Labor Market Search, Informality and Schooling Investments*

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Abstract

Many labor markets, typically in medium- and low-income countries, are characterized by high levels of informality. While informality may constitute an important margin to increase labor market flexibility, it may also dampen firms' and workers' productivity. This paper explores one long-term effect of informality: the possible under-investment in individuals' education *prior* to labor market entry. To do so, we formalize the presence of informal job opportunities in a search-matching-bargaining model of the labor market with endogenous schooling decisions. We estimate the model on individual-level data from the Mexican labor force survey. Estimation results show reasonable values of the model parameters, including those harder to identify like the firms' costs of evading the labor regulations and the workers' valuation of the extra-wage benefits for both legal and illegal contracts. Counterfactual experiments varying key policy parameters allow us to quantify the channels through which labor market frictions inhibit schooling investments.

Keywords: Labor market frictions, Search and matching, Nash bargaining, Informality, Returns to schooling.

JEL Codes: J24, J3, J64, O17

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1 Introduction

Labor markets in developing countries operate very differently than in developed ones. In these countries firms and workers are divided into a formal and an informal segment as a result of the interaction between tax laws including special regimes for certain types of firms; credit constraints and financial frictions; labor regulations with regards to minimum wages, and dismissal; and social insurance regulations that protect workers against various risks. Although there is an important debate as to the relative importance of these factors within and across countries, there is a growing consensus that the formal-informal divide has substantive implications for productivity as it affects the number, size and legal status of firms; the dynamics of firm entry and exit; and the type of contracts that are established between firms and workers.[1]

On one hand, economies with large informal sectors suffer a productivity penalty because of restricted access to financial markets; because informal firms innovate less and have higher failure rates; and because when workers are informally employed they have fewer opportunities for skill acquisition and on-the-job learning [Hsieh and Klenow, 2009; La Porta and Shleifer, 2014; Lagakos et al., forthcoming]. On the other hand, informality may constitute an important margin to increase labor market flexibility and improve workers' allocation across sectors and occupations.[2] A recognition that informality results partly from legal design and partly from frictions and distortions is essential for our understanding of the phenomenon and for policy design. At the analytical level it highlights the need to model institutional features that are peculiar to developing countries. At the policy level it highlights that some objectives that are commonly pursued – in particular, "eliminating informality" – may not be the appropriate ones. Ideally, one would like to distinguish the component of informality that derives from distortions and frictions from the component that is efficient and inherent to the institutional context to understand how each affects labor market outcomes.

This paper represents an attempt to carefully embedding some key institutional features that are ubiquitous in low and middle-income countries with a large informal sector in an

[1] At the most general level, informality is defined as any deviation from the labor contract as designed by law, including absence of workers protections, no or significantly lower payroll contributions and lack of conformity to other labor law statutes. The issue is particularly acute in Latin America where even large middle-income economies with well developed labor market institutions feature more than half of the labor force in the informal sector [Levy and Schady, 2013]. In Mexico, the country where we will perform our empirical analysis, about 63% of employed workers is informal.

[2] This claim is supported by some empirical regularities documenting the fluidity of the informality status, which is particularly evident for individuals with low and intermediate levels of education. Over that range of the skill distribution, workers tend to frequently move in and out the informality status while firms tend to hire a mix of formal and informal workers [Perry et al., 2007].

equilibrium model of the labor market. More specifically, we consider an environment in which individuals choose (i) whether becoming self-employed or remaining unemployed prior to searching for a job as employees and (ii) whether acquiring productivity-enhancing schooling prior to labor market entry. Potential employees are randomly matched with firms that could offer legal and illegal wage contracts. Upon observing match-specific productivity, firms optimally set the legal status of the job and simultaneously engage in bargaining over wages with workers. Workers are allowed to value differently the extra-wage benefits embedded in the two contract types. Also, the outside options in self-employment are heterogenous among workers, generating the substantial overlap in the wages and productivity distributions of legal and illegal jobs that is observed in the data. This framework not only allows us to document and characterize the extent to which labor market frictions affect workers' allocation across jobs and occupations but also to study a hitherto unexplored dimension of the formal-informal divide that potentially bears long-term implications for productivity and welfare: the possible under-investment in workers' education *prior* to labor market entry.

The model is estimated using the Method of Simulated Moments on individual-level data from the Mexican labor force survey (ENOE). While the model features allow for separate identification of most of the structural parameters, we rely on an additional source of variation in the data in order to identify one of the two valuation parameters for the extra-wage benefits. In particular, we use the time-staggered entry across municipality of one large-scale non-contributory health programs targeted to individuals not covered by employer- provided social security benefits. Estimation results show reasonable values of the model parameters, including those harder to identify like the firms' costs of evading legal employment requirements and the workers' valuation of the extra-wage benefits associated to legal and illegal contracts. We next perform counterfactual experiments changing the three main policy parameters of the model: enforcement of labor regulation, non-contributory social protection benefits and payroll contributions. Results show that, once equilibrium effects are taken into account, wages and informality rates are very sensitive and non-monotonically related to these policy levers, with a key role played by the redistribution component of the social security benefits in the formal sector. For instance, eliminating non-contributory social security benefits gets rid of illegal employment with very modest increases in unemployment rates. This is because the policy decreases workers' reservation values when accepting legal jobs, which leads to lower equilibrium wages in both schooling groups. Decreasing the tax rate on legal labor generates similar (albeit somewhat less extreme) effects in the labor market as a whole but with more pronounced responses for workers with higher education, thereby leading to a substantial increase in high school completion rates in the post-policy environment.

The informality literature in an equilibrium labor market context is scarce. Bosch and Esteban-Pretel [2012] calibrate a two sector model for Brazil where firms have a choice of hiring workers formally or informally. Albrecht et al. [2009] is an equilibrium search model studying the distributional implications of labor market policy in a labor market with an informal sector. Perhaps the paper in this literature that is closest to ours is Meghir et al. [2015]. The authors develop an equilibrium search model with wage posting in which firms endogenously locate in the formal or informal sector and estimate the structural parameters of the model on Brazilian labor force data, showing that stricter enforcement reduces informal employment and increases welfare by increasing competition in the formal sector.

We contribute to this literature along several dimensions. First, we include an endogenous schooling decisions and therefore policy experiments are allowed to alter both the returns to schooling investment and the equilibrium impacts of the resulting schooling choices. Indeed, our estimates show that the productivity costs of informality may go beyond the misallocation of workers across jobs, with potential long term consequences due to lower investments in human capital. Second, we propose a more nuanced definition of informality. We assume that wages are determined by bargaining between the worker and the employer. The legality status, instead, is posted by the employer. This structure better match both the institutional context and the observed patterns in the data: ex-ante any job can be legal or illegal but in equilibrium we observe a mixture of the two based on match-specific productivity and agents' outside options. Third, we critically distinguish between two margins of informality: illegal employment in firms and subsistence-level self-employment. In our model, those two groups of individuals respond to very different incentives. In fact, we show – in contrast to Meghir et al. [2015] – that stricter enforcement has contradictory effects on informal employment, decreasing the share of illegal salaried employment, but also increasing informal self-employment.

By allowing individuals to make productivity-enhancing schooling decisions prior to labor market entry, our paper is also related to a strand of literature studying the extent of the hold up problem on human capital investments. Acemoglu and Shimer [1999] examine the potential for hold-up problems in frictional markets and the role that contracts play to reduce the resulting externalities. More closely related to our paper, Flinn and Mullins [2015] extend the standard search and matching framework to allow for *ex-ante* schooling decisions. In the context of the US labor market, they find that the extent of the hold up inefficiency is very sensitive to the workers' bargaining power parameter. While the modeling of the schooling decision is similar to the one presented in Flinn and Mullins [2015], our objective is different. We model the labor market in order to capture the effects of frictions that are ubiquitous in informal economies – namely, a dual social insurance architecture, limited enforcement of labor regulations, and the prevalence of self-employed workers who search for better labor market opportunities as employees – in order to evaluate quantitatively their role on the incentives to acquire schooling.

Finally, our paper speaks to a recent and growing empirical literature that seek to explore how exogenous institutional changes altering the returns to schooling or labor demand shocks affect schooling investments [Munshi and Rosenzweig, 2006; Jensen, 2012; Abramitzky and Lavy, 2014; Heath and Mobarak, 2015; Atkin, forthcoming]. We complement this literature by proposing an equilibrium framework, which allows us to study the impacts on occupational choices and schooling decisions of alternative policies aimed at reducing the labor market frictions associated to informality.

