Universitat Autònoma de Barcelona

Three essays on the shadow economy

Omar Fernando Arias Reinoso

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Universitat Autònoma
de Barcelona

Three essays on the shadow economy

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❖ PART I: PRELIMINARIES

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General abstract

The aim of this work is to study some aspects of the intersector labor movement. We study two sectors: formal and shadow. Formal sector trades legal goods with regulated economic activities. The shadow sector, instead, trades legal and illegal goods with unregulated economic activities. If the goods are legal then the shadow sector is informal. It is illegal otherwise. We would like to shed light as to the effects of some government policies on the transition of workers from one sector to the other. In the first chapter we construct an undirected search model with exogenous enforcement. In the second chapter we construct a directed search and matching model with endogenous enforcement effort. Finally, the third chapter studies the intersector labor movement in an open economy with illegal immigration. One of the key contributions of these three chapters is to remark the importance of the deterrence policy on the shadow sector. Improvements in the monitory rates make both fiscal policy and unemployment subsidies more efficient policies to reduce the amount of workers going shadow.

Key words:

Intersector labor movement; Shadow sector; Informality; Illegality; Formal sector; Fiscal policy; Entry costs; Monitory rates; Law Enforcement; Border enforcement; Immigration.

JEL classification:

D73, D83, J46, J61, J64, I25.

Resumen general

El objetivo de este trabajo es estudiar algunos aspectos del movimiento laboral intersectorial. Estudiamos dos sectores: formal y sombra. El sector formal comercia bienes legales con actividades económicas reguladas. El sector sombra, por el contrario, comercia bienes legales e ilegales con actividades económicas desreguladas. Si los bienes son legales entonces el sector sombra es informal. En el otro caso, es ilegal. El objetivo es ofrecer una mejor comprensión en cuanto a los efectos de algunas políticas gubernamentales sobre el movimiento de trabajadores de un sector a otro. En el primer capítulo construimos un modelo de búsqueda no dirigida manteniendo exógeno el esfuerzo por cumplir la ley. En el segundo capítulo construimos un modelo de búsqueda y emparejamiento dirigido pero haciendo endógeno el esfuerzo por aplicar la ley. Finalmente, el tercer capítulo estudia el movimiento laboral intersectorial en una economía abierta con inmigración ilegal. Una de las contribuciones claves de estos tres capítulos es resaltar la importancia del cumplimiento de la ley sobre los agentes que deciden trabajar en las sombras. Mejores tasas de monitoreo hacen que la política fiscal y de subsidio al desempleo sean más eficaces en su objetivo de prevenir a las personas de estar fuera de la regulación gubernamental.

Palabras clave:

Movimiento laboral intersectorial; sector sombra; Informalidad; Ilegalidad; sector formal; política fiscal; costos a la entrada; tasa de monitoreo; cumplimiento de la ley; control en la frontera; inmigración.

Clasificación JEL:

D73, D83, J46, J61, J64, I25.

General introduction

There is a huge literature dealing with the shadow economy. Its definition happens to be fuzzy. Understanding the concept requires a sort of historical deconstruction. In doing so we have to think of informality as a fundamental concept behind shadow economy. Hart (1971)[14] is a good point to start with. He studied the economic structure of the third world and noticed the existence of certain activities not complaining with the governmental regulation. A particular case arises when the workers are self-employed. These activities are referred to as informal activities. That seminal work points out that informality is a characteristic feature of the under-developing economies. The geographic remark is not innocuous. Cowell (1990)[7] explains that the structure and functioning of the informal sector in the third world, developing and developed countries have substantial differences. Hart (1971)[14] takes a photograph of the problem but he does not offer the underlying reason for an agent to go towards informality.

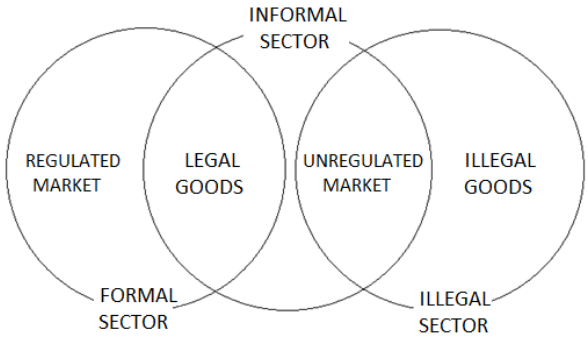
The International Labor Office (1972)[17] goes a step further. It asks about the logical reasons for an agent to choose between informality and formality. This question is crucial in understanding not just the impact of informality on the overall economy but its process of formation and evolution. However, it relies on the hypothesis that informality comes from an individual decision instead of the natural functioning of the market-based economy. The results are eclectic. Informality arises as a mechanism of subsistence for poor families. It is not a mechanism for people to become rich or accumulate capital but rather a way to provide the members of the family with the basics means to survive. In this thesis, informality emerges as an answer to poverty and, more specifically, inequality in the income distribution. Since informality avoids governmental regulations it has some illegal components. The International Labor Office (1972)[17] left the illegal feature of the informal sector unanswered.

Avoiding taxes and not compliance with the formal regulation are illegal activities *per-se*. De Soto (1989)[8] is a seminal work in studying the illegal component of informality. Going formal is costly. On one hand, firms assume hiring and firing costs because of governmental regulation; on the other hand, labor markets are competitive since firms try to reduce labor costs. Whatever the case, there is a set of agents who does not have any possibilities to do a job in the formal sector. It is because they are not productive enough to cope with the formal requirements. They rationally choose to go informal (or shadow henceforth) so as

to avoid regulations. This rational feature of the illegality comes from the literature emerged after Becker (1968)[2]. Agents decide to be either legal or illegal after solving a cost-benefit analysis. The point here is there is a differentiation between informality and illegality even though they are closely related.

There is a myriad of papers and books dealing with the differentiation between informality and illegality. Medina and Schneider (2017)[23] compresses most of them by using the term shadow economy[1]. Their work is particularly useful not only because of the conceptual differentiation but because they build an indicator for the shadow economy we have been working with during the whole thesis. Informal sector deals with legal goods or services but unregulated economic activities. Hiding from tax collectors and circumventing regulations are some causes for the informal sector to appear. Illegal sector, instead, deals with illegal goods or services with unregulated economic activities also. Think of illegal drugs, corruption and stealing of state property. Moral education and quality of state institutions are some of their causes. The line separating informality from illegality is thin. Avoiding tax payments, social security and labor market standards, occurring in the informal sector, are illegal activities in themselves. There is illegality in the informal activity even though there is no illegal production. We organize this idea in Figure 1.

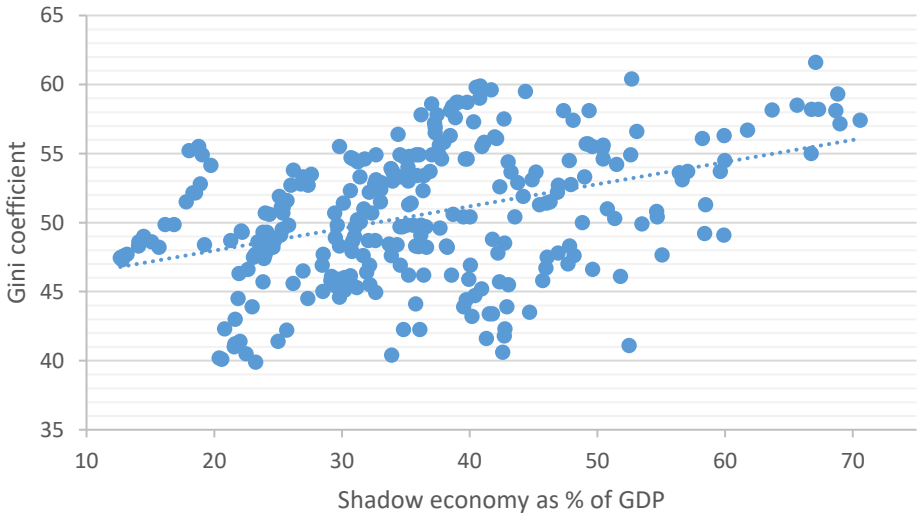
Figure 1: Relationship among formal, informal and illegal sectors



[1] Medina and Schneider (2017)[23] uses a set of economic, political and sociological variables to construct the index of shadow economy. First, fiscal policy. Thomas (1992)[28] remarks the analysis of taxes and subsidies as a burden to formality. Second, institutions. Johnson et al (1998[19],[20]) explains how corruption and the quality of institutions do affect the decision of some agents to become shadow. Third, education. Feld and Frey (2007)[12] studies the tax morale as an indicator of moral education and finally monitory rates for which Andreoni, Evard and Fenstei (1998)[1] studies deterrence as an incentive to become formal.

As depicted in Figure 1 informality could be seen as a bridge between legality and illegality. It shares part of the other two sectors. This remark is important in understanding the intersector labor mobility. Informality is the main source of income and employment for most of the labor force in the developing world. Many explanations arise as noticed in Medina and Schneider (2017)[23]. Income inequality is one candidate. There is a bidirectional relationship between informality and inequality as notice by Fender (1999)[11] and related literature[2]. Figure 2 depicts that relationship. Informal income happens to be demand-driven. It has profundous implications on the efficient use of the labor factor. If the demand is high then there will be exploitation of the already hired workers; if the demand is low, instead, then underemployment arises.

Figure 2: Shadow economy vs Gini coefficient in Latin America and Caribbean countries during 1996-2015



Source: Built form Medina and Schneider (2017)[23] and the World Bank.

[2] We divide the literature in two modelling approaches. First, there is a general equilibrium approach with papers such as Ehrlich (1973)[9], Fajnzylber, Lederman and Loayza (1997)[10] and Freeman (1996)[13]. On the other hand, a search and matching approach such as Burdett, Lagos and Wright (2003)[5], Burdett, Lagos and Wright (2004)[6]. Finally, Sah (1991)[26] and Imrohoroglu, Merlo and Rupert (2000)[16] adopts a hitherto political or conceptual approach.

There are basically two opposing approaches to the study of shadow economy. Both of them corresponds to different ways to understand the economy as a whole. On one hand, there is an orthodox/neoclassical approach[3]. It sees the shadow sector as inherently illegal. It emerges as a weakness of the governmental regulation. Tax burden and excessive legal requirements induce some agents to hide part of their production so as to minimize costs. Shadow economy is, thus, an autonomous sector apart of the legal apparatus. On the other hand, there is a heterodox or Keynesian/Marxist approach[4]. It sees the shadow sector as a natural consequence of the functioning of market-based economies. Informality is an answer for some individuals to survive under tough labor market conditions. It is defined, then, as the set of social relationships in which the reserve industrial army makes a temporary stay waiting for an opportunity to work in the formal sector. Under this conception, shadow economy is a complementary sector enclaved in the market economy. Using sociological jargon, orthodox approach is interactionist *à la* Weber; heterodox, functionalist *à la* Durkheim.

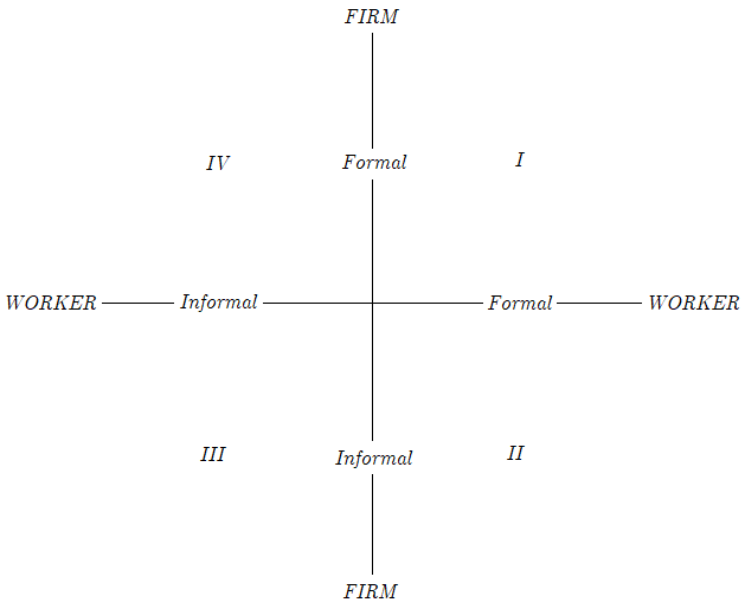
Informal employment could be bifurcated in wage and non-wage employment. Wage employment are basically subcontracted or home-based workers undertaking the production or distribution of goods and services. Most of them are women. On the other hand, the non-wage employment are self-employed or workers in family business. Most of them are men. There are multiple combinations of the formality/informality in the labor market as remarked in Biles (2009)[4]. Consider the Figure 2. We could have either formal/informal workers or formal/informal firms. Formal sector (*I*) is composed of formal workers and formal firms. Informal sector (*III*) is composed of informal workers and informal firms. There are two possible combinations between them. Some formal firms may hire some workers under informal conditions (*IV*). It is quite common in Latin-American countries. Some firms hide some workers to regulatory agencies in many forms. They could work to the firms directly or indirectly. The last panel (II) is quite unusual. Informal firms could hire informal workers. An example is

[3] Some papers related with the neoclassical approach are the aforementioned Hart (1973)[15], International Labour Office (1972[17],1993[18]). Another literature explains that state protectionism causes the shadow economy to appear. Some papers of this literature are Weeks (1975)[29], Mazumdar (1976)[22] and Roberts (1990)[25].

[4] We could bifurcate the literature here in subordination and interdependence theory. In the first group the papers Birkbeck (1979)[3] and Portes, castells and Benton (1989)[24] explain the shadow economy as a consequence of the ever-growing formal sector with the accumulation of capital. On the other hand, Sethuraman (1981)[27] belongs to the second group. In this last case, the growing of the formal sector causes the shadow economy to grow systematically because of an intersector dependence relationship.

immigrants. These workers need to legalize their residence and could get the documentation doing home-based works. In any case, informality is related with regulation of the economic activity as aforementioned in Figure 1.

Figure 3: Formality and informality from firm, worker and combinations



Source: Biles (2009)[4]

The rest of the thesis goes as follows. After this introduction we present three chapters. Chapter 1 deals with the heterodox approach. We study the relationship between entry fees in the formal sector and shadow economy. We ask how weaknesses in the governmental regulation or corruption in the formal procedures lead some entrepreneurs to go shadow. Chapter 2 deals with the orthodox approach. We extend the results from Chapter 1 to study how heterogeneity among agents might be a cause of informality and illegality. In particular, we assume individuals deliberately avoid governmental regulation by investing resources in a conflict against the public authority. Chapter 3 is a mix of the two approaches. We evaluate the impact of some enforcement policies on the relationship between international labor mobility and shadow economy. Results suggest that shadow economy appears not only because of an individual decision but also as an unintended consequence of the governmental regulation. Conclusions and references follow.

❖ ESSAY I

I. Intersector labor distribution and formal entry costs: A heterodox approach to the shadow economy

Abstract

The main purpose of this paper is to study the relationship between formal entry costs and shadow economy in a bisector search and matching model with homogeneous agents. In particular, we would like to know how differences in the entry costs due to corruption and bureaucracy explain the decision of an individual to either go shadow or remain formal. In constructing the model we follow closely the bisector search and matching model of Acemoglu (2001)[3] and Pissarides (2000)[25] with undirected search, fiscal and deterrence policies and homogeneity of individuals. In Chapter II we relax this assumption. Results indicate that wage bargaining in a non-competitive labor market is the mechanism through which formal entry costs do cause intersector labor movement.

Keywords:

Undirected search; exogenous enforcement; fiscal policy, entry costs.

JEL classification:

D73, E26, J46, J64, O17

1. Introduction

Shadow economy is ubiquitous. According to International Labour Office (2018)[18] the 61,2% of the global employment comes from the shadow economy. The emerging and developing economies explain 93% of that portion and the remaining 7% is explained by the developed world. One of the reasons for the shadow economy to be considered a problem is the lack of social security. It is particularly relevant in emerging and developing economies where shadow economy explains an important portion of the economic activity. As computed by Medina and Schneider (2017)[24] the shadow economy explained 37,8% of the GDP of the Latin-American economies during the period 2004-2015. Geographical differentiation is particularly relevant when explaining the effect of the shadow economy on the whole economic system. Cowell (1990)[9] remarks the structure and functioning of this sector depends strongly on the sort of society we are dealing with. In particular, underdeveloped economies have shadow activities in the primary sector; developing ones in the industry; finally, shadow activates are rife in the tertiary sector or services in advanced economies.

So far in the general introduction we explained the two approaches to the study of shadow economy: orthodox and heterodox. In this paper we are particularly interested in studying the heterodox approach. We leave the orthodox approach for the second chapter. Herein we would like to understand the structural reasons that make it possible for the shadow economy to emerge. Let us consider the region IV in the aforementioned Figure 2 of the general introduction. Some formal entrepreneurs in Latin-America hire both formal and informal workers at the same time so as to reduce costs. There is then a coexistence of formality with informality; capitalist and pre-capitalist labor relationships go together in economies locked in the primary sector and the low-productive zone of the secondary sector. These combinations invite us to think of the functioning of the government rather than differentials in labor productivities as a candidate to explain the genesis of the shadow economy.

The coexistence of the two sectors is possible when thinking of the economy as a continuum set. Both sectors are inter-correlated nonetheless. According to the Marxist critique shadow economy is simultaneously subordinate and dependent on the formal sector. It means formal sector causes the shadow economy to appear. The subordination relationship was initially studied in Birkbeck (1979)[5], Bromley and Gerry (1979)[7] and Portes (1978)[26] among others. The underlying

hypothesis is the center/periphery model of heterogeneous economic development. The dependence relationship, on the other hand, has been studied in the seminal works of Moser (1994)[23] and Allen (1998)[1] and the subsequent literature. The heterodox literature refers to the shadow economy as petty production of commodities. The prominent feature here is there is no excision between the property of the means of production and the labor force, that is, workers could also have means of production. It implies low scale of production and, more importantly, low labor productivity.

Following the heterodox literature the shadow economy is juxtaposed with the formal economy in a historical process of dependence. The economy as a whole is divided in center and periphery. The center is profitable and produces commodities with high added value. The periphery, instead, provides its members with subsistent means and produces commodities with low added value. This differentiation makes the center richer than the periphery, reinforcing the inequality in the income distribution. The center has a specific economic structure. According to the Marxist critique the center operates with oligopolies. Economic power is centralized and concentrated in a group of firms who colludes in prices so as to maximize their profits. In competing each other there is a technological progress that makes it possible for the firms to reduce the number of employees. The reduction of the labor demand along with an increase in the expected labor productivity leaves the job market with a growing unemployed labor force. This is the so called reserve industrial army. A paradox emerges. The demand for the shadow commodities comes from part of the formal workers who makes it possible for the cycle to reboot.

Institutions do explain economic development as studied in Acemoglu, Johnson and Robinson (2005)[2]. Shadow economy might be explained by the inappropriate functioning of governmental institutions following De Soto (1989)[12] and Loayza (1996)[21]. Fiscal policy is a friction for some agents to operate under formal economic relationships[5]. However, frictions emerge not only at the general level. Bureaucracy and corruption when implementing the policy are also frictions but at the local level. They inflate the entry costs making it more difficult for an agent to become formal as noticed in De Soto (1989)[12] and Djankov et al. (2002)[11]. The two levels of the government are mostly disconnected because of corruption. That

[5] As noticed by Castells and Portes (1989)[10] labor costs are the main criterion for agents to choose between formality and shadow economy. There is a huge set of papers studying the particular case of Latin-American countries. For instance, Monsted (2000)[22] and Gindling and Terrel (2004)[16] studies the incidence of fiscal measures on the labor costs. Schneider (2000)[27], 2001[28]) and Schneider and Enste (2000)[29] study the impact of labor market policies on the intersector labor distribution.

separation is studied in Duncan (2014)[13] as a center/periphery structure in which the local government is deliberately autonomous but the center is controlled. Frictions appear mostly in the periphery where there is no presence of the government. As Loayza (1996)[21] remarks those frictions increase the cost to open formal vacancies with which the bargaining power of the formal firm is weak in the wages determination process. In the long run, entry costs happens to explain the rise of the shadow economy.

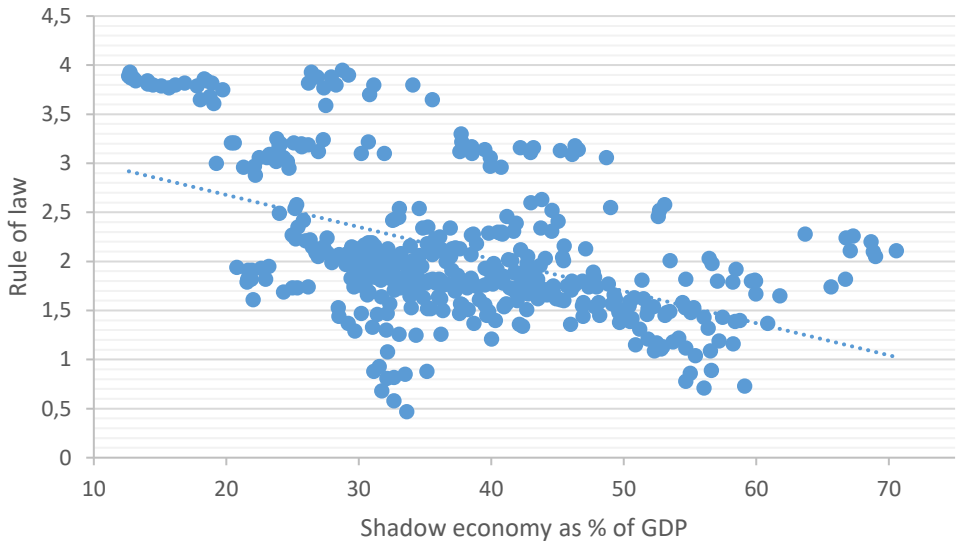
The main purpose of this paper is to study the relationship between entry costs and shadow economy in a search and matching model of the labor market with the underlying heterodox philosophical approach. In particular, we would like to know how differences in the entry costs to formality due to corruption and bureaucracy of governmental institutions explain the decision of an individual whether to go shadow or remain formal. We follow the bisector model of Acemoglu (2001)[3] and Pissarides (2000)[25] with undirected search and fiscal policy. We introduce monitory rates and punishment policies with exogenous success probabilities in the line of Bouev(2005)[30], Kolm and Larsen (2001[19], 2004[20]), Boeri and Garivaldi (2001)[6] and Fugazza and Jacques (2004)[15]. In the next chapter we relax the last assumption. We explicitly differentiate the entry cost for each sector and derive conditions under which formal and shadow economies coexist in stable equilibria. Wage bargaining is crucial in deriving the results of our model. It is the channel through which differences in entry costs implies differences in remuneration of workers and intersector labor distribution.

The rest of the paper goes as follows. After this introduction, we present some stylized facts regarding the relationship between shadow economy and corruption. We focus our attention in the Latin American and Caribbean countries during 1996-2015 because of data availability. Then we build a bisector search and matching model with exogenous monitory rates. We derive conditions for the existence and stability of equilibria consequently. We then apply a numerical exercise for what we consider is a representative developing or emerging economy and derive some policy recommendations. Discussion and references follow.

2. Stylized facts

Entry cost is a broad concept. In the next section we are going to quantify it but that measure, as any other in social science, is just one form of interpreting an abstract concept. When going formal agents face administrative and bureaucratic costs such as queues, elapsed administrative procedures, and onerous payments among others. Ineffective governments are typically sluggish to respond agent's demand. In those conditions, credibility of the public policy typically goes down. One way to measure those sentiments is the *rule of law index*. Broadly speaking it measures how confident are the agents in the efficiency of the government to enforce contracts. Figure 4 relates the rule of law index o with the shadow economy for the Latin America and Caribbean economies for the data availability. From the plot there seems that law abiding societies are supposed to be related with low levels of shadow economic activities.

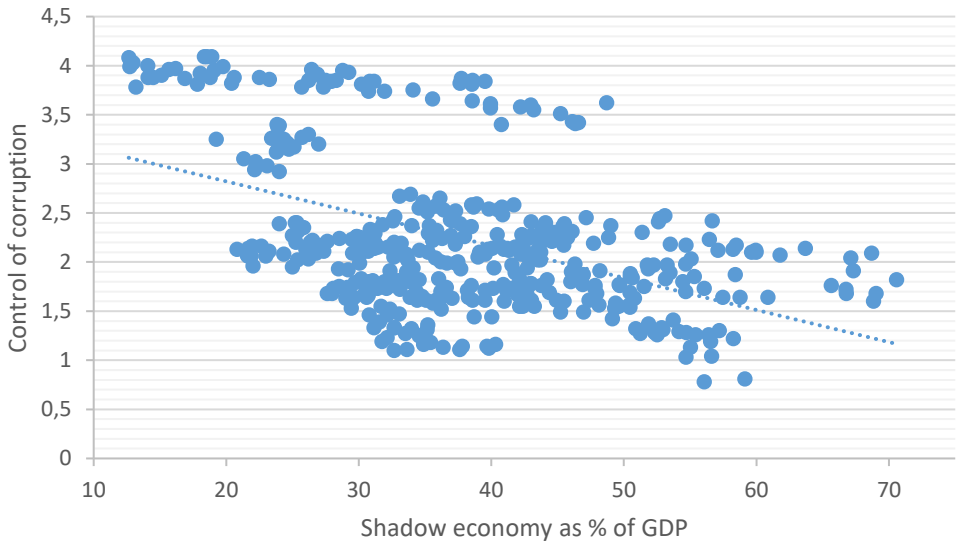
Figure 4: Shadow economy as percentage of the GDP vs Rule of law index in Latin America and the Caribbean during 1996-2015



Source: Built form Medina and Schneider (2017)[24] and the World Bank.

Public institutions are supposed to search for social welfare rather than private profits. As a social contract, government is supposed to prioritize social interests over the private ones. Corruption is the antithesis of it. The *control of corruption index* measures the perception of how the government is private-oriented rather than social-oriented. Figure 5 depicts an interesting fact. The lower the ability of the government to manage public affairs the higher the proportion of the shadow economy. People associate efficient public administration with private-oriented governments. It might be due to bureaucracy and certain inability of public administration to cope with private requests.

Figure 5: Shadow economy as percentage of the GDP vs control of corruption index in Latin America and the Caribbean during 1996-2015



Source: Built form Medina and Schneider (2017)[24] and the World Bank.

In Table 1 there is a set of descriptive statistics about the shadow economy, rule of law and control of corruption for the Latin American economies during the period 1996-2015. The countries in the sample have in common high levels of shadow economy with low levels of rule of law and control of corruption indexes. Table 2 depicts the covanriance/correlation matrix for the different variables we are working with. Notice there seems to be a statistical relationship between shadow economy and the two indexes aforeanalyzed.

Table 1: Descriptive statistics: mean, median, standard deviation and Kurtosis

	Shadow economy	Control of corruption	Rule of law	GDP per capita	Unemploy. Rate
Mean	37,84	2,23	2,09	6811,08	7,83
Median	36,50	2,09	1,91	4758	7,14
Maximum	70,57	4,09	3,95	32080	20,52
Minimum	12,64	0,78	0,47	662	2,01
Std. Dev.	11,60	0,78	0,73	6223,08	3,92
Skewness	0,32	0,96	0,87	2,29	0,69
Kurtosis	2,84	3,06	3,27	8,98	2,71
Jarque-Bera	7,94	65,30	55,49	995,07	35,28
Probability	0,01	0,00	0,00	0,00	0,00
Sum	15895,42	939,67	879,62	2860657	3292,52
Sum Sq. Dev.	56417,83	256,64	229,18	1.62E+10	6463,88
Observations	420	420	420	420	420

Table 2: Covariance/correlation matrix

	Shadow economy	Control of corruption	Rule of law	GDP Per Capita	Unemploym ent rate
Shadow economy	134.32				
	1.00				
Control of corruption	-4.39	0.61			
	-0.48	1.00			
Rule of law	-4.38	0.54	0.54		
	-0.51	0.94	1.00		
GDP Per Capita	-35185.28	3146.96	2824.65	38634589	
	-0.48	0.64	0.61	1.00	
Unemployment Rate	-7.01	0.63	0.54	5534.28	15.39
	-0.15	0.20	0.18	0.22	1.00

There is statistical evidence of a relationship between the shadow economy and both the rule of law and the control of corruption in the Latin American and Caribbean countries during 1995-2015. Table 1 reports the results. Entry costs or bureaucracy increases the importance of the shadow economy. Law abiding societies tend to have formal economies. We could see bureaucracy as a sort of barrier to entry to the formal economy inducing agents to go shadow. The Appendix of this chapter contains the results for the relationship between shadow economy and both rule of law index and control of corruption index for each of the 21 countries in the sample in the same period.

Table 3: Shadow economy vs rule of law and control of corruption

Predictor variable	(1)	(2)	(3)	(4)	(5)	(6)
Constant	206,3***	205,39***	220,3***	207,5***	45,31***	37,28***
	(16,7)	(9,5)	(15,9)	(9,34)	(2,32)	(2,95)
Rule of law	-2,44***	-1,00				-2,91***
	(0,73)	(0,66)				(0,83)
Control of Corruption			-5,09***	-3,35***	-5,89***	
			(0,88)	(0,85)	(1,01)	
Log(GDPperCapita)	-19,6***	-19,89***	-20,5***	-19,5***		
	(1,97)	(1,05)	(1,85)	(1,05)		
Unemployment rate	0,34***	0,42***	0,34***	0,44***	0,73***	0,85***
	(0,07)	(0,07)	(0,07)	(0,07)	(0,07)	(0,08)
N. of Obser. = 420						
R^2	0,95	0,60	0,95	0,6	0,94	0,23
A- R^2	0,95	0,60	0,95	0,6	0,93	0,23
RE		X		X		X
FE	X		X		X	

Note: Panel regression for the Latin American and Caribbean economies during the period 1996-2015 for the shadow economy being explained by the rule of law index and the control of corruption index controlling by Gross Domestic Product per capita and unemployment rate. The level of significance is determined by *p<0,05; **p<0,01; ***p<0,001. RE and FE stand for Randon and Fixed effects respectively. The number in parenthesis represent standard errors.

3. The model

We build a two-sector search and matching model. There is a formal sector (F) and an shadow sector (S). The counter for the sectors is $i \in \{F, S\}$. Formal sector produces legal goods with regulated economic activities. Shadow sector produces legal or illegal goods with unregulated economic activities. Both sectors have search frictions. Final product of each sector is perfect substitute each other. Being formal requires entrepreneurs to pay a registration cost. Registration costs could be seen not only as a fee but also as the opportunity cost of following the regular path. Shadow economy does not incur in registration costs. Formal agents pay taxes. Shadow agents avoid to pay taxes. They succeed with an exogenous probability $\mathcal{P} \in (0,1)$. In the following chapter we make it endogenous by modeling the conflict between illegal agents and the government.

Government in turn monitors shadow activity. It interdicts shadow activity with probability $1 - \mathcal{P}$. Shadow agents must pay a penalty $P > 0$ if caught. People working in the formal sector are formal workers; shadow workers otherwise. Formal and shadow workers are equally productive. Workers in the economy undertakes just one activity at a time and it is either formal, shadow or unemployed. Agents are risk-neutral in both sectors searching each other to allow a match. Entrepreneurs and workers negotiate wages when met. In both sectors wages are determined according to Nash bargaining. Each agent has bargaining power. Wage differential comes from both rent-sharing in the wage negotiation and governmental policies such as taxes and monitoring rates.

3.1 Unemployment

There is a continuum of workers of mass 1. There are U unemployed workers in the economy. It is at the same time the unemployment rate. Formal and shadow workers are denoted by F and S respectively. The population in this economy is divided as

$$F + S + U = 1 \qquad (I.1)$$

Each firm opens a vacancy at a time. Let $v \in (0,1)$ be the vacancy rate. The parameter $\theta = v/u$ is the thigh of the labor market. The matching function $X(u,v)$ is a continuous and differentiable function representing the number of job matches at each time. The probability of filling a vacancy is $q(\theta) = X(u,v)/v$. The duration of the vacancy is $1/q(\theta)$. The probability of finding a job is $\theta q(\theta) = X(u,v)/u$. The duration of the unemployment is $1/\theta q(\theta)$. These probabilities satisfy the following Inada conditions:

$$\lim_{\theta\to\infty} q(\theta) = 0; \quad \lim_{\theta\to 0} q(\theta) = \infty$$
$$\lim_{\theta\to\infty} \theta q(\theta) = \infty; \quad \lim_{\theta\to 0} \theta q(\theta) = 0$$

Only unemployed workers look for a job. Search is undirected. Unemployed workers receive simultaneously job offers from each of the two sectors. Unemployed workers will accept the first job offer who offers him an income at least as good as the unemployment benefit. The unemployment benefit is Z. The probability of receiving a formal job offer is $\phi \in (0,1)$. The probability of receiving a shadow job offer is $1-\phi$. These probabilities are exogenous. The value of being employed in sector i is E_i. The present value function of the unemployment is given by

$$rU = Z + \theta q(\theta)[\phi(E_F - U) + (1-\phi)(E_S - U)] \qquad (I.2)$$

The intuition of this equation is: Unemployed workers earn a subsidy Z and with probability $\theta q(\theta)\phi$ get a formal employment or with probability $\theta q(\theta)(1-\phi)$ get a shadow employment. In the formal sector jobs are destroyed at a Poisson rate $\delta \in (0,1)$. Formal workers who become unemployed are δF. The unemployed workers hired by the formal sector are $\theta q(\theta)\phi U$. The evolution of the formal employment is

$$\dot{F} = \theta q(\theta)\phi U - \delta F \qquad (I.3)$$

In the stationary state i.e $\dot{F} = 0$ we have

$$F = \frac{\theta q(\theta)\phi U}{\delta} \qquad (I.4)$$

On the other hand, shadow jobs are destroyed at a Poisson rate $1-\mathcal{P} \in (0,1)$. Shadow workers who become unemployed are $(1-\mathcal{P})S$. The unemployed workers hired by the shadow sector are $\theta q(\theta)(1-\phi)U$.

$$\dot{S} = \theta q(\theta)(1-\phi)U - (1-\mathcal{P})S \tag{I.5}$$

In the stationary state i.e $\dot{S} = 0$ we have

$$S = \frac{\theta q(\theta)(1-\phi)U}{1-\mathcal{P}} \tag{I.6}$$

Let us calculate the unemployment rate of the economy. People getting out of the unemployment is $\theta q(\theta)U$. The motion law of U is

$$\dot{U} = \delta F + (1-\mathcal{P})S - \theta q(\theta)U \tag{I.7}$$

In the stationary state i.e $\dot{U} = 0$ we have

$$U = \frac{\delta F + (1-\mathcal{P})S}{\theta q(\theta)} \tag{I.8}$$

We can calculate the portion of people in each sector in terms of the fundamental parameters of the model. Notice $F + S = 1 - U$. The proportion of people in the unemployment:

$$U = \frac{\frac{1}{\theta q(\theta)}}{\frac{\phi}{s} + \frac{1-\phi}{1-\mathcal{P}} + \frac{1}{\theta q(\theta)}} \tag{I.9}$$

The unemployment rate is inversely related with the tightness of the labor market. The relationship between U and ϕ will be studied later on since there is also a relationship between θ and ϕ. The proportion of people in the shadow sector.

$$S = \frac{\frac{1-\phi}{1-\mathcal{P}}}{\frac{\phi}{s} + \frac{1-\phi}{1-\mathcal{P}} + \frac{1}{\theta q(\theta)}} \tag{I.10}$$

The number of shadow workers is directly related with the tightness of the labor market. The proportion of people in the formal sector.

$$F = \frac{\frac{\phi}{s}}{\frac{\phi}{s} + \frac{1-\phi}{1-\mathcal{P}} + \frac{1}{\theta q(\theta)}} \qquad (I.11)$$

The number of formal workers is also directly related with the tightness of the labor market. The static comparative analysis will shed some light about the different relationships among the variables.

3.2 Formal and shadow economies

Workers only get money from working to firms. Wages in the formal sector are w_F. Formal employees pay τw_F to the government as a tax. The value function of the employment in the formal sector is

$$rE_F = w_F(1-\tau) + \delta(U - E_F) \qquad (I.12)$$

The intuition of this equation is the following: We could see rE_F as an expected value.
Formal workers obtain $w_F(1-\tau)$ with certainty and $U - E_F$ with probability δ. Each formal and shadow worker produces a fixed amount A. Let us assume that A represents the market value of the commodity. Formal employers open a vacancy whose value is V_F. Formal employers pay ρw_F to the government as a tax. The value function of a job in the formal sector

$$rJ_F = A - w_F(1+\rho) + \delta(V_F - J_F) \qquad (I.13)$$

The intuition of this equation is as follows: We could see rJ_F as an expected value. Formal employers obtain $A - w_F(1+\rho)$ with certainty and $V_F - J_F$ with probability δ. Firms incur in a fixed cost γ_i when opening a vacancy. This cost is irreversible. We assume $\gamma_F > \gamma_S$ because of the formal registration fees and the opportunity cost of following the regular path. The value function of a vacancy in each sector is

$$rV_i = q(\theta)(J_i - V_i) - \gamma_i \qquad (I.14)$$

Wages in the shadow sector are w_S. Shadow employees are caught with probability $1-\mathcal{P}$. They have to pay P as a penalty if caught. The value function of the employment in the shadow sector is

$$rE_S = \mathcal{P}w_S + (1-\mathcal{P})(U - E_S - P) \tag{I.15}$$

The intuition is as follows: We could again see rE_S as an expected value. Shadow employees obtain w_S with probability $\mathcal{P}$ and $U - E_S - P$ with probability $1-\mathcal{P}$. We do not discriminate the penalty of each agent in the Shadow sector. The value function of a job in the shadow sector

$$rJ_S = \mathcal{P}(A - w_S) + (1-\mathcal{P})(V_S - J_S - P) \tag{I.16}$$

This is a Von-Neumann-Morgenstern expected utility. Informal employers obtain $A - w_S$ with probability $\mathcal{P}$ and $V_S - J_S - P$ with probability $1-\mathcal{P}$.

3.3 Formal and Shadow wages

There is wage negotiation in each sector. The wage negotiation follows a Nash bargaining. Each part has certain bargaining power and the rent is distributed accordingly. That bargaining occurs after opening a vacancy but before the hiring. The wage does not change during the contract term. Assume $\beta \in (0,1)$ is the bargaining power of the workers. The bargaining power of the employers is $1-\beta$. The Nash bargaining function is

$$\Omega_i = (E_i(w_i) - U)^{\beta}(J_i(w_i) - V_i)^{1-\beta} \tag{I.17}$$

The first term $E_i(w_i) - U$ indicates the surplus of the worker. The second term $J_i(w_i) - V_i$ indicates the surplus of the employer. Solving this problem gives us the equation of wages in each sector. The solution is given in Proposition 1 and the proof is relegated to the Appendix.

Proposition 1: *Wages in each sector are given by*

$$w_F = \left(\frac{\beta}{1+\rho}\right)A + \frac{1}{1-\tau}[\,(1-\beta)z + \beta\theta\varphi(\phi;\gamma_F;\gamma_S)]$$
$$w_S = \beta A + \frac{1}{\mathcal{P}}[(1-\mathcal{P})(1-2\beta)P + (1-\beta)z + \beta\theta\varphi(\phi;\gamma_F;\gamma_S)]$$

Where

$$\varphi(\phi;\gamma_F;\gamma_S) = \left(\frac{1-\tau}{1+\rho}\right)\phi\gamma_F + (1-\phi)\gamma_S$$

Proof: See Appendix □

The two sectors coexist in the long-run. The behavior of the wages hinges upon the different parameters. In particular, they are related with each part bargaining power. Differences in entry costs and monitory rates are crucial in determining wages controlling for the respective bargaining power. Consider the particular case of wage posting. It seems that some developing countries do not negotiate wages. In particular, there is no negotiation in shadow wages. Even in those cases there are wage differential. Let us study the implications of $\beta = 0$ in our model.

Proposition 2: *If there is wage posting i.e* $\beta = 0$ *then*

$$w_F - w_S = \left(\frac{\tau}{1-\tau}\right)z - \left(\frac{1-\mathcal{P}}{\mathcal{P}}\right)P$$

Proof: Using Proposition 1 with $\beta = 0$ □

Formal wage increases with the tax; shadow wages with the monitory rate. Higher unemployment benefits and penalties increases formal and shadow wages respectively. If $\mathcal{P} = 1$ then $w_F > w_S$ reflecting the fact that monitory rates inflates shadow wages. The wage difference relies fundamentally on both fiscal and monitory policy.

3.4 Equilibrium

There is no market power in any labor market. There are many entrepreneur such that prices equals marginal costs. Free entry guarantee that markets for the final product clear. Opening a vacancy in each sector generates zero profits.

Definition 1: Given the vectors $\boldsymbol{J} = [J_S; J_F]$, $\boldsymbol{V} = [V_S; V_F]$ *and* $\boldsymbol{E} = [E_S; E_F]$ *an equilibrium in the bi-sector search economy is a vector* $[\theta^*; \phi^*; \boldsymbol{J}^*; \boldsymbol{V}^*; \boldsymbol{E}^*]$ *satisfying Equations (12)-(13)-(14)-(15)-(16).*

The equilibrium comes from the encounter of workers and firms in bargaining wages. Bargaining the wages implies certain market power. The stronger sector defines the type of equilibrium. If there is corner equilibrium in which one sector does not produce then it loses money and the other wins. We will analyze that later on in the section of economic welfare.

Proposition 3: *The equations of the equilibrium for each sector are*

$$A(1-\beta) - \frac{(r+\delta)\gamma_F}{q(\theta)} - \left(\frac{1+\rho}{1-\tau}\right)[(1-\beta)z + \beta\theta\varphi(\phi;\gamma_F;\gamma_S)] = 0$$

$$A\mathcal{P}(1-\beta) - \frac{(r+1-\mathcal{P})\gamma_S}{q(\theta)} - 2(1-\mathcal{P})(1-\beta)P - [(1-\beta)z + \beta\theta\varphi(\phi;\gamma_F;\gamma_S)] = 0$$

Proof: Using Proposition 1, Equations (13) and (16) along with $V_j = 0$ □

The equations in *Proposition 3* defines two loci for each sector in the (θ, ϕ)-plane. We are particularly interested in computing $\partial\theta/\partial\phi$ in each sector. The key parameters here are the fiscal policy and entry costs. We would like to have an expression of $\partial\theta/\partial\phi$ in terms of the tax parameter and entry costs. That is the purpose of *Proposition 4*.

Proposition 4: At $[\theta^*; \phi^*; \boldsymbol{J}^*; \boldsymbol{V}^*; \boldsymbol{E}^*]$ *from Proposition 3 we have*

$$sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_F\right\} = sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_S\right\} = sign\left\{\gamma_S - \left(\frac{1-\tau}{1+\rho}\right)\gamma_F\right\}$$

Proof: See Appendix □

Proposition 4 finds a relationship between θ and ϕ in terms of τ, ρ and the entry costs γ_F and γ_S. By definition $\gamma_F > \gamma_S$. However, the proportion $(1-\tau)/(1+\rho)$ make it possible $\gamma_F > \gamma_S$ do not stand. Fiscal policy parameters would make indeterminate the relationship between θ and ϕ. It gives us at least There are 8 possibilities. The 8 possibilities are depicted in the annex.

3.5 Comparative statics

From *Proposition 3* we undertake the static comparative analysis. The key point is to understand the impact of changes in the different parameters on the unemployment and employment rates. The *proposition 5* computes the impact of the different variables. As we see an increase in the fundamental variables increase the unemployment rate.

