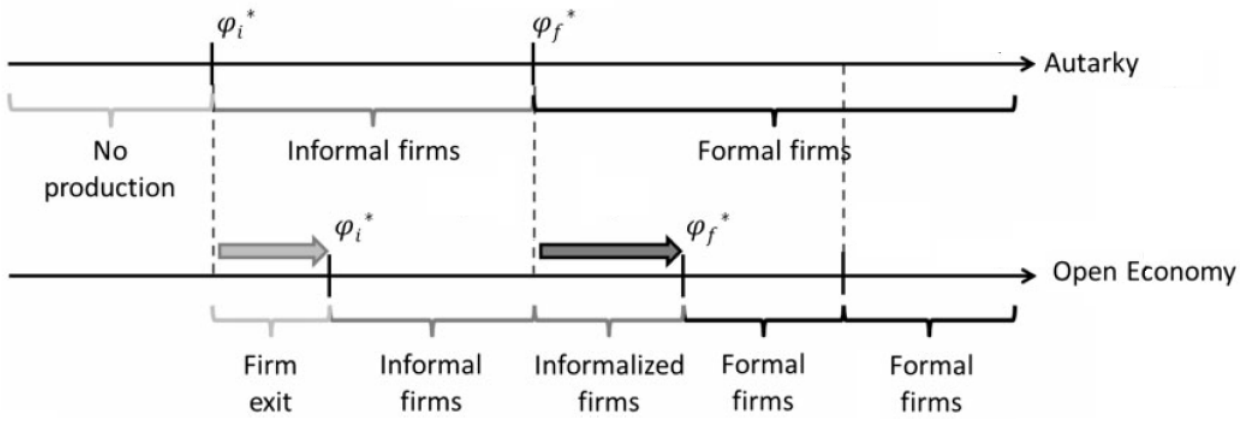

Figure 4 – Change in productivity cut-offs following trade liberalization

Observation: Figure from Becker (2018) with adaptions.

At productivity levels below φ_i^*, no firm finds it profitable to produce, therefore, they do not enter the market. Along the margin between the informal productivity cut-off φ_i^* and the formal productivity cut-off φ_f^*, informal finds have higher profits than formal firms. Within the framework of the model, this is the case where firms on the left side of φ_f^* and just above the zero-profit cutoff level (henceforth, φ_{π_0}) are barely productive enough in order to be profitable in the formal sector, thus cannot take advantage of the benefits of formality. On the right side of φ_f^*, larger and more productive firms are able to take advantage of formality, by benefiting from access to cheaper credit and new clients, also the avoidance of paying bribes and fines, and the ability to grow within the compliance of the law (Perry et al. (2007)).

As we assumed in section 3.2, discriminatory firms have the same profit function as non-discriminatory firms at the same productivity level. However, non-discriminatory firms are, on average, more productive than discriminatory firms (Yahmed (2018)). Given this assumption, in the productivity spectrum, it is more likely to find a discriminatory firm at the lower end of the distribution than a non-discriminatory firm. Therefore, a productivity shock that increases formal productivity cut-off may increase the displacement of formal firms into informality. In this case, if a substantial amount of discriminatory firms becomes informal, then one could expect a reduction in discrimination in the formal sector and an increase in discrimination in the informal sector. We will expand on this discussion in the following section.

3.4 Effects on discrimination

At the autarky formal productivity cut-off, the marginal firm could be either discriminatory or non-discriminatory. In particular, the margin between autarky and open economy formal productivity cut-offs incorporates informalized firms which are also either discriminatory or non-discriminatory. In light of this assumption, the following proposition states:

Proposition 1. *There is a finite number of* $\boldsymbol{N}$ *firms between the autarky and open economy formal productivity cut-offs that informalized their activities. In addition, each firm can be either discriminatory or non-discriminatory.*

The reallocation of formal discriminatory firms to the informal sector should increase discrimination even if we assumed a competitive setting. If N firms informalized their activities, but there are not discriminatory firms, then the coefficient of discrimination in the informal sector would not change. On the other hand, if all the firms that became informal were discriminatory, then the informal sector would have a substantial[10] increase in discrimination, measured by either employment or wage differential. The following proposition summarizes this point.

Proposition 2. *In the informal sector, the gender wage gap should increase if there are* $\boldsymbol{n} \leq N$ *discriminatory firms between the autarky and open economy formal productivity cut-offs that informalized their activities.*

Following Becker (2018), the marginal firm is indifferent between entering the informal or formal sector. In our framework, the marginal firm can also be either discriminatory or non-discriminatory. Following proposition 2, the number of discriminatory firms that entered the informal sector can be any integer in the interval $n \in [0, N]$. Therefore, as stated in proposition 2, the size of the increase in discrimination in the informal sector is positively correlated with the number of discriminatory firms that engaged in informality. However, an especial case arises from this fact, which is given by proposition 3:

Proposition 3. *If* $\boldsymbol{N - 1}$ *firms within the between the autarky and open economy formal productivity cut-offs were non-discriminatory firms but the* N^{th} *firm was discriminatory, then the gender wage gap should increase relative to the distance between the highest productive discriminatory firm that became informal and the marginal firm.*

In this case, the overall effect of trade liberalization on import competition and, thus, on productivity is indicative of the impact predicted by proposition 3. If local labor

[10] Notice that the amplitude of the change in discrimination is unknown. Our model focuses more on the direction of change relative to pre-liberalization levels. However, one can expect that a positive relationship between the number of discriminatory firms and discrimination.

markets facing a larger tariff reduction – especially if it has concentrated industries – has a greater increase in the formal productivity cut-off, then small and mid-size firms could be pushed out of the formal sector and into informality. Dix-Carneiro and Kovak (2017) provide evidence for Brazil on the effects of trade liberalization the reallocation of capital between local labor markets. In their findings, larger tariff declines increased exit rates throughout the establishment size distribution. Additionally, the decline in the number of formal firms was compounded by the reduction in the average size of remaining establishments. Pavcnik (2002) finds similar evidence for Chilean firms following trade liberalization.

Given our limitations in the observation of formal firms across time, especially when they enter informality, our empirical strategy will focus on the result of workers in both sectors from each local labor market. This approach, although not ideal to test the predictions of our model, provides sufficient reasoning of the effects of trade liberalization on the formal and informal gender wage gaps, with theoretical support of Becker (2010) taste-based discrimination model, regarding the impact of foreign competition on discrimination in the formal sector and empirical support of Ferreira and Rossi (2003) and Lisboa, Filho and Schor (2010), along the lines of change in overall and firms productivity, respectively.

4 Methodology

4.1 Data

Data from *Censo Demográfico* of the years 1991 and 2000 are the main sources of information for this work. The information involves gender, age, experience, number of hours in the contract, educational level, categories (3 digits) of occupations referring to the Brazilian Classification of Occupations (CBO - Dom), and, especially, formality status. Formal workers are the ones who reported to have a job with a work card, which is a document provided by the Ministry of Labor that regularizes work activity. Workers without a work card are considered informal. Informality, in this sense, has two categories: salaried informal work and self-employed. As discussed in section 3.1, workers may have different motivations for why they have an informal occupation. Voluntarily in the informal sector may give rise to selection bias. Perry et al. (2007) and Yahmed (2018) argues that self-employed individuals have a larger tendency to being voluntarily informal, given their preferences. Therefore, we exclude self-employed individuals from our analysis.

