The Effect of International Trade on Wages of Skilled and Unskilled Workers: Evidence from Brazil

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Abstract—This paper assesses the impact of trade on wages of skilled and unskilled workers in developing countries and presents new evidence for Brazil. The relation between trade and wages has been analyzed using a new econometric model that links (sectoral) trade intensity ratios of Brazilian states to wages of individuals active in the corresponding state (and sector), while controlling for individual characteristics. The findings are interpreted using trade theories of Melitz and Hekscher & Ohlin and show that imports have negatively affected wages of the skilled and unskilled, but disproportionately those of the skilled. Furthermore, exports seem to have positively affected wages of the skilled and unskilled, but disproportionately those of the unskilled. These results are in line with the theories of Melitz and Hekscher & Ohlin.

1. Introduction

The relation between international trade and wages of skilled and unskilled workers in developing countries has received much attention of academics worldwide. Nevertheless, the literature is not in consensus. This article attempts to provide new insights by using an alternative empirical strategy to analyze data for Brazil. The results will be interpreted in the context of prominent trade theories. The focus will be on the effects of trade on wages of skilled and unskilled workers, without any value judgment on the fairness of it, because this will depend on the arbitrary decision of how fairness is defined. Or as Jagdish Bhagwati, one of the world's leading economists specialized in the trade topic, formulates it:

"*Beauty is in the eye of the beholder. Fairness in trade also is the way you choose to define it.*"[1]

One of the most prominent trade theories is developed by Melitz (2003). He argues that due to export market entry costs, only the most productive firms will be able to reap the benefits from increased export opportunities. The less productive firms will be competed away by the entry of new more productive firms that now have greater incentive to enter the industry because of these potential profits from exports. He argues that this will result in a rise of average firm productivity in the industry and that this is welfare enhancing and will in general increase workers' wages. So according to Melitz, the most important force driving the higher productivity of firms is increased competition from national firms due to higher potential profits caused by increased export possibilities. Nissanke & Thorbecke et al. (2006) argue that also increased competition from foreign firms through increased imports is likely to have a positive influence on average productivity of firms within an industry. They argue that this effect will be observable in the medium/long run when a more efficient allocation of resources (induced by the increased foreign competition) can be realized. However, according to them, previously protected industries may be hurt by trade liberalization in the short run. While the integration into the world markets arguably makes this contribution to productivity and therefore economic growth, some fear that it will come at the expense of

[1] Rebuttal statement (nr 20) from Jagdish Bhagwati in a debate on fair trade on the website of the economist (direct link: http://www.economist.com/debate/days/view/514).

increased inequality within countries. Inequality will rise if only a small portion of people, the skilled, will benefit and the rest doesn't or even lose from trade liberalization. The well known Hekscher-Ohlin (HO) and Stolper-Samuelson (SS) theorems have been very influential in explaining how trade can have different effects on the wages of skilled and unskilled workers. The HO theory argues that increased trade openness will make countries specialize in goods of which the production requires most intensively their abundant production factor, so they can export these goods and import those of which the production requires their scarce production factor most intensively. The SS theory argues that a rise in the relative price of a product increases the relative return of the factor that is most intensively used in the production of that product and also a relative decrease in the return of the other factors of production. Since unskilled labor is usually the abundant production factor in developing countries the HO and SS theorems expect unskilled labor to relatively benefit more from trade than skilled labor in developing countries. These theories will be further discussed in part 2.1.

Brazil experienced a trade liberalization episode from 1988 to 1994. The trade reforms reduced the average tariff level from about 60 percent in 1987 to about 15 percent in 1998 (Pavcnik et al., 2002). Most researchers use these tariff rates as a proxy for integration in the world market (e.g. Green et al., 2001; Carneiro et al., 2003; Ferreira et al., 2003; Arbache et al., 2004; Nicita, 2004; Gonzaga et al., 2005). For several reasons I will not use the same approach, but will instead focus on the actual trade intensity ratios (imports relative to GDP and exports relative to GDP). The most important reason for this is that actual trade intensity ratios in Brazil didn't increase much during the period of trade liberalization, but only years after, around 1999. If tariff rates are used as the explanatory variable, even though they do not seem to influence actual trade flows much in the short/medium run, than one might ask what effect is being measured and if this is the effect that is most interesting for academics and policy makers. The reasons for choosing trade intensity ratios as opposed to tariff rates as the main explanatory variable will be further discussed in part 3.2.

The national export intensity ratio for Brazil decreased in the early nineties and doubled from 1999 to 2003 from around 0.06 in 1999 to around 0.12 in 2003. The national import intensity ratio steadily rose over the sample period and doubled from around 0.05 in

1992 to around 0.10 in 2003. Although import and export intensity ratios doubled, they are still relatively low compared to other countries in South America. For example, in Colombia in the early nineties import penetration was already above 30% of GDP. This difference can mainly be attributed to the large size of Brazil (Pavcnik et al., 2004).

These relatively large changes in the trade intensity ratios for Brazil over a relatively short time period have created an excellent setting to study the effects of trade on wages. Since Brazil is a country with one of the highest inequality levels in the world, it also provides an interesting setting to study the different effects of trade on skilled and unskilled workers. Finally, the existence of high quality national household surveys in Brazil makes it possible to analyze effects of trade on the micro level.

Many researchers have found different results implying different effects of trade on wages, and in particular on wages of the skilled and unskilled. I will build on Arbache et al. (2004), who also studied the link between trade and wages of workers with different educational levels in Brazil. They use data from the PNAD household surveys from 1980 to 1999. The most important difference is that they, like most researchers, use tariff rates as the main explanatory variable where I use actual trade intensity ratios. Therefore, differences between the findings of this research and theirs may help revealing the consequences of using trade intensity ratios instead of tariff rates when analyzing the effects of trade on wages. Arbache et al. (2004) find that in Brazil wages of the unskilled decreased due to increased trade openness and wages of the skilled weren't influenced significantly. Also, they find that average education levels rose during the trade liberalization period, but marginal returns to education decreased, except for college educated workers whose marginal return increased. They attribute the decrease in wages to a fall in rents due to increased competition caused by trade liberalization (contradicting the theory of Melitz). According to them the most skilled weren't affected because the demand for college workers rose relatively faster than the supply, since the expertise of college workers is needed for the transferring and utilizing of incoming new technologies. I will further discuss the empirical findings of previous studies in part 2.2.

The data used in this research is obtained by the National Household Survey of Brazil, called the Pesquisa Nacional por Amostra de Domicilios (PNAD). The surveys from 1992 to

2003 are used. It is a cross-section survey series that is nationally representative and gives information on around 117,000 individuals per year, including wages, number of completed years of schooling, gender, ethnicity, age, state of residence and industry in which the individual is active.[2] The quality of the PNAD data is known to be high (Sawyer, 1988). It has been combined with aggregated data of 27 states. State GDP data comes from the IPEA (Instituto de Pesquisa Econômica Aplicada) and the trade data comes from the Brazilian Foreign Trade Secretariat. It includes information on the size of import and export flows of each separate state in Brazil and even more importantly, information on the size of import and export flows of each sector within each state. These datasets combined are an excellent fundament for analyzing the effects of trade on wages of skilled and unskilled workers.

Individual characteristics are controlled for in the regressions according to the Mincerian earnings function (Mincer, 1974). This is particularly important for the case of Brazil where individual diversity is vast and a considerable determent of wage diversity in the country (Fally et al., 2010). In many other studies individual characteristics are controlled for on a more aggregated level. For example, a measure of average education of workers of a specific state and/or sector is used. This way one fails to account for the distribution of worker characteristics within each (sub)group which will, especially for the case of Brazil, lead to less accurate estimates.