Proposition 5: At $[\theta^*; \phi^*; \boldsymbol{J}^*; \boldsymbol{V}^*; \boldsymbol{E}^*]$ *we have*

$$sign\left\{\frac{\partial U}{\partial \theta}\right\} = sign\left\{\frac{\partial \theta}{\partial(1-\mathcal{P})}\right\} = sign\left\{\frac{\partial \theta}{\partial P}\right\} = sign\left\{\frac{\partial \theta}{\partial z}\right\} = sign\left\{\frac{\partial \theta}{\partial \tau}\right\} = sign\left\{\frac{\partial \theta}{\partial \rho}\right\} = -$$

Proof: See Appendix □

Now, we would like to see the impact of the parameter on the main employment ratios. Consider the ratio F/I given by $F/I = \phi(1-p)/s(1-\phi)$. We see an increase in $(1-p)$ decreases θ and increases F/I. The ratio I/U is given by $I/U = \theta q(\theta)(1-\phi)/(1-p)$. We see an increase in $(1-p)$ decreases θ and it decreases I/U. The ratio F/U is given by $F/U = \theta q(\theta)\phi/s$. We see an increase in θ increases F/U.

3.6 Welfare

We would like to know how efficient the private solution is. It implies defining a social welfare function that represents the preferences of the agents in the economy. There are basically three agents: formal, shadow and unemployed. Formal firms produce the amount FA of goods and services. Shadow firms produce the amount IpA of goods and services. Let us define a new parameter $\xi \in [0,1]$ representing the importance of the shadow sector to the society. We know the government would like to eliminate the shadow production. The shadow production involves legal and illegal commodities. Some of those commodities might improve the social welfare. Government values ξIpA the shadow production. The cost of capital in the Formal sector is $\theta U \phi \gamma_F$. The cost of capital in the Shadow sector is $\theta U(1-\phi)\gamma_S$. Cost of capital of the economy is $\theta U(\phi\gamma_F + (1-\phi)\gamma_S)$. Unemployed workers get zU.

Social utility function is

$$SU = \int_0^\infty e^{-rt}\big(FA + \xi IpA - \theta U\big(\phi\gamma_f + (1-\phi)\gamma_i\big) + zU\big)dt \qquad (I.18)$$

We know the interior solution is inefficient. It implies there is an inefficiently high amount of shadow work. Instead of studying the interior solution let us consider the corner equilibrium. That is, consider the case in which there is no shadow economy. Let us consider a corner solution when $\xi = 0$. It implies $\phi = 1$ since there is no shadow employment. The modified social utility function is

$$SU = \int_0^\infty e^{-rt}(A(1-U) - \theta\gamma_F U + zU)dt$$

Restrictions are defined by the evolution of the unemployment rate

$$\dot{U} = sF - \theta q(\theta)U$$

We are to write now the intertemporal problem as

$$\mathbb{H} = e^{-rt}(A(1-U) - \theta\gamma_F U + zU) + \lambda[s(1-U) - \theta q(\theta)U]$$

The first FOC $\mathbb{H}'_\theta = 0$ is given by

$$\lambda = -\frac{\gamma_F e^{-rt}}{q(\theta)(1-\eta)}$$

Where $\eta = \frac{\partial q(\theta)}{\partial \theta}\frac{\theta}{q(\theta)}$ is the elasticity of $q(\theta)$ respect θ. Notice $\dot{\lambda}/\lambda = -r$. The second FOC $\mathbb{H}'_u = r\lambda$ is given by

$$0 = (1-\eta)(A-z) - \eta\gamma_F\theta - \frac{(r+\delta)\gamma_F}{q(\theta)} = 0$$

Comparing the system

$$(1-\eta)(A-z) - \eta\gamma_F\theta - \frac{(r+\delta)\gamma_F}{q(\theta)} = 0$$
$$(1-\beta)\left(A - \left(\frac{1+\rho}{1-\tau}\right)z\right) - \beta\gamma_F\theta - \frac{(r+\delta)\gamma_F}{q(\theta)} = 0$$

The two equations are the same only when

$$\begin{aligned} \beta &= \eta \\ \rho + \tau &= 0 \end{aligned} \qquad (I.19)$$

The first condition is the Hosio's condition and it is the bargaining power of the worker is the same as the elasticity of $q(\theta)$ respect θ. The second condition is a fiscal redistribution. Efficiency requires the government transfer the amount of money it gets from one sector to the other. It implies two things: 1) Bargaining power of the workers must be equal to the elasticity of the matching function. 2) There must be a redistribution of the taxes to compensate each part. The private solution is then socially inefficient since $\rho > 0$ and $\tau > 0$.

4. Numerical simulations

The aim of this section is to implement some numerical experiments as to the effect of public policy on the intersector labor distribution. This section is divided in two parts. First, we make a construct the baseline economy. In this economy we use some parameters commonly used in the cited literature to match certain targets. Our main target here is the tightness of the labor market. We then apply the Newton-Raphson solution in Matlab® to solve the nonlinear equation for the wages

in each sector. Second, we implement changes in the policy instruments so as to see the impact it has on the fundamental variables of our model. This replica exercise of the comparative static analysis offers numerical information as to the ultimately consequence of public policy given the initial conditions. In particular, we would like to know how fiscal policy and unemployment benefits change the fundamental solution of our model given the monitory rates and differences in entry costs as we assume.

4.1 Baseline economy

In the following table we set the main parameter of the model. The idea here is to assign values to the fundamental coefficients of an economy bearing two things in mind; first, a shadow employment rate around 18-25% and a tightness of the labor market ranging around 8-15%. To cope with this target we select the value of each parameter from a uniform probability function maintaining the economic intuition of the search and matching model as to the determinacy of equilibria and their stability that we study in the corresponding annex.

Table 4: Parameter of the baseline economy

Parameter	Value	Definition
A	7,0	Labor productivity
P	1,0	Penalty for avoiding regulations
$\mathcal{P}$	0,5	Monitory rate of the shadow economy
β	0,3	Employer bargaining power
δ	0,1	Rate of destruction of labor contracts
r	0,05	Real interest rate
γ_F	1,5	Formal entry cost
γ_S	0,5	Shadow entry cost
ρ	0,3	Tax burden for the employer
τ	0,3	Tax burden for the employee
ϕ	0,3	Probability of receiving a formal job offers

We implement our Matlab® solution to the equilibrium equations in Proposition 3 with the information from Table 4. The results of this experiment comes in the next subsection.

4.2 Experiments

First, we analyze the impact of changes in the unemployment benefit. We present the results in Table 5. An increment in the unemployment subsidy reduces the thigtness of the labor market and increases the unemployment rate of the economy. Formal employment remains the same but the shadow employment rate goes down. The intuition is as follows. An increase in the unemployment rate make it possible for an agent to elapse the waiting time for a formal job offer. Meanwhile he receives the unemployment subsidy and the aggregation of that subsidy with the probability of being hired in the formal sector reduces the probability of receiving a shadow job.

Table 5: Changes in unemployment benefit with $\mathcal{P} = 0{,}4$

	Unemployment benefit ($\boldsymbol{z}$)		
Variables	0	0,5	1
$\boldsymbol{\theta}$	12,4	10,6	8,87
$\boldsymbol{u}$	6,3	6,8	7,4
$\boldsymbol{S}$	26,2	26,1	25,9
$\boldsymbol{F}$	67,4	67,1	66,6
$\boldsymbol{w_F}$	4,7	4,8	4,9
$\boldsymbol{w_S}$	8,2	8,3	8,4

Now let us replicate the analysis with a higher $\mathcal{P}$. We present the results in Table 6. The consequences of increasing the unemployment benefit are the same but there is an increment in the shadow unemployment rate with respect to the formal

unemployment rate. Notice the shadow wage is lower than it was in the previous case. It is because of a reduction in the risk of undertaking shadow activities. High shadow wages are associated with high risk. In either case, there is a reduction of the main variables as a consequence of increasing the unemployment benefit as it is shown in the comparative statics section.

Table 6: Changes in unemployment benefit with $\mathcal{P} = 0{,}6$

	Unemployment benefit ($\boldsymbol{z}$)		
Variables	0	0,5	1
$\boldsymbol{\theta}$	12,4	10,6	8,87
$\boldsymbol{u}$	5,6	6,1	6,6
$\boldsymbol{S}$	34,8	34,6	34,4
$\boldsymbol{F}$	59,6	59,3	58,9
$\boldsymbol{w_F}$	4,8	4,8	4,9
$\boldsymbol{w_S}$	6,1	6,1	6,2

Let us now turn out attention to the fiscal policy. We study two scenarios. We differentiate each analysis with ϕ. In the Table 7 we consider the case in which $\phi < 0{,}5$ where there is more probability of getting a shadow job than getting a formal job. The other case will be considered in the Table 5.

Increasing the taxes reduces both the tightness of the labor market and the unemployment rate. There is no a significant impact in the amount of people working in each sector notwithstanding. This result is particularly interesting in the political debate. Fiscal policy has historically been considered an instrument for the government to move people from one sector to the other. In particular, taxes are cited as a reason for many entrepreneurs to go shadow. However, our analysis suggest this intuition is questionable. Fiscal policy reduces its strength when considering substantial differences in the entry cost between the sectors.

Parameter ϕ plays a key role in our analysis. Let us implement a sensitivity analysis for this case. In Table 8, for instance, there is a high probability of getting a shadow job but there is also an important portion of people going shadow regardless the level of taxation. We conclude introducing differences in entry costs and allowing the possibility of some individuals go shadow shed some light as the efficiency of the policy instruments as to control what has been considered a pervasive phenomenon.

Table 7: Changes in fiscal policy with $\phi = 0{,}3$, $\mathcal{P} = 0{,}4$ and $z = 0$

	Fiscal policy $(\boldsymbol{\rho}, \boldsymbol{\tau})$		
Variables	$\rho = 0{,}3$ $\tau = 0{,}5$	$\rho = 0{,}5$ $\tau = 0{,}3$	$\rho = 0{,}5$ $\tau = 0{,}5$
$\boldsymbol{\theta}$	10,24	11,49	9,35
$\boldsymbol{u}$	6,9	6,6	7,2
$\boldsymbol{S}$	26,1	26,1	25,9
$\boldsymbol{F}$	66,9	67,2	66,7
$\boldsymbol{w_F}$	4,8	4,15	4,2
$\boldsymbol{w_S}$	6,7	7,5	6,2

Table 8: Changes in fiscal policy with $\phi = 0{,}6$, $\mathcal{P} = 0{,}4$ and $z = 0$

	Fiscal policy $(\boldsymbol{\rho}, \boldsymbol{\tau})$		
Variables	$\rho = 0{,}3$ $\tau = 0{,}5$	$\rho = 0{,}5$ $\tau = 0{,}3$	$\rho = 0{,}5$ $\tau = 0{,}5$
$\boldsymbol{\theta}$	9,8	10,4	9,35
$\boldsymbol{u}$	4,5	4,4	4,7
$\boldsymbol{S}$	9,5	9,5	9,5
$\boldsymbol{F}$	85,9	86,1	85,8
$\boldsymbol{w_F}$	4,8	4,2	4,2
$\boldsymbol{w_S}$	6,7	7,6	6,2

5. General discussion and conclusion

Shadow economy is a pervasive phenomenon. It is ubiquitous in almost all market-based economies. We could define it as the set of unregulated social relationships of production, distribution and consumption of goods and services. There is a never-ending discussion about the necessity of governmental regulation. Orthodox thinkers would say that any kind of governmental intervention is undesirable. It distorts the efficient distribution of resources from free markets. Individual ambition serves the common good following the Smithsonian logic. On the other hand, heterodox thinkers would remark the necessity of governmental intervention. Markets are inherently unstable and the invisible hand has the counterpart of the invisible elbow. Allowing people to freely follow their own interest is socially inefficient. *Lex dura sed lex* notwithstanding.

For the sake of social welfare the government regulates the economic activity in all of its phases. Some activities flee from that regulation. Think of street vendors, hawking or undeclared domestic work, on one hand; and organized crime, bribery, money laundering and forfeiting, on the other hand. We could think of a myriad of examples of unregulated economic activities. It is our interest to organize them in a comprehensible manner. The plethora of different terms used to describe informality, as Kabra (1995)[31] remarks, is a proof of the necessity of being clear in the definition. One way to do it is to differentiate the good or service in itself and its process of production and distribution. This is the key for our definition of the shadow economy. Illegality deals with illegal goods and services such as cocaine or robbery; informality with unregulated activities such as street vendors of legal goods or undeclared workers of legal workshops.

Hart (1973)[17] studies the Ghana's informal sector by using a dualistic approach. He divided the economy in two sectors: formal, which uses modern production systems, and informal, which uses traditional techniques. This differentiation also applies to the labor market. The formal labor market is characterized by wage earning jobs whereas the informal labor market has mainly self-employment. We could also identify each sector by its protection from the government. Weeks (1975)[22] identifies formality as a protected sector and informality as an unprotected one. Protection is understood out of technical and financial instruments. Bromley (1978)[8] explains that dividing the labor market in such a way is a replica of the division of the economy in different broad sectors. Think of the primary sector, agriculture, in which there is low labor productivity in comparison with the tertiary sector, services, who has high-productivity labor force. Even though they are related each sector is autonomous and has a particular market structure as explained in International Labor Office (1993)[18].

Working in the shadow makes the informal sector unable to reach public resources. Some inputs require governmental license. Informal entrepreneurs should go to the black market to achieve the needed resources for their economic activities. Working in small-scale causes the informal sector to be intensive in the use of labor. In particular, low-productive labor. In the case of wage employment there are low informal wages. Following the idea of the *Hecksher-Ohlin* model of international trade we would say that informal sector specializes in the production and distribution of those goods and services which are intensive in low-productive labor force. It exacerbates both the necessity for informal agents to hide so as to avoid tax payments and governmental regulations and enhance the income inequality with respect to the other two sectors of the economy.

Informality is indeed a social problem. Informal income does not generate taxes by definition. It affects the public finance. Low tax collection reduces the ability of the government to provide public services such as education and health. It is difficult even to estimate an optimal taxation scheme since there is no proper accountability. Most of the informal entrepreneurs and workers have low levels of education. They see monitory agents as enemies in their fight of social classes. Informal employment, nonetheless, has no social security whatsoever. In most of the cases the informal labor contracts are unfair and unstable subject to changes in the demand of the good or service they work on. One final remark goes on urban planning. Informality stands as a challenge for urban planners since they do not have a specific place to work. Street vendors move along the city and even a house who is supposed to be a quiet place become a workshop with some machinery and flow of workers.

Being in the shadow has serious threats. Literature is plenty of considerations, let us collect them. First, there are inner threats. Informal entrepreneurs have no managerial abilities to undertake business. It prevents them to enlarge the level of activity. Market strategies are not necessarily efficient either. Demand-driven business are inherently inefficient in the use of resources. Price competition, which is the norm in the informal sector, makes the income volatiles to many macroeconomic shocks. Second, there are external threats. The industrialization process and accelerated depreciation of capital reduces the productivity in the informal sector and increases the income inequality with respect to the formal sector. Even the cost of capital is a critical threat. Rising money in the informal sector requires informal entrepreneurs to search for informal lenders who charge huge interest rates. In both of the cases informal sector seems to be enclave in the economy with few possibilities to improve income and employment conditions.

6. Appendix

This appendix organizes the proof of some of the propositions stated throughout the paper. It also contains graphics and tables. The appendix is not intended for publication. It is intended as an explanation to the main points of the chapter.

6.1 Proofs

Proposition 1

The optimality condition for formal and informal sectors are respectively

$$\begin{aligned} \beta(1-\tau)(J_F(w_F)-V_F)-(1-\beta)(1+\rho)(E_F(w_F)-U)=0 \\ \beta\mathcal{P}(J_S(w_S)-V_S)-(1-\beta)\mathcal{P}(E_S(w_S)-U)=0 \end{aligned} \tag{A.1}$$

We can rewrite them as follows

$$\begin{aligned} \frac{E_F-U}{J_F-V_F}=\frac{\beta}{1-\beta}\left(\frac{1-\tau}{1+\rho}\right) \\ \frac{E_S-U}{J_S-V_S}=\frac{\beta}{1-\beta} \end{aligned} \tag{A.2}$$

In equilibrium $V_F=0$. *It implies*

$$(r+\delta)J_F=A-w_F(1+\rho) \tag{A.3}$$

From Equations (12)-(13)

$$E_F-U=\frac{w_F(1-\tau)-rU}{r+\delta} \tag{A.4}$$

On the other hand $V_S=0$. *It implies*

$$(r+1-\mathcal{P})J_F=\mathcal{P}(A-w_F)-(1-\mathcal{P})P \tag{A.5}$$

From Equations (15)-(16)

$$E_S - U = \frac{\mathcal{P} w_S - (1-\mathcal{P})P - rU}{r + 1 - \mathcal{P}} \tag{A.6}$$

Using (A.3), (A.4), (A.5) and (A.6) along with (A.2) the wage for each sector is given by the following conditions

$$w_F = \left(\frac{\beta}{1+\rho}\right)A + \left(\frac{1-\beta}{1-\tau}\right)rU \tag{A.7}$$

$$w_S = \beta A + \left(\frac{1-\mathcal{P}}{\mathcal{P}}\right)(1-2\beta)P + \left(\frac{1-\beta}{\mathcal{P}}\right)rU$$

Given $\overline{U}$ *if* $\beta > 1/2$ *then* $\partial w_i / \partial P < 0$. *Let us find an specification for* rU. *From (14) we have*

$$J_i = \frac{\gamma_i}{q(\theta)} \tag{A.8}$$

Replacing (A.4) in the first equation of (A.2) we have

$$E_F - U = \frac{\beta}{1-\beta}\frac{\gamma_F}{q(\theta)}\left(\frac{1-\tau}{1+\rho}\right) \tag{A.9}$$

Multiplying $\phi\theta q(\theta)$ *on both sides of (A.9)*

$$\phi\theta q(\theta)(E_F - U) = \left(\frac{\beta}{1-\beta}\right)\left(\frac{1-\tau}{1+\rho}\right)\gamma_F \phi\theta \tag{A.10}$$

Doing the same procedure in the second equation of (A.2) we have

$$(1-\phi)\theta q(\theta)(E_S - U) = \left(\frac{\beta}{1-\beta}\right)\gamma_S(1-\phi)\theta \tag{A.11}$$

Replacing Equations (A.10) and (A.11) in Equation (2) we have

$$rU = Z + \frac{\beta}{1-\beta}\theta\left[\left(\frac{1-\tau}{1+\rho}\right)\phi\gamma_F + (1-\phi)\gamma_S\right] \tag{A.12}$$

Reorganizing (A.12) we have

$$rU = z + \frac{\beta}{1-\beta}\theta\varphi(\phi;\gamma_F;\gamma_S) \tag{A.13}$$

With

$$\varphi(\phi;\gamma_F;\gamma_S) = \left(\frac{1-\tau}{1+\rho}\right)\phi\gamma_F + (1-\phi)\gamma_S \tag{A.14}$$

Replacing (A.13) in (A.7) we get the claimed result in Proposition 1. □

Proposition 4

Applying the implicit function theorem to Equation (1) in Proposition 3 we have

$$\left.\frac{\partial\theta}{\partial\phi}\right|_F = -\frac{-\left(\frac{1+\rho}{1-\tau}\right)\beta\theta\left[\left(\frac{1-\tau}{1+\rho}\right)\gamma_F - \gamma_S\right]}{-(r+\delta)\gamma_F\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) - \left(\frac{1+\rho}{1-\tau}\right)\beta\varphi(\phi;\gamma_F;\gamma_S)} \tag{A.15}$$

Since $\frac{\partial}{\partial\theta}\left(q(\theta)\right) < 0$ *then* $\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) > 0$ *thereby*

$$\left.\frac{\partial\theta}{\partial\phi}\right|_F = \frac{-\left(\frac{1+\rho}{1-\tau}\right)\beta\theta\left[\left(\frac{1-\tau}{1+\rho}\right)\gamma_F - \gamma_S\right]}{(r+\delta)\gamma_F\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) + \left(\frac{1+\rho}{1-\tau}\right)\beta\varphi(\phi;\gamma_F;\gamma_S)} \tag{A.16}$$

We conclude

$$sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_F\right\} = sign\left\{\gamma_S - \left(\frac{1-\tau}{1+\rho}\right)\gamma_F\right\} \tag{A.17}$$

Now, applying the implicit function theorem to Equation (2) in Proposition 3 we have

$$\left.\frac{\partial\theta}{\partial\phi}\right|_S = -\frac{-\beta\theta\left[\left(\frac{1-\tau}{1+\rho}\right)\gamma_F - \gamma_S\right]}{-(r+1-\mathcal{P})\gamma_F\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) - \beta\varphi(\phi;\gamma_F;\gamma_S)} \tag{A.18}$$

Since $\frac{\partial}{\partial\theta}\left(q(\theta)\right) < 0$ *then* $\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) > 0$ *thereby*

$$\left.\frac{\partial\theta}{\partial\phi}\right|_S = \frac{-\beta\theta\left[\left(\frac{1-\tau}{1+\rho}\right)\gamma_F - \gamma_S\right]}{(r+1-\mathcal{P})\gamma_F\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right) + \beta\varphi(\phi;\gamma_F;\gamma_S)} \tag{A.19}$$

We conclude

$$sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_S\right\} = sign\left\{\gamma_S - \left(\frac{1-\tau}{1+\rho}\right)\gamma_F\right\} \tag{A.20}$$

Therefore

$$sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_F\right\} = sign\left\{\left.\frac{\partial\theta}{\partial\phi}\right|_S\right\} = sign\left\{\gamma_S - \left(\frac{1-\tau}{1+\rho}\right)\gamma_F\right\} \tag{A.21}$$

As it is claimed in Proposition 4. □

Proposition 5

From Equation (9) we have

$$\frac{\partial U}{\partial\theta} = -\frac{\frac{\phi}{s} + \frac{1-\phi}{1-\mathcal{P}}}{\left[\left(\frac{\phi}{s} + \frac{1-\phi}{1-\mathcal{P}}\right)\theta q(\theta) + 1\right]^2} < 0 \tag{A.22}$$

Tightness vs monitoring rate:

$$\frac{\partial\theta}{\partial\mathcal{P}} = -\frac{A(1-\beta)+\frac{\gamma_S}{q(\theta)}+2(1-\beta)P}{-(r+1-\mathcal{P})\gamma_F\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)-\beta\varphi(\phi;\gamma_F;\gamma_S)} \tag{A.23}$$

Since $\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)$ *then*

$$\frac{\partial\theta}{\partial\mathcal{P}} = \frac{A(1-\beta)+\frac{\gamma_S}{q(\theta)}+2(1-\beta)P}{(r+1-\mathcal{P})\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right|+\beta\varphi(\phi;\gamma_F;\gamma_S)} > 0 \tag{A.24}$$

Consequently

$$\frac{\partial\theta}{\partial(1-\mathcal{P})} < 0 \tag{A.25}$$

Tightness vs penalty

$$\frac{\partial\theta}{\partial P} = \frac{-2(1-\beta)(1-\mathcal{P})}{(r+1-\mathcal{P})\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right|+\beta\varphi(\phi;\gamma_F;\gamma_S)} < 0 \tag{A.26}$$

Tightness vs unemployment subsidy

$$\frac{\partial\theta}{\partial z} = \frac{-(1-\beta)\left(\frac{1+\rho}{1-\tau}\right)}{(r+1-\mathcal{P})\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right|+\beta\varphi(\phi;\gamma_F;\gamma_S)} < 0 \tag{A.27}$$

Tightness vs taxes

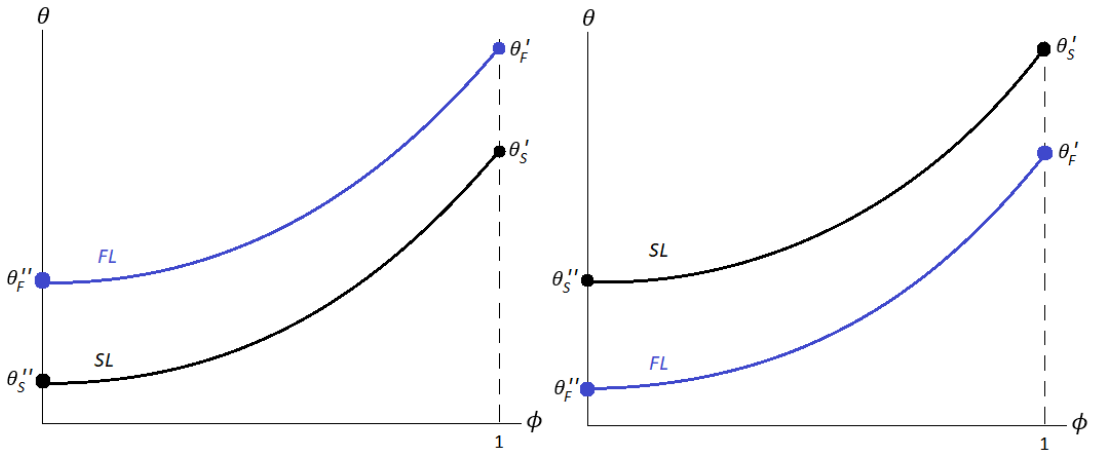
$$\frac{\partial\theta}{\partial\tau} = \frac{-\frac{(1+\rho)}{(1-\tau)^2}[(1-\beta)z+\beta\theta\varphi(\phi;\gamma_F;\gamma_S)]}{(r+1-\mathcal{P})\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right|+\beta\varphi(\phi;\gamma_F;\gamma_S)} < 0 \tag{A.28}$$

$$\frac{\partial\theta}{\partial\rho} = \frac{-\left(\frac{1}{1-\tau}\right)[(1-\beta)z+\beta\theta\varphi(\phi;\gamma_F;\gamma_S)]}{(r+1-\mathcal{P})\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right|+\beta\varphi(\phi;\gamma_F;\gamma_S)} < 0 \tag{A.29}$$

□

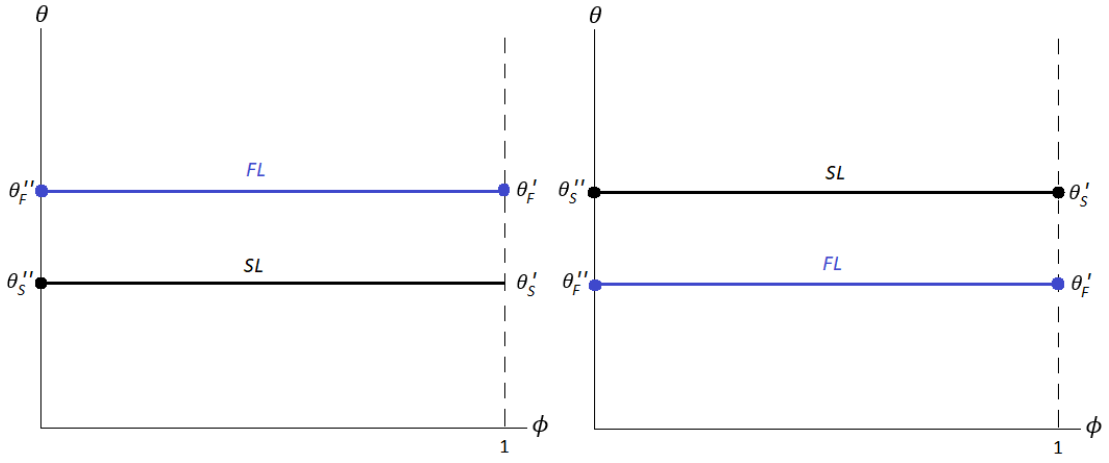
6.2 Analysis of equilibria

Figure 6: Corner equilibria type 1 with $\gamma_S > \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



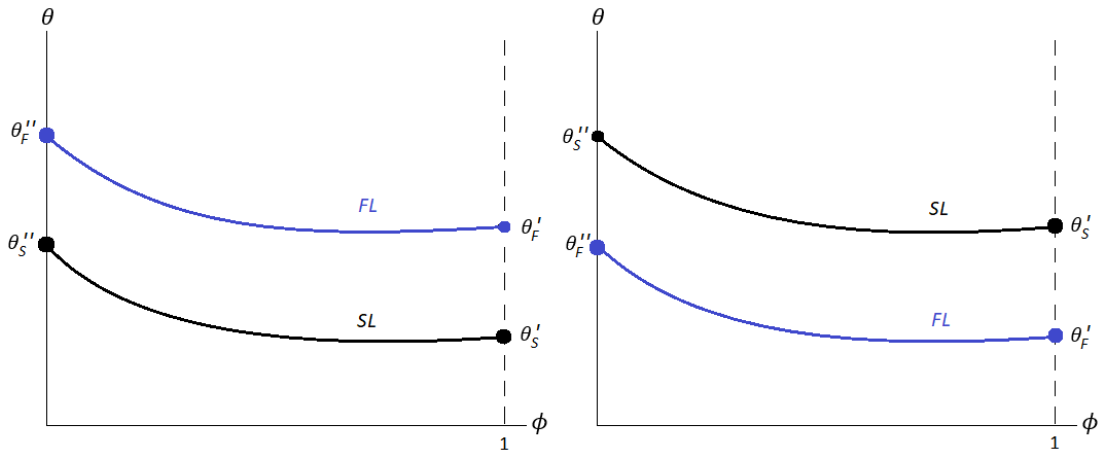
Panel a) There is an equilibrium with $\phi = 1$ since formal firms are more profitable than shadow firms in θ'_F. Panel b) There is an equilibrium with $\phi = 0$ since shadow firms are more profitable than formal firms in θ''_S.

Figure 7: Corner equilibria type 2 with $\gamma_S = \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



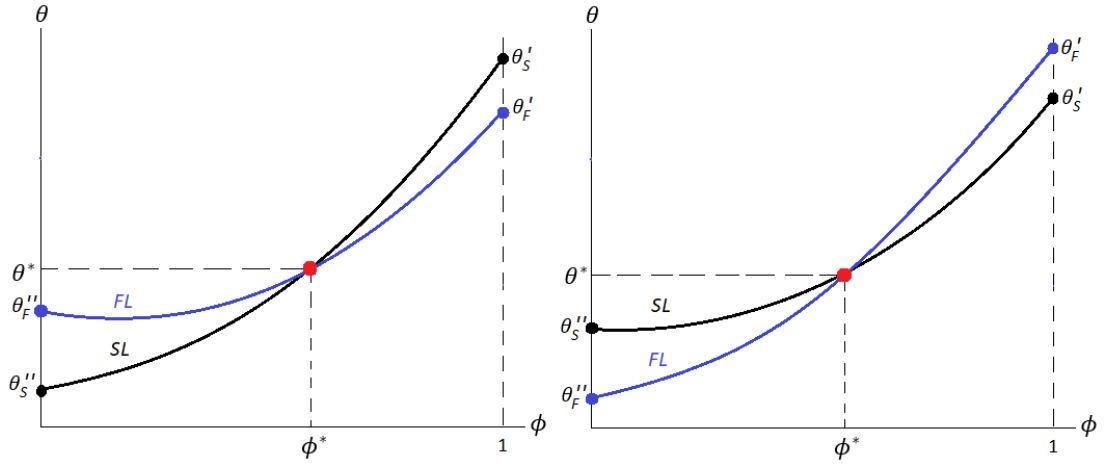
Panel a) There is an equilibrium with $\phi = 1$ since formal firms are more profitable than shadow firms in θ'_F. Panel b) There is an equilibrium with $\phi = 0$ since shadow firms are more profitable than formal firms in θ''_S.

Figure 8: Corner equilibria type 3 with $\gamma_S < \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



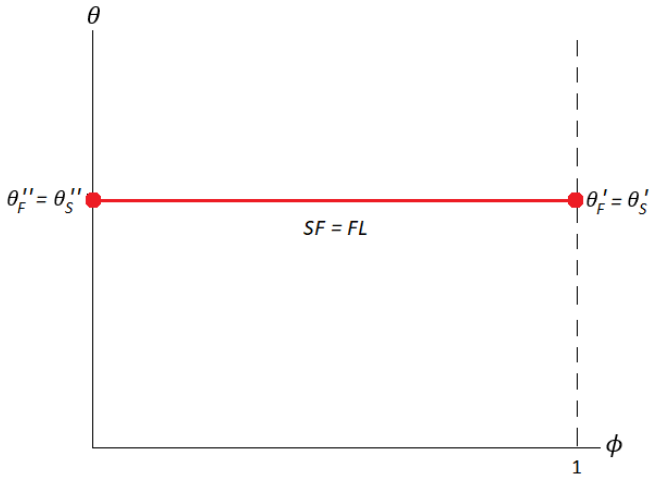
Panel a) There is an equilibrium with $\phi = 1$ since formal firms are more profitable than shadow firms in θ_F'. Panel b) There is an equilibrium with $\phi = 0$ since shadow firms are more profitable than formal firms in θ_S''.

Figure 9: Interior equilibria type 1 with $\gamma_S > \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



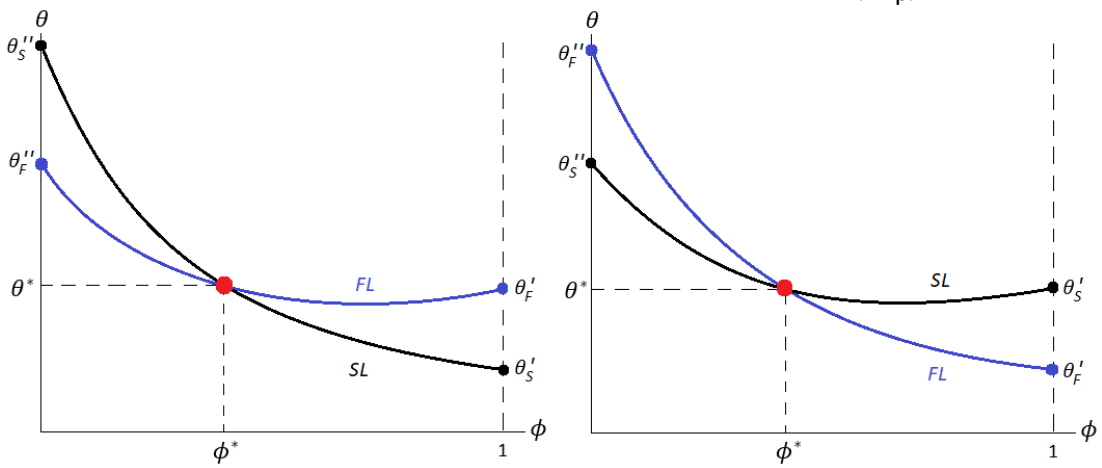
Panel a) There is an stable interior equilibrium. Panel b) There are three equilibria. There is an equilibrium with $\phi = 1$ since formal firms are more profitable than shadow firms in θ_F'. There is an equilibrium with $\phi = 0$ since shadow firms are more profitable than formal firms in θ_S''.

Figure 10: Interior equilibria type 2 with $\gamma_S = \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



There are multiple (infinite) equilibria since formal firms are as profitable as the shadow firms for all values of θ.

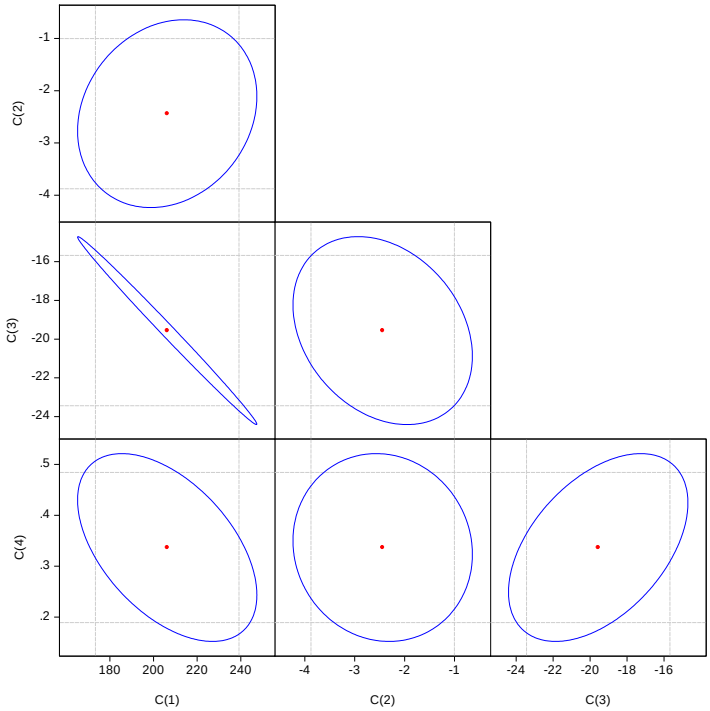
Figure 11: Interior equilibria type 3 with $\gamma_S < \left(\frac{1-\tau}{1+\rho}\right)\gamma_F$



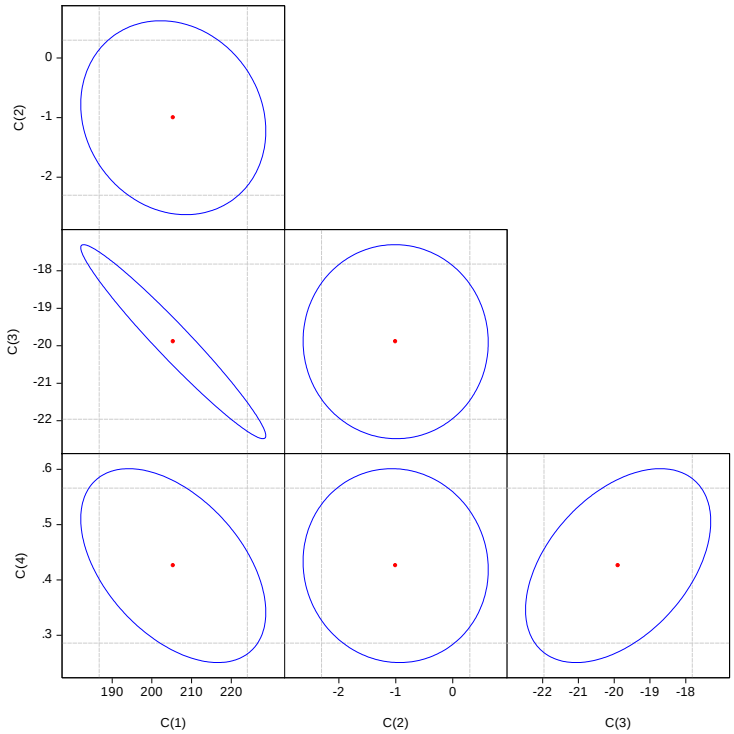
Panel a) There are three equilibria. There is an equilibrium with $\phi = 1$ since formal firms are more profitable than shadow firms in θ_F'. There is an equilibrium with $\phi = 0$ since shadow firms are more profitable than formal firms in θ_S''. Panel b) There is an stable interior equilibrium. The analysis of the equilibria follows closely Acemoglu (2001)[3] and Bouev (2005)[30].