2 Context and Data

2.1 Institutional Setting

Following Kanbur [2009] and Levy [2008], we define informality with reference to compliance with regulations on salaried labor.[3] In Mexico, as in most countries, firms are obligated to enroll salaried workers in the social security registry (IMSS, for its Spanish acronym) and pay a contribution proportional to workers' wages whose revenue is used to fund a bundled set of social security benefits. Unlike in the United States or Western European countries, those benefits are bundled in the sense that firms and workers must pay for a fixed-proportions package that includes health, life, work-risk and disability insurance, housing loans, day care services, sports and cultural facilities, and retirement pensions. Note that some benefits are directly proportional to the worker's individual wage (like disability or retirement pensions) while others are pooled among all workers (like day care services or health), implying redistribution within salaried workers. There is no unemployment insurance and thus no flow payments out of wages into an unemployment fund or individual accounts. Total taxes on salaried workers in Mexico are approximately 33 percent of the wage (excluding the contin-

[3]This definition of informality abstracts from other dimensions of legality that are possibly relevant for worker behavior like complying with income taxes. While conceptually relevant, in our context this is of second-order importance as labor income tax is small over the wage support that we consider in our sample (never more than 10%), and tax evasion is widespread – even among formal workers.

gent costs associated with firing and severance pay regulations). Because these regulations are imperfectly enforced, cheating occurs as a device for firms to save on labor costs. Henceforth, we refer to workers that are regularly registered in the social security system as 'legal employees' and the remaining part of salaried workers as 'illegal employees'.

To the extent that there is no firm-worker relationship, these rights and obligations do not apply to self-employed workers. For the most part of the individuals in our sample who are engaged in those activities, the notion of self-employment differ quite fundamentally from its counterpart in developed countries. It can be mostly ascribed as a "necessity" labor market state whereby individuals in need who do not have access to subsistence agriculture or formal safety nets will start their own micro-enterprises while also searching for a job (see, e.g., World Bank [2012]). Financial barriers to enter into self-employment do not appear as the most important obstacle (see McKenzie and Woodruff [2006] for evidence on micro-enterprises in urban Mexico, and Bianchi and Bobba [2013] for evidence on self-employment in rural Mexico), which is consistent with the fact that unemployment is in general very limited in those labor markets.

In the early 2000s the Federal Government designed a new system for social protection that was aimed at providing affordable health coverage for those not covered by employer-provided social security benefits. A key component of this reform was the *Seguro Popular* program. The program started as a pilot during 2002 in five states and by the end of 2007 virtually all municipalities in the country had enrolled in the program with more than 21 million beneficiaries. During the same period, similar programs were launched providing housing subsidies, pensions and day care facilities for working mothers. Spending in those non-contributory social protection programs over GDP has doubled over the last decade – from 0.8% in 2002 to 1.65% in 2013, a pattern that is in common across virtually all countries with a dual social insurance system [Frolich et al., 2014]. The voluntary, unbundled, and by and large free nature of non-contributory programs implies that valuation issues are substantially less complex than in the case of contributory programs. The fact that for the most part all services are provided within the same health infrastructures of state governments and IMSS facilities partly ameliorates possible concerns regarding inherent differences in the quality of benefits, rationing of some services, and regional disparities in service provision between contributory and non-contributory social security programs.

2.2 Data

The data is extracted from Mexico's official labor force survey (ENOE, by its Spanish acronym) for the year 2005. Similar to the US Current Population Survey, the survey has a panel component, as households stay in the sample for five consecutive quarters. We restrict the sample to nonagricultural, full-time, male, private-sector workers between the ages of 35 and 55 who reside in urban areas (defined as localities with a population greater than 15,000 inhabitants). We focus our analysis on workers at the mid-range of the skill distribution for whom the relevant education decision is to complete or not a secondary education career. We thus drop from the sample those who did not complete junior secondary schooling (i.e. below 9th grade) and those who completed college or a higher educational degree and split the resulting sample in two groups according to whether the worker has completed high school (i.e. 12th grade) or not.

We define as employed workers those who declare (i) being in a subordinate working relationship in their main occupation and (ii) receiving a wage as a result of that working relationship. Among them, we identify the legal or illegal employed workers depending on whether they report having access to health care through their employers.[4] We further define self-employed workers as those who declare (i) not being in a subordinate relationship in their main occupation and (ii) having a business by their own. In order to obtain a more homogenous population of self-employed individuals, we drop those who report having paid employees (roughly 30%). Earning distributions are trimmed at the top and bottom 1 percentile in each schooling group separately for legal employees, illegal employees and self-employed. The resulting sample is comprised of 15,212 worker observations stacked in any quarter of the year 2005, with 9,199 workers in the low schooling group and 6,013 workers (39.5%) in the high schooling group.

Table 1 reports descriptive statistics by schooling group for the final sample we use in the empirical analysis. The emerging patterns are quite typical of many labor markets in middle income countries. First, there is a significant mass of workers in each labor market

[4]We have cross-checked this definition of informality with two auxiliary data sources. First, we use the nationally representative household survey (ENIGH) that is collected in the same period. This information allows use constructing the exact definition of illegality that we have employed in the ENOE survey as well as an alternative definition based on more detailed information on respondents' occupations and access to health care benefits though their job. The resulting discrepancies at the individual-level in the categories of legal and illegal employees are minimal. Second, using our definition we use the survey weights in the ENOE in order to generate aggregate shares of formal workers at the national level. Those are by and large comparable with the share of formal workers resulting from aggregating the total number of individuals that are registered in the IMSS as a share of the total national workforce contained in the Mexican population census.

Table 1: Descriptive Statistics

	Low Schooling			High Schooling		
	Legal Empl.	Illegal Empl.	Self Empl.	Legal Empl.	Illegal Empl.	Self Empl.
Proportion of Workers (%)	49.97	22.30	23.55	52.34	19.31	23.85
Hourly Earnings: Mean	24.00	18.14	21.59	30.36	21.79	24.05
Hourly Earnings: Standard Deviation	11.93	9.91	12.68	18.31	15.29	15.45
	Low Schooling			High Schooling		
Unemployment Rate	4.19			4.51		
Mean (SD) Months In Unempl.	2.39 (4.15)			3.71 (6.02)		
Mean (SD) Months in Self-Empl.	133.74 (101.74)			122.88 (96.79)		

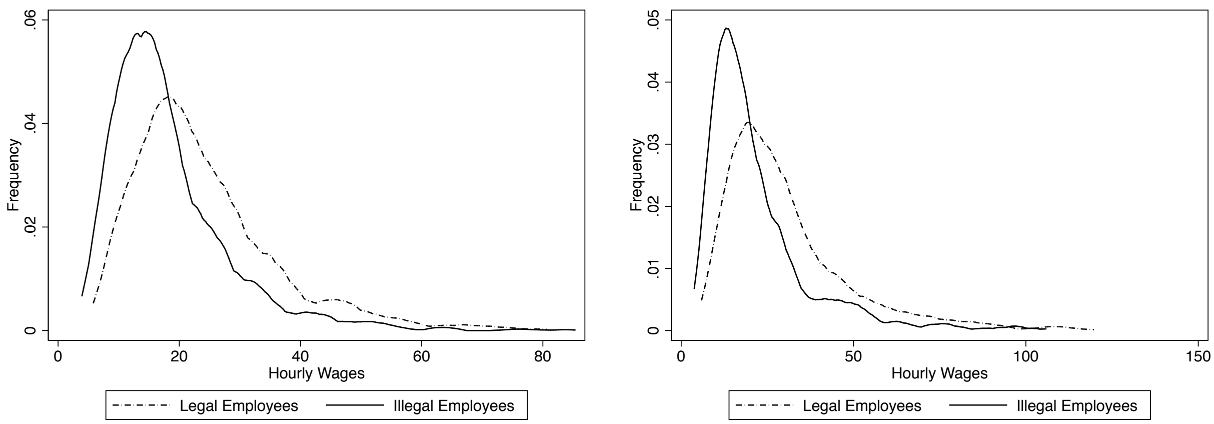
NOTE: Earning figures are reported in Mexican pesos (exchange rate: 10 Mex. pesos $\approx$ 1 US dollars in 2005). The legal status of the job is defined according to whether or not workers report having access to health care through their employers.

state, with a fair amount of transitions among employees between the formal and informal sector. Over a three month period, 7% of the registered employees is found to be employed 'off the books' while 19% of the non-registered employees is found to benefit from social security benefits. Second, there is a large overlap between the legal and the illegal accepted wage distributions (see Figure 1), with the former first-order stochastically dominating the latter.[5] Self-employed earnings are on average in between those of the legal employees and the illegal employees, with a larger standard deviation specially in the high schooling group. Third, unemployment rates are low (around 4-5% in both schooling groups), and average durations in unemployment are remarkably short suggesting a high degree of labor market dynamics. This is confirmed by the transition rates out of unemployment. Roughly 77% of the unemployed reporting to find a job over a period of three months. On the contrary, average durations in self-employment are much longer (between 11 and 12 years), with 23% of the self-employed transiting toward an employee job relationship (9% legal and 14% illegal) and less than 2% becoming unemployed over a period of three months.