Due to the availability of data on trade flows of different states of Brazil it is possible to analyze how the differences in the size of these trade flows between states influenced the wages of the skilled and unskilled in these states. The data includes differences in trade flows between regions but within a single country which has a significant advantage over cross-country trade data, because it eliminates structural differences across countries that could be the reason for misleading observable effects of trade on wages. Since the dataset also includes trade data on the sector level within each state it is possible to study the effects of changes of trade intensity ratios in a specific state for a specific sector on the wages of workers in the corresponding state and sector. This approach can provide more robust results because the effects are studied more directly.

[2] The PNAD doesn't follow individuals. Instead it interviews a different random sample of residents every year.

This research makes the following methodological contribution to the literature. It uses actual trade intensity ratios at the state-sector level, where other studies use aggregate trade flows or tariff rates. Furthermore, individual workers characteristics are added in the regressions so differences in workforce composition across (sub)groups are controlled for. Combining these two empirical strategies has not been done before for Brazil and makes this research unique.

To anticipate the main results, this research provides evidence supporting the theories of Melitz and Heckscher & Ohlin. Both skilled and unskilled workers seem to have benefitted from increased exports, but this positive effect seems to be larger and more significant for the unskilled. The theory of Nissanke & Thorbecke is not supported by the results, because increased import penetration seems to have had a negative effect on wages of the skilled and unskilled. Furthermore, this negative effect seems to be larger and more significant for the skilled.

This paper is organized as follows. Section 2 provides a theoretical framework and reviews the main empirical findings in the literature. In section 3 the data is discussed and the empirical strategy and main results are presented. Finally, section 4 summarizes and concludes.

2. Related Literature

2.1. Theoretical framework

Before examining the evidence it will be interesting to review some prominent theories in the literature that offer explanations on how trade can influence wages and if unskilled workers are affected differently than skilled workers. This will help understanding the mechanisms that are driving the results which are presented in the empirical part. The focus will be on two very influential theories regarding this subject. First the theory by Melitz (2003) is discussed and after that the theory by Hekscher & Ohlin (and Stolper & Samuelson).

2.1.1. Trade liberalization and productivity

A very influential theory involved is the one developed by Melitz (2003) about the influence of trade liberalization on the productivity of firms in an industry. Through the channel of intra-industry reallocations of production factors across firms he explains the effects of trade

on firm and industry performance. He argues that only the firms that are most productive will be able to pay export market entry costs and therefore only these firms will survive. The less productive firms will be competed away, not by increased import competition, but by the existing more productive domestic firms and by the entry of new more productive domestic firms that are both able to pay these export market entry costs and therefore reap the benefits from trade. The firms that are efficient enough to export will gain in market share and profits and the others will lose in both. One of the most robust and important findings of Melitz is that an increase in a country's exposure to trade, through the increase in the average productivity of firms (unproductive firms will be forced out of the market by new firms that enter the market because of the relatively higher profits of the exporting firms), will be welfare enhancing. This also means that industries in which export intensity is higher will ceteris paribus be more productive than industries with lower export intensity.[3] Feldstein (2008) shows in his research that productivity growth has a very strong positive effect on wages and moves proportionately with total compensation. So according to these authors, increased openness and higher export intensity ratios in particular, should have a positive influence on wages.

Nissanke & Thorbecke (2006) argue that the sub channel of increased imports is also responsible for long term growth. They reason that in the short run a switch from import substitution to free trade will hurt the previously protected industries, but that this increased competition will increase productivity because of more efficient allocation of resources and this will more than compensate the fall in output in the long run. Trade liberalization will be most successful when import liberalization is preceded by the promotion of exports, according to Nissanke & Thorbecke.

The views of Melitz and Nissanke & Thorbecke are compatible with each other, but Melitz attributes the increased productivity to increased export possibilities, where Nissanke & Thorbecke assign it also to increased import competition. Both theories expect trade to be welfare enhancing through increased productivity.

2.1.2. Trade liberalization and skilled and unskilled labor

A second very influential theory which is closely related to the topic of this paper is the one

[3] Assuming that labor is not completely mobile.

by Hekscher & Ohlin (H-O). They try to explain not only the effects of trade on wages in general, but also the separate effects on skilled and unskilled workers. Their main insight is that countries will in general export products that use their abundant (and therefore relatively cheap) factor of production and import products that use their scarce (and therefore relatively expensive) factor of production. Many economists worldwide have used the H-O framework to argue that the poor (the unskilled) in developing countries will gain from increasing international trade. H-O theory assumes that trade and wages are linked through changes in product prices. For example, the rise of the price of unskilled intensive goods relative to skilled intensive goods by an external force will raise the wages of the unskilled relative to the wages of the skilled. This linkage is known as the Stolper-Samuelson theorem and can exist because it assumes that technology is given. Therefore it assumes that a given amount of input of factors will produce a given amount of output of goods and that this relation doesn't change so that, without excess amounts of profit, the relation between the prices of goods and the payments to factors will be similarly fixed (Wood, 1995).

Although the intuition behind the story is interesting, it is very much simplified. First of all, that technology is given seems highly unrealistic. On the contrary, it is more realistic to assume that trade liberalization is accompanied with the introduction of higher levels of technology (Wood, 1995; Carneiro et al., 2003; Ravaillion, 2004), for example because of technology spill-over effects. Higher technology levels raise the demand for skilled labor relative to unskilled labor and this will lower the wages of the unskilled relative to the skilled.[4] This is consistent with the theory of Wood (1997) that greater openness in a country with a large supply of a third factor (for example (high tech) capital or certain natural resources), that is complementary to skilled labor, can result in an increase in the demand for skilled labor relative to unskilled labor in this country. A second reason is that developing countries often protect sectors that employ a high degree of unskilled workers (except agriculture), which implies that unskilled workers will be losing relatively more protection than skilled workers after trade liberalization. This can, especially in the short run, decrease wages of unskilled workers relative to skilled workers after trade liberalization (Aisbett et al.,

[4] This in turn increases the incentive to acquire education and therefore increased trade can indirectly have a positive effect on education (Attanasio et al., 2002).

2005, Pavcnik et al., 2004).[5] Another reason is that goods produced in sectors that are considered unskilled labor intensive in developed countries may even require more skills to be produced than the average unskilled worker in the developing country possesses. Wood (1997) also critics the H-O framework in his review about the link between openness and wage inequality, arguing that developing countries (like Brazil) do not in particular have a competitive advantage in unskilled labor, because China and other countries with a much bigger abundance of unskilled labor have entered the world market as well. This means that even developing countries can be abundant in medium skilled labor or can be capital intensive relatively to other developing countries.

Another problem with the H-O theory is that the competitive advantage of the unskilled will only increase (their wage will only rise) when they can freely move from contracting sectors to expanding ones and this doesn't seem to be the case in most developing countries where labor markets are characterized by significant rigidities. In this case one must not only look at the influence of trade on the country-wide skill premium, but also to the influence of trade on the industry wage premium (Pavcnik et al., 2002; Aisbett et al., 2005).