6.3 Confidence ellipse for the coefficients

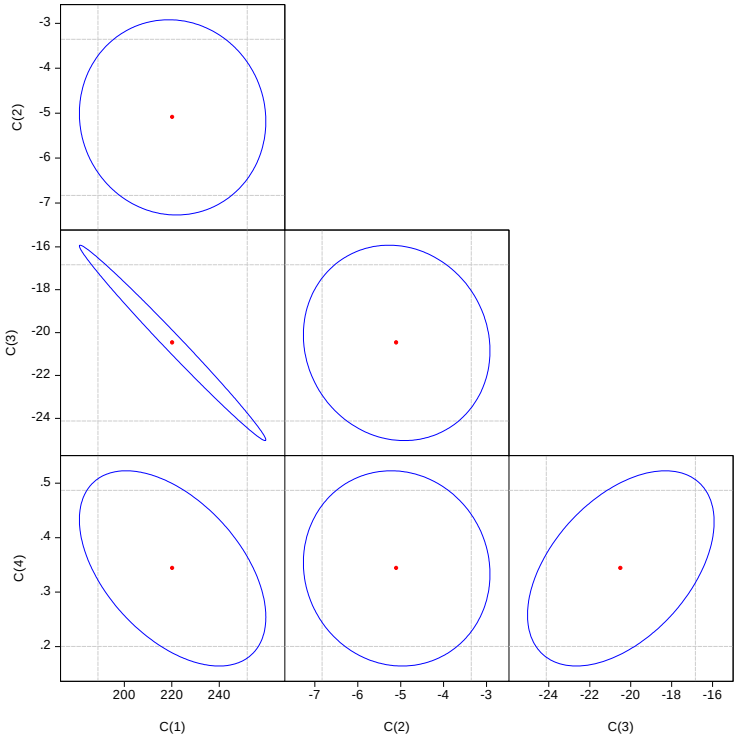
Model 1 (from the panel regressions in the stylized facts)



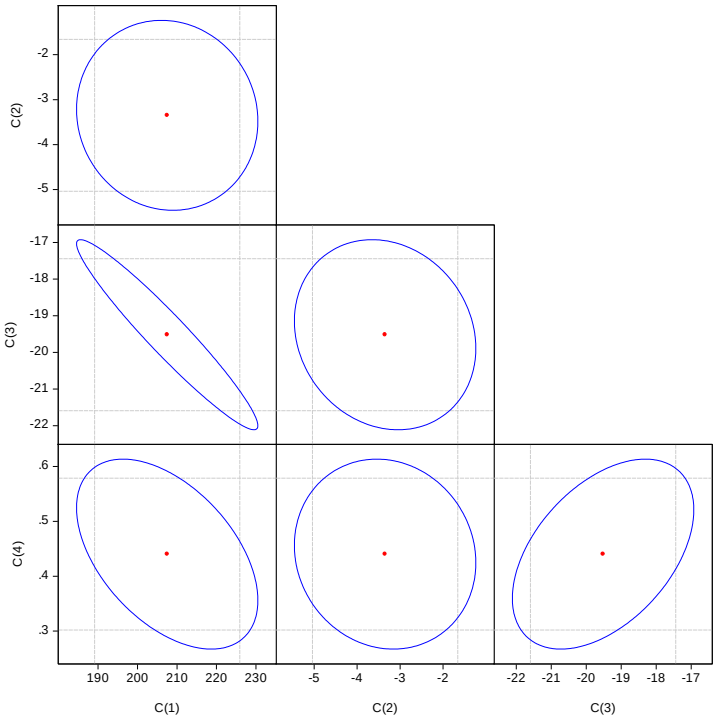
Model 2



Model 3

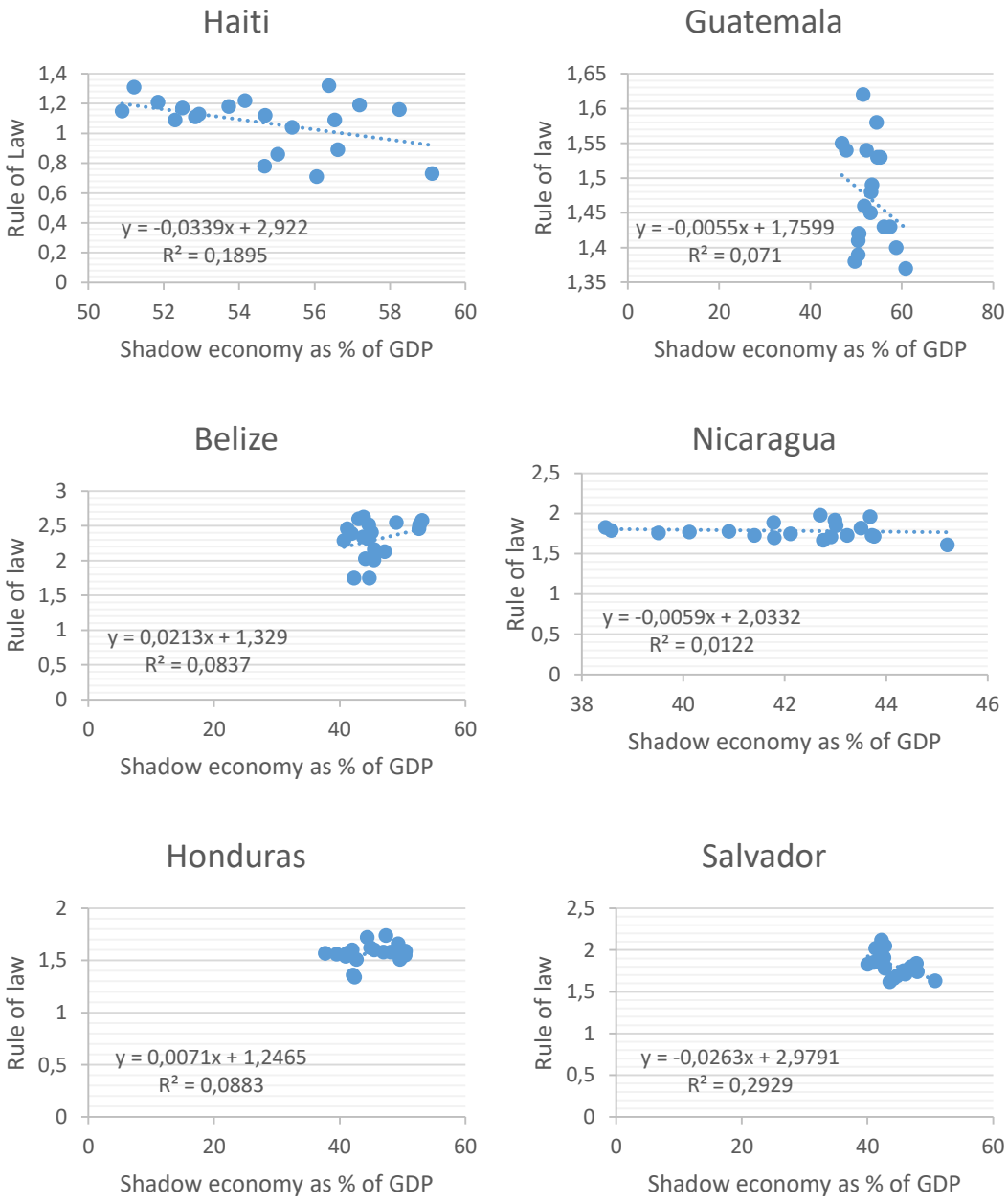


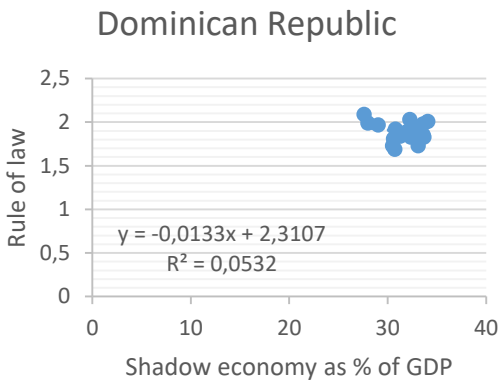
Model 4

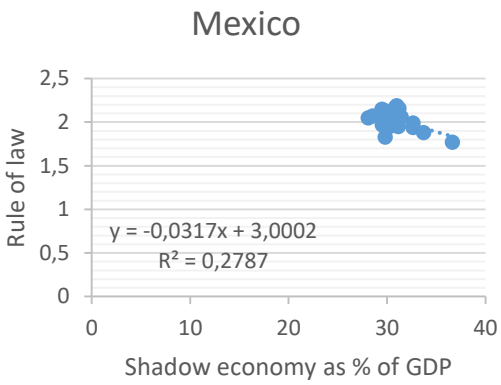


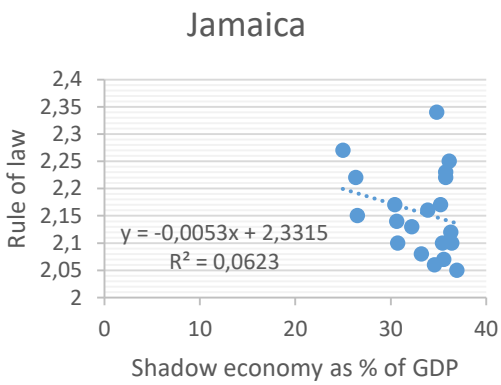
6.4 Individual regressions

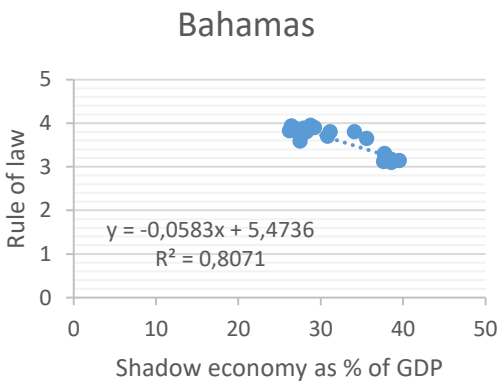
Figure 12: Shadow economy as percentage of the GDP vs Rule of law index in Latin America and the Caribbean during 1996-2015

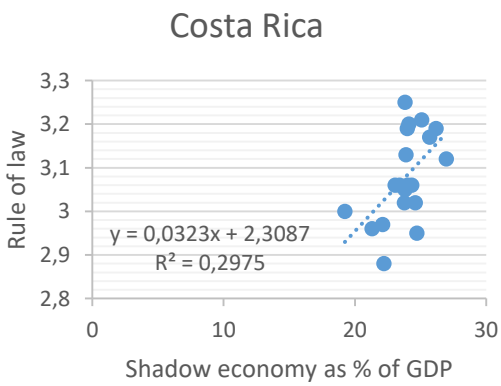


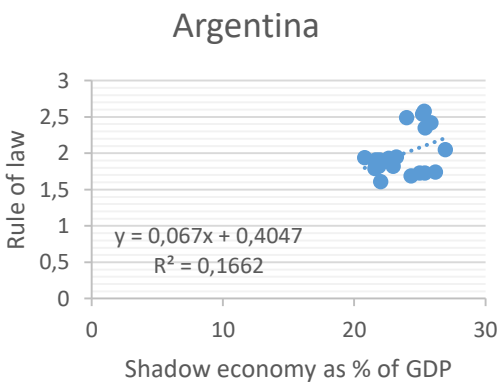

Dominican Republic
Rule of law
Shadow economy as % of GDP
y = -0,0133x + 2,3107
R² = 0,0532

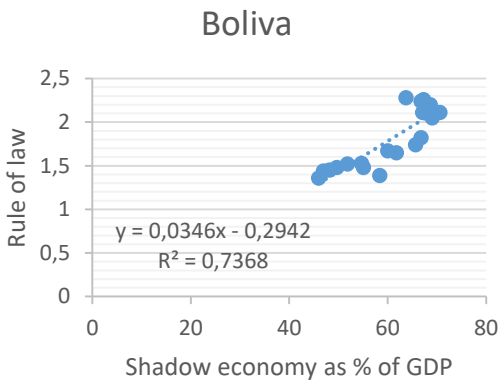

Mexico
Rule of law
Shadow economy as % of GDP
y = -0,0317x + 3,0002
R² = 0,2787

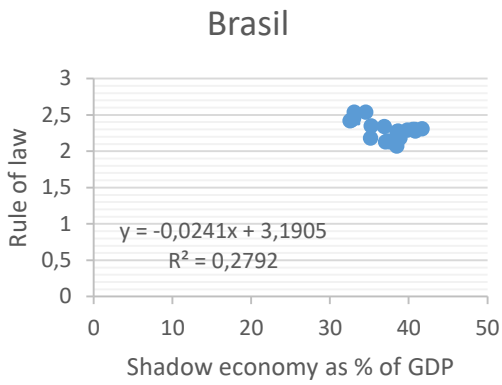

Jamaica
Rule of law
Shadow economy as % of GDP
y = -0,0053x + 2,3315
R² = 0,0623

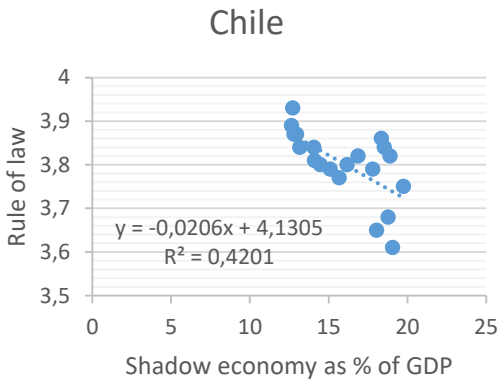

Bahamas
Rule of law
Shadow economy as % of GDP
y = -0,0583x + 5,4736
R² = 0,8071

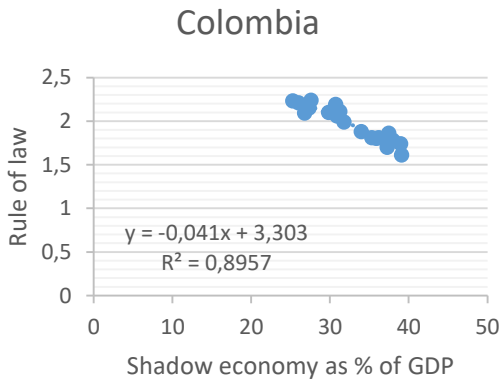

Costa Rica
Rule of law
Shadow economy as % of GDP
y = 0,0323x + 2,3087
R² = 0,2975

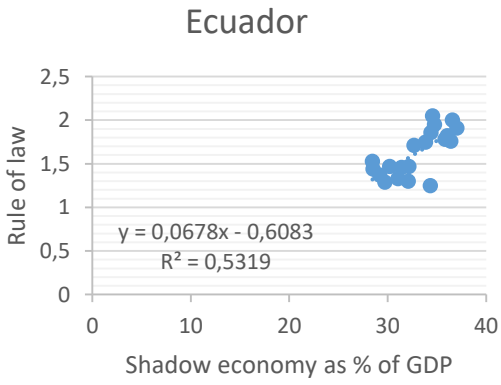

Argentina
Rule of law
Shadow economy as % of GDP
y = 0,067x + 0,4047
R² = 0,1662

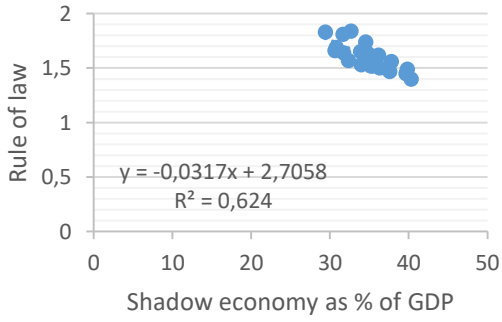

Boliva
Rule of law
Shadow economy as % of GDP
y = 0,0346x - 0,2942
R² = 0,7368
0
0,5
1
1,5
2
2,5
0
20
40
60
80

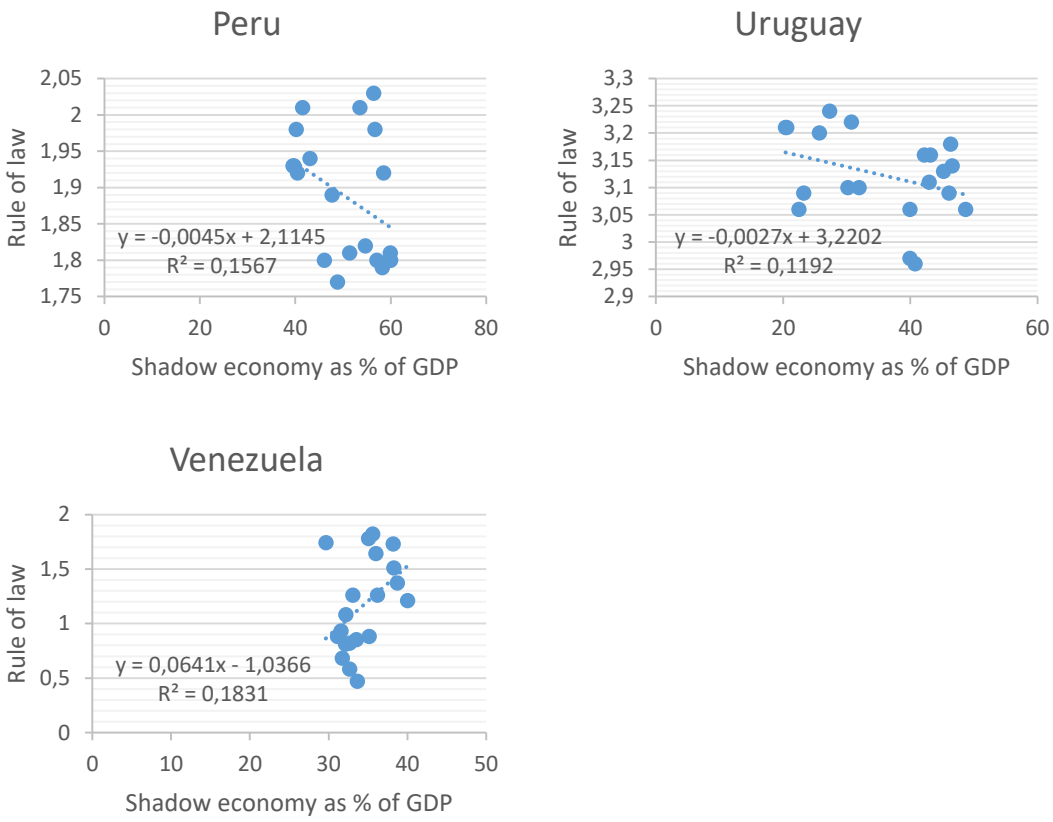

Brasil
Rule of law
Shadow economy as % of GDP
y = -0,0241x + 3,1905
R² = 0,2792
0
0,5
1
1,5
2
2,5
3
0
10
20
30
40
50


Chile
Rule of law
Shadow economy as % of GDP
y = -0,0206x + 4,1305
R² = 0,4201
3,5
3,6
3,7
3,8
3,9
4
0
5
10
15
20
25


Colombia
Rule of law
Shadow economy as % of GDP
y = -0,041x + 3,303
R² = 0,8957
0
0,5
1
1,5
2
2,5
0
10
20
30
40
50

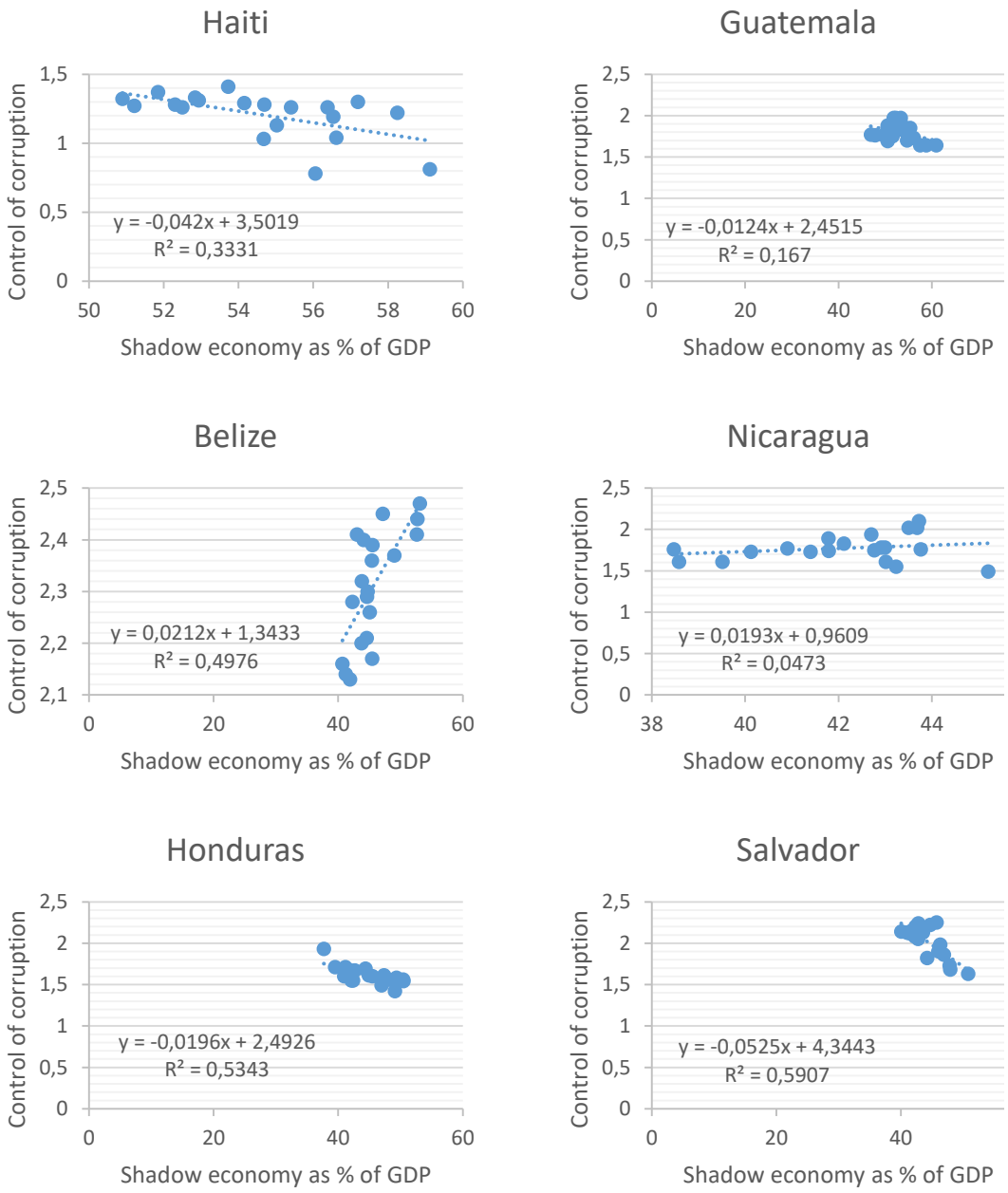

Ecuador
Rule of law
Shadow economy as % of GDP
y = 0,0678x - 0,6083
R² = 0,5319
0
0,5
1
1,5
2
2,5
0
10
20
30
40

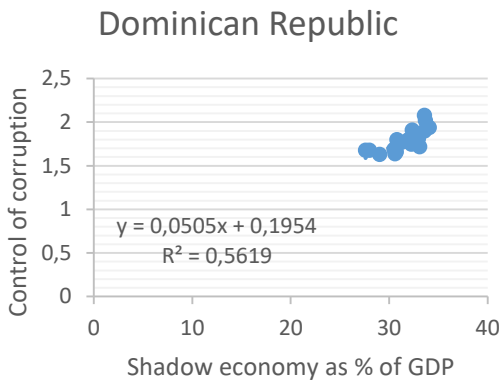

Paraguay
Rule of law
Shadow economy as % of GDP
y = -0,0317x + 2,7058
R² = 0,624
0
0,5
1
1,5
2
0
10
20
30
40
50

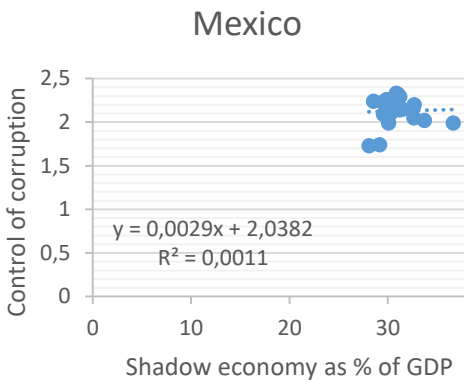


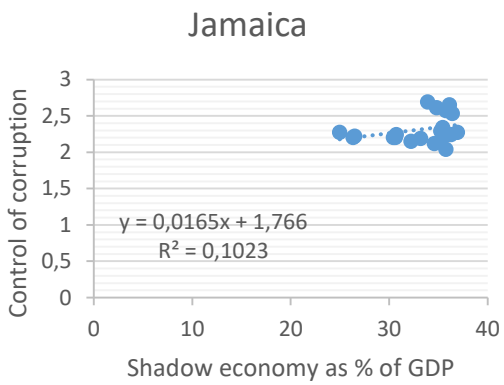
Source: Built form Medina and Schneider (2017)[23] and the World Bank.

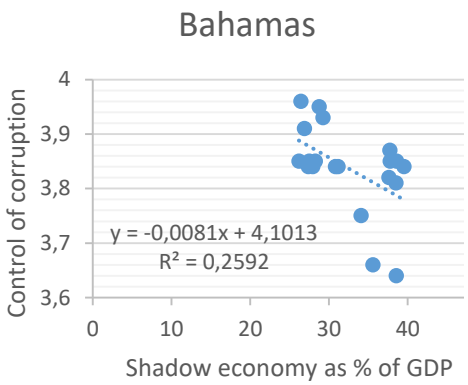
Figure 13: Shadow economy as percentage of the GDP vs control of corruption index in Latin America and the Caribbean during 1996-2015

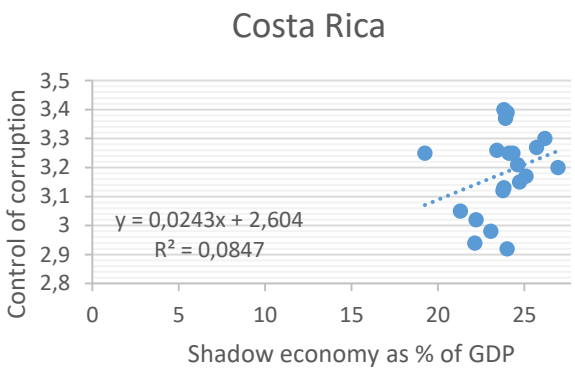


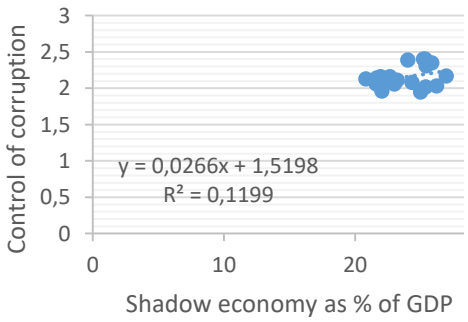

Dominican Republic
Control of corruption
Shadow economy as % of GDP
y = 0,0505x + 0,1954
R² = 0,5619

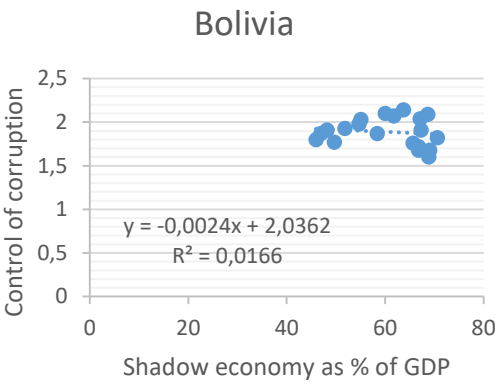

Mexico
Control of corruption
Shadow economy as % of GDP
y = 0,0029x + 2,0382
R² = 0,0011

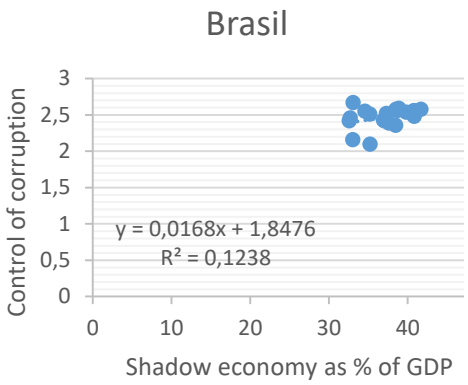

Jamaica
Control of corruption
Shadow economy as % of GDP
y = 0,0165x + 1,766
R² = 0,1023

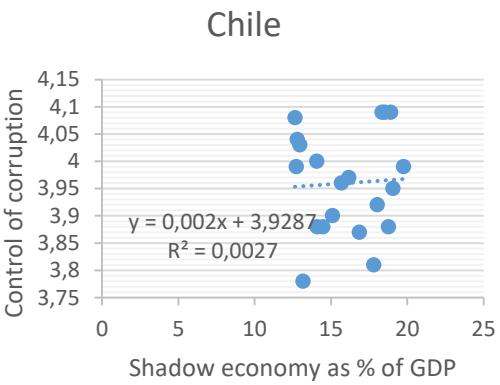

Bahamas
Control of corruption
Shadow economy as % of GDP
y = -0,0081x + 4,1013
R² = 0,2592

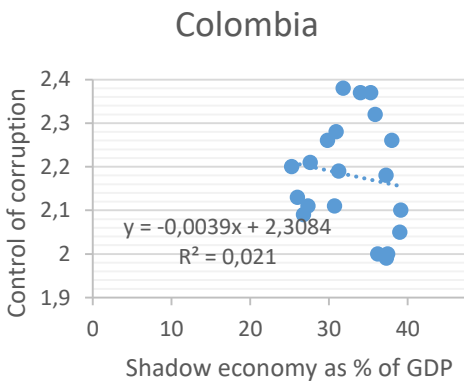

Costa Rica
Control of corruption
Shadow economy as % of GDP
y = 0,0243x + 2,604
R² = 0,0847

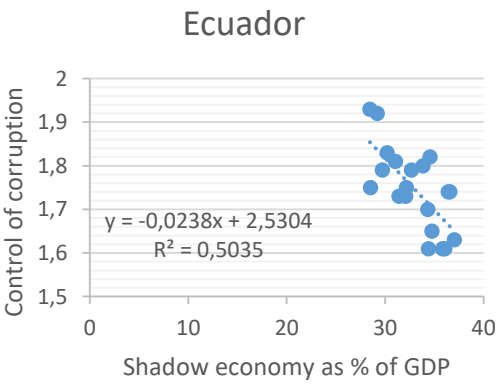

Argentina
Control of corruption
Shadow economy as % of GDP
y = 0,0266x + 1,5198
R² = 0,1199

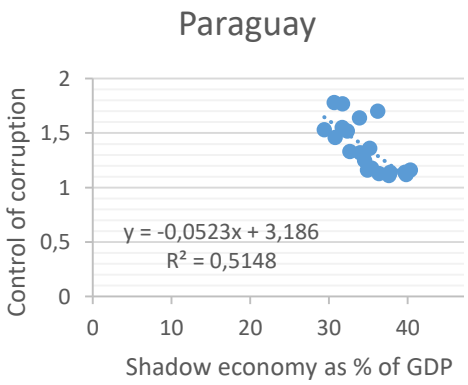

Bolivia
Control of corruption
Shadow economy as % of GDP
y = -0,0024x + 2,0362
R² = 0,0166

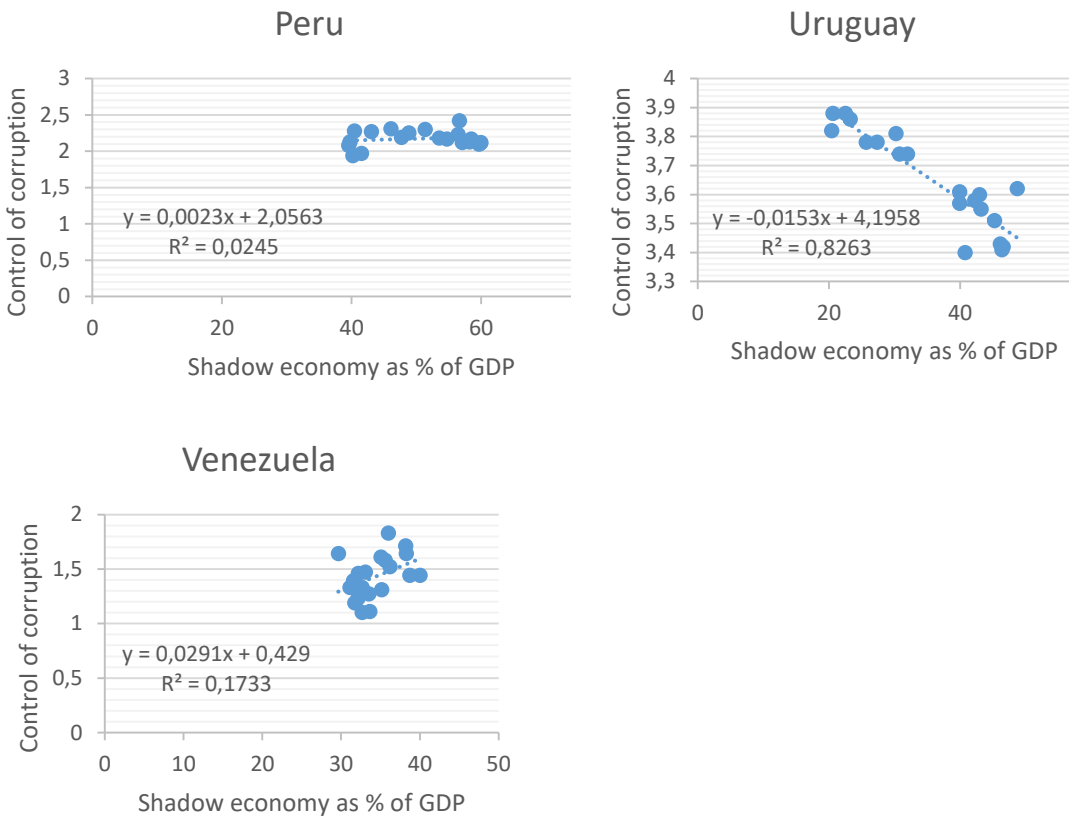

Brasil
Control of corruption
Shadow economy as % of GDP
y = 0,0168x + 1,8476
R² = 0,1238


Chile
Control of corruption
Shadow economy as % of GDP
y = 0,002x + 3,9287
R² = 0,0027


Colombia
Control of corruption
Shadow economy as % of GDP
y = -0,0039x + 2,3084
R² = 0,021


Ecuador
Control of corruption
Shadow economy as % of GDP
y = -0,0238x + 2,5304
R² = 0,5035


Paraguay
Control of corruption
Shadow economy as % of GDP
y = -0,0523x + 3,186
R² = 0,5148



Source: Built form Medina and Schneider (2017)[23] and the World Bank.

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❖ ESSAY II

II. Intersector labor distribution with heterogeneous agents: An orthodox approach to the shadow economy

Abstract

The main purpose of this chapter is to study intersector labor mobility in a directed search and matching model of two sectors with heterogeneous workers. As it was in Chapter 1 we build our model upon Acemoglu (2001)[1] and Pissarides (2000)[18]. Heterogeneity among agents comes from intersector skill distribution as Albrecht and Vroman (2002)[2]. Each shadow employer is engaged in a conflict against the government so as to sell his goods or services under unregulated economic activities. Mixing up search and matching and conflict theory literatures is not innocuous. Results indicate that efficiency of monitory rates are crucial in explaining the impact of both fiscal policy and unemployment subsidies on the intersector labor distribution.

Keywords:

Directed search; endogenous enforcement; fiscal policy, heterogeneity.

JEL classification:

D73, D74, E26, J46, J64, K42, O17, P46

1. Introduction

There are many approaches to studying the shadow economy. So far in Chapter 1 we studied it by following the heterodox approach. Differences in entry costs do cause the shadow economy to appear. These frictions come from juxtaposing pre-capitalist systems of production with capitalist ones. As we discussed in the general introduction there is also an orthodox approach notwithstanding. One distinctive feature of orthodoxy is considering shadow economy as an autonomous sector. Hart (1973)[8] differentiate each sector from the worker side: formal sector has wage-earning workers; informal sector, self-employed workers. The unit of analysis for the International Labor office (1972)[10] is the enterprise. Differences arise in terms of factor productivity. Another way to differentiate them is by state protection as for Weeks (1975)[22]. Formal sector is protected; informal sector, unprotected. One natural way to extend our results of Chapter 1 is to introduce heterogeneity among agents. This extension is tricky insofar as agents are not only technically but also morally heterogeneous. It requires us to discuss education as the fundamental variable behind the decision of an agent to be located at one of those sectors.

An individual is supposed to have a myriad of tools to be able to interact with others. On one hand, he is required to respect law. It requires him to be fair, that is, living in harmony with others. Law is meant to organize individual actions towards social welfare. Respecting law requires moral and ethical values besides intellectual ones. On the other hand, he has to be able to produce goods and services. This is a technical ability. If one is aiming to use others' services he must offer something instead. We could wrap this two parts up in one single concept: *education*. Think of education as both moral values and technical knowledge. We define it as a process to acquire moral and technical values that allows an individual to live in society. Education serves the common good inasmuch as it allows an individual to incorporate both the social damage and social welfare of his actions within his own value functions.

According to International Labour Office (2018)[11] the relationship between education and shadow economy is the same regardless the geographic region we are looking at. Improvements in the educational level of an individual increases the probability of being hired in the formal sector. In developed countries, according to the aforementioned study, the proportion of informal employment on total employment goes from 52,7% for individuals with no education to 16,1% for individuals with tertiary education. In developing and emerging economies, instead,

the proportion goes from 93,9% to 32% respectively. Education achievements have also an impact on the employers. Employers with no education have 40% more probability of working in the shadow than those with secondary level of education. In both of the cases, education happens to be a key variable when explaining intersector labor distribution. We need a precise definition of education notwithstanding.

Education is not a static but a dynamic concept. We are always learning new techniques and acquiring (or discarding) moral values. Dewey (1916)[4] interprets it as a continues process in which someone is getting knowledge about the world and, at the same time, transforming it. Most of the times, learning comes from doing or experiencing reality instead of just "*schooling*". According to Dewey (1938)[5] an educated person transforms reality so as to improve social welfare. Knowing techniques is necessary but not enough for a person to improve social welfare. Fromm (1979)[7] remarks a distinction between "*having*" and "*being*" in the same way as there is a distinction between "*possesing*" or "*loving*". Education requires an individual to question the ultimate value of the knowledge he possesses. According to Moore (2010)[15] morality should be a necessary part of education. Of course there are many interpretations of moral values such as utilitarianism, intuitionism and emotivism but we refer here to the Kantian categorical imperative in Kant (1949)[12] to see others as ends, not means.

Illegality is not just an economic but a moral problem. It has its roots in the system of values of a society. In particular, the ability of an individual as to consider the social damage of his activities. It is rather evident in human trafficking where the consumer faces the consequence of his actions. It is less evident in the case of illegal drugs where the consumer could just imagine the social problems related with production and distribution. For them individual welfare is more important than social damage. From the supply side the situation is similar. Producing or distributing illegal goods or services requires an individual to undertake violent actions. Land control, corruption, kidnapping and vengeance are common practices amidst gangsters who see other people as means to raise money. Whether consumption or production of illegal goods, agents lack moral education. One step further in understanding the concept depends on perusing the literature regarding moral philosophy and ethics in economics.

There is a huge literature studying the moral foundation of individual behavior. Hausman and McPherson (2006)[9] emphasizes the moral feature of individual behavior which, as explained in Etzioni (1988)[6], not always follow a pure individualistic rationality. The theory of sympathy of Smith (2009)[20] is particularly relevant in this regard. In many situations agents incorporate the social welfare or damage of their actions into their own value functions. Rose (2011)[19]

refers to it as a positive or negative externality. This is not an instrumental rationality however. The social fact is different from the physical one. DeMartino (2011)[3] discusses this as to the difference between social science and social engineering. Even in the very mercantile endeavor of supplying or demanding, the agent is motivated because of a plethora of reasons both materialistic and moral as explained in Vickers (1997)[21]. Studying those differences amidst agents enables us to figure out the implication of some governmental policies on the decision whether to remain formal or going shadow.

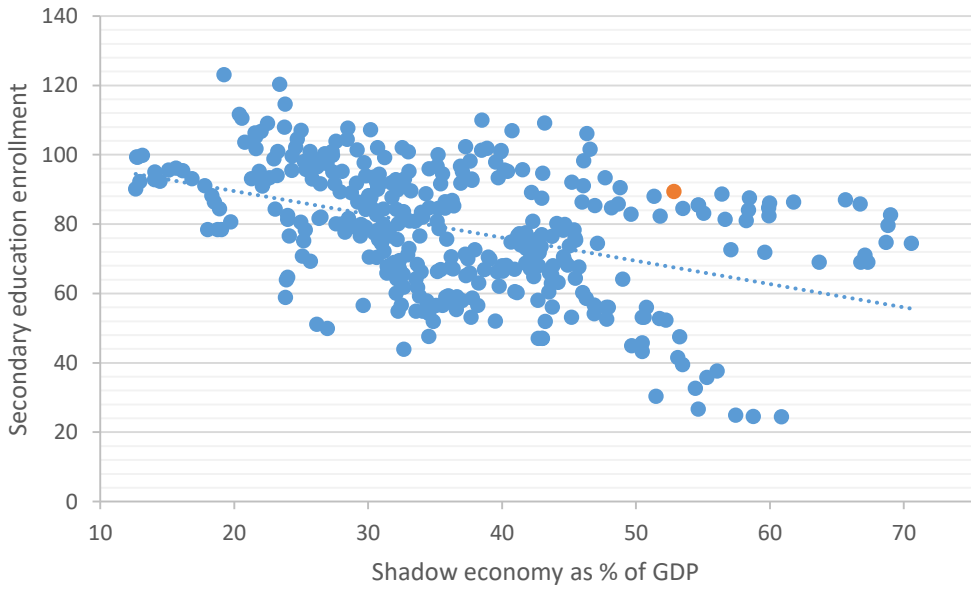
The main purpose of this chapter is to study intersector labor mobility in a directed search and matching model with heterogeneous workers. We build our model upon Acemoglu (2001)[1] and Pissarides (2000)[18]. There is an exogenous distribution of workers. Heterogeneity among agents comes from intersector skill distribution as Albrecht and Vroman (2002)[2]. Each shadow employer is engaged in a conflict against the government to be able to sell his goods or services in unregulated economic activities. The efficiency of the monitory rates depends on the efficiency of each part in the conflict. The public expenditure in the conflict is directly related with the proportion of shadow agents engaged in the conflict. We follow Mejia and Restrepo (2016)[13] and Naranjo (2007)[16] to model that conflict. We mix both literatures namely search and matching and conflict theory. We find that efficiency of monitory rates are crucial in explaining the effect of fiscal policy in the intersector labor distribution of the economy.

The rest of the paper goes as follows. After this introduction, we present some stylized facts regarding the relationship between shadow economy and education. Again we focus our attention in the Latin American and Caribbean countries during 1996-2015 as it was in Chapter 1. Then we build a bisector search and matching model with endogenous monitory rates. We derive conditions for the existence and stability of equilibria and apply a comparative statics analysis. We then apply a numerical exercise for what we consider a representative developing or emerging economy and derive policy recommendations. Discussion and references follow.

2. Stylized facts

Agents select the sector they would like to work with out of technical and moral reasons. As for the moral reasons consider the *rule of law index* of Chapter 1. As for the technical reasons consider the *school enrollment rate*. Education encompasses technical and moral values. We discuss some ideas behind this concept in the previous section. There is an exogenous distribution of education. Formal firms hire agents with high labor productivity so as to minimize costs and maximize profits. Shadow economy, instead, receive agents with low labor productivity to undertake low productive economic activities. This is depicted in Figure 14. We see an inverse relationship between secondary school enrollment and shadow economy for the Latin American and Caribbean economies during 1996-2015.

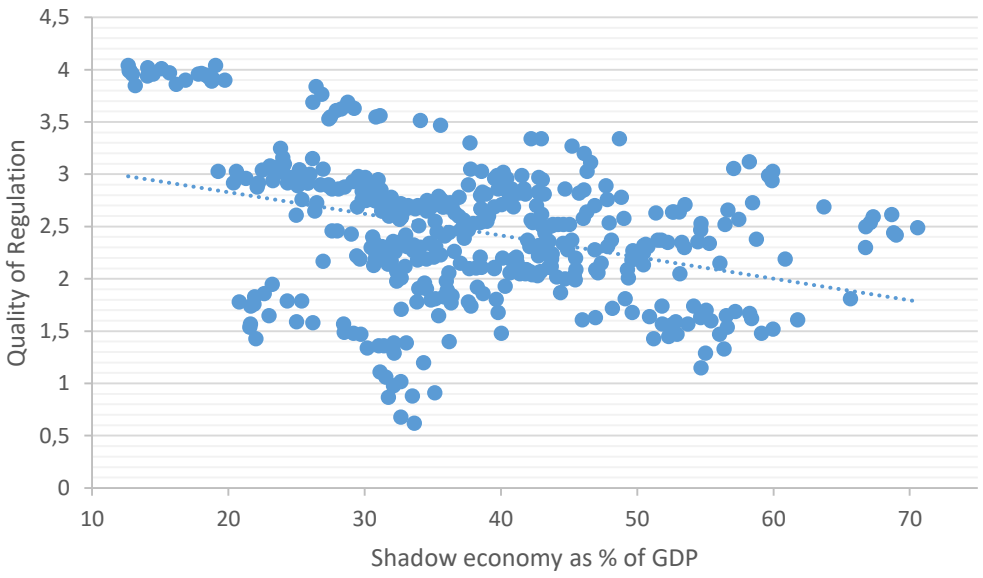
Figure 14: Shadow economy as percentage of the GDP vs secondary school enrollment in Latin America and the Caribbean during 1996-2015



Source: Built form Medina and Schneider (2017)[14] and the World Bank.

Agents in the shadow get lower wages than they would get in the formal sector. As it is very well stablished in the literature, wages are explained, among other variables, for the labor productivity. Notwithstanding the lower wages low-productive workers ultimately get employed in the shadow economy. Working in the shadow is a subsistence activity rather than a capital-accumulation activity. There is also an exogenous distribution of illegal abilities nonetheless. Illegal ability refers henceforth to the ability of an agent to avoid governmental regulation. Shadow economy is the sector for those agents able to undertake illegal activates without being caught by government. Besides the aforementioned rule of law index the *quality of regulation index* measures the ability of the government to enforce the law. In Figure 15 we see there is an inverse relationship between this index and the shadow economy for the used sample.

Figure 15: Shadow economy as percentage of the GDP vs secondary school enrollment in Latin America and the Caribbean during 1996-2015



Source: Built form Medina and Schneider (2017)[14] and the World Bank.

Table 9 reports the descriptive statistics and Table 10 the correlation/covariance matrix. Notice there seems to be a statistical relationship between shadow economy and both secondary school enrollment and quality of regulation index for the used sample. We investigate this in a panel regression.

Table 9: Descriptive statistics: mean, median, standard deviation and Kurtosis

	Secondary rate	Quality of regulation	Economic growth	Gini coefficient	Unemploym. rate	Trade /GDP	Migrant stock /population
Mean	80,29	2,53	3,45	50,24	7,21	59,46	2,12
Median	81,99	2,58	3,82	49,85	6,48	57,88	1,10
Maximum	123,09	4,04	18,29	61,60	20,52	135,75	16,16
Minimum	30,39	1,20	-10,89	39,90	2,01	21,38	0,24
Std. Dev.	16,83	0,63	3,36	4,46	3,79	22,45	2,53
Skewness	-0,09	0,27	-0,55	-0,06	1,06	0,68	2,11
Kurtosis	2,31	3,00	6,12	2,46	3,77	3,73	8,05
Jarque-Bera	5.429052	3,21	119,34	3,31	55,70	25,95	470,44
Probability	0.066236	0,20	0,00	0,19	0,00	0,00	0,00
Sum	20877.33	657,81	897,40	13062,90	1874,93	15459,86	552,28
Sum Sq. Dev.	73442.25	105,95	2936,82	5153,90	3727,97	130539,3	1660,54
Observ.	260	260	260	260	260	260	260

Table 10: Covariance/correlation matrix

Covariance / Correlation	Secondary rate	Quality of regul	Economic growth	Gini coefficin	Unempl. rate	Trade/GDP	Migration stock/pop	Shadow economy
Secondary rate	282.47							
	1.00							
Quality of regul	2.43	0.40						
	0.22	1.00						
Economic growth	4.23	0.11	11.29					
	0.07	0.05	1.00					
Gini coefficient	-25.45	-0.19	-0.71	19.82				
	-0.340	-0.06	-0.04	1.00				
Unemployment rate	7.28	0.23	-2.73	2.55	14.33			
	0.11	0.09	-0.21	0.15	1.00			
Trade/GDP	-137.45	-0.28	8.07	-8.72	-25.63	502.07		
	-0.36	-0.01	0.10	-0.08	-0.30	1.00		
Migration stock/POB	3.20	-0.00	0.47	-2.34	1.86	12.96	6.38	
	0.07	-0.00	0.05	-0.20	0.19	0.22	1.00	
Shadow economy	-75.18	-2.64	-2.51	21.10	-14.84	6.57	-11.71	149.00
	-0.36	-0.33	-0.06	0.38	-0.32	0.02	-0.379	1.00

There is statistical evidence of a relationship between the shadow economy and both the secondary school enrollment and quality of regulation in the Latin American and Caribbean countries. Table 11 reports the results. Notice there is at least one possibility of having a positive relationship between shadow economy and secondary school enrollment. This could be a puzzle. Buehn and Reza (2013)[23] find a related result for the decade of 2000 in a world-wide sample. Quality of regulation and education are closely related when explaining the dynamic of shadow economy. Agents with secondary education go formal when the government is efficient in enforcing contracts. They go shadow otherwise. In some cases, according to International Labor Office (2018)[11], agents with secondary education might combine formal with informal jobs so as to rise money from the low formal wages.