In addition, the categories of the activity sectors are detailed through the classification of subsectors of the Brazilian Institute of Geography and Statistics (IBGE). In order to standardize with the tariff data, we have added 20 tradable sectors and 1 non-tradable sector, similar to Kovak (2013), so that we can have a consistent industrial classification over the years. The main variables of interest are wages and employment levels. Monetary values are deflated using the National Consumer Price Index (INPC) for the year 2000.

The sample is restricted to individuals between 18 and 64 years of age who had positive wages and occupation and activity sector well defined by CBO-Dom and Subsectors IBGE, respectively. Workers employed in public administration and occupations linked to national defense (military, police, and firefighters) are excluded. To control the spatial dimensions used in the work, the concept of Minimally Comparable Areas (AMC) will be used, which makeup economically integrated and geographically similar municipalities and which are consistently comparable over the years. Each microregion represents a local labor market, which makes it possible to analyze the effects of trade policy on regional variations. During the period, there are 442 microregions and 108 mesoregions.

The data referring to nominal tariffs at Level 50 of industrial classification for the period between 1987 and 1999, similar to the Standard Industrial Classification (SIC), were obtained from Kume, Piani and Souza (1990), tabulated by Abreu (2011). The measure of the effects of liberalization on prices (tariff change) follows the literature for Brazil, more specifically, follows Kovak (2013), which uses the logarithmic difference in tariffs between

1990 and 1995.

4.2 Tariff policy shock on regional labor markets

The literature analyzing tariff shocks under local labor markets is based on the fact that liberalization induces a change in relative prices in the region. As the regions specialize in different productive activities and, therefore, differ in their industrial compositions, the tariff reduction will generate varied effects under the regional markets. In essence, the shocks induced by trade affect the demand for labor in the regions, so that the localities that have been subjected to greater tariff cuts should, in theory, have more expressive effects on the labor markets relative to the locations that have experienced lower tariff cuts. One example is the work of Dix-Carneiro and Kovak (2015). They found that, on average, the regions that faced a 1% greater reduction in tariffs saw a 1.3% higher decline in the regional premium during the 1991-2000 period. About to the model of local tariff shocks, we followed Kovak (2013) and defined the regional shock of demand for labor as:

$$\sum_i \beta_{ri} \hat{P}_i \tag{10}$$

$$\beta_{ri} = \frac{\lambda_{ri} \frac{1}{\theta_i}}{\sum_{j \in T} \frac{\lambda_{rj}}{\theta_j}} \tag{11}$$

The regional shock of demand for labor is the sum of the effects of the price changes induced by liberalization for each industry, weighted by the relative weight of the industry i in relation to the regional industrial composition, with greater weight for the sectors that have a greater participation initial work in a region. The subscript r indexes the regions, i indexes the industries, T is the set of all tradable industries (20 industries).

The variable λ_{ri} represents the initial proportion of workers in the region r allocated in sector i and we calculated it using the information from the 1991 Demographic Census. The variable θ_i is equivalent to the share in the cost of the sector-specific factor [1]. To calculate θ_i, we followed Kovak (2013), which considers the industry's i payroll share to be minus one, with data from the National Accounts (IBGE) for the year 1990. Finally, $\hat{P}_i$ measures the vector of price changes induced by liberalization for an i industry.

The vector of proportional price changes $\hat{P}_i$ can be calculated by changing tariffs during the liberalization period. The period 1990-1995 was considered as the period in

[1] Kovak (2013) warns that there are no (credible) estimates for the elasticity of labor demand in the industrial and regional sphere in Brazil and, therefore, considers that all industries use Cobb production functions -Douglas and $\theta_{ri} = \theta_i$.

which most of the trade opening reforms took place. Thus, the regional change in tariffs (RTC) is given by:

$$RTC_r = \sum_{i \in T} \beta_{ri} \hat{P}_i \tag{12}$$

$$\hat{P}_i = d\ln(1 + \tau_i) \tag{13}$$

Concerning equation 13, τ_i represents the nominal rate of the industry i, obtained in Kume, Piani and Souza (1990), d is equivalent to the difference of the type *long* between the 1990 and 1995 tariff levels. Thus, the variable RTC_r should be understood as the average variation in tariffs in the region r, weighted by the participation of labor in each sector of r. In this sense, the regions that have an industrial structure composed of sectors that have undergone greater tariff reductions have lower (more negative) values of the variable RTC.

Figure 5 shows the spatial distribution across microregions of the regional tariff change. Darker microregions represent a more negative region-level tariff change, while lighter regions faced smaller tariffs cuts.

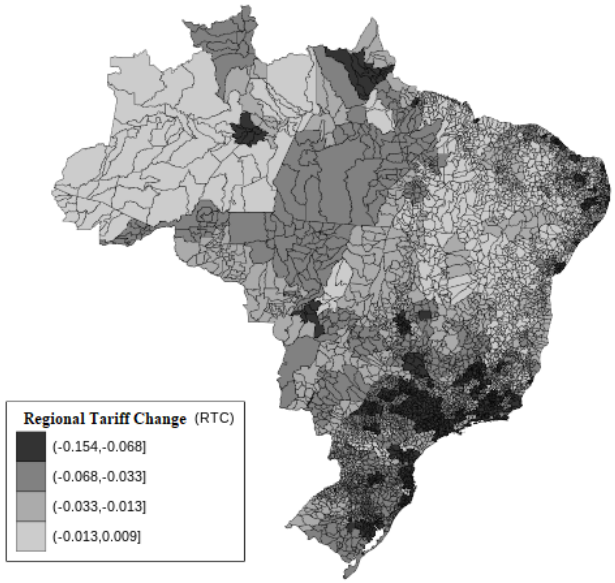

Figure 5 – Region-level tariff change

The evolution of regional wage differentiation in response to the liberalization shock is mainly determined by the mobility of the labor factor. As long as there is no cost of moving the labor factor across regional borders, then the migration process will arbitrate any difference between the levels of regional wages and the effect of tariff reduction on regional labor will tend to be zero. In this way, a microregion facing a greater tariff

reduction slower growth in wages over the years than a microregion facing a lower tariff reduction. In the context of wage differentiation between genders, this approach allows assessing the role of liberalization shock under the wage trajectory of men and women, assuming that they have the same degree of regional mobility over time.

4.3 Empirical strategy

Our empirical strategy is divided into two sections: first, we estimate Mincerian regressions for each sector to obtain the conditional gender wage gap in the formal and informal local labor markets for 1991 and 2000. In sequence, we obtain the conditional gender wage gap coefficients from the regressions and estimate a decennial difference between the coefficients on the regional tariff change measure. Hirata and Soares (2020) used the same strategy to investigate the effects of trade liberalization on the conditional racial wage gap.