This is in line with the sector specific model, which appears to be more realistic in the short/medium run. In the sector specific framework it is assumed that workers and machines are attached to a specific sector and therefore an increase in for example export activity in sector X will in the short/medium run result in a rise of wages of the workers in sector X, because the rise in export activity is assumed to put upward pressure on the price of the good that was previously less exported. This will in turn shift labor demand upwards, since producers have stronger incentives to increase production levels. In the sector specific model workers, at least in the short/medium run, lose or gain from globalization depending on which sectors they are attached to, while in the H-O model the winners and losers of globalization are indentified by their skill level, regardless of where they work. That labor mobility between sectors is low in Brazil has been shown by Menezes-Filho et al. (2008).

The dataset used in this research doesn't provide information on movement from individuals between sectors, but is does provide information on how the number of workers

[5] Although this is in contrast with Harrison et al. (2004) who argue that skilled labor intensive industries were disproportionately protected in Brazil. Furthermore, the theory of Nissanke & Thorbecke would expect the opposite effect, that higher tariff reductions would lead to higher wages in the long run due to increased productivity. So there are more perspectives possible.

in each sector changed during the sample period, so reallocation across sectors is captured. I will combine the Hekscher-Ohlin and sector specific models by analyzing how wages in a specific sector in a specific state will be affected by international trade while differentiating between skilled and unskilled workers. The empirical approach will be further explained in part 3.2.

2.2. Review main empirical findings

Now that the main theories on the link between trade and wages are discussed this section will proceed with the empirical findings of some influential articles regarding this topic. Articles about the general relation between trade and wages and articles that differentiate between the effect of trade on wages of the skilled and the unskilled will be discussed. The reason for studying the separate effects of trade on skilled and unskilled labor is because economic theory expects the effects of trade to be different for the two types of workers, as has been argued in the previous part.

The first part discusses cross-country evidence, while the second and third part review findings of country-specific case studies on respectively Colombia & Mexico and Brazil.

2.2.1. Cross-country evidence

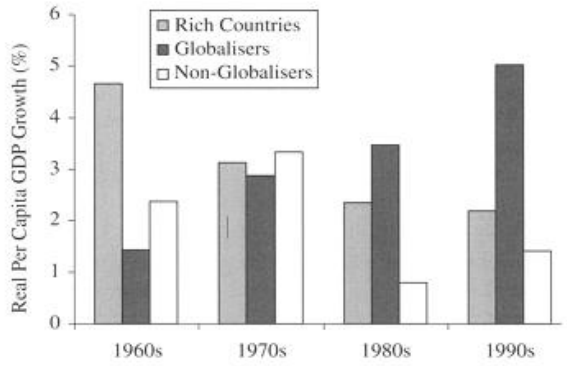
Dollar & Kraay (2002), in their much-cited article about trade, growth and poverty use a sample of 92 countries spanning from 1960 to 2000 to study the relation between trade and growth. Furthermore, they analyze the relation between growth of the average income and growth of the income of the poorest quintile. Their main results are shown in figure 1 and figure 2. Figure 1 shows that, in general, developing countries that started globalizing achieved higher real per capita GDP growth than developing countries that didn't globalize. Figure 2 shows that growth is in general good for poor people. Combining these two results they conclude that trade is in general good for the poor. These findings are in line with the theories of Melitz and Nissanke & Thorbecke.

The problem with the findings of Dollar & Kraay (2002) is that they can't rule out that the considerable GDP growth of the globalisers is (also) driven by other factors than trade. For example, they show that countries that globalized in general had higher real per capita

GDP growth, but these countries could have been in better shape in the first place and were therefore more likely to start globalizing.[6] For this reason it is difficult to determine the causality direction between trade and growth. Furthermore, it is possible that the results are driven by mammoth countries like China and India, for which it is clear that they globalized and had very high levels of real per capita GDP growth. However, even besides the question of causality it is very doubtful that this observed relation for China and India is generally applicable to other countries as well, because country-specific characteristics are heavily influencing the results.

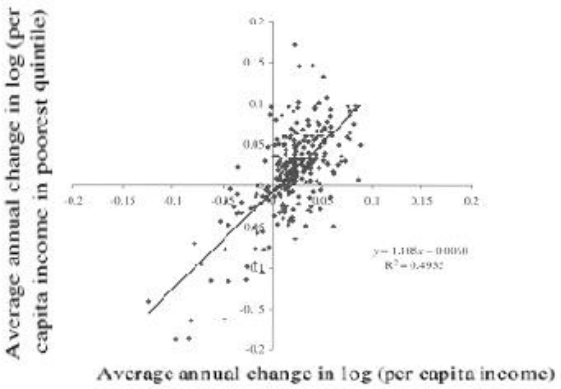
When looking at figure 2, the question arises if growth that resulted because of higher trade levels in particular is also just as beneficial for the poor and in which case it is more beneficial for them and in which case less. Not unlikely this is very dependent on the specifics of each country or even state (or even sector within each state), so generalizing like this will lead to results that are not broadly applicable. This view is supported by Srinivasan & Bhagwati (1999), who state that "…cross-country *regressions … are not the best tools for analyzing the problem of understanding the linkage between trade and growth*." They argue that the reason for this is that it is too difficult to control for institutional- and country-specific factors and therefore there will always be problems of endogeneity when using cross-country regression for analyzing the effects of trade.

Figure 1: Real per Capita GDP Growth



Source: Dollar & Kraay (2004)

Figure 2: Income of the poor and average incomes



Source: Dollar & Kraay (2002)

[6] With "in better shape" is meant that they might have had better institutions (besides trade policy) or were in a better situation in general (think of wars or bad or corrupt governments). These country properties are likely to lower the probability that the decision to deregulate trade is taken and at the same time are likely to have a negative effect on real per capita GDP growth.

There is an abundance of literature that shows a positive relation between trade and growth (e.g., Edwards, 1993; Frankel & Romer, 1999; Dollar & Kraay, 2004), but there is much less consensus on the specific effects of trade on wages of the skilled and unskilled. The remaining part of this section discusses the main findings in this area of some prominent country-specific case studies.

2.2.2. Country-specific case studies: Colombia and Mexico

Two countries that are comparable to Brazil and have been subject to intense research concerning the effects of trade on wages are Colombia and Mexico. Attanasio et al. (2002) find that in Colombia trade reforms had a positive influence on the returns to college education, in line with the theory of trade induced skill biased technological change. They also found that industry wage premiums have changed significantly because of the trade reforms. This result indicates that labor is not fully mobile as assumed in the H-O framework and that assuming significant labor market rigidity is more realistic, which is in line with the specific sector framework. They also found that the sectors with the largest tariff reductions were those that experienced the largest decrease in wages, which is not in line with Nissanke & Thorbecke who argued that increased import penetration will have a positive influence on wages in the long run. These results are in line with the theory of Stolper & Samuelson which predicts that wages will go down in sectors where import competition is most intense, because of downward pressure on the price due to increased competition, which will in turn lower the wages of workers. Since in Colombia these were the sectors with a relative high fraction of unskilled workers trade has increased the wage inequality over there.

Goldberg et al. (2002) get similar results in their study on Colombia. Also rejecting the H-O assumption of free labor mobility, they find that individuals in sectors with increasing import competition are likely to become poorer and sectors where exports are growing are less likely to become poorer. This is in line with the theory of Melitz, which predicts that the average firm will be more productive in sectors that have greater export opportunities and this higher productivity will result in higher wages for the workers in these sectors.