Table 11: Shadow economy vs secondary school enrollment

Predictor variable	(1)	(2)	(3)	(4)	(5)	(6)
Constant	12,23	14,26	-9,19	-8,23	35,78***	33,97***
	(8,37)	(8,5)	(8,19)	(8,37)	(2,44)	(5,05)
Secondary rate	0,19***	0,21***	0,24***	0,23***	0,07***	
	(0,06)	(0,06)	(0,06)	(0,06)	(0,02)	
Quality of regul.	6,30***	6,60***	7,34***	6,47***		-1,38*
	(2,26)	(2,3)	(2,43)	(2,48)		(0,66)
*Secondary*Quality*	-0,1***	-0,1***	-0,1***	-0,07***		
	(0,02)	(0,02)	(0,02)	(0,02)		
Economic growth	-0,15**	-0,2***	-0,2***		-0,23***	-0,13*
	(0,05)	(0,06)	(0,06)		(0,05)	(0,05)
Gini	0,31***	0,27***	0,48***	0,47***		0,23**
	(0,08)	(0,09)	(0,09)	(0,09)		(0,08)
Unemployment rate	0,3***	0,35***			0,49***	0,20*
	(0,10)	(0,10)			(0,09)	(0,09)
Trade/GDP	-0,2***	-0,2***			-0,12***	-0,15***
	(0,02)	(0,02)			(0,02)	(0,02)
Migrant stock/Pop.	1,45***					1,16***
	(0,47)					(0,39)
Num. of Obser. =210						
R^2	0,97	0,97	0,95	0,95	0,95	0,97
A- R^2	0,97	0,97	0,97	0,95	0,95	0,97
FE	X	X	X	X	X	X

Note: The level of significance is determined by *p<0,05; **p<0,01; ***p<0,001. The number in parenthesis represent standard errors.

3. The model

We build a two-sector search and matching model. There is a formal sector (F) and an shadow sector (S). The counter for the sectors is $i \in \{F, S\}$. Each sector is defined as it is in Chapter 1. Formal sector produces legal goods with regulated economic activities. Shadow sector produces legal or illegal goods with unregulated activities. Each sector produces an intermediate good necessary to produce the final product of the economy. Formal and shadow production is complementary. There are different registration costs for each sector as it is in Chapter 1. Shadow entrepreneurs invest $x > 0$ in avoiding law.

They succeed with probability $\mathcal{P}(x, y) \in (0,1)$. Government prosecutes shadow activity. The government invests $y > 0$ in enforcing the law. Government captures shadow agents with probability $1 - \mathcal{P}(x, y)$. Shadow agents must pay a penalty P if caught. Workers in this economy are heterogeneous. There is an exogenous distribution of the workers in each sector. A portion $\phi \in (0,1)$ are formal workers. A portion $1 - \phi$ are shadow workers. We do not ask for the nature of this distribution. It is given according to a myriad of different causes. In both sectors wages are determined according to Nash bargaining.

3.1 Final production

There is a final good (Y) with price $p_Y = 1$. Final good is produced out of two intermediates goods. One intermediate good is formal (Y_F) and the other one (Y_S) is shadow. The technology of production

$$Y = \left(\alpha Y_S^{\rho} + (1 - \alpha) Y_F^{\rho}\right)^{\frac{1}{\rho}} \qquad (II.1)$$

Where $\alpha \in (0,1)$ measures the importance of the shadow sector. The parameter $1 - \alpha$ measures the importance of the formal sector. The coefficient ρ is the elasticity of substitution between Y_S and Y_F. The marginal productivities are given by

$$p_S = \alpha \left(\frac{Y}{Y_S}\right)^{1-\rho} \qquad (II.2)$$

$$p_F = (1-\alpha)\left(\frac{Y}{Y_F}\right)^{1-\rho}$$

We could use a utility function instead of the production function. The analysis would be the same. In perfect competitive markets prices are equal to the value of the marginal productivity. In the case of the utility function we would have price equals marginal utility. The relative prices are then given by

$$\frac{p_S}{p_F} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{Y_F}{Y_S}\right)^{1-\rho} \qquad (II.3)$$

The value of the intermediate commodity is inversely related with its disposal. The higher Y_F respect to Y_S the lower p_F respect to p_S given the proportion $\alpha/(1-\alpha)$.

3.2 Unemployment

In each sector a job is filled or vacant. The value of a vacancy is V_i. The value of a job in sector i is E_i. Each firm assumes a fix cost of opening a vacancy γ_i. Let us assume $\gamma_F > \gamma_S$. A worker is employed or unemployed. The value of being employed in sector i is E_i. The unemployment rate is $u_i \in (0,1)$. The vacancy rate $v_i \in (0,1)$. Agents spend resources in search. Let $\theta_i = v_i/u_i$ be the thight of the formal labor market. The matching function is $X(u_i, v_i)$ satisfies the usual properties. The probability of filling a vacancy is $q(\theta_i) = X(u_i, v_i)/v_i$. The probability of finding a job is $\theta_i q(\theta_i) = X(u_i, v_i)/u_i$.

$$\lim_{\theta\to\infty} q(\theta) = 0; \quad \lim_{\theta\to 0} q(\theta) = \infty$$
$$\lim_{\theta\to\infty} \theta q(\theta) = \infty; \quad \lim_{\theta\to 0} \theta q(\theta) = 0$$

In the legal sector there is an unemployment benefit. The unemployment benefit is z. In the shadow sector there is no unemployment subsidy. There is free-entry which is a guarantee of zero profits. The value function of the unemployment in each sector

$$rU_F = z + \theta_F q(\theta_F)(E_F - U_F)$$
$$rU_S = \theta_S q(\theta_S)(E_S - U_S) \qquad (II.4)$$

The number of people getting unemployed in the formal and shadow sector are $\delta(\phi - U_F)$ and $\delta(1 - \phi - U_S)$ respectively. The number of people getting out of the unemployment in the formal and shadow sector are $\theta_F q(\theta_F) U_F$ and $\theta_S q(\theta_S) U_S$ respectively. The motion law of U_i is given by

$$\begin{aligned} \dot{U}_F &= \delta(\phi - U_F) - \theta_F q(\theta_F) U_F \\ \dot{U}_S &= \delta(1 - \phi - U_S) - \theta_S q(\theta_S) U_S \end{aligned} \qquad (II.5)$$

In the stationary state each sector satisfies $\dot{U}_F = 0$ and $\dot{U}_S$. The unemployment rate in each sector is

$$\begin{aligned} u_F &= \frac{\delta\phi}{\delta + \theta_F q(\theta_F)} \\ u_S &= \frac{\delta(1 - \phi)}{\delta + \theta_S q(\theta_S)} \end{aligned} \qquad (II.6)$$

The unemployment rate is inversely related with the tightness of the labor market in each sector. The static comparative analysis will shed some light about the different relationships among the variables.

3.3 Formal and shadow economy

Workers obtain money from working in each sector. In each sector jobs are destroyed at an exogenous Poisson rate $\delta \in (0,1)$. The wage in sector i is w_i. Formal employees pay τw_F to the government as a tax. The value function of the employment in the formal sector is

$$rE_F = w_F(1 - \tau) + \delta(U - E_F) \qquad (II.7)$$

Each formal worker produces p_F as it is in Equation *(2)*. Formal employers pay ρw_F to the government as a tax. The value function of a job in the formal sector is

$$rJ_F = p_F - w_F(1 + \rho) + \delta(V_F - J_F) \qquad (II.8)$$

Firms open vacancies with a fixed cost γ_i with $\gamma_F > \gamma_S$. The value function of a vacancy in each sector is

$$rV_i = q(\theta_i)(J_i - V_i) - \gamma_i \qquad (II.9)$$

Agents pay P if caught. Shadow agents are caught with probability $1 - \mathcal{P}(x, y)$. Workers do not participate in the conflict against the government. Only shadow entrepreneur invests resources in the conflict. The value function of the employment in the shadow sector is

$$rE_S = w_S - \big(1 - \mathcal{P}(x, y)\big)P + \delta(U - E_S) \qquad (II.10)$$

We could see rE_S as an expected value. Shadow entrepreneur pays a penalty P if caught with probability $1 - \mathcal{P}(x, y)$. We do not discriminate the penalty between worker and employer. Firms invest x in the conflict for p_S as it is in Equation *(2)*. The value function of a job in the shadow sector

$$rJ_S = \mathcal{P}(x, y)p_S - w_S - x - \big(1 - \mathcal{P}(x, y)\big)P + \delta(V_S - J_S) \qquad (II.11)$$

This is a Von-Neumann-Morgenstern expected utility. Shadow employers obtain p_S with probability $\mathcal{P}(x, y)$ and loses P with probability $1 - \mathcal{P}(x, y)$ after paying w_S to workers and investing x in the conflict.

3.4 The conflict

Shadow entrepreneurs engage in a conflict against the government. Their purpose of this conflict is to maximize the value of the shadow production. Workers participate indirectly in the conflict. They do not invest resources in the conflict but are subject to penalties. Agents in the shadow economy has conflict abilities. Conflict ability is the ability of not being caught from the government. Each shadow agent invests x in avoiding law with efficacy α. Bear in mind there are two α's and they are different. Later on we write them differently. Government invests y in enforcing the law with efficacy β.

3.4.1 Private effort

Let us study the private solution of the conflict. Shadow entrepreneur chooses x so as to maximize J_S. However, this maximization is not direct. We will clear this up later on. In doing this he has to consider the following definition:

$$\mathcal{P}(x,y) = \frac{\alpha x}{\alpha x + \beta y} \qquad (II.12)$$

Using *(12)* in *(11)* we have another expression for the shadow profit function

$$rJ_S = \left(\frac{\alpha x}{\alpha x + \beta y}\right) p_S - w_S - x - \left(\frac{\beta y}{\alpha x + \beta y}\right) P + \delta(V_S - J_S) \qquad (II.13)$$

We reorganize the expressions in *(13)* as the following

$$rJ_S = \left(\frac{\alpha x}{\alpha x + \beta y}\right)(p_S + P) - w_S - x - P + \delta(V_S - J_S) \qquad (II.14)$$

Let us retake the discussion of the maximization of profits. The purpose of the entrepreneur is to maximize *(14)* in terms of x. The objective of the agent is then

$$\max_{\{x\}} J'_S = (r+\delta)J_S = \left(\frac{\alpha x}{\alpha x + \beta y}\right)(p_S + P) - w_S - x - P + \delta V_S \qquad (II.15)$$

The FOC of *(15)* is $\partial J'_S/\partial x = 0$ which gives us a reaction function $x(y)$ showing the best answer of the shadow agent given the behavior of the government.

$$x = \sqrt{\frac{\beta}{\alpha}(p_S + P)y} - \frac{\beta}{\alpha}y \qquad (II.16)$$

Reorganizing *(16)* we have

$$\alpha x + \beta y = \sqrt{\alpha\beta(p_S + P)y} \qquad (II.17)$$

The total amount of resources spent in the conflict are directly related with the efficacy of each expenditure and the prize involved i.e the shadow production and the penalty. Solving *(17)* requires us to find an expression of y.

3.4.2 Public effort

Shadow sector destroys social welfare. They do not pay taxes nor registration fees. Shadow profits are then social costs. Government fights against shadow economy so as to minimize social cost, i.e. maximize social welfare. This is just one way to study social welfare. Later on in this chapter we are going to study specifically the social welfare function in this bisector search and matching model. Let us define the social cost in the following way. First, the total shadow production. Second, the money the government spends in the fighting. The last one could be seen as the opportunity cost. It could have been spent in other activities. Fighting shadow economy reduces the amount of resources to improve other social problems. Social cost (SC) is then defined as

$$SC = J_S'(1-\phi) + y \qquad (II.18)$$

The intuition is the following. There are J_S' shadow jobs as it is in Equation *(15)*. Each shadow job requires $1-\phi$ shadow workers. The total shadow production is then $J_S'(1-\phi)$. The government spends y resources in the conflict. The aim of the government is to minimize *SC* in Equation *(18)*. Replacing Equation *(15)* in *(18)* we have

$$SC = \left[\left(\frac{\alpha x}{\alpha x + \beta y}\right)(p_S + P) - w_S - x - P + \delta V_S\right](1-\phi) + y \qquad (II.19)$$

The objective of the government is $Min_y\, SC$ in Equation *(19)* which gives us the following reaction function

$$\alpha x + \beta y = \sqrt{\alpha\beta(p_S + P)x(1-\phi)} \qquad (II.20)$$

The total amount of resources spent in the conflict are in the public solution directly related with the efficacy of each expenditure, the prize involved and the number of shadow workers. Solving the conflict requires us to solve the system *(17)* and *(20)*. The solution is given by

$$y = (1-\phi)x \qquad (II.21)$$

The public expenditure grows with the amount of shadow workers and the amount of resources the shadow economy spends in the conflict. Replacing *Equation (21)*

in *Equation (17)* we have an expression for the amount of resources spent in the conflict

$$x^* = \frac{\alpha\beta(p_S + P)(1-\phi)}{\sqrt{\alpha + \beta(1-\phi)}} \qquad (II.22)$$

$$y^* = \frac{\alpha\beta(p_S + P)(1-\phi)^2}{\sqrt{\alpha + \beta(1-\phi)}}$$

Closing the model requires us to find specific expressions for the profits and probabilities which is the idea of the following section.

3.4.3 Solution

Equation *(21)* allows us to find two key parameters: probabilities and profits of the private sector. By default it gives us the social cost. Replacing Equation *(21)* in *(12)* we have

$$\mathcal{P}(x,y) = \frac{\alpha x}{\alpha x + \beta y} = \frac{\alpha}{\alpha + \beta(1-\phi)}$$
$$1 - \mathcal{P}(x,y) = \frac{\beta x}{\alpha x + \beta y} = \frac{\beta(1-\phi)}{\alpha + \beta(1-\phi)} \qquad (II.23)$$

Notice $\mathcal{P}(x,y)$ increases with ϕ indicating the public expenditure in the conflict increases with $1-\phi$ according to Equation *(21)*. Using Equation *(23)* in Equation *(14)* gives us the profit function

$$rJ_S = \left(\frac{\alpha}{\alpha + \beta(1-\phi)}\right)(p_S + P) - w_S - x - P + \delta(V_S - J_S) \qquad (II.24)$$

The higher the amount of shadow workers the stronger the government prosecution and the lower the illegal profits. It seems that the shadow sector would be better with lower amount of workers.

3.5 Equilibrium

Profits in each sector are equal to zero. There is no market power. Final prices equals marginal cost. Free entry guarantees that markets clear. Opening a vacancy generates zero profits. We define the equilibrium in this economy as

Definition 1: Given the vectors $= [p_F; p_S]$, $\boldsymbol{J} = [J_F; J_S]$, $\boldsymbol{V} = [V_F; V_S]$, $\boldsymbol{E} = [E_F; E_S]$, $\boldsymbol{\theta} = [\theta_F; \theta_S]$ *and the probability distribution* $\mathcal{P}(x, y)$ *an equilibrium in the bi-sector search economy is a vector* $[\boldsymbol{P}^*; \boldsymbol{J}^*; \boldsymbol{V}^*; \boldsymbol{E}^*; \boldsymbol{\theta}^*]$ *satisfying the equations (7)-(11) and (21).*

The three fundamental variables of *Definition 1* are relative prices and wages. Relative prices are determined by the marginal productivity in each sector. Wages come from private negotiation.

3.5.1 Relative prices

Prices are determined by the marginal productivity. Labor is the only input necessary to produce the final commodity. At the equilibrium production is proportional to the number of workers in each sector that are effectively working. That is,

$$\begin{aligned} Y_F &= \phi - u_F \\ Y_S &= 1 - \phi - u_S \end{aligned} \tag{II.25}$$

Using *Equations (25)* in *Equations (2)* we have the equilibrium prices.
Equilibrium prices are then defined as the marginal productivities computed at the final market equilibrium. That is,

$$\begin{aligned} p_F &= \alpha(\phi - u_F)^{\rho-1}[\alpha(1 - \phi - u_S)^{\rho} \\ &\quad + (1-\alpha)(\phi - u_F)^{\rho}]^{\frac{1-\rho}{\rho}} \\ p_S &= (1-\alpha)(1 - \phi - u_S)^{\rho-1}[\alpha(1 - \phi - u_S)^{\rho} + (1-\alpha)(\phi - u_F)^{\rho}]^{\frac{1-\rho}{\rho}} \end{aligned} \tag{II.26}$$

Prices reflect availability. Each production has an opportunity cost. Increasing the proportion of people working in the shadow sector reduces the proportion of people working in the formal sector. The relative prices reflect this trade-off,

$$\frac{p_F}{p_S} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{1-\phi-u_S}{\phi-u_F}\right)^{1-\rho} \qquad (II.27)$$

Increasing the proportion of formal workers ϕ increases the production of the formal sector and reduces the production of the shadow sector. The p_F decreases and p_S increases. If θ_S grows then u_S decreases and p_S/p_F also decreases. If θ_F grows then u_F decreases and p_S/p_F increases. The p_S/p_F is increasing in θ_F and decreasing in θ_S. We will study these implications later on in the comparative static.

3.5.2 Wages

The wage negotiation follows Nash bargaining. The wage does not change during the contract term. Assume $\beta \in (0,1)$ is the bargaining power of the workers. The bargaining power of the employers is $1-\beta$. The Nash bargaining function is

$$\Omega_i = (E_i(w_i) - U)^{\beta}(J_i(w_i) - V_i)^{1-\beta} \qquad (II.28)$$

The optimality condition is given by

$$\begin{aligned} \beta(1-\tau)(J_F(w_F) - V_F) - (1-\beta)(1+\rho)(E_F(w_F) - U) &= 0 \\ \beta(J_S(w_S) - V_S) - (1-\beta)(E_S(w_S) - U) &= 0 \end{aligned} \qquad (II.29)$$

Solving the system with *Equations (7)-(11)* gives us the wages of equilibrium in each sector.

Proposition 1: *Wages in each sector are given by*

$$\begin{aligned} w_F &= \left(\frac{\beta}{1+\rho}\right)(p_F + \gamma_F\theta_F) + \left(\frac{1-\beta}{1-\tau}\right)z \\ w_S &= \beta(\mathcal{P}(x^*, y^*)p_S - x + \gamma_S\theta_S) + \big(1 - \mathcal{P}(x^*, y^*)\big)(1-2\beta)P \end{aligned}$$

Formality and informality coexist in the long-run. It hinges upon the value of the different parameters of the model. In particular, it is related with fiscal policy, monitory rate and entry costs. As we did in the Chapter 1 let us consider the case in which workers do not have any bargaining negotiation.

Proposition 2: *If there is wage posting i.e* $\beta = 0$ *then*

$$w_F - w_S = \frac{z}{1-\tau} - (1-\mathcal{P})P$$

Proof: Using Proposition 1 with $\beta = 0$ □

Notice the difference in wages comes from the fiscal and monitory rates. In particular, higher taxes increases formal wages and tougher monitory rates reduces shadow wages.

3.5.3 Profits

The equilibrium comes from the encounter of workers and firms in bargaining wages. Bargaining the wages implies certain market power. The stronger sector defines the type of equilibrium. If there is corner equilibrium in which one sector does not produce then it loses money and the other wins. The equations of the equilibrium for each sector are

Proposition 3: *The equations of the equilibrium for each sector are*

$$(1-\beta)\left[p_F - \left(\frac{1+\rho}{1-\tau}\right)z\right] - \frac{(r+\delta)\gamma_F}{q(\theta_F)} - \beta\gamma_F\theta_F = 0$$

$$(1-\beta)\big(\mathcal{P}(x^*,y^*)p_S - x^* - 2\big(1-\mathcal{P}(x^*,y^*)\big)P\big) - \frac{(r+\delta)\gamma_S}{q(\theta_S)} - \beta\gamma_S\theta_S = 0$$

Proof: Using Proposition 1, Equations (7)-(11) along with $V_j = 0$ □

The equations in *Proposition 3* defines two loci for each sector in the (θ_F, θ_S)-plane. We are particularly interested in computing $\partial\theta_F/\partial\theta_S$ and $\partial\theta_S/\partial\theta_F$. That is the purpose of *Proposition 4*.

Proposition 4: At $[\boldsymbol{P}^*;\boldsymbol{J}^*;\boldsymbol{V}^*;\boldsymbol{E}^*;\boldsymbol{\theta}^*]$ *from Proposition 3 we have*

$$sign\left\{\left.\frac{\partial\theta_F}{\partial\theta_S}\right|_F\right\} = sign\left\{\left.\frac{\partial\theta_F}{\partial\theta_S}\right|_S\right\} = +$$

Proof: See Appendix □

Fiscal policy parameters would make indeterminate the relationship between θ and ϕ. It gives us at least There are 8 possibilities. The 8 possibilities are depicted in the *Figures 1, 2, 3 and 4*. Let us study the existence of equilibria. The two loci has the same slope.

Proposition 5: At $[\boldsymbol{P}^*;\boldsymbol{J}^*;\boldsymbol{V}^*;\boldsymbol{E}^*;\boldsymbol{\theta}^*]$ *from Proposition 4 we have*

$$\left.\frac{\partial^2\theta_F}{\partial\theta_S^2}\right|_F > 0$$

$$\left.\frac{\partial^2\theta_F}{\partial\theta_S^2}\right|_S < 0$$

Proof: See Appendix □

The Shadow locus is concave respect to the origin. The Formal locus is convex with respect to the origin. Both of them are continuous functions. There is a unique equilibrium. It is given in the respective figure.

3.6 Comparative statics

From *Proposition 3* we undertake the static comparative analysis. The key point is to understand the impact of changes in the different parameters on the unemployment and employment rates. The *proposition 5* computes the impact of the different variables. As we see an increase in the fundamental variables increase the unemployment rate.

Proposition 6: At $[\boldsymbol{P}^*;\boldsymbol{J}^*;\boldsymbol{V}^*;\boldsymbol{E}^*;\boldsymbol{\theta}^*]$ *we have*

$$sign\left\{\frac{\partial U_F}{\partial \theta_F}\right\} = sign\left\{\frac{\partial U_S}{\partial \theta_S}\right\} = -$$
$$sign\left\{\frac{\partial \theta_F}{\partial \mathcal{P}(x^*,y^*)}\right\} = sign\left\{\frac{\partial \theta_S}{\partial \mathcal{P}(x^*,y^*)}\right\} = +$$
$$sign\left\{\frac{\partial \theta_F}{\partial P}\right\} = sign\left\{\frac{\partial \theta_S}{\partial P}\right\} = -$$
$$sign\left\{\frac{\partial \theta_F}{\partial \tau}\right\} = sign\left\{\frac{\partial \theta_S}{\partial \tau}\right\} = -$$
$$sign\left\{\frac{\partial \theta_F}{\partial \rho}\right\} = sign\left\{\frac{\partial \theta_S}{\partial \rho}\right\} = -$$

Proof: See Appendix □

Fiscal policy reduces unemployment rate in each sector. Penalties reduce unemployment rate in each sector. Monitory rates reduce unemployment rate in each sector.

3.7 Welfare

There are three agents: formal, shadow and unemployed. Social welfare function is as follows. Formal firms produce the amount $(\phi - u_F)p_F$ of goods and services. Shadow firms produce the amount $(1-\phi-u_S)p_S$ of goods and services. Cost of capital in the formal sector: $\theta_F U_F \gamma_F$. Cost of capital in the shadow sector: $\theta_S U_S \gamma_S$. Unemployed workers get zU. Social utility function is

$$SU = \int_0^\infty e^{-rt}\big((\phi - u_F)p_F + (1-\phi-u_S)p_S - \theta_F U_F \gamma_F - \theta_S U_S \gamma_S + zU\big)dt \qquad (II.30)$$

Restrictions are

$$\dot{U}_F = \delta(\phi - u_F) - \theta_F q(\theta_F)u_F$$
$$\dot{U}_S = \delta(1-\phi-u_S) - \theta_S q(\theta_S)u_S$$

We are to write now the intertemporal problem as

$$\mathbb{H} = e^{-rt}\big((\phi - u_F)p_F + (1-\phi-u_S)p_S - \theta_F U_F \gamma_F - \theta_S U_S \gamma_S + zU\big) \\ + \lambda_F[\delta(\phi - u_F) - \theta_F q(\theta_F)u_F] + \lambda_S[\delta(1-\phi-u_S) - \theta_S q(\theta_S)u_S]$$

The first FOC's $\mathbb{H}'_{\theta_i} = 0$ are given by

$$\lambda_i = -\frac{\gamma_i e^{-rt}}{q(\theta_i)(1-\eta_i)}$$

Where $\eta_i = \frac{\partial q(\theta_i)}{\partial \theta_i}\frac{\theta_i}{q(\theta_i)}$ is the elasticity of $q(\theta_i)$ respect θ_i. Notice $\dot{\lambda}_\iota/\lambda_i = -r$. Notice $\dot{\lambda} = 0$. The second FOC $\mathbb{H}'_{u_i} = r\lambda_i$ is given by The comparison of the two equations are

$$(1-\beta)\left[p_F - \left(\frac{1+\rho}{1-\tau}\right)z\right] - \frac{(r+\delta)\gamma_F}{q(\theta_F)} - \beta\gamma_F\theta_F = 0$$
$$(1-\eta_F)(\phi p_F - z) - \frac{(r+\delta)\gamma_F}{q(\theta_F)} - \eta_F\gamma_F\theta_F = 0$$

The two equations are the same only when

$$\beta = \eta$$
$$\rho + \tau = 0$$

The first condition is the Hosio's condition. The second condition is a fiscal redistribution. Efficiency requires doing equitative transferences. The other Equations are

$$(1-\beta)\big(\mathcal{P}(x^*,y^*)p_S - x^* - 2\big(1-\mathcal{P}(x^*,y^*)\big)P\big) - \frac{(r+\delta)\gamma_S}{q(\theta_S)} - \beta\gamma_S\theta_S = 0$$

$$(1-\eta_S)(1-\phi)p_S - \frac{(r+\delta)\gamma_S}{q(\theta_S)} - \eta_S\gamma_S\theta_S = 0$$

The two set of 4-equations are the same only when

$$\begin{matrix}\beta = \eta \\ x = 0\end{matrix} \qquad \textit{(II.31)}$$

Which only applied when there is no a shadow economy and the Hosio's condition applied to the bargaining power and elasticity of the labor demand.

4. Numerical simulations

We implement here a similar numerical exercise as we did in Chapter 1. We also divide the analysis in two parts. First, we make a baseline economy. We set a target to choose parameters so as to match it. Second, we change some fundamental variables to see the comparative statics numerically. We continue using the Matlab ® implementation of the Newton-Raphson method. However, we add some new features. First, there is heterogeneity among the workers. Heterogeneity not only in terms of the labor productivity but also in term of the conflict technology. Second, we introduce an explicit competition between illegal agents and government to define the monitory rates. This two concepts are closely related in the contest success function. It is quite interesting to extend the analysis of the Chapter 1 in several directions. The key point here is to evaluate the efficiency of economic policy in moving people from one sector to the other. As we shall see fiscal policy might have been overestimated in this regard. Introducing conflict distorts the typical conclusion since there appears additional effects such as balloon effects or hydra effects –which we are going to discuss in the next Chapter 3- that reduces the efficacy of the economic policy.

4.1 Baseline economy

In the following table we set the main parameters of the model. For the sake of clarity in the exposition α_p stands for the individual productivity in avoiding the governmental regulation hitherto. In any case do not confuse this parameter with α from the importance of shadow production on the total production of the economy. In the model we use the same notation but made the point clear there. The parameters were selected with a target of tightness in the labor market around 5-10% and unemployment rates around 2-5%. Our selection from a uniform probability distribution is presented in Table 12.

Table 12: Parameter of the baseline economy

Parameter	Value	Definition (a concise definition is within the text)
P	0,1	Penalty for avoiding regulations
α	0,5	Proportion of shadow economy.
β	0,3	Employer bargaining power.
α_p	0,5	Individual productivity of avoiding regulation.
β_p	0,5	Government productivity of law enforcing.
δ	0,1	Rate of destruction of labor contracts.
r	0,05	Real interest rate.
γ_F	0,1	Formal entry cost.
γ_S	0,05	Shadow entry cost.
ρ	0,1	Tax burden for the employer.
τ	0,1	Tax burden for the employee.
ϕ	0,5	Proportion of formal workers in the economy.

In the following section we run some experiments to study the impact of fiscal policy and monitory rates on the main variables of the model such as unemployment rate, formal employment rate and shadow employment rate by using the information in Table 12.

4.2 Experiments

First, we analyze the impact of changes in the unemployment benefit given the parameters of the contest function. Table 13 reports the results. Increasing the unemployment benefit reduces the thigtness of the labor market and increases the unemployment rate in the formal sector. The labor productivities and the unemployment rate of the shadow sector remain constant. The intuition here is similar to the one in Chapter 1. Increasing the unemployment rate makes it possible for an agent to increase the waiting time for a job offer. Meanwhile he receives the unemployment subsidy and reduces the probability of getting a shadow job.

Table 13: Changes in unemployment benefit with $\alpha_p = 0{,}5$

	*Unemployment benefit (**z**)*		
Variables	0	0,1	0,2
$\boldsymbol{\theta_F}$	10,1	7,5	4,9
$\boldsymbol{\theta_S}$	7,1	7,1	7,1
$\boldsymbol{u_F}$	1,5	1,7	2,2
$\boldsymbol{u_S}$	1,8	1,8	1,8
$\boldsymbol{p_F}$	0,5	0,5	0,5
$\boldsymbol{p_S}$	0,5	0,5	0,5

Now let us consider another situation. Let us assume that there is an exogenous increment in the ability of individuals to go shadow. That is, there is a reduction in the probability of being captured by the government. The results are shown in Table 14. Unemployment rate in the shadow sector remains constant but the corresponding values are higher than the previous ones. It shows that reducing the probability of success in the shadow sector increases the unemployment rate even though there is no any impact at all due to the unemployment benefit. This remark is useful when thinking about the implication of unemployment subsidies given a certain ability of the shadow sector to hide from the government.

Table 14: Changes in unemployment benefit with $\alpha_p = 0{,}3$

	Unemployment benefit ($\mathbf{z}$)		
Variables	0	0,1	0,2
$\boldsymbol{\theta_F}$	10,1	7,4	4,8
$\boldsymbol{\theta_S}$	4,6	4,6	4,6
$\boldsymbol{u_F}$	1,5	1,7	2,1
$\boldsymbol{u_S}$	2,2	2,2	2,2
$\boldsymbol{p_F}$	0,5	0,5	0,5
$\boldsymbol{p_S}$	0,5	0,5	0,5

Let us consider now the other policy. That is, the changes in the proportion of penalties. The results are shown in Table 15. Notice there is a reduction in the thigtness of the labor market in each sector. The formal unemployment remains unchanged as it was expected. However, there is an increment in the unemployment rate in the shadow sector. Tougher penalties along with more efficient monitory rates increase the unemployment in the shadow sector. This set of policies are complementary to fiscal policies and allow the government to ameliorate the impact of its own inefficiency on the intersector labor distribution.

Table 15: Changes in penalties with $z = 0$

	*Penalty (**P**)*		
Variables	*0*	*0,05*	*0,1*
$\boldsymbol{\theta_F}$	4,9	4,9	4,9
$\boldsymbol{\theta_S}$	8,9	6,7	4,5
$\boldsymbol{u_F}$	2,1	2,1	2,1
$\boldsymbol{u_S}$	1,6	1,8	2,2
$\boldsymbol{p_F}$	0,5	0,5	0,5
$\boldsymbol{p_S}$	0,5	0,5	0,5

Let us now study the impact of changes in the fiscal policy. We consider basically two scenarios. We differentiate each analysis according to different proportion of people in each sector. In the Table 16 we consider the case there is a uniform distribution in each sector. The other case will be considered in the Table 17. The results are the following.

Increasing taxes implies reductions of the tightness of the labor market in each sector. But there is no a significant impact in the amount of people working in each sector. The analysis is similar to the one studied in the previous chapter. Fiscal policy does not seem to be the best way to induce intersector labor movement. This is conditional to the existence of a shadow economy that fights against the government so as to avoid regulation. This competition is not innocuous. Spending resources in the conflict, in particular, increasing the ability of the government to enforce the law, makes the other policies more efficient in reaching their objectives. Weak monitory rates is an incentive for people to leave the formal sector toward the shadow one regardless fiscal incentives. This is one of the key finding in these two chapters. In a nutshell, the efficiency of the economic policy in moving people from one sector to the other is conditional to the ability of the government to enforce the law and fight shadow economic activities.

Table 16: Changes in fiscal policy with $\phi = 0{,}5$, $z = 0{,}1$ and $\alpha_p = 0{,}5$

	Fiscal policy $(\boldsymbol{\rho}, \boldsymbol{\tau})$		
Variables	$\rho = 0{,}1$ $\tau = 0{,}2$	$\rho = 0{,}2$ $\tau = 0{,}1$	$\rho = 0{,}2$ $\tau = 0{,}2$
$\boldsymbol{\theta_F}$	7,1	7,2	6,8
$\boldsymbol{\theta_S}$	7,1	7,1	7,1
$\boldsymbol{u_F}$	1,8	1,7	1,8
$\boldsymbol{u_S}$	1,8	1,8	1,8
$\boldsymbol{p_F}$	0,5	0,5	0,5
$\boldsymbol{p_S}$	0,5	0,5	0,5

Table 17: Changes in fiscal policy with $\phi = 0{,}6$, $z = 0{,}1$ and $\alpha_p = 0{,}5$

	Fiscal policy $(\boldsymbol{\rho}, \boldsymbol{\tau})$		
Variables	$\rho = 0{,}1$ $\tau = 0{,}2$	$\rho = 0{,}2$ $\tau = 0{,}1$	$\rho = 0{,}2$ $\tau = 0{,}2$
$\boldsymbol{\theta_F}$	6,3	6,4	6,1
$\boldsymbol{\theta_S}$	10,3	10,3	10,3
$\boldsymbol{u_F}$	2,3	2,2	2,3
$\boldsymbol{u_S}$	1,2	1,2	1,2
$\boldsymbol{p_F}$	0,4	0,4	0,4
$\boldsymbol{p_S}$	0,5	0,5	0,5

5. General discussion and conclusion

Let this discussion be a place to connect philosophical concepts from these two chapters. The market economy is a connected set. It is composed of multiple markets interconnected each other through a complex set of social relationships. Dividing the market in sectors such as formal, informal and illegal is risky since that separation may ignore the multiple social relationships among them. This is particularly important in economic policy. The government would like to move people from one sector to another. This separation comes from a dualistic view of society. The formal sector is associated with modern technology and complex managerial skills, whereas the informal sector is seen as traditional, rudimentary technology and basic managerial skills. Under this view, formal agents are productive and thereby rich, high profits and wages; informal agents, instead, are less productive and thereby poor, low profits and wages. This is a simplistic approach. We would like to ask for historical or even structural reasons that lead some individuals to work shadow.

Instead of talking about the informal production, in the first chapter and the general introduction we talk about petty production. There are no two sectors but a continuum of different sectors intimately related each other. Bromley and Geary (1979)[24] distinguish various categories of casual work instead of the simplistic wage-employment and self-employment. Among them there are short-term work and dependent work which connect the two poles of the dualistic/orthodox approach we have been working with in this chapter. Portes (1978)[25] emphasize the dependence relationship among the two sectors. Instead of being separated the two so-called sectors are in a close relationship. Informality offers cheap goods and services to formality because of the low costs of production. It enables formal workers to reduce the living cost and requires less wage with which formality enhance the process of generating profits. Inequality in income distribution could, then, be seen as a cause and consequence of informality.

Informality is a marginal pole of the market economy. It could be seen as a juxtaposition of two systems of production. We mention this idea in the general introduction. On one hand, there is a capitalist system of production where there is separation of capital and labor. Capitalists have capital and hires workers to use it so as to get economic profits from producing and distributing goods and services. Searching for economic profits is the spirit of this system. Individual ambition serves the common good would say Smith in his analysis of a market based system. On the other hand, there is a pre-capitalist system of production. The key point here is not economic profit but subsistence of the family. There is no a separation of capital and labor but entrepreneurs may have both of them at the same time. This is the basic ingredient of the informal economy. Most of the developing world had and has this system of production. The coexistence of formality and informality is explained thus as a juxtaposition of a capitalist system of production and the pre-capitalist conditions inherent in certain societies.

That juxtaposition allows us to interpret the economic development as an unequal process. Formal sector is the leader in the economic progress. An important part of the profits goes there. The accumulation of capital makes that sector stronger. Informal sector, instead, will remain underdeveloped. It is plenty of cheap goods and services and labor force. It is a place to be for the reserve industrial army. There is then a subordination of informality to formality. Formality becomes the center and informality the periphery as an analogy to the international economic system studied by Prebish at CEPAL. Concentration and centralization of capital will make the formal sector intensive in high-productivity labor force. A significant portion of the always-increasing urban labor supply will find no place in formality so there is needed informality to take them. They become consumers of the formal production and the play goes on. This circular movement explains

why informality is a natural consequence of the functioning of a market-based economy.

Tokman (1978)[26] organizes the different approaches and particularities from each one. He explains that the coexistence of the two systems implies both processes subordination and exploitation. First, the informal sector is subordinated to the formal one. This subordination is not simply technical but sociological. On one hand, informality incorporates the residual and obsolete technology from the formal sector. There is a permanent delay since informality has no incentive to accumulate capital. On the other hand, it modifies the social relationships. Following the Marxian analysis there appears a fetishism of the labor. Informal workers are then considered as undesirable workers with no social respect. This is the reason necessary for the formal sector to exploit the informal one. Subordination and exploitation makes informality a social and political problem for any society.

Informal agents remain in the shadow. Government as a social contract has the mission of evaluate and punish the behavior of individuals. Following Foucault (1994)[27] the power will try to be invisible to not be punished. It is not rational to have a representation of the shadow agents. Lack of representability makes them vulnerable to economic policy since they are systematically ignored or what is worse they are seen as enemies of the state. While waiting for being hired for the formal economy if possible they modify the social structure. According to Bordieu (1977)[28] there appears a social capital. Informality creates a set of social relationships making possible its own existence. In the developing world there is a myriad of examples. Street vendors are inserted in the social life selling small-scale legal goods and services useful for many formal workers or entrepreneurs. Small workshops in houses are the supply for many products of first necessities and hiring single mother without regular permissions are consider even charity. In *Bordieu* terms there is a social consciousness regarding informality.

6. Appendix

This appendix organizes the proof of some of the propositions stated throughout the paper. It also contains graphics and tables. The appendix is not intended for publication. It is intended as an explanation to the main points of the chapter.

6.1 Proofs

Proposition 4

Applying the implicit function theorem to Equation (1) in Proposition 3 we have

$$\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_F = -\frac{(1-\beta)\frac{\partial p_F}{\partial \theta_S}}{(1-\beta)\frac{\partial p_F}{\partial \theta_F} - (r+\delta)\gamma_F \frac{\partial}{\partial \theta_F}\left(\frac{1}{q(\theta_F)}\right) - \beta\gamma_F} \tag{A.1}$$

Notice $\partial p_F/\partial \theta_S > 0$ *and* $\partial p_F/\partial \theta_F < 0$. *Since* $\frac{\partial}{\partial \theta}\left(q(\theta)\right) < 0$ *then* $\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right) > 0$ *Thereby*

$$\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_F = \frac{(1-\beta)\frac{\partial p_F}{\partial \theta_S}}{(1-\beta)\left|\frac{\partial p_F}{\partial \theta_F}\right| + (r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta_F}\left(\frac{1}{q(\theta_F)}\right)\right| + \beta\gamma_F} \tag{A.2}$$

We conclude

$$sign\left\{\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_F\right\} = + \tag{A.3}$$

Applying the implicit function theorem to Equation (2) in Proposition 3 we have

$$\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_S = -\frac{(1-\beta)\mathcal{P}\frac{\partial p_S}{\partial \theta_S} - (r+\delta)\gamma_S \frac{\partial}{\partial \theta_S}\left(\frac{1}{q(\theta_S)}\right) - \beta\gamma_S}{(1-\beta)\mathcal{P}\frac{\partial p_S}{\partial \theta_F}} \tag{A.4}$$

Notice $\partial p_S/\partial \theta_F > 0$ *and* $\partial p_S/\partial \theta_S < 0$. *Since* $\frac{\partial}{\partial \theta}\left(q(\theta)\right) < 0$ *then* $\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right) > 0$ *Thereby*

$$\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_S = \frac{(1-\beta)\mathcal{P}\left|\frac{\partial p_S}{\partial \theta_S}\right| + (r+\delta)\gamma_S \left|\frac{\partial}{\partial \theta_S}\left(\frac{1}{q(\theta_S)}\right)\right| + \beta\gamma_S}{(1-\beta)\mathcal{P}\frac{\partial p_S}{\partial \theta_F}} \tag{A.5}$$

We conclude

$$sign\left\{\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_S\right\} = + \tag{A.6}$$

Then combining (A.6) with (A.3)

$$sign\left\{\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_F\right\} = sign\left\{\left.\frac{\partial \theta_F}{\partial \theta_S}\right|_S\right\} = + \tag{A.7}$$

□

Proposition 5

Taking the second derivative in (A.2)

$$\left.\frac{\partial^2 \theta_F}{\partial \theta_S^2}\right|_F = \frac{\left[(1-\beta)\left|\frac{\partial p_F}{\partial \theta_F}\right| + (r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta_F}\left(\frac{1}{q(\theta_F)}\right)\right| + \beta\gamma_F\right](1-\beta)\frac{\partial^2 p_F}{\partial \theta_S^2}}{\left[(1-\beta)\left|\frac{\partial p_F}{\partial \theta_F}\right| + (r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta_F}\left(\frac{1}{q(\theta_F)}\right)\right| + \beta\gamma_F\right]^2} \tag{A.8}$$

Since $\partial^2 p_F/\partial \theta_S^2 > 0$ *then*

$$\left.\frac{\partial^2\theta_F}{\partial\theta_S^2}\right|_F > 0 \tag{A.9}$$

On the other hand,

$$\left.\frac{\partial^2\theta_F}{\partial\theta_S^2}\right|_S = \frac{(1-\beta)\mathcal{P}\frac{\partial p_S}{\partial\theta_F}\left[(1-\beta)\mathcal{P}\frac{\partial^2 p_S}{\partial\theta_S^2} + (r+\delta)\gamma_F\frac{\partial^2}{\partial\theta_S^2}\left(\frac{1}{q(\theta_S)}\right)\right]}{\left[(1-\beta)\mathcal{P}\frac{\partial p_S}{\partial\theta_F}\right]^2} \tag{A.10}$$

Since $\partial^2 p_S/\partial\theta_S^2 < 0$ *and* $\frac{\partial^2}{\partial\theta_S^2}\left(\frac{1}{q(\theta_S)}\right) < 0$ *then*

$$\left.\frac{\partial^2\theta_F}{\partial\theta_S^2}\right|_S < 0 \tag{A.11}$$

□

Proposition 6

From Equation (6) we know $\frac{\partial U_F}{\partial\theta_F} < 0$ *and* $\frac{\partial U_S}{\partial\theta_S} < 0$.
Tightness vs monitoring rate

$$\frac{\partial\theta_S}{\partial\mathcal{P}(x^*,y^*)} = \frac{(1-\beta)p_S + 2P}{(r+\delta)\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} > 0 \tag{A.12}$$

Since $\frac{\partial\theta_F}{\partial\theta_S} > 0$ *then* $\frac{\partial\theta_F}{\partial\mathcal{P}(x^*,y^*)} > 0$.
Tightness vs penalty

$$\frac{\partial\theta_S}{\partial P} = \frac{-2\left(1-\mathcal{P}(x^*,y^*)\right)}{(r+\delta)\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \tag{A.13}$$

Since $\frac{\partial \theta_F}{\partial \theta_S} > 0$ *then* $\frac{\partial \theta_F}{\partial P} < 0$.
Tightness vs unemployment subsidy

$$\frac{\partial \theta_F}{\partial z} = \frac{-(1-\beta)\left(\frac{1+\rho}{1-\tau}\right)}{(r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.14)$$

Since $\frac{\partial \theta_F}{\partial \theta_S} > 0$ *then* $\frac{\partial \theta_S}{\partial z} < 0$.
Tightness vs taxes

$$\frac{\partial \theta_F}{\partial \tau} = \frac{-(1-\beta)\frac{(1+\rho)}{(1-\tau)^2}z}{(r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.15)$$

Since $\frac{\partial \theta_F}{\partial \theta_S} > 0$ *then* $\frac{\partial \theta_S}{\partial \tau} < 0$.
Finally

$$\frac{\partial \theta_F}{\partial \rho} = \frac{-(1-\beta)\left(\frac{1}{1-\tau}\right)z}{(r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.16)$$

Since $\frac{\partial \theta_F}{\partial \theta_S} > 0$ *then* $\frac{\partial \theta_S}{\partial \rho} < 0$.

