

ABSTRACT

Title of Document:

ESSAYS ON INTERNATIONAL TRADE AND
INEQUALITY

Lourenço Senne Paz, Doctor of Philosophy,
2009

Directed By:

Professor Nuno Limão
Department of Economics

In this dissertation I assess the impact of developing country trade liberalization on their wage inequality by focusing on two possible channels, namely job formality and inter-industry wage premium.

Informal workers are a large share of the workforce, more than 30% in Brazil and Colombia, and this share within manufacturing has increased in some countries that underwent trade liberalization. In chapter one I develop a theoretical model that endogenously generates informal jobs due to a payroll tax, and in which domestic and foreign import tariffs affect the industry-level share of informal workers and the formal-informal wage gap. My model predicts that a decrease in import tariffs increases both the informality share and the formal-informal wage gap, whereas a decrease in foreign tariffs has the opposite effect.

In chapter two I verify if these predictions are supported by data from the Brazilian trade liberalization episode (1989-2001), which contain information about

workers' employment, demographic characteristics, and payroll tax compliance. To avoid endogeneity concerns I employ an instrumental variables technique. I find that a percentage point decrease in import tariffs leads to a 0.8 percentage point increase in the informality share and a 0.4 percentage point increase in the wage gap. A percentage point reduction in foreign tariffs implies a decrease of 0.35 percentage point in the informal share and a 0.17 percentage point decrease in the wage gap.

In chapter three I investigate the inter-industry wage premium channel by focusing on two aspects ignored by the existing literature. The first is whether trade policy affects wage premium for tradable and non-tradable industries differently. The second aspect is if productivity determines both the wage premium and import tariffs, then its omission will generate inconsistent estimates of the effect of import tariffs. Using late 1980s data from the Colombian trade liberalization episode, I find that only the tradable and manufacturing industries wage premia are sensitive to changes in import tariffs. Furthermore, productivity is an important determinant of the wage premium and the import tariff (as an included instrument). Its omission generates a 100% larger estimated impact of trade liberalization impact on the wage premium.

ESSAYS ON INTERNATIONAL TRADE AND INEQUALITY.

By

Lourenço Senne Paz

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2009

Advisory Committee:
Professor Nuno Limão, Chair
Professor Christopher McKelvey
Professor Alexis Piquero
Professor Ingmar Prucha
Professor Seth Sanders

© Copyright by
Lourenço Senne Paz
2009

Dedication

I dedicate this dissertation to my wife and daughter for the long hours I spent away from them and to my parents and grandparents for the support during this long journey.

Acknowledgements

I am indebted to my advisor Professor Nuno Limão for his support and guidance through this project. I'd like to thank Professor Seth Sanders and Professor Christopher McKelvey for suggesting several improvements in earlier drafts of this dissertation.

Part of the data used in chapter 2 was kindly provided by Honório Kume (IPEA), Marcela Eslava (Universidad de Los Andes), Emanuel Ornelas (LSE), Antoni Estevadeordal (IABD), and Fábio A. Gomes (IBMEC-SP).

Data used in chapter 3 was kindly provided by Marcela Eslava (Universidad de Los Andes), Pinelopi Goldberg (Princeton University), and Nina Pavcnik (Dartmouth College).

Table of Contents

DEDICATION	II
ACKNOWLEDGEMENTS	III
TABLE OF CONTENTS.....	IV
LIST OF TABLES	VI
LIST OF FIGURES	VIII
INTRODUCTION	1
CHAPTER 1 - TRADE LIBERALIZATION AND INFORMAL LABOR	
MARKETS: THEORETICAL MODEL.....	7
Literature Review.....	11
Informal labor market definition and stylized facts	11
Stylized facts about trade	19
Related Literature.....	24
Theoretical Model.....	26
Model set-up	27
Autarky	33
Open economy	40
Comparative Statics	48
Final Remarks	55
CHAPTER 2 - TRADE LIBERALIZATION AND INFORMAL LABOR	
MARKETS: EMPIRICAL ASSESSMENT	57
Description of the data	59
Workers data	59
Trade data.....	65
Estimations and Results	66
Share of informal workers	67
Formal-informal wage gap.....	73
Robustness checks	76
Final Remarks	87
CHAPTER 3 - TRADE LIBERALIZATION AND INDUSTRY WAGE PREMIA:	
THE MISSING ROLE OF PRODUCTIVITY	90
Methodology	93
Data	105
Estimations and results	107
Industry characteristics and the import tariff effect on the wage premium	107

The role of productivity	114
Final Remarks	119
APPENDIX.....	121
Proof of Propositions and Lemmas from Chapter 1	121
BIBLIOGRAPHY.....	129

List of Tables

Table 1.1 – Manufacturing industry workers characteristics in Brazil	16
Table 1.2 - Formal-informal job transitions between 1991 and 1996 using May 1996 PME special supplement	17
Table 1.3 – Brazilian import tariffs and export tariffs descriptive statistics for the 1989-2001 period	22
Table 2.1 – Equivalence among PNAD/Census manufacturing industry classification and IBGE Nível50 and ISIC3 classifications	60
Table 2.2 - Weighted OLS regression of the log of hourly wage on the workers’ observable characteristics	63
Table 2.3 - Linear probability of model of having an informal job	69
Table 2.4 - Effect of tariffs on the formal-informal wage gap regressions	74
Table 2.5 - Linear probability of model of having an informal job with interactions between industry indicators, years of education, age and male indicator	76
Table 2.6 - Linear probability of model of having an informal job with log(1+tariff) instead of tariff variables	78
Table 2.7 - Probit and IVProbit models of informal employment likelihood	79
Table 2.8 – Probability models of having an informal job without export tariff variable	81
Table 2.9 – Effect of tariffs on the formal-informal wage gap regressions, using log(1+tariff) instead of tariff variables	83
Table 2.10 – Effect of tariffs on the formal-informal wage gap regressions without export tariff variables	85
Table 3.1 - First difference of equation (3.1) estimated by IV using only non- manufacturing industries (ISIC 1,2,4,6,8, and 9)	109
Table 3.2 - First difference of equation (3.1) estimated by IV using only manufacturing industries (ISIC 3)	110

Table 3.3 - First difference of equation (3.1) estimated by IV using only tradable industries (ISIC 1-3)	112
Table 3.4 - Equation (3.2) estimated by IV using only manufacturing industries	116
Table 3.5 - Equation (3.2) estimated by IV using only manufacturing industries with Hausman test for productivity endogeneity	117

List of Figures

Figure 1.1 - Informality share in services and manufacturing in Brazil using 1984-2003 PNAD Census data	15
Figure 1.2 - Kernel density of the residuals of the regression of log hourly wage on age, age ² , years of education, black indicator, literacy indicator, and male indicator. The data used is from the food and beverage industry in 1997	19
Figure 1.3 - Wage (w_i) and expected wage bill (b_i) for formal and informal labor contracts in autarky	36
Figure 1.4 - Physical productivity (φ_i) and expected wage bill (b_i) space and firms' choice of labor contracts and markets served in an open economy	43
Figure 3.1 - Colombian non-manufacturing industries nominal import tariffs	95
Figure 3.2 - Colombian manufacturing industries nominal import tariffs	96
Figure 3.3 - Colombian non-manufacturing industries wage premium in terms of retail industry (ISIC 62) wage premium	101
Figure 3.4 - Colombian manufacturing industries wage premium expressed in terms of retail industry (ISIC 62) wage premium	102
Figure 3.5 - Colombian manufacturing industries productivity (log of TFP)	103

Introduction

The significant trade liberalization episodes that occurred in many developing countries throughout the 1980s and 1990s raised several concerns about the effects of trade policy changes on wage inequality in these countries. Several labor market outcomes can impact wage inequality directly, such as return to skills, inter-industry wage premium (part of the wage that is attributed to the worker's industry affiliation), and type of job (formal or informal).

The changes in return to skills cannot account entirely for the change in the wage inequality in Mexico (Cragg and Epelbaum, 1996), Colombia (Attanasio, Goldberg and Pavcnik, 2004), and Brazil (Gonzaga, Menezes and Terra, 2005). Therefore, researchers began to consider whether trade policy could affect wage inequality through the other channels mentioned earlier, namely type of job (formal and informal) and inter-industry wage premium. This is the path I follow in this dissertation.

The informality channel is important because informal labor markets are large in developing countries (cf. Perry et al., 2007). In particular at least a third of the jobs in Brazil and Colombia are informal jobs, as reported by Goldberg and Pavcnik (2003), Kugler (1999) and Neri (2002). Job informality affects wage inequality because informal jobs pay systematically lower wages, and if trade policy changes don't affect industries uniformly, then wage inequality will increase in informality prone industries, which are also intensive in unskilled workers.

At the same time of the trade reforms, Perry et al. (2007) reported a significant rise in informality across several measures in Latin American countries. Surprisingly,

there's scarcely any literature about the causal link between trade policy changes and informal labor markets in developing countries. To fill this gap, in chapter 1 I develop a theoretical model in which trade policy changes affect the formal status of jobs.

The conceptual and empirical difficulties in identifying informal workers are some of the reasons why people have not invested much time studying informality. For Latin America, however, there's increasing evidence that informality is related to the costs of having a legal contract, and payroll taxes are the major part of this cost.

My first contribution is to model theoretically the payroll tax compliance as the key distinction between formal and informal workers, and thus provide a mechanism that generates informal jobs endogenously. Then, I generalize the Davis and Harrigan (2007) trade model by embedding this mechanism in a general equilibrium model. My theoretical model considers the effects of changes in trade policy on two outcomes related to informal labor markets: the industry-level share of informal workers and the formal-informal wage gap, which is the difference between the average formal and informal wages. The trade policy options considered are changes in the import tariff and changes in the trade partners' import tariff (export barriers). The latter is my second contribution to the literature, since the effect of the export side of the economy has been ignored both theoretically and empirically so far.

More specifically, my model predicts that a decrease in foreign trade barriers affects the firms by two channels. The first channel is through the increase in the volume exported, which raises formal employment by the existing exporters and the new exporting firms. The second channel is through the exit of the least productive firms, which can increase or decrease the formal share of employment, but is

dominated by the first channel under reasonable conditions on the joint distribution of productivity and wage. In this case, foreign liberalization lowers the informality share and the formal-informal wage gap in a given industry. Similar comparative statics for own liberalization shows that industries with larger import tariff reductions have higher informality share and wage gap.

In chapter 2, I use the Brazilian trade liberalization (1989-2001) to test the predictions of my theoretical model. This is an important episode because it allows the identification of informal workers in the data by the same criterion used in the theoretical model, i.e. compliance with payroll taxes, and to the best of my knowledge it is the first time in the literature that this matching between theory and data is this close. Moreover, Brazil went through a trade liberalization program that reduced significantly its import tariffs and its trade partners also reduced substantially their import tariffs. Last, but not least, there was no change in labor regulations during this period.

An important finding is that the Brazilian import tariff is endogenous with respect to informal share and formal-informal wage gap. To circumvent this problem, I use an instrumental variable approach, and the instrument used is the trade liberalization path of a similar country. Furthermore, when trade partner import tariffs are omitted from the estimated models, the estimates are not statistically significant. This fact highlights the importance of not neglecting the export side of the economy as many studies of trade reforms do.

I assessed the industry-level informality share prediction by estimating the effect of Brazilian and foreign tariffs on the worker probability of having an informal

job. Contrary to the previous literature that reported no effect of trade on informality, my findings indicate that reducing within industry Brazilian import tariff by a percentage point increased informal share by 0.8 percentage points. On the other hand, a percentage point decrease in foreign tariff reduces informality by 0.4 percentage points. Both effects have the same signs as predicted by my model.

To test the formal-informal wage gap predictions I follow the standard two-step procedure in the wage inequality literature. First, I estimate the wage gap using a Mincer-type earnings equation for each year. In the second step, I regress the estimated wage gap on Brazilian and foreign tariffs in addition to year and industry effects. I also find strong support for my model here: a one percentage point decrease in own tariff increases the wage gap by 0.4 percentage point and a 1 percentage point decrease in the foreign tariffs decreases the gap by 0.17 percentage points.

The policy implications of my results are that unilateral trade liberalization can indeed increase job informality; however, reciprocal trade liberalization can mitigate this increase in informality and maybe even decrease it.

Chapter 3 contains the empirical assessment of the effect of trade policy on inter-industry wage premium for Colombia. Wage inequality can be increased if trade policy changes in a way that there is a very small effect on the wage premium of skilled worker intensive industries, for example.

The literature relating wage premium to import tariff changes has found mixed evidence so far. Feliciano (2001) found that the change in tariffs didn't affect wage premium in Mexico, and so did Pavcnik et al. (2004) for Brazil. Goldberg and Pavcnik (2005) uncovered evidence that a reduction in tariffs decreased the wage

premium for Colombia. On the other hand, Mishra and Kumar (2007) found that the decrease in import tariffs increased wage premium in India.

The existing work has ignored two key aspects. The first is whether trade policy changes affect differently wage premium based on industry characteristics. So, I use the methodology of previous studies, such as Goldberg and Pavcnik (2005), to assess if the tariff effect is similar for manufacturing and non-manufacturing or for tradable and non-tradable industries.

The second aspect is the role of productivity in determining both the industry wage premium and import tariffs. Ignoring productivity can be an important source of endogeneity of import tariffs and is therefore the central issue that I address. Its omission not only generates inconsistent estimates, but from a theoretical perspective it also leaves room for the effect of tariffs on wages to have an ambiguous sign. This happens because the tariff coefficient in this case is the net result of the effect of tariffs on productivity (which may be positive or negative *ex ante*) and the effect of tariffs on industry rents shared with workers (which is positive *ex ante*). Therefore, I ask if trade liberalization increases or decreases the inter-industry wage premia after we account for the impact of productivity on trade policy. I also assess the magnitude of the bias in previous studies that fail to account for this source of endogeneity.

Using the Colombian trade liberalization (1984-1998) I find that only the manufacturing and the tradable industries wage premia are sensitive to changes in import tariffs. When productivity is incorporated into the estimated model, my results indicate that it is indeed an important determinant of the wage premium, and as an included instrument it does affect the change in tariffs (endogenous variable). In

addition, the impact of trade liberalization on the manufacturing industries wage premium is about 100% larger when productivity is omitted.

Chapter 1 - Trade Liberalization and Informal Labor Markets:

Theoretical Model

The existence of informal labor market is a common phenomenon throughout the world (cf. Schneider and Enste, 2000), and its incidence varies by country and economic sector. In developing countries, informality takes more dramatic contours because informal workers are present in every sector of the economy including manufacturing, and they also account for a significant share of the workforce¹.

Moreover, trade liberalization episodes in Latin America were accompanied by a significant increase in the share of informal workers in manufacturing in those countries, as found by Perry et al. (2007). For example, in Brazil, before trade liberalization in 1984, the share of informal workers in manufacturing was 12%, and it grew to 20% in 2000, after trade liberalization. Thus, trade could affect labor markets not only through wages and employment but also through the quality of the jobs available (formal and informal).

Trade liberalization episodes in Latin America, contrary to what happened in the U.S. (cf. Kambourov and Manovskii, 2008), present the interesting feature of no significant reallocation of workers across industries during and after the tariffs decline, as found by Wacziarg and Wallack (2004) in a cross-country study, Hanson and Harrison (1999) and Feliciano (2001) for Mexico, Attanasio et al. (2004) for Colombia, and Pavcnik et al. (2004) for Brazil. In other words, the tariff changes are not correlated with changes in the industry shares in total employment. In fact,

¹ In Brazil and Colombia household surveys indicate that at least 30% of all jobs are informal as reported by Perry et al. (2007).

Attanasio et al. (2004) found a correlation of 0.99 between 1986 and 1998 industry employment shares for Colombia, and for Brazil Pavcnik et al. (2004) found correlation of 0.96 between 1987 and 1998.

Since there's no industry switching and informal employment expanded, some of the former formal workers became informal in the same industry, as suggested by Goldberg and Pavcnik (2003). They decomposed the change in the share of the informal workers in within and between industries variation and found that within industry employment changes accounted for almost all of the change in Colombia. For Brazil, I conducted a similar calculation and the within variation accounted for 85% of the total variation.

For Latin America there's increasing evidence that informality is related to the costs of having a legal contract, payroll tax being the major part of this cost. My first contribution is a mechanism that generates informal jobs endogenously due to the existence of payroll tax. Thus, I theoretically model payroll tax compliance as the key distinction between formal and informal workers.

If a firm hires a formal worker, its expected wage bill will consist of the wage, an ad valorem payroll tax, and a tax preparation and record keeping expenditure, which is a fixed per worker cost. Every firm in the economy can be audited by the government with a certain probability, and if the firm is caught employing informal workers, it will have to pay an ad valorem fine over the wages paid. Thus, the firm expected wage bill of an informal worker is the wage plus the expected value of the fine.

The firms minimize their expected cost of labor by choosing formal or informal labor contracts. So, low wage firms find informal workers cheaper because the relatively high per worker tax preparation cost. By the same token, high wage firms find formal workers cheaper. Empirical evidence indicates that informal workers earn lower wages in relation to formal workers. This is the first time in the literature, in which a theoretical model is able to generate endogenously different formal and informal wages for identical workers².

This mechanism is able to replicate other important stylized facts about informal labor markets. First, formal and informal workers co-exist in a range of different industries, so informality does not have a simple industry specific explanation. Second, while the average characteristics of formal and informal workers differ in some industries, they are similar in others, and in fact, workers transition between formal and informal jobs more frequently than we would expect if informality were simply a function of workers characteristics.

The mechanism I devised need to be inserted in a trade model that have two features: wage heterogeneity and within industry reallocation of employment. A model that satisfies these requirements is Davis and Harrigan (2007) “Good Jobs, Bad Jobs” trade model. I generalize it by incorporating two types of jobs: formal and informal, in addition to introducing the payroll tax mechanism just described. In the Davis and Harrigan (2007) model firms are heterogeneous in two dimensions: wage (which is crucial to have payroll tax causing informality) and productivity. The productivity heterogeneity follows Melitz (2003) framework and it is also necessary

²² In my model, the workers are compensated for the effort exerted, thus they are indifferent between jobs. It is not clear in the literature if from the workers’ perspective a formal job is always better than an informal job. I will discuss this topic in more detail later.

because almost all informality changes happen within the industry, and this framework portrays the effect of trade liberalization through the within industry reallocation of production. Another important result from the Melitz model is that only the most productive firms can overcome fixed costs to export, and these firms are also the largest in terms of employment, results that are supported by empirical evidence. So, in addition to these results, it can account for a positive correlation between size and formality that is strong in the data. Small firms in my model do not export and some of them still pay high wages and thus will prefer formal workers, facts that are supported by empirical evidence.

The comparative statics consider the effects of changes in the import tariffs and in the trade partners import tariffs (export barriers). The latter has been widely neglected in the literature and, as we will see, it has a very important role in my model. The results can be summarized as follows. A decrease in the import tariffs increases both the informality share and the formal-informal wage gap. On the other hand, decrease in foreign trade barriers decreases both the informality share and the formal-informal wage gap in a given industry. This reduction in export barriers increases the demand for the currently exported goods, as a result, there is an increase in formal employment to cope with it. Additionally, some firms now find profitable to export in this case and they also increase formal employment by either hiring more formal workers or switching from informal to formal workers in order to export. Moreover, the less efficient firms exit the market and destroy both formal and informal jobs. Under mild sufficient conditions, the first effect dominates the second.

In the remainder of the chapter, I present first a brief literature review about the definitions of informal labor, stylized facts and related papers. And then I discuss in details my theoretical model and present the comparative statics results.

Literature Review

Informal labor market definition and stylized facts

The definition of an informal labor market is closely related to what is considered informal or underground economy. There are two types of definitions in the informal economy literature. The first definition is based on the employment level of the economic unit, and it establishes a cutoff level below which the economic unit is considered informal, and its workers are considered informal too.

The second definition of an informal economic unit is according to its legal status, as is exemplified by Hernando de Soto (1989): “the informal sector is defined as the set of economic units that do not comply with government-imposed taxes and regulations”. Schneider and Enste (2000) makes it more precise by adding that “informal economy encompasses legal value-added creating activities which are not taxed or registered and where the largest part can be classified as clandestine labor, which means that unpaid or ‘pure’ household production, voluntary nonprofit (social) services and criminal activities are excluded”.

By analogy, the legal status definition of an informal job is one in which the employer doesn't comply with labor regulations³, and that's the one used here. Now, labor laws cover several aspects of employment relationship and, as a consequence,

³ Schneider and Enste (2000) provides an in-depth discussion of the factors influencing regulation compliance.

partial compliance may exist. Thus, it is necessary to draw a line between formality and informality, which implies choosing observable aspects of the regulation that matters in the firm decision regarding the formality status of its employees.

The major reason behind the use of informal labor is explained by Portes et al. (1989, p.30); “the best-known economic effect of the informalization process is to reduce the costs of labor substantially”. Furthermore, Tokman (1992) found that the additional costs related to labor regulations are the most important component of the permanency costs in the formal sector for small firms in Latin America. Among these labor costs, the main distinction between a formal and an informal job in Argentina and in Brazil seems to be related to the costs of having a legal contract (in particular payroll taxes) and not related to the quality of the job per se, according to Pratap and Quintin (2006) and Neri (2002) respectively. Moreover, the latter presents evidence that some labor legislation, like workload, payment practices, and minimum wage seems to uniformly affect both formal and informal work relationships. An advantage of using payroll tax compliance is its direct observability in household surveys since the worker is questioned about it. Indeed, this is the widely used formal job indicator in the empirical literature, and it is employed for Colombia by Goldberg and Pavcnik (2003), for Argentina by Pratap and Quintin (2006), and for Brazil by Neri (2002).

In general, payroll taxes consist of an ad valorem tax on wages, and in some countries there's also a specific tax per worker. In Brazil, for example, payroll taxes are composed of social security contributions (currently the employer part is 20% of the wage paid) and other taxes not related to social security. Furthermore, firms also incur substantial per worker costs of calculating and preparing the tax related

paperwork, in addition to the costs of keeping tax records. Boisvert et al. (2001) conducted a survey among Brazilian firms and found that these preparation costs per worker are between 43 and 86 dollars, or between 15 and 30% of the minimum wage prevailing in Brazil.

If the payroll taxes were social security contributions, the formal workers would have some utility by its payment by the employer. Brazil and many other developing countries have a pay-as-you-go social security system, and in this system the workers tend to see the social security contributions simply as a tax that provides no clear benefits to them. The benefits paid are calculated by some sort of average of the last wages received by the worker, and these benefits will be funded by the next generation of workers contributions. Thus, future benefits have a very loose relation with the amounts contributed over time.

Although the lack of payroll tax compliance makes informal workers cheaper at a first glance, firms are subject to government audit. In Brazil there are two agencies that conduct such audits. The first agency, INSS, is in charge of payroll tax collection. In the AEPS (2005) they provide statistics regarding the number of establishments visited. The series started in 1992, in which 112,327 establishments were visited. The number of visits increased until 1994 to a level of 144,069, and then presented a downward trend to 89,000 establishments visited in 2001. The other agency, Ministry of Labor, enforces the remaining labor regulations including the existence of a signed labor contract. In MTB(2008) there's a report on the total number of firms audited. The first observation is for 1990 in which 414,875 firms were audited. For 1991 the number of audits declined to 327,398, and then increased

to 384,562 in 1993, 407,732 in 1994, and 420,893 in 1995. After some oscillation between 350,000 and 300,000 firms audited, the number of visits ended up at 296,741 in 2001. So, it seems that there is some variability in the enforcement intensity over the years. Unfortunately, there's no available data on audits disaggregated by type of legislation enforced and by industry. In the theoretical model developed in this paper, I'll use this payroll tax structure, government enforcement of such laws, and the workers' indifference⁴ regarding employer compliance with payroll taxes, in the firms decisions about the type of worker hired.

Using 1984-2001 Brazilian Household Surveys data (PNAD-Pesquisa Nacional por Amostra de Domicílios) combined with 1991 and 2000 Brazilian Census data, I calculated the share of informal workers according to the social security criterion. There's a significant increase in informality in the manufacturing sector over time, whereas the share of informal workers in services sector remained stable. We can see from figure (1.1) that in the services sector the informality share was 28% in 1984 and after some oscillation it ended up at 25.5% in 2003. On the other hand, the informality share in manufacturing increased from 12% to 20.4% over the same period. So it seems that something besides a common shock across industries affected the manufacturing sector.

This increase in informality could have happened because of changes in composition of employment across manufacturing industries with different informality share, or within industry changes in informality, or both. I found that

⁴ It's not clear that a formal job is better than an informal job. For example, there's income tax incidence in the former but not in the latter. On the other hand, only a formal job comes along with unemployment benefits, just to mention a few differences. Since the theoretical model abstracts from all these features, I think it's more appropriate to assume that workers are indifferent between both types of jobs.

within industry change in informality accounted for 85% of the variation in informality in the 1989-2001 period⁵. The theoretical model developed in this paper will allow for the existence of within industry variation in informality.

Table (1.1) contains some descriptive statistics of the data used here in the form of industry-level statistics that were averaged over time. We can see that informality is present in every industry, although the share differs by industry. The average characteristics of formal and informal workers (years of education, age, and gender) are similar in some industries like apparel and more different in industries like nonmetallic mineral products.

Furthermore, the Brazilian labor market features workers switching between formal and informal jobs. Table (1.2) presents evidence of this switching using data from the May 1996 special supplement of the PME (Pesquisa Mensal de Emprego - Brazilian Monthly Employment Survey). In this supplement, every worker interviewed reported her formality status in 1991 and in 1996. We can see that approximately one sixth of people employed in the formal market in 1991 switched to the informal market in 1996. On the other hand, approximately one third of the workers in the informal market in 1991 migrated to the formal labor market in 1996. Hence, informality doesn't seem to be exclusively determined by either workers or industries characteristics. These facts will be taken into account by the theoretical model.

⁵ Using a different data set, the 1987-1998 PME (Pesquisa Mensal de Emprego - Brazilian Monthly Employment Survey), Goldberg and Pavcnik (2003) showed found that 88% of the variation in informality was within industry.

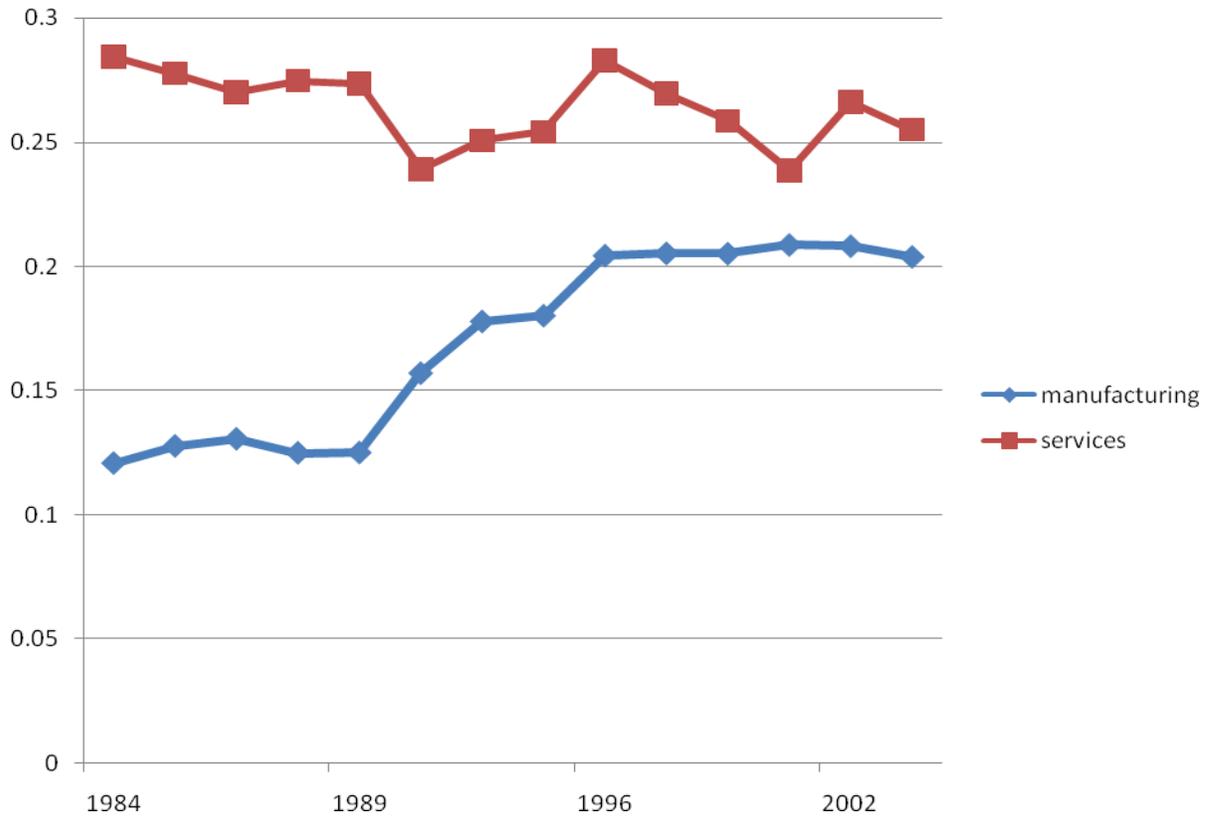


Figure 1.1 - Informality share in services and manufacturing in Brazil using 1984-2003 PNAD Census data.