The formal-informal distinction is not as sharp in the case of firms because they often enroll only part of their salaried workers in the social security registries. For instance, Perry et al. [2007] show that in Mexico 50% to 70% of the firms between 5 to 15 employees use

[5]The Komolgorov-Smirnov (KS) test statistic for the directional hypothesis that legal wages FOSD illegal wages is equal to 0.28 for incomplete secondary and 0.33 for complete secondary.

Figure 1: Wage Density Functions



(a) Low Schooling

(b) High Schooling

NOTE: The figure shows the empirical densities of the hourly earnings (in Mexican Pesos) for nonagricultural male private-sector employees between the ages of 35 and 55 who reside in urban areas with uncompleted secondary schooling (Panel a) and completed secondary schooling (Panel b). The legal status of the job is defined according to whether or not workers report having access to health care through their employers.

both formal and informal contracts simultaneously in a given point time. Ulyssea [2015] documents that in small formal firms in Brazil (up to 5 employee) 40 percent of workers are informal, and that 52 percent of all informal workers are employed in large firms (with 11 employees or more) that are unlikely to be informal.

3 Model

3.1 Environment

The model assumes stationarity, continuos time and infinitely lived agents. All agents are subject to a common discount rate ρ. There are four labor market states: unemployment, self-employment, illegally employed as employee and legally employed as employee. The informal sector is composed by the self-employed and by the illegal employees.

Before entering the labor market, agents make an irrevocable one-shot decision about which schooling level they want acquire. For consistency with the empirical analysis, we assume only two schooling levels denoted by $h \in \{0, 1\}$, with 1 indicating the higher level and 0 the lower one. Each agent incurs an individual-specific cost $\kappa \sim T(\kappa)$ when acquiring schooling level $h = 1$ instead of staying at schooling level $h = 0$. Therefore κ summarizes any monetary and utility costs associated with acquiring additional schooling.

Unemployed individuals search for a job as employees receiving job offers at the Poisson rate λ_h. The subscript $_h$ denotes that the arrival rate – as most of the other structural parameters – is allowed to vary by schooling level. While searching, unemployed agents receive an instantaneous utility (or disutility) flow ξ_h which summarizes all costs and benefits of being an unemployed searcher. Additionally, they receive universal non-contributory social benefits denoted by B_0. B_0 is the amount spent by the government to provide social security benefits such as health services. It is *universal* because it is received by all the individuals in the economy that do not already receive social security benefits through legal employment. It is *non-contributory* because the agents receiving the benefits do not provide any contributions to finance it. The benefit is fixed and distributed equally among all the individuals receiving it. This setting is a parsimonious specification of the current institutional setting in Mexico and of the type of social benefits that have become widespread in a large number of Latin American and middle-income Asian countries.[6]

Self-employed individuals receive the benefit B_0 and income from their self-employment activity. Self-employment income is denoted by y which we assume to be drawn from the exogenous distribution $R(y|h)$. Heterogeneity in y reflects differences in self-employment opportunities, costs and abilities and it is allowed to vary with the schooling level h. While working, self-employed agents can still search for a job as employee. We introduce this feature to match the numerous transitions between self-employment and employment as employee that we observe in the data. They receive employee offers at the Poisson rate γ_h.

A meeting between a potential employee and a firm produces a match-specific monetary value x, modeled as a draw from the exogenous distribution $G(x|h)$. Again education is allowed to impact the whole distribution. In this representation, firm-side and work-side heterogeneity are summarized by the unique value produced by the meeting of a specific worker with a specific firm.[7] The match value is observed by both parties upon meeting. If the match is formed, it can be terminated by an exogenous Poisson process with rate η_h. The labor relation when the match is formed may be legal or illegal employment. We denote the legality status of the job with $f \in \{0, 1\}$, where $f = 1$ denotes a legal job. The legality status of the job offer is posted by the firm optimally, based on the observed schooling level h and the match-specific productivity x. Assuming that the authority to post the legality status is in the hand of the firm is consistent with the institutional setting in Mexico and

[6]See Section 2 for details.

[7]It is the representation commonly used in search-matching-barganinig models of the labor market, including Eckstein and Wolpin [1995], Cahuc et al. [2006] and Flinn [2006]. It is motivated by the theoretical work of Wolinsky [1987] and Jovanovic [1979]. For a recent review, see Chapter 4.2 in Keane et al. [2011].

other LAC countries. Conditioning on x and f, workers and firms engage in bargaining to determine wage and to finally decide if accepting the match or not.

Workers' flow utility when working as employees is:

$$w_f(x; y, h) + \beta_{f,h}[f B_1(w_1(x; y, h)) + (1 - f)B_0], \tag{1}$$

where w_f is the net wage; B_f is the amount spent to provide social security benefits such as pensions and health services; and $\beta_{f,h}$ is the valuation that the workers give to each pesos spent to provide the benefit. As discussed before, B_0 is non-contributory and received by the illegal employees in a fixed amount equal for everybody. B_1 is endogenous, it is a function of wages and productivity and it is only received by the legal employees. B_1 is defined as follows:

$$B_1(w_1(x; y, h)) \equiv \tau t\,[w_1(x; y, h)] + b_1, \tag{2}$$

where τ denotes the share of the total contribution $t\,[w_1(x; y, h)]$ that is returned one-to-one to the worker. This portion represents proportional benefits such as a defined contribution retirement plan. The $(1 - \tau)$ share of the total contribution is instead redistributed equally among all the contributors. The equal amount received by each agent is denoted by b_1. b_1 is endogenous because it depends on the total amount contributed by the legal employees which is itself a function of how many agents works as legal employees in equilibrium and at what wages.[8] The b_1 benefit is meant to capture another institution present in the system: contributory and *universal within* the set of the contributors. The most notable example is health insurance. Again, see Section 2 for more details on how this two-tier benefit system is a parsimonious representation of institutions in Mexico and many Latin American and Asian countries. The system has important distributional implications. Since the collection of contributions is proportional and the b_1 is equal for all legal employees, the system implies progressive redistribution within the legal employees. It does imply redistribution from high-wage earners to low-wage earners. Moreover, since the b_1 is not schooling-specific and since higher levels of schooling earn higher wages, it does also imply redistribution from high level of schooling workers to low level of schooling workers. This feature introduces a crucial equilibrium link between the high and low schooling groups which are otherwise separated in two segmented labor markets.

As seen in Section 2, the valuation of public service provision is a major concern in implementing and evaluating public policies. The problem seems particularly acute in Latin

[8] See Appendix A.3 for the formal derivation of b_1 in equilibrium.

America in general and in Mexico in particular. The introduction of the parameter $\beta_{f,h}$ allows to capture this phenomenon. It represents the preferences for the non-monetary components of the labor market state and – since we assume linear preferences – has a direct interpretation as the marginal willingness to pay for the benefit.[9]

Firms search to fill vacancies and they meet workers at a Poisson rate ζ_h. To keep a vacancy open, firms incurr a flow cost ν_h.

Once they meet a worker, the same behavior and chain of events described above take place: a match specific value x is observed, the formality status f is posted, a wage $w_f(x; y, h)$ is determined by bargaining, a decision about accepting or rejecting the match is finally taken. In making their decisions, firms take into account their flow payoffs, i.e. the instantaneous profits from a filled job. Fir given productivity, the profits are different if hiring illegally or legally. They are respectively defined as:

$$x - w_0(x; y, h) - c_h x \tag{3}$$

$$x - (1 + t)w_1(x; y, h) \tag{4}$$

where x is the match-specific value generating revenues for the firm; w_0 and w_1 are the wages paid to the workers; and t and c_h are two institutional parameters. The parameter t was described in equation (2): it is the proportional social security contribution. Equation (4) clarifies that it is withdrawn at the source by the firm. The parameter c_h is the way we model the cost of illegality in the employee sector. As discussed in Section 2, there is a positive probability of being discovered hiring workers illegally. When this happens, the firm pays the penalty but not all firms have the same probability of being discovered: The larger and more productive the firm, the higher the probability of being audited and discovered. Given this institutional context and since our model does not allow to pin down firm size, we assume that the cost simply increases with productivity (in our notation, the match value x.) Since we do not have direct observation of the monitoring process in in our data, we impose a particularly parsimonious specification: the linear, one-parameter function $c_h x$.