Second, we use the Oaxaca Blinder decomposition to test the effects of trade liberalization on the discrimination, i.e. unobserved differences in wages, initially without two-step sample selection correction, but including it after. This serves not only as a robustness check but provides an additional discussion on the possible confounding effects of selection bias on our estimates.

4.4 Conditional gender wage gap

In the first stage, we estimate Mincerian log wage regressions separately for the formal and informal sectors at each year by OLS. The main specification is:

$$lnw_{irt} = \beta_t \mathbf{X}_{irt} + \sum_r \delta_{rt} \text{male}_{irt} \cdot \text{microregion}_{rt} + u_{irt} \tag{14}$$

The subscripts i, r, and t represent individual, microregion, and year, respectively. In this framework, X_{irt} is the set of independent variables that comprehend age, years of education, dummies for occupation and industry. Additionally, we use an interaction between a set of microregion dummies and a dummy indicating males (male = 1) to capture the conditional gender wage gap for a formal (informal) local labor market r in year t. Hirata and Soares (2020) argue that the coefficient δ_{rt} expresses the wage advantage of a male worker relative to a female worker with similar observable characteristics. In particular, we estimate the regression for each sector so results can only be comparable accordingly because informal workers have, on average, lower education, are not in prime-age (either young or old), and work in smaller businesses. Therefore, if there is any degree of labor market segmentation, then equally comparable workers from each sector should present a wage differential due to different returns on their observable attributes.

In the second stage, the difference in the conditional gender wage gap between the year t and the base year (1991) was estimated in relation to the liberalization shock (RTC_r). In this specification, the fixed effects by state (α_{st}) were added and the standard errors of the regression were clustered at the mesoregion level. Also, we weighted the second stage regression with the inverse of the standard error of $\Delta(\hat{\delta}_r)$. Thus, the equation is given by:

$$\hat{\delta}_{rt} - \hat{\delta}_{r,1991} = \alpha_{st} + \gamma_{rt} RTC_r + \epsilon_{rt} \tag{15}$$

The variable of interest in the second stage is the coefficient γ_{rt}, which captures the effects of change in relative prices, given a reduction in average nominal tariffs, on the demand of labor for each sector. A microregion facing a greater tariff reduction will experience increased import competition across time than a microregion facing a lower tariff reduction. Following Becker (2010) theory of taste-based discrimination, in the context of gender wage differentiation, a higher level of competition in final goods market should increase the cost of discrimination which, in turn, would improve women's labor market outcomes in the formal sector and result in $\gamma_{rt} > 0$. Our model predictions suggest that the entry of informalized discriminatory firms on the informal sector would produce the opposite effect, where labor market outcomes would worsen for women. Therefore, for the informal sector, we should expect $\gamma_{rt} \leq 0$.

In order to capture the effect of trade liberalization on concentrated local labor markets, we use Ferreira and Facchini (2005)[2] data on industry concentration. The authors used four-firm concentration (CR4), which measures the share of sector revenue appropriated by the four largest firms. To fit the data to our measure of local labor markets, we collected the share of workers in each sector and calculated the weighted sum along with the CR4 index, similar to the calculation of regional tariff change. The theory of taste-based discrimination of Becker (2010) predicts discrimination persists with the presence of pure economic rents. Discriminatory employers, when shielded from competition, are able to maintain less preferable labor market outcomes for women. Therefore, trade liberalization should have larger effects on concentrated local labor markets. However, the coefficient measuring the effect of trade liberalization relative to market concentration should be significant only in the formal sector. This is because the informal sector is composed largely of small and low productive firms, thus with very little market concentration. Also, according to Becker's theory, discrimination is likely to be greater in labor markets with initial high female participation. Our analysis focus on tradable industries, given the direct effect of trade liberalization, and therefore, on the regression framework, we use female participation in tradable industries in 1991 as a control for initial female

[2] Black and Brainerd (2004) used a similar strategy to evaluate the effect of import competition on concentrated markets in the United States. For Brazil, Hirata and Soares (2020) used the same data and strategy as described to .

participation. In essence, these controls are used on the regression framework to extend the body of predictions of taste-based discrimination theory in regards to the effects of trade liberalization.

Our model predicts that wage differential should be smaller in larger firms due to the relative scarcity of discriminatory firms in high productivity levels. Therefore, microregions with a larger initial share of small firms (less than 10 employees) should have a greater decrease in conditional gender wage gap in the formal sector, due to the process of reallocation of discriminatory formal firms to informality, while in the informal sector, microregions with a larger initial share of small firms should present a higher increase for the same reason. To test this hypothesis, we use data about establishment from *Relação Anual de Informações Sociais* (RAIS) to retrieve information on the share of small firms in each microregion in 1991.

4.5 Oaxaca-Blinder decomposition

To test the hypotheses that foreign competition reduces discrimination in the formal sector and increases discrimination in the informal sector, the Oaxaca Blinder decomposition was used to evaluate changes in wages across the period 1991-2000, for workers in each of the sectors. The Oaxaca Blinder decomposition[3] can assess the average wage differential in two components: An "explained"component that measures wage differentiation by differences between the observable characteristics of each group, such as education, age, or occupation; and another residual component that measures wage differentiation for groups of "unobservable"characteristics. Empirically, the decomposition OB[4] is calculated using:

$$W_M - W_F = \overline{X}_M(\hat{\beta}_F - \hat{\beta}_M) + (\overline{X}_F - \overline{X}_M)\hat{\beta}_M \tag{16}$$

$$W_M - W_F = \hat{\Delta}_S^{\mu} \quad + \quad \hat{\Delta}_X^{\mu} \tag{17}$$

The component $\hat{\Delta}_X^{\mu}$ is the part of the resulting differential that is explained by the differences between the observable characteristics - the predictors - of the groups. $\overline{X}_F$ and $\overline{X}_M$ represent the vectors with the mean values of the predictors for women and men, respectively, while $\hat{\beta}_M$ represents the vector of estimated coefficients for wage regression for men. On the other hand, the component $\hat{\Delta}_S^{\mu}$ is the "unexplained"part of the decomposition, which measures the contribution to the coefficients, including the difference

[3] For a detailed analysis of the decomposition methods, see Fortin, Lemieux and Firpo (2011).

[4] Male gender was used as a base category because it is assumed that men are paid according to their characteristics, while women suffer discrimination. If the categories were reversed, it would be assumed that women would be paid according to their abilities, but that men would be paid disproportionately more (O'Donnell et al. (2008)).

in the intercepts. This part of the decomposition is usually attributed to discrimination (Fortin, Lemieux and Firpo (2011)), however, Jann (2008) highlights the importance of recognizing that this component captures all potential unobservable effects.

$$\hat{\Delta}^{\mu}_{c,r,t} - \hat{\Delta}^{\mu}_{c,r,1991} = \alpha_s + \gamma_{rt} RTC_r + \epsilon_{rt} \tag{18}$$

The wage regressions of the OB decomposition are estimated using the categories[5] of education, age, age squared, industries, and occupations. Then, the change in each component for each microregion in the 1991-2000 periods was estimated in relation to the liberalization shock (RTC_r), weighted by the microregion population in 1991, along with the fixed effects at the level state (α_s).