Another country in Latin America which has been intensively studied, is Mexico. Hanson (2004) analyzes the changes in the distribution of labor income across regions in Mexico during its decade of globalization in the nineties. He defines the extend of exposure

of each state and measured this by trade intensity ratios and FDI ratios. He finds that on average labor income of high exposure states increased by 10 % relative to labor income of low exposure states and wage poverty increased by 7 % in low exposure states relative to high exposure states. He doesn't differentiate between the effects of imports and exports, so he doesn't draw any conclusion on the specific effects of imports and exports. His results imply that trade is good for all workers, skilled and unskilled, but he doesn't explain if this is because of increased productivity caused by import competition or caused by increased export possibilities. Since he doesn't control for sector specific effects, trade flows in one sector are also linked to wages of workers from other sectors. Depending on how mobile labor in Mexico is across sectors it can be argued that the effects of trade will be more directly measured when looking at them in a specific sector on workers' wages of the corresponding sector. This will be the case for Brazil, because as discussed before labor is not very mobile across sectors over there. In the next part, the main findings from case studies on the effects of trade on wages in Brazil will be discussed.

2.2.3. Country-specific case studies: Brazil

The link between trade and wages in Brazil has also been a subject of intense research. Brazil is still mainly rooted in the developing world, at least when looking at the average worker. Where Mexico has seen significant increases in average wages in the eighties and nineties, Brazilian wages have, on average, remained mostly stable during this period. The main difference between Colombia and Mexico on the one hand and Brazil on the other is that Brazil has lower levels of trade intensity ratios which means that the total influence of trade will likely be smaller in Brazil than in Colombia and Mexico. This is supported by Filho et al. (2006), who state that the effects of trade liberalization in Brazil may be not negligible but also not very pronounced. The main reason why Brazil has relatively low trade intensity ratios is that it's a very large country with a large domestic market. The same can be observed for other large countries. Pavcnik et al. (2004) even conclude that in Brazil trade liberalization had no statistically significant impact on wage inequality between the skilled and unskilled through changes in industry wage premiums.

The influence of trade on the skill level and the skill premium has been extensively studied and can help explain the influence of trade on wages for different skill levels. Pavcnik et al. (2002) find that the skill level of the average worker rose during this period (consensus

in the literature on this point). They also find growing returns to educated workers in Brazil caused by trade liberalization, which is in line with the findings of Carneiro et al. (2003) and Arbache et al. (2004). Carneiro et al. (2003) uses a computable general equilibrium modeling approach to come to this conclusion. This is in contrast with Gonzaga et al. (2005) who find evidence that the skilled/unskilled earnings differentials decreased during trade liberalization. They find that employment shifted from skilled intensive sectors to unskilled intensive sectors, and that therefore the earnings inequality decreased in Brazil. These findings are supported by Fally et al. (2010) who find that increased market access raised the wages of the unskilled relatively more than the wages of the skilled. Harrison et al. (2004) also find evidence for the fact that the unskilled have benefitted more from trade liberalization than the skilled. According to them this is because before trade liberalization capital intensive industries were disproportionately protected.[7] Therefore, they argue that during trade liberalization resources shifted from these relatively skilled labor intensive industries to more unskilled labor intensive industries, like agriculture and less capital-intensive manufacturing industries. Green et al. (2001) find that both college workers' and illiterate workers' wages rose during the trade liberalization episode, but they find a total decrease in wage inequality, because of the relative low share of college workers in Brazil.

It's interesting to see that even for the same country the literature is not in consensus. Where the findings of Pavcnik et al. (2002), Carneiro et al. (2003) and Arbache et al. (2004) are not in line with the basic H-O theory, the findings of Gonzaga et al. (2005), Harrison et al. (2004) and Fally et al. (2010) are and the findings of Green et al. (2001) and Pavcnik et al. (2004) are inconclusive.

All researchers just discussed find results that are consistent with the theory of trade induced skill biased technological change, at least when looking at the rise of the education levels during the nineties. Pavcnik et al. (2001) find that skilled biased technological change was more apparent in sectors where import penetration was largest, suggesting that this skill biased technological change was caused by increased foreign competition. This resulted in an increase in the industry wage premium in these sectors, which is in line with the theory of Nissanke & Thorbecke. This is in contrast with the in the previous part discussed results for Colombia, where the findings of Attanasio et al. (2002) and Goldberg et al. (2002)

[7] Capital intensive industries in general employ relatively more skilled workers, because capital can be seen as a complement to skilled labor, as argued before.

weren't compatible with the theory of Nissanke & Thorbecke. The same can be said for some articles on Brazil, like Arbache et al. (2004) who find that during trade liberalization wages in Brazil in the traded sectors fell in contrast to wages in the non-traded sectors, contradicting the previously discussed articles on Brazil and therefore not in line with the theory of Melitz (and Nissanke & Thorbecke) either.

Carneiro et al. (2003) argue against the H-O assumption of free labor mobility as well (in Brazil). They show that most changes in labor demand were observed on the intra-industry level, which indicates that these labor demand changes were caused by technology changes and not production composition. Overall, their results indicate that trade liberalization has contributed to economic welfare in the form of greater output and higher labor demand, but that these benefits are disproportionately appropriated by the most skilled workers, so also contradicting the main forecast of the H-O theory.

The findings of Pavcnik et al. (2002) confirm that labor is not very mobile in Brazil They show that the structure of employment patters across industries have remained relatively stable during the years of the trade liberalization. Furthermore, Pavcnik et al. (2004) argue that industry wage premiums may vary between skilled and unskilled workers, because skilled workers may be more mobile in the labor market and have more sector-specific human capital and therefore may have more bargaining power than unskilled workers. These differences may increase the possibilities for skilled workers relative to unskilled workers to benefit from trade. This is in line with Winters et al. (2002), who also point out, in their extensive article on trade and poverty, that richer households are more able to protect themselves against negative effects of trade and taking advantage of the positive opportunities created by increased trade.

Although the free labor market mobility condition seems very unrealistic, the basic mechanism behind the H-O theory still represents an important force behind the effect of trade on wages of the skilled and unskilled, even though many new theories discussed in part 2.1 have weakened the expected influence of this mechanism.

3. Empirics

3.1. Data

In this section the data sources will be presented and the variables that are used in the regressions will be discussed. Individual data on workers characteristics is combined with international trade data at the state and sector level.

3.1.1. Individual data

The individual data used in this study comes from the National Household Survey of Brazil, Pesquisa Nacional por Amostra de Domicilios (PNAD). This cross-section survey series has been carried out every year starting from 1976, except a few years, among others 1994 and 2000.[8] It is nationally representative and the surveys have been conducted with the use of a consistent methodology developed by the statistical agency of the Brazilian government. Therefore, the data is comparable over the years. The PNAD doesn't interview the same individuals each year but instead interviews a different random sample of residents each year. In this research data from 1992 to 2003 is used. Even though the PNAD data is known to be of high quality (Sawyer, 1988), a relatively small amount of outliers have been removed. After this 'cleaning up' of the dataset there are about 117,000 individuals left per annum and in total over 1.3 million observations are used. This dataset includes information on wages, number of completed school years, sex, ethnicity, age, state of residence and industry in which the individual is active.

The dependent variable is the hourly wage which also includes wages of self-employed and individuals working in the informal sector. The hourly wage is calculated by dividing the reported monthly wage by the reported amount of hours weekly worked multiplied by 4.33.[9] Wages are harmonized across years and are thus corrected for inflation.