The following matrix summarizes the environment just described and introduces the notation for the value functions. We write the environment conditioning on the schooling

[9]A similar setting and interpretation is used by Dey and Flinn [2005] to evaluate health insurance and by Flabbi and Moro [2012] to evaluate job flexibility.

level h:

State	Value Function	Measure	Shock	Flow Utility
Workers:				
Pre Labor Market	$Z(h)$	p_h	$-$	$-$
Unemployed	$U(h)$	$u_h p_h$	λ_h	$\xi_h + \beta_{0,h} B_0$
Self-Employed	$S(y,h)$	$s_h p_h$	γ_h	$y + \beta_{0,h} B_0$
Illegal Employee	$E_0[w,y,h]$	$e_h p_h$	η_h	$w_0(x;y,h) + \beta_{0,h} B_0$
Legal Employee	$E_1[w,y,h]$	$l_h p_h$	η_h	$w_1(x;y,h) + \beta_{1,h} B_1[w_1(x;y,h)]$
Firms:				
Filled Illegal Job	$F_0[x,y,h]$	$e_h p_h$	η_h	$x - w_0(x;y,h) - cx$
Filled Legal Job	$F_1[x,y,h]$	$l_h p_h$	η_h	$x - (1+t)w_1(x;y,h)$
Vacancy	$V[h]$	$v_h p_h$	ζ_h	ν_h

The last element that needs to be added to complete the description of the two-sided search environment is the specification of the matching process. We have anticipated that both firms and workers search at random and meet each other at Poisson rates λ_h, γ_h, and ζ_h. Since the equilibrium proportion of workers searching for jobs and of firms searching to fill vacancies is endogenous, the meeting rates must also be endogenous. We capture this endogeneity by assuming a standard matching function formulation.[10] The number of matches per worker m_h is governed by the following:

$$m_h = (u_h + \psi_h s_h)^{\iota_h} (v_h)^{1-\iota_h} \tag{5}$$

where $\psi_h \in (0,1]$ is a parameter denoting the lower search efficiency of the self-employed with respect to the unemployed. It may be interpreted as the time spent searching by each self-employed or as the proportion of self-employed searching at each moment in time.[11] Formally, it denotes the measure of self-employed searchers. We can now write all the contact rates as endogenous since they are all function of the tightness $\omega_h \equiv \frac{v_h}{u_h + \psi_h s_h}$:

$$\begin{aligned} \lambda_h &= \frac{m_h}{u_h}\frac{u_h}{u_h+\psi_h s_h} &&= \omega_h^{1-\iota_h} \\ \gamma_h &= \frac{m_h}{s_h}\frac{\psi_h s_h}{u_h+\psi_h s_h} &&= \psi_h \omega_h^{1-\iota_h} \\ \zeta_h &= \frac{m_h}{v_h} &&= \omega_h^{-\iota_h} \end{aligned}$$

[10] See Petrongolo and Pissarides [2001] for a survey. See Meghir et al. [2015], Arroyo Miranda et al. [2014] and Bosch and Esteban-Pretel [2012] for applications to Latin American countries.

[11] A similar interpretation is used by Flinn and Mullins [2015] that also develop a search model of the labor market with endogenous schooling choice.

3.2 Value Functions

3.2.1 Workers

Before entering the labor market, workers are assigned an individual-specific cost $\kappa \sim T(\kappa)$ of acquiring schooling level $h = 1$. Since the cost is uncorrelated with future labor market performance, the only relevant state variable affecting the present discounted value of participating in the labor market is the schooling level h actually acquired. To characterize this choice we just need to present the value function of completing a given schooling level *before* any labor market shock occurs and *before* any value of self-employment is revealed. It is the function that we denote with $Z(h)$:

$$Z(h) = \int_0 Q(y,h)dR(y) \quad (6)$$

$$Q(y,h) \equiv \max\{S(y,h), U(h)\} \quad (7)$$

where we introduce the functional $Q(y, h)$ to simplify the conditioning on y in the rest of the paper. The present discounted value of participating in the labor market with a given schooling level h is the value of searching in that market. However, individual can choose if they want to search as unemployed $U(h)$ or as self-employed $S(y, h)$. If they choose the second, they enjoy income from the self-employment activity but they may meet employers at a lower rate.

The trade-off is clarified by looking at the value functions of these two searching states:

$$(\rho + \lambda_h)U(h) = \xi_h + \beta_{0,h}B_0 + \lambda_h \sum_{f=0}^{1} \int_x \max\{E_f[w_f(x), y, h], U(h)\}dG(x|h) \quad (8)$$

$$(\rho + \gamma_h)S(y,h) = y + \beta_{0,h}B_0 + \gamma_h \sum_f \int_x \max\{E_f[w_f(x), y, h], S(y,h)\}dG(x|h) \quad (9)$$

The arrival rates of offers are λ_h and γ_h. The meeting can be with an employer offering a formal or an informal job. The formality status choice is a function of the match-specific productivity x but it is posted by the firm: that is why, from the point of view of the worker, it appears in the option value as a simple sum. Conditioning on the formality status and the specific productivity draw, agents bargain over wages decide if accepting the match or not. The optimal decision is represented by the maximization between the current state (either $U(h)$ or $S(y, h)$) and the new employee state (either $E_0[w_f(x), y, h]$ or $E_1[w_f(x), y, h]$).[12]

[12]Notice that we force notation a bit by not differentiating between employees coming from unemployment and employees coming from self-employment. To be precise, we should eliminate the dependence of y from the value of employment of agents searching as unemployed just as the value of unemployment $U(h)$ does

If the option values of the two searching states have a very similar structure, there is an important difference between their flow values. Both states receive a constant flow value of non-contributory benefits $\beta_{0,h}B_0$. But the self-employment state also receives income from self-employment denoted by y. This income is potentially different between the different self-employed searchers, affecting their behavior when meeting a potential employers. All the unemployed searchers, instead, have the same utility or disutility from searching ξ_h. This ex-ante homogeneity is the usual assumption in search-matching-bargaining models while the heterogeneity between self-employed searchers is more similar to the dynamic of an on-the-job search model.

The values of working as an employee with an illegal or a legal job contract are, respectively:

$$
\begin{aligned}
(\rho + \eta_h) E_0[w_0(x; y, h), y, h] &= w_0(x; y, h) + \beta_{0,h} B_0 + \eta_h Q(y, h) && (10) \\
(\rho + \eta_h) E_1[w_1(x; y, h), y, h] &= w_1(x; y, h) + \beta_{1,h} B_1[w_1(x; y, h)] + \eta_h Q(y, h) && (11)
\end{aligned}
$$

The flow values received by employees is the sum of the wage and the social security benefit. The wage is a function of productivity, schooling level, formality status and, possibly, self-employment income. As it will be shown in section 3.3.3, wages depend on schooling and self-employment income because they both potentially affect the worker's outside option when bargaining with the employer. The social security benefit is fixed for the illegally employed but it is increasing in wages and productivity for the legally employed. As mentioned in Section 3.1, the rate of the increase is non-linear, creating scope for redistribution. The only shock received by employees is a termination shock, received at the Poisson rate η_h. If employees receive the shock, they go back to their respective searching state: either $U(h)$ or $S(y, h)$. We describe this transition using the notation introduced in (7): $Q(y, h) \equiv \max\{S(y, h), U(h)\}$.

3.2.2 Firms

Firms post vacancies and search for workers to fill them. The value of a posted vacancy is:

$$
\begin{aligned}
(\rho + \zeta_h) V[h] &= \nu_h + \zeta_h \Big[\frac{u_h}{u_h + \psi_h s_h} \int_x \max\{F_1[x, y, h], F_0[x, y, h], V[h]\} dG(x|h) && (12) \\
&+ \frac{\psi_h s_h}{u_h + \psi_h s_h} \int_y \int_x \max\{F_1[x, y, h], F_0[x, y, h], V[h]\} dG(x|h) dR(y|h) \Big]
\end{aligned}
$$

not depend on y.

The flow cost of keeping a vacany open is denoted by ν_h. Employers meet potential employees at a rate ζ_h. Since potential employees may be unemployed or self-employed, the probability of metting one or the other is a function of their proportion in the equilibrium measure of searcher. This is taken into account by the two fractions multiplying the integrals. If the employer meets an unemployed searcher, a match-specific productivity is extracted. Based on its value and the knowledge of the outside option of the potential employee (unemployment), the employer optimally decides if posting the job offer as legal or illegal. This is captured by the max operator over three possible options: $F_0[x,y,h], F_1[x,y,h]$ and the status quo option $V[h]$. If the employer meets a self-employed searcher, the same dynamic is taking place but now the employer must also take into account that the potential employee's outside option changes with self-employment income y. This is incorporated in expression (12) by integrating over $R(y|h)$, the distribution of y values.

Once the job is filled either illegally or legally, the corresponding value functions are:

$$(\rho+\eta_h)F_0[x,y,h] = x - w_0(x;y,h) - c_h x + \eta_h V[h] \tag{13}$$

$$(\rho+\eta_h)F_1[x,y,h] = x - (1+t)w_1(x;y,h) + \eta_h V[h] \tag{14}$$

The expressions are analogous to the workers side expressions (10) and (11): flow values plus the option value given by the probability of the termination shock η_h times the value of the searching state. The flow values are simply the flow profits but they parsimoniously incorporate all the complexity of the institutional system. When hiring illegally, firms face a risk of paying a penalty which is increasing in productivity. We capture this feature by introducing the flow cost $c_h x$. When hiring legally, firms withdraw at the source the social security contribution which is linearly increasing in wages $(-tw_1(x;y,h))$. Since workers are fully aware of the institutional constraints, they will take them into account when bargaining for wages. This is why the mapping between productivity and wage paid by the firm depends on the legality status. We rapresent this feature by indexing the wages with the status indicator f, leading to w_0 in equation (13) and to w_1 in equation (14).