4.5.1 Labor market segmentation and selection bias

The problem of selection bias arises especially due to the self-selection of low productivity workers into the informal sector (Perry et al. (2007)). This margin is even more relevant when evaluating each gender's motives regarding self-selection into informality. Tables 9 and 10 show that men are much more prone to self-select into informality for different reasons. While men reported the main reasons to enter informality were an expectation of higher earnings and an inability to find other jobs (using results from table 11), women's motives gravitate towards a complementary source of income and, more notably, flexibility to take care of the household. In this sense, one might expect a possible estimation bias, given different unobservable characteristics that lead men and women to enter formal and informal jobs. Blau and Kahn (2017) argue that selection bias is also likely to be influenced by the decision of the individuals whether or not they enter the labor market. Women are more likely to be out of the labor market for longer periods; therefore, selection bias might appear on this margin. Tto evaluate selection bias on the unemployment status, Yahmed (2018) estimates a multinomial logit model on the work statuses (informal salaried, formal salaried, non-employment), finding that having young children increases the probability of inactivity for women, while it reduces for men. This result is consistent with literature that finds a motherhood penalty on labor market participation (Becker (1985)) and provides additional support for the possible existence of selectivity bias.

To deal with selection bias with cross-section household survey data, we proxy unobserved factors by estimates of the relative probabilities that individuals work as formal and informal salaried and include these in the decompositions. This is a modification of conventional Heckman-selectivity corrections (Heckman (1979)). According to Perry et al. (2007), the extent to which this procedure corrects fully or partially for self-selection biases

[5] The standardization procedure proposed by Yun (2005) to circumvent the problem of the omitted group of categorical variables was used in the estimates

depends on the strength of variables that affect sector participation but not earnings. Therefore, the first-stage selectivity-correction regression draws some insight from Botelho and Ponczek (2011) and Yahmed (2018). Our set of variables included are the position in the household, the presence of children less than 16 years old, marital status, an indicator of lone mother, and an indicator of multiple occupations.

Along with the first Oaxaca-Blinder decomposition, the empirical strategy will estimate the decomposition controlling for endogenous selection into the formal and informal sectors. The inclusion of the controls of selection bias provides an extra margin of analysis, which we can explore the effects of selection bias on the observation of gender wage gaps. Both results will be present in the following results section.

5 Results

Table 4 presents the results from the estimation of the conditional gender wage gap. Column 1 shows the baseline estimation coefficient, without states fixed effects and educational variables. For Panel A, the coefficient is positive and significant, meaning that in the formal sector, trade liberalization had a reducing effect on the gender wage gap. To put this result into perspective, a region facing a 10% tariff reduction had a reduction of 3.63% on the conditional gender wage gap. Therefore, regions that faced larger reductions in tariffs presented a greater reduction in the conditional gender wage gap in the formal sector. In Panel B, we find the opposite result, showing a negative correlation between tariff reduction and the conditional gender wage gap. For the informal sector, a negative regional tariff change of 10% increases the conditional gender wage gap by 5.33%. The addition of state fixed-effects in column 2, in order to control for spatial heterogeneity, produces the same result, but in Panel B, the coefficient loses significance.

In column 3, we add controls for changes in skill level earnings. In panel A, the coefficient of the conditional gender wage gap is negative, but not significant. On the other hand, the conditional gender wage gap for the informal sector is negative and strongly significant. Thus, regions facing larger tariff cuts presented an increase in the gender wage gap in the informal sector.

The analysis of skill level controls informs additional results. The main theoretical framework that offers a causal relationship between trade and labor market outcomes for skilled is the Stolper-Samuelson theorem, a special case of the Heckscher-Ohlin (H-O) model. One of the conclusions that the model establishes is that trade has an inequality reducing effect in countries with abundant unskilled labor (*low skill*), which represents a large part of Latin American countries, including Brazil. This is because trade increases the (real) return on an abundant factor in a country, due to productive specialization, and reduces the return on other factors[1]. Considering factors such as skilled and unskilled labor, the return on unskilled labor in a country whose unskilled labor is plentiful will tend to increase after trade, and the return of skilled workers will tend to reduce, thus promoting a reduction in inequality (Harrison, McLaren and McMillan (2010)). The informal sector concentrates a larger share of low-skilled workers, while the formal sector has, on average, a higher share of high-skilled workers. The relative changes in labor demand by skill level are, at most, ambiguous in the informal sector. Our results appear to be in line with the predictions of H-O model, at least for the formal sector. However, as pointed out by Hirata and Soares (2020), there is hardly any consensus on the effects of trade liberalization on the returns to skill in Brazil.

[1] This result is known as the Stolper-Samuelson theorem. See Stolper and Samuelson (1941)

Table 4 – Conditional Gender Wage Gap - 1991/2000

	1991-2000		
	(1)	(2)	(3)
Panel A: Formal Sector			
RTC	0.363**	0.328*	-0.344
	(0.172)	(0.186)	(0.212)
Low Skill			0.077***
			(0.029)
High Skill			0.201***
			(0.052)
State Fixed-Effects	No	Yes	Yes
R^2	0.009	0.241	0.300
Panel B: Informal Sector			
RTC	-0.533***	-0.051	-0.852***
	(0.200)	(0.178)	(0.199)
Low Skill			0.150***
			(0.028)
High Skill			0.117**
			(0.049)
State Fixed-Effects	No	Yes	Yes
R^2	0.013	0.151	0.528

Notes: 441 microregions. P-values: * 10%; ** 5%; *** 1%

The effects of trade liberalization on the conditional gender wage gap with controls are shown in table 5. The result from column 1 in Panel A is the regression of the conditional gender wage gap on regional tariff change and market concentration. The coefficient is positive and significant for the interaction variable, which in turn represents that a 1% decrease in average regional tariff would lead to a 2.714% decrease in the gender wage gap in the formal sector; therefore a reduction in market concentration is correlated with a reduction in observable differences in pay. However, comparing this result with the informal sector in Panel B, market concentration does not seem to interact with the informal conditional gender wage gap. In column 4, when added the state fixed effects and the average change in log wage of high skill and low skill to the regressions, same as in table 4, only the regional tariff change (RTC) in the informal sector remains significant with the predicted sign.