Manufacturing Industry in PNAD-Census data	Share of Informal		Avg. Years of Education		Avg. Age		Avg. Share of Males	
	Mean	Std Dev	Formal	Informal	Formal	Informal	Formal	Informal
Wood Sawing and Wood Products	0.363	0.052	5.610	4.978	31.336	27.773	0.870	0.945
Nonmetallic Mineral Product	0.298	0.038	5.993	4.111	32.309	26.686	0.879	0.921
Apparel	0.269	0.043	6.734	6.212	30.843	30.265	0.223	0.192
Coffee, Food, Beverage, Animal Feed and Tobacco	0.200	0.031	6.565	5.219	31.845	27.441	0.738	0.698
Footwear and leather products	0.189	0.030	6.189	5.609	28.657	29.527	0.569	0.455
Pulp and Paper Production, Paper Products, Printing and Publishing	0.152	0.042	8.253	7.774	31.410	28.515	0.751	0.700
Metals Production and Processing	0.147	0.042	7.318	6.093	32.856	28.277	0.886	0.922
Pharmaceutical, Perfume, Soap, Detergent, and Candle	0.116	0.027	9.034	8.327	32.041	30.697	0.620	0.565
Textiles	0.115	0.029	6.732	5.704	31.230	29.670	0.588	0.477
Plastic Products	0.100	0.024	7.095	6.498	31.148	29.017	0.647	0.689
Machinery, Equipment and Commercial Installation (including parts)	0.099	0.033	7.846	6.723	33.241	31.276	0.851	0.777
Electrical and Electronic Equipment	0.088	0.029	8.524	7.972	30.896	26.706	0.712	0.751
Rubber Products	0.082	0.036	7.146	6.236	32.350	30.277	0.851	0.750
Non-petrochemical Chemical and Fertilizer	0.081	0.020	7.760	5.812	33.633	30.472	0.806	0.710
Automobile, Truck and Bus (including parts)	0.068	0.019	7.909	6.941	33.287	31.069	0.873	0.835

Table 1.1 – Manufacturing industry workers characteristics in Brazil.

Number of people with at least 20 years old and working in 1991		Employment status in May 1996					
		Formal job	Informal job	Self-employed	Employers	No-wage employment	Totals
Employment status in May 1991	Formal job	41.4%	10.1%	8.1%	1.4%	0.2%	61.2%
	Informal job	4.9%	8.5%	2.9%	0.4%	0.1%	16.9%
	Self-employed	2.1%	2.4%	11.2%	1.8%	0.3%	17.8%
	Employers	0.3%	0.2%	0.9%	1.9%	0.1%	3.5%
	No-wage employment	0.1%	0.1%	0.1%	0.0%	0.1%	0.3%
	Non-declared	0.1%	0.1%	0.1%	0.0%	0.0%	0.3%
	Totals	48.9%	21.4%	23.4%	5.5%	0.8%	100.0%

Table 1.2 - Formal-informal job transitions between 1991 and 1996 using May 1996 PME special supplement. Source: IBGE website.

Workers in every manufacturing industry in Brazil with the same observable characteristics earn different hourly wages. This wage heterogeneity can be seen as the residual of a Mincer type regression consisting of regressing the natural logarithm of hourly wages on age, age squared, years of education and a male indicator variable. Figure (1.2) shows the kernel density of the residuals of this regression estimated separately for formal and informal workers in the food and beverage industry in 1997 PNAD sample. This graph shows that even after controlling for workers' observable characteristics, there's still significant wage dispersion for both formal and informal workers. The graph is similar for other industries and years of my sample. This finding seems to happen in other countries (see Amiti and Davis, 2008, for more references). Wage heterogeneity will be an important part of my theoretical model.

Stylized facts about trade

Until the end of the 1980s, Brazilian trade policy was dictated by two factors: the import substitution policy and Balance of Payments deficits⁶. The former implied different protection across industries, in particular high import tariffs and non-tariff barriers on foreign goods that competed with similar domestic products. The latter generated large import tariffs across all industries to curb imports. Moreover, since Brazil is a developing country, it used article XVIII of GATT to not participate in earlier rounds of tariff decreases.

⁶ A good description of Brazilian trade policy in the 1980s and 1990s is presented in Kume et al. (2003).

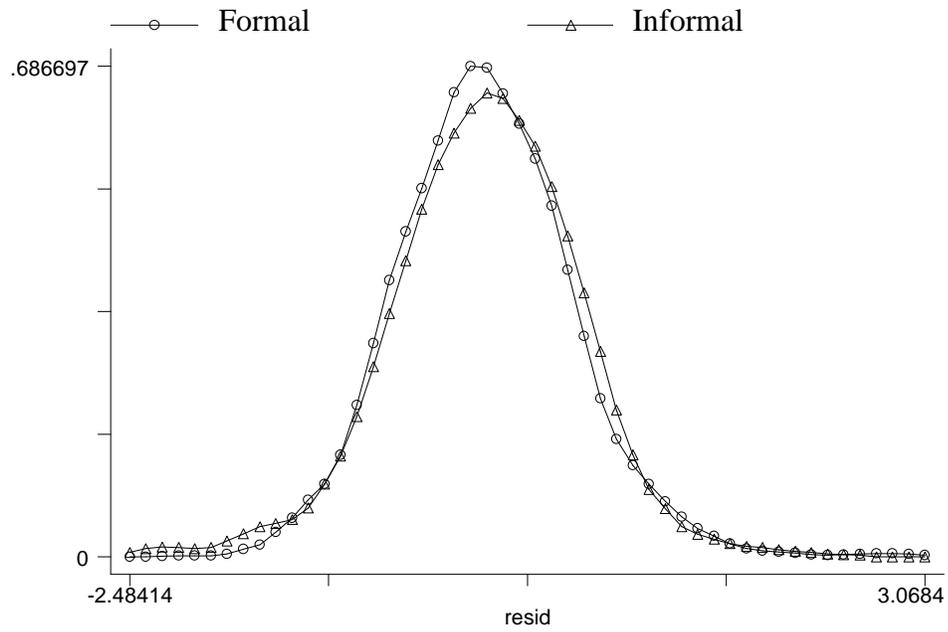


Figure 1.2 - Kernel density of the residuals of the regression of log hourly wage on age, age², years of education, black indicator, literacy indicator, male indicator, and a constant. The data used is from the food and beverage industry in 1997.

Then in the late 1980's Brazilian trade policy started to change. During 1988 and 1989 nominal tariffs were reduced from an extremely high level to just high levels; however, non-tariff barriers (NTBs) remained unchanged. Such decrease in nominal tariffs didn't affect the volume of imports because the NTBs were in effect, as documented by Kume et al. (2003). In 1990, Brazil was under a new president and in March of this year he reduced drastically NTBs and adopted a schedule for nominal tariff reductions to start in 1990 and finish in 1994. The decrease in tariffs was not identical across industries, as shown in Kume et al. (2003). The protection changed over time and across industries, in particular, some industries still receive extra tariff protection as decided by the Brazilian government, namely computer hardware and software, biotechnology, new materials, some of non-petrochemical chemicals, electronic appliances, machinery parts, and industries with strong backward and forward linkages such as automobiles. The decrease in import tariffs had real effects on the economy. Import penetration in manufacturing increased from 5.7% in 1987 to 11.6% in 1998, and manufacturing goods imports increased by more than 200% in the 1990-1998 period.

Brazilian firm access to foreign markets also changed in this period due to the Uruguay Round tariff reductions, Mercosur customs union implementation, and China's ascension to the World Trade Organization (WTO). The Uruguay Round negotiations led to a decrease in tariffs imposed by the U.S., Japan, European Union, and other developed countries on several trade partners, including Brazil. The Mercosur customs union encompasses Argentina, Brazil, Paraguay and Uruguay and went into effect in 1995. The import tariffs for inside the block trade became zero for

the majority of goods. During the 1990s China agreed to decrease its import tariffs in order to join the WTO in 2001. All these trade partner tariff reductions were accompanied by an increase of 68% in Brazilian manufacturing goods export in the 1990-1998 period. Table (1.3) presents the average and standard deviation of the Brazilian import tariffs and its trade partners import tariffs (export tariffs).

At the firm-level, evidence gathered by Ellery and Gomes (2007) using Brazilian trade data revealed that only a small percentage of Brazilian firms are engaged in exporting. The exporting firms are substantially larger and more productive than firms serving only the domestic market. These facts seem to happen in several countries like the U.S. (Bernard, Jensen, and Schott, 2005) and Colombia (Roberts and Tybout, 1997). Although the industry classification used by Ellery and Gomes (2007) is slightly different from ours, the industry-level share of exporting firms seems to be inversely related to the share of informal workers. For example, in the machinery industry, about 37 percent of firms export while only nine percent of its workers are informal. In the apparel industry, only 12 percent of firms export but the informal share is about 27 percent. Menezes and Muendler (2007) found that due to trade liberalization, manufacturing output shifted to more productive firms in Brazil. Last, but not least, Muendler (2004) found that the less productive firms were more likely to exit the market during the Brazilian trade liberalization episode in the 1990s.

Industry in PNAD-Census data	Import Tariff			Export Tariff		
	Average	Std. Dev	Change	Average	Std. Dev	Change
Apparel	0.314	0.175	-0.552	0.202	0.077	-0.204
Automobile, Truck and Bus	0.370	0.127	-0.370	0.106	0.053	-0.168
Coffee, Food, Beverage, Animal Feed and Tobacco industries	0.183	0.053	-0.159	0.352	0.058	-0.212
Electrical and Electronic Equipment	0.236	0.098	-0.278	0.086	0.041	-0.105
Footwear and leather products	0.198	0.067	-0.216	0.180	0.067	-0.158
Machinery, Equipment and Commercial Installation	0.210	0.089	-0.271	0.066	0.032	-0.088
Metals Production and Processing	0.130	0.032	-0.101	0.069	0.033	-0.085
Nonmetallic Mineral Product	0.161	0.078	-0.221	0.109	0.048	-0.12
Non-petrochemical Chemical and Fertilizer	0.149	0.055	-0.190	0.073	0.028	-0.070
Pharmaceutical, Perfume, Soap, Detergent, and Candle	0.151	0.091	-0.264	0.091	0.048	-0.119
Plastic Products	0.220	0.091	-0.244	0.129	0.052	-0.129
Pulp and Paper Production, Paper Products, Printing and Publishing	0.142	0.050	-0.150	0.068	0.032	-0.079
Rubber Product	0.220	0.132	-0.351	0.085	0.040	-0.098
Textiles	0.230	0.110	-0.400	0.156	0.063	-0.164
Wood Sawing and Wood Products	0.148	0.054	-0.163	0.110	0.058	-0.139

Table 1.3 – Brazilian import tariffs and export tariffs descriptive statistics for the 1989-2001 period.

Household surveys that include questions about the employer characteristics reveal that not all firms offer informal jobs. Indeed, smaller firms are more likely to use informal workers, as found by Dabla-Norris et al. (2008) for several countries, and Carneiro and Henley (2001) for Brazil. All these firm level facts will be outcomes of the theoretical model I develop in this paper.

Related Literature

This paper is connected to the development economics literature about informal labor market economy, where Rauch (1991) is an important paper because it is one of the first to make informal labor markets an endogenous outcome due to a labor market distortion: minimum wage. His model is based on Lucas (1978), in which agents have heterogeneous managerial ability. Depending on her managerial ability, the agent chooses between being an employer or an employee. The employers then have to decide to hire either minimum wage formal workers or lower wage informal, while taking into account the minimum wage enforcement rule. As a result, all small firms will use only informal labor. This prediction is not supported by the data since there are small firms that use formal employment, and minimum wage doesn't seem to be the reason behind labor informality in Brazil and other countries as discussed before. My theoretical model improves on Rauch (1991) by using a more realistic distortion to generate informality endogenously, which allows for formal and informal employment in small firms, and by embedding the distortion in a trade model.

A second connection is with the international trade literature concerned with the effect of trade policy changes on labor market outcomes. Goldberg and Pavcnik (2003) presents a representative firm model in which formal workers receive efficiency wages that increase according to the probability of being fired without justification, and informal workers that receive reservation wage and pose no adjustment costs, because firms purchase a costly perfect monitoring technology to use on them. So, informal workers would be hired and fired in order to accommodate demand fluctuations. Trade liberalization consists of mean decreasing change in the stochastic part of the demand curve. This change decreases the formal employment and therefore increases the share of informal workers.

Their two-step empirical strategy⁷ relied upon intra-industry variation in tariffs that happened along the trade liberalization process in Brazil and Colombia. In the first step, the probability of having an informal job is estimated by a linear probability model for every year of the sample, controlling for the observable characteristics of the individuals and a set of industry affiliation indicators, which was intended to capture the variation in informal employment due to industry affiliation and not the worker characteristics. In the second step, these estimated industry affiliation effects were linearly regressed on trade related measures, in addition to time and industry indicators. According to them, there was almost no evidence that trade policy changes affected the informal labor market in Brazil, and some small effect for Colombia which seemed stronger before the 1994 labor market reform.

The reason for using informal workers in their model is at odds with labor regulation of several countries since there are special labor contracts for temporary

⁷ Attanasio et al. (2004) performed a similar empirical exercise using Colombian data.

workers with lower costs in relation to permanent employees. Besides using a more realistic reason for employing informal workers, my model improves on Goldberg and Pavcnik (2003) by allowing firms to have different size, which is important because trade policy affects firms differentially according to their size, which also matters for informal labor markets because smaller firms are more likely to hire informal workers than larger firms.

Moreover, I have no need to resort to assumptions that firms have different monitoring ability because of the labor contract used. My theoretical model shows a clear mechanism for the effect of trade policy changes on the labor markets, and it also incorporates the export side of the economy. Furthermore, it presents predictions on a second outcome, the formal-informal wage gap. On the empirical part, I not only include export side variables previously ignored, but also use an instrumental variable approach to deal with omitted variable bias and reverse causation issues.

Theoretical Model

My model is a generalization of Davis and Harrigan (2007), in which I introduce payroll taxes and two types of labor contracts: formal and informal. Their model combines the monopolistic competition with heterogeneous firm productivity model of Melitz (2003) with the efficiency wage model of Shapiro and Stiglitz (1984). Firms will differ in physical productivity and in workers monitoring productivity. The former determines the amount of output produced per worker and the latter determines how well the firm induces the worker to exert effort. The better the monitoring productivity the lower the wage needed to motivate the worker, as in

efficiency wage models. Thus, similar workers hired by firms with similar physical productivity might earn different wages.

I decided to build on Davis and Harrigan (2007) work because its trade predictions match several international trade stylized facts discussed before, and because the wage heterogeneity present in the model allows me to introduce the mechanism that generates formal and informal jobs endogenously. The original model by Davis and Harrigan (2007) becomes a particular case of mine when there is no payroll tax.

Model set-up

The theoretical model is a one-sector economy composed of risk-neutral firms and workers. Homogeneous labor is the only factor of production. As in Davis and Harrigan (2007), workers have identical preferences and their utility function is additively separable in effort and consumption. The disutility of the former is measured in the same units as the wage, and the latter is given by a standard Dixit-Stiglitz CES aggregate of differentiated goods with an associated price index P . The equation below shows the worker's indirect utility (u_i) of being employed at firm i , in which w_i is the wage received, e is the effort exerted (0 or 1)⁸, and tr are governmental lump-sum transfers that are equal across all workers (employed and unemployed). In my theoretical model there's the assumption that the workers do not have any benefit from the payroll taxes and there's no unemployment benefit, so workers are ex-ante indifferent between a formal and an informal job.

⁸The model rests on the dichotomy that workers exert or not effort, i.e. $e \in \{0, \bar{e}\}$ with $\bar{e} > 0$. For sake of simplicity, I follow Davis and Harrigan (2007) in the assumption that $\bar{e} = 1$.

$$u_i = \frac{w_i - e - r}{P}$$

This efficiency wage modeling strategy is based on Shapiro and Stiglitz model but Davis and Harrigan (2007) incorporated heterogeneous monitoring productivity⁹ at the firm level.

A worker can lose her job by being caught shirking or by exogenous firm death, since every firm in the economy regardless of its characteristics can face an exogenous bad shock with probability δ^0 that forces it to exit the market. Firms catch shirkers by monitoring all workers. The monitoring productivity (likelihood of catching a shirker) is a firm-specific random variable, whose inverse is m_i . The maximum monitoring productivity corresponds to $1-\delta$ so that the overall probability of being fired (exogenous firm death plus shirking motive) doesn't exceed 1. The inverse of the maximum monitoring productivity is $m_0 \equiv (1-\delta)^{-1}$ and $m_i \in [m_0, \infty)$. Contrary to what has been done before in the informal labor market literature, the monitoring ability in this model is independent of the type of labor contract, i.e. firm i has the same monitoring ability despite the use of formal or informal workers.

The derivation of the equation that links firm monitoring productivity to the wage paid consists of finding the wage that firm i needs to pay the worker to avoid shirking. Now, let's proceed with solution to the efficiency wage problem in a similar fashion to Davis and Harrigan (2007).

The fundamental asset equations for formally employed non-shirkers at firm i and formally employed shirkers at firm i are (1.1) and (1.2) respectively, in which r is

⁹It is also called monitoring ability in the efficiency wage literature.

¹⁰ I assume that $\delta < 0.5$.

the discount rate, $V_{Ei}^{for,N}$ is the value function of a formal non-shirker worker at firm i , $V_{Ei}^{for,S}$. I present here the calculations for workers under formal labor contract only, because the mathematical derivations from equation (1.1) to (1.6) are analogous for a worker under informal contract, since the former and the latter share the same utility function and their supplied labor is identical. I assume that unemployed workers receive zero wage, either coming from a formal or informal job. Thus $V_U^{for} = V_U^{inf} = V_U$. An unemployed worker is able to search for formal and informal jobs regardless of the type of her previous job.

$$rV_{Ei}^{for,N} = (w_i - e + tr) + \delta(V_u - V_{Ei}^{for,N}) \quad (1.1)$$

$$rV_{Ei}^{for,S} = w_i + tr + (\delta + m_i^{-1})(V_u - V_{Ei}^{for,S}) \quad (1.2)$$

To avoid shirking the firm must pay a wage such that the value of shirking for the worker is smaller than the value of not shirking. This is translated in the non-shirking constraint: $V_{Ei}^{for,N} \geq V_{Ei}^{for,S}$. Imposing it at firm i with equality $V_{Ei}^{for,N} = V_{Ei}^{for,S}$,

we obtain

$$w_i = rV_U - tr + e + (r + \delta)em_i \quad (1.3)$$

Plugging (1.3) into (1.1)

$$V_{Ei}^{for} = V_U + em_i \quad (1.4)$$

Analogously for the informal worker, we have

$$V_{Ei}^{inf} = V_U + em_i \quad (1.5)$$

Since equations (1.4) and (1.5) reflect the required no-shirking wage choice of any firm i , an unemployed worker will accept the first job offer, because the flow of benefits from being employed is sufficient to compensate the disutility of exerting

effort. Additionally, I follow Davis and Harrigan (2007) assumption that expected job tenure doesn't vary across firms since in equilibrium no one shirks in both formal and informal jobs. Job loss would happen only at the common exogenous rate δ of firm death, which is the same for firms employing formal or informal workers.

Let $f(w_i)^{for}$ be the equilibrium density of formal workers employed at firm i .

The average lifetime utility of a formally employed non-shirker is given by V_E^{for} .

Similarly, let \bar{w}^{for} and \bar{m}^{for} be the average formal wage and the average monitoring ability for formal workers respectively.

$$V_E^{for} \equiv \int V_{Ei}^{for} f(w_i)^{for} di \quad (1.6)$$

The benefits flow of being unemployed consists entirely of the expected capital gain from re-employment as shown below, in which a is the instantaneous probability of re-employment.

$$rV_U = a^{for}(V_E^{for} - V_U) + a^{inf}(V_E^{inf} - V_U) + tr \quad (1.7)$$

Taking averages over i from equation (1.4) for formal workers and from equation (1.5) for informal workers, we obtain

$$V_E^{for} - V_U = e\bar{m}^{for}; \quad V_E^{inf} - V_U = e\bar{m}^{inf} \quad (1.8)$$

Substituting (1.8) into (1.7)

$$rV_U = a^{for} e\bar{m}^{for} + a^{inf} e\bar{m}^{inf} + tr \quad (1.9)$$

Let L be the total size of the labor force, L^{inf} be the number of workers in informal jobs, L^{for} be the number of workers in formal jobs, U be the total number of unemployed, and u be the unemployment rate, defined as $u \equiv \frac{U}{L}$.

Since L^{inf} and L^{for} are endogenously determined in equilibrium, a^{for} and a^{inf} can be examined in terms of the steady state, by the fact that inflows and outflows from unemployment must be equal. In steady state, only exogenous separations take place, and at a rate δ for both formal and informal workers.

$$a^{\text{inf}}U = \delta L^{\text{inf}} = \delta \Upsilon(L-U), \quad \Upsilon \equiv \frac{L^{\text{inf}}}{L-U} \quad (1.10)$$

$$a^{\text{for}}U = \delta L^{\text{for}} = \delta(1-\Upsilon)(L-U) \quad (1.11)$$

Plugging equations (1.10) and (1.11) into (1.9), we obtain:

$$rV_U = e\delta[\bar{m}^{\text{for}}(1-\Upsilon) + \bar{m}^{\text{inf}}\Upsilon] \frac{(1-u)}{u} + tr \quad (1.12)$$

Plugging equation (1.12) into (1.3):

$$w_i = \delta e[\bar{m}^{\text{for}}(1-\Upsilon) + \bar{m}^{\text{inf}}\Upsilon] \frac{(1-u)}{u} + e + (r+\delta)em_i$$

Let \bar{m} be the average m_i , $\bar{m} = \bar{m}^{\text{for}}(1-\Upsilon) + \bar{m}^{\text{inf}}\Upsilon$, and following Melitz (2003), let $r \rightarrow 0$, we've got

$$w_i = \delta e \bar{m} \frac{(1-u)}{u} + e + \delta em_i \quad (1.13)$$

Averaging over i

$$\bar{w} = \delta e \bar{m} \frac{(1-u)}{u} + e + \delta e \bar{m} \quad (1.14)$$

Now, we're ready to solve for $w_i(u, m_i)$. Solving for \bar{m} in equation (1.14), and plugging it into equation (1.13),

$$w_i = (\bar{w} - e)(1-u) + e + \delta em_i \quad (1.15)$$

A firm with $m_i = m_0$ (maximum monitoring ability) will pay a wage of w_L ,

which is defined as the *numeraire* of the economy.

$$w_L = (\bar{w} - e)(1 - u) + e + \delta e m_0 \equiv 1 \quad (1.16)$$

Plugging (1.16) into (1.15), we obtain Davis and Harrigan equation 1.11, which is equation (1.17) in this paper. This equation links the firm monitoring ability to the wage paid in a one-to-one positive relationship.

$$w_i = 1 + \delta e(m_i - m_0) \quad (1.17)$$

On the production side, every firm has to pay a once and for all entry fixed cost, f_e units of labor, to enter the market and know its drawing of monitoring productivity and physical productivity (m_i, φ_i) . If the firm decides to stay in the market and produce, it then incurs a fixed cost of f units of labor every period it operates, and a variable cost composed of labor used in activities that varies in amount according to the output (q) .

The workers in the variable activity cost can be hired using formal or informal labor contracts. In both contracts the firm has to pay the efficiency wage (w_i) , but only firms offering formal contracts have to pay payroll taxes composed of a specific tax per worker (θ) and an ad valorem tax (t) on wage. Alternatively, θ can be interpreted as the per worker costs of calculating and preparing the tax forms¹¹. The expected wage bill (b_i) for a formal worker is

$$b_i^{for} = T w_i + \theta; \quad T \equiv 1 + t \quad (1.18)$$

Under the informal labor contract, firm i does not comply with payroll taxes. All firms may be audited by the government with a probability ζ . If a firm is caught

¹¹In this case, I would have to add a constant returns to scale sector to produce such accounting services, and the model results wouldn't change.

using informal labor, it will be subject to an *ad valorem* fine of η of the wage paid to each informal worker. The payroll taxes and fines collected are used in lump-sum transfers to all workers, employed and unemployed, in the economy. The expected informal worker wage bill is

$$b_i^{\text{inf}} = \lambda w_i; \quad \lambda \equiv (1 + \eta \zeta) \quad (1.19)$$

Following Davis and Harrigan (2007), all firms pay the same wage for workers in the fixed costs activities¹². Without loss of generality I'll fix a wage of 1 for these workers, and there is no incidence of payroll taxes of any sort on it. These fixed cost activities can also be interpreted as a homogeneous intermediate input produced under constant returns to scale.

The physical labor demand, $\lambda(b_i, \varphi_i)$, is given by equation (1.20); in which the first term in the right-hand side is the per period fixed cost and the last term of the right-hand side represents the labor used in the variable cost activities.

$$\lambda(b_i, \varphi_i) = f + \frac{q(\varphi_i / b_i)}{\varphi_i} \quad (1.20)$$

The firm productivity¹³ (s) is a random variable defined as the output produced by dollar spent on the wage bill, i.e. $s_i \equiv \varphi_i / b_i$, which is the inverse of the marginal cost, and is a continuous function in (m_i, φ_i) .

Autarky

From the consumer expenditure minimization problem, the demand curve for

¹²It is crucial to the model that the amount paid on each type of fixed cost be the same for all firms, otherwise there's no guarantee of the existence of general equilibrium in the model.

¹³Davis and Harrigan (2007) defined a similar variable, $z_i \equiv \varphi_i / w_i$, which was the inverse of the marginal cost in their model.

firm i output that is priced p_i is given by equation (1.21), in which Q is the aggregate production level of the economy, $\rho \in (0,1)$ is the parameter of the CES part of the worker utility, like in Dixit and Stiglitz (1977), and $\sigma \equiv (1-\rho)^{-1} > 1$ is the elasticity of substitution across goods.

$$q_i = \left[\frac{p_i}{P} \right]^{-\sigma} Q \quad (1.21)$$

Firm i maximizes its profit, equation (1.22), by choosing the price p_i given by equation (1.23), i.e. the price is a mark-up on the marginal cost.

$$\pi_i = p_i q_i - f - b_i \frac{q_i}{\varphi_i} \quad (1.22)$$

$$p_i = \frac{b_i}{\rho \varphi_i} = \frac{1}{\rho s_i} \quad (1.23)$$

Firm i chooses to hire formal employees for its variable cost activities if and only if expected profit (π_i^{for}) of employing them is larger than the expected profit (π_i^{inf}) of employing informal workers. Since labor is homogeneous, the only difference between the two types of workers resides on the wage bill. Thus, firms will choose the cheapest labor contract, and in equilibrium, firms won't hire both formal and informal workers. Firm i will hire only formal workers if $b_i^{for} < b_i^{inf}$, hereafter called a formal firm. Otherwise firms will hire only informal workers and will be called an informal firm. This mechanism used to generate informal jobs would also work in other models that display wage heterogeneity. Notice that we can express this inequality in terms of the wage received by the workers. Firm i will hire formal workers if

$$w_i > \frac{\theta}{\lambda - T} \equiv \chi \quad (1.24)$$

or, in terms of monitoring productivity,

$$m_i > m_0 + \frac{\theta - \lambda + T}{\delta(\lambda - T)} \equiv m^* \quad (1.25)$$

Hence, in autarky the firm monitoring productivity will determine the type of labor contract it offers. In order to have both formal and informal jobs in the economy, I need the technical assumptions of $\eta\zeta > t$ and $\theta > \lambda - T$, which guarantee the existence of an interval of $m_i > \frac{1}{1-\delta}$ in which the expected wage bill of an informal worker is smaller than the expected wage bill of a formal worker.

In figure (1.3), both the formal and informal expected wage bill functions are plotted. We can see that $b_i = \min\{b_i^{for}, b_i^{inf}\}$ is a continuous and bijective function of m_i . Additionally, informal jobs will be generated by low wage firms. The lowest wage received by a worker employed in variable cost activity will be w_L , i.e. 1, and the respective wage bill (also the lowest) will be λ , since this worker will have an informal job.

The wage cutoff, χ , is decreasing in λ , as a consequence it is also decreasing in η and ζ , which means that either an increase in the fine or an increase in the likelihood of an audit will decrease the cutoff and therefore the set of firms offering informal labor contracts gets smaller, implying a decrease in the informality share. On the other hand, an increase in either one of the payroll taxes leads to an increase in χ , enlarging the set of firms offering informal labor contracts. If the enforcement probability (ζ) goes to one there will be no firms offering informal labor contracts.

These properties are in line with findings that both taxation and its enforcement are determinants of informal economy (cf. Schneider and Enste, 2000).