3.3 Equilibrium

3.3.1 Schooling

Agents with the potential to becomes workers have first to decide whether acquiring the high schooling level $h=1$ or remaining at the default schooling level $h=0$. Since acquiring the additional schooling requires an investment $\kappa \sim T(\kappa)$, agents decide based on the following maximization:

$$\max_h \{Z(0), Z(1) - \kappa\}$$

where $Z(h)$ – defined in equation (6) – is the present discounted value of participating in the labor market given schooling level h. The cost κ is assigned by nature and does not vary over time. Since $Z(1) - \kappa$ is decreasing in κ and $Z(0)$ does not vary in κ, there exists a unique:

$$\kappa^* : Z(0) = Z(1) - \kappa^* \tag{15}$$

The optimal decision rule is therefore a reservation value rule where only agents with $\kappa < \kappa^*$ acquire the additional schooling.

3.3.2 Searching Status

Once schooling is completed, agents take a draw from the self-employment income distribution $R(y|h)$. Upon observing the draw, they decide if searching for an employee job while also working as self-employed or not. Given the notation just introduced, the decision is equivalent to the following maximization:

$$\max\{S(y,h), U(h)\} \tag{16}$$

Since S is monotone increasing in y and $U(h)$ is constant in y, there exists a unique:

$$y^*(h) : S(y^*(h), h) = U(h) \tag{17}$$

The optimal decision rule is again a reservation value rule where only agents with $y \geq y^*(h)$ search for an employee job while also working as self-employed.

3.3.3 Labor Market Dynamic

Upon meeting a worker and observing the match-specific productivity x, the schooling level h, and the worker's outside option $Q(y,h)$, the firm chooses the formality status based on the following maximization:

$$\max_f \{F_0[x,y,h], F_1[x,y,h]\} \tag{18}$$

Upon meeting a firm, the worker also observes the match-specific productivity x and she is presented by the firm with a formality status proposal f. Worker and firm then engage in bargaining to determine the wage and to decide if accepting the match or not. We assume the axiomatic Nash bargaining solution, which is equivalent to solving:

$$\max_{w|f}\{E_f[w,y,h]-Q(y,h)\}^{\alpha_h}\{F_f[x,y,h]-V[h]\}^{(1-\alpha_h)}, \tag{19}$$

To proceed in defining equilibrium conditions and optimal decision rules, it is useful to start from the firms' entry decision. Since the arrival rate of offers to a given firm is decreasing in the number of firms entering the market, the value of posting a vacancy $V[h]$ is monotone decreasing in v_h. We assume free-entry of firms in both markets. As a result, firms enter until the value of posting a vacancy reaches zero:

$$V[h]=0 \tag{20}$$

Imposing condition (20) in problem (19) leads to the following wage schedules:

$$w_1(x;y,h)=\frac{\alpha_h}{1+t}x+\frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)}[\rho Q(y,h)-\beta_{1,h}b_1] \tag{21}$$

$$w_0(x;y,h)=\alpha_h(1-c)x+(1-\alpha_h)[\rho Q(y,h)-\beta_{0,h}B_0] \tag{22}$$

Solving backward, since F_f is linearly increasing in x, for any y there exists a unique:

$$\tilde{x}(y,h):F_0[\tilde{x},y,h]=F_1[\tilde{x},y,h] \tag{23}$$

By equations (21)-(22) and the definitions of the value functions, we obtain:

$$\tilde{x}(y,h) = \frac{1}{c_h}[\beta_{0,h}B_0-\phi_h\beta_{1,h}b_1+(\phi_h-1)\rho Q(y,h)] \tag{24}$$

where:

$$\phi_h \equiv \frac{1+t}{1+\beta_{1,h}\tau t};\ \phi_h\in[1,1+t]$$

This is the relevant reservation value in the formality status decision.

Since the value of accepting the match increasing in x for both workers and firms, for any y there exist two unique productivity reservation values at which workers are indifferent between accepting the firm's offer or keep searching for a better match, and analogously firms are indifferent between filling the vacancy or not:

$$x_0^*(y,h) : F_0[x_0^*, y, h] = 0 \quad \Longleftrightarrow \quad E_0[w_0[x_0^*(y,h)], y, h] = Q(y,h)$$
$$x_1^*(y,h) : F_1[x_1^*, y, h] = 0 \quad \Longleftrightarrow \quad E_1[w_1[x_1^*(y,h)], y, h] = Q(y,h)$$

The agreement result is assured by the Axiomatic Nash bargaining solution. By the definition of the value functions and and by the wage schedules (21) and (22), we obtain:

$$x_0^*(y,h) = \frac{1}{1-c_h}[\rho Q(y,h) - \beta_{0,h} B_0] \tag{25}$$
$$x_1^*(y,h) = \phi_h[\rho Q(y,h) - \beta_{1,h} b_1] \tag{26}$$

These are the two relevant reservation values in accepting the match for given formality status.

Equations (25)-(26) state that job legal status $f \in \{0,1\}$ has two opposite effects on the reservation productivity values at which the match is formed. It decreases the reservation value because employees receive additional benefits associated to the match (b_1 or B_0), but it also increases the reservation value because the firm faces some costs (t or c) in order to activate one or the other job contract. As a result of these two effects, the equilibrium is characterized by different optimal decision rules depending on parameters and on y, h. However, all the decision rules retain the reservation value property so we can state the following:

Proposition 1 ***Equilibrium Characterization: optimal decision rules.***

There are only two possible decision rules, for any y, h:

If $\tilde{x}(y,h) > x_1^*(y,h)$:

$$\begin{array}{rcccl} & x & < & x_0^*(y,h) & \Longleftrightarrow \quad \{Q(y,h); 0\} \\ x_0^*(y,h) & \leq & x & < \tilde{x}(y,h) & \Longleftrightarrow \quad \{E_0[w_0(x), y, h]; F_0[x, y, h]\} \\ \tilde{x}(y,h) & \leq & x & & \Longleftrightarrow \quad \{E_1[w_1(x), y, h]; F_1[x, y, h]\} \end{array}$$

If $\tilde{x}(y,h) \leq x_1^*(y,h)$:

$$\begin{array}{rcccl} & x & < & x_1^*(y,h) & \Longleftrightarrow \quad \{Q(y,h); 0\} \\ x_1^*(y,h) & \leq & x & & \Longleftrightarrow \quad \{E_1[w_1(x), y, h]; F_1[x, y, h]\} \end{array}$$

The proof is reported in the Appendix A. An example of the first type of decision rule is given in Figure 2.

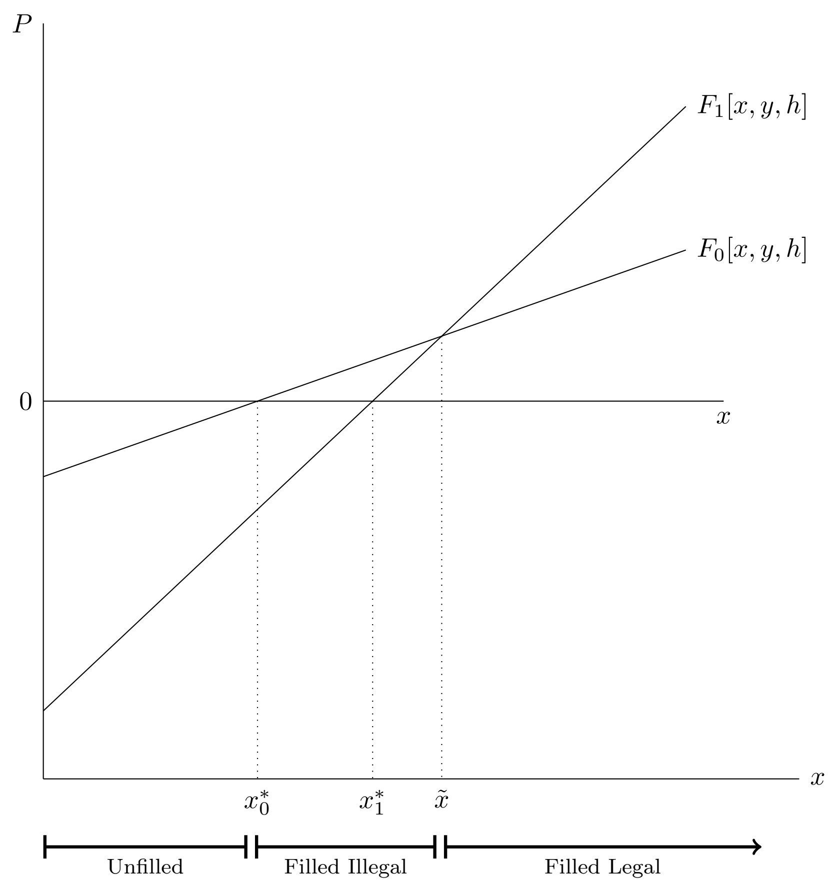


Figure 2: Equilibrium Representation

By substituting the optimal decision rules in Proposition 1 in the expressions (8)-(14), we obtain the following expressions for the workers' value functions.