□

6.2 Analysis of equilibria

Figure 2: Indeterminacy of equilibrium

Figure 16: Indeterminacy of equilibrium

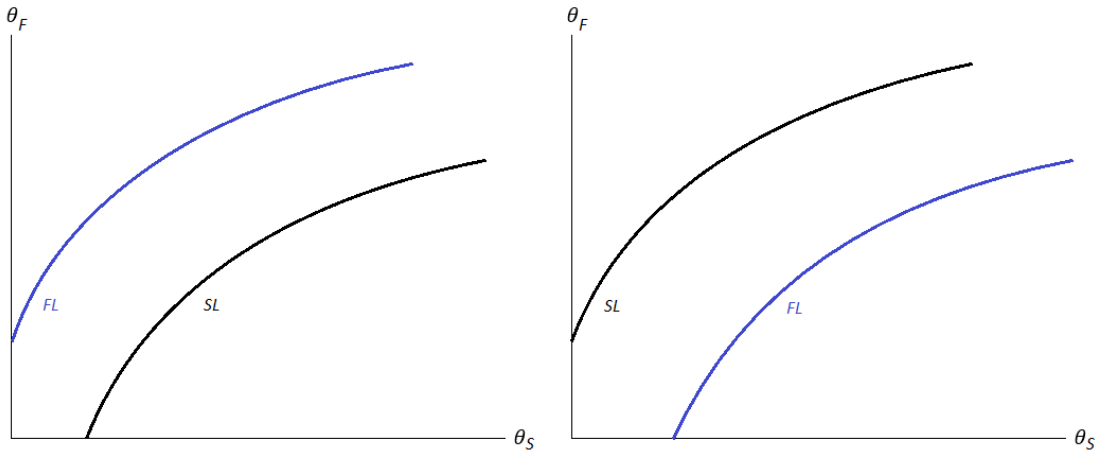
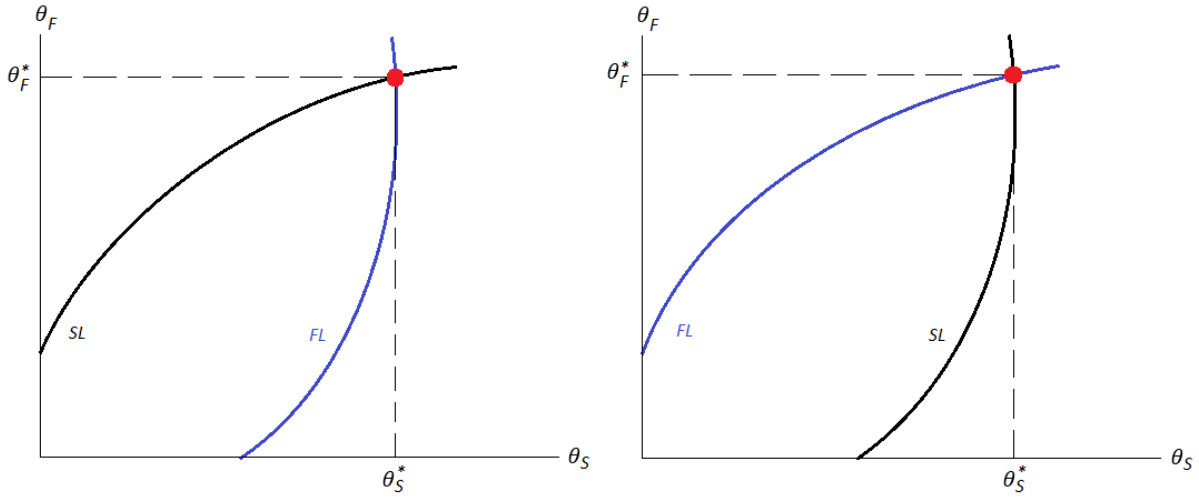


Figure 3: Determinacy of equilibrium

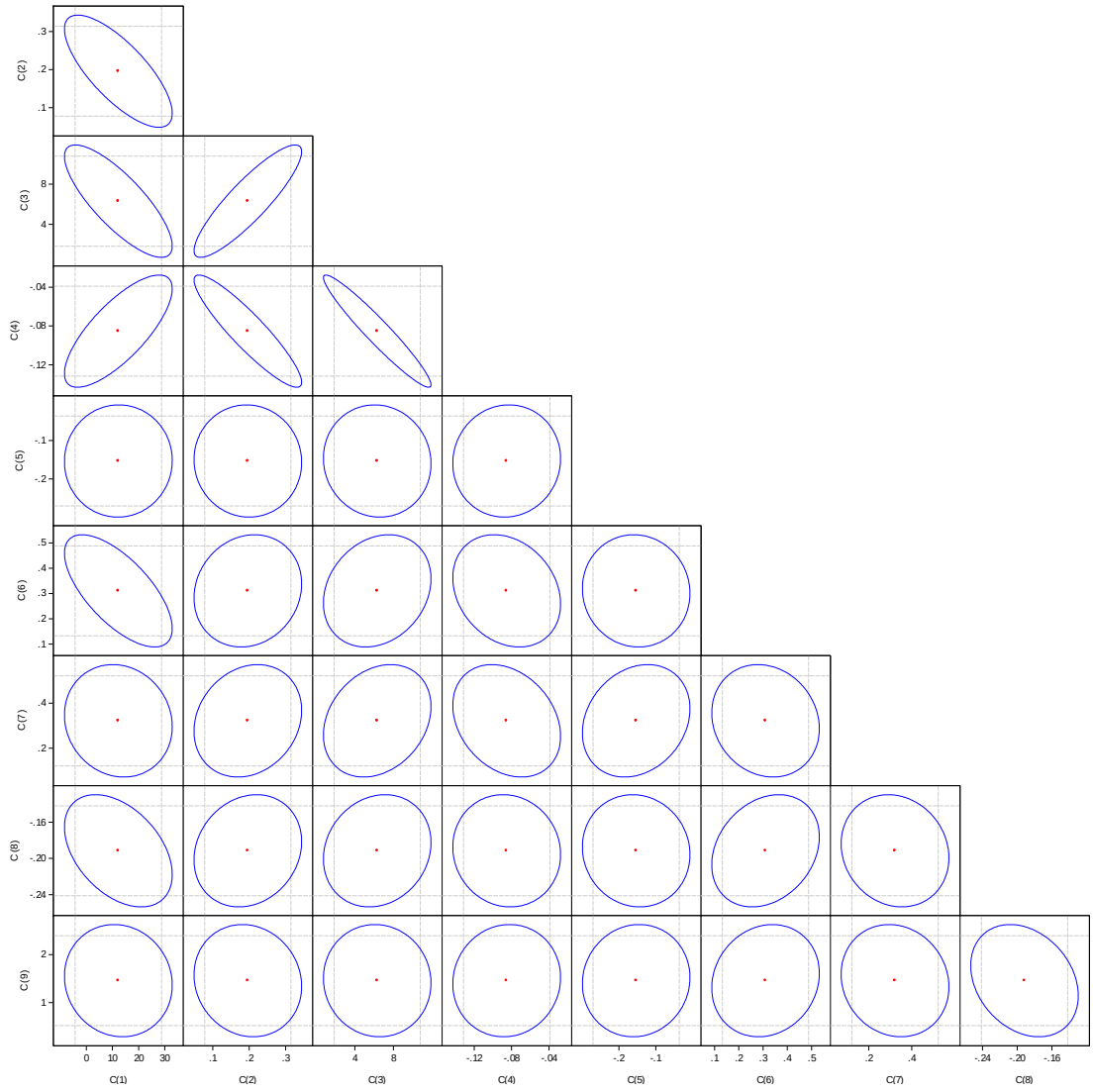
Figure 17: Determinacy of equilibrium



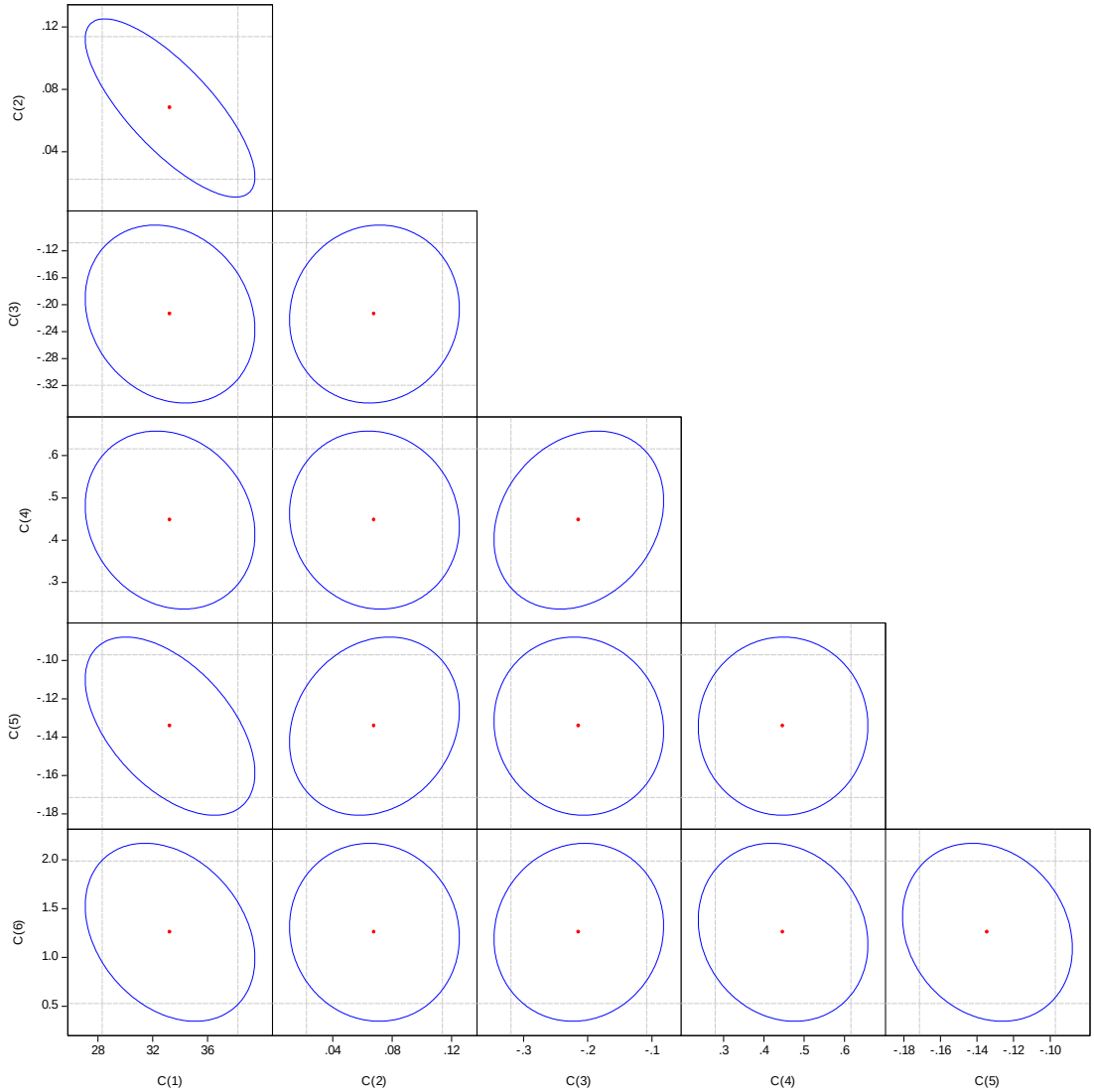
6.3 Confidence ellipse for the coefficients

(From the panel regression in the stylized facts section)

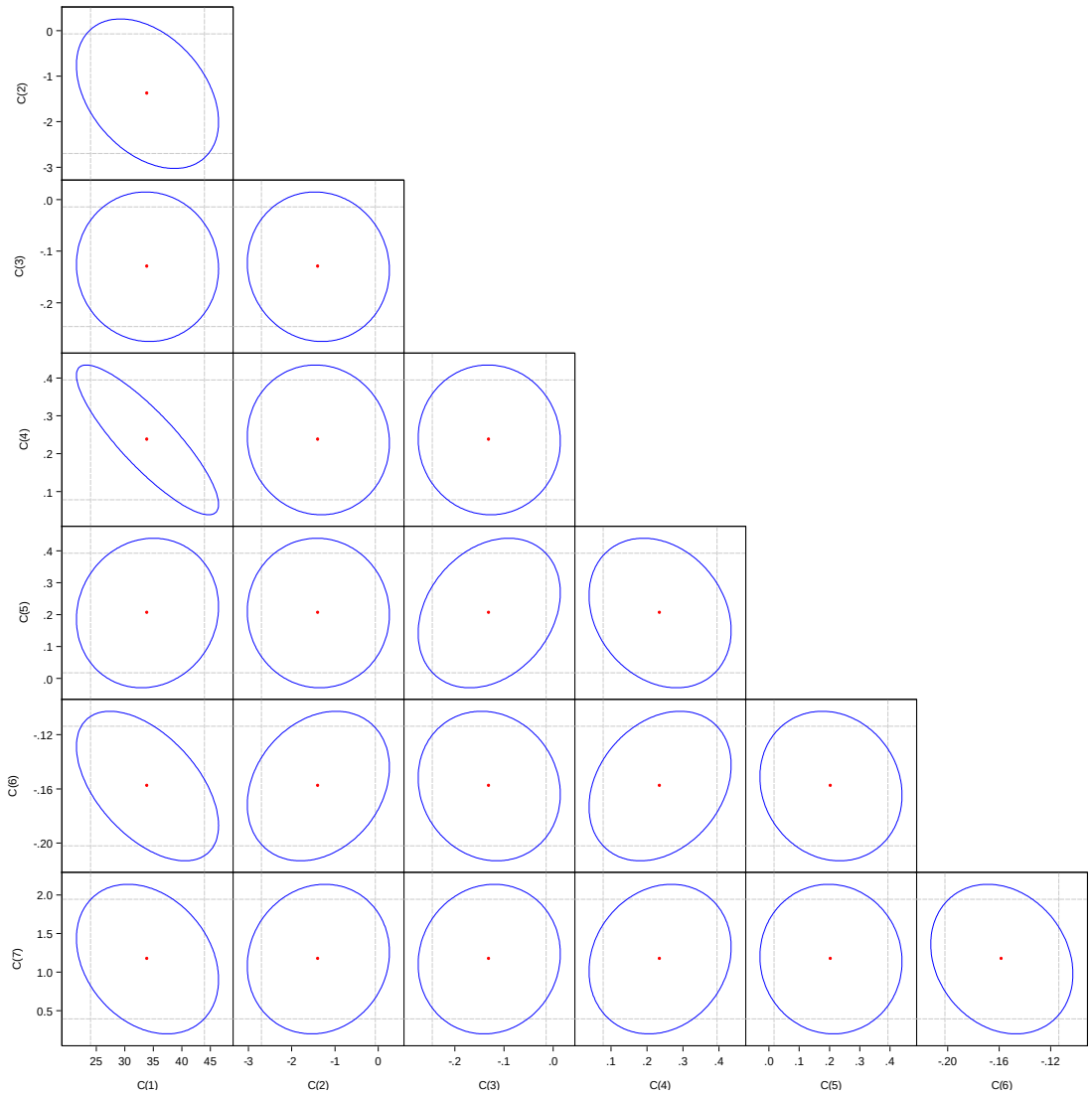
Model 1



Model 5)

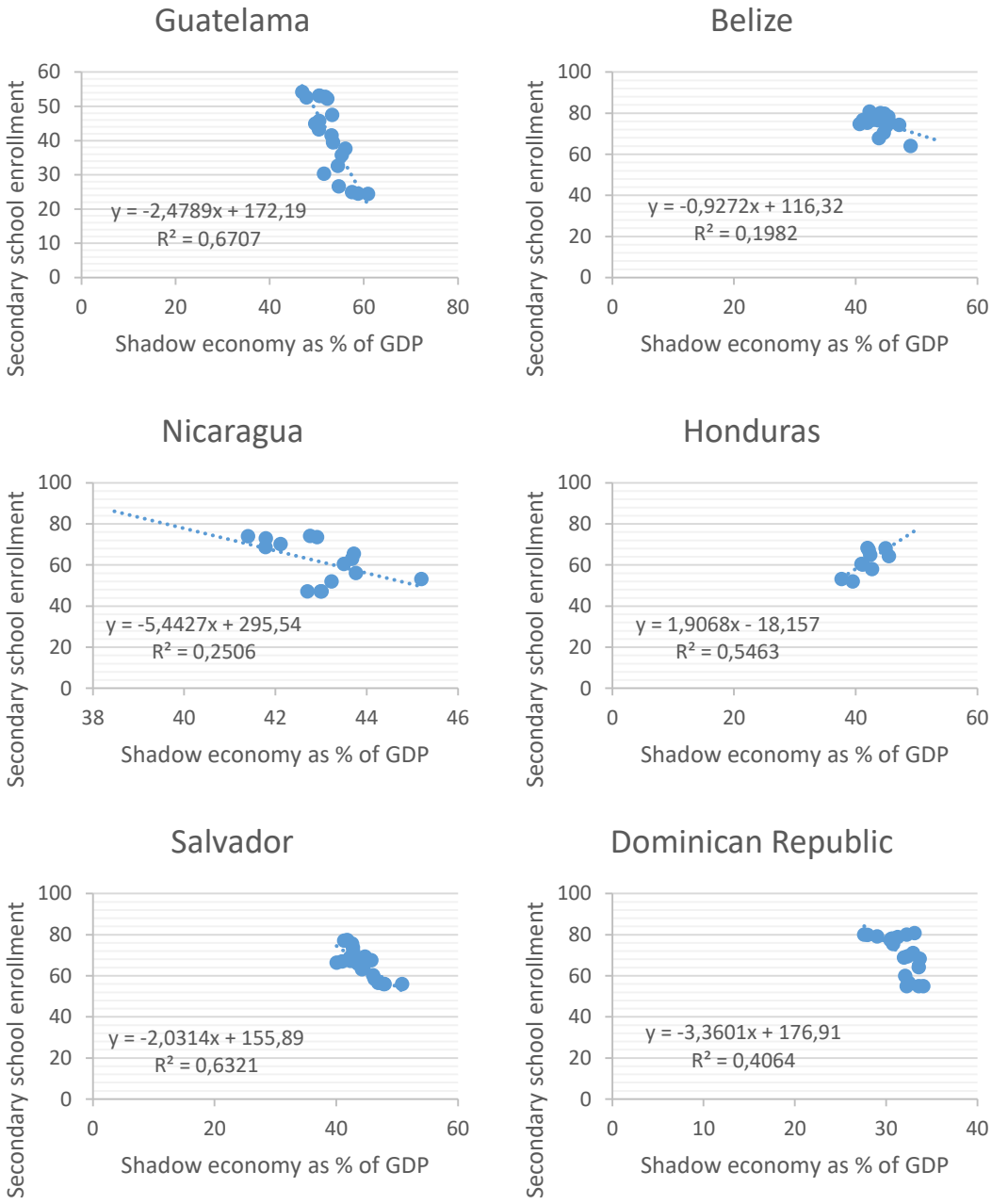

C(2)
.12
.08
.04
C(3)
-.12
-.16
-.20
-.24
-.28
-.32
C(4)
.6
.5
.4
.3
C(5)
-.10
-.12
-.14
-.16
-.18
C(6)
2.0
1.5
1.0
0.5
28
32
36
C(1)
.04
.08
.12
C(2)
-.3
-.2
-.1
C(3)
.3
.4
.5
.6
C(4)
-.18
-.16
-.14
-.12
-.10
C(5)

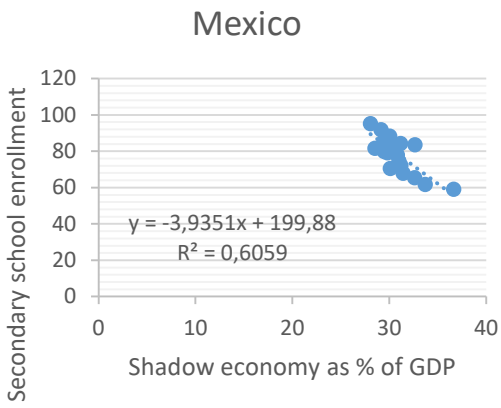
Model 6)

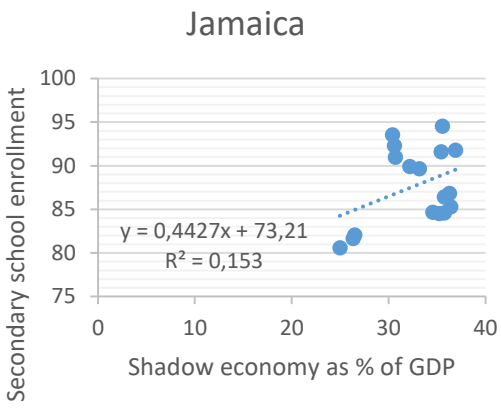


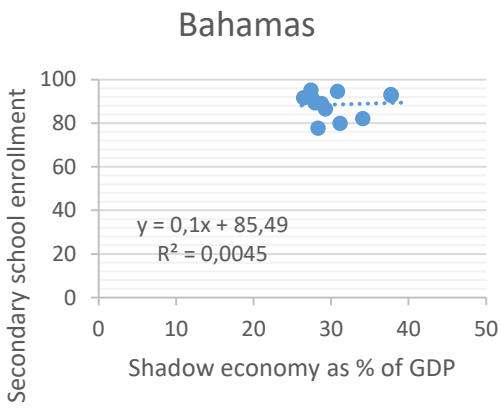
6.4 Individual regressions

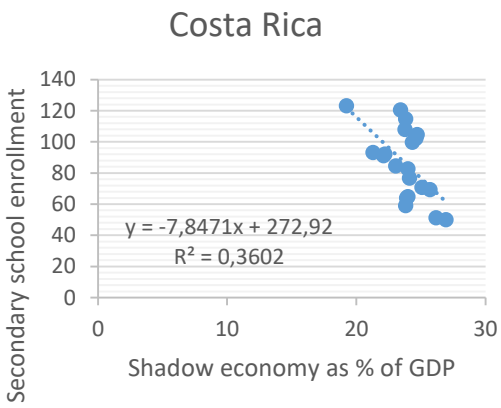
Figure 18: Shadow economy as percentage of the GDP vs secondary school enrollment in Latin America and the Caribbean during 1996-2015

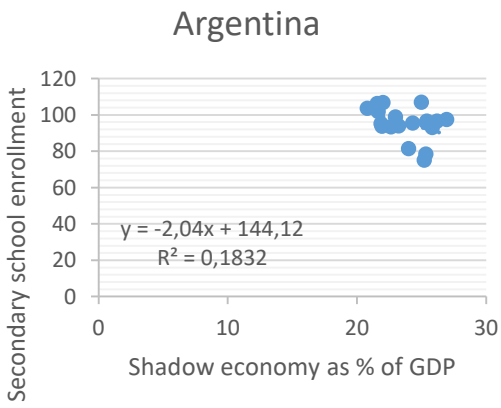


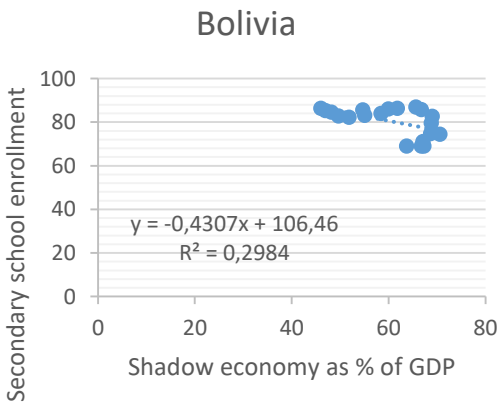

Mexico
Secondary school enrollment
Shadow economy as % of GDP
y = -3,9351x + 199,88
R² = 0,6059

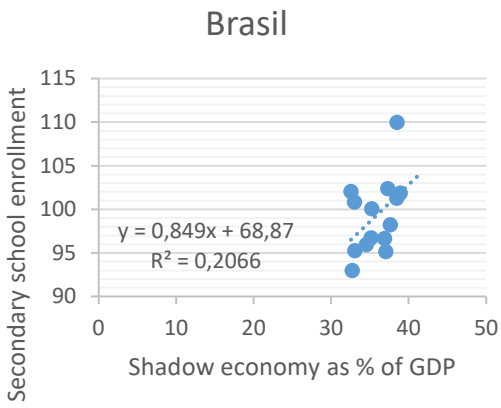

Jamaica
Secondary school enrollment
Shadow economy as % of GDP
y = 0,4427x + 73,21
R² = 0,153

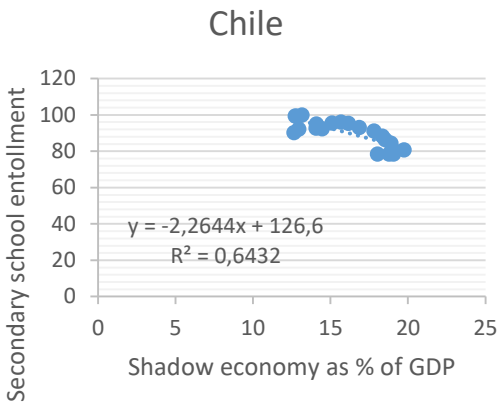

Bahamas
Secondary school enrollment
Shadow economy as % of GDP
y = 0,1x + 85,49
R² = 0,0045

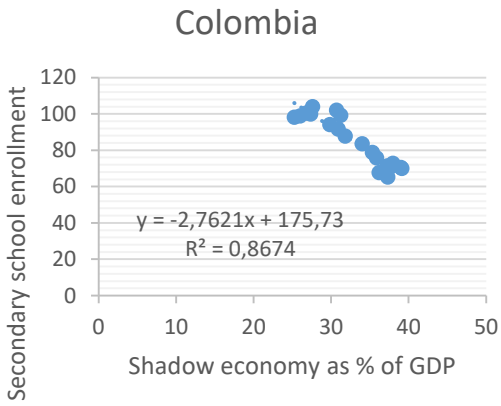

Costa Rica
Secondary school enrollment
Shadow economy as % of GDP
y = -7,8471x + 272,92
R² = 0,3602

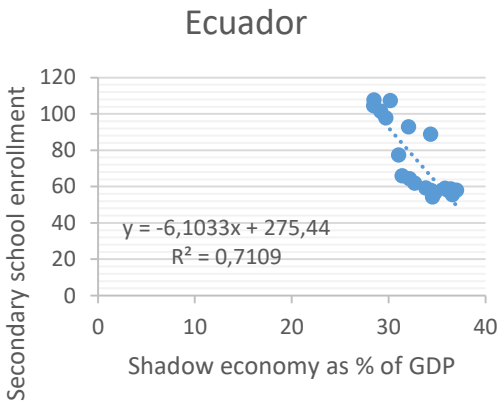

Argentina
Secondary school enrollment
Shadow economy as % of GDP
y = -2,04x + 144,12
R² = 0,1832

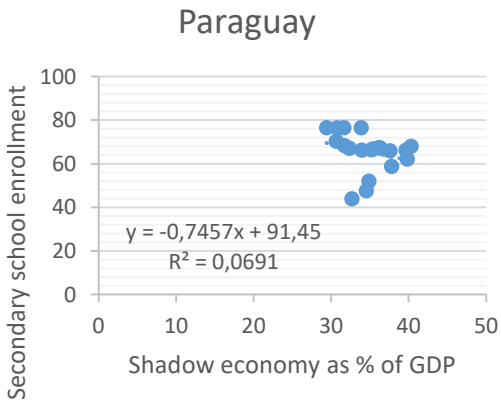

Bolivia
Secondary school enrollment
Shadow economy as % of GDP
y = -0,4307x + 106,46
R² = 0,2984

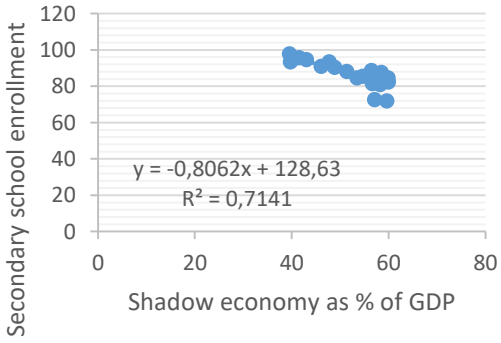

Brasil
Secondary school enrollment
Shadow economy as % of GDP
y = 0,849x + 68,87
R² = 0,2066

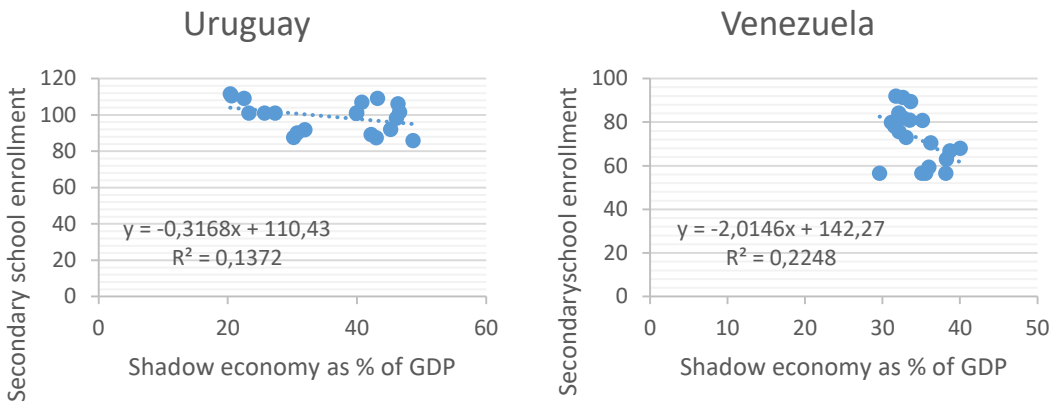

Chile
Secondary school entollment
Shadow economy as % of GDP
y = -2,2644x + 126,6
R² = 0,6432


Colombia
Secondary school enrollment
Shadow economy as % of GDP
y = -2,7621x + 175,73
R² = 0,8674


Ecuador
Secondary school enrollment
Shadow economy as % of GDP
y = -6,1033x + 275,44
R² = 0,7109


Paraguay
Secondary school enrollment
Shadow economy as % of GDP
y = -0,7457x + 91,45
R² = 0,0691


Peru
Secondary school enrollment
Shadow economy as % of GDP
y = -0,8062x + 128,63
R² = 0,7141



Source: Built form Medina and Schneider (2017)[23] and the World Bank.

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❖ ESSAY III

III. Building the wall or enforcing the law? An illegality approach to the shadow economy

Abstract

The main purpose of this paper is to study the impact of both border and internal enforcement on the intersector labor distribution in a host country with legal and illegal immigration. In doing so we model two separate but dependent labor markets as it is in Zenou (2008)[22]. Formal labor markets are subject to frictions derived from search and matching but illegal markets are frictionless in a perfect competitive environment. Results are suggestive. Both policies do have a significant impact on the intersector labor distribution but their impact on the shadow economy is not coincident whatsoever. Building walls seems to enhance the illegal market whilst internal enforcement seems to worsen it.

Keywords:
Bisector search and matching model; border enforcement, internal enforcement, immigration.

JEL classification:
D50, D73, E26, J46, J61, J64, K42, O17

1. Introduction

International labor mobility is a trending topic. Migrants typically search for better economic conditions and life improvements. Multiple concerns arise in host countries regarding to immigration. Some people would think of it as an advantage. Migration improves labor efficiency and diversification. Others would think of it as a disadvantage. In this other case, an immigrant is an opportunist whose only objective is to take advantage of the social security system. Moreover, they would think of immigrants as a fundamental cause of illegality. There is radicalism in both cases. Immigration is a natural consequence of globalization. There are simultaneously positive and negative consequences of immigration in host countries. Understanding these consequences is crucial for governments to design better economic policies.

Legality and illegality coexist in all societies. Multiple reasons arise as to why individuals engage in criminal behavior. As we studied in Chapter 2, one crucial variable is education. In particular, moral education. Criminals do not consider social costs when breaking the law. This is an interesting hypothesis studied in Kolm and Larsen (2001)[12] and Ibañez and Martinsson (2013)[11] where moral cost is studied as an externality determining the intersector labor distribution. Think of illegal drugs trafficking. People consume drugs so as to get pleasure. Drug consumers only care about his own welfare regardless the social problems generated in drug-producing countries. Illegality is not a simple consequence of international labor mobility but a sub-product of the rational individual behavior. It is ubiquitous in all societies.

There is no a clear relationship between immigration and illegality. Some papers suggests that the common sense in misleading in this regard; there is no such a relationship. Bianchi, Buonanno and Pinotti (2012)[3] explains that illegal immigration only explains a small part of the crime rate in host countries. Some of those crimes are basically property crimes according to Bell, Machin and Fasani (2010)[2]. As for Bianchi, Buonanno and Pinotti (2012)[3] and Borrego, Garoupa and Vazquez (2011)[4] the specific types of crime are robberies, and considering robberies as a minor criminal offense, then the impact of immigration on crime rate is near zero. Interestingly, some other papers find there is a negative relationship between immigration and illegality. Ozden, Testaverde and Wagner (2018)[16] and Light and Miller (2018)[13] find immigration reduces the crime rate in the host countries. The hypothesis is as follows. Most of immigrants go to informal

activities, not necessarily illegal ones, because of their inability of get rid of public authorities.

Studying the impact of immigration on illegality might jeopardize the impact it has on legal labor markets. An eclectic analysis in needed. Friedberg and Hunt (1995)[9] and Borjas (2003)[5] find immigration (either legal or illegal) have a significant impact on the legal labor market. In particular, it reduces wages for the native workers, on one hand, and it also increases labor productivity and per-capita income, on the other. This is a desirable consequence following a standard neoclassical interpretation. The reduction of wages comes from an increasing labor supply; the increments in labor productivity comes from competition in the labor market. According to Venturini (1999)[21], illegal hiring reduces legal hiring basically in the primary sector of the host country which is negligible in the advanced economies which are the primary focus for immigration.

Immigration policies in host countries may affect the relationship between immigration and criminality. According to Hines and Peri (2018)[10] apprehensions of illegal immigrants do not necessarily reduce the levels of criminality. In contrast, Pinotti (2017)[18] along with Mastrobuoni and Pinotti (2015)[14] find that legalizing illegal immigrants reduces the criminal rate in the long-run. Bauer, Lofstrom and Zimmermann (2000)[1] study how immigration policy affects legal labor markets and, more importantly, sentiments towards immigrants. There is a paradox in immigration policies. Väyrynen (2003)[20] finds that strict border controls cause illegal immigration to increase. It reduces illegal supply with the subsequent increase in the price and profits. On the contrary, Comino, Mastrobuoni and Nicoló (2016)[7] finds empirical evidence that illegal immigration increases the rate of crime. After legalization, the crime rates gets reduced. These policies may ameliorate the negative effects of immigration on criminal rates. It is not the solution notwithstanding.

There is a relationship between immigration and illegality. Dell'Aringa and Neri (1987)[8] is one of the seminal papers studying this relationship. Migration channels themselves could be either legal or illegal. Legal immigration follows the regular path according to international conventions. Illegal immigration, instead, does not respect conventions. Legal entrepreneurs are not allowed to hire illegal immigrants. Illegal immigrants apply for illegal jobs in the host country. Illegal labor markets are typically frictionless. Legal immigrants and native people apply to both legal and illegal jobs. Inequality is one important reason for that discrimination. Legal labor markets do discriminate between native people and immigrants. The higher discrimination (inequality) in the host country, the lower the probability for an immigrant of getting hired in the legal sector. Illegal labor markets are composed of native and immigrants (either legal or illegal) Camacho,

Mariani and Pensieroso (2017)[6] find that host countries with low labor absorption capacity will have strong illegal labor markets.

Governments have to fight against illegality so as improve social welfare. Two main strategies can be distinguished. One is building walls. We understand here building walls as all the border enforcement strategies. This strategy is aimed to curb illegal immigration. In terms of the labor market, it reduces the supply of illegal workers. The other strategy is enforcing the law into the country. The objective here is to control the national territory so as to reduce illegality. This strategy is aimed to weak the production of illegality. In terms of the labor market, it reduces the demand of illegal workers. Ozler and Waldman (1987)[17] is one of the very first attempts to measure the efficiency of each policy in a general equilibrium model. They find internal enforcement is a more efficient policy than border enforcement in controlling the number of illegal immigrants.

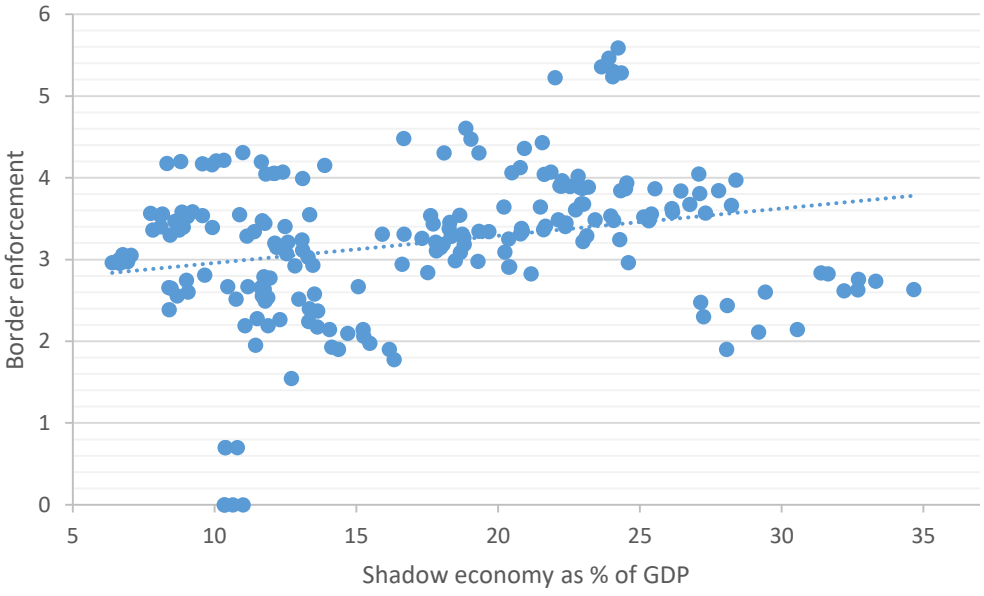
The main purpose of this paper is to model the impact of both border and internal enforcement on the intersector labor distribution in a host country with legal and illegal immigration. In doing so we model two separate but dependent labor markets as Zenou (2007)[22] with search and matching and general equilibrium. Formal labor markets are subject to frictions derived from search and matching but illegal markets are frictionless in a perfect competitive environment. We study the impact of each policy separately. Building walls increases illegal wages since it reduces the illegal labor supply. Higher illegal wages distorts the distribution of workers into the country. Illegal workers are better off and legal workers are worse off with the policy. Internal law enforcement, instead, reduces illegal wages since it reduces the illegal labor demand. Lower illegal wages also distorts the distribution of workers into the country. Illegal workers are worse off and legal workers are better off in this particular case.

The rest of the paper goes as follows. After this introduction, we present some stylized facts regarding the relationship between shadow economy and both border and internal enforcement. We focus our attention in the European Union during 2009-2015 because of data availability. Then we build a model with two sort of labor markets: legal labor market has frictions; the illegal one is frictionless. We solve the model and apply a numerical exercise for what we consider is a representative economy and derive policy recommendations. Discussion and references follow.

2. Stylized facts

Border and internal enforcement do have an impact on the intersector labor distribution. Let us define here border enforcement as the ability of the government to capture and deport immigrants who does not comply with the formal regulation. We expect this to impact the shadow economy. Capturing people in the frontier reduces the amount of illegal immigrants in the country. It reduces the amount of people dedicated to shadow activities in the host country. However, the shadow wage grows with a scarce labor force. It is an incentive for resident people to go shadow so as to get this non-appropriated profits. Figure 19 depicts this relationship for the European Union during 2009-2015.

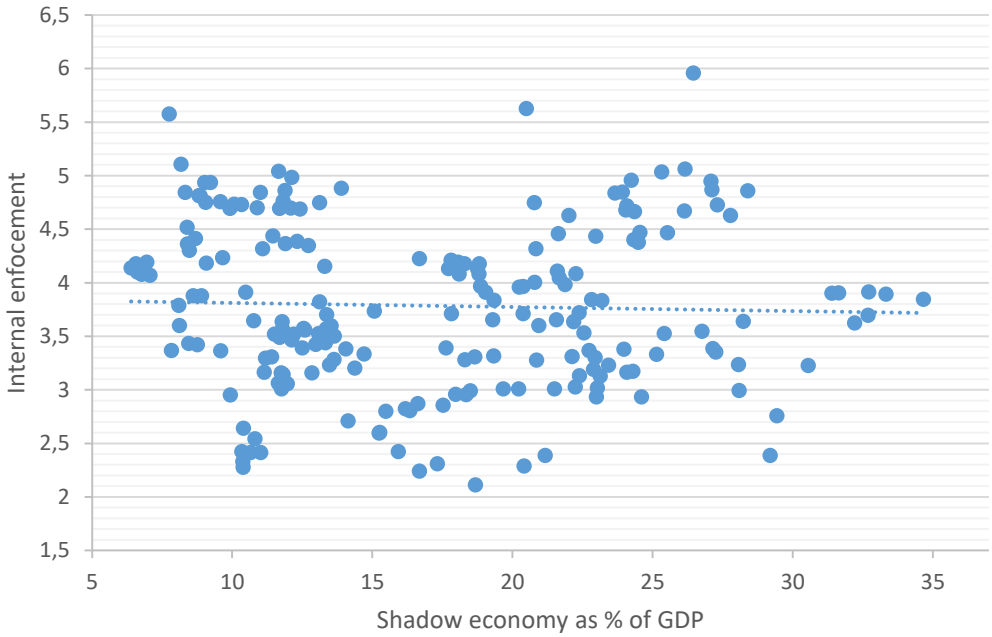
Figure 19: Shadow economy as percentage of the GDP vs border enforcement for the European Union during 2009-2015



Source: Build form Medina and Schneider (2017)[15] and the OECD.

On the other hand, internal enforcement reduces the demand of illegal workers. Fighting the illegal producers rather than illegal immigrants the government should be able to reduce the demand of illegal workers. In doing so shadow wages go down and subsequently the amount of people going shadow. Figure 20 depicts this idea for the used sample. In both of the cases, border and internal enforcement, there is a reduction of the illegal aliens in the host country but the effect of each policy on the resident people is quite different.

Figure 20: Shadow economy as percentage of the GDP vs internal enforcement for the European Union during 2009-2015



Source: Build form Medina and Schneider (2017)[15] and the OECD.

In Table 12 there are the descriptive statistics regarding to border and internal enforcement plus some controls we have been working with in the panel regression for the European Union. In Table 13 could see there is a weak statistical relationship among the variables and that is the reason why we try to get deep in the relationship with the panel.