The fixed cost activity implies that in equilibrium not all firms will be producing because some firms will make negative profits and exit the market as soon as they observe their draw of m and φ . The active firms are the ones with productivity above the threshold s^* , i.e. they make at least zero profit. The cumulative distribution function of s_i is $G(s) \equiv \Pr[S \leq s]$ and its density is given by $g(s)$. The equilibrium density of firms with positive output in the autarkic economy is defined by:

$$\mu(s) = \frac{g(s)}{1 - G(s^*)}, \quad s \in [s^*, \infty)$$

Let M be the mass of firms, and the number of firms at any given level of s is $Mg(s)$, as a consequence, the number of surviving firms is given by $M\mu(s)$. The variable \tilde{s} is a measure of aggregate inverse marginal costs, and it will be finite if the $\sigma - 1$ uncentered moment of $\mu(s)$ is finite, an assumption that is made here.

$$\tilde{s}(s^*) \equiv \left[\int_{s^*}^{\infty} s^{\sigma-1} \mu(s) ds \right]^{\frac{1}{\sigma-1}} \quad (1.26)$$

To determine s^* we use two equations relating average profits of the successful entrant ($\bar{\pi}$) and the productivity of the marginal entrant (s^*). The first equation is what Melitz (2003) called the free entry condition (FE), given by equation (1.27), which states that from an unbounded set of *ex ante* identical firms, a sufficient mass enters the market so that the average profits from entry equal the fixed cost of entry.

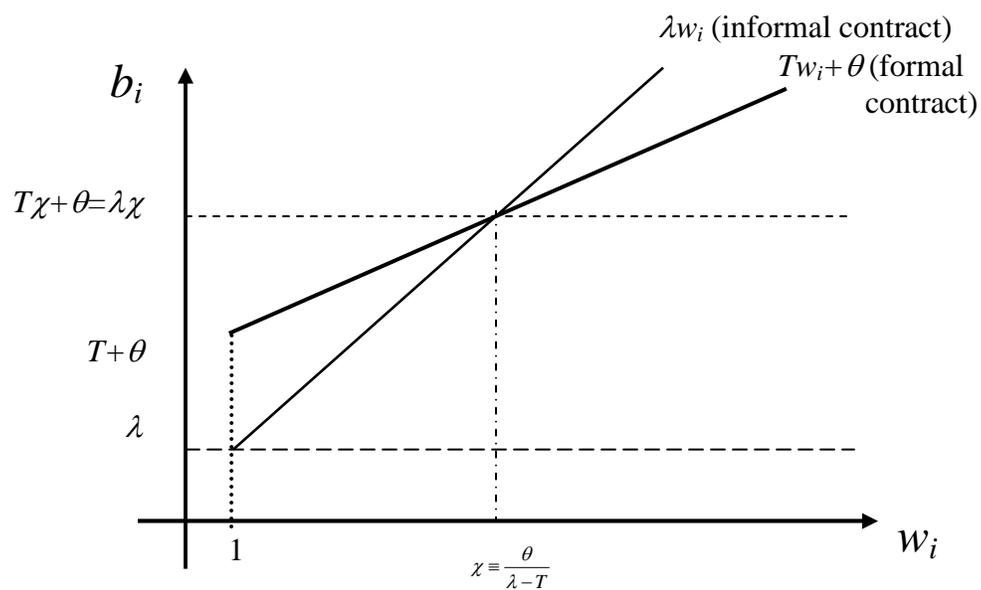


Figure 1.3 - Wage (w_i) and expected wage bill (b_i) for formal and informal labor contracts in autarky.

$$\bar{\pi}(s^*) = \frac{\mathcal{J}_e^*}{1 - G(s^*)} \quad (1.27)$$

The other condition is the zero cutoff productivity (ZCP), given by equation (1.28), which requires that the marginal entrant firms (the less productive active firms) have variable profits (π^v) equal to the per period fixed cost of production.

$$\bar{\pi} = f\kappa(s^*) \quad (1.28)$$

$$\kappa(s^*) \equiv \left[\frac{\tilde{s}(s^*)}{s^*} \right]^{\sigma-1} - 1$$

The FE and ZCP equations fully determine s^* , and, as proven in Melitz (2003) a unique solution exists. The next step is to solve for the model scale, namely the mass of firms, M , the average wage, \bar{w} , the unemployment rate, u , and the government transfers, tr . The first equation needed is the labor market clearing equation. The labor force is divided into five elements, namely the unemployed (U), workers in fixed entry cost sector (L_e), workers in per-period fixed cost activities (L_{fc}), formal workers in variable cost activities (L_v^{for}), and informal workers in variable cost activities (L_v^{inf}). The aggregate labor force constraint is given by equation (1.29).

$$L = U + L_e + L_{fc} + L_v^{for} + L_v^{inf} \quad (1.29)$$

In a steady state, the mass of active firms doesn't change, so the mass of entrants should be enough to replace the mass of firms that received a bad shock and exited the market. The amount of labor used in the entry fixed cost activity is $L_e = \delta M f_e$ and the level of employment in per-period fixed cost activity is $L_{fc} = M f_c$.

From the joint distribution of (φ_i, m_i) , parameters θ, λ, T , and the equilibrium s^* , we can construct the equilibrium joint density of productivity and wage bill, $\phi(\varphi_i, b_i)$.

The total employment in variable costs is given by the sum of the formal workers (L_v^{for}) and informal workers (L_v^{inf}) in this activity:

$$L_v^{for} = M \int_{\lambda \chi s^*}^{\infty} \int_{\lambda \chi}^{\frac{\varphi_i}{s^*}} \frac{q(\frac{\varphi_i}{b_i})}{\varphi_i} \phi(\varphi_i, b_i) didb_i d\varphi_i$$

$$L_v^{inf} = M \int_{\lambda s^*}^{\lambda \chi s^*} \int_{s^*}^{\frac{\varphi_i}{\lambda}} \int_{i \in s_i} \frac{q(\frac{\varphi_i}{b_i})}{\varphi_i} \phi(\varphi_i, b_i) didb_i d\varphi_i +$$

$$M \int_{\lambda \chi s^*}^{\infty} \int_{\lambda}^{\lambda \chi} \int_{i \in s_i} \frac{q(\frac{\varphi_i}{b_i})}{\varphi_i} \phi(\varphi_i, b_i) didb_i d\varphi_i$$

Equation (1.30) depicts that the labor market clearing condition in quantity terms is

$$(1-u)L = M \left[\mathcal{J}_e + f + \frac{L_v^{for} + L_v^{inf}}{M} \right] \quad (1.30)$$

The total wages paid by each firm is given by its employment level times the respective wage paid, as portrayed by equation (1.31).

$$w_i \lambda_{vi}(s_i, \varphi_i) = \frac{w_i}{\varphi_i} q\left(\frac{\varphi_i}{b_i}\right) = \frac{w_i}{\varphi_i} Q(\rho P)^\sigma s_i^\sigma \quad (1.31)$$

Then, we have to sum the wages paid over all active firms to obtain the total amount paid to variable cost activity workers (twp_v). The total payments to labor must also include payments to workers in the fixed cost activities. To obtain the average wage (\bar{w}) we have to divide the total wages paid by the number of employed workers, as shown in equation (1.32).

$$\bar{w} = \frac{M}{(1-u)L} [(\mathcal{J}_e + f) + twp_v] \quad (1.32)$$

All the taxes and fines collected are returned in a lump-sum to all individuals in the economy. So the *per capita* government transfer (tr) is:

$$tr = \frac{(t\bar{w}^{for} + \theta)L_v^{for} + \eta\zeta\bar{w}^{inf}L_v^{inf}}{L} \quad (1.33)$$

And from the efficiency wage problem, we obtain the relation between the unemployment rate and the average wage that is the fourth and last equation needed.

$$u = \frac{\bar{w} - 1 + \delta em_0}{\bar{w} - e} \quad (1.34)$$

The proof of equilibrium existence is similar to Davis and Harrigan (2007) and is omitted here. A solution of this system can be obtained by isolating $\frac{1}{(1-u)L}M$ on equation (1.30) and plugging it in equation (1.32) to obtain \bar{w} . Then, with \bar{w} and equation (1.34) we can calculate u . To obtain M we can plug u into equation (1.30). Finally, tr can be solved for by plugging M into equation (1.33).

Open economy

The world economy is composed by two identical countries¹⁴. Trade costs consist of a per period fixed cost of f_x units of labor¹⁵ and an iceberg variable export cost, in which the firm ships τ units ($\tau > 1$) and 1 unit arrives. The variable export cost may include transportation costs and trade partner import tariffs, for example. In order to have some firms exporting and others not, I assume the sufficient condition of $f_x > f$, which is also used in Baldwin (2005). An explanation suggested by him is the existence of standards and regulations, also called technical barriers to trade

¹⁴The results presented here are easily generalized for $n, n+1 > 2$, symmetric countries.

¹⁵In a similar fashion to the per period fixed cost of production, I assume that firms a wage of 1 to workers in the export fixed cost activity, and there's no payroll tax incidence.

(TBTs), which increase the fixed cost for exported units. The European Union standards are examples of TBTs. A by-product of this assumption is that every exporting firm will also serve the domestic market.

The home and foreign governments monitor international trade by collecting information on who exports, quantity exported and prices, item description, and destination. This information can be matched to the firm payroll taxes data. So, if firm i exports and there's no payroll taxes paid, probability of enforcement for that firm (ζ) will be one, and then it's not profitable for the firm to have informal workers and export. If a firm is an exporter, government will also know that it serves domestic market and its employment level. Therefore, the possibility of employing formal workers in the export orders and informal in domestic orders is ruled out. But, informal firms serving domestic markets have the choice of becoming an exporter by paying payroll taxes on all variable cost activity workers, plus the per period export fixed cost. Thus, this assumption generates the fact that the larger the share of exporting firms, the smaller the informality share.

The payroll tax enforcement rule can be specified in a different fashion by making the audit likelihood an increasing function of the firm employment level. Since exporters are also large firms, a large share of exporting firms in a given industry implies a smaller informality share. Since the comparative statics using both types of enforcement rules are similar, I'll use the first specification for sake of simplicity.

The firms *ex post* profits in an open economy are given by $\pi = \max\{0, \pi_d^{\text{inf}}, \pi_d^{\text{for}}, \pi_d^{\text{for}} + \pi_x^{\text{for}}\}$, where $\pi_d(s_i)$ and $\pi_x(s_i)$ are the maximum profit

from serving domestic and foreign markets respectively. It means that the firm can choose between staying out of the market, producing for domestic consumers using informal workers, producing for domestic consumers using formal workers, or producing for domestic and foreign consumers using formal workers. The profit from serving the foreign market has to take into account the iceberg export variable cost, τ , and the export fixed cost, f_x .

$$\pi_x(s_i) = \max_{p_{xi}} p_{xi} q_{xi} - f_x - \tau \frac{b_i}{\varphi_i} q_{xi} \quad (1.35)$$

The optimal price and quantity of the exported good are respectively

$$p_{xi} = \frac{\tau}{\rho s_i}, \quad q_{xi} = \left[\frac{\rho s_i P^{foreign}}{\tau} \right]^\sigma Q^{foreign} \quad (1.36)$$

The entry cutoff can be similarly defined as $s_{open}^* = \inf\{s : \pi(s) > 0\}$. The export cutoff can be defined as

$$s_{x,for}^* = \inf\{s_i : \pi_{i,d}^{for} + \pi_{i,x}^{for} > \pi_{i,d}^{for} \text{ for } m_i \geq m^*, \text{ and } \pi_{i,d}^{for} + \pi_{i,x}^{for} > \pi_{i,d}^{inf} \text{ for } m_i < m^*\}$$

The first term applies to the firms whose monitoring productivity implies that formal workers are always cheaper. The second term refers to firms that in autarky would hire only informal workers, but now they have the option to comply with payroll taxes in order to have access to foreign markets. Figure (1.4) summarizes some features of my model on the expected wage bill-productivity space. The first feature is the horizontal line at $b_i = \lambda\chi$. Every firm with $b_i \geq \lambda\chi$ (above the line) offers only formal labor contracts, and if $b_i < \lambda\chi$ (below the line) firms may offer formal or informal labor contracts. The productivity, s , can be represented as a ray from the origin and its slope is the marginal cost (b_i / φ_i). The second feature is

portraying which firms are active in the economy. So, every firm located on the left of the s_{open}^* ray will exit the market as soon as they learn their pair (m_i, φ_i) , and the active firms will be on the right side of it.

Intuitively, the firms that will profit by becoming formal and exporting are the ones whose marginal cost will end up smaller than the marginal cost cut off for export even after adjusting b_i for payroll taxes. Since the difference between informal and formal wage bill decreases in w_i , the borderline between the firms that will become formal and export and the ones that will remain informal won't be a ray starting at the origin, i.e. it has an intercept different from the s_i lines. This borderline is the segment AB depicted in figure (1.4). The line that contains the AB segment is described by equation (1.37).

$$b_i = \frac{\lambda}{Ts_{x,for}^*} \varphi_i - \frac{\lambda\theta}{T} \quad (1.37)$$

On figure (1.4), the informal firms are the ones located inside the polygon ABCD. The exporters are located to the right of $s_{x,for}^*$. We can see that in the open economy the exporters are firms with larger size and productivity. The firms employing informal workers are small firms and there are also small firms hiring formal workers.

The economy structure is determined by the equilibrium values of s_{open}^* , $s_{x,for}^*$, and their counterparts in the foreign economy. In steady state equilibrium the density of active firms is defined by:

$$\mu_{open}(s) = \frac{g(s)}{1 - G(s_{open}^*)}, \quad s \in [s_{open}^*, \infty)$$

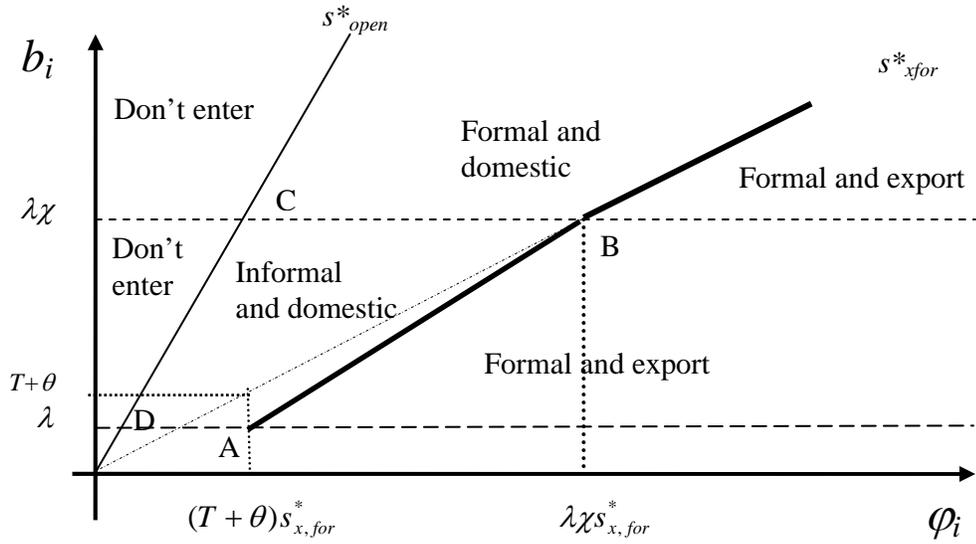


Figure 1.4 - Physical productivity (φ_i) and expected wage bill (b_i) space and firms' choice of labor contracts and markets served in an open economy.

The probability of being an exporter is given by $\Pr(\text{export})$ which is the probability of a firm productivity being larger than the export cutoff, $s_{x,for}^*$.

$$\begin{aligned} \Pr(\text{export}) = & \frac{1}{1 - G(s_{open}^*)} \left[\int_{\lambda \chi s_{x,for}^*}^{\infty} \int_{\lambda}^{\lambda \chi} \phi(\varphi_i, b_i) db_i d\varphi_i + \right. \\ & + \int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \int_{\lambda}^{\frac{\lambda \varphi_i}{T}} \frac{\lambda \theta}{T} \phi(\varphi_i, b_i) db_i d\varphi_i \\ & \left. + \int_{\lambda \chi s_{x,for}^*}^{\infty} \int_{\lambda \chi}^{\frac{\varphi_i}{\lambda}} \phi(\varphi_i, b_i) db_i d\varphi_i \right] \end{aligned} \quad (1.38)$$

The mass of exporter firms is given by $M_x = \Pr(\text{export})M$. The computation of \tilde{s} is as before, equation (1.26), but now under the new cut off, $\tilde{s}(s_{open}^*)$. The aggregate measure of productivity for exporters will be \tilde{s}_x . The overall average across all domestic firms of combined profit $\bar{\pi}$ (earned from both domestic and export sales) is given by

$$\bar{\pi} = \pi_d(\tilde{s}) + \Pr(\text{export})\pi_x(\tilde{s}_x) \quad (1.39)$$

The zero cutoff productivity (ZCP) equation is now built taking into account the exporters profits from foreign market, as shown in equation (1.40).

$$\bar{\pi} = f\kappa(s_{open}^*) + \Pr(\text{export})f_x\kappa(s_{x,for}^*) \quad (1.40)$$

$$\kappa(s^*) \equiv \left[\frac{\tilde{s}_l(s^*)}{s^*} \right]^{\sigma-1} - 1$$

We obtain from the ratio of the zero profit conditions, where $r_d(s)$ and $r_x(s)$ are the domestic and foreign sales revenue, a relation between the entry cutoff in the destination country and the export cutoff of the exporter country.

$$\frac{r_x(s_{x,for}^*)}{r_d^{foreign}(s_{open}^{*,foreign})} = \frac{\left(\frac{s_{x,for}^*}{\tau}\right)^{\sigma-1} [\rho P^{foreign}]^{\sigma} Q^{foreign}}{(s_{open}^{*,foreign})^{\sigma-1} [\rho P^{foreign}]^{\sigma} Q^{foreign}} = \frac{f_x}{f}$$

$$s_{x,for}^* = \tau s_{open}^{*,foreign} \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \quad (1.41)$$

Similarly, for the foreign country,

$$s_{x,for}^{*,foreign} = \tau^{foreign} s_{open}^* \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \quad (1.42)$$

The free-entry condition (FE) equation is like before, in steady state a sufficient mass of firms enters so that the average profits from entry equal the fixed cost of entry, as depicted by equation (1.43).

$$\bar{\pi} = \frac{\delta_e^f}{1 - G(s_{open}^*)} \quad (1.43)$$

From the open economy ZCP and FE relations, equations (1.40) and (1.43), we obtain a system for home and foreign equations that determines in equilibrium the pair $(s_{open}^*, s_{open}^{*,foreign})$. This is so because $s_{x,for}^*$ and $s_{x,for}^{*,foreign}$ are functions of $s_{open}^*, foreign$ and s_{open}^* respectively, as shown by equations (1.41) and (1.42). Following Melitz (2003) let's define $j(s) \equiv [1 - G(s)]\kappa(s)$. Then, we can write the system as

$$\begin{cases} F_1 = j(s_{open}^*)f + j(s_{x,for}^*)f_x - \delta_e^f = 0 \\ F_2 = j(s_{open}^{*,foreign})f + j(s_{x,for}^{*,foreign})f_x - \delta_e^f = 0 \end{cases} \quad (1.44)$$

A solution to this system is a pair of $(s_{open}^*, s_{open}^{*,foreign})$ such that $F_1 = F_2 = 0$.

This solution can be represented in the $s_{open}^* \times s_{open}^{*,foreign}$ space by the intersection of the

$F_1 = 0$ and $F_2 = 0$ schedules.

Proposition 1. *There exists a solution to the system (1.44) and it is unique.*

Proof. Let's differentiate F_1 and F_2 at the loci $F_1=0$ and $F_2=0$ respectively.

$$\left. \frac{\partial s_{open}^*}{\partial s_{open}^{*,foreign}} \right|_{F_1=0} = - \frac{\frac{\partial F_1}{\partial s_{open}^{*,foreign}}}{\frac{\partial F_1}{\partial s_{open}^*}} = - \frac{j'(s_{x,for}^*) \frac{s_{x,for}^*}{s_{open}^{*,foreign}} f_x}{j'(s_{open}^*) f}$$

$$\left. \frac{\partial s_{open}^*}{\partial s_{open}^{*,foreign}} \right|_{F_2=0} = - \frac{\frac{\partial F_2}{\partial s_{open}^{*,foreign}}}{\frac{\partial F_2}{\partial s_{open}^*}} = - \frac{j'(s_{open}^{*,foreign}) f}{j'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^*}{s_{open}^{*,foreign}} f_x}$$

There will be an intersection if the schedules have different slopes.

$$\Delta = \frac{\left. \frac{\partial s_{open}^*}{\partial s_{open}^{*,foreign}} \right|_{F_1=0}}{\left. \frac{\partial s_{open}^*}{\partial s_{open}^{*,foreign}} \right|_{F_2=0}} = \frac{j'(s_{x,for}^*) \frac{s_{x,for}^*}{s_{open}^{*,foreign}} f_x}{j'(s_{open}^*) f} \frac{j'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^*}{s_{open}^{*,foreign}} f_x}{j'(s_{open}^{*,foreign}) f}$$

Notice that $0 < \frac{j'(s_{x,for}^*) f_x s_{x,for}^*}{j'(s_{open}^*) f s_{open}^{*,foreign}} < 1$, and a similar condition holds for the

foreign country, as a consequence, we have $0 < \Delta < 1$, which implies that the schedules intersect each other, i.e. the equilibrium exists, and the intersection is unique. These last two facts are due to the monotonicity of the $j(\cdot)$ function as shown in Melitz (2003). ■

To solve for the model scale, we need the labor market clearing equation, which now has to include the number of workers employed in the export fixed cost activity (L_x , $L_x = M_x f_x$). The number of workers employed in the variable cost activity, λ_{vi} , for firm i is given by equation (1.45), where the first term corresponds to the number of workers employed by an exporting firm that would hire informal workers in autarky; the second term corresponds to an exporting firm that would hire formal workers anyway. The last term refers to the firms that serve only the domestic market, and they may use formal or informal workers.

$$\lambda_{v_i}(b_i, \varphi_i) = \begin{cases} \frac{(1+\tau^{-\sigma})}{\varphi_i} q\left(\frac{\lambda\varphi_i}{Tb_i+\lambda\theta}\right), & \text{if } w_i < \chi \text{ and } \frac{\lambda\varphi_i}{Tb_i+\lambda\theta} \geq s_{x,for}^* \\ \frac{(1+\tau^{-\sigma})}{\varphi_i} q\left(\frac{\varphi_i}{b_i}\right), & \text{if } w_i \geq \chi \text{ and } \frac{\varphi_i}{b_i} \geq s_{x,for}^* \\ \frac{1}{\varphi_i} q\left(\frac{\varphi_i}{b_i}\right), & \text{else} \end{cases} \quad (1.45)$$

With each firm level of employment in the variable cost activity, we can calculate the overall demand for workers in the variable cost activity. The labor market clearing condition is

$$(1-u)L = M \left[\delta f_e + f + \Pr(\text{export})f_x + \frac{L_v^{\text{inf}}}{M} + \frac{L_v^{\text{for}}}{M} \right] \quad (1.46)$$

The equation (1.47) is the average wage (\bar{w}) that is obtained by adding the fixed cost activity workers wage bill to the variable cost activity total wage, which now includes the export fixed cost workers and their wages.

$$\bar{w} = \frac{1}{(1-u)L} M \left[(\delta f_e + f + \Pr(\text{export})f_x) + \frac{twP_{v,open}}{M} \right] \quad (1.47)$$

The last two equations needed are the relation between unemployment and average wage, equation (1.33), and the equation (1.34) that describes the government transfers. The procedure to solve for M , u , \bar{w} , and tr is similar to the closed economy case and the proof of equilibrium existence is again similar to Davis and Harrigan (2007), and omitted here.

Comparative Statics

The effect of trade policy changes in the informal labor markets is assessed in this paper by the impact of changes in foreign and home country import tariffs, τ and τ^{foreign} respectively, on the share of informal workers and on the formal-informal wage gap. The share of informal workers in the variable cost activity is defined as

$$share \equiv \frac{L_v^{inf}}{L_v^{for} + L_v^{inf}}, \quad 0 < share < 1 \quad (1.48)$$

The effect of a change in τ on the informality share is given by equation (1.49). We can see that M , P , and Q can be factored out when calculating the *share*, because they are common factors in L_v^{for} and in L_v^{inf} . Thus, these terms are crossed out, so the share is a function of the structure of the economy (s_{open}^* and $s_{x,for}^*$) and not of its scale.

$$\left. \frac{dshare}{d\tau} \right|_{\bar{\tau}^{foreign}} = \frac{\partial share}{\partial \tau} + \frac{\partial share}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} + \frac{\partial share}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} \quad (1.49)$$

The first term of the right-hand side is positive. A decrease in the export barriers leads to an increase in demand due to a reduction in the price paid by foreign consumers. The current exporters will hire more formal workers to cope with it. Then, the share of informal workers decreases.

The second term on the right-hand side is positive. A decrease in τ decreases the export cutoff, $s_{x,for}^*$, and some domestic firms will enter the foreign market. These new exporters will increase their formal employment to increase production and in some cases they will switch from informal to formal workers in order to export. As a result, the informal share decreases.

The third term represents the effect of the firms exiting the market and it is a product of two effects. The first is that a decrease in marginal cost entry cutoff, s_{open}^* ray rotates to the right in figure (1.4), makes the highest marginal cost active formal and informal firms exit the market. Hence the number of formal and informal jobs decrease and the effect on the informality share is indeterminate. The second effect is

negative because a decrease in export variable costs makes the foreign market more attractive for domestic firms by increasing their expected profits. As a consequence, a decrease in the marginal cost entry cutoff (an increase in s_{open}^*) is needed to re-establish expected zero profits for new entrants.

Informality share is affected by changes in $\tau^{foreign}$ by the two channels described in equation (1.50).

$$\left. \frac{dshare}{d\tau^{foreign}} \right|_{\bar{\tau}} = \frac{\partial share}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau^{foreign}} + \frac{\partial share}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau^{foreign}} \quad (1.50)$$

The first channel (term) is positive and it is the effect on the exporters that are at the margin. A decrease in $\tau^{foreign}$ increases $s_{open}^{*,foreign}$ by the mechanism described before, and through equation (1.40), it increases the domestic export cutoff, $s_{x,for}^*$. As a consequence, some firms exit the foreign market and fire formal workers. Among these firms, the ones with $w_i < \chi$ will switch back to informal workers. The second channel is the effect of $\tau^{foreign}$ changes on the domestic market entry cutoff. A decrease in $\tau^{foreign}$ reduces s_{open}^* because the increase in the domestic export cutoff decrease the overall expected profits and then s_{open}^* has to decrease to meet the zero profit condition.

The sign of $\frac{\partial share}{\partial s_{open}^*}$ depends on the joint density of wages and physical productivity, $\Psi(w_i, \phi_i)$, since there is a one-to-one relationship between wages (w) and monitoring ability (m), as dictated by equation (1.17). All else equal, if there's more informal firms in the s_{open}^* ray, a rotation to the right (increase in s_{open}^*) would reduce informal employment by more than the reduction in the formal employment, and the

share would decrease. Now, changes in the payroll taxes and enforcement parameters would alter the formal-informal wage cutoff, χ . All else equal, a higher χ implies a larger number of informal firms in the s_{open}^* ray, and as explained before, an increase in s_{open}^* would decrease the informal share. On the other hand, a lower χ could make the informal share increase after an increase in s_{open}^* .

A conservative, approach in specifying sufficient conditions to circumvent this sign indeterminacy is imposing conditions that are likely to hold in real life, and when there's no such guidance, opt for restrictions that seem plausible.

The partial derivatives of τ and $\tau^{foreign}$ on the variables describing the economy structure are calculating using the Cramér rule. The first step is to find the sign of the Jacobean matrix of the system of equations that describe the economy structure, which is proved in Lemma 1 to be positive.

Lemma 1. *The determinant of the Jacobean matrix of the system (1.44) is positive.*

Proof. See Appendix.

The next step is finding the signs of the partial derivatives of s_{open}^* and $s_{x,for}^*$ with respect to τ and $\tau^{foreign}$, which are done in Lemma 2 and 3 respectively.

Lemma 2. *For $d\tau^{foreign} = 0$, we have $\frac{\partial s_{open}^*}{\partial \tau} < 0$, $\frac{\partial s_{open}^*, foreign}}{\partial \tau} > 0$, $\frac{\partial s_{x,for}^*}{\partial \tau} > 0$, and $\frac{\partial s_{x,for}^*, foreign}}{\partial \tau} < 0$.*

Proof. See Appendix.

Lemma 3. *For $d\tau = 0$, we have $\frac{\partial s_{open}^*}{\partial \tau^{foreign}} > 0$, $\frac{\partial s_{open}^*, foreign}}{\partial \tau^{foreign}} < 0$, $\frac{\partial s_{x,for}^*}{\partial \tau^{foreign}} < 0$, and $\frac{\partial s_{x,for}^*, foreign}}{\partial \tau^{foreign}} > 0$.*

Proof. See Appendix.

Now, in Proposition2 we can calculate the model predictions about the share of informal workers.