$$
\begin{aligned}
\text{If } \tilde{x}(y,h) &> x_1^*(y,h): \\
\rho Q(y,h) &= \xi_h \mathbb{1}_{y<y^*(h)} + y\mathbb{1}_{y\geq y^*(h)} + \beta_{0,h}B_0 \qquad (27)\\
&+ \frac{\lambda_h^{\mathbb{1}_{y<y^*(h)}}\gamma_h^{\mathbb{1}_{y\geq y^*(h)}}\alpha_h}{\rho+\eta_h}\left\{\begin{array}{c} \int_{x_0^*(y,h)}^{\tilde{x}(y,h)}[(1-c_h)x+\beta_{0,h}B_0-\rho Q(y,h)]dG(x|h) \\ +\int_{\tilde{x}(y,h)}[\frac{1}{\phi_h}x+\beta_{1,h}b_1-\rho Q(y,h)]dG(x|h)\end{array}\right\}\\
\text{If } \tilde{x}(y,h) &\leq x_1^*(y,h): \\
\rho Q(y,h) &= \xi_h \mathbb{1}_{y<y^*(h)} + y\mathbb{1}_{y\geq y^*(h)} + \beta_{0,h}B_0 \qquad (28)\\
&+ \frac{\lambda_h^{\mathbb{1}_{y<y^*(h)}}\gamma_h^{\mathbb{1}_{y\geq y^*(h)}}\alpha_h}{\rho+\eta_h}\left\{\int_{x_1^*(y,h)}[\frac{1}{\phi_h}x+\beta_{1,h}b_1-\rho Q(y,h)]dG(x|h)\right\}
\end{aligned}
$$

while on the firms' side we obtain following expression implied by free entry:

$$
\begin{aligned}
0 &= \nu_h+\zeta_h[\frac{u_h R(y^*(h)|h)}{u_h+\psi_h s_h}\left(\int_{x_0^*(0,h)}^{\tilde{x}(0,h)}P_0[x,0,h]dG(x|h)+\int_{\tilde{x}(0,h)}^{\infty}P_1[x,0,h]dG(x|h)\right) \qquad (29)\\
&+ \frac{\psi_h s_h}{u_h+\psi_h s_h}\int_{y^*(h)}^{\infty}\left(\int_{x_0^*(y,h)}^{\tilde{x}(y,h)}P_0[x,0,h]dG(x|h)+\int_{\tilde{x}(y,h)}^{\infty}P_1[x,0,h]dG(x|h)\right)dR(y|h)] \qquad (30)
\end{aligned}
$$

We can now propose the following:

Definition 2 ***Equilibrium Definition.***

Given the vector of parameters $\Theta_h = \{\rho, \xi_h, \iota_h, \eta_h, \beta_{0,h}, \beta_{1,h}, \alpha_h, c_h, \nu_h\}$ *and the probability distribution functions* $\{R(y|h), G(x|h), T(\kappa)\}$ *a* ***search model equilibrium*** *in an economy with institutional parameters* $\{B_0, \tau, t\}$ *is a set of values* $Q(y,h)$ *that:*

1. *solves the equilibrium equations (27)-(28);*

2. *satisfies steady state conditions over the measures* $\{p_h, u_h, s_h, e_h, l_h, v_h\}$*;*

3. *satisfies firms' free-entry condition.*

3.4 Empirical Implications

The equilibrium of the model is able to replicate the main stylized facts that characterize informal labor markets. These are also the main data features described in Section 2 in reference to the Mexican labor market.

First, the market is not segmented in formal and informal jobs. Individuals ex-ante identical may end up in jobs with different formality status and the same firms may hire both legally and illegally. Morever, workers transit between formal and informal jobs over their labor market careers. To see how our model can deliver these implications, consider an agent searching in the labor market as unemployed. If the match with a potential employer is high but not too high – i.e. $x_0^*(y,h) \leq x < \tilde{x}(y,h)$ –, she will accept a job as an illegal employee; if the match is high enough – i.e. $x \geq \tilde{x}(y,h)$ –, she will accept a job as a legal employee. In either case, the employment relationship may end, leading to a new spell of unemployment which may lead to a new job with a different formality status generating transitions between legal and illegal jobs.

Second, legal employees have on average higher wages than illegal employees but the wage distributions of legal and illegal employees overlap over a large portion of their support. Both results are delivered by the reservation match productivity value being higher for legal employment (Proposition 1) and by the two wage schedules being both monotonically increasing in the match productivity value but at a different rate (equations (21) and (22)).

The main economic intuition for the average higher wage of legal employees is that the reservation match value required to accept a legal job is higher than the one required to accept an illegal job and that the legal wage schedule is more sensitive to the match productivity value. If there may well be a range of x over which illegal job pay higher wages, as x increases only legal jobs will be acceptable increasing the average value of the corresponding legal employees' wages.

The main economic intuition for the overlap between the two wage distributions is that legal employee receives a lower net wage than illegal employees with same productivity because they are compensated by the non-wage benefits $\beta_{1,h}B_1[w_1(x;y,h)]$. Figure 3 helps to understand and formalize the intuition. It shows, for a given outside option (y,h), the wage schedules for legal and illegal employee as a function of the match value x (equations (21) and (22)). The figure reports the most likely configuration of parameters where the informal wage schedule is more sensitive to x and has higher intercept.[13] Define the reservation match

[13]The slope of $w_0(x;y,h)$ is higher when the cost of informality c with respect to the formal contribution rate t is small enough (formally, when $c < t/(1+t)$). This condition is always satisfied at our parameter estimates and its violation leads to a proportion of informal workers which is in general too low to fit the data. The representation in Figure 3 also shows a higher intercept for $w_0(x;y,h)$. This is the case when the valuation of the non-contributory benefit is small enough with respect to formal contributory benefits (formally, when $\frac{1}{(1+\beta_{1,h}\tau t)}[\rho Q(y,h) - \beta_{1,h}b_1] < [\rho Q(y,h) - \beta_{0,h}B_0]$). Again, this is what we find at our parameter estimates for most of the (y,h) combinations. This condition may be violated without major changes in the argument.

values $x'(y,h)$ and $x''(y,h)$ as:

$$x'(y,h) : w_0(x'(y,h); y,h) = w_1(\tilde{x}(y,h); y,h) \tag{31}$$

$$x''(y,h) : w_1(x''(y,h); y,h) = w_0(\tilde{x}(y,h); y,h) \tag{32}$$

then all the $x \in [x'(y,h), \tilde{x}(y,h)]$ map accepted wages in *illegal* employment in the interval:

$$[w_1(\tilde{x}(y,h); y,h), w_0(\tilde{x}(y,h); y,h)]$$

At the same time, all the $x \in [\tilde{x}(y,h), x''(y,h)]$ map accepted wages in *legal* employment in the same interval. As a result, accepted wages in legal and illegal employment will overlap.