Based on the number of completed school years all individuals are divided in two groups. More than 10 years of completed education (in general at least some secondary education) are labeled "skilled" and less than 10 years of completed education (in general no more than primary education) are labeled "unskilled". The mean hourly wage of skilled workers was about 3 times higher than the mean hourly wage of unskilled workers during

[8] Years that are missing within the sample period used in this research.
[9] Average number of weeks in a month.

the sample period (see figure 3). The evolution of the skilled-unskilled ratio is shown in figure 4. It can be seen that workers increasingly became more skilled (more educated) from 1992 till 2003.[10] This is in line with the findings of previous articles (e.g. Pavcnik et al., 2002; Arbache et al., 2004).

Figure 3: Mean wage per hour

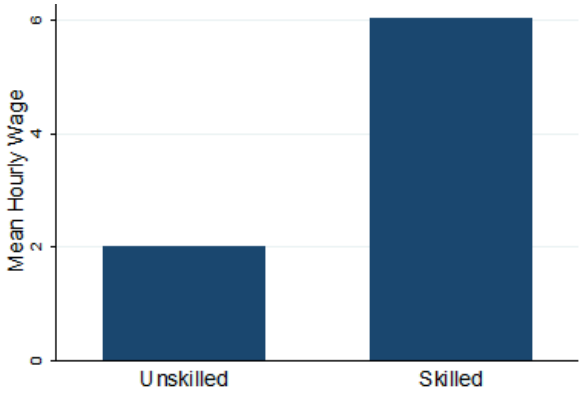
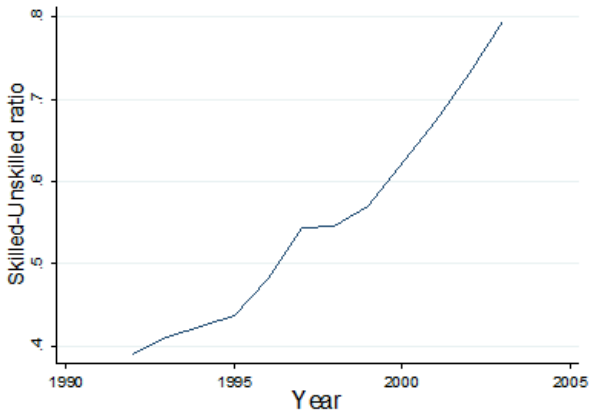


Figure 4: Evolution of the skilled-unskilled ratio



Source: Own calculations

3.1.2. Trade data

The trade data comes from the Brazilian Foreign Trade Secretariat (SECEX, Secretaria de Comércio Exterior) and gives information on total state import, total state export flows and even on the sectoral composition of these trade flows. Using these data econometric analysis can be applied, not only on the effects of trade in a specific state on wages of workers in that specific state, but more interestingly, on the effects of trade in a specific sector in a specific state on wages of workers in the corresponding sector and state. All together 27 states are included and within each state 17 sectors. In 13 of the 17 sectors goods are produced that are traded and in the other 4 sectors goods are produced that are not. Dividing the trade flows for each state or each sector within each state by state GDP gives the trade intensity ratios which are used in the regressions. Both GDP variables and trade flow variables have been lagged one year in order to reduce endogeneity. State GDP data comes from the IPEA (Instituto de Pesquisa Econômica Aplicada).

International trade flows at the state level are rarely available for developing countries. Brazilian states are a positive exception, especially because even information on

[10] One must keep in mind that an individual who completed 10 or more years of education he or she will be labeled skilled, while an individual with nine years of completed education is labeled unskilled.

the sectoral composition of trade flows is included. This dataset on trade flows combined with the dataset on individual worker characteristics provides an excellent starting point for analyzing the effects of trade on wages of skilled and unskilled workers in Brazil.

3.2. Empirical strategy

3.2.1. Trade intensity ratios vs. tariffs

As mentioned before, the major trade opening episode in Brazil was from 1987 to 1995. The reason why this period is defined as the major trade opening episode is because during this period the average effective rate of protection fell from 56 percent to 20 percent. Interesting enough, this considerable size reduction in trade barriers did not raise the national trade intensity ratios much until around 1999-2000 (see figure 4). Thorbecke et al. (2008) analyze the impact of globalization on the poor in Latin America, and argue in their article that there's a "*disconnect between the timing of trade liberalization policies and the resulting increase in trade intensity*". Surprisingly, most research about the effect of trade on wages in Brazil has been done using trade barriers as the main explanatory variable of interest and not trade intensity ratios (e.g. Pavcnik et al., 2001; Carneiro et al., 2003; Ferreira et al., 2003; Arbache et al., 2004; Nicita, 2004; Gonzaga et al., 2005). Gonzaga et al. (2005) even stated the following: "*The behavior of earnings differentials after 1995 is not the focus of this paper, since their movements are not related to the effects of trade liberalization.*"

So, in Brazil the decline in tariff rates is mainly noticeable in the level of trade flows many years later. This means that for many years tariff rates were declining on a high pace, while trade flows remained fairly constant (especially exports). Therefore, in this case, one might ask what effects on wages are actually measured if for these years econometric analysis is used to find a link between these tariff rates and wages when during the years of the trade liberalization ('87-'05) until '99/'00 import intensity ratios increased a bit, but export intensity ratios didn't increase at all, even decreased slightly (see figure 4). From this fact can be concluded that the impact that these tariff reductions had on wages can't be due to increased trade, so it must be caused by other mechanisms. An optimistic view would be that the link that is found represents the effect that tariffs had directly or indirectly on wages. A more pessimistic view (and perhaps also more realistic) is that the link that is found actually represents also the effects that other policies had on wages, ones that have been

implemented approximately simultaneously with trade liberalization policies. For example, when a right-wing government has come to power, in general they opt for reducing government interference, not only in the trade field, but in many other fields as well (examples are privatization, deregulation of international investment and banking and deregulation of the labor market) (Galiani et al., 2003). These policies are also likely to affect wages. In short, there is reason to assume that colinearity between a more open trade policy and other policies that affect wages could be high. Naturally, trade intensity ratios will not be the only factor affecting wages and will also be correlated with other factors but the effect is more direct than that of tariff rates.

It is true that when analyzing the effect of trade volume instead of tariff rates the policy implications aren't immediately clear, since trade flows are not a policy variable. Still, information about the effects of trade flows on wages can be very interesting and an important starting point for the decision between engaging in policies that promote or in ones that restrain these trade flows.

Figure 4: Evolution of national import/export intensity ratios

Source: Own calculations.

Another advantage of using trade flows is that it allows for differentiating between the effects of imports and exports. This makes it possible to study the separate effects that these have on wages. A problem is that wages may influence state import levels as well. To

illustrate, when individuals receive higher wages they will in general consume more and this may lead directly or indirectly (through intermediate goods imported by firms) to increased imports. Therefore, the trade variables are lagged by one year. Furthermore, this relation will pose less of a threat when analyzing the effects of imports of a specific sector on the wages of people working in that sector because only part of the wage of the individual will be spend in the sector where he or she works.

Finally, even though official tariff rates are easily obtained, the same can't be said about non-tariff barriers which are often not (fully) reported, especially by developing countries (Goldberg et al., 2007).[11] Because these non-tariff barriers have a considerable influence on trade openness, not including them or not including the correct values in any trade openness variable may lead to inaccurate results. For the reasons mentioned above the approach of using tariff rates as the main explanatory variable has not been taken. Instead, trade intensity ratios are used in the regressions.

3.2.2. Main models

As explained in the previous part, the main independent variables of interest will be trade intensity ratios and the dependent variable will be workers' wages. All the regressions have been run for all workers together, but also a distinction has been made between the effects on the skilled and unskilled, by running all the regressions also separately for skilled and unskilled workers.