As addressed in section 4, a relatively large initial share of female workers is correlated with higher levels of discrimination. Therefore, microregions with a larger share of female workers in 1991, especially in the tradable sector, should have a greater reduction in differences in wages in the formal sector, while in the informal sector, the opposite should happen. The coefficient of the interaction between regional tariff change and the share of females in the tradable sector is statistically insignificant for the formal sector, in panel A, but statistically significant and negative for the informal sector. Therefore, microregions

Table 5 – Conditional Gender Wage Gap - With Controls - 1991/2000

	1991-2000					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Formal Sector						
RTC	-0.193	0.045	-0.590	-0.564	-0.427	-0.683
	(0.356)	(0.334)	(0.483)	(0.370)	(0.331)	(0.471)
RTC * Market Concentration	2.714*		2.971*	1.147		1.224
	(1.620)		(1.633)	(1.590)	0.279	(1.603)
RTC * % Female Tradable		0.901	1.118		(0.874)	0.358
		(0.915)	(0.920)			(0.881)
State Fixed-Effects	No	No	No	Yes	Yes	Yes
Avg Change log Wage by Skill	No	No	No	Yes	Yes	Yes
R^2	0.014	0.016	0.017	0.336	0.335	0.336
Panel B: Informal Sector						
RTC	-1.002**	0.030	-0.325	-1.075***	-0.675**	-0.826*
	(0.404)	(0.378)	(0.548)	(0.346)	(0.310)	(0.440)
RTC * Market Concentration	2.098		1.660	0.889		0.726
	(1.841)		(1.852)	(1.489)		(1.500)
RTC * % Female		-2.027*	-1.906*		-0.802	-0.755
		(1.035)	(1.044)		(0.817)	(0.824)
State Fixed-Effects	No	No	No	Yes	Yes	Yes
Avg Change log Wage by Skill	No	No	No	Yes	Yes	Yes
	No	No	No	Yes	Yes	Yes
R^2	0.023	0.028	0.030	0.553	0.554	0.555

Notes: 441 microregions. P-values: *10%; **5%; ***1%

with a higher fraction of female workers in the tradable sector in 1991 experienced larger increases in the gender wage gap in the informal sector following the trade reform from the 1990s. Nevertheless, when we replicate these regressions along with additional controls, the estimates become statistically insignificant.

Table 6 replicates the same estimation as in table 5 but focusing on the effects of initial small firm (less than 10 employees) participation on the changes in the conditional gender wage gap. A corollary discussed by Perry et al. (2007) is that a high cost of entry into formality endogenously makes smaller firms choose less formality because they benefit less from it than more productive firms. Thus, a productivity shock, such as extensive trade liberalization policy, should intensify the process of informalization of small and mid-size firms, especially in local labor markets disproportionately affected by trade reform.

Table 6 – Conditional Gender Wage Gap - Small firm control - 1991/2000

	1991-2000					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Formal Sector						
% Small Firm	0.140*		0.142	-0.063		-0.170
	(0.077)		(0.111)	(0.100)		(0.111)
RTC * % Small Firm		0.335	0.196		0.393	0.574**
		(0.221)	(0.245)		(0.239)	(0.266)
State Fixed-Effects	No	No	No	Yes	Yes	Yes
R^2	0.007	0.005	0.008	0.271	0.275	0.280
Panel B: Informal Sector						
% Small Firm	-0.255**		0.137	0.061		0.015
	(0.114)		(0.160)	(0.121)		(0.135)
RTC * % Small Firm		-1.518***	-1.651***		0.261	0.244
		(0.318)	(0.160)		(0.290)	(0.324)
State Fixed-Effects	No	No	No	Yes	Yes	Yes
R^2	0.011	0.049	0.050	0.510	0.510	0.511

Notes: 441 microregions. P-values: *10%; **5%; ***1%

Based on the assumptions of the model described in section 3, discriminatory firms are, on average, less productive than non-discriminatory firms. As the competitive pressure of trade liberalization increases, discriminatory firms must exit the formal sector at a higher rate than non-discriminatory firms within the same industry and microregion. Hence, microregions with a higher initial share of smaller firms should have a larger reduction in the conditional gender wage gap in the formal sector, while in the informal sector, the opposite should occur. Column 1 from table 6 indicates that the initial share of small firms is correlated with the changes in the conditional gender wage gap, both in the formal and informal sectors, with the corrected predicted sign. When interacting the regional tariff change with the share of small firms in column 2 from panel A, the coefficient is not significant. In column 2 from panel B, our result for the informal sector are negative and larger than the estimate from column 1/panel B in table 4, which suggests that microregions with a higher share of large firm share in 1991 had a larger increase in wage differential between genders. The same result remains when regressing both variables together in column 3. Columns 4-6 include state-fixed effects, which in turn makes our estimates not statistically significant, except for the interaction variable in column 6 from panel A. The coefficient is positive, significant, and larger than column 2 from panel A in table 4, indicating that microregions with a larger share of small firms in 1991 experienced a greater reduction in the conditional gender wage gap, given the tariff reduction policy.

Table 7 – Gender wage gap decomposition - Formal and Informal sectors - 1991/2000

	Formal (1991 - 2000)			Informal (1991 - 2000)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Differences in coefficient						
Regional Tariff Change (RTC_r)	0.315	0.697*	0.785***	-0.703**	-0.662**	-0.222
	(0.314)	(0.368)	(0.197)	(0.289)	(0.315)	(0.180)
State Fixed-Effects	No	Sim	Sim	No	Sim	Sim
Weight - Population (1991)	No	No	Sim	No	No	Sim
R^2	0.002	0.112	0.156	0.013	0.245	0.308
Panel B: Differences in explained component						
Regional Tariff Change (RTC_r)	1.974*	1.218	1.702**	-1.005**	-0.871*	-1.910***
	(1.047)	(1.271)	(0.691)	(0.406)	(0.480)	(0.326)
State Fixed-Effects	No	Sim	Sim	No	Sim	Sim
Weight - Population (1991)	No	No	Sim	No	No	Sim
R^2	0.008	0.045	0.080	0.013	0.112	0.234
Panel C: Differences in unexplained component						
Regional Tariff Change (RTC_r)	-0.679	-0.257	-0.240	-1.402**	-1.409**	-0.898***
	(0.520)	(0.618)	(0.323)	(0.492)	(0.589)	(0.330)
State Fixed-Effects	No	Sim	Sim	No	Sim	Sim
Weight - Population (1991)	No	No	Sim	No	No	Sim
R^2	0.002	0.094	0.066	0.018	0.089	0.129
Panel D: Differences in interaction component						
Regional Tariff Change (RTC_r)	-0.979	-0.263	-0.671	1.704	1.617**	2.586***
	(1.054)	(1.28)	(0.689)	(0.564)	(0.688)	(0.420)
State Fixed-Effects	No	Sim	Sim	No	Sim	Sim
Weight - Population (1991)	No	No	Sim	No	No	Sim
R^2	0.001	0.039	0.060	0.020	0.061	0.220

Notes: 440 microregions. All regressions are estimated with states fixed-effects and weighted with the micro region population in 1991. P-values: *10%; **5%; ***1%

The results of the regression of the components of the Oaxaca-Blinder decomposition on regional tariffs change are shown in table 7. In the formal sector, the results suggest that exposure to trade reduced the wage differentiation by gender, evidenced by the estimates in columns 2 and 3 from panel A. Using the results in column 3 as the main specification, a microregion that presented a 10% reduction in average tariffs had a reduction of 7.85% in the estimated average wage differentiation. Also, in column 3 on Panel B, the formal sector experienced an increase in the explained component of the decomposition, which can be viewed as men and women with similar observable characteristics are more equal after trade reform. In the formal sector, the shock of liberalization appears to reduce the wage differentiation based on remuneration on observable characteristics, because the coefficient of the unexplained component, which includes the differences not observed between the predictors (a proxy for discrimination can be used), is not statistically significant.