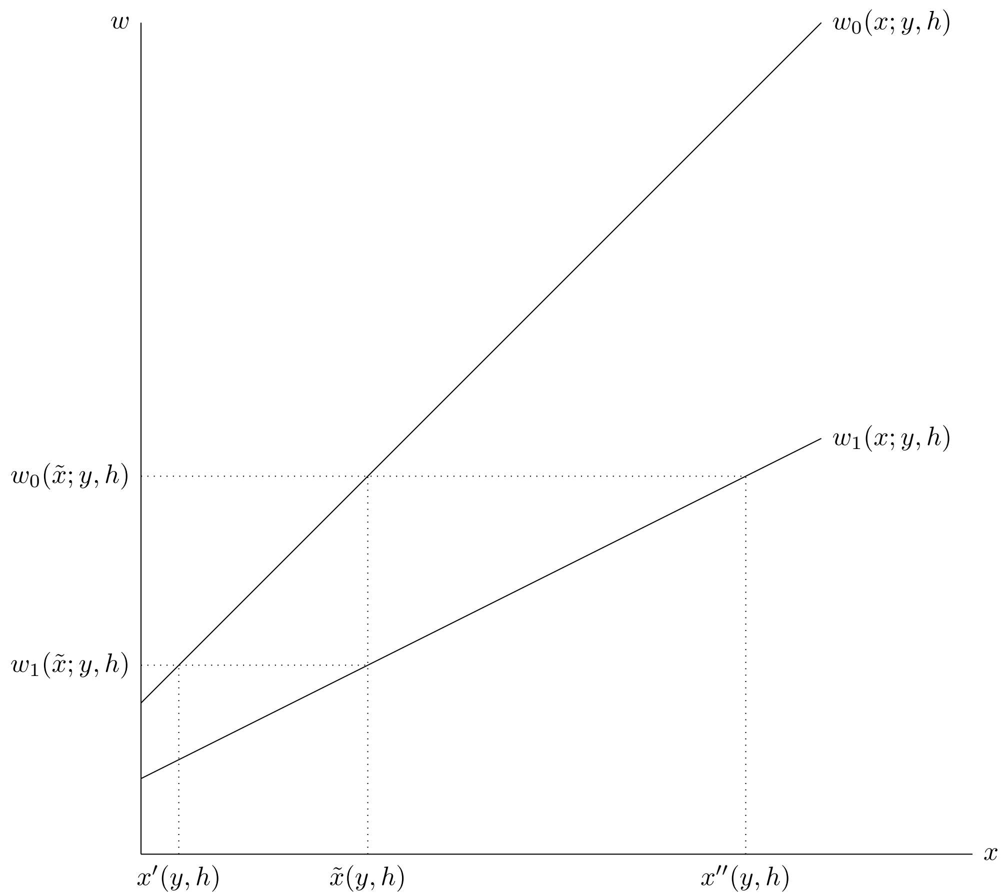
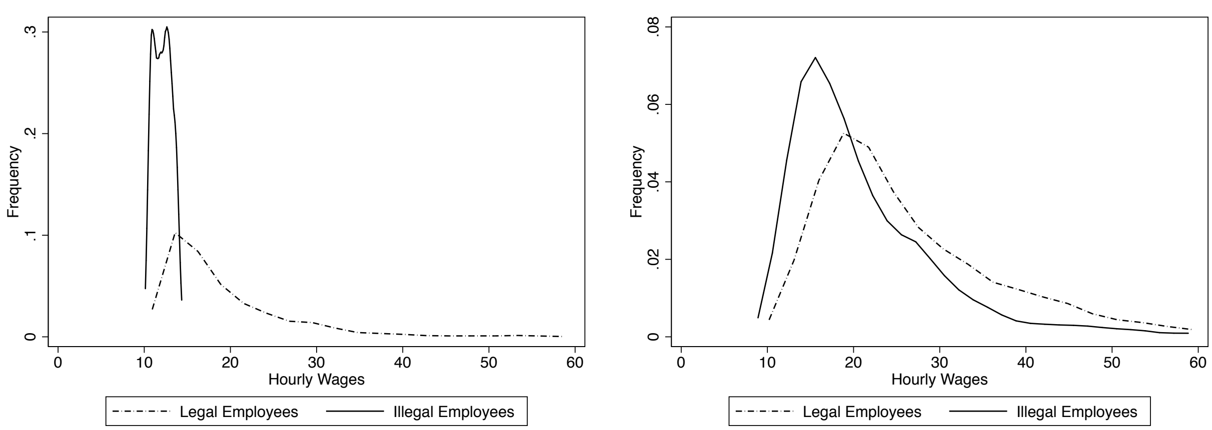


Figure 3: Wage Schedules and Overlap

Notice also that the equilibrium of the model generates as many overlaps as (y,h) combinations. To be precise, all the agents searching as unemployed (i.e. such that $y < y^*(h)$) will generate one unique overlap but all the agents searching as self-employed will generate as many different overlaps as many $y > y^*(h)$. It is this second property that allows for the overlap to extend over the entire support of the accepted wage distributions: the larger the y, the larger the reservation value $\tilde{x}(y, h)$, the more to the right the location of the overlap. Figure 4 shows these features on simulations based on our parameter estimates. The left panel shows the overlap considering only workers transiting from unemployment to legal and illegal employment. The overlap is present but it is limited to a relative narrow portion of the support. The right panel considers only workers transiting from self-employment to legal and illegal employment. As expected the overlap is now much larger, covering the entire support of the accepted wage distributions. Finally, the fact that the optimal decision rules depend on the self-employment income also generates an overlap in support between the self-employment labor income distribution and the employee wages, another empirical feature we observe in the Mexican data.

The previous arguments show how the equilibrium of the model may qualitatively replicate all the main stylized facts of informal labor markets. Section 4 will show how the main structural parameters of the model can be identified by the data at our disposal. Section 5 will then use the identification strategy to estimate the model showing goodness of fit on a much wider range of data moments than those presented here.

Figure 4: Simulated Accepted Wage Distributions and Overlap



(a) Outside Option is Unemployment

(b) Outside Option is Self-employment

4 Identification

The data available for identification are presented in Section 2.2 and can be described by the following set:

$$\{w_0(i;h); w_1(i;h); y(i;h); t_U(i;h); t_S(i;h)\}_{i=1}^{n} \tag{33}$$

where w_0, w_1 and y are hourly earnings as illegal employee, legal employee and self-employed and t_U and t_S are monthly durations in unemployment and self-employment. We observe the same set of variables on both schooling groups $h \in \{0, 1\}$.

Definition 2 shows that – in an institutional context that allows for the observation of $\{B_0, \tau, t\}$ – we need to identify the following set of parameters and the following probability distribution functions:

$$\{\rho, \xi_h, \lambda_h, \gamma_h, \eta_h, \psi_h, \iota_h, \beta_{0,h}, \beta_{1,h}, \alpha_h, c_h, R(y|h), G(x|h), T(\kappa)\} \tag{34}$$

We split the identification discussion in four parts. We first discuss the usual search-matching-bargaining parameters. We then focus on the preferences for social security benefits and the cost of informality. In the third part we consider the identification of the matching function and the other demand side parameters. We conclude with the cost of schooling distribution.

4.1 Search, Matching and Bargaining Parameters

The identification of the mobility parameters $\{\lambda_h, \eta_h\}$ and the match-specific productivity distribution $G(x|h)$ is standard and follows from results in Flinn and Heckman [1982]. Duration information and steady state conditions identify hazard rates out of unemployment and termination rates out employment. No additional progress in the identification of the model can be made without a parametric assumption on the exogenous match specific productivity distribution. If we assume a recoverable distribution – i.e. a distribution that can be identified by observing its truncation – then the identification can proceed as follows. Observed wages in the data correspond to accepted wages in the model. Accepted wages in the model can be mapped to accepted match-specific productivity by inverting the wage schedules (22) and (21). Finally, this truncated accepted productivity distribution recovers the primitive $G(x|h)$ thanks to the recoverability property of the distribution. Following previous literature on empirical job search models,[14] we assume that the productivity distri-

[14]See for example the numerous works cited in the survey article Eckstein and van den Berg [2007]

bution belongs to a two-parameter lognormal distribution, and denote the schooling-specific location and scale parameters as (μ_h, σ_h). The lognormal distribution possesses the recoverability condition necessary for identification and guarantees a good fit of the accepted wage data.

With the identification of $G(x|h)$ secured, durations information is enough to separate the probability of accepting job offer in the exogenous arrival rate component λ_h and in the acceptance probability component. Termination rates η_h are identified by exploiting the equilibrium rate of unemployment implied by the model which impose a cross-constraint between unemployment rate, hazard rate out of unemployment and termination rate.

In the identification discussion we have exploited the one-to-one mapping of the wage schedules (22) and (21). However, the mapping involves a set of model parameters belonging to Θ_h and that need to be identified. We discuss a number of them in Section 4.2 while here we focus only on the Nash bargaining coefficient α_h. Previous literature has shown that the parameter is very hard to identify without demand-side information.[15] We follow Flinn [2006] and Flinn and Mullins [2015] in using labor shares to identify the parameter.[16]

The argument we used to identify $\{\lambda_h, \eta_h\}$ and $G(x|h)$ can be applied in a simpler version to identify the exogenous arrival rates of employee offers while self-employed γ_h and the primitive distribution of self-employed labor income $R(y|h)$. In this case too, we observe a truncation of the primitive distribution (labor incomes of individuals working as self-employed) and the durations in the self-employed state. We can then use the same identification strategy if we assume that $R(y|h)$ belongs to a recoverable parametric distribution but without any appeal to a mapping between wages and productivity since the truncation is directly on the distribution of interest $R(y|h)$. We make the same parametric assumption by assuming log-normality and we denote location and scale parameters with (μ_{yh}, σ_{yh}).

The last result that we exploit from Flinn and Heckman [1982] is that the parameters ξ_h and ρ can only be jointly identified. Following their example and more recent literature, we fix a value for the monthly discount rate ρ and use equations (27)-(28) to recover ξ_h.

[15] See Cahuc et al. [2006] and Flinn [2006] for a formal discussion and Eckstein and Wolpin [1995] for a seminal contribution.

[16] We obtain labor shares for Mexico in 2005 using data on Adjusted wage share collected by AMECO (the Annual Macro-ECOnomic database of the European Commission's Directorate General for Economic and Financial Affairs).

4.2 Preferences and Informality Parameters

The second set of parameters to be identified is specific to our labor market model with a large informal sector. They are the preference parameters $\beta_{0,h}$ and $\beta_{1,h}$ – representing the valuation that workers give to each pesos spent to provide the social benefits – and the cost parameter c_h – representing the amount firms set aside to cover for the expected costs of being caught hiring workers illegally.