Different trade variables have been used in the models. The ratio of the yearly import and export flows *for each state* to state GDP and the ratio of the yearly import and export flows for *each sector within each state* to state GDP. The intuitions behind these different variables will be discussed in the results section.

The effects of trade on skilled and unskilled workers will be analyzed through the effects on production only and not through the effects on consumption. In other words, the focus is on how trade influences the wages of skilled and unskilled workers and not how trade influences the price of the average consumption basket of the skilled and unskilled. According to Goldberg et al. (2007), the effect of trade on production through wages

[11] Countries can have many reasons for not (fully) reporting non tariff barriers. For example when pressured by other countries to increase trade openness. Tariff rates can be easily observed, but for non tariff barriers this is more difficult.

dominates the effects of trade on consumption through relative prices, so the focus on wages alone is not very limiting.

When analyzing any determinant of wages at the micro level it is important to control for sufficient individual characteristics. In all models the following individual workers characteristics are controlled for: years of schooling, age (and also age^2), gender and ethnicity. It's important to emphasize that the dependent variable and the control variables are not weighted means of (sub)groups, but are varying with each individual. Therefore different effects within (sub)groups can be observed, so estimates will be more accurate than when averages would have been used. This is especially the case for Brazil where the differences in these individual characteristics are very large and therefore have a serious influence on the wage distribution in the country. The models in this article correspond to the Mincerian earnings function (Mincer, 1974).

In this research skilled and unskilled workers are defined by looking at the number of completed school years (this is the standard way). The conventional way of defining (potential) work experience is to take age minus years of schooling minus six (Arbache et al., 2004). For the case of a poor country like Brazil where many people hardly have any education (or even no education at all) this way of defining work experience is a bit problematic because people are given credit for labor market experience from unrealistically young ages. For this reason age (and age^2) will be used to control for work experience (and work experience^2), to avoid the otherwise in some cases unrealistically high values of work experience. Furthermore, year dummies have been added to control for yearly variations in the wages not captured by the variables in the model. State-industry fixed effects are also controlled for to capture wage disparities that are caused by the fact that an individual is active in a specific state in a specific sector (also called state and industry wage premiums).

It is suspected that the error terms within each state-sector group are correlated, because the observable and unobservable characteristics of various workers within the same state and industry may be correlated. According to Moulton (1986), this may lead to serious understating of the errors which will result in overestimating the significance of the coefficients when working with typical OLS regressions. To control for this correlation, the standard errors of the workers within these state-sector groups have been clustered.

3.3. Results

In this section the most important regression results will be presented, interpreted and discussed. As argued in the previous parts, it will be less likely that the obtained results will be mainly caused by other macroeconomic policy and/or institutional changes that occurred in the period of interest, because trade intensity ratios are used as opposed to trade policy variables (tariff rates). Still it is possible that other macroeconomic policies have been implemented around the same time. The year dummies included in all regressions should control for this by capturing the effects of these macroeconomic policies and other macroeconomic shocks on wages that are common to all states.

The first part will cover the regressions that relate state trade intensity ratios to workers' wages in the corresponding state and the second part will cover the regressions that relate trade intensity ratios of a specific sector in a specific state to workers' wages in the corresponding sector and state.

3.3.1. Total state trade flows

In this section the main results will be discussed of the regressions which use state import and export flows relative to GDP as the main explanatory variables. As mentioned before, sector-state fixed effects and individual characteristics are controlled for, year dummies have been included and the standard errors of the workers within the state-sector groups have been clustered. The regressions have been run three times. Once for individuals of all skill levels simultaneously, once for individuals who are defined as "unskilled" and once for individuals who are defined as "skilled". The results are presented in table 1. The first column shows the aggregated results for all workers and the second and third column show the results for unskilled and skilled workers respectively.

The interpretation of the coefficients, for example the coefficient of the state import/GDP ratio for all education levels, should be as follows: a unit increase of the state import/GDP ratio will decrease wages by 20.4%. Or more realistically, an increase of the state import/GDP ratio by the size of one standard deviation of the import/GDP variable will decrease wages by 1.05% (0.0513 * 20.4%).[12] The coefficient is significant at the 1% level.

[12] Summary statistics of the key variables are shown in table A-2 of the appendix.

More interesting are the separate effects on the skilled and unskilled. State import intensity doesn't have a significant impact on wages of unskilled individuals from the same state and has a negative effect on wages of skilled individuals which is significant at the 1% level. The problem that increased wages may positively affect state import flows, as discussed earlier, is not relevant anymore when looking at the sign of the coefficient, because the negative effect of increased state import flows is clearly working in the other direction and is much stronger.

Table 1: Total state import/export flows relative to state GDP
Dependent variable: ln(wage per hour)

	All Education Levels	Unskilled Only	Skilled Only
import/GDP	-0.204[c]	-0.0308	-0.413[c]
	(0.0386)	(0.0466)	(0.0652)
export/GDP	-0.00419	0.224[c]	-0.190[c]
	(0.0399)	(0.0491)	(0.0656)
school years	0.132[c]	0.0972[c]	0.216[c]
	(0.000163)	(0.000338)	(0.000593)
age	0.0225[c]	0.0165[c]	0.0274[c]
	(0.0000565)	(0.0000663)	(0.000117)
age^2	-0.0000220[c]	-0.0000162[c]	-0.0000269[c]
	(8.44e-08)	(9.79e-08)	(0.000000165)
ln(GDP)	0.165[c]	0.177[c]	0.118[c]
	(0.0126)	(0.0156)	(0.0204)
gender (1=female)	-0.321[c]	-0.313[c]	-0.329[c]
	(0.00139)	(0.00173)	(0.00222)
ethnicity (1=white)	0.142[c]	0.106[c]	0.187[c]
	(0.00152)	(0.00182)	(0.00260)
N	1293405	828694	464711
R^2	0.394	0.165	0.421

OLS regressions with robust standard errors and sector-state fixed effects
Standard errors clustered within sector- state group
Year dummies are included in the regressions (omitted from table)
Statistical significance: [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

It can be concluded that trade has a different impact on wages of skilled and unskilled workers, since table 1 shows very different results for the skilled and unskilled. Furthermore, table 1 shows that these differences are quite large and that not

differentiating between skilled and unskilled workers gives misleading results. The aggregation of all workers hides the heterogeneous impact across different types of workers. State export flows seem to have no significant effect on workers' wages when including workers of all skill levels in the regression. However, when only skilled or unskilled workers are included in the regression it becomes clear that export flows do have a significant effect on workers' wages (even at the 1% level). Since the effect is positive for unskilled workers and negative for skilled workers these two effects practically cancel each other out when both groups are included in the regression. This explains why the aggregated effect is not significant.

The theoretical framework presented earlier can help providing an underlying economic intuition for these findings. The Hekscher-Ohlin theory discussed over there is in particular interesting for explaining these results. Assuming Brazil is a developing country with an abundance of unskilled labor, the H-O theory expects Brazil to export goods that use unskilled labor most intensively in their production process and import goods that use skilled labor (the relative scarce factor of production) most intensively in their production process. The consequence is that increased exports induce a relative increase in demand for unskilled labor and a relative decrease in demand for skilled labor (scarce factor of production) which in turn increases the relative price (wage) of unskilled labor and decreases the relative price (wage) of skilled labor. This is exactly what the regression results indicate.