Table 18: Descriptive statistics: mean, median, standard deviation and Kurtosis

	Shadow economy	Border enforcement	Internal Enforcement	GDP per capita	GDP deflactor
Mean	17.21	12056.65	26506.08	104.11	96.88
Median	16.68	2050.00	5145.00	96.00	98.50
Maximum	34.66	387015.0	911470.0	269.00	103.42
Minimum	6.39	0.00	130.00	43.00	82.70
Std. Dev.	6.87	44614.40	77719.28	43.91	3.98
Skewness	0.37	5.84	8.48	1.61	-0.92
Kurtosis	2.15	39.51	89.14	6.57	3.18
Jarque-Bera	10.69	12430.62	65200.34	196.30	29.12
Probability	0.00	0.00	0.00	0.00	0.00
Sum	3495.29	2447500.	5380735.	21136.00	19667.74
Sum Sq. Dev.	9548.18	4.02E+11	1.22E+12	389599.2	3204.45
Observations	203	203	203	203	203

Table 19: Covariance/correlation matrix

	Shadow economy	Border enforcement	Internal enforcement	GDP per capita	Deflactor of the GDP
Shadow economy	47,03				
	1,00				
Border enforcement	55251.40	1.98E+09			
	0,18	1.00			
Internal enforcement	20601,87	3.80E+08	6.01E+09		
	0,03	0.11	1.00		
GDP per capita	-169,56	-151576.1	-193860.6	1919.20	
	-0,56	-0.07	-0.05	1.00	
Deflactor of the GDP	-1,37	-1177.05	33369.50	-1.02	15.78
	-0,05	-0.00	0.10	-0.00	1.00

There is statistical evidence of a relationship between the shadow economy and the border and internal enforcement. Table 14 reports the results. Border enforcement increases the size of the shadow economy in the host countries. On the other hand, internal law enforcement decreases the amount of people going shadow in the host country. The Appendix of this chapter contains the results for the relationship between shadow economy and both border enforcement and internal enforcement for each of the countries in the sample (EU).

Table 20: Shadow economy vs border and internal enforcement

Predictor variable	(1)	(2)	(3)	(4)
Constant	76,73***	82,43***	61,19***	66,77***
	(5,52)	(4,86)	(10,10)	(9,70)
Log(Border)	0,32*	0,24		
	(0,14)	(0,14)		
Log(Internal)			-3,85***	-3,74***
			(1,09)	(1,09)
Deflactor of GDP	-0,08**	-0,14***	-0,43***	-0,49***
	(0,03)	(0,02)	(0,10)	(0,09)
Log(GDPperCapita)	-11,76***	-11,51***		
	(1,01)	(0,96)		
*Log(Internal)*Deflactor*			0,037***	0,036***
			(0,01)	(0,01)
N. O.=203				
R^2	0,99	0,51	0,98	0,25
A- R^2	0,98	0,50	0,98	0,24
RE		X		X
FE	X		X	

Note: Panel regression for the Latin American and Caribbean economies during the period 1996-2015 for the shadow economy being explained by the border and internal enforcement controlling by Gross Domestic Product and deflactor of the GDP. The level of significance is determined by *p<0,05; **p<0,01; ***p<0,001. RE and FE stand for Randon and Fixed effects respectively. The number in parenthesis represent standard errors.

3. The model

The economy is divided in two sectors. First, there is a legal economy. The legal economy pays taxes. It also pays extortions to the shadow sector. Governments attack the shadow activity. The aim is to enforce the law and reduce extortion. It increases legal production thereby. In our model shadow is a market. As any market it is divided in two parts: demand and supply. First, there is shadow demand. Shadow entrepreneurs hire shadow workers. Some of them are residents other are immigrants. Second, there is shadow supply. Shadow supply comes from two sources: residents and immigrants. Government would like to eliminate shadow. There are at least two instruments for doing it. One is enforcing the immigration laws. Reducing the number of immigrants and strengthening border controls are some examples immigration policies. Other policy is to enforce the law inside the national territory. Attacking shadow producers and interdicting shadow production is the other way to enforce the law. Understanding the relationship between these variables in crucial in the discussion about the relevance of each instrument.

3.1 Unemployment

Let $P_n > 0$ be the native labor supply. The government fixes a quota of immigration $q \in (0,1)$. The enlarged labor supply is $P_e = (1+q)P_n$. A proportion $\alpha \in (0,1)$ of P_e works in the legal sector. Legal entrepreneurs only hire legal workers. Let $U > 0$ be the unemployed workers in the legal sector. Employed workers in the legal sector are $L_l > 0$. Legal labor supply is then

$$S_l = \alpha P_e = L_l + U \qquad (III.1)$$

The proportion $1-\alpha$ of P_e works in the shadow sector. There are I shadow immigrants. Shadow entrepreneurs hire both legal and shadow labor supply. There is no unemployment in the shadow sector. Employed workers in the shadow sector are $L_i = (1-\alpha)P_e$. Shadow labor supply is then

$$S_i = L_i + 0 = (1-\alpha)P_e \qquad (III.2)$$

The labor force of the economy is

$$P_T = S_l = L_l + U \qquad (III.3)$$

Shadow workers are not accounted in the labor force since they are not searching for a (legal) job.

3.2 Legal sector

There are search friction in the legal market. Unemployment here comes from the fact that agents receive information of the other part from a probability distribution. The unemployment rate in the legal sector is given by

$$u = \frac{U}{P_T} \qquad (III.4)$$

Let $v \in (0,1)$ be the vacancy rate. Let $\theta = v/u$ be the tightness of the formal labor market. The matching function is $X(u,v)$ satisfying the usual properties. The probability of filling a vacancy is $q(\theta) = X(u,v)/v$. The duration of a vacancy is $1/q(\theta)$. The probability of finding a job is $\theta q(\theta) = X(u,v)/u$. The duration of the unemployment is is $1/\theta q(\theta)$. These probabilities satisfy Inada conditions:

$$\lim_{\theta\to\infty} q(\theta) = 0; \quad \lim_{\theta\to 0} q(\theta) = \infty$$
$$\lim_{\theta\to\infty} \theta q(\theta) = \infty; \quad \lim_{\theta\to 0} \theta q(\theta) = 0$$

Jobs are destroyed at an exogenous Poisson rate $\delta \in (0,1)$. The interest rate is r. The value of being employed is E. Legal wage is w_l. The unemployment benefit is $Z > 0$. The value function of the unemployment is

$$rU = Z + \theta q(\theta)(E - U) \qquad (III.5)$$

This is an expected utility function in which the unemployment worker gets z with certainty and change his state from unemployment to employment with probability $\theta q(\theta)$. Workers obtain money from working in the legal sector. Legal employees pay τw_l. The value function of the employment is

$$rE = w_l(1-\tau) + \delta(U-E) \qquad (III.6)$$

The worker obtains w_l with certainty and gets unemployed with probability δ. Let us assume $p_l = 1$. Each worker produces a fixed amount A. Formal employees pay ρw_l. The value function of a job

$$rJ = A - w_l(1+\rho) + \delta(V-J) \qquad (III.7)$$

Employers get $A - w_l(1+\rho)$ with certainty and loose the job, i.e he transforms a job in a vacancy, with probability δ. The searching cost for filling a vacancy is $\gamma > 0$. The value function of a vacancy is

$$rV = -\gamma + q(\theta)(J-V) \qquad (III.8)$$

Opening a vacancy generates a cost γ and it becomes a job with probability $q(\theta)$. Wages are negotiated in the legal sector. The Nash bargaining function is

$$\Omega = (E_l(w_l) - U)^{\beta}(J_l(w_l) - V)^{1-\beta} \qquad (III.9)$$

Where β indicate the worker bargaining power. The optimality condition is given by $\partial\Omega/\partial w_l$ which is

$$(1-\tau)\beta(J_l(w_l) - V) - (1+\rho)(1-\beta)(E_l(w_l) - U) = 0 \qquad (III.10)$$

Solving the set of Bellman equations we have the equilibrium wage. The legal wage is given by the following condition

$$w_l = \left(\frac{\beta}{1+\rho}\right)(A + \gamma\theta) + \left(\frac{1-\beta}{1-\tau}\right)Z \qquad (III.11)$$

Legal wage grows with A. The stronger the control from the shadow agents the lower the value of the legal producer and thereby the legal wages. Using Equations *(11), (7)* and *(8)* with $V = 0$ we have

$$A - (r+\delta)\frac{\gamma}{q(\theta)} - w_l(1+\rho) = 0 \qquad (III.12)$$

Inserting *(11)* in *(12)*

$$(1-\beta)\left[A-\left(\frac{1+\rho}{1-\tau}\right)z\right]-(r+\delta)\frac{\gamma}{q(\theta)}-\beta\gamma\theta=0 \qquad (III.13)$$

Let us see the unemployment rate in the stationary state. Workers going to unemployment are $P_T(1-u)\delta$. Workers going out of the unemployment are $P_T u\theta q(\theta)$. The motion law of U is

$$\dot{U}=P_T(1-u)\delta-P_T u\theta q(\theta) \qquad (III.14)$$

In the stationary state $\dot{U}=0$. The unemployment rate is

$$u=\frac{\delta}{\delta+\theta q(\theta)} \qquad (III.15)$$

The unemployment rate is inversely related with the tightness of the labor market. Let us understand the impact of the shadow behavior on the tightness of the legal labor market so as to have a whole picture of the relationship among the variables.

3.3 Shadow sector

Shadow producers generate violence out of two inputs: workers and capital. The workers come from resident people and immigrants (legal and shadow). The maximization problem of shadow immigrants generates optimal shadow demand. Enforcing the law inside the national territory is a form of reducing shadow labor demand. On the other hand, there is a process of generating shadow immigrants. They constitute part of the shadow labor supply. Enforcing the border law is a form or reducing the shadow labor supply. Policies against shadow labor supply and demand have different implications in terms of wage and intersector labor distribution.

3.3.1 Demand of shadow workers

There are shadow producers inside the national territory. The shadow producer fights against the government. They would like to have territorial control. Territorial control implies having the ability to produce shadow commodities and imposing some sort of fiscal policy. Extortion is one key factor in producing shadow. Let us assume there is no competition against shadow producers. We do not model war within maphia. Shadow agents invest x in avoiding law with efficacy α_d. Government invests y in enforcing the law with efficacy β_d. The winning probability for the shadow producer is

$$\sigma_d = \frac{\alpha_d x_d}{\alpha_d x_d + \beta_d y_d} \qquad (III.16)$$

The prize of the competition is B. The shadow agent wins $\sigma_d B$ which is given by

$$\sigma_d B = \left(\frac{\alpha_d x_d}{\alpha_d x_d + \beta_d y_d}\right) B \qquad (III.17)$$

Shadow entrepreneur uses $\sigma_d B$ as an input to produce the shadow good. Shadow entrepreneur also demands D_i units of shadow work. The problem for the shadow producer is

$$\underset{\{x_d, D_i\}}{Max}\ \pi_i = (\sigma_d B)^{1-\rho} D_i^{\rho} - w_i D_i - x \qquad (III.18)$$

Where w_i stands for the shadow wage. Finding the optimal combination of factors require us to solve it simultaneously. Maximizing *(16)* in D_i we get the following condition

$$w_i = \rho(\sigma_d B)^{1-\rho} D_i^{\rho-1} \qquad (III.19)$$

The shadow labor demand is then given by

$$D_i = \sigma_d B \left(\frac{\rho}{w_i}\right)^{\frac{1}{1-\rho}} \qquad (III.20)$$

This is an estimation of the shadow labor demand. It depends inversely on the shadow wages and directly on the territorial control. Replacing *(18)* in *(16)* we get the following expression for the profit function

$$\underset{x_d}{Max}\, \pi_i = \sigma\varphi - x_d$$

Where

$$\varphi = B\left(\rho^{\frac{\rho}{1-\rho}} - \rho^{\frac{1}{1-\rho}}\right)\left(\frac{1}{w_i}\right)^{\frac{\rho}{1-\rho}}$$

It is symmetrical to a contest function *á la* Tulloc. Maximizing π_i in terms of x we have

$$\alpha_d x_d + \beta_d y_d = \sqrt{\varphi \alpha_d \beta_d y_d} \qquad (III.21)$$

Now, let us study the government decision. The government would like to reduce the social cost generated from the shadow production (activity). In doing so it chooses the amount y_d that minimizes the social cost generated from the shadow production. The components of social cost are shadow profits and the amount of resources the government spent in the conflict. On one hand, shadow profits fuel violence. On the other hand, there is an opportunity cost of investing public resources in the conflict. The social cost function is then

$$SC = \pi_i + y \qquad (III.22)$$

The objective of the government is the following

$$\min_{\{y_d\}} CS = \sigma_d \varphi - x_d + y_d \qquad (III.23)$$

Solving this problem implies finding a reaction function for the government. Notice the problem is symmetrical to the private problem. The solution is given by

$$\alpha_d x_d + \beta_d y_d = \sqrt{\varphi \alpha_d \beta_d y_d} \qquad (III.24)$$

Combining *(19)* and *(22)* we have

$$x_d = y_d \qquad (III.25)$$

With the optimality condition we have a solution for the probabilities and shadow profits. The probabilities are given by

$$\begin{aligned} \sigma_d &= \frac{\alpha_d}{\alpha_d + \beta_d} \\ 1 - \sigma_d &= \frac{\beta_d}{\alpha_d + \beta_d} \end{aligned} \qquad \textit{(III.26)}$$

Replacing *(24)* in *(16)* we will get an expression for the individual profits. The profit function is then given by

$$\pi_i = \left(\frac{\alpha_d}{\alpha_d + \beta_d}\right)^2 B \left(\rho^{\frac{\rho}{1-\rho}} - \rho^{\frac{1}{1-\rho}}\right)\left(\frac{1}{w_i}\right)^{\frac{\rho}{1-\rho}} \qquad \textit{(III.27)}$$

Replacing *(24)* in *(18)* we have

$$D_i = \left(\frac{\alpha_d B}{\alpha_d + \beta_d}\right)\left(\frac{\rho}{w_i}\right)^{\frac{1}{1-\rho}} \qquad \textit{(III.28)}$$

We will do some static comparative analysis later on when combining it with the shadow supply.

3.3.2 Supply of shadow workers

Shadow supply comes from two sources. First, legal workers who want to become shadow $L_i = (1 - \alpha)P_e$. Second, shadow immigrants. We do not ask for the reasons behind the decision of a person to migrate either legally or shadow. Let us build a production function for shadow immigrants. Shadow agents invest x_s in avoiding law with efficacy α_s. Government invests y_s in enforcing the law with efficacy β_s. The territorial control of the shadow producer is

$$\sigma_s = \frac{\alpha_s x_s}{\alpha_s x_s + \beta_s y_s} \qquad \textit{(III.29)}$$

Shadow suppliers use σ_s as an input to produce the shadow good. Shadow suppliers use L_i units of shadow work. The production of shadow immigrants is

$$Z = \sigma_s^{1-\rho} L_i^{\rho} \qquad (III.30)$$

The problem for the shadow supplier is

$$\underset{\{x_s, L_i\}}{Max}\, \pi_i = w_i \sigma_s^{1-\rho} L_i^{\rho} - p_i L_i - x_s \qquad (III.31)$$

Where w_i stands for the shadow wage. The solution is simultaneous. Shadow immigrants simultaneously chooses the amount of shadow workers and capital. Maximizing *(31)* in D_i we get the following condition

$$p_i = w_i \sigma_s^{1-\rho} \rho L_i^{\rho-1} \qquad (III.32)$$

Reorganizing *(32)* the shadow labor supply is then given by

$$L_i = \sigma_s \left(\rho \frac{w_i}{p_i}\right)^{\frac{1}{1-\rho}} \qquad (III.33)$$

It depends directly on the shadow wages and inversely on the price of the other factors. Replacing this function in the production function

$$Z = \sigma_s \left(\rho \frac{w_i}{p_i}\right)^{\frac{\rho}{1-\rho}} \qquad (III.34)$$

Replacing *(34)* in *(31)* we get the following expression for the profit function

$$\underset{\{x_s\}}{Max}\, \pi_i = \sigma_s \varphi - x_s$$

Where

$$\varphi = \left(\frac{w_i^{1/\rho}}{p_i}\right)^{\frac{\rho}{1-\rho}} \left(\rho^{\frac{\rho}{1-\rho}} - \rho^{\frac{1}{1-\rho}}\right)$$

Again, it is symmetrical to a contest function a la Tulloc. Maximizing *(31)* in terms of x_s we have

$$\alpha_s x_s + \beta_s y_s = \sqrt{\varphi \alpha_s \beta_s y_s} \qquad (III.35)$$

Let us study the government decision. The aim of the government is to reduce the social cost generated from the shadow immigration. The components of the social cost are shadow profits and the amount of resources spent in enforcing border controls. Shadow profits stimulated shadow immigration and in turn it increases the level of violence in host countries. On the other hand, there are opportunity costs associated to public expenditure in law enforcement. The objective of the government is the following

$$\min_{\{y_s\}} \pi_i = \sigma_s \varphi - x_s + y_s \qquad (III.36)$$

Minimizing *(36)* in terms of y_s we have

$$\alpha_s x_s + \beta_s y_s = \sqrt{\varphi \alpha_s \beta_s y_s} \qquad (III.37)$$

The solution is given by

$$x_s = y_s \qquad (III.38)$$

We solve the model with this optimality condition. Replacing *(38)* in *(29)* the probabilities are given by

$$\begin{aligned} \sigma_s &= \frac{\alpha_s}{\alpha_s + \beta_s} \\ 1 - \sigma_s &= \frac{\beta_s}{\alpha_s + \beta_s} \end{aligned} \qquad (III.39)$$

Replacing *(39)* in *(31)* we get the profit function is then given by

$$\pi_i = \left(\frac{\alpha_s}{\alpha_s + \beta_s}\right)^2 \left(\frac{w_i^{1/\rho}}{p_i}\right)^{\frac{\rho}{1-\rho}} \left(\rho^{\frac{\rho}{1-\rho}} - \rho^{\frac{1}{1-\rho}}\right) \qquad (III.40)$$

Replacing *(39)* in *(34)* we get the shadow labor supply

$$Z = \left(\frac{\alpha_s}{\alpha_s + \beta_s}\right) \left(\rho \frac{w_i}{p_i}\right)^{\frac{\rho}{1-\rho}} \qquad (III.41)$$

Shadow labor supply and demand conform the shadow labor market in the host country. The natural step is finding the shadow wage in the equilibrium.

3.3.3 Shadow wages

The supply of shadow immigrants is the following: 1) Shadow supply of workers. Portion of resident people devoting themselves to shadow activities. The total supply of shadow workers is

$$S_i = ZL_i = \sigma_s \left(\rho \frac{w_i}{p_i}\right)^{\frac{\rho}{1-\rho}} (1-\alpha)P_e \qquad \textit{(III.42)}$$

Equations *(42)* and *(28)* defined the equilibrium in the shadow market. The equation for the equilibrium is

$$\sigma_d B \left(\frac{\rho}{w_i}\right)^{\frac{1}{1-\rho}} = \sigma_s \left(\rho \frac{w_i}{p_i}\right)^{\frac{\rho}{1-\rho}} (1-\alpha)P_e \qquad \textit{(III.43)}$$

The final equation is given by

$$w_i = \left(\frac{\sigma_d}{\sigma_s} \frac{\rho B p_i^{\frac{\rho}{1-\rho}}}{(1-\alpha)P_e}\right)^{\frac{1-\rho}{1+\rho}} \qquad \textit{(III.44)}$$

The intuition of this function is as follows 1) Increases in σ_d increases w_i. Stronger shadow sector increases the demand for shadow workers and it rises its price. 2) Increases in σ_s decreases w_i. Stronger shadow suppliers increases the shadow supply and it reduces the shadow wage. 3) Increases in $(1-\alpha)P_e$ decreases w_i. The higher the amount of people going toward the shadow sector the lower the shadow wage.

3.4 Intersector labor distribution

There is labor mobility between formal and shadow sectors. Individuals choose between shadow and formality. Economic profits is not the fundamental cause of intersector labor mobility. There is a portion of peoples willing to become shadow workers. However, the portion of those people do move according to the economic profit and monetary reasons. They compare the value of working in the shadow with the value of applying to a job in the legal sector. The value of applying to a legal job is rU_l. The value of applying to an shadow job is w_i. The proportion of shadow workers must satisfy

$$rU_l = w_i \tag{III.45}$$

Using *Equation (5)* –after solving the bargaining problem- and *Equation (44)* in *Equation (45)* we have

$$z + \frac{\beta}{1-\beta}\gamma\theta = \left(\frac{\sigma_d}{\sigma_s}\frac{\rho B p_i^{\frac{\rho}{1-\rho}}}{S_i}\right)^{\frac{1-\rho}{1+\rho}} \tag{III.46}$$

Solving for $(1-\alpha)P_e$ will give us the amount of resident people going toward the shadow sector as the following

$$S_i = \frac{(\sigma_d/\sigma_s)\rho B p_i^{\frac{\rho}{1-\rho}}}{\left(z + \frac{\beta}{1-\beta}\gamma\theta\right)^{\frac{1+\rho}{1-\rho}}} \tag{III.47}$$

The portion $(1-\alpha)P_e$ in *Equation (47)* is directly related with σ_d and inversely related with σ_s. Increases in z and θ decreases $(1-\alpha)P_e$. We will consider this Equation later on when making the comparative static analysis.

3.5 Comparative statics

From *Equation (13)* and *(47)* we undertake the static comparative analysis. The key point is to understand the impact of changes in the different parameters on the legal and shadow sectors of the economy. The *Proposition 1* computes the impact of the different variables. In the set of different parameter we see there is a determinant sign of the relationship. The exception is the unemployment benefit.

Proposition 1: At the equilibrium we have

$$sign\left\{\frac{\partial S_i}{\partial z}\right\} = sign\left\{\left|\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right)\right| - \left(\frac{\beta}{r+\delta}\right)\left(\frac{\rho+\tau}{1-\tau}\right)\right\}$$

$$sign\left\{\frac{\partial S_i}{\partial \tau}\right\} = sign\left\{\frac{\partial S_i}{\partial \rho}\right\} = +$$

$$sign\left\{\frac{\partial S_i}{\partial \sigma_d}\right\} = +$$

$$sign\left\{\frac{\partial S_i}{\partial \sigma_s}\right\} = -$$

Proof: See Appendix □

The impact of the unemployment subsidy is indeterminate. Fiscal policy affects directly the amount of shadow workers. Tougher fiscal policy make it costly to become formal inducing workers to become shadow. There are different impact regarding to the enforcement policy. Border enforcement is ineffective in reducing the number of shadow workers. The reason is the following. Reducing the supply of shadow workers increases the wage inducing resident people to become shadow. On the other hand, reducing the demand of illegal workers is more effective. Tougher enforcement law inside the country make it costly to become shadow regardless the individual is resident or immigrant. Border enforcement is just one of the instruments for the government to reduce the number of shadow workers. Actually, it is the less effective one. Fiscal policies and enforcing the law inside the country are key ingredients in regulating the shadow sector.

4. Numerical simulations

This section is divided in two parts. First, we make a baseline economy. Second, we change some fundamental variables to see the comparative statics. The idea is similar to the other two chapters.

4.1 Baseline economy

In the following table we set the main parameters of the model. The idea here is to parametrize the fundamental coefficients of an economy with an important shadow economy; in particular, a shadow employment rate around 2-6%. We introduce the parameters of the contest function and the initial distribution of workers between the two sectors.

Table 21: Parameters of the baseline economy

Parameter	*Value*	*Definition*
A	*5,0*	Value of the formal labor productivity.
B	*100*	Value of shadow labor productivity.
α	*0,5*	Proportion of formal workers.
β	*0,3*	Employer bargaining power.
δ	*0,1*	Rate of destruction of labor contracts.
r	*0,05*	Real interest rate.
γ	*1,5*	Entry cost.
ρ	*0,2*	Tax burden for the employer.
τ	*0,2*	Tax burden for the employee.

In the following section we run some experiments to see the impact of fiscal policy and law enforcement on unemployment rate, formal employment rate and shadow employment rate using scenarios for border and internal enfocement.

4.2 Experiments

First, we analyze the impact of changes in the unemployment subsidy. Let us consider three scenarios. The first one represents the situation in which the efficiency of both border enforcement and internal enforcement is the same. This is the Table 22. An increase in the unemployment subsidy reduces the market tightness and increases the unemployment rate. It also increases the number of people going shadow. The intuition here is that unemployed people in the formal sector could easily get employed for the illegal sector with a low wage but not low enough to cover the unemployment subsidy. Notice the illegal wage is going down since there are more workers in that sector.

Table 22: Changes in unemployment benefit with $\sigma_d = \sigma_s = 0{,}5$

	*Unemployment benefit (**z**)*		
Variables	0	0,5	1
$\boldsymbol{\theta}$	10,1	8,5	6,8
$\boldsymbol{u}$	3,1	3,3	3,7
$\boldsymbol{S}$	2,6	2,8	3,1
$\boldsymbol{w_i}$	4,3	4,1	3,9

Tables 23 and 24 show the results for the other scenarios. Table 23 shows the results when the border enforcement is strong but the internal enforcement is weak. The results are similar to Table 22. However, there are some differences worthy to discuss. First, notice an increase in the unemployment rate is associated with a reduction in the labor market tightness and an increase in both formal unemployment rate and the number of people going shadow. It comes from our analysis of the comparative statics. Strong border enforcement reduces the supply of illegal workers but it increases the illegal wage. Higher illegal wages are an incentive for resident people to leave formality and become illegal agents.

Table 23: Changes in unemployment benefit with $\sigma_d = 0{,}6$ and $\sigma_s = 0{,}3$

	*Unemployment benefit (**z**)*		
Variables	*0*	*0,5*	*1*
$\boldsymbol{\theta}$	10,07	8,5	6,8
$\boldsymbol{u}$	3,1	3,3	3,7
$\boldsymbol{S}$	5,7	6,1	6,6
$\boldsymbol{w_i}$	4,3	4,1	3,9

Table 24: Changes in unemployment benefit with $\sigma_d = 0{,}3$ and $\sigma_s = 0{,}6$

	*Unemployment benefit (**z**)*		
Variables	*0*	*0,5*	*1*
$\boldsymbol{\theta}$	10,07	8,5	6,8
$\boldsymbol{u}$	3,1	3,3	3,7
$\boldsymbol{S}$	1,2	1,3	1,4
$\boldsymbol{w_i}$	4,3	4,1	3,9

Table 24 shows the opposite case. There is a strong internal law enforcement but a weak border enforcement. The analysis is the other way round. First, weak border enforcement allows immigrants to get easily into the country. It increases the supply of illegal agents. Wages fall. Lower wages are an incentive for individuals to stay unemployed or continuing being formal. That is the reason for the unemployment rate to increase and the portion of illegal people to get down. Internal law enforcement reduces the demand and the prices in the illegal sector. Finally, Table 25 shows the analysis of fiscal policy. Notice fiscal policy is again not the best instrument in dealing with the intersector labor mobility.

Table 25: Changes in fiscal policy with z = 0,5

	Fiscal policy $(\boldsymbol{\rho}, \boldsymbol{\tau})$		
Variables	$\rho = 0{,}4$ $\tau = 0{,}2$	$\rho = 0{,}2$ $\tau = 0{,}4$	$\rho = 0{,}4$ $\tau = 0{,}4$
$\boldsymbol{\theta}$	8,2	7,9	7,6
$\boldsymbol{u}$	3,4	3,4	3,5
$\boldsymbol{S}$	2,5	3,1	2,9
$\boldsymbol{w_i}$	4,1	3,9	3,7

Comparing border and internal enforcement is similar to comparing, for instance, eradication with interdiction policy in the case of illegal drug production. Following a neoclassical analysis there is no difference whatsoever in the structure and functioning of the input markets such as capital or labor. They are studied in the literature with minor differences. In this sense, thinking on cost-efficiency the discussion proposed in this chapter is much broader than what we have been dealing with. Let us consider the case of illegal drug production. The first question that arises is what part of the market should be attacked with more enthusiasm: supply or demand. Going even deeper in the argument we could also ask another question: what is the best policy between eradicating illegal production and interdicting illegal traffic. Answering these questions is not substantially different from answering the proposed question in this paper. That is the reason why we are going to discuss the case of illegal drug production in more detail in the general discussion and conclusion.

5. General discussion and conclusion

The cocaine market produces huge economic profits comparable with those of important multinationals as Microsoft and McDonald's altogether. According to UNODC (2010)[27], around the 65% of the cocaine produced in Colombia is bought in USA and Europe for an approximate value of $35 billion each year. Those profits fuels crime and violence worldwide but more importantly in the producer countries. How does the government deal with that problem? There are basically two ways: demand and supply-side policies. On one hand, the government fosters educational programs to reduce illegal consumption. On the other hand, it captures traffickers

and dealers. In practice, the so called "*war against illegal drugs*" has relied mainly on supply-side policies. The underlying idea of the government is reducing the illegal supply so as to increase the price and thereby reduce illegal consumption. However, a couple of decades after that war, an exorbitant increase in the illegal profits was seen. There seems to be a puzzle in the prohibition policy[6].

One of the main programs of the war against illegal drugs is the *Plan Colombia*. It was an agreement between the governments of USA and Colombia to deter production and trafficking of cocaine. It had two main objectives: reducing the supply of coca-leaf and cocaine, on one hand, and recovering the national territory from illegal group's hands. According to Departamento Nacional de Planeación (2006)[10] the results of the *Plan* are ambiguous. It was ineffective in the first front, but effective enough in the second one. The government was able to reduce the ability of the illegal agents to control the national territory. It enables the government to eradicate or destroy the coca-leaf production, the key input to produce cocaine. The efficacy of the policy is weak notwithstanding. As Mejia and Restrepo (2013)[18] remarks large balloon effects makes eradication ineffective in reducing the coca-leaf and cocaine production.

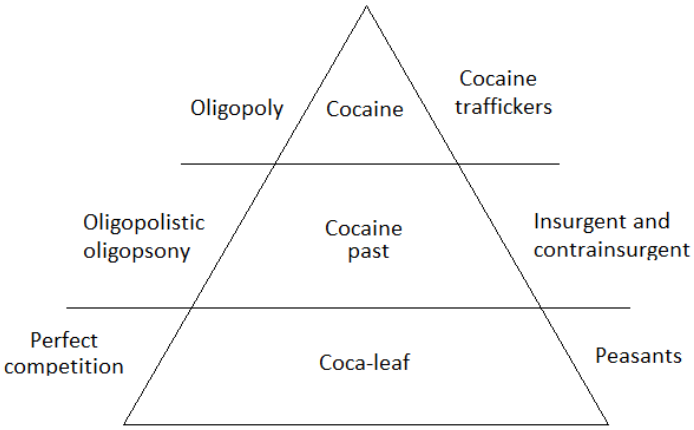
Despite the supply-side policies, the production of illegal drugs has increased and the final price has decreased according to UNODC (2010)[27]. It might be explained as a consequence of increasing illegal labor productivity. Persecution obligates peasants to produce more (or the same) in a smaller space; and traffickers develop new and more efficient roads to distribute drugs. In the first case, Engelhardt (2008)[11] studies how the market structure changes so as to allow a specific distribution of profits. In particular, profits are earned in terms of the risk involved. That distribution ends up being heterogeneous. On the second case, Galenianos and Gavazza (2014)[12] models the labor market of cocaine in a consumer country by using a search and matching model. Prohibition policy obligates traders to reduce the quality of the final product so as to enlarge the amount of drugs finally sold in the market.

Among the illegal drugs, cocaine is an interesting case of study. Colombia, Perú and the Plurinational state of Bolivia have historically been the main

[6] The puzzle is not innocuous. Becker, Murphy and Grossman (2006)[2] explains it by using the price elasticity of demand. Given an inelastic demand, reducing the supply increases the economic profits. The reduction in quantity ends up being less than the increase in price so the total income of the producer grows when reducing the total supply. The analysis is the inverse when reducing the demand. This last policy is the best one in dealing with both reducing the total profits and controlling the number of individuals going towards illegal activities.

worldwide producers. Literature suggests that the production of coca leaf, the main raw material for cocaine, can only be made on the mountains of Los Andes due to geographical conditions. Even though each of these countries have similar technical conditions, the cocaine production is highly heterogeneous amidst them. Strong supply-side policies in Peru and Bolivia, balloon effects, sociological and historical features have made it possible for Colombia to control most of the worldwide production. That country had a long internal conflict in which money from cocaine fueled terrorist activities from FARC-EP and Paramilitaries. According to UNODC and Gobierno de Colombia (2001-2014)[26] violence allowed those illegal groups to build a vertical structure as Figure 21 so as to rise money from and for violence.

Figure 21: Colombian cocaine market



Besides the geographical reasons, there are anthropological and sociological reasons that make it possible for the cocaine production to be as strong as it is in Colombia. First, anthropological reasons. Thoumi (1990[23], 2002[24], 2015[25]) argues in certain regions it is folklore to get rich whatever the cost. Low moral costs cause the illegal sector to give rise. Second, the administrative organization of the government might create conditions for the illegal sector to appear. Duncan (2014[8], 2009[9]) argues that decentralization might enable corruption and illegality to appear in small cities where there is no strong presence of the government. Absence of governmental authorities in certain regions, argues Puentes (2006)[19], allows illegal power to appear especially in regions able to produce illegal drugs. Somebody appears there to get those economic profits. Vargas (1999)[28] discusses how illegal drug production has been used to fuel insurgent and contra-insurgent groups in their conflict against the state.

The specific industrial organization of the illegal market is a result of the prohibition policy. Illegal agents are obliged to diversify the risk in a vertically

integrated market structure with fuzzy information. It allows them to reduce the likelihood of getting apprehended. Koop (2010)[15] and Krauthausen and Sarmiento (1991)[14] follow that reasoning and find that imperfect competition and fuzzy information are *sine-qua-non* condition for the illegality to continue working in the shadows. There seems to be a similitude between illegal and legal markets. So far in the general introduction we referred to the heterodox literature in its critique to the functioning of the market-based economy. Doing the parallel we could also say there is concentration of the capital in the illegal market. Cooper (1990)[7], Zaitch (2004)[29] and Reuter (2004)[21] studies how the illegal market tends to be imperfectly competitive. In particular, there is an oligopolistic-oriented market structure. It was what happened in Colombia during the 90's with the so called cartel structure. Baquero (2012)[1] and Duncan (2009)[9] refer to it when explaining the nature and causes of the market of cocaine in Colombia.

According to Mejia and Posada (2007)[17] there are producers of coca-leaf, base or paste of cocaine, and finally cocaine. The farmers and insurgent groups participate in the production of coca-leaf and paste of cocaine, and the drug traffickers operate in the final market. The coca-leaf is a necessary input for producing base or paste of cocaine and, in turn, this is a necessary input for producing cocaine. With the sake of a policy evaluation, Grossman and Mejia (2007)[13] models the war against drugs by considering some supply policies such as eradication and interdiction. With eradication the government curbs the coca-leaf production; with interdiction, instead, it deters the amount of traded illegal drug. Mejia and Restrepo (2013)[18] extends that analysis by considering a competitive vertical integration of the market. Because of balloon effects and hold-up problems, interdiction ends up being a more efficient policy than eradication in attacking both the illegal production and trade.

Studying the imperfect competitive features of the Colombian cocaine market offers useful information regarding the illegal price formation. First, the price of coca-leaf and paste of cocaine is related with the coca-leaf elasticity of supply. The in-elasticity of this supply enables insurgent groups to acquire important profits by putting relatively low prices to coca-leaf, and obtaining relatively high prices to the paste of cocaine. This elasticity is also related with the returns to scale of the coca-leaf production function and the eradication or interdiction programs from the national government. Second, the price of the cocaine is not only determined by marginal costs and risks, but also because of the number of traffickers. This industrial organization that results from market power in both output and input markets produces extraordinary profits. It basically enables the traffickers to exploit them achieving a biased distribution along the chain of production and distribution.

6. Appendix

6.1 Proofs

Proposition 1

Tightness vs unemployment subsidy
From Equation (13) we have

$$\frac{\partial\theta}{\partial z} = \frac{-(1-\beta)\left(\frac{1+\rho}{1-\tau}\right)}{(r+\delta)\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.1)$$

From (47) taking $\partial S_i/\partial z$ *we have*

$$\frac{\partial S_i}{\partial z} = \left(\frac{\sigma_d}{\sigma_s}\right)\rho B p_i^{\frac{\rho}{1-\rho}}\left(\frac{1+\rho}{\rho-1}\right)\left(z+\frac{\beta}{1-\beta}\gamma\theta\right)^{\frac{1+\rho}{\rho-1}-1}\left(1+\frac{\beta}{1-\beta}\gamma\frac{\partial\theta}{\partial z}\right)$$

It implies

$$sign\left\{\frac{\partial S_i}{\partial z}\right\} = sign\left\{1+\frac{\beta}{1-\beta}\gamma\frac{\partial\theta}{\partial z}\right\}$$

From (A.1) it implies

$$sign\left\{\frac{\partial S_i}{\partial z}\right\} = sign\left\{\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right| - \frac{\beta}{r+\delta}\left(\frac{\rho+\tau}{1-\tau}\right)\right\} \qquad (A.2)$$

Tightness vs taxes

$$\frac{\partial\theta}{\partial\tau} = \frac{-(1-\beta)\frac{(1+\rho)}{(1-\tau)^2}z}{(r+\delta)\gamma_F\left|\frac{\partial}{\partial\theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.3)$$

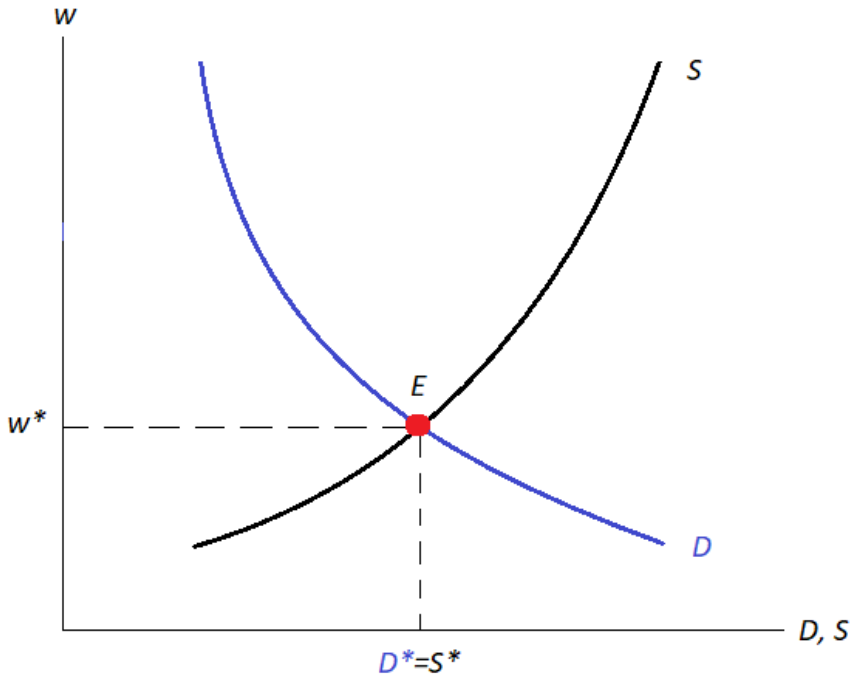
Since $\frac{\partial s_i}{\partial \theta} < 0$ *then* $\frac{\partial s_i}{\partial \tau} > 0$. *Finally*

$$\frac{\partial \theta}{\partial \rho} = \frac{-(1-\beta)\left(\frac{1}{1-\tau}\right)z}{(r+\delta)\gamma_F \left|\frac{\partial}{\partial \theta}\left(\frac{1}{q(\theta)}\right)\right| + \beta\gamma_S} < 0 \qquad (A.4)$$

Since $\frac{\partial s_i}{\partial \theta} < 0$ *then* $\frac{\partial s_i}{\partial \rho} > 0$.