Proposition 2. *If the sufficient conditions (S1)-(S4) hold, a decrease in τ implies a decrease in the informal share ($\left. \frac{dshare}{d\tau} \right|_{\bar{\tau}^{foreign}} > 0$) and a decrease in $\tau^{foreign}$ increases the informal share ($\left. \frac{dshare}{d\tau^{foreign}} \right|_{\bar{\tau}} < 0$).*

$$(S1) \frac{\partial \Psi(\varphi, w)}{\partial \varphi} < 0; (S2) \frac{\partial \Psi(\varphi, w)}{\partial b} < 0; (S3) \sigma > 3; (S4) \chi > \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}}$$

Proof. See Appendix.

The above conditions assure that two positive (negative) terms inside $\left. \frac{dshare}{d\tau} \right|_{\bar{\tau}^{foreign}}$ ($\left. \frac{dshare}{d\tau^{foreign}} \right|_{\bar{\tau}}$) will be larger in absolute value than the expression that contain the $\frac{\partial share}{\partial s_{open}^*}$ negative (positive) term. In other words, the amount of workers affected by changes in the export side of the economy is large enough to overcome what happens in the import side of the economy.

Condition (S1) imply that given a level of expected wage bill, it's more likely to find a firm with low physical productivity than with high physical productivity, which is what is found in the empirical literature about productivity and firm size, as discussed in Melitz (2003). Condition (S2) states that given a level of physical productivity, a low-wage firm is more likely to exist than a high-wage firm. Both conditions (S1) and (S2) are met by the widely used *Pareto* distribution, for example.

Condition (S3) is reasonable since Broda et al. (2008) using trade data at HS-4 level of aggregation estimated the elasticity of substitution and found a median above 3 for 15 developing countries, among them several in Latin America. Notice that my model is set in a much more disaggregated level, so we should expect these elasticities to increase in more disaggregated level.

The last condition, (S4), means that in order to have the proposition results we need the informal labor market to have at least a certain size. And this condition is likely to be met as long as f_x is not much larger than f .

The effect of a symmetric decrease in trade variable cost would be given by the sum of equations (1.49) and (1.50).

$$\frac{dshare}{d\tau} = \left. \frac{dshare}{d\tau} \right|_{\bar{\tau}^{foreign}} + \left. \frac{dshare}{d\tau^{foreign}} \right|_{\bar{\tau}} \quad (1.54)$$

Notice again that the sign of $\frac{dshare}{d\tau}$ is indeterminate, unless we impose the same sufficiency conditions as done before.

Proposition 3. *A symmetric decrease in τ and $\tau^{foreign}$ decreases the share of informal workers if conditions (S1)-(S4) are met.*

Proof. From Lemmas (5), (6) and (7) we can see that the terms from $\left. \frac{dshare}{d\tau} \right|_{\tau^{foreign}}$ are larger in absolute value than the terms in $\left. \frac{dshare}{d\tau^{foreign}} \right|_{\tau}$. The sufficiency assumptions are the same used in the previous propositions, completing the proof that $\frac{\partial share}{\partial \tau} > \left| \frac{\partial share}{\partial \tau^{foreign}} \right|$

■

The formal-informal wage gap is defined as the difference between average formal wage (\bar{w}^{for}) and average informal wage (\bar{w}^{inf}), as shown by equation (1.55). Again, only the workers employed in variable cost activities are considered in calculations, and only the structure of the economy, and not its scale, is what matters for the wage gap.

$$wagegap \equiv \bar{w}^{for} - \bar{w}^{inf} = \frac{twP_{V,open}^{for}}{L_v^{for}} - \frac{twP_{V,open}^{inf}}{L_v^{inf}} \quad (1.55)$$

The effect of τ and $\tau^{foreign}$ on the formal-informal wage gap also suffers from the sign ambiguity, but now not only through the number of formal and informal workers but also through the total wages paid to formal and informal workers. Thus the assumptions made here are somewhat similar to the ones used in the informal share propositions, but they're now tailored to a specific joint density of (φ, m) or (φ, w) .

Proposition 4. *If conditions (W1)-(W3) hold, a decrease in τ decreases the formal-informal wage gap ($\left. \frac{dwagegap}{d\tau} \right|_{\bar{\tau}^{foreign}} > 0$) and a decrease in $\tau^{foreign}$ increases the formal-informal wage gap ($\left. \frac{dwagegap}{d\tau^{foreign}} \right|_{\bar{\tau}} < 0$).*

(W1) φ and w are independently Pareto distributed in which $k_1, k_2 > \sigma > 2$ are the scale parameters respectively.

$$(W2) \frac{k_1 + k_2}{k_1 + k_2 + 1} \frac{[1 - \chi^{-k_1 - k_2 - 1}]}{[1 - \chi^{-k_1 - k_2}]} > 1; \quad (W3) \frac{T^{\sigma + k_2} (\sigma + k_1)}{(k_1 + k_2 + 1)} > 1$$

Proof. See Appendix.

Assumption (W1) is a particular case of assumptions (S1) and (S2) used before, and the conditions on k_1 and k_2 are needed for the existence of first moments of both φ and w . The last two conditions, (W2) and (W3), are used to guarantee that a decrease in total wage paid to informal workers due to a change in $s_{x, for}^*$ is smaller than the induced variation in the number of informal workers times the average wage. In other words, the informal jobs destroyed are the ones with wages below the informal average wage.

The total effect in the symmetric change in τ and $\tau^{foreign}$ on the wage gap is

given by equation (1.56).

$$\frac{dwagegap}{d\tau} = \frac{dwagegap}{d\tau} \Big|_{\bar{\tau}^{foreign}} + \frac{dwagegap}{d\tau^{foreign}} \Big|_{\bar{\tau}} \quad (1.56)$$

Proposition 5. *A symmetric decrease in τ and in $\tau^{foreign}$ decrease the formal-informal wage gap ($\frac{dwagegap}{d\tau} < 0$) if conditions (W1)-(W3) hold.*

Proof. In the symmetric case, we have that $\tau = \tau^{foreign}$ and

$$\frac{d(\bar{w}^{for} - \bar{w}^{inf})}{d\tau} = \frac{d(\bar{w}^{for} - \bar{w}^{inf})}{d\tau} \Big|_{\bar{\tau}^{foreign}} + \frac{d(\bar{w}^{for} - \bar{w}^{inf})}{d\tau^{foreign}} \Big|_{\bar{\tau}}$$

From the lemmas (5), (6) and (7) we can see that the derivatives with respect to τ are larger than the ones with respect to $\tau^{foreign}$. ■

Under some plausible assumptions on the joint distribution of physical and monitoring productivities and on the payroll tax and enforcement parameters, the model predictions are that a decrease in home import tariffs increases both the informality share and the formal-informal wage gap in home whereas a decrease in foreign tariffs has the opposite effect.

Final Remarks

In this chapter I presented a novel theoretical model in which trade policy changes do affect informal labor markets, which encompasses a significant amount of workers in developing countries. The first novel feature of my theoretical model is that informal labor markets arise endogenously due to payroll taxes, which has been identified as the most important reason for informality. My model is able to generate several stylized facts such as informality in every industry of the economy, so

informality is not industry specific, and it doesn't require workers to be heterogeneous, i.e. informality is not a function of the workers characteristics. Moreover, the theoretical model displays a positive correlation between size and formality, and small firms do not export and do not all hire informal workers, in fact, the high wage small firms prefer formal workers, facts that are supported by empirical evidence.

Changes in trade policy impact two labor market outcomes related to informality: the share of informal workers and formal-informal wage gap at the industry level. This impact works through affecting the distribution of active and exporting firms and the quantity produced by each firm. The trade policy instruments considered are import tariffs and trade partner import tariff (export barriers).

From the comparative statics of the model, a decrease in import tariffs leads to an increase in the share of informal workers and in the formal-informal wage gap. A reduction in export barriers decreases both the informality share and the wage gap. The latter is another novel feature of my model that has very important implications. We can see that the effect of the export barrier has an opposite effect to the import barriers. Therefore, if both effects have similar magnitudes but opposite directions, when the effects of trade liberalization on either the informality share or the wage gap is estimated omitting the export barriers variable will lead to no estimated effect.

Chapter 2 - Trade Liberalization and Informal Labor Markets: Empirical Assessment

The comparative statics of my theoretical model provide testable predictions of the effects of import tariffs and export barriers on the share of informal workers and on the formal-informal wage gap. I use the 1989-2001 Brazilian trade liberalization to estimate these effects.

The Brazilian trade liberalization episode is a very good candidate for empirical investigation for several reasons. First, informal workers are clearly and directly identified in the data as the individuals whose employers do not pay payroll taxes. In addition, Brazil went through a major decrease in import tariffs that started in 1989. Later, in the 1990s, its trade partners decreased their import tariffs on Brazilian goods. As a result, manufacturing imports increased by more than 200% and so did exports by 68%. Finally, Brazilian labor institutions didn't change in this period, which is a nice feature since several countries that went on a trade liberalization program also reformed labor regulations.

The data used consists of industry level Brazilian and foreign tariffs, and Brazilian household surveys in the form of repeated cross-sections between 1989 and 2001. The surveys contain workers demographic and employment characteristics including industry affiliation and informality status.

I assessed the effect of Brazilian and foreign tariffs on the industry-level share of informal workers by estimating a linear probability model using worker level data, in which the dependent variable is the informality status indicator. Given the possibility of selection into informality based on observables, I control for the

workers observable characteristics available in the data. My findings indicate that reducing within industry Brazilian import tariff by a percentage point increased informal share by 0.8 percentage points. On the other hand, a percentage point decrease in foreign tariff reduces informality by 0.4 percentage points. Both effects have the same signs as predicted by my model, and their magnitudes are plausible.

To test the formal-informal wage gap predictions I follow the standard two-step procedure in the wage inequality literature. In the first step, I estimate a Mincer-type earnings equation for each year of the sample, where the industry-level formal-informal gap is given by the estimated coefficient of the interaction between formality indicator and the industry affiliation indicator. In the second step, the estimated wage gap is regressed on Brazilian and foreign tariffs in addition to year and industry effects. I also find strong support for my model here: a one percentage point decrease in own tariff increases the wage gap by 0.4 percentage point and a 1 percentage point decrease in the foreign tariffs decreases the gap by 0.17 percentage points.

An important finding is that the Brazilian import tariff is endogenous with respect to informal share and formal-informal wage gap. To circumvent this problem, I use an instrumental variable approach, and the instrument used is the liberalization path of a similar country.

Last, but not least, my findings are not robust to the omission of foreign tariffs from the estimated model. This fact highlights the importance of not neglecting this source of gains as many studies of trade reforms do.

Description of the data

Workers data

It is not easy to obtain data about informal labor contracts because of their illegal nature. However, in Brazil there are annual cross-section household surveys that ask the workers questions about their job formality status in addition to questions about demographic and employment characteristics. These surveys are called PNAD-Pesquisa Nacional por Amostra de Domicílios and are conducted by the IBGE-Instituto Brasileiro de Geografia e Estatística (Brazilian Bureau of Geography and Statistics). They cover the whole country except rural areas of the Northern Region (less than 5% of Brazilian population and no manufacturing). PNAD is not conducted in the years in which there's census survey (1991 and 2000) and it was not conducted in 1994. To fill the gap for 1991 and 2000, I used the Brazilian census microdata sample for 1991 and 2000, which asks the same questions as PNAD. The census data came from IPUMS-International (Minnesota Population Center, 2007). The data used in this paper covers from 1989 to 2001, but excludes 1994.

There are two important issues regarding the incentives the workers have to reveal the truth in the survey informality status questions. The first is that the information provided by the interviewed person is confidential and according to Brazilian Law, it can't be used as evidence in court. Furthermore, in Brazil the informal worker suffers no fine, imprisonment or any other penalty when caught by the authorities, only the employer suffers penalties. The second issue is that the worker knows about her informal status, i.e. it is common knowledge when the employer pays social security contributions because according to Brazilian law the

employee pays a share of the social security contribution, which is deducted from her wage. The work card is signed by the employer during the hiring process and then returned to the worker, who uses it as a proof of employment.

The workers characteristics used in this paper are age, gender, years of education, industry affiliation, monthly wage, hours usually worked in a week, informality status according to employer social security contributions. I discarded all observations with missing data in any of the before mentioned variables. My sample includes only employees, so employers and self-employed people are excluded from my sample. I consider only workers between 15 and 65 years-of-age. This sample cut was chosen to avoid workers that are informal for being too young to be a formal worker (must be at least 14 years-of-age) and people receiving social security benefits and as a consequence are not authorized to work formally (older than 65 years-of-age). When a worker had multiple jobs, I considered only the main or primary job hourly wage (built as the monthly wage divided by four times the hours worked per week). The total number of observations is 767,087.

The industry aggregation level used in this paper is dictated by PNAD industry classification, which consists of 16 manufacturing industries, but is not as coarse as the 2-digit ISIC classification, and is not as disaggregated as the 3-digit ISIC. The industry classification is depicted on table (2.1) with their equivalence to IBGE *Nível 50* industry classification, which is used in Brazilian import tariffs, and 3-digit ISIC classification, which is used in international trade data and tariffs.

Industry in PNAD-Census data	IBGE Nível50	ISIC3
Nonmetallic Mineral Product	4	361-2,369
Metals Production and Processing	5,6,7	371-2,381
Machinery, Equipment and Commercial Installation (including parts)	8	382
Electrical and Electronic Equipment	10,11	383
Automobile, Truck and Bus (including parts)	12,13	384
Wood Sawing and Wood Products	14	121-2,331-2
Pulp and Paper Production, Paper Products, Printing and Publishing	15	341-2
Rubber Product	16	355
Non-petrochemical Chemical and Fertilizer	17,19	351
Pharmaceutical, Perfume, Soap, Detergent, and Candle	20	352
Plastic Products	21	356
Textiles	22	321
Apparel	23	322
Footwear and leather products	24	323-4
Coffee, Food, Beverage, Animal Feed and Tobacco industries	25 to 31	311 to 314

Table 2.1 – Equivalence among PNAD/Census manufacturing industry classification and IBGE Nível50 and ISIC3 classifications.

The informality indicator constructed is based on the social security contribution status, i.e. the *informal* variable is "1" if the worker employer doesn't pay social security contributions, and "0" otherwise. The share of informal worker in industry i and year t according to each criterion consists of the weighted average of the informality indicator, and the weights are the sample weights provided by PNAD-Census.

The job informality questions have very few missing observations that account for three tenths of a percentage point in each year of the sample. However, the missing observations tend to be concentrated in only one industry: petroleum refining and petrochemicals, in which at least ten percent of observations are missing every year. Thus, I decided to exclude this sector from my analysis because I do not believe it would cause any impact in the results since it is a sector that employs a small number of workers and most of it is composed by government owned firms.

The formal-informal wage gap of industry i in year t consists of the difference between the average formal wage and the average informal wage. So, the wage gap measured here is the difference in the hourly wage that can be attributed to the formality status, i.e. after we control for worker observable characteristics that can also influence the wage such as education and experience, gender, color and industry affiliation. Experience is not observable in our data, thus I adopt the standard solution in the literature that is control for the age and its square. To obtain the wage gap we need to estimate equation (2.1) by weighted OLS for every year in my data set, using the PNAD/Census sample weights.

$$\ln(\text{wage}_{jk}) = \beta_0 + \beta_1 \text{age}_{jk} + \beta_2 \text{age}_{jk}^2 + \beta_3 \text{male}_{jk} + \beta_4 \text{educ}_{jk} + \beta_5 \text{black}_{jk} + \gamma_1 * \text{industry}_j + \gamma_2 * (1 - \text{informal}_{jk}) * \text{industry}_j + \varepsilon_{jk} \quad (2.1)$$

in which age_{jk} is the age in years of person k working in industry j , $male$ is an indicator if person k is a male, $educ$ is the number of years of formal schooling, $black$ is an indicator if person k is black, $\mathbf{industry}_j$ is a vector of industry affiliation indicators, and $informal_{jk}$ is an indicator if person k works under an informal labor contract in industry j .

The estimated wage gap is given by the vector of coefficients γ_2 , and it can be interpreted as the average percentage increase in the wage that a worker would receive by having a formal instead of an informal contract. These coefficients and their estimated standard errors are normalized by the Haisken-DeNew and Schmidt (1997) two-step restricted least square procedure. The inverse of these standard error estimates will be used as weights when wage gap is the dependent variable.

Table (2.2) reports the estimated coefficients for selected years of the sample. The results indicate that wages are increasing in age and in years of education. Males receive wages at least 28 percent higher than females. Formal workers in the apparel industry receive a wage 24 percent higher than informal workers in 1987 for example. The wage gap estimated coefficients are jointly statistically significant for all years, nevertheless some might not be significant in some years.

Independent Variables	Dependent Variable : log(hourly wage)			
	(1)	(2)	(3)	(4)
Formal*apparel	0.243*** (0.061)	0.290*** (0.040)	0.170*** (0.051)	0.126*** (0.036)
Formal*metal production	0.581*** (0.080)	0.537*** (0.066)	0.361*** (0.042)	0.366*** (0.040)
Age	0.086*** (0.004)	0.077*** (0.003)	0.078*** (0.003)	0.072*** (0.003)
Age ²	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Male	0.305*** (0.017)	0.328*** (0.015)	0.319*** (0.014)	0.279*** (0.013)
Black	-0.192*** (0.028)	-0.105*** (0.027)	-0.156*** (0.024)	-0.106*** (0.021)
Years of education	0.088*** (0.002)	0.104*** (0.002)	0.106*** (0.002)	0.096*** (0.002)
Observations	13271	12816	12951	13639
R-squared	0.435	0.498	0.512	0.467
Year	1989	1993	1997	2001

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Sample weights used.
Industry effects and their interaction with formal indicator included in all regressions.

Table 2.2 - Weighted OLS regression of the log of hourly wage on the workers' observable characteristics.

Trade data

The data about Brazilian import tariffs¹⁶ at Nível 50 aggregation comes from Kume et al. (2003). The data is aggregated by industry value-added, and it encompasses the 1987-2001 period. I further aggregated the tariffs into my 15 manufacturing industries, using the industry value added as Kume et al. (2003).

The tariffs faced by Brazilian exporters vary according to each trade partner. Data availability constrained the choice of partners used in the empirical analysis, which are Argentina, China, Japan, USA, France, Italy, Germany, United Kingdom, Belgium-Luxemburg, Netherlands, Portugal and Spain. They account for more than 60 % of all Brazilian exports in the 1989-2001 period.

For every country, except Argentina, data at 3-digit ISIC level was obtained from the Trade, Production, and Protection 1974-2006 by Nicita and Olarreaga (2006), from which I used the *tar_savg_mfn* series that is the simple average tariff rate in percentage points that must be paid for the good at the border of the importing country by a most favored nation (MFN). This tariff measure can be understood as an upper bound of the tariffs imposed on Brazilian products. Each partner export tariff data was aggregated into my 15 industries classification by simple average. There is no data for the 1989-1991 period for China, so I assumed that in these years the tariff level was the same as 1992.

The Argentinean import tariffs on Brazilian products data at 4-digit ISIC level for the 1991-2001 period comes from Freund et al. (2008). This data was first aggregated into 3-digit ISIC level by simple average and then aggregated into my 15

¹⁶A 20% import tariff is expressed as 0.20.

industries classification by simple average, again. The data for 1990 at 3-digit ISIC level comes from Liftschitz (1991), and it was also used for 1989, since there's no data for this year. The partners import tariffs were aggregated across partners by industries using simple average.

The U.S. dollar is the predominant currency used in foreign trade transactions in Brazil. The nominal exchange rate data comes from the Brazilian Central Bank (Banco Central do Brasil), and it is the mid-month U.S. dollar per Brazilian currency unit. To calculate the real exchange rate faced by a Brazilian manufacturer, I used the IPA-OG (Índice de Preços por Atacado - Oferta Global) wholesale price index calculated by Fundação Getúlio Vargas as the Brazilian producers price index, and for U.S. the Producer Price Index calculated by the U.S. Census Bureau. I chose August of 1994 as the base month, which means IPA-OG and PPI are rebased to be equal to one at this date. The calculations are similar to Muendler (2004), but my series range from 1989 to 2001.

The Colombian import tariff data for 1983-1998 come from the Colombian National Planning Department (DNP) and are aggregated at 4-digit ISIC, using number of tariff lines as weights. I further aggregated it to my industry classification by simple average.

Estimations and Results

First, I investigate the model prediction on the share of informal workers. Next, the predictions about formal-informal wage gap are assessed, and last, but not least, I present some robustness checks of the specifications estimated. Throughout

this section, I assume that τ and $\tau^{foreign}$ contain only foreign countries import tariffs (hereafter called export tariffs) and Brazilian import tariffs respectively.

Share of informal workers

The first empirical exercise conducted is to estimate the effects of changes in τ and $\tau^{foreign}$ on the share of informal workers. The empirical strategy used to estimate these effects comes from equation (1.54) in the theoretical model. As seen in the previous section, the observable characteristics of formal and informal workers are not equal. A problem on the consistency of estimates from equation (1.54) using a constructed informality share directly from the informal indicator arises if there's selection into informal jobs based on the observable characteristics of the worker. So, I'll estimate a worker level pooled cross-section regression in which the dependent variable is the informality indicator, $informal_{ijt}$, which incorporates the workers characteristics. In this specification, the informal share is interpreted as the sum of all the workers expected job formality status. Thus, an increase in the likelihood of having an informal job is translated as an increase in the expected share of informal workers.

The specification used is described by equation (2.2), where $extar_{jt}$ is the export tariff faced by Brazilian made goods in industry j in year t , $imptar_{jt}$ is the import tariff faced by foreign produced goods in industry j in year t , \mathbf{year}_t is a vector of year specific dummy variables, $\mathbf{industry}_j$ is a vector of industry indicators, $\mathbf{characteristics}_{ijt}$ is a matrix of worker observable characteristics such as age, age², years of education, male indicator and black indicator; and ε_{ijt} is the unobservable

error term. All estimations using the informal indicator as dependent variable used the PNAD/Census sample weights. The standard errors of the estimated coefficients were clustered on industry by year. Proposition (2) predicts that a decrease in Brazilian import tariffs ($\tau^{foreign}$) increases the share of informal workers whereas a decrease in export tariffs faced by Brazilian producers (τ) decrease the informality share, thus $\beta_1 > 0$ and $\beta_2 < 0$ are expected.

$$\begin{aligned} \ln \text{ormal}_{ijt} = & \beta_0 + \beta_1 \text{extar}_{jt} + \beta_2 \text{imptar}_{jt} + \alpha * \text{year}_t + \\ & + \gamma * \text{industry}_j + \psi * \text{characteristics}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (2.2)$$

Year effects were included in the estimated model to control for economy-wide shocks, such as business cycles. Consider the case that business cycle could affect independently informal share and import tariffs, e.g. suppose in recessions firms employing formal workers are more likely to reduce employment and at the same time government raises tariffs in response to recessions, as a result a spurious relation between tariffs and informal share would be found unless the estimated model contains year effects.

Furthermore, some industry specific characteristic variables that are correlated with right-hand side variables may have been omitted and this could lead to an omitted variable bias and inconsistent estimates. One example is across industry differences in the likelihood of government audits. This can happen because of either political economy reasons or easiness in hiding operations, since it is easier to hide an apparel firm which can vary a lot in size than hide a steel mill, which can't be small due to technological constraints. As long as these industry characteristics are stable over time, a vector of industry dummies (industry_j) is added to the regression to

tackle this problem. Thus, the identification of β_1 and β_2 will come from within industry variation in these tariffs over time.

Table (2.3) reports the OLS estimates of equation (2.2) in column (1), in which the estimated import and export tariff coefficients were not statistically significant. A percentage point decrease in import tariffs implies an increase in the likelihood of becoming an informal worker by 0.28 percentage points, or equivalently an increase of 0.28 percentage points in the informal share. For a similar change in export tariffs the effect is an increase in informality share of 0.03 percentage points.

A major concern is the endogeneity of the import tariff variable. One reason is the way the import tariffs were aggregated, because the value added by industry is jointly determined with the share of informal workers and the average formal and informal wages. A second reason is when government has disutility over unemployment and is indifferent if jobs are formal or informal. In this case, one could expect larger import tariffs cut in industries in which it is possible to have a large share of workers in informality. Thus, there would be a reverse causation between import tariffs and informality variables. A third reason is from a public finance perspective. A decrease in import tariffs destroys formal jobs and decreases the payroll tax revenues. The government can respond by increasing enforcement or raising payroll taxes to increase revenues. Although the latter didn't happen in Brazil, the former is unobservable¹⁷, and will be correlated with import tariffs. Finally, there may exist other time varying factors affecting both share of informal workers and import tariffs. To cope with these issues I employ an instrumental variable approach.

¹⁷As discussed earlier, the only evidence available is the increase in the number of firms visited by auditors during trade liberalization in Brazil.

Independent Variables	Dependent Variable: informal job indicator			
	(1)	(2)	(3)	(4)
Import tariff	-0.280 (0.231)	-0.795*** (0.232)	-0.803*** (0.241)	-0.728*** (0.169)
Export tariff	-0.033 (0.100)	0.349** (0.161)	0.356** (0.167)	0.294** (0.144)
Technique	OLS	2SLS	2SLS	2SLS
Observations	767087	767087	767087	767087
Under identification test (Kleibergen-Paap rk LM statistic)		4.70** [0.030]	4.47** [0.034]	7.24** [0.027]
Weak identification test Kleibergen-Paap rk Wald F statistic		159021	152138	93855
Stock-Yogo 10% max IV size critical values		16.38	16.38	19.93
Hausman Endogeneity Test		8.918*** [0.003]	8.892*** [0.003]	6.376** [0.012]
Hansen Over identification test				0.913 [0.339]
1 st stage <i>F</i> statistic		316821	312812	315631
Instruments (estimated coefficients in the 1 st stage)				
Colombian tariff		0.426*** (0.001)		4.587*** (0.029)
Real exchange rate*Colombian tariff			0.326*** (0.001)	-3.238*** (0.023)

Standard errors clustered on industry by year reported in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; p-values in brackets

Year and industry effects, worker characteristics, and a constant were included in every stage of all estimated models. Sample weights used.

Table 2.3 - Linear probability of model of having an informal job.

Both Brazil and Colombia pursued an import substitution policy in the recent past. Then, in a certain moment, they decided to engage in a trade liberalization of the manufacturing sector. Colombia's trade liberalization started after 1984 ended by the middle of the 1990s. The use of lagged Colombian import tariffs as instruments for the Brazilian import tariffs is based on the idea that the change in trade policy that happened in both countries had two components. The first is a trade liberalization motive, which leads to a decrease in all tariffs. The second is the effect of the local informal labor market on the trade policy, where the reverse causation comes from. To be a valid instrument, the correlation between the Colombian tariff and the Brazilian tariff should only come from the trade liberalization component. According to Goldberg and Pavcnik (2005, p. 78) the Colombian government conducted the trade liberalization to achieve a somewhat uniform tariff rate negotiated with the WTO, to be more precise the agreement was to have a uniform tariff of 13% across industries. As a consequence, Colombian policy-makers were less able to let informality concerns affect the tariff reduction. Thus, I believe that the effect of Colombian informal labor market on the Colombian import tariffs is not correlated with the effect of the Brazilian informal labor market on the Brazilian import tariffs.

The 1984 Colombian tariff level will be considered as the pre-reform level and I'll match the 1984 Colombian tariffs to 1989 Brazilian tariffs, and so on. The use of a five year lagged tariffs has the advantage that contemporaneous Brazilian tariffs wouldn't affect past Colombian tariffs. They present a raw correlation of 0.5. In the estimates, I'll use the Colombian tariffs and its interaction with Brazilian real exchange rates (rer_t) as instruments. The use of this interaction brings another source

of exogenous variation, real exchange rate, which affects trade and is industry-invariant.

The 2SLS estimates of equation (2.2) are reported in columns (2), (3), and (4) of table (2.3). In all three specifications the estimated coefficients had the expected signs, were statistically significant and similar in magnitude. The results from column (2) can be interpreted as follows. A percentage point decrease in import tariffs increases the informal share by 0.8 percentage points and a percentage point decrease in export tariffs decreases the share by 0.35 percentage points. The magnitude of these estimates are reasonable. Using the average decrease in import tariffs of 22 percentage points and the average decrease in export tariff of 10 percentage points, we would expect an increase in the informal share by 14 percentage points while the observed increase was 9 percentage points, which is inside the confidence interval of our estimate.

The exogeneity of import tariffs were rejected at the 5% level in all specifications by the Hausman test. There was no rejection in the over-identification test for model (4), which is the only over-identified model estimated. The first stage variation occurs at the industry-year level, so the next econometrics tests involve the first stage estimates, and they were calculated from first stage estimates without clustering the standard error on industry by year. The instruments used were statistically significant in the first stage regressions, and their F -statistics were above 10 and very large indeed. One may suspect that this last result is due to the large number of included instruments, however the Kleibergen-Paap test of under-identification rejected the null hypothesis of under-identification in the first stage at

the 5% level in all specifications. The under-identification occurs when the matrix of included and excluded instruments does not have full rank.