In the informal sector, our results suggest an opposite reaction of wage differentiation in relation to trade liberalization. In columns 1 and 2 from panel A, the estimates of average wage differentiation are negative and significant. Therefore, regions facing larger tariff reductions experience an increase in the gender wage gap. However, in column 3, the coefficient is not significant. Columns 4 to 6 from panel B show that microregions facing larger tariff reductions experienced an increase in the observable gender wage gap. This result is consistent with the discussion made by Perry et al. (2007). The authors argue that

the informal has overall lower remuneration on observable skills and abilities. In addition, although we have controlled for occupations and industry in the OBD regressions, gender differences in occupations may still play a large part in explaining the gender wage gap (Blau and Kahn (2017)).

The results on the differences in the unexplained component in columns 4-6 from panel C indicate an increase in differences in pay relative to unobservable characteristics. While our data cannot directly test the hypothesis of the flow of discriminatory firms into informality, these results give support to our model's prediction that following a productivity shock, gender discrimination in the informal sector should increase. Other explanations have a part in explaining an increase in the gender wage gap in the informal sector or, at the very least, increasing difference earnings on observable and unobservable characteristics. Gaddis and Pieters (2017) argued that if trade liberalization had a larger impact on gender differences in industries that had larger gender segregation due to the higher requirement of physical strength, then any differences in pay related to working in physically demanding or insalubrious jobs in the informal sector should be reflected by changes in the unobservable component.

Table 8 – Gender wage gap decomposition - Formal and Informal sectors - With selection bias correction - 1991/2000

	Formal (1991 - 2000)			Informal (1991 - 2000)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Differences in coefficient						
Regional Tariff Change (RTC_r)	0.323	0.783*	0.852***	-0.743**	-0.670**	-0.265
	(0.315)	(0.372)	(0.197)	(0.290)	(0.318)	(0.181)
State Fixed-Effects	No	Yes	Yes	No	Yes	Yes
Weight - Population (1991)	No	No	Yes	No	No	Yes
R^2	0.002	0.112	0.165	0.014	0.246	0.307
Panel B: Differences in explained component						
Regional Tariff Change (RTC_r)	3.315**	3.069*	2.285**	-0.851**	-0.640*	-1.731***
	(1.501)	(0.182)	(0.943)	(0.432)	(0.512)	(0.332)
State Fixed-Effects	No	Yes	Yes	No	Yes	Yes
Pesos - População (1991)	No	No	Yes	No	No	Yes
R^2	0.011	0.066	0.073	0.008	0.113	0.236
Panel C: Differences in unexplained component						
Regional Tariff Change (RTC_r)	-0.029	0.639	0.324	-0.942*	-0.434	-0.216
	(0.635)	(0.763)	(0.387)	(0.564)	(0.681)	(0.413)
State Fixed-Effects	No	Yes	Yes	No	Yes	Yes
Weight - Population (1991)	No	No	Yes	No	No	Yes
R^2	0.0005	0.077	0.066	0.006	0.076	0.173
Panel D: Differences in interaction component						
Regional Tariff Change (RTC_r)	-2.963*	-2.925	-1.756*	1.050	0.404	1.682***
	(1.584)	(1.921)	(0.981)	(0.671)	(0.815)	(0.490)
State Fixed-Effects	No	Yes	Yes	No	Yes	Yes
Weight - Population (1991)	No	No	Yes	No	No	Yes
R^2	0.007	0.065	0.051	0.005	0.065	0.190

Notes: 440 microregions. All regressions are estimated with states fixed-effects and weighted with the micro region population in 1991. P-values: *10%; **5%; ***1%

Table 8 presents the results from the Oaxaca-Blinder decomposition with selection bias correction. In the formal sector, the coefficients from columns 1-3 measuring the

average gender wage gap in Panel A remain significant after sample correction and, in column 3, the point estimate is larger than the coefficient from table 7, without correction. Relative to trade reform effects, a region facing a 10% tariff reduction had a reduction of 8.52% on the average gender wage gap. The effect is 7.86% higher when accounting for self-selection into formality. In Panel B, we find similar results from those in table 7, but the coefficients are larger in table 8, with statistical significance in all specifications. Therefore, trade reform positively affected female advantage on observable characteristics among formal employees. In regards to the unexplained component estimation from panel C, the point estimate result despite positive does not suggest that changes in the differences in the unexplained component (which is a proxy for discrimination) were significant when accounting for selection bias.

Columns 4-6 in table 8 contain the results from the OB component regressions for the informal sector. Comparing the estimates from panel A in table 7, the results from panel A in table 8 are slightly larger but similar in terms of sign and statistical significance. Using the coefficient from column 5, a microregion facing a 10% tariff reduction would experience a 6.70% increase in the average gender wage gap in the informal sector. However, in the main specification (column 6), the result is not statistically significant. The same reasoning of panel A applies in panel B, in which estimates across columns 4-6 have the predicted sign, are significant, but are slightly smaller than in table 7. In regards to the discussion on self-selection into informality, workers might have differences in motivations, especially if men and women value attributes including greater flexibility or family and personal motivations differently, which can be reflected by the results of tables 9 to 11[2]. This may lead to women seeking less demanding jobs or working fewer hours in order to balance household activities, while men work longer hours and, consequently, earn higher wages. For results in panel C, column 1 indicates that trade reform increased differences in the unexplained component in the informal sector, but in column 3, the coefficient is not significant.

[2] Although the tables present responses from workers in self-employed informal workers in Brazil, Perry et al. (2007) argues that the majority of informal salaried workers appear to be involuntary, which in turn would favor the exclusionary view of informality, as the authors show in the table 2.9 for other countries in Latin America.

6 Conclusion

Brazilian trade policy in the early 1990s is a widely studied economic episode. Evidence about the economic effects of the liberalization shock especially covers the labor market, addressing the results of employment (Menezes-Filho and Muendler (2011); Gaddis and Pieters (2017)) and wages (Kovak (2013)). Also, several studies expand towards the analysis of *skill premium* and wage inequality (Ferreira, Leite and Wai-Poi (2007); Dix-Carneiro and Kovak (2015)) and, more recently, addresses the regional effects and dynamics of the labor market (Dix-Carneiro (2014); Dix-Carneiro and Kovak (2017)), and also reach social effects, such as crime (Dix-Carneiro, Soares and Ulyssea (2018)).

This paper contributes to the literature on the economic effects associated with trade exposure relative to the gender pay gap in the formal and informal sectors. The literature provides for two main transmission channels through which trade can affect gender pay inequality. First, external competition raises the cost of committing discriminatory acts and, in the long run, will eliminate firms that have a "taste for discrimination"in the formal sector. The relative increase in the informalization of discriminatory firms increases the gender wage gap in the informal sector. Second, the productivity of firms is heterogeneously distributed in an industry and a reduction in the costs of doing trade - tariff reduction, for example - generates an incentive for more productive firms to enter the export market and, since informal firms do not export, it reduces the gender wage gap in the formal sector.