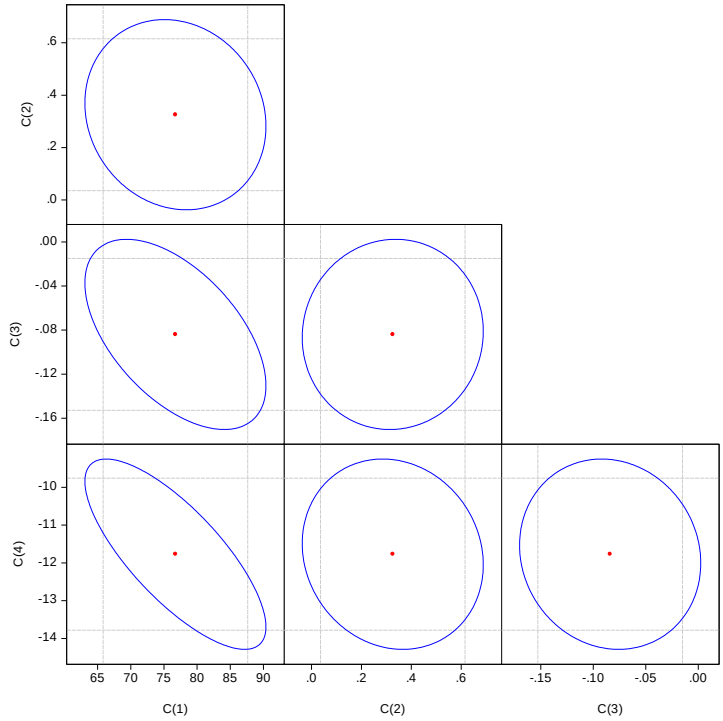
6.2 Analysis of equilibria

Figure 22: Equilibrium

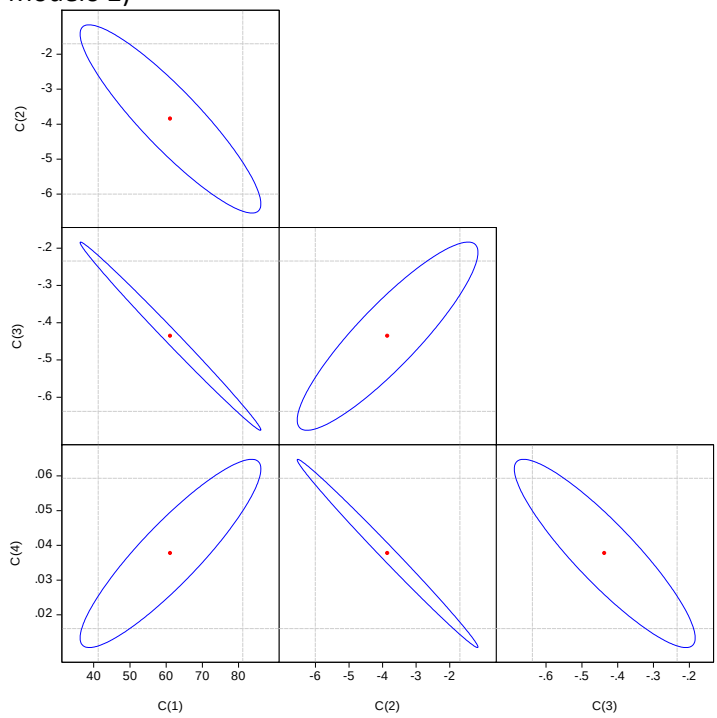


6.3 Confidence ellipses for coefficients

Model 1) (From the panel regressions in the stylized facts section)

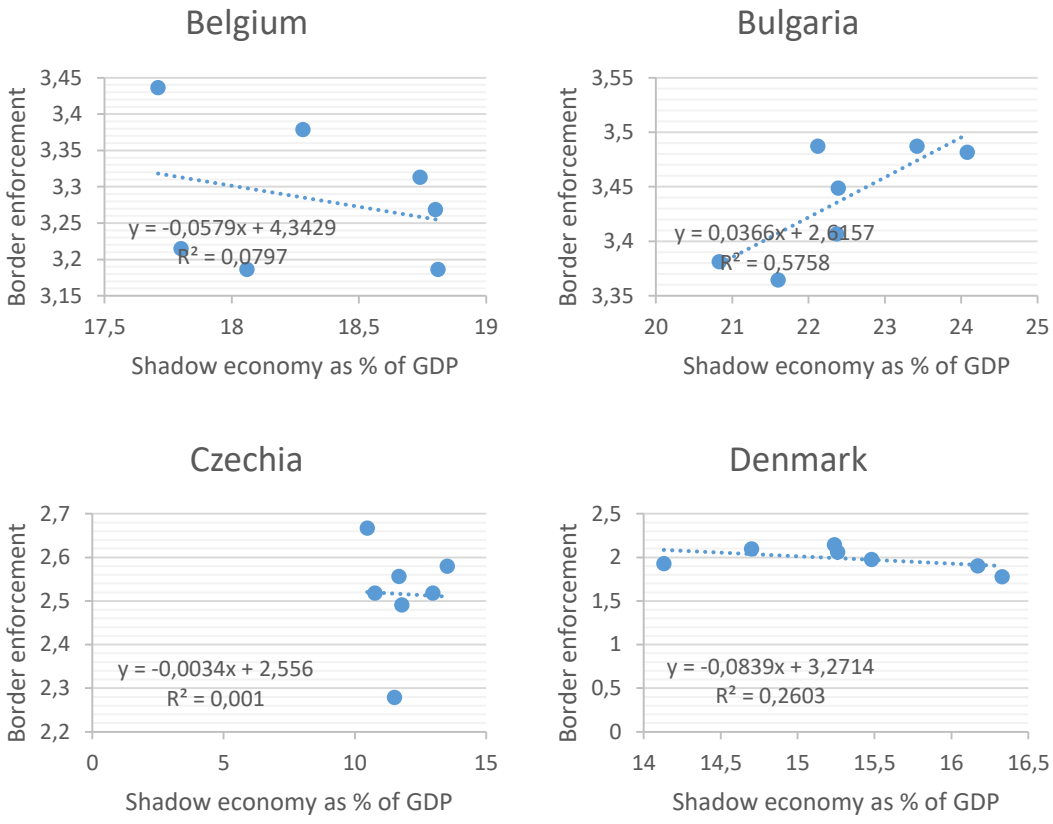


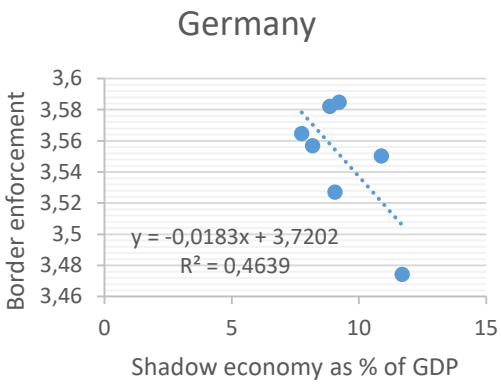
Modelo 2)

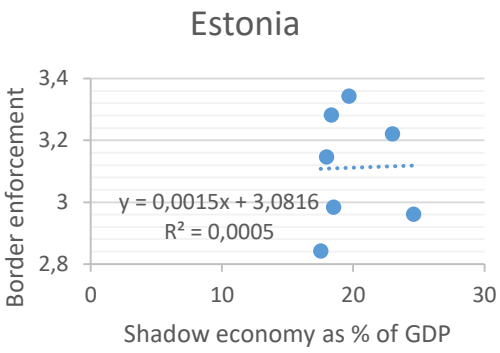


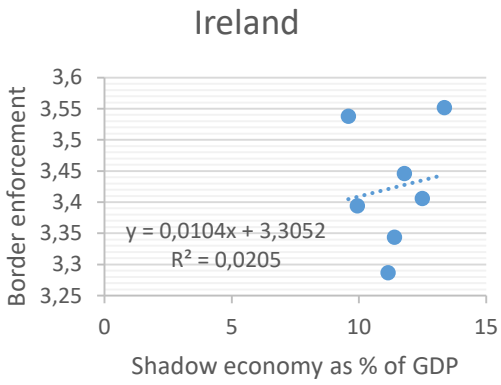
6.4 Individual regressions

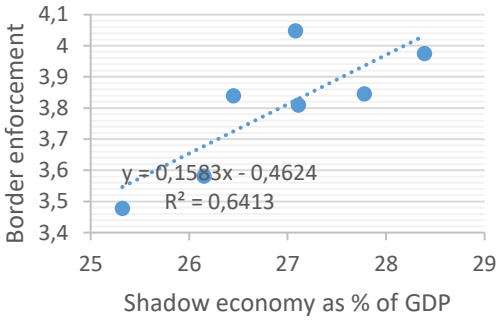
Figure 23: Shadow economy as percentage of the GDP vs border enforcement UE 2009-2015

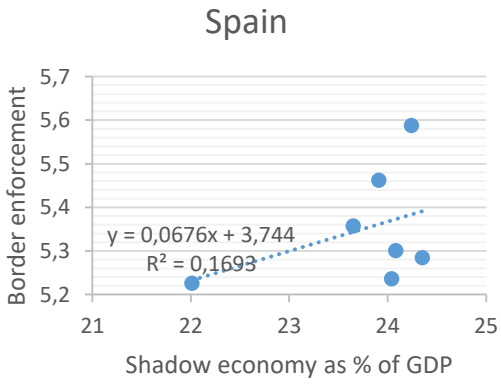


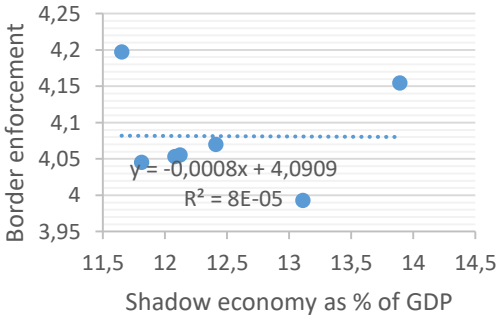

Germany
Border enforcement
3,6
3,58
3,56
3,54
3,52
3,5
3,48
3,46
y = -0,0183x + 3,7202
R² = 0,4639
0
5
10
15
Shadow economy as % of GDP

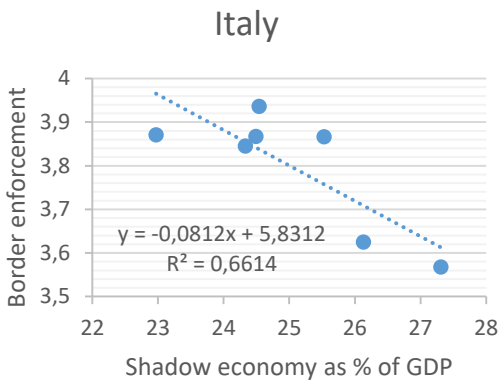

Estonia
Border enforcement
3,4
3,2
3
2,8
y = 0,0015x + 3,0816
R² = 0,0005
0
10
20
30
Shadow economy as % of GDP

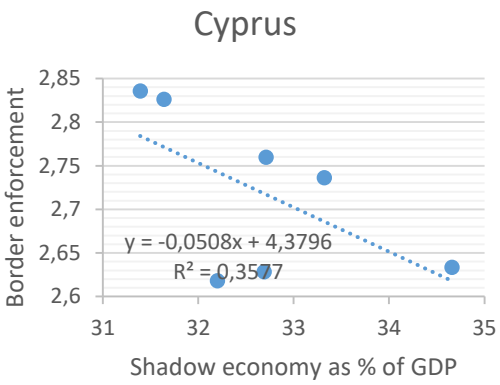

Ireland
Border enforcement
3,6
3,55
3,5
3,45
3,4
3,35
3,3
3,25
y = 0,0104x + 3,3052
R² = 0,0205
0
5
10
15
Shadow economy as % of GDP

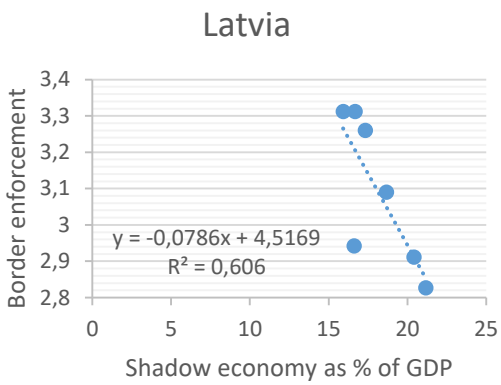

Greece
Border enforcement
4,1
4
3,9
3,8
3,7
3,6
3,5
3,4
y = 0,1583x - 0,4624
R² = 0,6413
25
26
27
28
29
Shadow economy as % of GDP

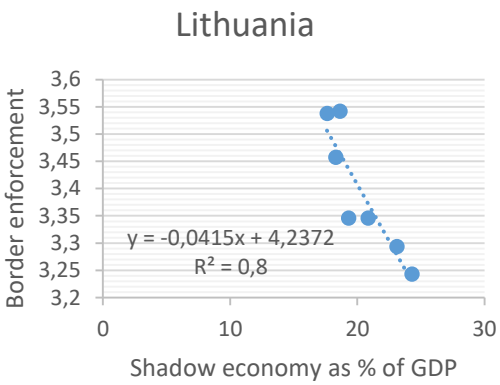

Spain
Border enforcement
5,7
5,6
5,5
5,4
5,3
5,2
y = 0,0676x + 3,744
R² = 0,1693
21
22
23
24
25
Shadow economy as % of GDP

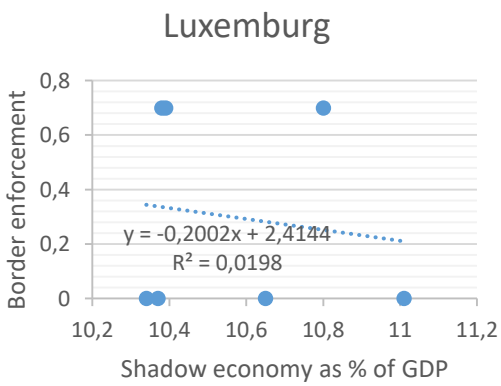

France
Border enforcement
4,25
4,2
4,15
4,1
4,05
4
3,95
y = -0,0008x + 4,0909
R² = 8E-05
11,5
12
12,5
13
13,5
14
14,5
Shadow economy as % of GDP

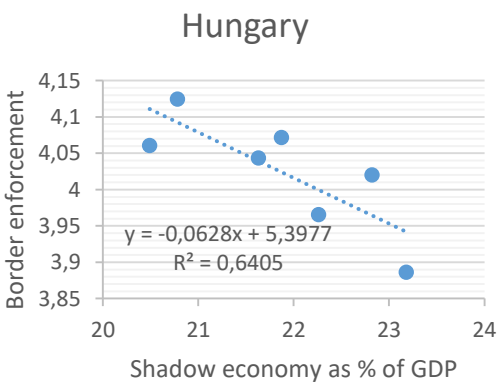

Italy
Border enforcement
4
3,9
3,8
3,7
3,6
3,5
22
23
24
25
26
27
28
y = -0,0812x + 5,8312
R² = 0,6614
Shadow economy as % of GDP

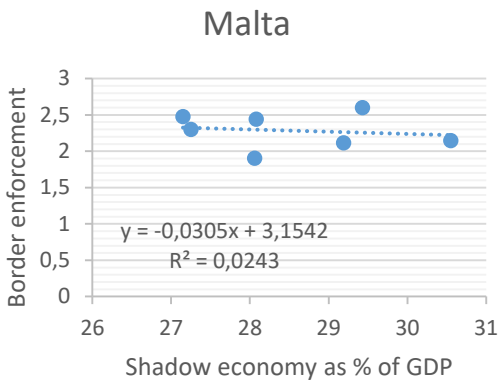

Cyprus
Border enforcement
2,85
2,8
2,75
2,7
2,65
2,6
31
32
33
34
35
y = -0,0508x + 4,3796
R² = 0,3577
Shadow economy as % of GDP

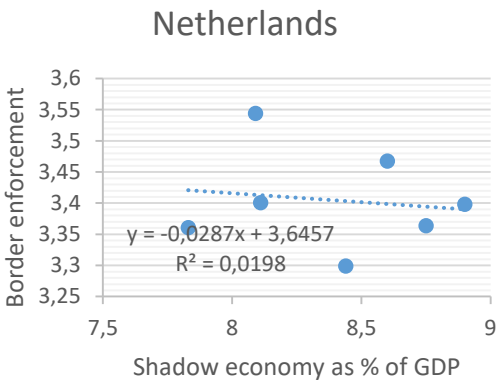

Latvia
Border enforcement
3,4
3,3
3,2
3,1
3
2,9
2,8
0
5
10
15
20
25
y = -0,0786x + 4,5169
R² = 0,606
Shadow economy as % of GDP

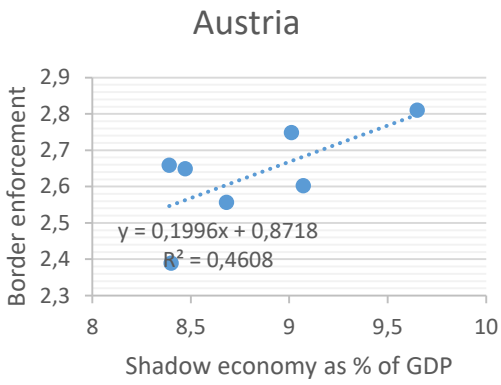

Lithuania
Border enforcement
3,6
3,55
3,5
3,45
3,4
3,35
3,3
3,25
3,2
0
10
20
30
y = -0,0415x + 4,2372
R² = 0,8
Shadow economy as % of GDP

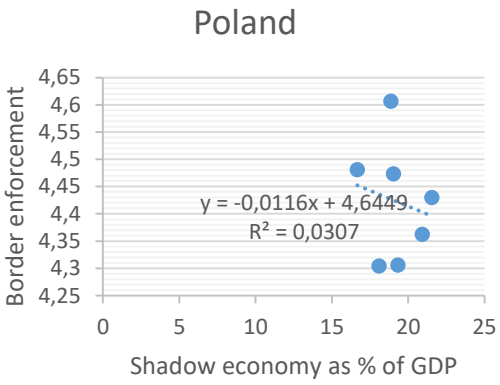

Luxemburg
Border enforcement
0,8
0,6
0,4
0,2
0
10,2
10,4
10,6
10,8
11
11,2
y = -0,2002x + 2,4144
R² = 0,0198
Shadow economy as % of GDP

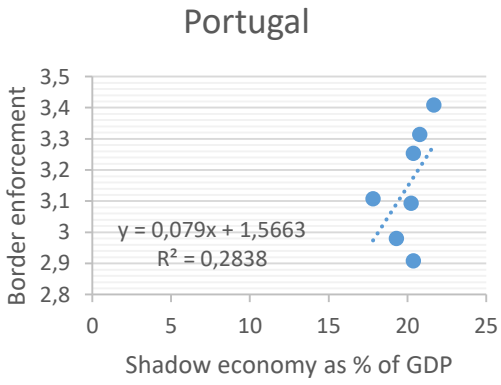

Hungary
Border enforcement
4,15
4,1
4,05
4
3,95
3,9
3,85
20
21
22
23
24
y = -0,0628x + 5,3977
R² = 0,6405
Shadow economy as % of GDP

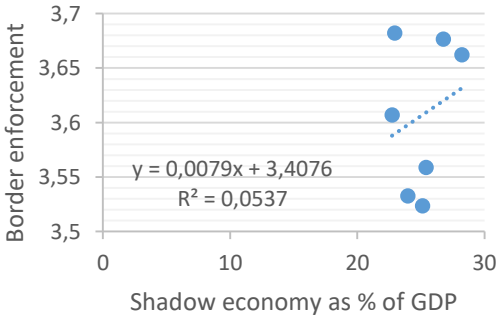

Malta
Border enforcement
Shadow economy as % of GDP
y = -0,0305x + 3,1542
R² = 0,0243

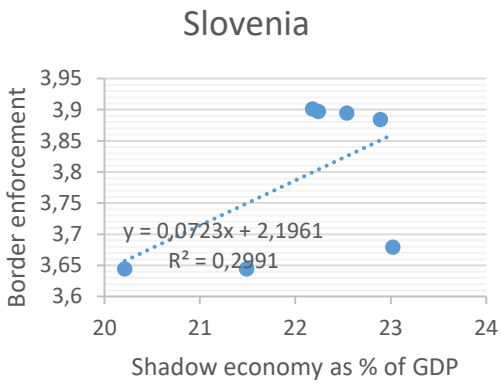

Netherlands
Border enforcement
Shadow economy as % of GDP
y = -0,0287x + 3,6457
R² = 0,0198

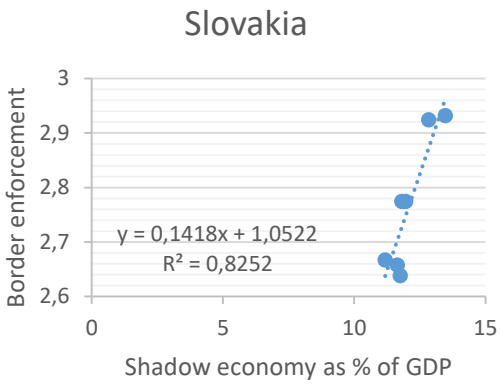

Austria
Border enforcement
Shadow economy as % of GDP
y = 0,1996x + 0,8718
R² = 0,4608

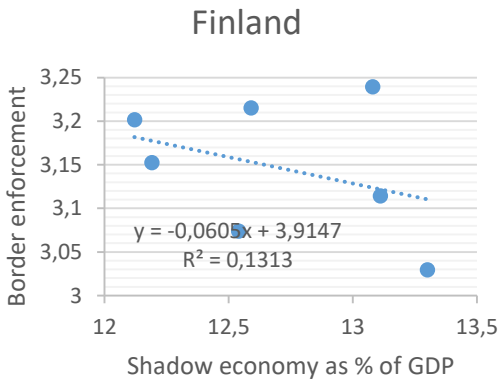

Poland
Border enforcement
Shadow economy as % of GDP
y = -0,0116x + 4,6449
R² = 0,0307

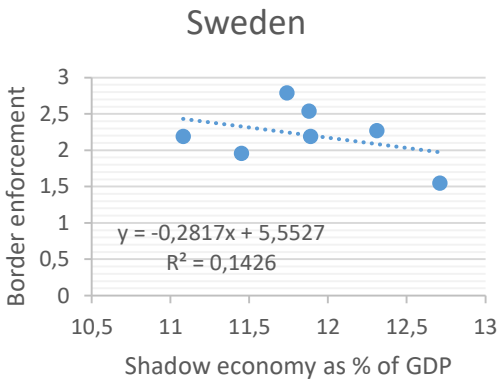

Portugal
Border enforcement
Shadow economy as % of GDP
y = 0,079x + 1,5663
R² = 0,2838

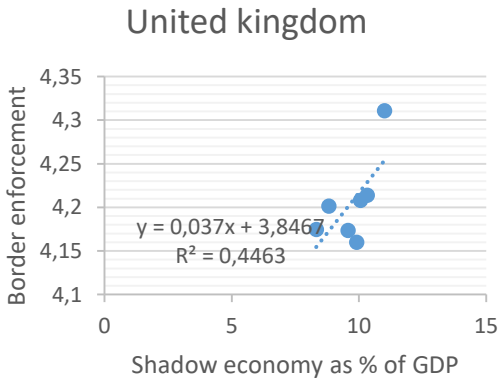

Romania
Border enforcement
Shadow economy as % of GDP
y = 0,0079x + 3,4076
R² = 0,0537

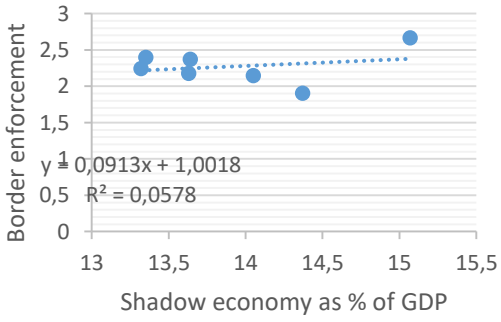

Slovenia
Border enforcement
3,95
3,9
3,85
3,8
3,75
3,7
3,65
3,6
y = 0,0723x + 2,1961
R² = 0,2991
20
21
22
23
24
Shadow economy as % of GDP

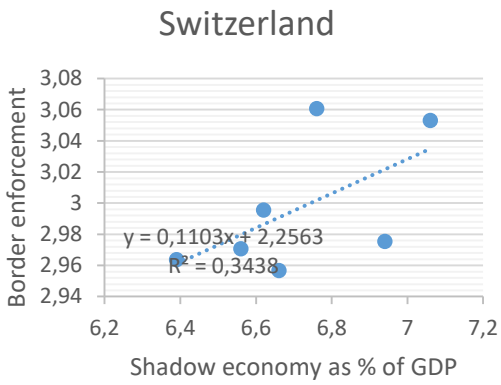

Slovakia
Border enforcement
3
2,9
2,8
2,7
2,6
y = 0,1418x + 1,0522
R² = 0,8252
0
5
10
15
Shadow economy as % of GDP


Finland
Border enforcement
3,25
3,2
3,15
3,1
3,05
3
y = -0,0605x + 3,9147
R² = 0,1313
12
12,5
13
13,5
Shadow economy as % of GDP


Sweden
Border enforcement
3
2,5
2
1,5
1
0,5
0
y = -0,2817x + 5,5527
R² = 0,1426
10,5
11
11,5
12
12,5
13
Shadow economy as % of GDP

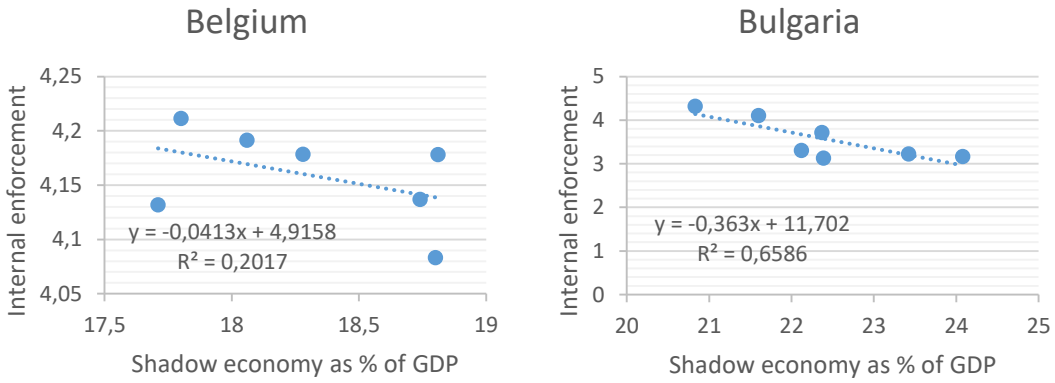

United kingdom
Border enforcement
4,35
4,3
4,25
4,2
4,15
4,1
y = 0,037x + 3,8467
R² = 0,4463
0
5
10
15
Shadow economy as % of GDP

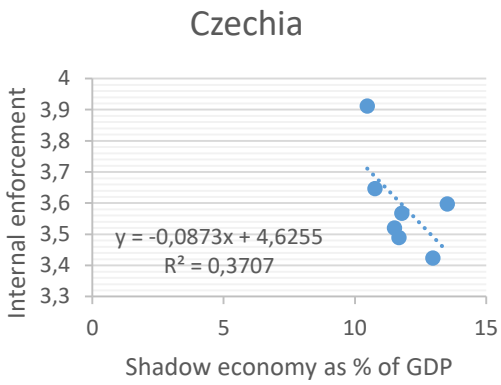

Norway
Border enforcement
3
2,5
2
1,5
1
0,5
0
y = 0,0913x + 1,0018
R² = 0,0578
13
13,5
14
14,5
15
15,5
Shadow economy as % of GDP

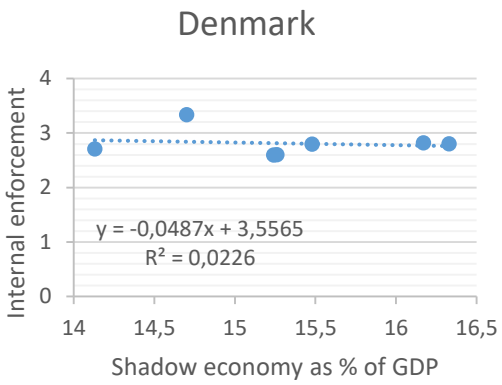


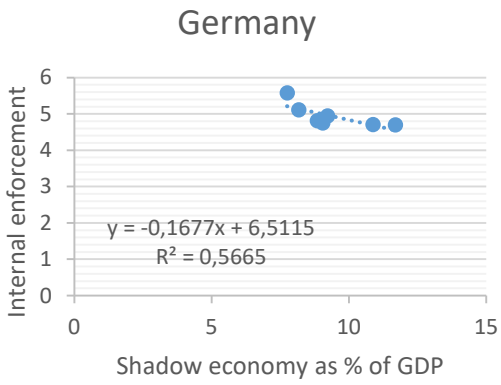
Source: Built form Medina and Schneider (2017)[23] and the OECD.

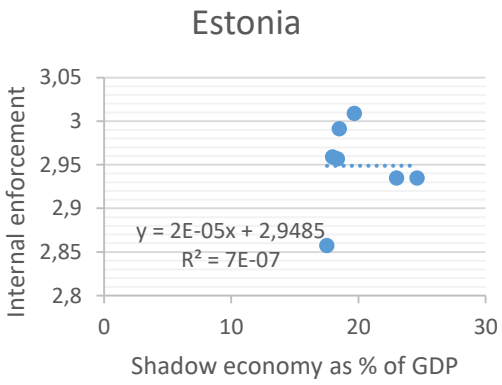
Figure 24: Shadow economy as percentage of the GDP vs internal enforcement UE 2009-2015

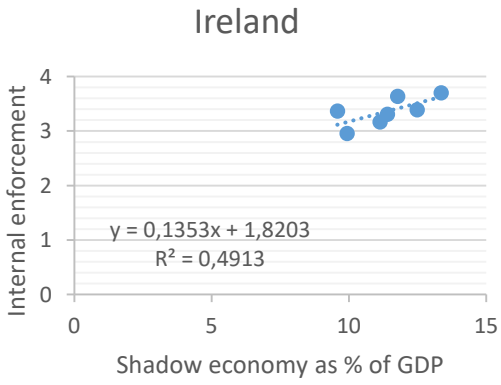


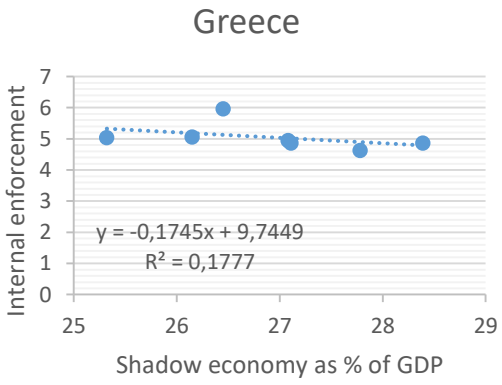

Czechia
Internal enforcement
4
3,9
3,8
3,7
3,6
3,5
3,4
3,3
y = -0,0873x + 4,6255
R² = 0,3707
0
5
10
15
Shadow economy as % of GDP

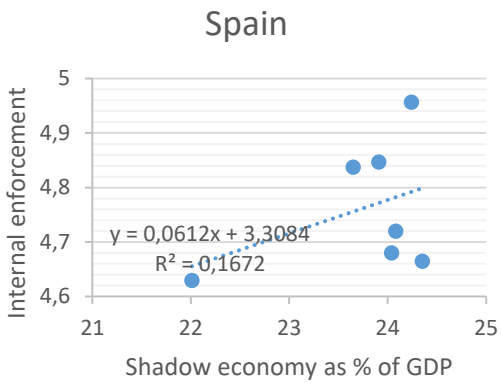

Denmark
Internal enforcement
4
3
2
1
0
y = -0,0487x + 3,5565
R² = 0,0226
14
14,5
15
15,5
16
16,5
Shadow economy as % of GDP

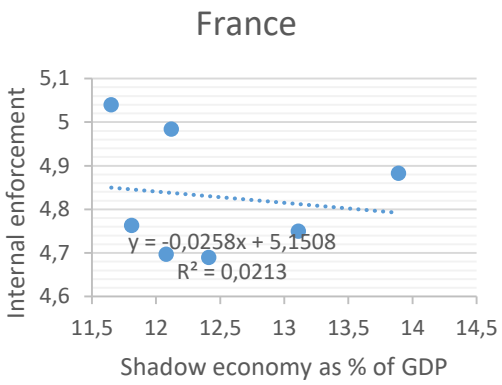

Germany
Internal enforcement
6
5
4
3
2
1
0
y = -0,1677x + 6,5115
R² = 0,5665
0
5
10
15
Shadow economy as % of GDP

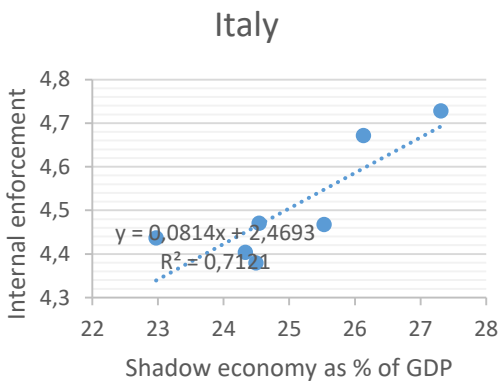

Estonia
Internal enforcement
3,05
3
2,95
2,9
2,85
2,8
y = 2E-05x + 2,9485
R² = 7E-07
0
10
20
30
Shadow economy as % of GDP

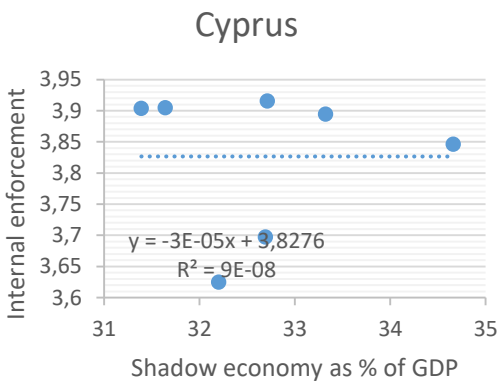

Ireland
Internal enforcement
4
3
2
1
0
y = 0,1353x + 1,8203
R² = 0,4913
0
5
10
15
Shadow economy as % of GDP

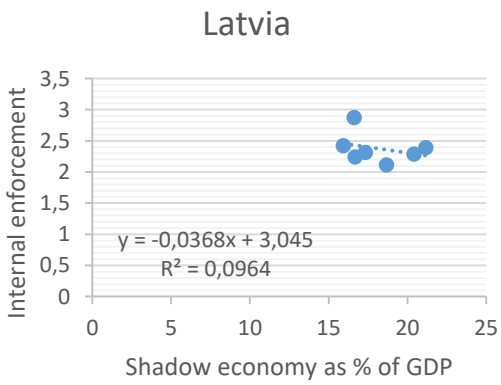

Greece
Internal enforcement
7
6
5
4
3
2
1
0
y = -0,1745x + 9,7449
R² = 0,1777
25
26
27
28
29
Shadow economy as % of GDP

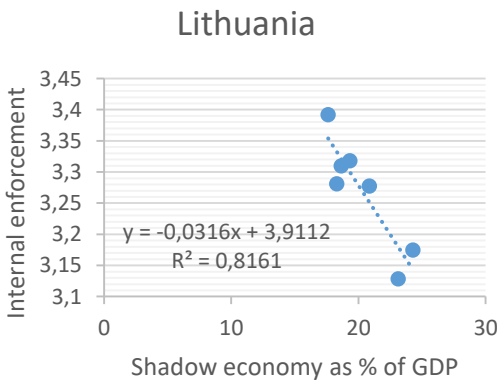

Spain
Internal enforcement
5
4,9
4,8
4,7
4,6
y = 0,0612x + 3,3084
R² = 0,1672
21
22
23
24
25
Shadow economy as % of GDP

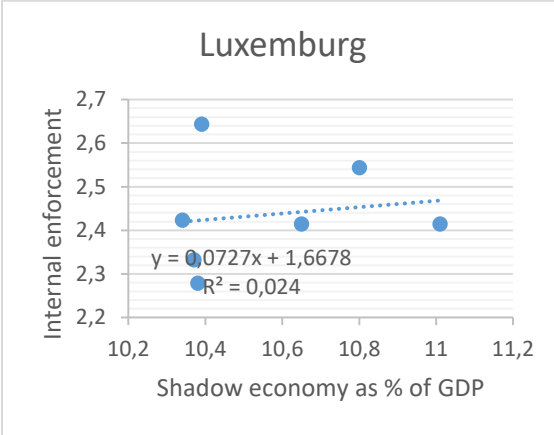

France
Internal enforcement
5,1
5
4,9
4,8
4,7
4,6
y = -0,0258x + 5,1508
R² = 0,0213
11,5
12
12,5
13
13,5
14
14,5
Shadow economy as % of GDP

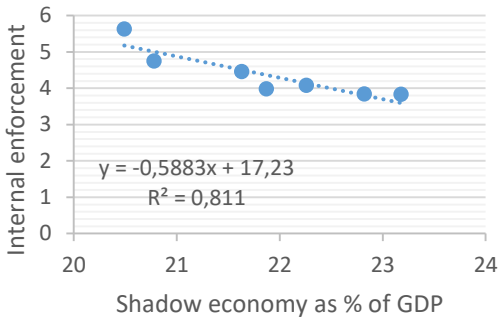

Italy
Internal enforcement
4,8
4,7
4,6
4,5
4,4
4,3
y = 0,0814x + 2,4693
R² = 0,7121
22
23
24
25
26
27
28
Shadow economy as % of GDP

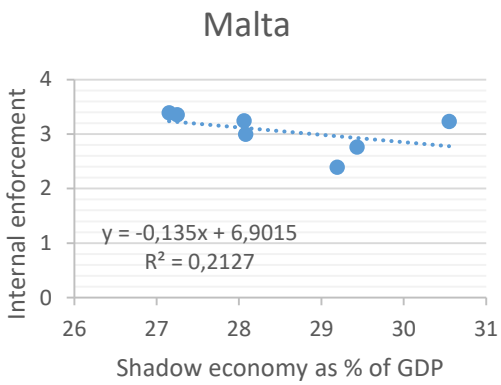

Cyprus
Internal enforcement
3,95
3,9
3,85
3,8
3,75
3,7
3,65
3,6
y = -3E-05x + 3,8276
R² = 9E-08
31
32
33
34
35
Shadow economy as % of GDP

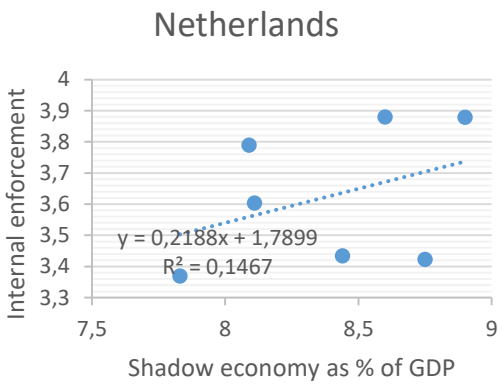

Latvia
Internal enforcement
3,5
3
2,5
2
1,5
1
0,5
0
y = -0,0368x + 3,045
R² = 0,0964
0
5
10
15
20
25
Shadow economy as % of GDP

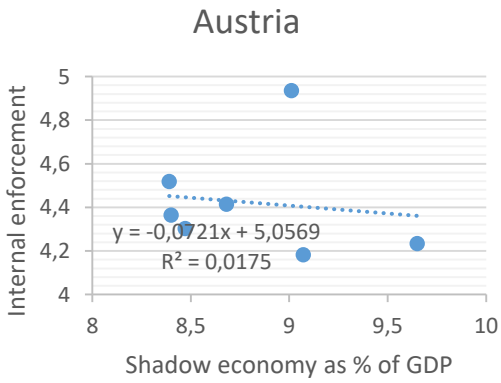

Lithuania
Internal enforcement
3,45
3,4
3,35
3,3
3,25
3,2
3,15
3,1
y = -0,0316x + 3,9112
R² = 0,8161
0
10
20
30
Shadow economy as % of GDP

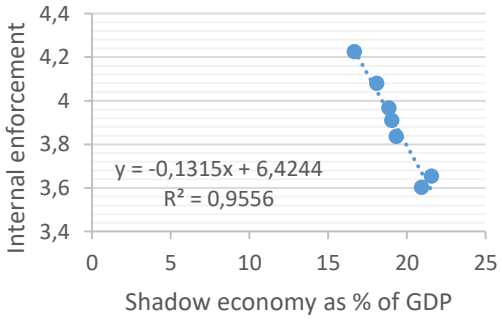

Luxemburg
Internal enforcement
2,7
2,6
2,5
2,4
2,3
2,2
y = 0,0727x + 1,6678
R² = 0,024
10,2
10,4
10,6
10,8
11
11,2
Shadow economy as % of GDP

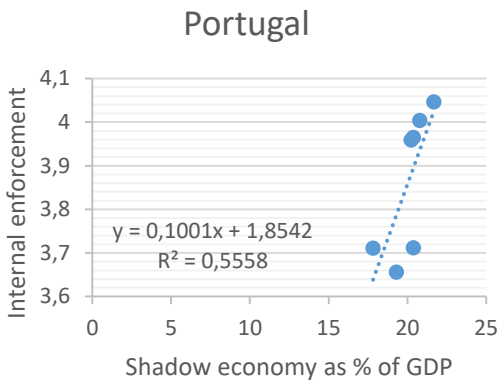

Hungary
Internal enforcement
6
5
4
3
2
1
0
y = -0,5883x + 17,23
R² = 0,811
20
21
22
23
24
Shadow economy as % of GDP

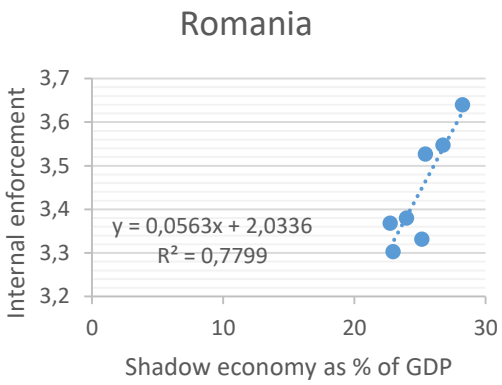

Malta
Internal enforcement
4
3
2
1
0
y = -0,135x + 6,9015
R² = 0,2127
26
27
28
29
30
31
Shadow economy as % of GDP

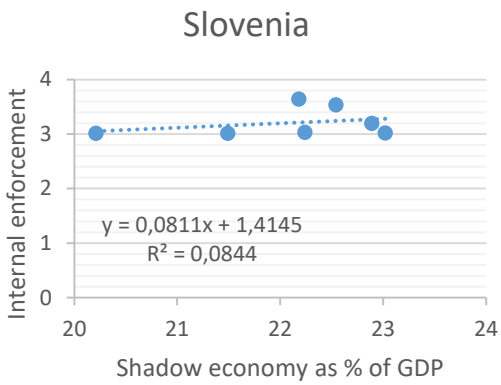

Netherlands
Internal enforcement
4
3,9
3,8
3,7
3,6
3,5
3,4
3,3
y = 0,2188x + 1,7899
R² = 0,1467
7,5
8
8,5
9
Shadow economy as % of GDP

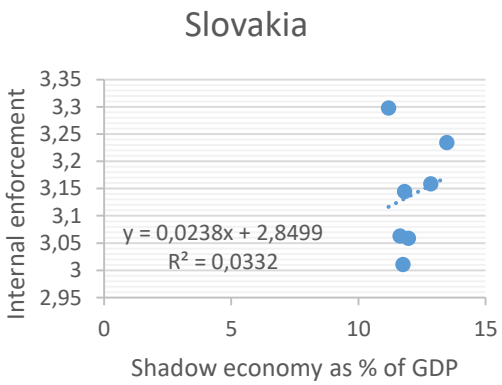

Austria
Internal enforcement
5
4,8
4,6
4,4
4,2
4
y = -0,0721x + 5,0569
R² = 0,0175
8
8,5
9
9,5
10
Shadow economy as % of GDP

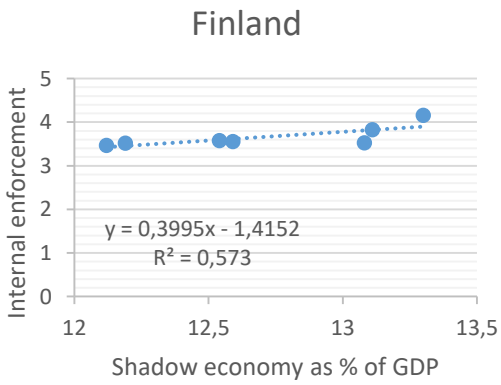

Poland
Internal enforcement
4,4
4,2
4
3,8
3,6
3,4
y = -0,1315x + 6,4244
R² = 0,9556
0
5
10
15
20
25
Shadow economy as % of GDP

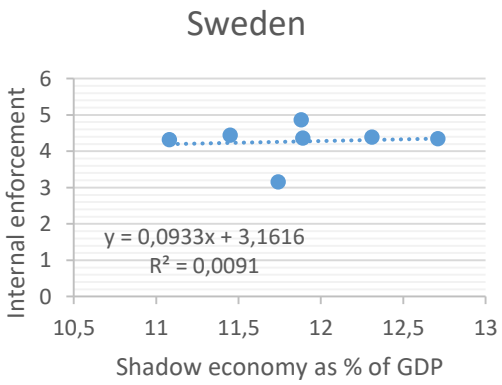

Portugal
Internal enforcement
4,1
4
3,9
3,8
3,7
3,6
y = 0,1001x + 1,8542
R² = 0,5558
0
5
10
15
20
25
Shadow economy as % of GDP

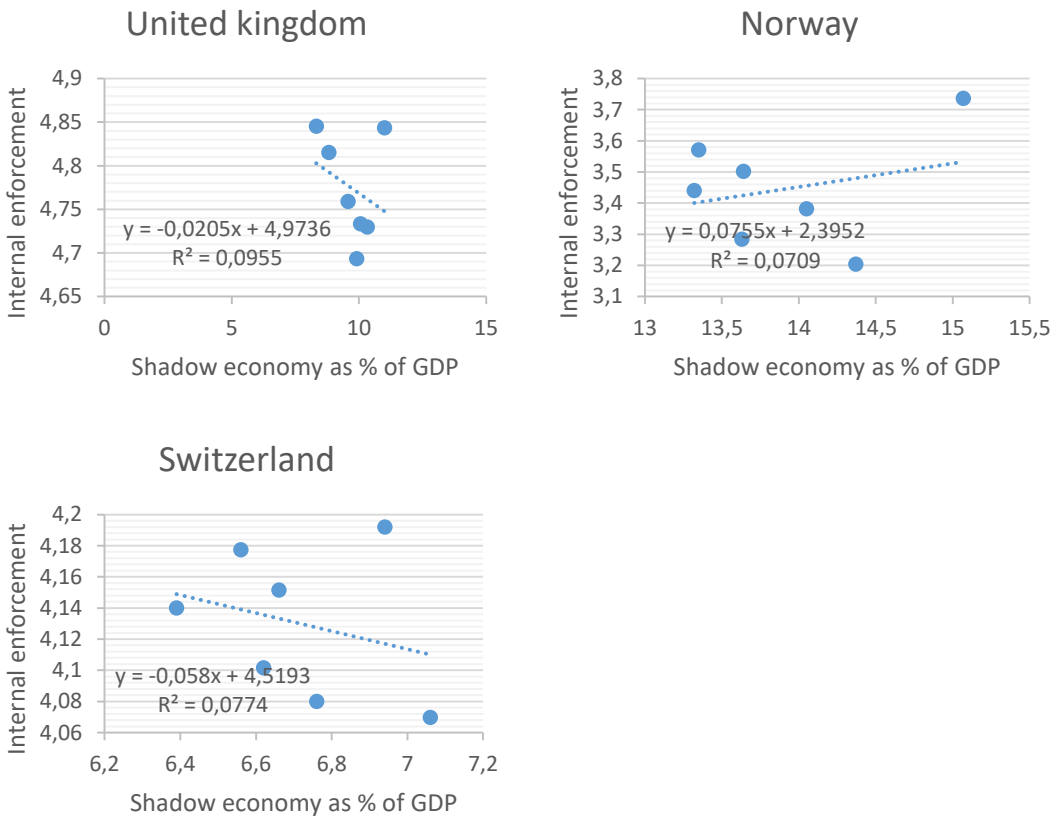

Romania
Internal enforcement
3,7
3,6
3,5
3,4
3,3
3,2
y = 0,0563x + 2,0336
R² = 0,7799
0
10
20
30
Shadow economy as % of GDP


Slovenia
Internal enforcement
4
3
2
1
0
y = 0,0811x + 1,4145
R² = 0,0844
20
21
22
23
24
Shadow economy as % of GDP


Slovakia
Internal enforcement
3,35
3,3
3,25
3,2
3,15
3,1
3,05
3
2,95
y = 0,0238x + 2,8499
R² = 0,0332
0
5
10
15
Shadow economy as % of GDP


Finland
Internal enforcement
5
4
3
2
1
0
y = 0,3995x - 1,4152
R² = 0,573
12
12,5
13
13,5
Shadow economy as % of GDP


Sweden
Internal enforcement
6
5
4
3
2
1
0
y = 0,0933x + 3,1616
R² = 0,0091
10,5
11
11,5
12
12,5
13
Shadow economy as % of GDP



Source: Built form Medina and Schneider (2017)[23] and the OECD.