In table 1 the estimated effects of total state trade flows on wages of both individuals working in the traded and individuals working in the non-traded sector are presented. It will be interesting to see how these estimated effects change when including in the regressions either only those that are active in the traded sector or only those active in the non-traded sector. These estimated effects of total state trade flows on individuals working in the non-traded sector and the estimated effects of individuals working in the traded sector are presented in table 1a and table 1b respectively. First of all, the results in table 1a indicate that trade doesn't have a significant effect on wages of individuals working in the non-traded sector, except for the effect of export on the skilled, which is negative and significant at the 10% level (this explains the negative sign of the coefficient in table 1 for the effect of exports on wages of the skilled). A possible explanation for this effect is that trade increases the incentives for individuals to acquire more education which results in an increased supply of

skilled labor. When the demand for skilled labor is not increased as much in the non-traded sectors this may lead to a decline in the wage of skilled labor in non-traded sectors.[13]

That the significance of the coefficients in table 1a are much lower than in table 1b shows that trade mainly influences wages of individuals working in the traded sectors. This is

Table 1a: State import/export flows relative to state GDP (non-traded sectors only)
Dependent variable: ln(wage per hour)

	All Education Levels	Unskilled Only	Skilled Only
import/GDP	-0.176	-0.0574	-0.256
	(0.236)	(0.254)	(0.269)
export/GDP	-0.224	-0.0585	-0.351[a]
	(0.208)	(0.268)	(0.184)
school years	0.112[c]	0.0745[c]	0.198[c]
	(0.00288)	(0.00212)	(0.00443)
age	0.0239[c]	0.0184[c]	0.0264[c]
	(0.000396)	(0.000398)	(0.000592)
age^2	-0.0000233[c]	-0.0000180[c]	-0.0000258[c]
	(0.000000403)	(0.000000404)	(0.000000602)
ln(GDP)	0.132[b]	0.136[a]	0.111[a]
	(0.0608)	(0.0734)	(0.0597)
gender (1=female)	-0.305[c]	-0.279[c]	-0.329[c]
	(0.00673)	(0.00821)	(0.00995)
ethnicity (1=white)	0.140[c]	0.0969[c]	0.175[c]
	(0.00694)	(0.00837)	(0.00860)
N	870407	530808	339599
R^2	0.314	0.148	0.374

OLS regressions with robust standard errors and sector-state fixed effects
Standard errors clustered within sector-state group
Year dummies are included in the regressions (omitted from table)
Statistical significance: [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

what would be intuitively expected and these findings strengthen the allegation that the observed effects of trade on wages are not mainly driven by external factors that are not controlled for in the regressions. These results confirm that labor in Brazil is not very mobile across sectors, because in that case wages of individuals with the same characteristics would not differ so much between sectors.

[13] Wages of skilled workers in traded sectors can still rise, since labor is not very mobile across sectors in Brazil.

Table 1b: State import/export flows relative to state GDP (Traded Sectors Only)
Dependent variable: ln(wage per hour)

	All Education Levels	Unskilled Only	Skilled Only
import/GDP	-0.367	-0.123	-0.688[c]
	(0.264)	(0.222)	(0.244)
export/GDP	0.406[a]	0.539[b]	0.388[b]
	(0.230)	(0.218)	(0.188)
school years	0.118[c]	0.0800[c]	0.196[c]
	(0.00310)	(0.00330)	(0.00326)
age	0.0194[c]	0.0133[c]	0.0301[c]
	(0.00112)	(0.000622)	(0.000687)
age^2	-0.0000191[c]	-0.0000132[c]	-0.0000296[c]
	(0.00000107)	(0.000000564)	(0.000000731)
ln(GDP)	0.176[b]	0.179[b]	0.0363
	(0.0719)	(0.0750)	(0.0552)
gender (1=female)	-0.304[c]	-0.303[c]	-0.283[c]
	(0.0152)	(0.0199)	(0.0151)
ethnicity (1=white)	0.161[c]	0.130[c]	0.216[c]
	(0.00878)	(0.0133)	(0.00939)
N	422998	297886	125112
R^2	0.278	0.112	0.412

OLS regressions with robust standard errors and sector-state fixed effects
Standard errors clustered within sector-state group
Year dummies are included in the regressions (omitted from table)
Statistical significance: [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

Interestingly enough, when only looking at individuals working in the traded sector, the state export intensity ratio has a positive effect on wages of the skilled. This is different from the effect presented in table 1, which indicates that exports have a negative effect (significant at the 10% level) on wages of the skilled working in the non-traded sectors. As discussed before, a possible explanation is that these higher export intensity ratios increase the incentives to follow secondary and college education because they lead to more jobs for skilled workers in the traded sector.[14] This could be caused by technology spillover effects due to increased trade and/or because of productivity improvements caused by increased trade (Melitz), as discussed in the theoretical framework. The result is an increase in the

[14] The regression results presented in table A-1 in the appendix indicate that this relation may well exist because it shows, although only at the 10% significance level, positive coefficients for state trade export (and import) intensity ratios on the amount of education completed by individuals.

supply of skilled labor, which will cause a decline of wages of the skilled when the demand for skilled labor doesn't increase as well. If the demand for skilled labor was increasing in the traded sectors because of these increased exports but not in the non-traded sectors, this could explain the findings that increased exports raised the wages of workers in the traded sector and lowered the wages in the non-traded sectors.

Table 1b, which shows the general relation between trade flows of a specific state and the wages of individuals working in the traded sector in that state, is best suited to compare with the theoretical framework. The theory of Nissanke & Thorbecke, that increased import penetration has a positive influence on productivity and therefore wages, is not supported by the results. Instead, increased import penetration seems to hurt workers, especially the more skilled. The theory of Melitz that an increase in export intensity has a positive effect on productivity and therefore workers' wages seems to hold for both skilled and unskilled workers. This also seems in line with the predictions of standard H-O theory, because unskilled labor, which is assumed to be the relative abundant factor of production of Brazil, seems to benefit more from increased export flows than skilled labor and to lose a lot less from increased import penetration than skilled labor. So taking the two effects together it can be concluded from table 1b that skilled workers in Brazil in traded sectors in general lose from increased state trade flows while unskilled workers benefit. Therefore, these findings seem to be in line with the H-O theory predictions.

The findings in table 1b show how much trade intensity ratios affect the wages of individuals that work in any of the traded sectors. So the coefficients represent the effects of changes in the aggregated trade flows of all traded sectors on the wages of individuals from that specific state working in the traded sector. To illustrate, an increase of the export flows in the agriculture sector in a specific state will be assumed to influence wages of individuals working in different sectors of that state as well. This may especially be realistic in case labor is freely mobile across sectors.[15] In that case, workers will move to the sector where they will receive the highest wage until wages are approximately equal in all sectors within each state.[16] The problem is that this assumption is not very realistic for the case of Brazil, as

[15] It could also be realistic when labor is not mobile across sectors when technological spillover effects are present, which could increase productivity in other sectors as well, or because of interlinkages between sectors. But the effect of trade in one sector on other sectors will in these cases in general not be as large as when labor is freely mobile.

[16] For workers with similar characteristics, like educational attainment, age, gender, etcetera.

argued before. Therefore, in the next section, the results will be presented of the regressions that are based on the sector specific model, discussed in the theoretical framework, which assumes that labor is not freely mobile across sectors. In these regressions trade flows of a specific sector in a specific state will be linked directly to the wages of workers in the corresponding sector and state.