The next concern is relative to weak instruments that I assessed by calculating the weak identification Kleibergen-Paap rK Wald F -statistic. The values obtained were superior to the Stock-Yogo 10% maximum IV size critical values. It means that the null hypothesis of a bias larger than 10% due to weak instruments was rejected. So far the results supported strongly the predictions from the theoretical model. To calculate how much of the variation in informality indicator the estimated model can explain, I used Wooldridge (2002, p. 465) suggestion to find the percent of correctly predicted outcome. If the predicted probability of having an informal job is larger than 0.5, I'll assume that the individual has an informal job, otherwise the individual has an informal job. The estimated model in column (2) was able to explain 12% of the variation in the informality indicator, which is reasonable given the dichotomous nature of the informal indicator.

Formal-informal wage gap

The other informal labor market outcome we are interested in is the formal-informal wage gap. Equation (2.3) describes the specification used to assess the impact of trade policy changes on the estimated wage gap. Proposition (4) states that a decrease in Brazilian import tariffs ($\tau^{foreign}$) increases the wage gap and a decrease in export tariffs (τ) decrease the wage gap, thus $\beta_1 > 0$ and $\beta_2 < 0$ are expected. The motivation for including year and industry effects are the same as before and again it may be the case that import tariffs are endogenous.

$$\widehat{wagegap}_{jt} = \beta_0 + \beta_1 extar_{jt} + \beta_2 imptar_{jt} + \alpha * year_t + \gamma * industry_j + \varepsilon_{ijt} \quad (2.3)$$

Table (2.4) reports the estimates of equation (2.3) by OLS in column (1) and by 2SLS in columns (2), (3), and (4). The estimated standard errors are robust to heteroskedasticity and autocorrelation. In all estimates the weights used were the inverse of the estimated wage gap standard errors. The tariff coefficient estimates reported in column (1) were not statistically significant and didn't have the expected signs. The 2SLS estimates of the import and export tariff coefficients were all statistically significant at 5% level, had the expected signs and were similar in magnitude across specifications. The estimated coefficients in column (2) indicate an increase of 0.4 percentage point in the wage gap for a percentage point decrease in import tariffs, and a 0.17 increase in wage gap for a percentage point decrease in export tariffs. The model in column (2) is able to account for 50% of the variation in the formal-informal wage gap.

The exogeneity of import tariffs was rejected by the Hausman test in all three 2SLS specifications. The first stage F -statistics were larger than ten and the excluded instruments were significant at 5% level in columns (2) and (3), but not in column (4). I suspect this lack of statistical significance comes from colinearity between them since they were jointly statistically significant. The null hypothesis of under-identification in the first stage using Kleibergen-Paap rk LM statistic was rejected for all models. Moreover, the Kleibergen-Paap rk Wald F -statistic used in the weak identification test was larger than the Stock-Yogo critical values for all cases. So we were able to reject the null hypothesis of weak instruments. The over-identified model in column (4) presented no rejection in the Hansen over-identification test.

Independent Variables	Dependent Variable: formal-informal wage gap			
	(1)	(2)	(3)	(4)
Import tariff	0.100 (0.103)	-0.403** (0.189)	-0.394** (0.191)	-0.406** (0.188)
Export tariff	-0.055 (0.113)	0.169** (0.075)	0.168** (0.075)	0.170** (0.075)
Technique	OLS	2SLS	2SLS	2SLS
Observations	180	180	180	180
2 nd stage <i>F</i> statistic	414.6	219.21	9.371	7.168
Under identification test (Kleibergen-Paap rk LM statistic)		46.519*** [0.000]	45.18*** [0.000]	46.66*** [0.000]
Weak identification test Kleibergen-Paap rk Wald F statistic		54.86	52.70	27.35
Stock-Yogo 10% max IV size critical values		16.38	16.38	19.93
Hausman Endogeneity Test		4.955** [0.026]	4.519** [0.034]	5.064** [0.024]
Hansen Over identification test				0.139 [0.710]
1 st stage <i>F</i> statistic		80.01	82.34	79.79
Instruments (estimated coef. in 1 st stage)				
Colombian tariff		0.546*** (0.177)		0.745 (0.708)
Real exchange rate*Colombian tariff			0.394*** (0.132)	-0.147 (0.487)

Heteroscedasticity and autocorrelation robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets.

Year and industry effects and a constant were included in every stage of all estimated models.

Weights used are the inverse of the wage gap estimated standard errors.

Table 2.4 - Effect of tariffs on the formal-informal wage gap regressions.

Robustness checks

The first robustness check of the informal share results consists of dealing with a possible different effect of education on the likelihood of having an informal job across industries, and it can be accounted for in the empirical specification by including interactions between the years of education variable and the industry indicator vector. The estimates are reported in columns (1)-(4) of table (2.5). The OLS estimates were again not statistically significant, but I confirm that the 2SLS estimates were significant and had the expected signs. The import tariff coefficients were slightly smaller than before and the export tariff coefficients decreased by one third in relation to the results from table (2.5). In all 2SLS regressions the Hausman test rejected the exogeneity of the import tariff variable.

In the same line, I further augmented the previous empirical specification by incorporating interactions of age and male indicator with the industry indicator vector. The estimates are reported in columns (5) to (8) of table (2.5). The estimated tariff coefficients in the OLS estimate, column (5), were not statistically significant again. As before, the 2SLS estimates were significant and had the expected signs. The Hausman tests rejected the exogeneity of the import tariff coefficients.

Independent Variables	Dependent Variable: informal job indicator							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Import tariff	-0.361 (0.239)	-0.765*** (0.230)	-0.772*** (0.239)	-0.704*** (0.170)	-0.358 (0.222)	-0.657*** (0.212)	-0.664*** (0.221)	-0.599*** (0.155)
Export tariff	-0.020 (0.102)	0.257** (0.117)	0.263** (0.121)	0.207** (0.103)	0.011 (0.094)	0.192** (0.094)	0.198** (0.096)	0.144** (0.072)
Technique	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS
Observations	767087	767087	767087	767087	767087	767087	767087	767087
Education interacted with industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age and male interacted with industry	No	No	No	No	Yes	Yes	Yes	Yes
Hausman Endogeneity Test		7.856*** [0.005]	7.823*** [0.005]	5.947** [0.015]		7.264*** [0.007]	7.233*** [0.007]	5.470** [0.019]
Hansen Over identification test				0.776 [0.379]				0.806 [0.369]
Instruments								
Colombian tariff		X		X		X		X
Real exchange rate * Colombian tariff			X	X			X	X

Standard errors clustered on industry by year reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets.

Year and industry effects, worker characteristics, and a constant were included in every stage of all estimated models. Sample weights used.

Table 2.5 - Linear probability of model of having an informal job with interactions between industry indicators, years of education, age and male indicator.

In the next robustness check I'm interested in finding out if the results are driven by some observations with large values. Instead of using tariffs in the previous specifications, I used a nonlinear and monotonic transformation in the tariffs, i.e. instead of the tariffs, I'll be using $\log(1 + tariff)$ in my estimates. This logarithmic re-scaling has the advantage of reducing the influence of large values in the estimates. The regressions output are displayed in table (2.6), in which columns (1)-(4) refers to the baseline specification, columns (5)-(8) specifications include the interaction between education and industry indicators, and specifications in columns (9)-(12) include interactions between age and industry indicators and between male indicator and industry indicators.

In the baseline specification, column (1) of table (2.6) displays the OLS tariff coefficient estimates that were not statistically significant. They can be interpreted as percentage changes. So, a change in import tariffs by one percent increase informal share by 0.44 percent. For a similar change in the export tariff the informal share responds with an increase of 0.007 percent. Now, the 2SLS estimates portrayed in columns (2)-(4) showed statistically significant tariff coefficients with the expected signs. When the interactions were added to the baseline specification the 2SLS coefficients remained statistically significant and their magnitude declined, similar to what happened in table (2.7). Surprisingly, the OLS estimates from columns (5) and (9) presented estimated coefficients with the expected signs with import tariffs being statistically significant at 10% in column (1) and at 5% in column (9), with magnitudes of about 50% of the 2SLS estimates. The exogeneity of import tariffs were rejected by the Hausman test in all 2SLS specifications.

Independent Variables	Dependent Variable: informal job indicator											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log(1+import tariff)	-0.447 (0.292)	-1.20*** (0.414)	-1.22*** (0.436)	-1.06*** (0.288)	-0.56* (0.299)	-1.13*** (0.399)	-1.15*** (0.419)	-1.02*** (0.286)	-0.55** (0.279)	-0.97*** (0.361)	-0.98*** (0.380)	-0.86*** (0.256)
log(1+export tariff)	-0.007 (0.126)	0.586** (0.284)	0.603** (0.293)	0.470** (0.235)	0.011 (0.127)	0.436** (0.216)	0.450** (0.228)	0.335** (0.167)	0.050 (0.117)	0.325** (0.159)	0.338** (0.168)	0.232** (0.115)
Technique	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS
Observations	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087
Education interacted with industry dummies	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age and male interacted with industry	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Hausman		7.787***	7.801***	4.658**		6.738***	6.732***	4.461**		6.181**	6.173**	4.193**
Endogeneity Test		[0.005]	[0.005]	[0.031]		[0.009]	[0.009]	[0.035]		[0.013]	[0.013]	[0.041]
Hansen Over identification test				0.923 [0.337]				0.719 [0.397]				0.722 [0.396]
Instruments												
log(1+Colombian tariff)		X		X		X		X		X		X
Rer*log(1+Colombian tariff)			X	X			X	X			X	X

Standard errors clustered on industry by year reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets. Rer is the real exchange rate. Year and industry effects, worker characteristics, and a constant were included in every stage of all estimated models. Sample weights used.

Table 2.6 - Linear probability of model of having an informal job with log(1+ tariff) instead of tariff variables.

Independent Variables	Dependent Variable: informal job indicator											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Import tariff	0.720 (0.796)	-2.96*** (1.004)	-2.986*** (1.032)	-2.743*** (0.789)	0.592 (0.789)	-2.77*** (0.955)	-2.795*** (0.981)	-2.59*** (0.758)	0.649 (0.705)	-2.17** (0.848)	-2.186** (0.873)	-2.01*** (0.658)
Export tariff	-0.498 (0.303)	2.688* (1.463)	2.712* (1.473)	2.518* (1.421)	0.486* (0.291)	2.432* (1.374)	2.452* (1.381)	2.287* (1.353)	-0.304 (0.249)	2.144* (1.212)	2.161* (1.218)	2.022* (1.196)
Technique	Probit	IVProbit	IVProbit	IVProbit	Probit	IVProbit	IVProbit	IVProbit	Probit	IVProbit	IVProbit	IVProbit
Observations	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087	767087
Education interacted with industry dummies	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age and male interacted with industry	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Endogeneity Test		7.031*** [0.008]	6.772*** [0.009]	9.108*** [0.003]		6.835*** [0.009]	6.583*** [0.010]	8.838*** [0.003]		5.745** [0.017]	5.527** [0.019]	7.576*** [0.006]
Instruments												
Colombian tariff		X		X		X		X		X		X
Rer*Colombian tariff			X	X			X	X			X	X

Standard errors clustered on industry by year reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets. Rer is the real exchange rate. Year and industry effects, worker characteristics, and a constant were included in every stage of all estimated models. Sample weights used.

Table 2.7 - Probit and IVProbit models of having an informal job.

Now, given the binary nature of the informality indicator I'll use econometric techniques that take this fact into account. Thus, I used Probit instead of OLS and IVProbit instead of 2SLS. The estimates are reported in table (2.7), where columns (1)-(4) refers to the baseline specification, columns(5)-(8) specifications include the interaction between education and industry indicators, and specifications in columns (9)-(12) are augmented with interactions between age and industry indicators and between male indicator and industry indicators. The Probit regressions, columns (1), (5) and (9), didn't present any statistically significant estimates for the tariff variables at 5% level of significance. The IVProbit estimates, the remaining columns, presented estimated coefficients with the expected signs, in which the import tariff coefficient were always significant at 5% level whereas the export tariff coefficient were significant at the 10% level, with p -values between six and seven percent. In all IVProbit estimates the exogeneity of the import tariffs were rejected at the 1% level. The share of correctly predicted outcomes calculated for the estimated model in column (2) was 0.18, almost twice the share of the linear IV probability model. In sum, it seems that trade policy changes indeed affected the share of informal workers in Brazil.

The last exercise involving the informality indicator consists of omitting the export tariff variable in the some of the previous specifications. The standard errors are again clustered on industry by year. Table (2.8) displays the output of these estimates.

Independent Variables	Dependent Variable: informal job indicator							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Import tariff	-0.080 (0.114)	-0.602*** (0.230)	-0.599** (0.236)	-0.611*** (0.217)	-0.350 (0.345)	-1.549* (0.858)	-1.508* (0.866)	-1.658* (0.958)
Technique	OLS	2SLS	2SLS	2SLS	Probit	IVProbit	IVProbit	IVProbit
Observations	767087	767087	767087	767087	767087	767087	767087	767087
Endogeneity Test		11.85*** [0.000]	11.58*** [0.000]	12.66*** [0.000]		5.065** [0.024]	4.528** [0.033]	4.408** [0.036]
Hansen Over identification test				0.146 [0.702]				
Instruments								
Colombian tariff		X		X		X		X
Real exchange rate*Colombian tariff			X	X			X	X

Standard errors clustered on industry by year reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets.
Year and industry effects, worker characteristics, and a constant were included in every stage of all estimated models.
Sample weights used.

Table 2.8 – Probability models of having an informal job without export tariff variable.

Column (1) of table (9) contains the OLS import tariff coefficient estimate, which are not statistically significant as before. The 2SLS estimates, in columns (2)-(4), were significant at 5% level and had the expected negative sign. The magnitude of the coefficients was about 25% smaller than the estimates from table (2.3), even though this difference is not statistically significant. The exogeneity of import tariffs was rejected by the Hausman test in these three specifications.

The Probit estimate is shown in column (5), and the import tariff coefficient wasn't statistically significant. Columns (6)-(8) contain the estimates using the IV Probit technique. The estimated coefficients of import tariffs were not statistically significant at 5% level, though they were significant at 10% level. The exogeneity of import tariffs was rejected in all cases. These results mean that omitting export tariffs even in an instrumental variable framework may matter for the estimates. In sum, it seems that trade policy changes indeed affected the share of informal workers in Brazil.

The robustness checks for the formal-informal wage gap models consists of the use of a log transformation of tariffs instead of the tariffs themselves, and in estimate the previous specifications without including the export tariff variables. Table (2.9) presents estimates of the previous specification of the wage gap, but now using $\log(1+tariffs)$ instead of the tariff variables. Column (1) contains the OLS estimated coefficients and although they had the expected signs, they were not statistically significant. The 2SLS estimates, columns (2)-(4) had the expected signs and were statistically significant. The estimates from column (2) imply that a one

Independent Variables	Dependent Variable: formal-informal wage gap			
	(1)	(2)	(3)	(4)
Log (1+import tariff)	-0.076 (0.155)	-4.324*** (1.425)	-4.631** (1.831)	-4.226*** (1.380)
Log (1+export tariff)	0.116 (0.126)	3.010** (1.232)	3.085** (1.260)	2.986** (1.230)
Technique	OLS	2SLS	2SLS	2SLS
Observations	180	180	180	180
2 nd stage <i>F</i> statistic	421	10.41	10.40	10.35
Under-identification test (Kleibergen-Paap rk LM statistic)		40.70*** [0.000]	40.05*** [0.000]	40.72*** [0.000]
Weak identification test Kleibergen-Paap rk Wald <i>F</i> statistic		45.908	44.935	22.82
Stock-Yogo 10% max IV size critical values		16.38	16.38	19.93
Hausman Endogeneity Test		6.121** [0.013]	5.518** [0.019]	6.026** [0.014]
Hansen Over identification test				0.167 [0.712]
1 st stage <i>F</i> statistic		56.64	44.82	56.70
Instruments (estimated coefficients in 1 st stage)				
log(1+Colombian tariff)		-0.177*** (0.044)		-0.248*** (0.088)
Real exchange rate*log(1+Colombian tariff)			-0.084*** (0.024)	0.056 (0.045)

Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; p-values in brackets.

Year and industry effects and a constant were included in every stage of all estimated models.

Table 2.9 – Effect of tariffs on the formal-informal wage gap regressions, using log(1+ tariff) instead of tariff variables.

percent decrease in import tariff increases wage gap by 4 percent, and the effect of one percent decrease in export tariff is a three percent decrease in the wage gap. The results of the econometric tests performed were similar to the results presented in table (2.6), in particular the exogeneity of import tariff variable was rejected at 5% level in all 2SLS estimates.

Omitting the export tariffs in the estimated models had a dramatic effect on the estimates, as presented in table (2.10). Column (1) contains the OLS estimate in which the import tariff wasn't statistically significant. Columns (2)-(4) shows the 2SLS estimates. The estimated import tariff coefficients were not statistically significant in any specification. Notice that in the first stage of the 2SLS estimates, the instruments behaved in a similar fashion to the estimates that included export tariffs. So, export tariffs matter in the second stage of the estimation procedure. For the wage gap, the omission of export tariff makes a large difference in the estimates.

Independent Variables	Dependent Variable: formal-informal wage gap			
	(1)	(2)	(3)	(4)
import tariff	-0.015 (0.080)	-0.153 (0.164)	-0.160 (0.165)	-0.154 (0.164)
Technique	OLS	2SLS	2SLS	2SLS
Observations	180	180	180	180
Hansen Over identification test				0.112 [0.738]
Hausman Endogeneity Test		1.069 [0.301]	1.145 [0.285]	1.069 [0.301]
1 st stage <i>F</i> -statistic		63.66	54.02	61.78
Instruments				
Colombian tariff		0.503*** (0.162)		0.505 (0.692)
Real Exchange rate*Col. tariff			0.377*** (0.124)	-0.001 (0.494)
HAC robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; p-values in brackets Year and industry effects and a constant were included in every stage of all estimated models Weights used are the inverse of the wage gap estimated standard errors				

Table 2.10 – Effect of tariffs on the formal-informal wage gap regressions without export tariff variables.

Final Remarks

I used the 1989-2001 Brazilian trade liberalization to assess my theoretical model predictions about the effects of trade policy changes on the industry share of informal workers and on the formal-informal wage gap. This episode data allows the identification of informal workers according to payroll tax compliance, which is exactly the same way they are defined in my theoretical model. This clear connection between theory and empirics is a novel feature in the informal labor literature.

Interestingly, I find that the Brazilian import tariff is endogenous with respect to informal share and formal-informal wage gap. To circumvent this problem, I use an instrumental variable approach, and the instrument used is the liberalization path of a similar country, which was less influenced by informal labor markets. This finding suggest that the government is not passive with respect to informal labor market in the sense that it may choose optimally the level of payroll tax enforcement taking into account its trade policy. This point certainly deserves more investigation.

According to my estimates, a percentage point decrease in Brazilian import tariffs led to an increase of 0.8 percentage points in the informal share, while the same decrease in trade partners import tariff (export barriers) decreased informal share by 0.35 percentage points. These results are in line with my theoretical model predictions. Importantly, the magnitude of the effect is very plausible since at the average change of import tariffs and export barriers it returns a 12 percentage points increase in informality, while the observed is about 9 percentage points. These results are in sharp contrast with the previous literature (Goldberg and Pavcnik, 2005) that found no effect of tariffs on the informal share.

The formal-informal wage gap estimates also provide strong support for the respective theoretical predictions. A percentage point decrease in import tariffs implied an increase in the wage gap by 0.4 percentage points, whereas a percentage point decrease in export barriers decreased the wage gap by 0.17 percentage points. About 50% of the variation in the estimated wage gap variation can be explained by my empirical model. At the end of the day, I found that trade policy does indeed affect informal labor markets, at least in the Brazilian case.

I check the robustness of my estimates by performing several exercises. The only case my findings are not robust happens when the export barriers are omitted in the estimated models. This fact supports my theoretical model, in which export barriers not only have a counterbalance effect to import barriers but also have a significant quantitative effect. The latter seems to be the case because when the export barriers are omitted, the estimated effect of import barriers is not statistically significant.

These results have important policy implications. Contrary to previous findings, unilateral trade liberalization can increase the informality share and the formal-informal wage gap. And, reciprocal trade liberalizations can mitigate and even overcome this increase in informality.

In sum, the theoretical model was designed to make informal jobs generation as close as possible to reality, in addition it has strong empirical support for its predictions. Hence I believe it is a very good framework to study informal labor markets from several aspects, for example the interaction between import and export

tariffs and payroll taxation which might lead to an optimal size of informal labor market from the government point of view.

Chapter 3 - Trade Liberalization and Industry Wage Premia: The missing role of Productivity

In this chapter I will study the effect of trade liberalization on inter-industry wage premium. Changes in wage premium can increase inequality if the wage premium decreases less in skill intensive sectors, for example. Several papers like Krueger and Summers (1988), Katz and Summers (1989), and Borjas and Ramey (2000) found that industry wage premium is an important share of the wage in U.S., and the wage premium has significant variation across industries. For developing countries, Pavcnik et al. (2004) also found that wage premium accounted for a large share of wages in Brazil. On the other hand, Goldberg and Pavcnik (2005) found it is not the case in Colombia.

The literature relating wage premium to import tariff changes is recent, but its ancestors were interested in the effect of tariffs on industry rents (measured by mark-ups) and the effect of tariffs on productivity. Harrison (1994) for Cote d'Ivoire, Levinsohn (1993) for Turkey, Currie and Harrison (1997) for Morocco found that tariffs decline implied lower markups, which could affect wage premia if industry rents are shared with the workers.

The studies that assess directly the effect of trade policy changes on inter-industry wage premium provide mixed evidence of its sign and magnitude. Feliciano (2001) found that the change in tariffs didn't affect wage premium in Mexico. Pavcnik, Blom, Goldberg and Schady (2004) found no effect for Brazil. Goldberg and Pavcnik (2005) uncovered evidence that a decrease in tariffs led to a smaller wage

premium in Colombia, and Mishra and Kumar (2007) found that a decrease in tariffs led to an increase in wage premia in India.

I assess the effect of trade liberalization on the inter-industry wage premium by focusing on the Colombian episode that started in the 1980s and on two key aspects ignored by the previous literature. The first is whether trade policy changes affect differently wage premium based on industry characteristics. I use the methodology of previous studies such as Goldberg and Pavcnik (2005) to assess if the tariff effect is similar for tradable and non-tradable industries, and manufacturing and non-manufacturing industries. I find that wage premia were sensitive to changes in import tariffs only the tradable industries, in particular manufacturing.

The second question is the role of productivity in simultaneously determining the industry wage premium and import tariffs. Although the reasons for the existence of the wage premia are not clear, there's evidence that higher productivity industry workers enjoy higher wage premium¹⁸. The potential endogeneity of import tariffs due to political economy concerns has been handled by the use of instrumental variables technique, which also takes care of omitted variable problem. Goldberg and Pavcnik (2005) and others use the pre-trade reform import tariff level as an instrument for the import tariff change. Nevertheless, this type of instrument may not work when productivity is an omitted variable and is part of the error term. Karacaovali (2005) presented a theoretical model of political economy of trade liberalization in which the benefits of trade protection increases with productivity. He also found empirical evidence for Colombia that productivity influenced the level of

¹⁸ See Krueger and Summers (1988), Katz and Summers (1989), and Borjas and Ramey (2000) for example.

import tariffs. Given that productivity is a process with some time persistence, and Karacaovali (2005) showed it's the case for Colombia, current productivity would still be correlated with the pre-trade reform tariff level, and thus the instrument will be correlated with the error term.

Furthermore, from a theoretical perspective the omission of productivity leaves room for the effect of tariffs on wages to have an ambiguous sign because in this case the tariff coefficient would be the net result of the effect of tariffs on productivity (which may be positive or negative ex ante) and the effect of tariffs on industry rents shared with workers (which is positive ex ante). Therefore, I ask if trade liberalization increases or decreases the inter-industry wage premia after we account for the impact of productivity on trade policy. I also assess the magnitude of the bias in previous studies that fail to account for this source of endogeneity for the Colombian case.

By incorporating productivity into the estimated model, I find that productivity is an important determinant of the wage premium, and as an included instrument it does affect the change in tariffs (endogenous variable), thus it's an important time-varying factor in the import tariff setting. In addition, the impact of trade liberalization on the manufacturing industries wage premium is about 50% smaller than the result previously obtained by ignoring productivity (using Goldberg and Pavcnik, 2005, methodology). As a byproduct, I find in my estimations that productivity is an exogenous variable, thus concerns about reverse causation between wage premium and productivity do not seem relevant in this particular context.

Methodology

The inter-industry wage premium is defined in the literature as the share of the worker's wage that is attributed to industry affiliation. Its possible sources can be: (i) compensating differentials, (ii) different marginal productivity of labor in comparison with other industries due to sector specific inputs, and (iii) industry rents from imperfect competition in the output market.

The industry compensating differentials paid to workers reflect specific conditions given by technology or institutions that generate disutility to work in this industry. So it shouldn't be affected by trade policy in case of no significant change in technology or institutions, which are very unlikely in the short run.

The second motive can be affected by trade policy because trade liberalization can increase total factor productivity, as found by Pavcnik (2002) for Chile, Ferreira and Rossi (2003) for Brazil and Karacaovali (2005) for Colombia. All else equal, an increase in productivity leads to an increase in excess profits, leaving room for an increase in wage premium.

Finally, trade policy affects the level of competitiveness in domestic markets. A decrease in import tariffs would force either a decrease in domestic prices¹⁹ or a decrease in quantity demanded, thus both effects imply a decrease in industry rents to be shared among factors of production. There is evidence using firm-level data for U.S. labor markets that higher profits induce higher wages due to rent-sharing, as shown by Blanchflower, Oswald and Sanfey (1996) and by Hildreth and Oswald (1997). Another possible channel is that more competition might decrease the bargain

¹⁹ In a monopolistic competition framework, one can model the increase in competitiveness as a shock in the price-elasticity of demand for output, i.e. more competitiveness results in a more elastic demand.

power of unions and/or shift their focus from wages to job security; therefore the share of rent wage premium would also decrease. However, this channel will depend on the specific negotiation framework of each industry and/or country. Over all, the net effect of trade openness over wage premia is ambiguous.

In general, changes in trade policy happen over time and across industries. In a situation in which non-tariff barriers (NTBs) are decreasing similarly for all industries or non-existent, an appropriate way to measure its changes is through import tariffs, which certainly affect the prices. In Colombia, tariffs were at a high level in the early 1980s. The trade liberalization started when President Virgilio Vargas took office in 1986 and it was completed by his successor President Cesar Gaviria by 1992. This reform consisted not only in a large decrease in all import tariffs across all industries (generating a large decrease in average tariff) and removal of NTBs, but also in a change of the protection across industries because the decrease in tariffs was not uniform. This can be seen from figures (3.1) and (3.2) which show import tariffs along time for non-manufacturing and manufacturing industries respectively. So, this inter-industry tariff variation could be used to identify the relationship between wage premium and import tariffs.

Like in many developing countries, Colombian trade reforms were accompanied by other reforms. There were the labor market reform in 1990 that reduced dismissal costs and introduced a new severance payment system and the banking system reform started in 1990 and continued in 1991 aimed at liberalizing deposit rates, extinguish credit subsidies and modernize capital markets. Moreover, foreign direct investment restrictions were greatly reduced in 1991, when

multinational companies were given basically the same treatment dispensed to Colombian firms. Finally, in 1993 there was a major change in the social security system²⁰. All these reforms stress the importance of the time dimension in the estimates, because the wage premium could be changing as a result of these other reforms. I'll use year dummy variables to control for such environment changes.

The changes in tariffs across industries have received a great deal of attention by the political economy of trade protection literature. Such research agenda provides theoretical (Helpman and Grossman, 1994, and Karacaovali, 2005) and empirical (Trefler, 1993, Goldberg and Maggi, 2001, and Karacaovali, 2005) evidence that tariffs are set taking into account some characteristics of the industry, e.g. market concentration, share of unskilled workers, etc. So, if some of these characteristics also influence the wage premium, the current tariff level becomes an endogenous variable. Thus, ordinary least squares (OLS) estimation is not consistent. Time invariant industry characteristics that affect tariff setting can be controlled by adding industry fixed effects to the estimated model. In fact, a higher wage premium in a given industry might induce its workers to lobby against trade liberalization²¹

²⁰ Eslava et al (2004) and Kugler (1999) are good references for the Colombian economic reforms.

²¹ A possible time variant political economy factor is union activity. Fortunately, it doesn't seem to be case as Edwards (2001) provides anecdotal evidence of almost no union activity in Colombia.