Our results show that trade liberalization does have a differentiated effect on the gender wage gap concerning the formal and informal sectors. Microregions facing larger tariff reductions have larger decreases in the formal gender wage gap and larger increases in the informal gender wage gap. In particular, microregions with higher market concentration, a higher share of small firms, and female workers in tradable industries in 1991 experienced larger decreases in the formal gender wage gap and larger increases in the informal gender wage gap, although it should be mentioned that these results are not particularly robust. In addition, across all specifications, the difference in earnings on observable characteristics between men and women has decreased in the formal sector while men and women in the informal sector are remunerated differently on approximately the same observable characteristics, as measured by the explained component of Oaxaca-Blinder decomposition. Concerning the effects of trade liberalization on discrimination, our results without correction on selection bias find increased discrimination in the informal sector. When accounting for selectivity, microregions facing larger tariff reductions showed a reduction in the difference in wages between males and females, especially in the differences in earnings on observable characteristics in the formal sector, while the gender difference for informal employees experienced an opposite result.

The transition of labor across sectors within the same region is a key component of the empirical strategy developed by Kovak (2013). Trade liberalization affects tradable industries the most, and labor could reallocate to the services or informal sectors. This is especially relevant because women have a larger participation in the non-tradable sector relative to men in the formal and informal sectors, and the trend in female participation is increasing in those sectors. Female workers in the formal sector have beneficial work-related assistance when it comes to motherhood decisions, while informal female workers have to balance child-rearing and work activities, which may reduce the number of available working hours. Additionally, social norms may play a part when it comes to household decisions of labor supply (Codazzi, Pero and Sant'Anna (2018)) and occupational choice (Madalozzo (2010)).Trade liberalization might induce job polarization into relative lower-paying occupations for women in the informal sector or an "informality trap", in which if female workers do not move out of informal employment, they may experience longer informal spells. This is an insightful avenue of research for a better understanding of the trade liberalization effects on the Brazilian labor market and for a more successful implementation of public policies that aim to decrease regional gender inequalities in the labor market.

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APÊNDICE A – Additional Content

Table 9 – Share of informal employed workers that would like to enter formality by gender - Brazil - 1990

	Would you like to leave [your current] job for a job with a signed work contract? (Self-employed)									
	Male					Female				
Response	All	15–18 years	19–24 years	25–54 years	55 –70 years	All	15–18 years	19–24 years	25–54 years	55 –70 years
No	67.9	29.9	52.6	68.3	80.6	55.5	24.6	41.8	55.2	71.2

Observation: Table extracted from Perry (2007). Author's estimates based on Pesquisa Nacional por Amostra de Domicílios (PNAD) 1990.

Table 10 – Reported reasons to be informal self-employed by gender - Brazil - 1990

	Would you like to leave [your current] job for a job with a signed work contract? (Self-employed)									
	Male					Female				
Response	All	15–18 years	19–24 years	25–54 years	55 –70 years	All	15–18 years	19–24 years	25–54 years	55 –70 years
Earn more in current job	18.0	13.4	17.6	21.0	9.6	10.6	5.1	13.3	12.1	3.9
Needed to care for home	0.2	0.0	0.0	0.1	0.4	26.9	15.3	22.8	27.5	28.8
Need time for other activities	2.9	7.5	3.2	2.5	3.2	6.7	6.8	7.9	6.6	6.8
Happy in current job	64.9	69.5	68.3	64.0	67.6	44.1	59.3	47.7	44.8	39.0
Did not want the commitment	10.1	8.0	9.8	10.0	10.6	7.5	8.5	7.6	6.9	9.8
No answer	4.0	1.6	1.1	2.2	8.6	4.1	5.1	0.8	2.2	11.6
Percent of sample	73.5	0.8	5.0	51.3	13.7	26.5	0.3	1.7	20.0	3.9
Percent of gender	100	1.1	6.8	69.8	18.6	100	1.0	6.3	75.4	14.8

Observation: Table extracted from Perry (2007). Author's estimates based on Pesquisa Nacional por Amostra de Domicílios (PNAD) 1990.

Table 11 – Reported reasons that led informal self-employed to start a business by gender - Brazil - 1997

Reason that led them to start a business (self employed)		
Response	Male	Female
Did not find other job	31.1	19.7
Opportunity	1.6	1.8
Flexible schedule	1.0	4.8
Independence	21.3	15.1
Family Tradition	8.9	5.1
Complement household income	10.5	35.5
Experience in the field	9.7	4.3
Promising business	8.7	5.8
Secondary job	2.5	1.1
Other reason	4.0	6.3
Did not declare	0.1	0.07
Percent in sample	64.4	35.5

Source: Economia Informal Urbana (ECINF) - 1997

Table 12 – Formality share by sectors - 1991-2000

Industry	1991	2000
Agriculture	11.4	19.0
Mineral Mining	32.8	47.4
Petroleum and Gas Extraction and Coal Mining	85.1	91.0
Nonmetallic Mineral Goods Manufacturing	61.3	59.4
Iron and Steel, Nonferrous, and Other Metal Production and Processing	86.5	66.9
Machinery and Equipment and Tractor Manufacturing	88.8	72.5
Eletrical, Electronic and Communication Equipment and Components Manufacturing	92.0	85.0
Automobile, Transportation and Vechile Parts Manufacturing	78.6	86.9
Wood Products, Furniture Manufacturing	46.7	47.3
Paper Manufacturing, Publishing and Printing	83.6	69.2
Rubber Product Manufacturing	91.3	88.2
Chemical Product Manufacturing	91.5	85.9
Petroleoum Refining and Petrochemical Manufacturing	92.2	91.2
Pharmaceutical Products, Perfumes and Detergents Manufacturing	88.1	77.6
Plastics Products Manufacturing	88.5	86.2
Textiles Manufacturing	79.9	57.2
Apparel and Apparel Accessories Manufacturing	33.4	36.2
Footwear and Leather and Hide Products Manufacturing	79.9	71.9
Food Processing	79.6	65.5
Miscellaneous Other Products Manufacturing	70.1	50.3
Non tradables	44.3	36.5

Observations: Data from Brazillian Demographic Census. Individuals with 18-64 years old, outside of public and defense services.

Table 13 – Female share by sectors - 1991-2000

Industry	1991	2000
Agriculture	13.06	12.70
Mineral Mining	7.74	5.79
Petroleum and Gas Extraction and Coal Mining	13.01	8.94
Nonmetallic Mineral Goods Manufacturing	12.20	10.05
Iron and Steel, Nonferrous, and Other Metal Production and Processing	12.35	9.00
Machinery and Equipment and Tractor Manufacturing	14.08	10.51
Eletrical, Electronic and Communication Equipment and Components Manufacturing	29.87	28.81
Automobile, Transportation and Vechile Parts Manufacturing	10.27	12.21
Wood Products, Furniture Manufacturing	10.85	8.94
Paper Manufacturing, Publishing and Printing	23.64	25.22
Rubber Product Manufacturing	19.10	15.76
Chemical Product Manufacturing	17.59	17.85
Petroleoum Refining and Petrochemical Manufacturing	17.27	14.69
Pharmaceutical Products, Perfumes and Detergents Manufacturing	40.31	41.25
Plastics Products Manufacturing	29.70	26.08
Textiles Manufacturing	45.79	51.58
Apparel and Apparel Accessories Manufacturing	81.53	85.95
Footwear and Leather and Hide Products Manufacturing	41.36	44.76
Food Processing	25.25	25.65
Miscellaneous Other Products Manufacturing	36.87	30.49
Non tradables	40.36	44.73

Observations: Data from Brazillian Demographic Census. Individuals with 18-64 years old, outside of public and defense services.