3.3.2. Sectoral trade flows

A way to link trade flows more directly to workers' wages is to analyze the effects of trade flows of a specific sector in a specific state on workers' wages that are active in the corresponding sector and state. The coefficients presented in table 2 represent this relation. The interpretation of the coefficients is similar to the interpretation of the coefficients in the previous part. They are higher because the trade flows of a specific sector relative to state GDP are naturally much lower than the trade flows of the total state relative to state GDP. The size of the coefficients will not be interpreted because this will not be very intuitive since the size of different sectors is varying a lot.[17] These models are especially relevant when assumed that labor is not fully mobile across sectors (like the specific sector model does). The findings differ from the findings in the previous part. When looking at sector trade flows, increased imports seem to affect the wages of the unskilled negatively, where total state import flows didn't, although this effect is only significant at the 10% level. Table 2 doesn't show significant results for the relation between sectoral export flows and wages of skilled workers active in the corresponding sector. A possible explanation for this is that skilled workers are more mobile across sectors (as previously discussed in part 2.2.3.) and therefore total exports are more important because this influences the total demand for skilled labor. When exports in their own sector decrease they can just move to a sector with higher exports and more jobs.[18] But more importantly, also here the most robust results are the negative effect of import flows on wages of the skilled and the positive effect of export flows on wages of the unskilled (both statistically significant at the 1% level). These findings are, as stated before in line with the theory of Melitz and not in line with theory of Nissanke & Thorbecke.

[17] Obviously, the effect of an equal increase in trade flows relative to total state GDP will in general be larger for a small sector than for a large sector.

[18] But since this is not the case for sectoral import flows (which are still significant) this explanation is not perfect.

Table 2: State import/export flows *per sector* relative to state GDP

Dependent variable: ln(wage per hour)

	All Education Levels	Unskilled Only	Skilled Only
sector imports/GDP	-4.029[c]	-3.405[a]	-3.826[c]
	(1.456)	(1.773)	(1.427)
sector exports/GDP	1.331[c]	1.254[c]	0.485
	(0.320)	(0.375)	(0.407)
school years	0.113[c]	0.0761[c]	0.198[c]
	(0.00227)	(0.00180)	(0.00332)
age	0.0222[c]	0.0163[c]	0.0274[c]
	(0.000604)	(0.000517)	(0.000511)
age^2	-0.0000218[c]	-0.0000160[c]	-0.0000269[c]
	(0.0000005 82)	(0.000000495)	(0.000000519)
ln(GDP)	0.147[c]	0.138[c]	0.134[b]
	(0.0452)	(0.0515)	(0.0545)
gender (1=female)	-0.306[c]	-0.287[c]	-0.317[c]
	(0.00658)	(0.00854)	(0.00877)
ethnicity (1=white)	0.146[c]	0.108[c]	0.185[c]
	(0.00560)	(0.00748)	(0.00701)
N	1301393	834818	466575
adj. R^2	0.301	0.133	0.384

OLS regressions with robust standard errors and sector-state fixed effects
Standard errors clustered within sector-state group
Year dummies are included in the regressions (omitted from table)
Statistical significance: [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

Although the assumption of free labor mobility cannot hold, the findings seem to be in line with the H-O theory only on a more disaggregated level. On the sector level within each state the predictions of the H-O theory can be observed. The size of the coefficients in table 2 indicates that on average, increased imports have hurt the skilled relatively more than the unskilled and increased exports have benefited the unskilled relatively more than the skilled. Therefore, it can be concluded that the findings of this research indicate that trade in Brazil in general has been more beneficial for the unskilled than for the skilled.

Comparing these findings to the ones in the previously discussed articles on Brazil, resemblances and differences can be observed. The findings of this research differ from the

findings of Pavcnik et al. (2002), Carneiro et al. (2003) and Arbache et al. (2004). All these articles find/argue that increased trade will be more beneficial for the skilled than for the unskilled. The findings of Harrison et al. (2004), Gonzaga et al. (2005) and Fally et al. (2010) resemble the findings of this research that increased trade in general has been more beneficial for the unskilled than for the skilled in Brazil. [19] The most important explanation for the differences in findings is that researchers who argued that trade liberalization will increase inequality have mainly used tariff rates in their models as the main explanatory variable. Furthermore, Arbache et al (2004) compared the wages of skilled and unskilled workers before trade liberalization with their wages after trade liberalization (while controlling for individual worker characteristics) and concluded that the differences must be caused by the trade liberalization. They do not control for other forces that could have influenced wages during this period. Furthermore, they use a different sample period, ranging from 1988 to 1995. This paper uses one ranging from 1992 to 2003.

In this research actual trade flows have been used as the main explanatory variables in the models and an attempt has been made to control for external forces. The fact that in the case of Brazil the decrease in tariff rates only resulted in increased trade intensity ratios many years later explains why the findings in this article are different from the findings in articles that used tariff rates as the main explanatory variable.

4. Conclusion

This paper has examined the effect of trade on wages of skilled and unskilled workers in Brazil. The effect of (sectoral) trade intensity ratios of Brazilian states on wages of skilled and unskilled workers active in the corresponding state (and sector) has been analyzed using new regression models. The models control for individual characteristics and year dummies have been included to control for macroeconomic shocks on wages.

The main findings indicate that imports negatively affected wages and exports positively. Furthermore, this positive effect of exports was more significant for the unskilled where the negative effect of imports was more significant for the skilled.

[19] Although these researchers used different empirical strategies, their aim, finding the effect of increased trade on wages of the skilled and unskilled, was similar.

These findings are compatible with the predictions of the theories of Melitz and Hekscher & Ohlin and contradict the predictions of the theory of Nissanke & Thorbecke. Other papers on Brazil have presented results arguing against the Hekscher-Ohlin theory. The main difference is that this paper uses as the main explanatory variable actual trade intensity ratios instead of tariff rates, because this paper has argued that trade intensity ratios are more appropriate for several reasons. The main arguments are that actual trade flows affect workers more directly than tariff rates and that trade liberalization policies are often approximately simultaneously implemented with other deregulation policies that may influence wages, which makes it difficult to disentangle the effect of tariff rates on wages. Since it has been shown that the correlation between tariff rates and trade intensity ratios (especially export intensity ratios) is very low for the case of Brazil these differences in findings did not come as a surprise.

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Appendix

Table A-1: Effect state import/export flows relative to state GDP on educational attainment
Dependent variable: years of schooling

	All Workers
import/GDP	1.098[a]
	(0.604)
export/GDP	1.078[a]
	(0.634)
age	-0.0574[c]
	(0.00212)
age^2	0.0000542[c]
	(0.00000204)
ln(GDP)	0.126
	(0.172)
gender	0.668[c]
	(0.0706)
ethnicity	1.522[c]
	(0.0422)
N	1293405
adj. R^2	0.086

OLS regressions with robust standard errors and sector-state fixed effects
Standard errors clustered within sector-state group
Year dummies are included in the regressions (omitted from table)
Statistical significance: [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

Table A-2: Summary statistics of key variables

Variable	Mean	Std. Dev.	Min.	Max.
hourly wage	3.453428	8.709657	.0000679	1938.598
total state imports / GDP	.0614212	.0514184	0	.3812487
total state exports / GDP	.0793395	.0571601	0	.2967877
sectoral imports/GDP	.0012759	.0059303	0	.2287951
sectoral exports/GDP	.0032631	.0108635	0	.1618589
school years	7.717201	4.42294	1	16
age	35.27814	13.07514	5	105
GDP	5.26e+10	6.68e+10	3.33e+08	2.87e+11
gender	.382276	.4859437	0	1
ethnicity	.5266617	.4992888	0	1

GDP and sectoral imports/exports are measured at the state level