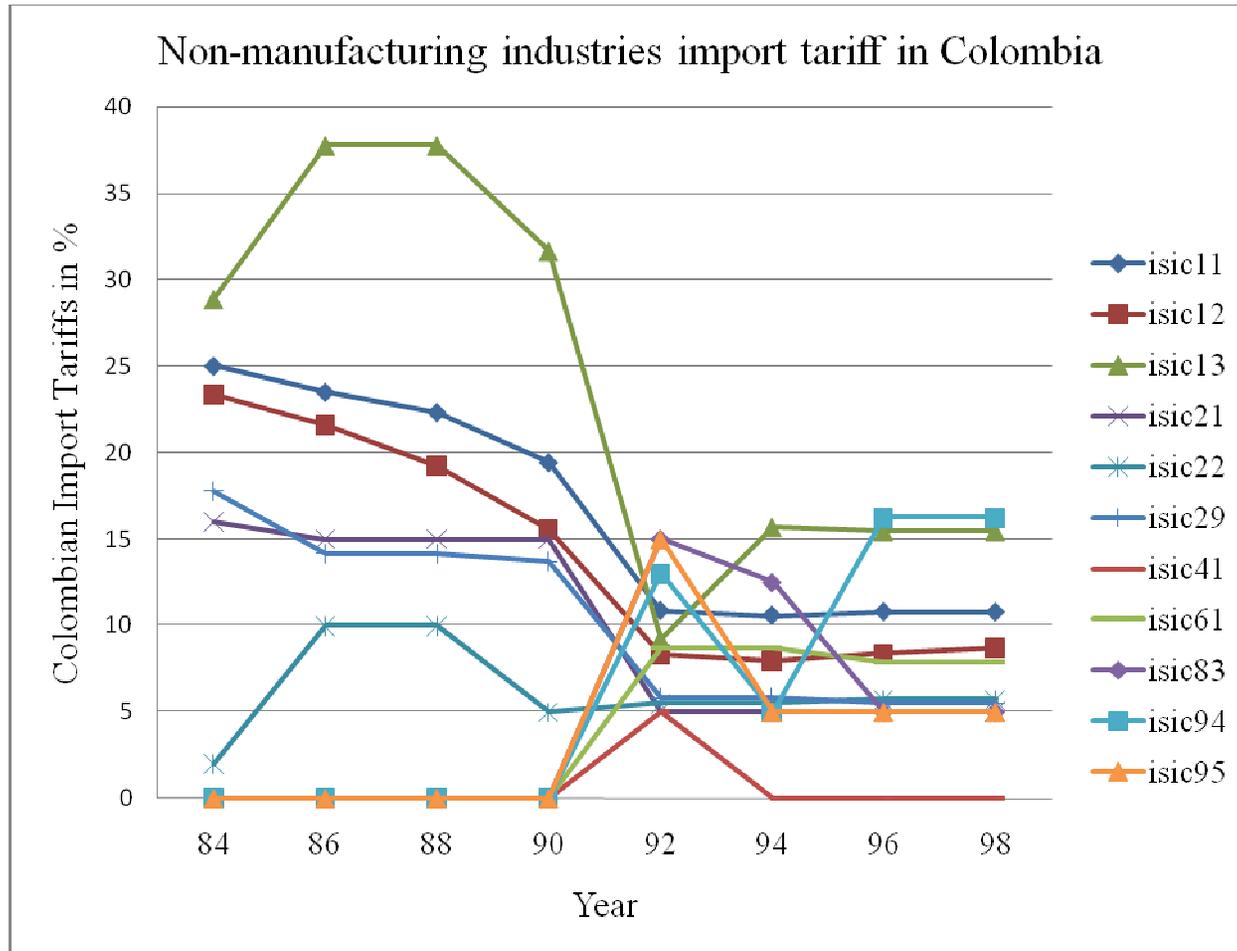


Figure 3.1 – Colombian non-manufacturing industries nominal import tariffs.

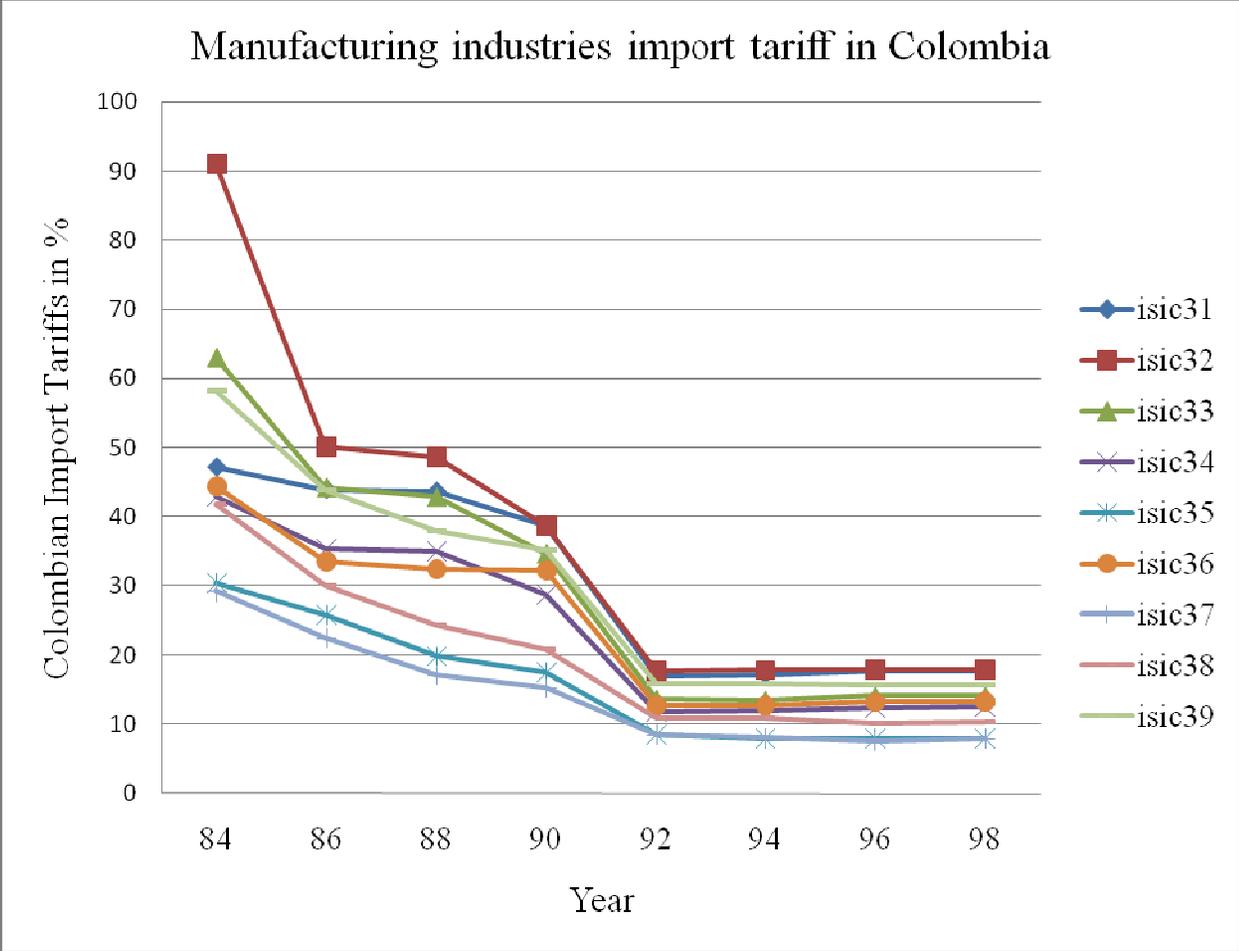


Figure 3.2 - Colombian manufacturing industries nominal import tariffs.

In the presence of industry fixed effects and year dummy variables, the identification of the tariff coefficient will come from within industry tariff variation, excluding the variation due to a common time trend on tariffs across all industries.

The model estimated by Goldberg and Pavcnik (2005) is given by equation (3.1)

$$\widehat{wagepremium}_{it} = \alpha + \beta Tariffs_{it} + \delta_i + \theta_t + error_{it} \quad (3.1)$$

where i is the industry index and t is the time index, δ_i is a set of industry fixed effects and θ_t are the time effects.

Since this specification does not account for other time varying variables that affect tariffs and wage premium simultaneously, tariffs are not necessarily orthogonal to the error term. Goldberg and Pavcnik (2005) acknowledged this possibility and suggested the estimation of the first difference of equation (3.1) by two-stage least squares (2SLS), using instruments for the change in tariffs. The instruments chosen by them are the 1983 tariff level and its interactions with exchange rate and coffee price. The reason behind the choice of 1983 tariff level is that it is the tariff level some years before the trade policy changes and Goldberg and Pavcnik showed that the tariff cut is proportional to the initial tariff level, i.e. the higher the 1983 tariff the larger the tariff decrease in absolute terms. The use of the interactions with exchange rate and coffee prices (the most important Colombian export product) are based on the perception that the Colombian trade reform was conducted taking into account the trade balance levels. So, exchange rate devaluations (smaller import volumes) would lead to larger decrease in tariffs and increases in coffee prices (larger export revenues) would also lead to larger decrease in tariffs.

In the labor literature, Bartel and Sicherman (1999) and Borjas and Ramey (2000) found evidence of a positive correlation between productivity and wage premium for U.S., however, the reasons behind this correlation are not clear. One possibility could be that an increase in productivity leads to an increase in excess profits, which are then shared with the workers. Thus productivity is an omitted variable in equation (3.1). Once it's accounted for, we would be able to identify separately the effects of the different marginal productivity of labor in comparison with other industries due to sector specific inputs, and of the industry rents on the wage premium.

Karacaovali (2005) presents both theoretical and empirical evidence that manufacturing industry productivity is an important political economy factor that affects tariff setting. In special, his empirical evidence is about the same Colombian trade liberalization episode discussed here. According to his theoretical model, the higher the industry productivity the higher the benefits from protection accrued to the firms of that industry. So, the initial (1983) tariff level was established taking into account the productivity at that time. He also presented empirical evidence that productivity in Colombia is correlated with import tariffs and it shows a lot of time persistence, therefore old tariffs are correlated with current productivity levels, e.g. 1983 tariff level has a 0.22 correlation with 1990 productivity.

The omission of the productivity variable in equation (3.1) generates omitted variable bias. Additionally, the 1983 tariff level is correlated with current productivity, which is in the error term. Therefore it is not a valid instrument. In order to get consistent estimates of the impact of tariffs on wage premium I incorporate

productivity in the estimated model to solve the omitted variable problem and to remove the correlation between the instrument (1983 tariff level) and the error term due to productivity.

The productivity measure I use is the natural logarithm of the total factor productivity (TFP), which is the measure used by Bartel and Sicherman (1999) for the US. In the manufacturing industries sample used in this paper, the simple correlation between productivity and the wage premium is 0.373, and the correlation between the first-difference of the same variables is 0.45. Figures (3.3) and (3.4) show the wage premium along time for non-manufacturing and manufacturing industries respectively. Figure (3.5) exhibits the evolution of productivity for manufacturing industries along time. We can see that wage premium and productivity vary along time and their ranking also changes over time.

I incorporate the productivity of industry j at time t , $\log(TFP_{jt})$, as a regressor in equation (3.1) and then take the first difference. The resulting model is shown in equation (3.2).

$$\widehat{\Delta wagepremium}_{jt} = \beta \Delta Tariffs_{jt} + \gamma \Delta \log(TFP_{jt}) + \Delta \theta_t + \Delta error_{jt} \quad (3.2)$$

where $\Delta wagepremium_{jt} = wagepremium_{jt} - wagepremium_{jt-1}$. A similar definition applies to all other variables preceded by the “ Δ ”.

The introduction of the productivity variable on the right-hand side may generate a potential problem: reverse causation. This can occur if the firms pay efficiency wages, which means they pay wages higher than the marginal productivity

of labor to avoid shirking²². And by doing so, the workers' productivity increases. Since there are industries in which monitoring may be easier, the efficiency wage will vary over industries and be at least partly captured by the wage-premium.

To address this source of reverse causality and check if it is a real concern, I estimate equation (3.2) by instrumental variables considering at first both productivity and tariffs as endogenous, and then considering only tariffs as endogenous. The next step consists in performing a Durbin-Wu-Hausman test to test if productivity is really an endogenous variable. Similarly to Karacaovali (2005) I employ the following instruments for productivity: the contemporaneous natural logarithm of the capital stock of the industry, and the contemporaneous natural logarithm of material prices minus natural log of aggregated level PPI-Producer Price Index. Since the estimations of (3.2) are in first differences, I'll work with the first difference of the above instruments.

²² This would be the case in a simple Shapiro-Stiglitz efficiency wage model. However, this may not be the case in models with heterogeneous monitoring ability like the one presented in Chapter 1.

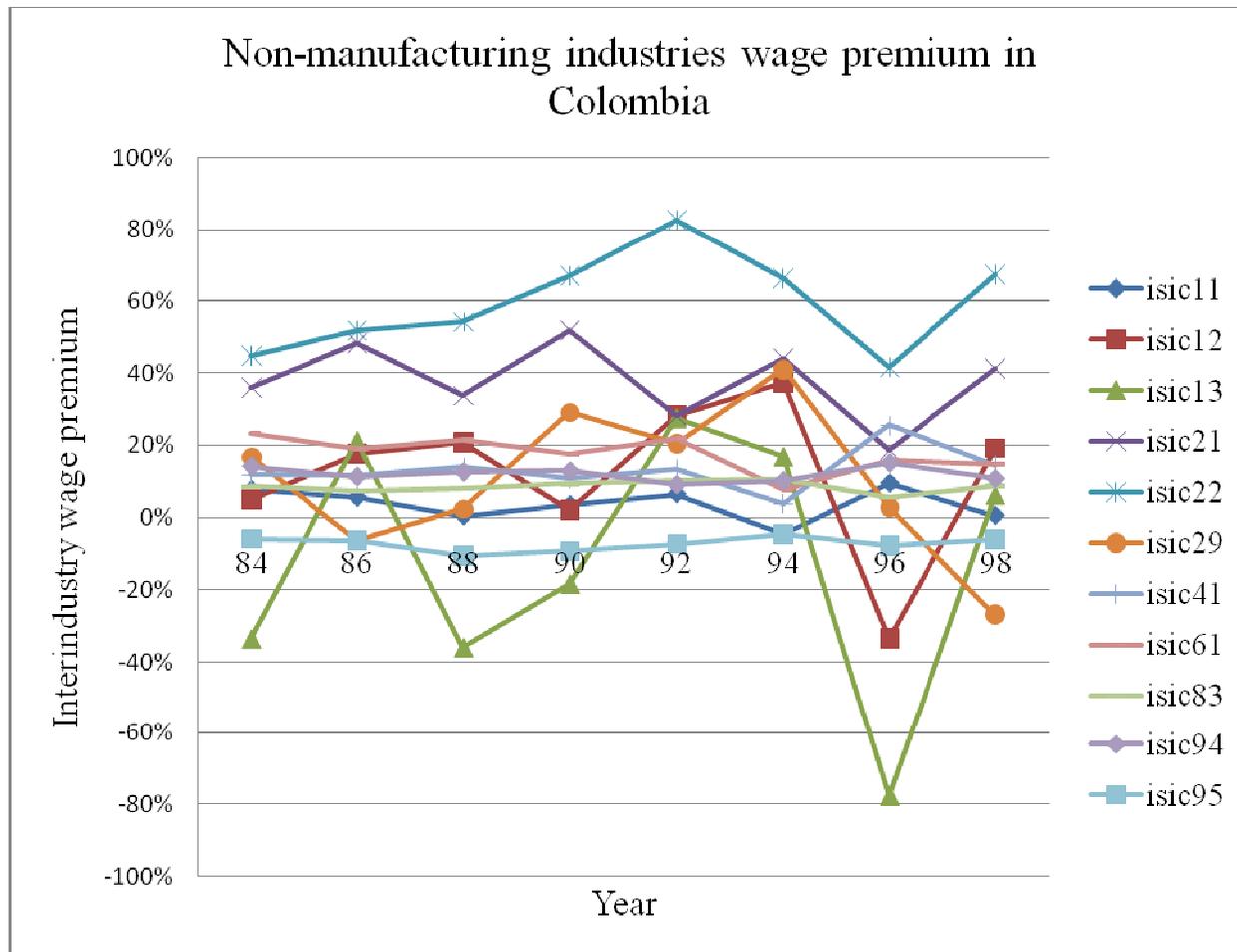


Figure 3.3 - Colombian non-manufacturing industries wage premium in terms of retail industry (ISIC 62) wage premium.

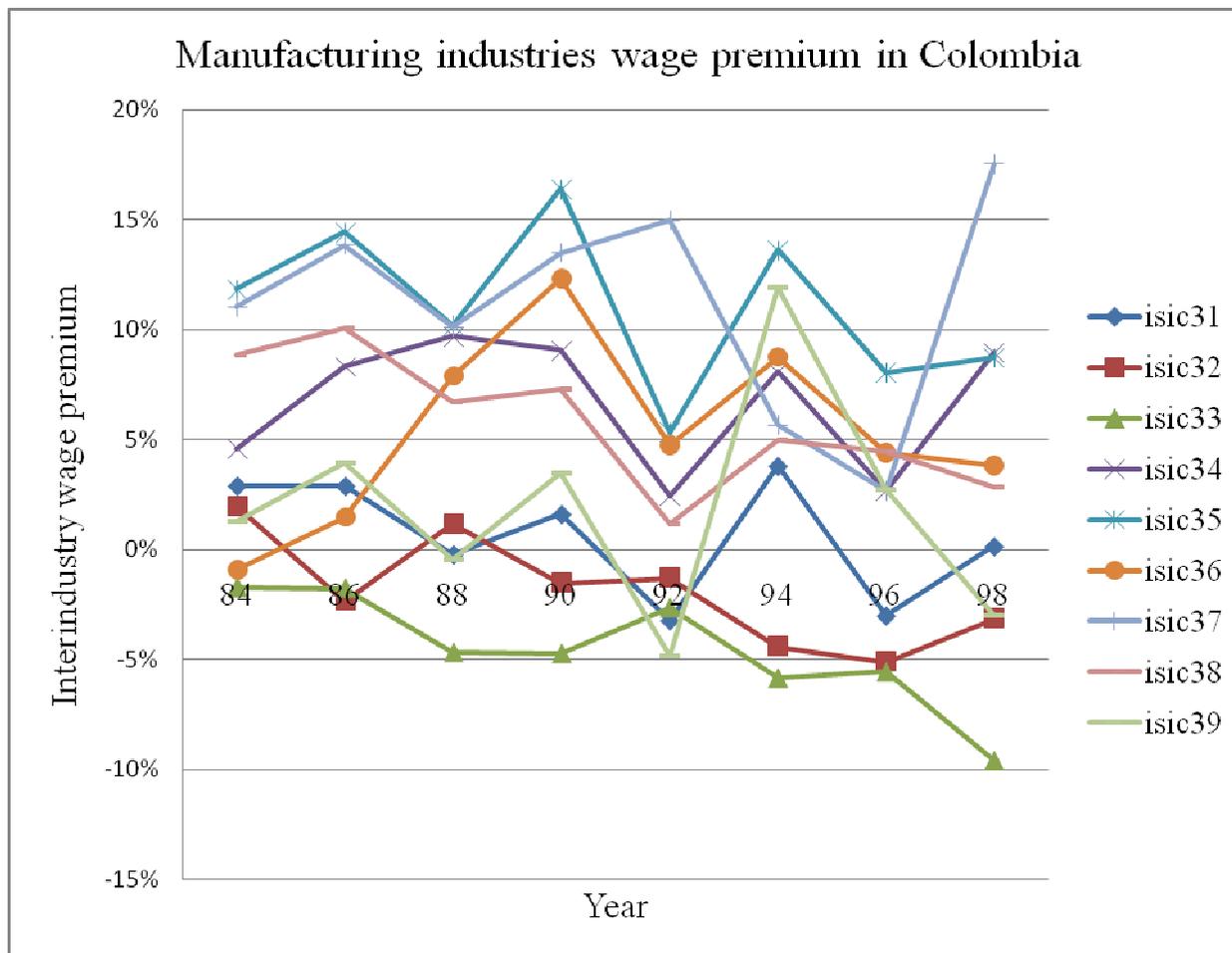


Figure 3.4 - Colombian manufacturing industries wage premium expressed in terms of retail industry (ISIC 62) wage premium.

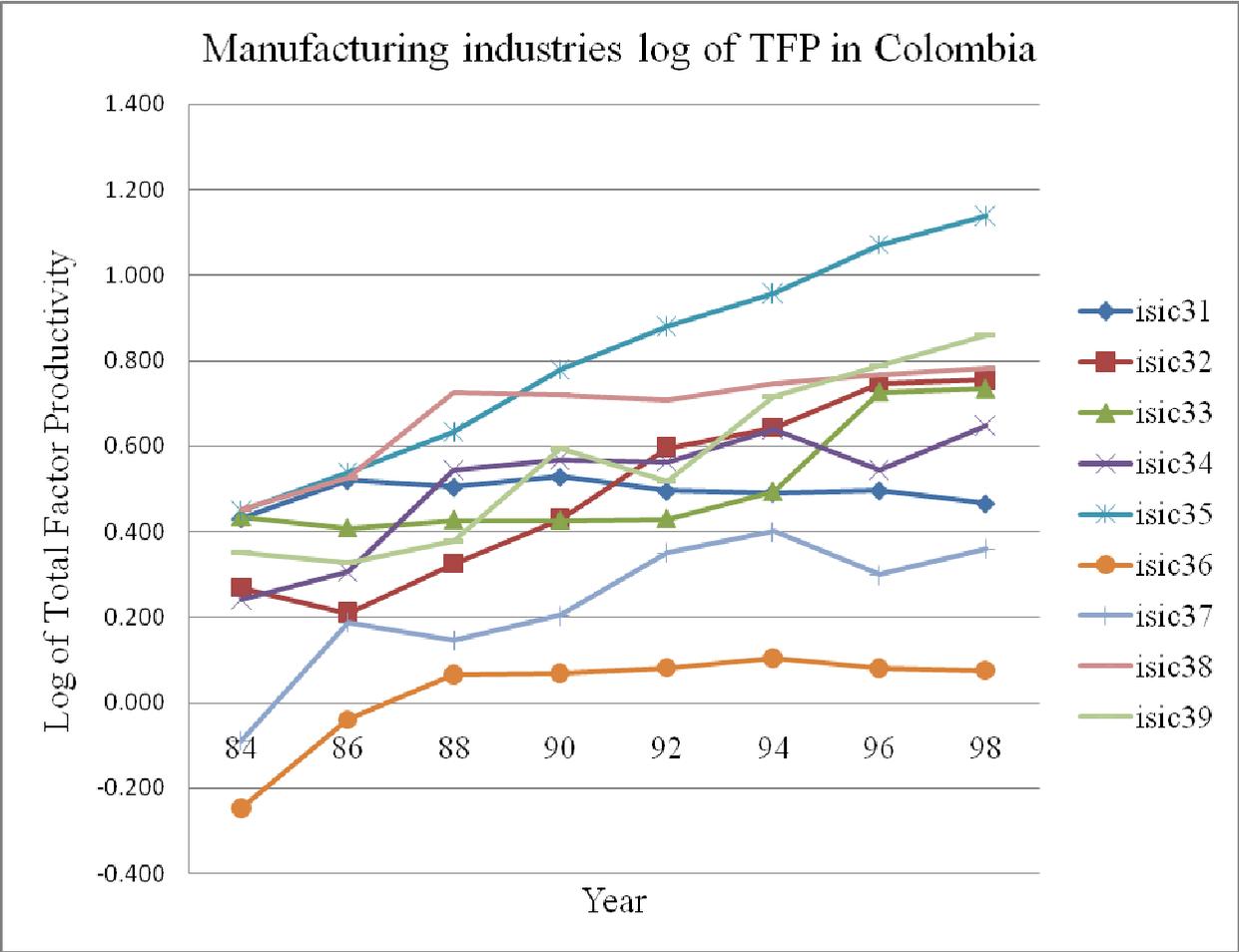


Figure 3.5 - Colombian manufacturing industries productivity (log of TFP).

Data

The data used in this paper includes the variables in Goldberg and Pavcnik (2005), namely tariff, exchange rate and coffee price data and their estimated wage premium and its standard error. And the productivity and its instruments data come from Eslava, Haltiwanger, Kugler and Kugler (2004). The years encompassed by my sample are 1984, 1986, 1988, 1990, 1992, 1994, 1996 and 1998.

The data set used to estimate the wage premium consists of the June waves of Colombian National Household Survey – NHS (*Encuesta Nacional de Hogares*) conducted by the Colombian Statistical Agency (*DANE*). This survey is a repeated cross-section covering urban areas of Colombia. It contains questions about demographic characteristics (age, gender, marital status, education, literacy, etc...), job type, industry of employment at 2-digit ISIC level (total of 33 industries), and region of residence.

Similar to Krueger and Summers (1988), Katz and Summers (1989), and Borjas and Ramey (2000), Goldberg and Pavcnik (2005) estimated the industry wage premium separately for every year of the sample using equation (3.3).

$$\ln(w_{ijt}) = \mathbf{H}_{ijt} \beta_H + \sum_j I_{ijt} * wagepremium_{jt} + \varepsilon_{ijt} \quad (3.3)$$

where $\ln(w_{ijt})$ is the natural logarithm of the worker's hourly wage for worker i affiliated to industry j at time t , \mathbf{H}_{ijt} is a vector that contains worker's age, age squared, male indicator, married indicator, head of the household indicator, completed elementary, secondary and college education indicators (the omitted

category is incomplete elementary education), literacy indicator, residence in Bogotá indicator, occupational indicators and job type indicators. I_{ijt} is “1” if person i worked in industry j in year t and its coefficient captures the share of the wage attributed to industry affiliation, i.e. inter-industry wage premium. Goldberg and Pavcnik (2005) used all available industries (33 industries) under 2-digit ISIC classification to compute the wage premium, in which industry ISIC 62 (retail sales) is the omitted category. The estimated wage premium was then normalized as deviations from the employment-weighted average wage premium and their standard errors were calculated using the Haisken-DeNew and Schmidt (1997) two-step restricted least-squares procedure.

This type of specification does not control for worker’s choice of industry. I believe this is not an important problem because Borjas and Ramey (2000) casts serious doubt about this possibility for U.S., and there’s evidence of little inter-industry switching by workers in Colombia, as portrayed by Goldberg and Pavcnik (2003). So, if there’s sorting it seems to be stable over time, and the industry fixed effects on the second stage estimation would take care of it.

Goldberg and Pavcnik (2005) tariff data at 2-digit ISIC level comes from the Colombian Planning Department (DNP). It is available for only 20 industries, the manufacturing industries (ISIC31-39) are among them, and it consists of the weighted average of the tariffs of the more disaggregated categories by the number of product lines. The exchange rate is the nominal effective rate from IMF, which is a currency bundle encompassing the currencies of the most important Colombian trade partners. Coffee price series comes from the IFS (2001).

The Eslava et al. (2004) productivity data is constructed from the firm-level data from the Colombian Annual Manufacturers Survey (AMS) conducted by DANE. Such nice dataset allows less biased firm-level estimates because there's no need to rely in non-parametric methods and industry level price deflators as proxies for missing plant-level data. The variables used in this paper are the total factor productivity estimated with KLEM methodology, capital stock, and material prices deviated from producers' price index (PPI). The data were aggregated using production shares from firm-level estimates. The productivity data is available only for manufacturing at 2-digit industry level (ISIC 31-39).

Estimations and results

Industry characteristics and the import tariff effect on the wage premium

The first question to be answered is whether the effect of tariffs on wage premium changes according to industry characteristics, in particular between manufacturing and non-manufacturing industries, and between tradable industries and non-tradable industries. This question is important because manufacturing and/or tradable industries are more exposed to foreign producer competition relative to service industries.

I split the data between manufacturing (ISIC 3) and non-manufacturing industries, i.e. agriculture (ISIC 1), mining (ISIC 2) and services (ISIC 4, 6, 8, and 9), and estimated the first difference of equation (3.1) by two-stage least squares (2SLS)

for each sample, equivalent to what Goldberg and Pavcnik (2005) did in their table 6b using all the industries. The instruments used are the 1983 tariff level and its interactions with exchange rate and coffee prices as instruments.

In all estimations presented in this chapter the variables used are aggregated at two-digit industry level (tariffs, productivity, and wage premium). For sake of comparability, I follow Goldberg and Pavcnik (2005) and use industry clustered standard errors. And perform the regressions using the inverse of the standard error of the estimated wage premium as weights, since the dependent variable is an estimate.

The results for non-manufacturing are reported in table (3.1). Model (1) is estimated by OLS and the remaining by IV. The estimated tariff coefficients from Goldberg and Pavcnik (2005) table 6b are reported at the bottom of table (3.1). In model (1) the tariff coefficient isn't statistically significant. In models (2) through (5) the tariff coefficient are not statistically significant. Only model (6) presented a statistically significant tariff coefficient of -0.204, which means that an increase of one percentage point in tariffs lead to a wage premium decrease of 0.204 percentage points. The first stage regressions have F -statistics larger than ten and the excluded instruments are all statistically significant. So, given the validity of the instruments, finite sample bias shouldn't be a concern here. There are no rejections in the over-identification tests for the over-identified models (4) and (6). These results are not compatible with Goldberg and Pavcnik (2005) findings using all industries. It seems that their results are not driven by the non-manufacturing industries.

On table (3.2) I present the output of the regressions using the manufacturing industries sample. Model (1) is estimated by OLS and displays a statistically

significant tariff coefficient of 0.143, which implies a wage premium increase of 0.143 percentage points when tariff is increased by one percentage point. Models (2) to (6) are estimated by IV, and the tariff coefficients for these models are positive, but statistically significant only in models (4), (5) and (6), in which the coefficients range from 0.096 to 0.198. The first stage regressions have F -statistics larger than ten and the instruments are always statistically significant. The over-identification test for model (4) can't reject that the model is correctly specified, but for model (6) it is rejected at the 5% level of confidence.