Table 14 – Share of informal workers by occupation - 1991-2000

Informal Sector - Males			
1991		2000	
Ocupation description	Share	Ocupation description	Share
Agricultural producers	22.5	Agricultural producers	15.2
Other workers in agriculture	19.6	Other workers in agriculture	10.2
Bricklayer	7.61	Bricklayer	8.4
Drivers	4.6	Drivers	5.8
Merchants	3.7	Self-employed merchants	4.0
Informal Sector - Females			
1991		2000	
Ocupation description	Share	Ocupation description	Share
Unskilled domestic workers	24.2	Unskilled domestic workers	27.1
Other workers in agriculture	11.7	Elementary school teachers (1st to 4th grade)	4.55
Tailors and dressmakers	6.3	Tailors and dressmakers	4.54
Self-employed merchants	3.6	Other occupations in street trade	3.8
Elementary school teachers (1st to 4th grade)	3.4	Agricultural producers	3.3

Observations: Data from Brazillian Demographic Census. Sample with Individuals with 18 to 64 years old.

Table 15 – Share of informal salaried workers by occupation - 1991-2000

Informal Salaried Sector - Males			
1991		2000	
Ocupation description	Share	Ocupation description	Share
Other workers in agriculture	38.4	Other workers in agriculture	21.9
Agricultural producers	6.9	Bricklayer	5.8
Merchants	5.9	Drivers	5.3
Vendors	2.5	Bricklayer assistant	5.9
Bricklayer assistant	2.4	Vendors	3.7
Informal Salaried Sector - Females			
1991		2000	
Ocupation description	Share	Ocupation description	Share
Unskilled domestic workers	32.5	Unskilled domestic workers	29.6
Other workers in agriculture	15.7	Elementary school teachers (1st to 4th grade)	7.0
Elementary school teachers (1st to 4th grade)	4.4	Other workers in agriculture	4.3
Cleaning lady	3.2	Vendors	3.67
Vendors	2.9	Servants	3.65

Observations: Data from Brazilian Demographic Census. Sample with Individuals with 18 to 64 years old.

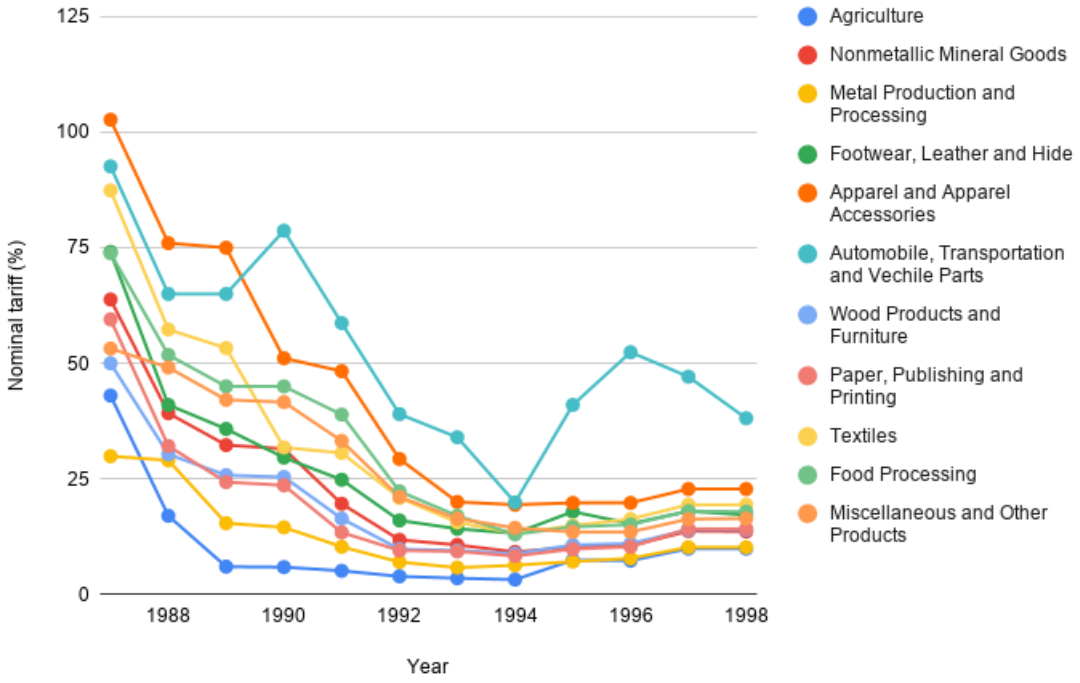

Figure 6 – Average nominal tariff by sector - 1987/1998

Observation: Data from Kume, Piani and Souza (1990)

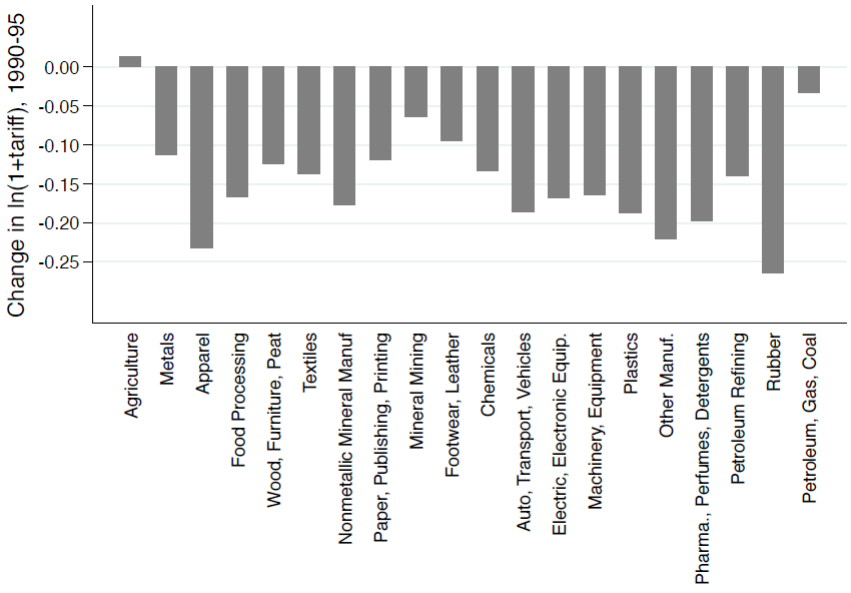

Figure 7 – Changes in log nominal tariff by sector - 1990/1995

Observation: Data from Kume, Piani and Souza (1990)