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❖ CONCLUDING

Final discussion

Following *Rousseau* we could understand the government as a social contract. It is expected from the government to design welfare-improving policies. There is a myriad of these policies. One of them is law enforcement. Government has to control the national territory. Control here means applying the law. In this particular case, it implies creating the necessary conditions for individuals to work according to law. This policy is costly not just because of the monetary disburse but more importantly because of its efficiency. Public policies *compete* each other for a slide of the constrained public budget. Distributing resources to each policy comes from a political debate in which social welfare is explained out of a set of different variables. Law enforcement emerges as one variable in this set. Health and education are among the others.

As a social contract government has to enforce the law. Supposedly law propends for the social welfare. We say "supposedly" and not "certainly" because the concept of social welfare, as any other social construct, is just an interpretation. In the particular case of political debate there are no truths, *Nietzsche* would say, but interpretations. Some of these interpretations become law. What makes them law is the political power expressed in either democracy or tyranny. In any case, *Foucault* would say, it is the power what makes an interpretation to become a law and we use it as a criterion to evaluate what is good or bad. Law enforcing has the aim of obliging people to accept and implement those decisions that the government interprets as social-welfare enhancing. The social order emerges, then, as a materialization of an interpretation using both power and, of course, violence.

Let us divide law enforcement in two different but related policies. On one hand, controlling the national territory. It implies both gaining territory for the government and taking away territory from the illegal individuals. In the first case, the government allows individuals to legally exploit the resources; in the second case, it prevents illegal agents to use national resources. This policy is not only costly but inefficient. Consider how difficult it is for the government to monitor all the vast geography of a country, even a single city. It is almost impossible. This impossibility is an opportunity for illegal agents to emerge. According to *Foucault*, if there is an opportunity-in this case, an economic opportunity- power will always emerge. Even if the government is able to detect and expulse illegal agents from a portion of the territory, there will be other places for them to go where the

government is absent. This is called the *balloon effect* and constitutes a real challenge for the law enforcing agents everywhere.

One way to tackle the problem of controlling the national territory is specialization. Important resources will be spent in controlling that portion of the territory useful to produce high added-value goods. This is the *center*. Less resources will be spent to the other portion, the *periphery*, since it produces low added-value goods. Dividing the territory between center and periphery creates geographic inequality. The center will be rich; the periphery, poor. The natural development of the economy in each region will increase that difference up to the point in which the periphery will be consider marginal. The national territory becomes then a disconnected set. The weak presence of the government at the periphery is an incentive to illegal agents to take control. The input requirement of certain illegal activities also fuels illegality. Some illegal goods are intensive in land. Consider, for instance, the production of cocaine whose main input is the coca-leaf. Inequality, in this particular case geographic inequality, arises as one cause of illegality.

Consider now the second policy, capturing illegal agents. Understanding the threats for this policy requires us to define the structure of the group of illegal agents. This structure is specific to the kind of illegal market. It is not the same hierarchy for the illegal drugs market than it is in the human trafficking and forfeiting. Even within each category there is a plethora of subcategories. The organization of agents in the cocaine market is completely different from the one in the heroin or cannabis market. Let us be general notwithstanding. Capturing criminals could result in at least two possibilities. First, the head of the regime may fall. If there is cartel competition it makes the market power of the remaining heads to become stronger. There will be less competitors in the market. Second, pawns of the regime may fall. Government expects a *domino effect*. Criminals might change the market structure to reduce risks. *Maphia* will turn up to be less vertical and there will appear sub-structures smaller than the previous ones but more difficult to fight for the government. This is called a *hydra effect*.

Enforcement policy generates labor mobility. It can move people from one place to another, as it is in the balloon effect, or it may also move people from one sector to another as it is in the hydra effect. In any case, there is movement of workers between and within the different sectors of the economy. In this paper we have studied basically three sectors: legal, informal and illegal. Illegality deserves a full-length study since there are multiple sort of illegal business with completely different market and social structures. We studied it here as an economic activity of illegal goods and services under unregulated economic activities. Our departing point is the informal sector which is intimately related with the other two sectors.

Informality and illegality have unregulated economic activities; informality and legality, instead, have legal goods and services. Having legality and illegality at the same time makes the informal sector useful for us to understand the intersector labor mobility. It could be seen as a bridge connecting the other two sectors.

There are multiple definitions of informality. We define it here as the set of unregulated economic activities producing and trading legal goods and services. Perusing the related literature we find there are at least two broad approaches to the informal sector. On one hand it could be seen as an autonomous sector. This is the orthodox approach. Informal sector emerges as a place for unproductive individuals fleeing from fiscal policy. On the other hand informal sector could also be seen as a complement to the other two sectors. This is the heterodox approach. Informality here is interpreted as a temporary step for the reserve industrial army. It is a guarantee for the legal sector to have enough low-cost labor force to sustain the whole production of the economy. In the first interpretation, informality emerges as a market for a specific actor isolated from the other sectors; in the second, instead, it is the result of a historical problem enclaved in the economy as a whole.

Illegality is a market. As any market it has a specific industrial organization. There is market power. That power goes from the final market to the labor market. In the final market there are oligopolies and *maphias*. In the labor market there are oligopsonies. In some cases the market structure is monopolistic competition in which customers trust only one seller. Enforcing contracts requires violence. Stronger armory allows illegal agents to enforce private contracts. It is interesting to notice how illegality and its related violence reproduces and intensifies the *center/peripheria* division. Let us consider the case of the cocaine market. At the periphery they produce coca paste which has low added-value. It is produced for poor farmer and peasants in the mountains. The profits are tiny. At the center, instead, they do money laundering. There are banks and financial organizations making it possible. It requires financial skills with high added-value for the industry. Profits are huge. There is concentration and centralization following the *Marxian* interpretation.

There are multiple reasons for an individual to locate himself in one of the three sectors. The trade-off between legality and informality seems to be based on technical reasons. Unproductive individuals go informal so as to avoid tax burden. It is a strategy for them to reduce costs and increase economic profits. The trade-off between legality/informality-illegality seems to be a moral problem. Economic activities do generate economic and social costs. Legal activities are supposed to generate social profits; illegal activities, instead, generate social costs. Moral education is the key variable for an individual to endogenize social profits or costs.

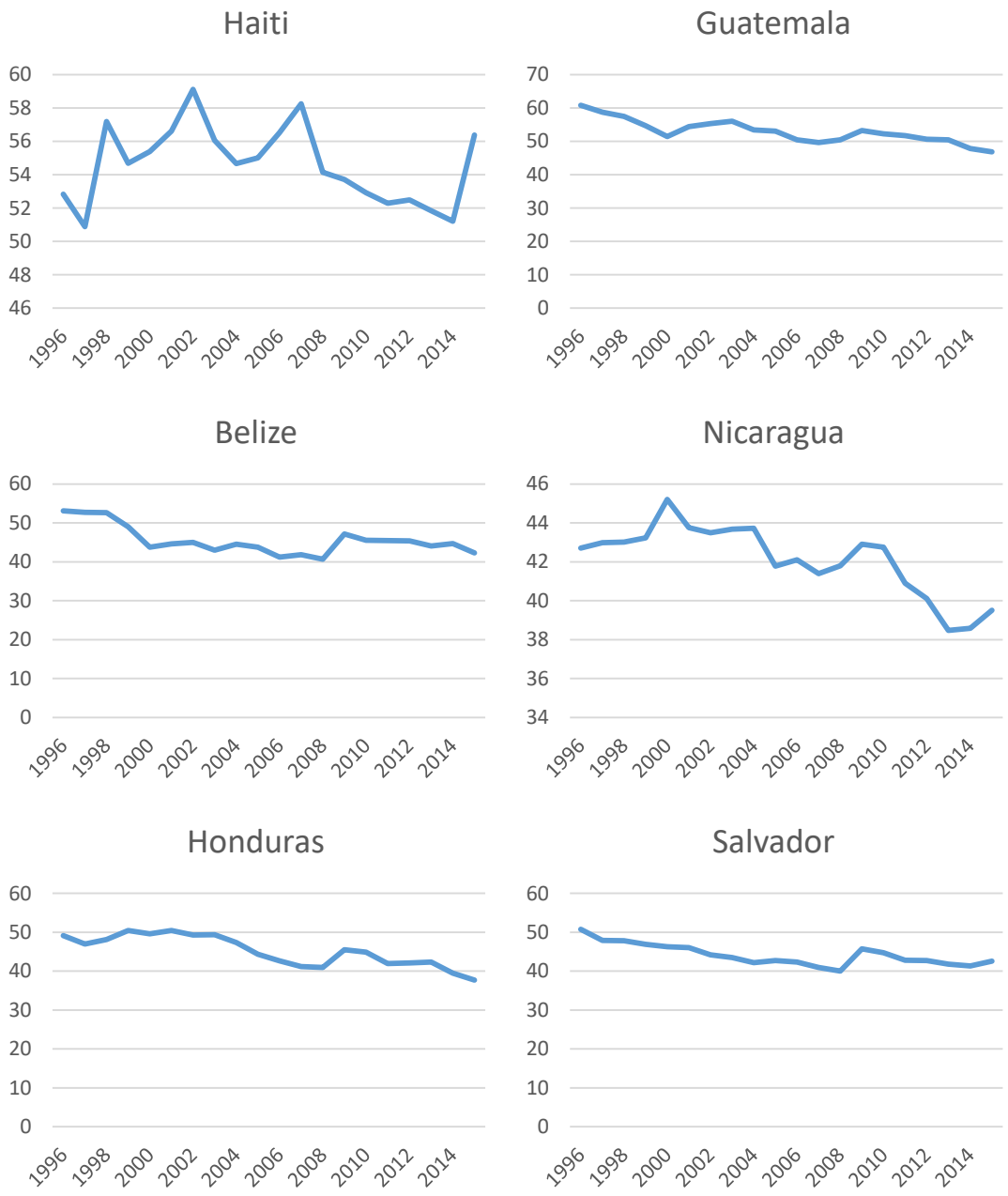
Comparing the economic profits with the social cost the individual is able to decide whether to participate or not in the illegal business. We could also say that the trade-off between legality and informality is a moral problem since hiding information and avoiding the tax payments do generate social costs. However, even morally educated people weight it with a low social cost due to bureaucracy and corruption.

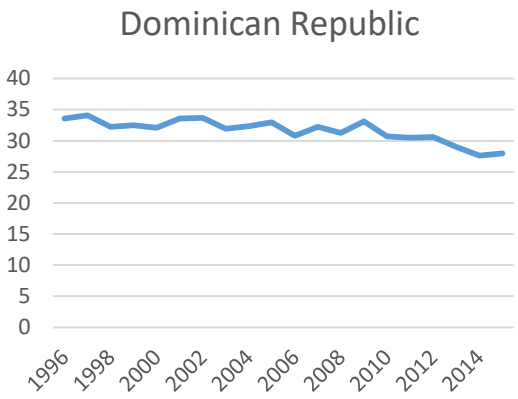
Governments induce labor movement with the economic policy. Think of the fiscal policy. Working in the legal sector requires workers and firms to pay taxes. Corruption aside those taxes are redistribute among the individuals of the country in the form of public services. Some individuals do not compensate the taxes they pay with the public services they receive so they prefer to go informal. Tax burdens and tough regulations *contribute* to the labor movement from legality toward illegality. Think now of the enforcement policy. Increasing the risk in participating in illegal activities may incentivize individuals to go toward informality or, under certain conditions, to be more efficient in the illegal business so as to get the always-increasing illegal economic profits. In either case the informal sector filters the labor movement between the other two sectors.

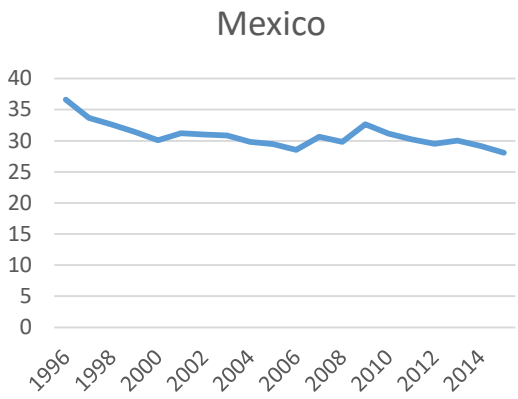
The aim of this work is to study some aspects of the intersector labor movement. We would like to shed some light as to the effects of some governmental policies on the transition of workers from one sector to the other. We consider three policies: fiscal, monitory rates and unemployment benefits. In the first chapter we construct an undirected search model with exogenous enforcement. An interesting insight from this chapter is the importance of the monitory rates on the efficiency of the other policies. In the second chapter we construct a directed search and matching model with endogenous enforcement effort. In light of the first chapter we make the enforcement endogenous by explicitly model the contest problem between government and shadow economy. Finally, the third chapter studies the intersector labor movement in an open economy with illegal immigration. We discuss here the implications of enforcing the law at the border and inside the national territory on the intersector labor movement within the host economy.

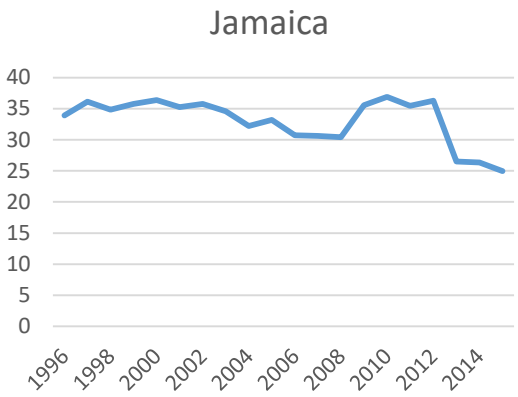
Appendix

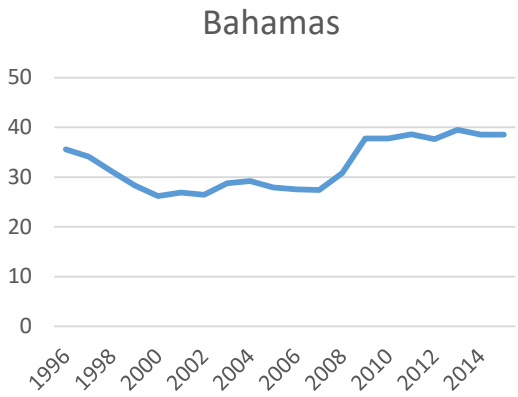
Figure 25: Shadow economy as percentage of the GDP in Latin America and the Caribbean during 1996-2015




Dominican Republic
40
35
30
25
20
15
10
5
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Mexico
40
35
30
25
20
15
10
5
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Jamaica
40
35
30
25
20
15
10
5
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Bahamas
50
40
30
20
10
0
1996
1998
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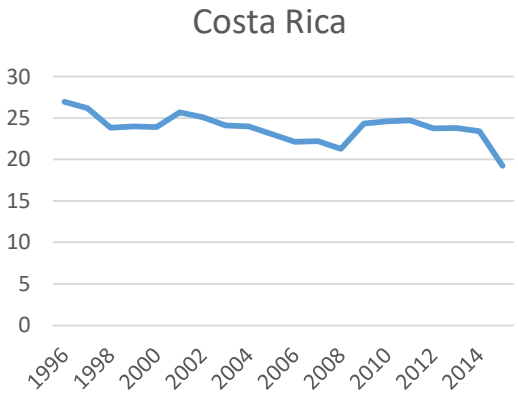
Costa Rica
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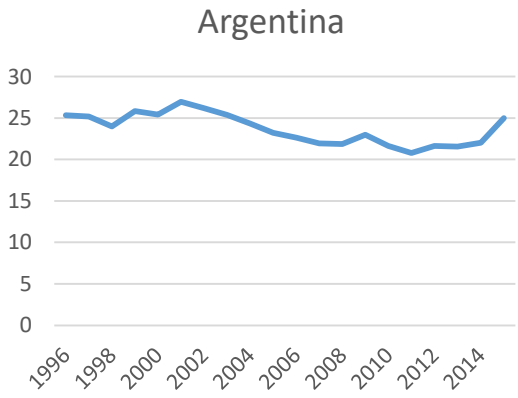
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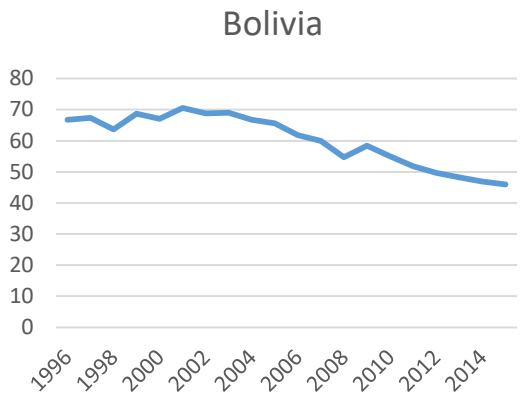
Bolivia
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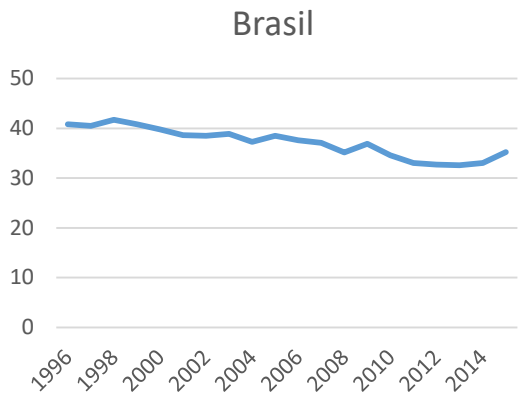
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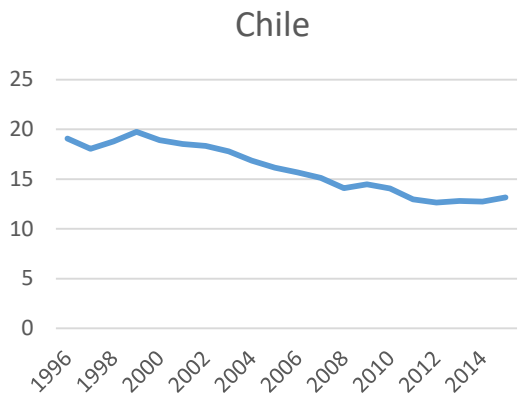
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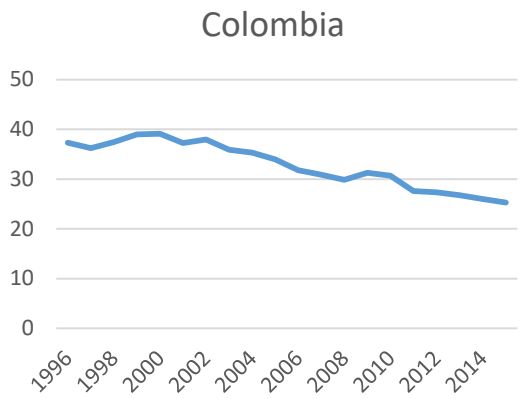
Colombia
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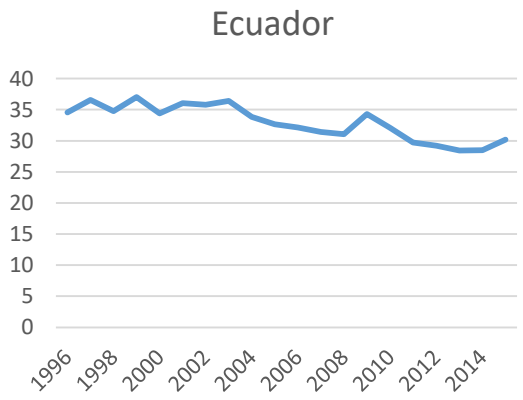
Ecuador
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1996
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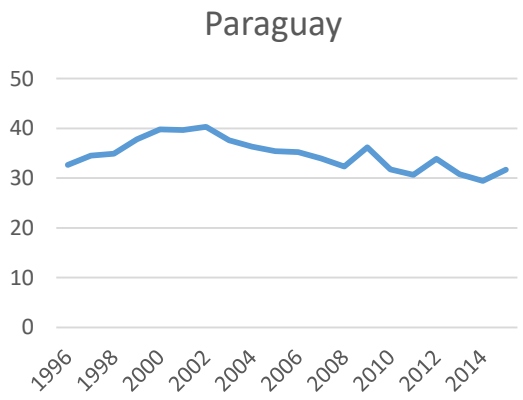
Paraguay
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1996
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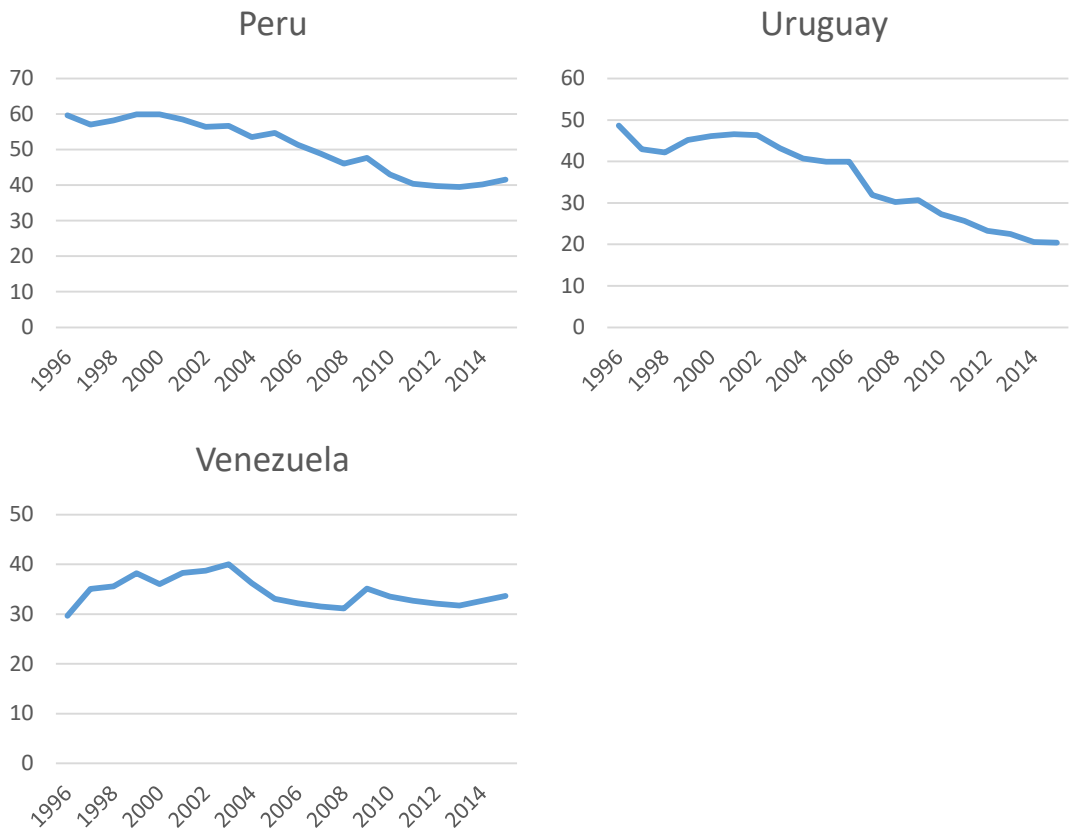
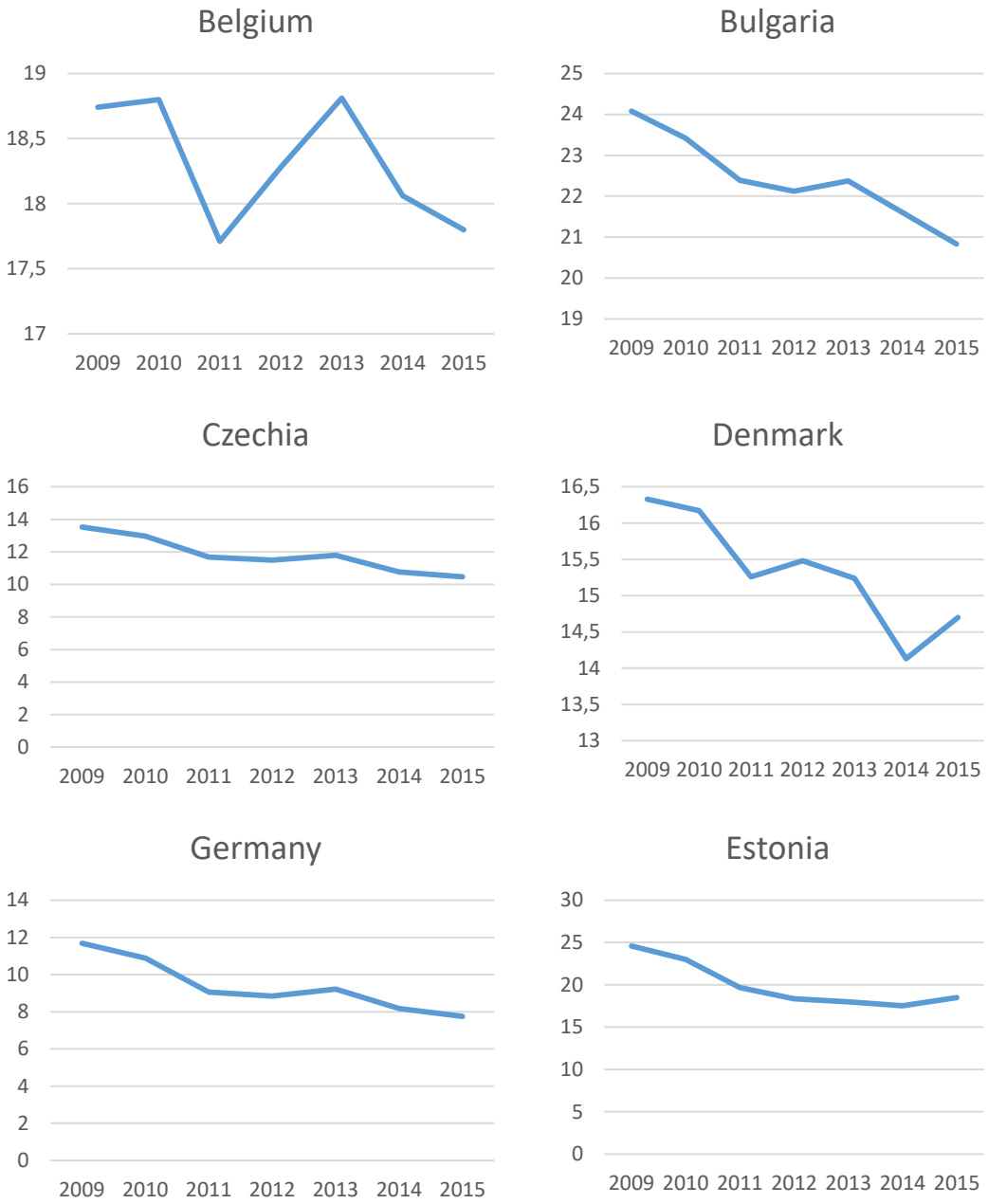
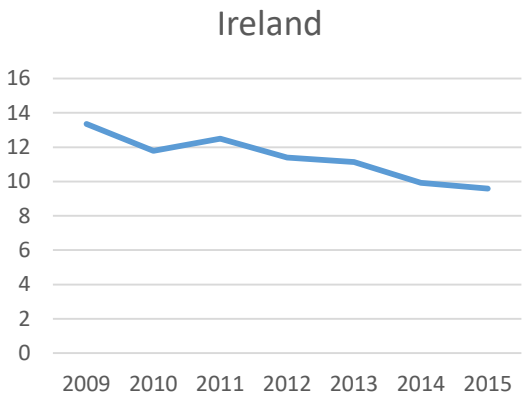
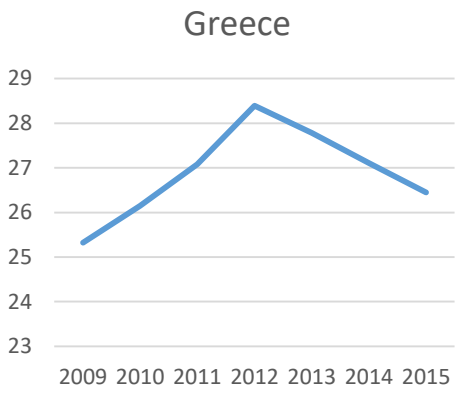


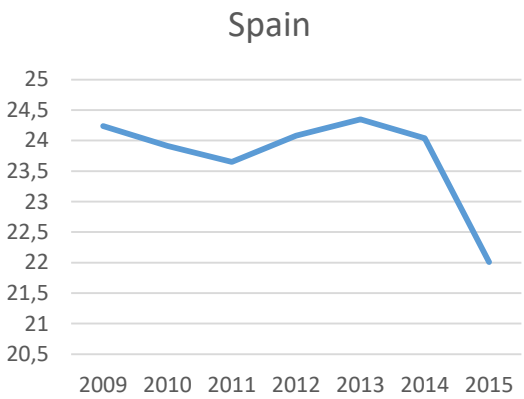
Source: Medina and Schneider (2017)

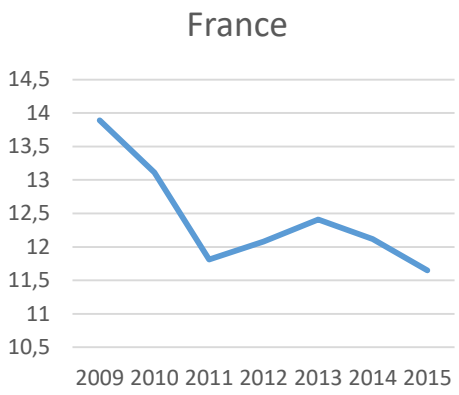
Figure 26: Shadow economy as percentage of the GDP in the European Union during 2009-2015

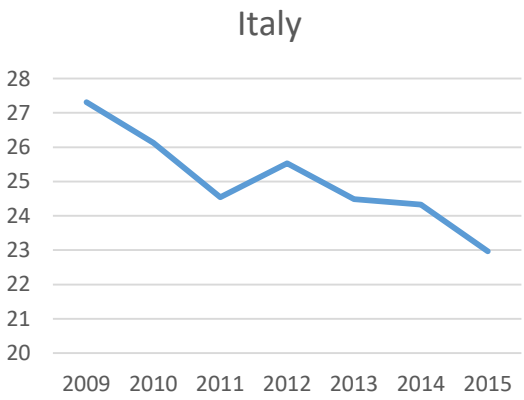



Ireland
16
14
12
10
8
6
4
2
0
2009 2010 2011 2012 2013 2014 2015


Greece
29
28
27
26
25
24
23
2009 2010 2011 2012 2013 2014 2015


Spain
25
24,5
24
23,5
23
22,5
22
21,5
21
20,5
2009 2010 2011 2012 2013 2014 2015


France
14,5
14
13,5
13
12,5
12
11,5
11
10,5
2009 2010 2011 2012 2013 2014 2015


Italy
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27
26
25
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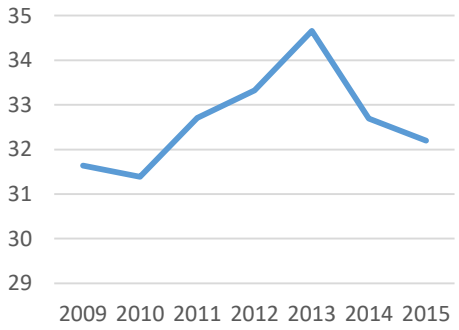
21
20
2009 2010 2011 2012 2013 2014 2015


Cyprus
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34
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32
31
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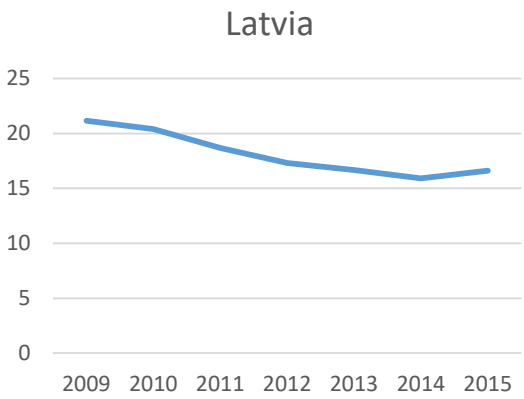
29
2009 2010 2011 2012 2013 2014 2015


Latvia
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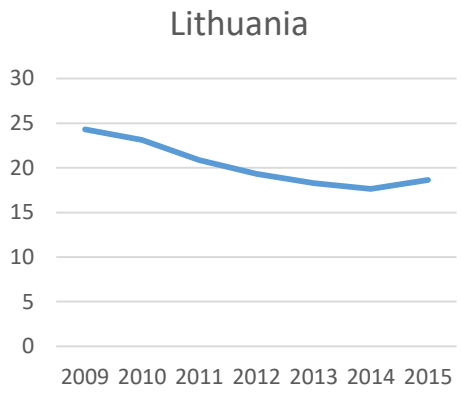
2009 2010 2011 2012 2013 2014 2015


Lithuania
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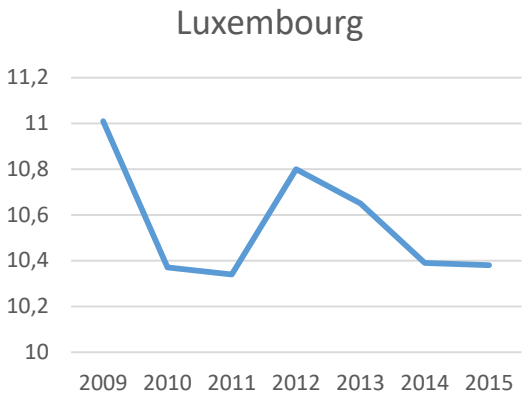
2009 2010 2011 2012 2013 2014 2015


Luxembourg
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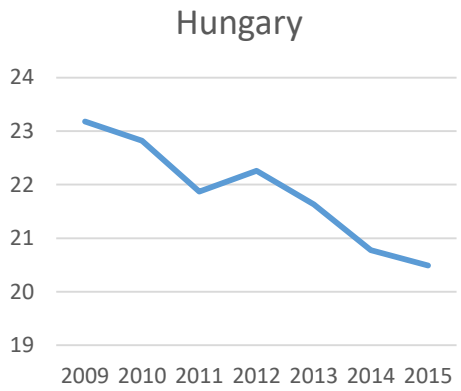
11
10,8
10,6
10,4
10,2
10
2009 2010 2011 2012 2013 2014 2015


Hungary
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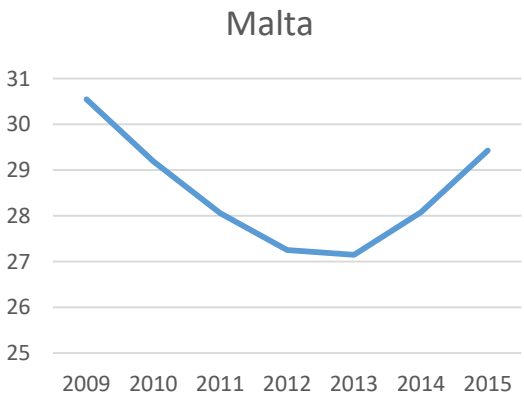
Malta
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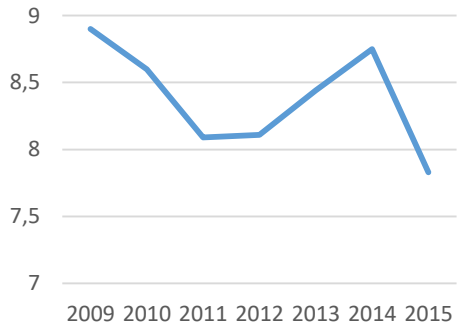
2009 2010 2011 2012 2013 2014 2015


Netherlands
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8,5
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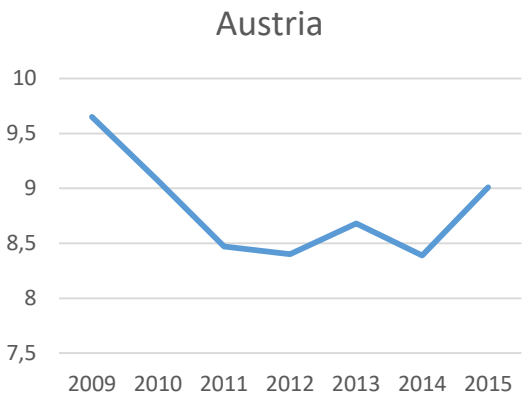
7,5
7
2009 2010 2011 2012 2013 2014 2015


Austria
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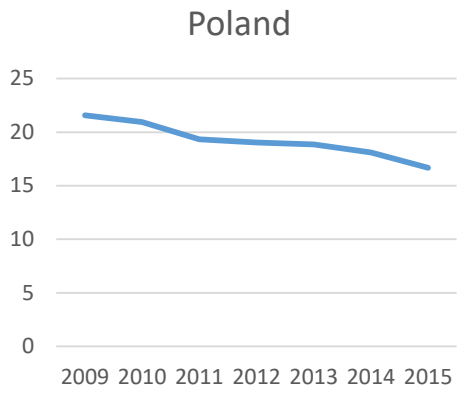
Poland
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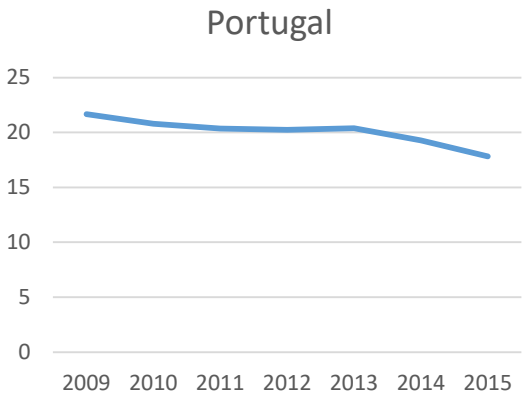
Portugal
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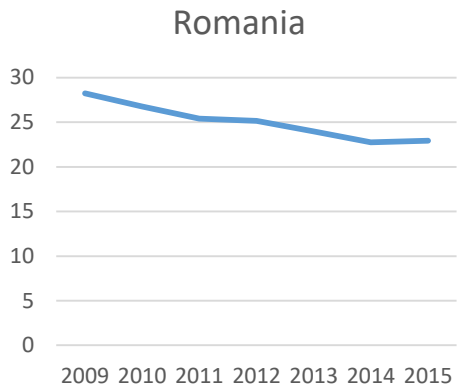
Romania
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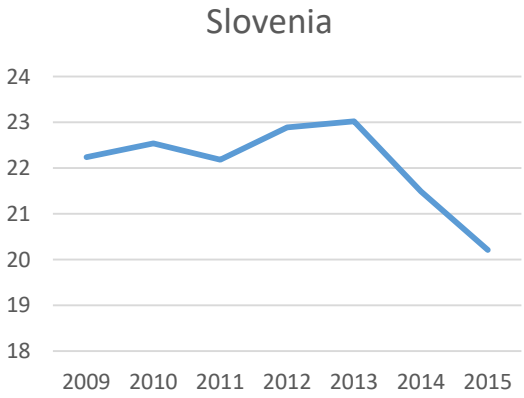
Slovenia
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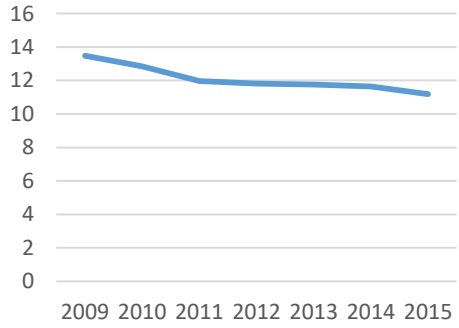
Slovakia
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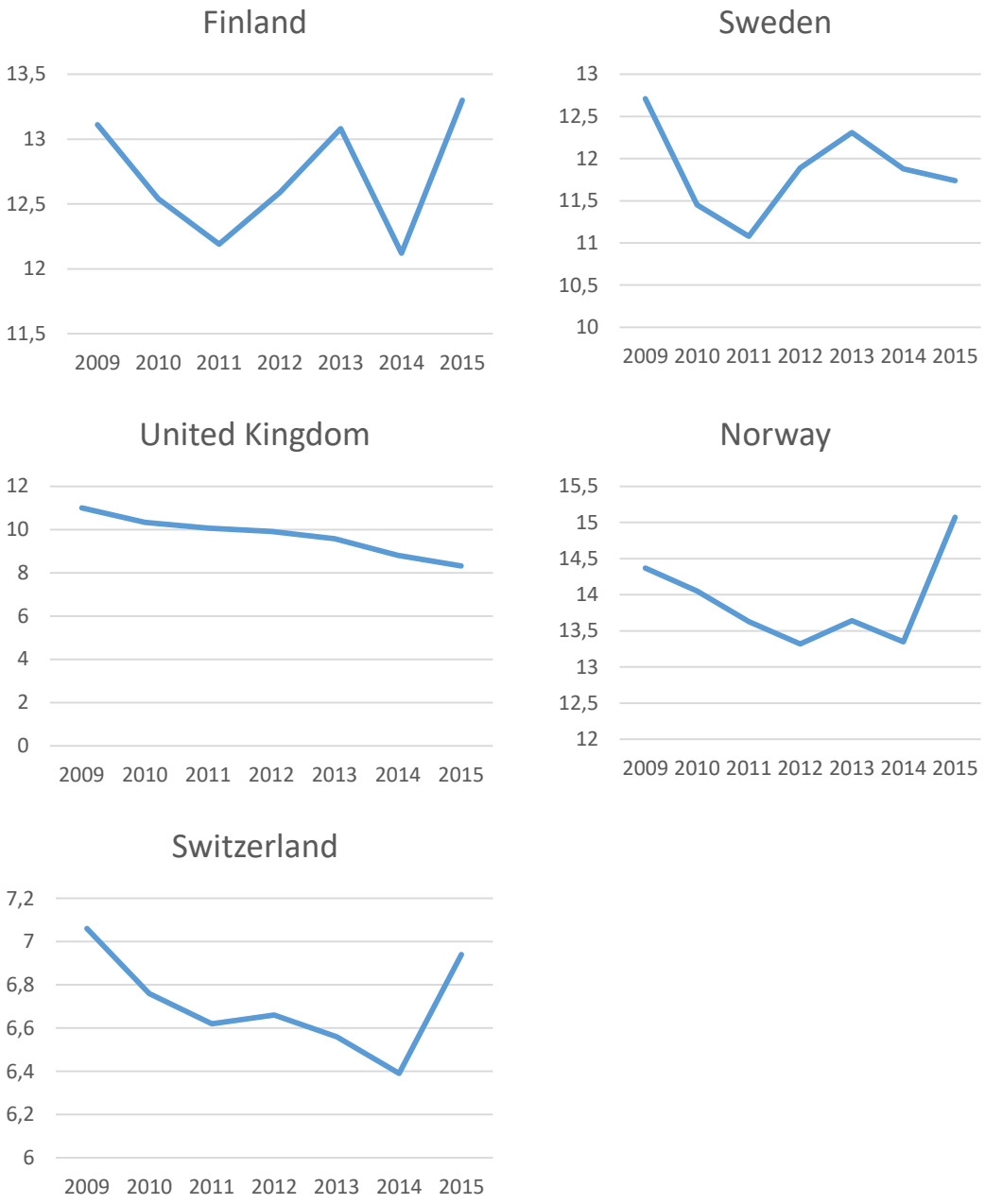

Source: Medina and Schneider (2017)

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