Independent Variables	Dependent Variable: wage premium					
2 nd Stage	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.0278 [0.205]	-0.075 [0.367]	-0.055 [0.356]	-0.105 [0.385]	0.121 [0.989]	-0.204** [0.072]
Instrument	<i>None</i>	<i>Tariffs 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>
Year dummies in both stage	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	77	77	77	77	77	77
1 st Stage						
Exchange rate* Tariff 83			-0.001** [0.000]	0.003** [0.001]		
Coffee Price* Tariff 83					-0.001** [0.000]	0.011** [0.001]
Constant		0.002 [0.002]	0.002 [0.002]	0.001 [0.001]	0.001 [0.001]	-0.003 [0.004]
<i>F</i> -statistic		110.47	72.43	68.42	66.91	504.31
Over-identification test						
Hansen-Sargan Statistic				0.517 (0.472)		0.065 (0.798)
Goldberg and Pavcnik (2005) results using all industries (133 observations)						
Tariff	0.1191** (0.000)	0.0462** (0.021)	0.0444** (0.001)	0.0416 (0.104)	0.0362* (0.087)	0.0496* (0.053)

Dependent variable is the 1st difference of wage premium, and all variables are in first difference. Robust standard errors are clustered on industry, and are reported in brackets. *p*-values are reported in parenthesis. All variables are used in their first difference. ** and * indicate statistical significance at 5% and 10% level respectively.

Table 3.1 - First difference of equation (3.1) estimated by IV using only non-manufacturing industries (ISIC 1,2,4,6,8, and 9).

Independent Variables	Dependent Variable: wage premium					
	2 nd Stage	(1)	(2)	(3)	(4)	(5)
Tariff	0.143**	-0.006	0.050	0.167**	0.096**	0.198**
	[0.037]	[0.037]	[0.031]	[0.035]	[0.035]	[0.050]
Instrument	<i>None</i>	<i>Tariffs 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>
				<i>Tariffs83</i>		<i>Tariffs 83</i>
Year dummies in 2 nd stage	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	63	63	63	63	63	63
1 st Stage						
Year 1988		0.183**	.149**	0.001	0.136**	0.074*
		[0.028]	[0.026]	[0.031]	[0.027]	[0.037]
Year 1990		0.143**	0.099**	-0.092**	0.061*	-0.050
		[0.028]	[0.027]	[0.037]	[0.030]	[0.055]
Year 1992		0.027	-0.027	-0.264**	-0.075**	-0.216**
		[0.029]	[0.028]	[0.044]	[0.033]	[0.067]
Year 1994		0.203**	0.164**	-0.010	0.167**	0.118**
		[0.033]	[0.031]	[0.037]	[0.031]	[0.036]
Year 1996		0.207**	0.152**	-0.092**	0.149**	0.071
		[0.030]	[0.029]	[0.045]	[0.030]	[0.043]
Year 1998		0.206**	0.134**	-0.184**	0.158**	0.092**
		[0.031]	[0.031]	[0.057]	[0.030]	[0.040]
Tariffs 83		-0.169**		0.95**		0.299**
		[0.042]		[0.154]		[0.125]
Exchange rate* Tariff 83			-0.002**	-0.010**		
			[0.0003]	[0.001]		
Coffee Price* Tar. 83					-0.0023**	-0.006**
					[0.0004]	[0.001]
Constant		-0.122**	-0.062*	0.100**	-0.054	0.007
		[0.029]	[0.032]	[0.037]	[0.035]	[0.042]
F-statistic 1 st stage		17.47	22.12	37.11	21.60	21.23
Over-identification test						
Hansen-Sargan Statistic				1.106		4.307**
				(0.293)		(0.038)
Goldberg and Pavcnik (2005) results using all industries (133 observations)						
Tariff	0.1191**	0.0462**	0.0444**	0.0416	0.0362*	0.0496*
	(0.000)	(0.021)	(0.001)	(0.104)	(0.087)	(0.053)

Dependent variable is the 1st difference of wage premium, and all variables are in first difference. Robust standard errors are clustered on industry, and are reported in brackets. *p*-values are reported in parenthesis. All variables are used in their first difference.

** and * indicate statistical significance at 5% and 10% level respectively.

Table 3.2 - First difference of equation (3.1) estimated by IV using only manufacturing industries (ISIC 3).

When contrasting the models from table (3.2) in which both Goldberg and Pavcnik (2005) and I get statistically significant coefficients, we can see that my estimates are larger by 50% in model (1) and by more than 200% in models (5) and (6). After all, we saw that non-manufacturing wage premia weren't affected by change in tariffs, while manufacturing wage premia were. If we combine both samples (Goldberg and Pavcnik, 2005), we still obtain that wage premia is affected by tariffs, but with a smaller coefficient. Therefore manufacturing industries seems to be driving Goldberg and Pavcnik (2005) findings.

The other exercise consists of splitting the sample between tradable industries (ISIC 1, 2, and 3) and non-tradable industries (ISIC 4, 6,8 and 9). In this case, I'll only be able to estimate the first difference of equation (3.1) for the tradable industries, because there's only five non-tradable industries, and the number of regressors in the model would be larger than the number of clusters (cf. Baum et al., 2003)²³.

The results for tradable industries are exhibited in table (3.3), in which model (1) is estimated by OLS and the remaining models by IV. All models present a positive estimated tariff coefficient, which is significant in all specifications except in model (2). The estimated tariff coefficient sizes and standard deviations are similar to the ones obtained using the manufacturing sample reported in table (3.2). Moreover, the excluded instruments are all statistically significant in the first stage regressions, whose *F*-statistics are above 600. There are no rejections in the over-identifying restrictions test.

²³ Notice that the results obtained by Goldberg and Pavcnik (2005) vanish when the models are estimated without clustered standard errors. Such regressions are available upon request.

Independent Variables	Dependent Variables: wage premium					
	(1)	(2)	(3)	(4)	(5)	(6)
2 nd Stage						
Tariff	0.157** [0.033]	0.023 [0.044]	0.065** [0.032]	0.150** [0.028]	0.093** [0.037]	0.161** [0.048]
Instrument	<i>None</i>	<i>Tariffs 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>
Year dummies in 2 nd stage	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	105	105	105	105	105	105
1 st Stage						
Year 1988		0.174* [0.090]	0.142 [0.083]	0.005 [0.051]	0.130 [0.080]	0.073 [0.064]
Year 1990		0.136* [0.073]	0.094 [0.064]	-0.086* [0.040]	0.057 [0.057]	-0.044 [0.052]
Year 1992		0.023 [0.077]	-0.029 [0.067]	-0.251** [0.055]	-0.076 [0.060]	-0.203** [0.071]
Year 1994		0.196** [0.088]	0.157* [0.080]	-0.005 [0.047]	0.161* [0.080]	0.117 [0.068]
Year 1996		0.199** [0.087]	0.145* [0.076]	-0.082* [0.043]	0.143* [0.075]	0.072 [0.058]
Year 1998		0.197 [0.087]	0.128 [0.073]	-0.168** [0.052]	0.150* [0.077]	0.091 [0.063]
Tariffs 83		-0.169** [0.006]		0.910** [0.117]		0.279** [0.094]
Exchange rate* Tariff 83			-0.002** [0.000]	-0.010** [0.001]		
Coffee Price* Tariff 83					-0.002** [0.000]	-0.005** [0.001]
Constant		-0.116 [0.071]	-0.059 [0.059]	0.093** [0.040]	-0.052 [0.058]	0.004 [0.05]
F-statistic 1 st stage		905.80	1139.61	14184.42	612.97	1141.61
Over-identification test						
Hansen-Sargan Statistic				1.460 (0.227)		1.707 (0.191)
Goldberg and Pavcnik (2005) results using all industries (133 observations)						
Tariff	0.1191** (0.000)	0.0462** (0.021)	0.0444** (0.001)	0.0416 (0.104)	0.0362* (0.087)	0.0496* (0.053)

Dependent variable is the 1st difference of wage premium, and all variables are in first difference. Robust standard errors are clustered on industry, and are reported in brackets. *p*-values are reported in parenthesis. All variables are used in their first difference.

** and * indicate statistical significance at 5% and 10% level respectively.

Table 3.3 - First difference of equation (3.1) estimated by IV using only tradable industries (ISIC 1-3).

The results in Table (3.3) indicate that not only manufacturing industry wage premia but also the other tradable industry wage premia are indeed affected by changes in tariffs. Although it's not possible to estimate the tariff coefficient for non-tradable industries, based on the results from table (3.1) I believe it wouldn't be positive and statistically significant, because these industries are a subset of the non-manufacturing industries and are the ones to present the smallest variation in wage premium over time. So, Goldberg and Pavcnik (2005) results are driven by the observations from the tradable industries, which respond for about a quarter of overall employment.

The role of productivity

The next question I address is the role of productivity in the determination of the effect of tariffs over wage premium. The availability of productivity data constrains my analysis to manufacturing industries only, but as seen in the previous section these are the industries that are driving Goldberg and Pavcnik (2005) results.

Now I incorporate the productivity variable in equation (3.1), and estimate its first difference, as shown in equation (3.2), considering tariffs as the only endogenous regressor, and using only the Goldberg and Pavcnik (2005) instruments: 1983 tariff level and its interactions with exchange rate and coffee price. The results are reported in table (3.4), in which model (1) is estimated by OLS and the remaining models are estimated by IV.

The productivity coefficient is positive and statistically significant in all models with values ranging from 0.155 to 0.176, similar to table (3.4). The tariff coefficient is positive in all models, but it is statistically significant in models (1), (4), (5), and (6). The first stage F -statistics are all above ten, and only in model (6) there's an excluded instrument (1983 tariff) that is not statistically significant. Productivity variable is statistically significant in the first stage regressions of models (2), (3) and (5). This fact corroborates the fact that industry productivity can be an important factor of import tariff setting and its omission invalids the instruments used by Goldberg and Pavcnik (2005). There's no rejection in the over-identifying tests, in particular the rejection found in model (6) of table (3.2) disappears when the productivity variable is included in the model. The productivity variable seems to be important in the determination of wage premium and at the same time its inclusion decreases the estimated tariff coefficient by 20 to 50% in comparison to the ones from table (3.2).

In the last set of regressions, I address the reverse causation concern, i.e. productivity might depend on the wage premium. So, I estimate IV models similar to models (2) to (6) displayed in table (3.4) using the following additional instruments: the first difference of material prices and of log of capital stock.

First, productivity is considered exogenous and the estimated models are shown in table (3.5). The productivity variable is positive and statistically significant in all specifications of this table, ranging from 0.159 to 0.177. Model (1) productivity coefficient implies that a unit increase in the $\log TFP$ leads to an increase of 0.177

percentage points in the wage premium. The tariff coefficient is positive in all models, but statistically significant only in models (3), (4), and (5).

Although additional instruments are used here, the tariff coefficients of these models are smaller than the ones from table (3.2) models (3), (4), and (5). The first stage regressions F -statistics are all above ten. Productivity is statistically significant in the first stage of all models, except model (3). In model (3) the *material* prices instrument is not statistically significant in its first stage regression, and in model (6) neither 1983 tariffs nor its interaction with coffee price are statistically significant. There's no rejection in the over-identifying tests. The estimated coefficients in table (3.5) are similar to the estimates from table (3.4), and again, the inclusion of the productivity variable affected the estimated tariff coefficient by decreasing it, in addition to explaining part of the variation in the wage premium.

Then, table (3.5) models are estimated by instrumental variables technique considering both tariff and productivity as endogenous variables²⁴, and a Durbin-Wu-Hausman²⁵ endogeneity test for productivity is conducted. The results of the tests are reported on the bottom of table (3.5). In all specifications, the exogeneity of productivity can't be rejected at 10% level of confidence. Thus, the possibility of reverse causation due to efficiency wages doesn't seem relevant.

²⁴ The results are omitted but available upon request.

²⁵ Implemented according to Baum, Schaffer, and Stillman (2005) p. 20.

Independent Variables	Dependent Variables: wage premium						
	2 nd stage	(1)	(2)	(3)	(4)	(5)	(6)
Tariff (endogenous)	0.092**	0.036	0.058	0.106**	0.078*	0.111**	
	[0.036]	[0.065]	[0.044]	[0.026]	[0.034]	[0.032]	
Log TFP (exogenous)	0.160**	0.176**	0.170**	0.156**	0.164**	0.155**	
	[0.043]	[0.046]	[0.044]	[0.043]	[0.045]	[0.046]	
Instrument	<i>No</i>	<i>Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>	<i>Coffee Price* Tariff 83</i>	
Year dummies in 2 nd stage	Yes	Yes	Yes	Yes	Yes	Yes	
Number of Obs.	63	63	63	63	63	63	
1 st stage							
Year 1988		0.160**	0.129**	0.008	0.121**	0.087**	
		[0.027]	[0.025]	[0.032]	[0.027]	[0.038]	
Year 1990		0.131**	0.088**	-0.080**	0.054*	-0.011	
		[0.026]	[0.026]	[0.039]	[0.029]	[0.061]	
Year 1992		0.014	-0.039	-0.248**	-0.082**	-0.166**	
		[0.027]	[0.026]	[0.047]	[0.032]	[0.075]	
Year 1994		0.196**	0.157**	0.003	0.163**	0.135**	
		[0.030]	[0.029]	[0.039]	[0.030]	[0.038]	
Year 1996		0.194**	0.139**	-0.074	0.141**	0.096**	
		[0.028]	[0.028]	[0.048]	[0.029]	[0.045]	
Year 1998		0.211**	0.137**	-0.154**	0.163**	0.121**	
		[0.029]	[0.030]	[0.063]	[0.029]	[0.044]	
Log TFP		0.333**	0.293**	0.097	0.245**	0.172	
		[0.103]	[0.095]	[0.088]	[0.099]	[0.117]	
Tariffs 83		-0.183**		0.867**		0.182	
		[0.039]		[0.171]		[0.147]	
Exchange rate* Tariff 83			-0.002**	-0.010**			
			[0.0003]	[0.001]			
Coffee Price* Tariff 83					-0.002**	-0.004**	
					[0.0004]	[0.002]	
Constant		-0.124**	-0.069**	0.084**	-0.064*	-0.024	
		[0.027]	[0.030]	[0.039]	[0.034]	[0.046]	
<i>F</i> -statistic 1 st stage		19.15	23.50	33.26	21.56	19.52	
Over identification test							
Hansen-Sargan Statistic				1.073		0.846	
				(0.301)		(0.358)	

Dependent variable is the 1st difference of wage premium, and all variables are in first difference. Robust standard errors are clustered on industry, and are reported in brackets. *p*-values are reported in parenthesis. All variables are used in their first difference. ** and * indicate statistical significance at 5% and 10% level respectively.

Table 3.4 - Equation (3.2) estimated by IV using only manufacturing industries .

Independent Variables	Dependent Variable: wage premium				
	2 nd stage	(1)	(2)	(3)	(4)
Tariff (endogenous)	0.031 [0.052]	0.050 [0.038]	0.097** [0.025]	0.064* [0.032]	0.073** [0.030]
Log TFP (exogenous)	0.177** [0.046]	0.172** [0.045]	0.159** [0.044]	0.168** [0.046]	0.166** [0.046]
Instrument	<i>Tariffs 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Exchange rate* Tariff 83</i>	<i>Coffee price* Tariff 83</i>	<i>Coffee price* Tariff 83</i>
	<i>Log Stock of Capital Material prices</i>				
Year dummies in both stages	Yes	Yes	Yes	Yes	Yes
Number of Observations	63	63	63	63	63
1st Stage					
Log TFP	0.339** [0.101]	0.292** [0.093]	0.088 [0.088]	0.260** [0.098]	0.235* [0.118]
Tariffs 83	-0.181** [0.037]		0.810** [0.169]		0.058 [0.152]
Exchange rate* Tariff 83		-0.002** [0.0003]	-0.009** [0.001]		
Coffee Price* Tariff 83				-0.002** [0.0004]	-0.003 [0.002]
Log Stock of Capital	0.074** [0.027]	0.072** [0.026]	0.062** [0.021]	0.062** [0.027]	0.058* [0.029]
<i>Material Prices</i>	-0.191** [0.087]	-0.162* [0.080]	-0.066 [0.070]	-0.167* [0.085]	-0.161* [0.087]
Constant	-0.115** [0.026]	-0.063** [0.029]	0.080** [0.038]	-0.064* [0.032]	-0.52 [0.046]
<i>F</i> -statistic 1 st stage	18.51	22.49	31.19	19.65	17.58
Over identification test					
Hansen-Sargan Statistic	4.078 (0.870)	1.376 (0.497)	1.906 (0.408)	1.190 (0.448)	1.527 (0.323)
Durbin-Wu-Hausman test	0.264 (0.607)	0.211 (0.646)	1.652 (0.199)	0.223 (0.637)	1.768 (0.184)
exogeneity of Log TFP					

Dependent variable is the 1st difference of wage premium, and all variables are in first difference. Robust standard errors are clustered on industry, and are reported in brackets. *p*-values are reported in parenthesis. All variables are used in their first difference.

** and * indicate statistical significance at 5% and 10% level respectively.

Table 3.5 - Equation (3.2) estimated by IV using only manufacturing industries with Hausman test for productivity endogeneity.

Final Remarks

In this chapter I assessed whether the import tariff effect over inter-industry wage premium depended on industries characteristics, and showed empirically that the omission of productivity variable (which affects both tariff setting and wage premium) leads to inconsistent estimations of the tariff effect over wage premium.

I found that the effect of tariffs depends on industries characteristics, because the wage premium only seemed to be affected by changes in tariffs in manufacturing and tradable industries. In the case approached here, the inclusion of sectors not affected by trade reform led to a five times smaller estimated impact of import tariffs on wage premium.

When productivity is incorporated in the estimated model, we can see that it indeed affects the wage premium and as an included instrument it is an important factor in import tariff setting. I found that the impact of the change in tariffs on the wage premium is about 50% smaller than the impact estimated using Goldberg and Pavcnik (2005) model with manufacturing data. The important lesson from this chapter is that using pre-reform import tariff levels as an instrument for changes in tariffs when the dependent variable is related to productivity is not a good idea. And in fact, this could be an explanation for the lack of effect of tariffs on wage premium in Brazil and Mexico, and for the positive effect found for India.

As a byproduct of my estimations, I found that productivity is an exogenous variable with respect to wage premium in the case of Colombia. Hence, a possible

reason for reverse causation like efficiency wages (in its basic Shapiro-Stiglitz formulation) does not seem important in this context.

Appendix

Proof of Propositions and Lemmas from Chapter 1

Lemma 1. *The determinant of the Jacobean matrix of the system (1.44) is positive.*

Proof. The total derivative of the system is

$$\begin{cases} \frac{\partial F_1}{\partial s_{open}^*} ds_{open}^* + \frac{\partial F_1}{\partial s_{open}^{*,foreign}} ds_{open}^{*,foreign} = -[\frac{\partial F_1}{\partial \tau} d\tau + \frac{\partial F_1}{\partial \tau^{foreign}} d\tau^{foreign}] \\ \frac{\partial F_2}{\partial s_{open}^*} ds_{open}^* + \frac{\partial F_2}{\partial s_{open}^{*,foreign}} ds_{open}^{*,foreign} = -[\frac{\partial F_2}{\partial \tau} d\tau + \frac{\partial F_2}{\partial \tau^{foreign}} d\tau^{foreign}] \end{cases} \quad (1.51)$$

$$J = \begin{bmatrix} \frac{\partial F_1}{\partial s_{open}^*} & \frac{\partial F_1}{\partial s_{open}^{*,foreign}} \\ \frac{\partial F_2}{\partial s_{open}^*} & \frac{\partial F_2}{\partial s_{open}^{*,foreign}} \end{bmatrix} = \begin{bmatrix} j'(s_{open}^*)f & j'(s_{x,for}^*)\frac{s_{x,for}^*}{s_{open}^{*,foreign}}f_x \\ j'(s_{x,for}^*)\frac{s_{x,for}^*}{s_{open}^{*,foreign}}f_x & j'(s_{open}^*)f \end{bmatrix} \quad (1.52)$$

$$= j'(s_{open}^*)j'(s_{open}^{*,foreign})ff - j'(s_{x,for}^*)\tau\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} j'(s_{x,for}^*)\tau^{foreign}\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} f_x f_x \quad (1.53)$$

Let's prove that the first term in the right-hand side of equation (1.53) is larger than the second term:

$$\begin{aligned} & \frac{j'(s_{open}^*)j'(s_{open}^{*,foreign})ff}{j'(s_{x,for}^*)\tau\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} j'(s_{x,for}^*)\tau^{foreign}\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} f_x f_x} = \\ & = \tau^{\sigma-1} \left(1 + \frac{\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi}{\int_{s_{x,for}^*}^{s_{open}^*} \xi^{\sigma-1} g(\xi) d\xi}\right) (\tau^{foreign})^{\sigma-1} \left(1 + \frac{\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi}{\int_{s_{x,for}^*}^{s_{open}^*} \xi^{\sigma-1} g(\xi) d\xi}\right) > 1 \end{aligned}$$

Therefore $|J| > 0$. ■

Lemma 2. *For $d\tau^{foreign} = 0$, we have $\frac{\partial s_{open}^*}{\partial \tau} < 0$, $\frac{\partial s_{open}^{*,foreign}}{\partial \tau} > 0$, $\frac{\partial s_{x,for}^*}{\partial \tau} > 0$, and $\frac{\partial s_{x,for}^{*,foreign}}{\partial \tau} < 0$.*

Proof. See Appendix.

$$J \begin{bmatrix} \frac{\partial s_{open}^*}{\partial \tau} \\ \frac{\partial s_{open}^{*,foreign}}{\partial \tau} \end{bmatrix} = - \begin{bmatrix} \frac{\partial F_1}{\partial \tau} \\ \frac{\partial F_2}{\partial \tau} \end{bmatrix} = - \begin{bmatrix} j'(s_{x,for}^*) \frac{s_{x,for}^*}{\tau} f_x \\ 0 \end{bmatrix}$$

Using Cramér rule,

$$\frac{\partial s_{open}^*}{\partial \tau} = - \frac{j'(s_{x,for}^*) \frac{s_{x,for}^*}{\tau} f_x j'(s_{open}^{*,foreign}) f}{|J|} = \frac{< 0}{> 0} < 0$$

$$\frac{\partial s_{open}^{*,foreign}}{\partial \tau} = - \frac{-j'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^{*,foreign}}{s_{open}^*} f_x j'(s_{x,for}^*) \frac{s_{x,for}^*}{\tau} f_x}{|J|} = \frac{> 0}{> 0} > 0$$

Now, we will calculate the partial derivatives for $s_{x,for}^*$ and $s_{x,for}^{*,foreign}$. From equations (1.41) and (1.42),

$$\frac{\partial s_{x,for}^*}{\partial \tau} = s_{open}^{*,foreign} \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} + \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \frac{\partial s_{open}^{*,foreign}}{\partial \tau} = \frac{s_{x,for}^*}{\tau} \left[\frac{j'(s_{open}^*) j'(s_{open}^{*,foreign}) ff}{|J|} \right] > 0$$

and

$$\frac{\partial s_{x,for}^{*,foreign}}{\partial \tau} = \frac{\partial s_{open}^*}{\partial \tau} \tau^{foreign} \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} < 0. \blacksquare$$

Lemma 3. For $d\tau = 0$, we have $\frac{\partial s_{open}^*}{\partial \tau^{foreign}} > 0$, $\frac{\partial s_{open}^{*,foreign}}{\partial \tau^{foreign}} < 0$, $\frac{\partial s_{x,for}^*}{\partial \tau^{foreign}} < 0$, and $\frac{\partial s_{x,for}^{*,foreign}}{\partial \tau^{foreign}} > 0$.

Proof.

$$J \begin{bmatrix} \frac{\partial s_{open}^*}{\partial \tau^{foreign}} \\ \frac{\partial s_{open}^{*,foreign}}{\partial \tau^{foreign}} \end{bmatrix} = \begin{bmatrix} \frac{\partial F_1}{\partial \tau^{foreign}} \\ \frac{\partial F_2}{\partial \tau^{foreign}} \end{bmatrix} = \begin{bmatrix} 0 \\ j'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x \end{bmatrix}$$

Using Cramer rule,

$$\frac{\partial s_{open}^*}{\partial \tau^{foreign}} = - \frac{-j'(s_{x,for}^*) \frac{s_{x,for}^*}{s_{open}^{*,foreign}} f_x j'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x}{|J|} = \frac{> 0}{> 0} > 0$$

$$\frac{\partial s_{open}^{*,foreign}}{\partial \tau^{foreign}} = - \frac{j'(s_{open}^*) ff'(s_{x,for}^{*,foreign}) \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x}{|J|} = \frac{< 0}{> 0} < 0$$

$$\frac{\partial s_{x,for}^*}{\partial \tau^{foreign}} = \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \frac{\partial s_{open}^{*,foreign}}{\partial \tau^{foreign}} < 0$$

and similarly,

$$\frac{\partial s_{x,for}^{*,foreign}}{\partial \tau^{foreign}} = s_{open}^* \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} + \tau^{foreign} \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \frac{\partial s_{open}^*}{\partial \tau^{foreign}} > 0. \blacksquare$$

Lemma 4. *The sign of $\frac{\partial share}{\partial s_{x,for}^*}$ is positive.*

Proof.

$$\frac{\partial share}{\partial s_{x,for}^*} = \frac{\partial \left(\frac{L_v^{inf}}{L_v^{for} + L_v^{inf}} \right)}{\partial s_{x,for}^*} = \frac{\frac{\partial L_v^{inf}}{\partial s_{x,for}^*} L_v^{for} - L_v^{inf} \frac{\partial L_v^{for}}{\partial s_{x,for}^*}}{(L_v^{for} + L_v^{inf})^2}$$

Since $\frac{\partial L_v^{for}}{\partial s_{x,for}^*} < 0$ and $\frac{\partial L_v^{inf}}{\partial s_{x,for}^*} > 0$, we have that $\frac{\partial share}{\partial s_{x,for}^*} > 0$. \blacksquare

Lemma 5. *The following inequality holds given countries are symmetric*

$$\frac{s_{x,for}^*}{\tau} j'(s_{open}^*) j'(s_{open}^{*,foreign}) ff > \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} j'(s_{x,for}^*) f_x j'(s_{open}^{*,foreign}) f$$

Proof.

$$\frac{\frac{s_{x,for}^*}{\tau} j'(s_{open}^*) j'(s_{open}^{*,foreign}) ff}{\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} j'(s_{x,for}^*) f_x j'(s_{open}^{*,foreign}) f} = \frac{(s_{open}^{*,foreign})^{\sigma+1} \tau^{\sigma-1} [1 - G(s_{open}^*)] [\tilde{s}(s_{open}^*)]^{\sigma-1}}{(s_{open}^*)^{\sigma+1} [1 - G(s_{x,for}^*)] [\tilde{s}(s_{x,for}^*)]^{\sigma-1}} =$$

Since countries are symmetric,

$$= \frac{\tau^{\sigma-1} \left(\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi + \int_{s_{x,for}^*}^{s_{open}^{*,foreign}} \xi^{\sigma-1} g(\xi) d\xi \right)}{\int_{s_{x,for}^*}^{s_{open}^{*,foreign}} \xi^{\sigma-1} g(\xi) d\xi} = \tau^{\sigma-1} \left(1 + \frac{\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi}{\int_{s_{x,for}^*}^{s_{open}^{*,foreign}} \xi^{\sigma-1} g(\xi) d\xi} \right) > 1. \blacksquare$$

Lemma 6. *The following inequality holds given countries are symmetric*

$$\frac{s_{x,for}^*}{\tau} j'(s_{open}^*) j'(s_{open}^{*,foreign}) ff > \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} j'(s_{x,for}^*) f_x j'(s_{open}^{*,foreign}) f$$

Proof.

$$\frac{\frac{s_{x,for}^*}{\tau} j'(s_{open}^*) j'(s_{open}^{*,foreign}) f f}{\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^*}{\tau^{foreign}} j'(s_{x,for}^*) f_x j'(s_{x,for}^{*,foreign}) f_x} =$$

$$(\tau^{foreign})^\sigma \tau^{\sigma-1} \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} \left[\frac{\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi}{\int_{s_{x,for}^*}^{s_{x,for}^{*,foreign}} \xi^{\sigma-1} g(\xi) d\xi} + 1 \right] \left(1 + \frac{\int_{s_{open}^*}^{s_{x,for}^*} \xi^{\sigma-1} g(\xi) d\xi}{\int_{s_{x,for}^*}^{s_{x,for}^{*,foreign}} \xi^{\sigma-1} g(\xi) d\xi} \right) > 1$$

Lemma 7. *The following inequality holds given countries are symmetric*

$$\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^*}{\tau^{foreign}} f_x j'(s_{x,for}^*) j'(s_{open}^*) f > \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^*}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign}) j'(s_{x,for}^*) f_x$$

Proof.

$$\frac{\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^*}{\tau^{foreign}} f_x j'(s_{x,for}^*) j'(s_{open}^*) f}{\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^*}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign}) j'(s_{x,for}^*) f_x} > 1$$

Proposition 2. *If the sufficient conditions (S1)-(S4) hold, a decrease in τ implies a decrease in the informal share ($\frac{dshare}{d\tau} \Big|_{\tau^{foreign}} > 0$) and a decrease in $\tau^{foreign}$ increases the informal share ($\frac{dshare}{d\tau^{foreign}} \Big|_{\tau} < 0$).*

$$(S1) \frac{\partial \Psi(\varphi, w)}{\partial \varphi} < 0; (S2) \frac{\partial \Psi(\varphi, w)}{\partial w} < 0; (S3) \sigma > 3; (S4) \chi > \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$$

Proof. Since these are sufficient conditions, I need to prove that there's a positive term that is larger in absolute terms than the only negative term in $\frac{dshare}{d\tau} \Big|_{\tau^{foreign}}$.

$$\frac{dshare}{d\tau} \Big|_{\tau^{foreign}} = \frac{M(\rho P)^\sigma Q}{(L_V^{inf} + L_V^{for})^2} [\sigma \tau^{\sigma-1} L_V^{inf} ($$

$$\int_{\lambda \chi s_{x,for}^*}^{\infty} \int_{\chi}^{\frac{\varphi_i}{T s_{x,for}^*}} \frac{\theta}{T} \frac{w_i}{\varphi_i} \left(\frac{\varphi_i}{T w_i + \theta}\right)^\sigma \Psi(\varphi_i, w_i) dw_i d\varphi_i +$$

$$\begin{aligned}
& + \int_{(T+\theta)s_{x,for}^*}^{\lambda\chi s_{x,for}^*} \int_1^{\frac{\varphi_i - \theta}{Ts_{x,for}^*}} \frac{w_i}{\varphi_i} \left(\frac{\varphi_i}{Tw_i + \theta} \right)^\sigma \Psi(\varphi_i, w_i) dw_i d\varphi_i + \\
& + \int_{\lambda\chi s_{x,for}^*}^\infty \int_1^\chi \frac{w_i}{\varphi_i} \left(\frac{\varphi_i}{Tw_i + \theta} \right)^\sigma \Psi(\varphi_i, w_i) dw_i d\varphi_i + \frac{-j'(s_{x,for}^*) \frac{s_{x,for}^*}{\tau} f_x j'(s_{open}^*, foreign) f}{|J|} (L_V^{for} \{ \\
& \frac{(s_{open}^*)^{\sigma-2}}{\lambda} [-\int_{\lambda\chi s_{open}^*}^{\lambda\chi s_{open}^*} \Psi(\varphi_i, w_i = \frac{\varphi_i}{\lambda s_{open}^*}) d\varphi_i] + L_V^{inf} \{ -\frac{(s_{open}^*)^{\sigma-2}}{T} \int_{\lambda\chi s_{open}^*}^\infty \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{open}^*} - \frac{\theta}{T}) d\varphi_i \} + \\
& + \frac{s_{x,for}^*}{\tau} \left[\frac{j'(s_{open}^*) j'(s_{open}^*, foreign) ff}{|J|} \right] \left(\frac{s_{x,for}^*}{T^{1-\sigma}} L_V^{for} \{ [\int_{(T+\theta)s_{x,for}^*}^{\lambda\chi s_{x,for}^*} \lambda^{-\sigma} \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^\sigma \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i] \} \right) \\
& + L_V^{inf} \{ \tau^{-\sigma} \int_{\lambda\chi s_{x,for}^*}^\infty \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i + (1 + \tau^{-\sigma}) \int_{(T+\theta)s_{x,for}^*}^{\lambda\chi s_{x,for}^*} \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \} \}
\end{aligned}$$

the remaining sufficient inequalities in conjunction with the lemmas (5) and (6) imply that

$$\begin{aligned}
& \left| \frac{s_{x,for}^*}{\tau} \left[\frac{j'(s_{open}^*) j'(s_{open}^*, foreign) ff}{|J|} \right] L_V^{inf} \frac{\tau^{-\sigma}}{T} (s_{x,for}^*)^{\sigma-2} \{ \int_{\lambda\chi s_{x,for}^*}^\infty \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i + \right. \\
& \left. + (1 + \tau^{-\sigma}) \int_{(T+\theta)s_{x,for}^*}^{\lambda\chi s_{x,for}^*} \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \} \right| > \\
& \left| \frac{s_{x,for}^*}{\tau} \left[\frac{j'(s_{open}^*) j'(s_{open}^*, foreign) ff}{|J|} \right] L_V^{inf} \left\{ \frac{\tau^{-\sigma}}{T} (s_{x,for}^*)^{\sigma-2} \int_{\lambda\chi s_{x,for}^*}^\infty \left[\Psi(\varphi_i, w_i) \mid w_i = \frac{\varphi_i}{Ts_{x,for}^*} \right] d\varphi_i + \right. \\
& \left. + (1 + \tau^{-\sigma}) \frac{(s_{x,for}^*)^{\sigma-2}}{T} \int_{(T+\theta)s_{x,for}^*}^{\lambda\chi s_{x,for}^*} \left(\Psi(\varphi_i, w_i) \mid w_i = \frac{\lambda\chi}{T} \right) d\varphi_i \right\} \right| \\
& > \left| -\frac{j'(s_{x,for}^*) \frac{s_{x,for}^*}{\tau} f_x j'(s_{open}^*, foreign) f}{|J|} L_V^{inf} \frac{(s_{open}^*)^{\sigma-2}}{T} \int_{\lambda\chi s_{open}^*}^\infty \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{open}^*} - \frac{\theta}{T}) d\varphi_i \right|
\end{aligned}$$

For

$$\begin{aligned}
\frac{dshare}{d\tau^{foreign}} &= \frac{\frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign})}{|J| (L_v^{inf} + L_v^{for})^2} M(\rho P)^\sigma Q(j'(s_{x,for}^*) f_x [\\
&\quad -L_v^{for} \{ [(s_{open}^*)^{\sigma-2} \int_{\lambda \chi_{open}^*}^{\lambda \chi_{open}^*} \left[\phi(\varphi_i, b_i) | b_i = \frac{\varphi_i}{s_{open}^*} \right] d\varphi_i \}] \} \\
&\quad +L_v^{inf} \{ (s_{open}^*)^{\sigma-2} \int_{\lambda \chi_{open}^*}^{\infty} \phi \left(\varphi_i, b_i = \frac{\varphi_i}{s_{open}^*} \right) d\varphi_i \}] + \\
&\quad -j'(s_{open}^*) f [L_v^{for} \{ [\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi_{x,for}^*} \frac{\lambda \varphi_i}{T(s_{x,for}^*)^2} \left[\frac{1}{\varphi_i} \left(\frac{\varphi_i}{b_i} \right)^\sigma \phi(\varphi_i, b_i) | b_i = \frac{\lambda \varphi_i}{Ts_{x,for}^*} - \frac{\lambda \theta}{T} \right] d\varphi_i \}] \} \\
&\quad +L_v^{inf} \{ \tau^{-\sigma} (s_{x,for}^*)^{\sigma-2} \int_{\lambda \chi_{x,for}^*}^{\infty} \left[\phi(\varphi_i, b_i) | b_i = \frac{\varphi_i}{s_{x,for}^*} \right] d\varphi_i + \\
&\quad + (1 + \tau^{-\sigma}) \frac{\lambda (s_{x,for}^*)^{\sigma-2}}{T} \int_{(T+\theta)s_{x,for}^*}^{\lambda \chi_{x,for}^*} \left(\phi(\varphi_i, b_i) | b_i = \frac{\lambda \varphi_i}{Ts_{x,for}^*} - \frac{\lambda \theta}{T} \right) d\varphi_i \}] \}
\end{aligned}$$

We make use of the inequalities and lemmas (6) and (7) to show that

$$\begin{aligned}
& \left| \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign}) j'(s_{open}^*) f L_v^{inf} \frac{\tau^{-\sigma}}{T} (s_{x,for}^*)^{\sigma-2} \left\{ \int_{\lambda \chi_{x,for}^*}^{\infty} \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right. \right. \\
& \quad \left. \left. + (1 + \tau^{-\sigma}) \int_{(T+\theta)s_{x,for}^*}^{\lambda \chi_{x,for}^*} \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right\} \right| \\
& > \left| \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign}) j'(s_{open}^*) f L_v^{inf} \left\{ \frac{\tau^{-\sigma}}{T} (s_{x,for}^*)^{\sigma-2} \int_{\lambda \chi_{x,for}^*}^{\infty} \left[\Psi(\varphi_i, w_i) | w_i = \frac{\varphi_i}{Ts_{x,for}^*} \right] d\varphi_i + \right. \right. \\
& \quad \left. \left. + (1 + \tau^{-\sigma}) \frac{(s_{x,for}^*)^{\sigma-2}}{T} \int_{(T+\theta)s_{x,for}^*}^{\lambda \chi_{x,for}^*} \left(\Psi(\varphi_i, w_i) | w_i = \frac{\lambda \chi}{T} \right) d\varphi_i \right\} \right| \\
& > \left| \frac{s_{x,for}^*}{s_{open}^{*,foreign}} \frac{s_{x,for}^{*,foreign}}{\tau^{foreign}} f_x j'(s_{x,for}^{*,foreign}) j'(s_{x,for}^*) f_x L_v^{inf} \frac{(s_{open}^*)^{\sigma-2}}{T} \int_{\lambda \chi_{open}^*}^{\infty} \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{open}^*} - \frac{\theta}{T}) d\varphi_i \right|
\end{aligned}$$

■

Proposition 4. *If conditions (W1)-(W3) hold, a decrease in τ decreases the formal-informal wage gap ($\frac{dwagegap}{d\tau} \Big|_{\tau^{foreign}} > 0$) and a decrease in $\tau^{foreign}$ increases the formal-informal wage gap ($\frac{dwagegap}{d\tau^{foreign}} \Big|_{\bar{\tau}} < 0$).*

(W1) φ and w are independently Pareto distributed in which $k_1, k_2 > \sigma > 2$ are the scale parameters respectively.

$$(W2) \frac{k_1 + k_2}{k_1 + k_2 + 1} \frac{[1 - \chi^{-k_1 - k_2 - 1}]}{[1 - \chi^{-k_1 - k_2}]} > 1; \quad (W3) \frac{T^{\sigma + k_2} (\sigma + k_1)}{(k_1 + k_2 + 1)} > 1$$

Proof.

$$\frac{dwagegap}{d\tau} \Big|_{\bar{\tau}^{foreign}} = \frac{\frac{dtpw^{for}}{d\tau} \Big|_{\bar{\tau}^{foreign}} - \bar{w}^{for} \frac{dL_v^{for}}{d\tau} \Big|_{\bar{\tau}^{foreign}}}{L_v^{for}} + \frac{\bar{w}^{inf} \frac{dL_v^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}} - \frac{dtpw^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}}}{L_v^{inf}}$$

The first step is to show that

$$\begin{aligned} & \bar{w}^{inf} \frac{dL_v^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}} - \frac{dtpw^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}} = \bar{w}^{inf} \frac{\partial L_v^{inf}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} + \\ & + \bar{w}^{inf} \frac{\partial L_v^{inf}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} - \frac{\partial tpw^{inf}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} - \frac{\partial tpw^{inf}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} > 0 \end{aligned}$$

Notice that

$$\begin{aligned} & \bar{w}^{inf} \frac{dL_v^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}} - \frac{dtpw^{inf}}{d\tau} \Big|_{\bar{\tau}^{foreign}} = \bar{w}^{inf} \frac{\partial L_v^{inf}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} + \bar{w}^{inf} \frac{\partial L_v^{inf}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} - \frac{\partial tpw^{inf}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} - \frac{\partial tpw^{inf}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} = \\ & - \frac{\partial s_{open}^*}{\partial \tau} \bar{w}^{inf} \frac{(s_{open}^*)^{\sigma-2}}{\lambda} \left[\int_{\lambda s_{open}^*}^{\lambda \chi s_{open}^*} \Psi(\varphi_i, w_i = \frac{\varphi_i}{\lambda s_{open}^*}) d\varphi_i \right] + \\ & \bar{w}^{inf} \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^*}{\lambda^\sigma} \frac{\sigma-2}{\lambda} T^{\sigma-1} \left[\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^\sigma \Psi(\varphi_i, w_i = \frac{\varphi_i}{T s_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right] + \\ & + \frac{\partial s_{open}^*}{\partial \tau} \frac{(s_{open}^*)^{\sigma-3}}{\lambda^2} \left[\int_{\lambda s_{open}^*}^{\lambda \chi s_{open}^*} \varphi_i \Psi(\varphi_i, w_i = \frac{\varphi_i}{\lambda s_{open}^*}) d\varphi_i \right] + \\ & + \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^*}{\lambda^\sigma} \frac{\sigma-2}{\lambda} T^{\sigma-1} \left[- \int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \left(\frac{\varphi_i}{T s_{x,for}^*} - \frac{\theta}{T} \right) \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^\sigma \Psi(\varphi_i, w_i = \frac{\varphi_i}{T s_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right] \end{aligned}$$

Plugging the Pareto distributions, we obtain

$$\begin{aligned}
&= -\frac{\partial s_{open}^*}{\partial \tau} \frac{(s_{open}^*)^{\sigma-2}}{\lambda} \frac{k_1 k_2 (\lambda s_{open}^*)^{-k_1}}{k_1 + k_2 + 1} [1 - \chi^{-k_1 - k_2 - 1}] + \frac{\partial s_{open}^*}{\partial \tau} \frac{(s_{open}^*)^{\sigma-3}}{\lambda^2} \frac{k_1 k_2 (\lambda s_{open}^*)^{1-k_1}}{k_1 + k_2} [1 - \chi^{-k_1 - k_2}] \\
&+ \bar{w}^{inf} \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^* \sigma^{-2} T^{\sigma-1}}{\lambda^\sigma} \left[\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^\sigma \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right] + \\
&- \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^* \sigma^{-2} T^{\sigma-1}}{\lambda^\sigma} \left[\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \left(\frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T} \right) \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^\sigma \Psi(\varphi_i, w_i = \frac{\varphi_i}{Ts_{x,for}^*} - \frac{\theta}{T}) d\varphi_i \right] \\
&= -\frac{\partial s_{open}^*}{\partial \tau} \bar{w}^{inf} \frac{(s_{open}^*)^{\sigma-2}}{\lambda} \frac{k_1 k_2 (\lambda s_{open}^*)^{-k_1}}{k_1 + k_2 + 1} [1 - \chi^{-k_1 - k_2 - 1}] + \frac{\partial s_{open}^*}{\partial \tau} \frac{(s_{open}^*)^{\sigma-3}}{\lambda^2} \frac{k_1 k_2 (\lambda s_{open}^*)^{1-k_1}}{k_1 + k_2} [1 - \chi^{-k_1 - k_2}] \\
&+ \bar{w}^{inf} \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^* \sigma^{-2} T^{\sigma-1} (Ts_{x,for}^*)^{k_2}}{\lambda^\sigma} \left[\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} Ts_{x,for}^* \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^{\sigma+k_2+1} \varphi_i^{-k_1 - k_2 - 1} d\varphi_i \right] + \\
&- \frac{\partial s_{x,for}^*}{\partial \tau} \frac{s_{x,for}^* \sigma^{-2} T^{\sigma-1} (Ts_{x,for}^*)^{k_2}}{\lambda^\sigma} \left[\int_{(T+\theta)s_{x,for}^*}^{\lambda \chi s_{x,for}^*} \left(\frac{\varphi_i}{\varphi_i - \theta s_{x,for}^*} \right)^{\sigma+k_2} \varphi_i^{-k_1 - k_2 - 1} d\varphi_i \right]
\end{aligned}$$

The third term is larger than the fourth term. In order to have the first term larger than

the second, we need $\frac{[1 - \chi^{-k_1 - k_2 - 1}]}{k_1 + k_2 + 1} > \frac{[1 - \chi^{-k_1 - k_2}]}{k_1 + k_2}$. Then, we have to show:

$$\left. \frac{dtwp^{for}}{d\tau} \right|_{\bar{\tau}^{foreign}} - \bar{w}^{for} \left. \frac{dL_V^{for}}{d\tau} \right|_{\bar{\tau}^{foreign}} > 0$$

which is expanded in the expression below

$$\begin{aligned}
\left. \frac{dtwp^{for}}{d\tau} \right|_{\bar{\tau}^{foreign}} - \bar{w}^{for} \left. \frac{dL_V^{for}}{d\tau} \right|_{\bar{\tau}^{foreign}} &= \frac{\partial twp^{for}}{\partial \tau} + \frac{\partial twp^{for}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} + \frac{\partial twp^{for}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} + \\
&+ \left[-\bar{w}^{for} \frac{\partial L_V^{for}}{\partial \tau} - \bar{w}^{for} \frac{\partial L_V^{for}}{\partial s_{open}^*} \frac{\partial s_{open}^*}{\partial \tau} - \bar{w}^{for} \frac{\partial L_V^{for}}{\partial s_{x,for}^*} \frac{\partial s_{x,for}^*}{\partial \tau} \right]
\end{aligned}$$

Using the same procedure as before, we can obtain the desired result if

$$\frac{T^{\sigma+k_2} (\sigma + k_1)}{(k_1 + k_2 + 1)} > 1. \blacksquare$$

Bibliography

- AEPS (2005). Anuário Estatístico da Previdência Social, Suplemento Histórico 2005. Ministério da Previdência, Brasil.
- Almeida, Rita and Pedro Carneiro (2005). Enforcement of Regulation, Informal Labor and Firm Performance. IZA Discussion paper 1759.
- Amiti, M. and D. Davis (2008). Trade, Firms and Wages: Theory and Evidence. Mimeo.
- Attanasio, Goldberg, P. and N. Pavcnik (2004). Trade Reforms and Wage Inequality in Colombia, *Journal of Development Economics*, 74, August 2004, pp. 331-366.
- Baldwin, Richard, (2005) "Heterogeneous Firms and Trade: Testable and Untestable Properties of the Melitz Model", 2005. NBER Working Papers 11471.
- Bartel, Ann P. and Nachum Sicherman (1999). Technological Change and Wages: An Interindustry Analysis. *The Journal of Political Economy*, 107(2), 285-325.
- Baum, C. and M. Schaffer and S. Stillman (2003). Instrumental variables and GMM: Estimation and Testing. Boston College Department of Economics Working Paper n. 545.
- Bernard, A. and B. Jensen and P. Schott (2005). Importers, Exporters, and Multinationals: A Portrait of Firms in the U.S. that Trade Goods. Institute for International Economics Working Paper Series WP05-10.
- Blanchflower, D. and A. Oswald and P. Sanfey (1996). Wages, Profits, and Rent-Sharing. *Quarterly Journal of Economics*, 111, pp. 227-251.

- Boisvert, H. and R. Bernard and A. Queiróz (2001). Benchmarking da função
finanças: uma análise comparativa do custeio da folha de pagamento. Mimeo.
- Borjas, George and Valerie Ramey (2000). Market Responses to Interindustry wage
differentials. NBER Working paper 7799.
- Bosch, Mariano, Edwin Goni and William Maloney (2006). The Determinants of
Rising Informality in Brazil: Evidence from Gross Worker Flows. Mimeo.
- Broda, C. and N. Limão and D. Weinstein (2008). Optimal Tariffs and Market Power:
The Evidence. *American Economic Review*, December. 98(5), p. 2032-65.
- Carneiro, F. and A. Henley. (2001). Modeling Formal vs. informal Employment and
Earnings: Micro-econometric Evidence for Brazil. Mimeo.
- Constantini, James and Marc Melitz (2007). The Dynamics of Firm-Level
Adjustment to Trade Liberalization. Mimeo.
- Cragg, M.I. and M. Epelbaum (1996). Why has wage dispersion grown in Mexico? Is
it the incidence of reforms or the growing demand for skills?. *Journal of
Development Economics*, 51, 99-116.
- Curi, A. Z. and N. Menezes (2004). Os determinantes das transicoes ocupacionais no
mercado de trabalho brasileiro. *Anais do XXXII Encontro Nacional da Anpec*.
- Currie, J. and A. Harrison (1997). Trade Reform and Labor Market Adjustment in
Morocco. *Journal of Labor Economics*, 15, S44-71.
- Dabla-Norris, E. and M. Gradstein and G. Inchauste (2008). What causes firms to
hide output? The determinants of informality. *Journal of Development
Economics*, 85, 1-27.

- Davis, Donald and James Harrigan (2007). Good Jobs, Bad Jobs, and Trade Liberalization. NBER Working Paper 13139.
- de Soto, Hernando de (1989). The Other Path. Harper & Row, New York.
- Edwards, S. (2001). The Economics and Politics of Transition to an Open Market Economy: Colombia. Paris: OECD.
- Ellery, Roberto Jr. and Victor Gomes (2007). Perfil das Exportações, Produtividade e Tamanho das Firms no Brasil. Brazilian Review of Economics (Revista Brasileira de Economia), 61(1), p. 33-48.
- Eslava, Marcela and John Haltiwanger and Adriana Kugler and Maurice Kugler (2004). The effects of Structural Reform on Productivity and Profitability Enhancing Reallocation: Evidence from Colombia". Journal of Development Economics, 75(2), 333-371.
- Feliciano, Z. (2001) Workers and Trade liberalization: The impact of trade reforms in Mexico on wages and employment. Industrial and Labor Relations Review, 55(1), 95-115.
- Ferreira, P. C. and J. L. Rossi (2003). New Evidence from Brazil on Trade Liberalization and Productivity Growth. International Economic Review, 44(4), 1383-1405.
- Freund, C., E. Ornelas, and A. Estevadeordal (2008). Does Regionalism Affect Trade Liberalization towards Non-Members? Quarterly Journal of Economics, forthcoming.
- Goldberg, P. and G. Maggi (1999). Protection for Sale: An empirical investigation. American Economic Review, 89(5), 1135-1155.

- Goldberg, P. and N. Pavcnik (2003). The Response of the Informal Sector to Trade Liberalization. *Journal of Development Economics*, 72, 463-496.
- Goldberg, P. and N. Pavcnik (2005). Trade, Wages, and the Political Economy of Trade Protection: Evidence from the Colombian Trade Reforms. *Journal of International Economics*.
- Goldberg, P. and N. Pavcnik (2007). Distributional Effects of Globalization in Developing Countries. *Journal of Economic Literature*, 45(1).
- Gonzaga, G. and N. Menezes and C. Terra (2006). Trade Liberalization and the Evolution of Skill Earnings Differentials in Brazil. *Journal of International Economics*, 68(2), 345-367.
- Grossman, G. and E. Helpman (1994). Protection for sale. *American Economic Review*, 84, 833-850.
- Haisken-DeNew, J.P. and C.M. Schmidt (1997). Inter-industry and inter-region wage differentials: mechanics and interpretation. *Review of Economics and Statistics*, 79(3), 516-521.
- Hanson, G. and A. Harrison (1999). Who gains from trade reform? Some remaining puzzles. *Journal of Development Economics*, 59, 125-154.
- Harrison, A. (1994). Productivity, Imperfect Competition and Trade Reform: Theory and evidence". *Journal of International Economics*, 36 (1-2), 53-73.
- Hildreth, A. and A. Oswald (1997). Rent-Sharing and Wages: Evidence from Company and Establishment Panels. *Journal of Labor Economics*, 15, pp. 318-337.

- IBGE (2001). Mapa do Mercado de Trabalho no Brasil 1992-1997. Informações Demográficas e Socioeconômica número 7.
- Idson, T. and W. Oi (1999). Workers Are More Productive in Large Firms. *American Economic Review Papers and Proceedings*, 89(2):104-108.
- IFS (2001). International Financial Statistics. International Monetary Fund.
- Kambourov, G. and I. Manovskii (2008). Occupational Mobility and Wage Inequality. *The Review of Economic Studies*, forthcoming.
- Karacaovali, Baybars (2005). Productivity Matters for Trade Policy: Theory and Evidence. Mimeo, University of Maryland.
- Katz, L. and L. Summers (1989). Industry Rents: Evidence and Implications. *Brookings Papers on Economic Activity*, 209-75.
- Kugler, Adriana (1999). The impact of Firing costs on Turnover and Unemployment: Evidence from the Colombian Labor Market Reform. *International Tax and Public Finance Journal*, 6(3), pp. 389-410.
- Krueger, A. and L. Summers (1988). Efficiency Wages and the Inter-Industry Wage Structure. *Econometrica*, **56**, 259-293.
- Kume, H., G. Piani, and C.F. Souza (2003). Instrumentos de Política Comercial no Período 1987-1998 in Corseuil, C. H. and H. Kume (eds.) "A abertura comercial brasileira nos anos 1990: impactos sobre emprego e salário". Rio de Janeiro: Ipea, 2003.
- Levinsohn, J. (1993). Testing the Imports-as-Market-Discipline Hypothesis. *Journal of International Economics*, 35(1-2), 1-22.

- Lifschitz, Edgardo (1991). Cálculo de los niveles de protección efectiva legal de los sectores productores de bienes 1990-1991. Documento de trabajo del proyecto: Competitividad e Integración Internacional de la economía Argentina, SIC-PNUD ARG.86-R01, abril.
- Lucas, R. (1978). On the size distribution of business firms. *Bell Journal of Economics*, 9, pp. 508-523.
- Melitz, M. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71 (6), 1695-1725.
- Menezes, N. and M. Mendes and S. E. de Almeida (2004). O diferencial de salarios formal-informal no Brasil: segmentação ou viés de seleção? *Brazilian Review of Economics*, 58(2).
- Menezes, N. and Marc-Andreas Muendler (2007) Labor Reallocation in Response to Trade Reform. UCSD working paper.
- Minnesota Population Center (2007). Integrated Public Use Microdata Series - International: Version 3.0. Minneapolis: University of Minnesota.
- Mishra, P. and U. Kumar (2007). Trade Liberalization and Wage Inequality: Evidence from India. *Review of Development Economics*, 12(2), pp.291-311.
- MTB (2008) Quadro Comparativo da Fiscalizaao do trabalho, 1990-2007. Ministério do Trabalho, Brasil.
- Muendler, Marc-Andreas (2004). Trade, Technology, and Productivity: A Study of Brazilian Manufacturers, 1986-1998.
- Neri, Marcelo C. (2002). Decent Work and the Informal Sector in Brazil. *Ensaio Econômicos EPGE* n. 461.

- Nicita, A. and M. Olarreaga (2006). Trade, Production and Protection 1976-2004. Mimeo.
- Pavcnik, N. (2002). Trade liberalization, Exit and Productivity Improvements: Evidence from Chilean Plants. *Review of Economic Studies*, 69(1), 245-76.
- Pavcnik, N. and A. Blom and P. Goldberg and N. Schady (2004). Trade Liberalization and Industry Wage Structure: Evidence from Brazil. *World Bank Economic Review*, 18(3), p. 319-344.
- Perry, G. and W. Maloney and O. Arias and P. Fajnzylber and A. Mason and J. Saavedra-Chanduvi (2007). Informality: Exit and Exclusion. *World Bank Latin American and Caribbean Studies*. Washington D.C., The World Bank.
- Portes, A., M. Castells and L. Benton (1989). *World Underneath: The Origins, Dynamics and Effects of the Informal Economy*. *The Informal Economy: Studies in Advanced and Less Developed Countries*. Eds. A. Portes, M. Castells, and L. Benton. John Hopkins, Baltimore.
- Pratap, Sangeeta and Erwan Quintin (2006). Are labor markets segmented in developing countries? A semiparametric approach. *European Economic Review*, 50, pp.1817-1841.
- Rauch, James (1991). Modeling the informal sector formally. *Journal of Development Economics*, 35, pp. 33-47.
- Roberts, M. and J. Tybout (1997). The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. *American Economic Review*, 87(4), 545-564.
- Schneider, F. and D. Enste (2000). Shadow Economies: Size, Causes, and Consequences. *Journal of Economic Literature*, 38, pp. 77-114.

- Shapiro, C. and J. Stiglitz (1984). Equilibrium Unemployment as a Worker Discipline Device. *American Economic Review*, 74(3), pp. 433-444.
- Tokman, V. (1992). The Informal Sector in Latin America: From Underground to Legal. *Beyond Regulation: The informal Economy in Latin America*. Ed. V. Tokman. PREALC, Lynne Rienner, Boulder, Colorado.
- Trefler, D. (1993). Trade Liberalization and the Theory of Endogenous Protection – an Econometric study of the United-States Import Policy. *Journal of Political Economy*, 101(1), 138-160.
- Wacziarg, R. and J. Wallack (2004). Trade liberalization and intersectoral labor movements. *Journal of International Economics*, 64, 411-439.
- Wooldridge, J. (2002). *Econometric analysis of cross-section and panel data*. MIT Press.
- Wormald, G. and J. Rozas (1996). Microenterprises and the Informal Sector in the Santiago Metropolitan Area. *Regulation and the Informal Economy: Microenterprises in Chile, Ecuador and Jamaica*. Ed. V. Tokman and E. Klein, Lynne Rienner, Boulder, Colorado.