We first discuss the identification of $\beta_{1,h}$ and c_h assuming $\beta_{0,h}$ is known. We identify $\beta_{1,h}$ and c_h by exploiting the location and extent of the overlap between the accepted wages distribution for legal employees and the accepted wages distribution for illegal employees. This is a crucial data feature that our model is able to replicate. Recall from section 3.4 that in the relevant range of the parameters space we have:

$$w_0(\tilde{x}(y,h); y,h) - w_1(\tilde{x}(y,h); y,h) > 0 \tag{35}$$

i.e. at the reservation productivity value $\tilde{x}(y,h)$, the wage received working illegally is higher than the one received working legally. This implies an overlap in the support of the legal and illegal accepted wage distributions. The difference between the two wages represents the extent of the overlap while the reservation value $\tilde{x}(y,h)$ governs the location of the overlap.

The parameters of interest $\beta_{1,h}$ and c_h impact the extent and location of the overlap in a quite intuitive way. A legal employee receives a lower net wage than an illegal employee with same productivity because she is compensated by the non-wage benefits $\beta_{1,h}B_1[w_1(x; y,h)]$. Therefore, $\beta_{1,h}$ has a direct impact on the overlap: The higher $\beta_{1,h}$, the more sensitive the worker to the added benefit, the larger the overlap. At the same time, an illegal employee receives a higher net wage than a legal employee with same productivity because firms do not pay social security contributions. However, firms pay the cost of illegality c_h: the higher c_h, the less convenient to hire illegally, the smaller the overlap. Finally, the location of the overlap is determined by $\tilde{x}(y,h)$ which, in general, depends negatively on both $\beta_{1,h}$ and c_h.[17] $\tilde{x}(y,h)$ decreases in both $\beta_{1,h}$ and c_h since both a larger valuation of formal benefits and a higher cost of informality make legal employment more attractive.

If the previous results show how both $\beta_{1,h}$ and c_h have an impact on location and extent of the overlap, they still do not show separate identification since they do not indicate how

[17] This holds for most of the parameter space. It is still possible that for a particular combination of the parameters and for specific values of y, the equilibrium effects are so large to change the sign. Equilibrium effects work here through the outside option $Q(y,h)$ and the endogenous redistributive component b_1. Even when this is the case, the impact on the overall mixture distribution is limited because it involves only specific values of y.

the two parameters impact these data features *differently*. The intuition for the differential impact is illustrated in Figure 5. The figure reports the benchmark wage schedules of Figure 3 – denoted by $w_0(x; y, h)$ and $w_1(x; y, h)$ – and the wage schedules resulting by changing $\beta_{1,h}$ and c_h – denoted by $w'_0(x; y, h)$ and $w'_1(x; y, h)$. To simplify the discussion, we focus only on the direct effect of the parameters, ignoring for the moment the equilibrium effects acting through the reservation value $\tilde{x}(y, h)$, the outside option $Q(y, h)$ and the redistributive component b_1.

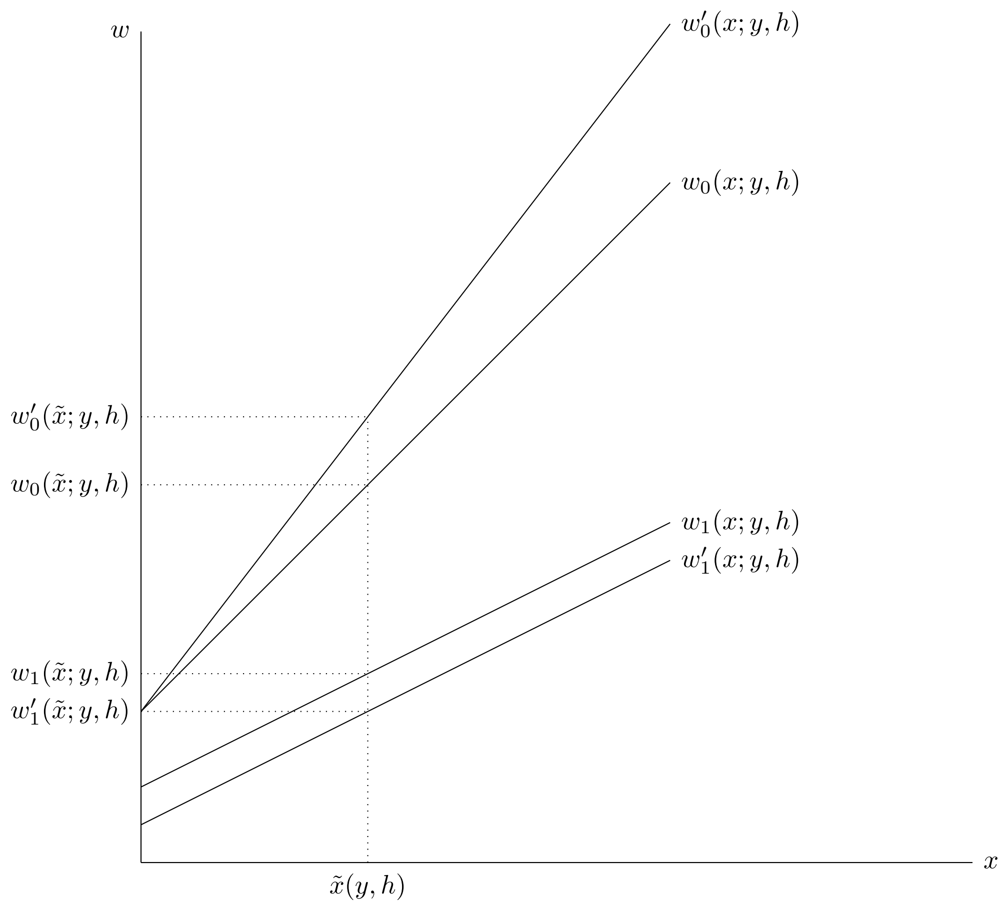


Figure 5: Overlap and Identification of $\beta_{1,h}$ and c_h

A decrease in c_h increases the sensitivity of illegal wages to productivity x because it implies a lower cost of illegality. Graphically, it is equivalent to rotating the w_0 wage schedule up. Ignoring equilibrium effects, a change in c_h has no direct impact on legal wages leaving the w_1 wage schedule unaffected. As a result, the overlap increases because the upper bound moves up reaching $w'_0(\tilde{x}(y, h); y, h)$ while the lower bound remains unchanged at $w_1(\tilde{x}(y, h); y, h)$.

The direct impact of an increase in $\beta_{1,h}$ also leads to a larger overlap but by affecting a different margin. If $\beta_{1,h}$ increases, legal wages decrease at each productivity value x because the non-monetary benefits are now valued more. Graphically, it is equivalent to a parallel down shift of the w_1 wage schedule. Ignoring equilibrium effects, a change in $\beta_{1,h}$ has no direct impact on illegal wages leaving the w_0 wage schedule unaffected. As a result, the overlap increases because the *lower* bound moves down reaching $w_1'(\tilde{x}(y,h);y,h)$ while the upper bound remains unchanged at $w_0(\tilde{x}(y,h);y,h)$.

In conclusion, if movement in $\beta_{1,h}$ and c_h can achieve the same extent of the overlap, they do so by moving its location in different directions generating a different shape in the accepted wage distribution of legal and illegal employee. The heterogeneity in the outside options (unemployment or the different states of self-employment for the different values of y) generates many such overlaps, as we pointed out in Section 3.4. The presence of many overlaps magnifies the differential impact of $\beta_{1,h}$ and c_h and helps with the empirical identification. This is the case since the observed wage distributions are mixtures over different accepted wages distributions, each of which belongs to agents with different outside options and therefore different overlaps. It is the presence of many overlaps *and* the joint action of $\beta_{1,h}$ and c_h that can potentially extend the overlap over the entire support of the accepted wage distributions, a feature we observe in our and many similar data. For example, looking again at Figure 5, we could never reach the overlap $[w_1'(\tilde{x}(y,h);y,h), w_0'(\tilde{x}(y,h);y,h)]$ without both a decrease in c_h and an increase in $\beta_{1,h}$.

As mentioned, the above discussion does not take into account equilibrium effects. When equilibrium effects are considered – i.e. when the outside options $Q(y,h)$ and the redistributive component b_1 are allowed to change – the differential impact may be stronger or weaker depending on the specific region of the parameters space and on the specific value of the outside option. However, the main identification argument for the differential impact of $\beta_{1,h}$ and c_h does not change.

The above discussion concerns the separate identification of $\beta_{1,h}$ and c_h, assuming $\beta_{0,h}$ known. It is not possible to make progress on the identification of $\beta_{0,h}$ without additional sources of variation in the data since this preference parameter involves exactly the same trade-offs we have already used to identify $\beta_{1,h}$ and c_h. We find additional data variation by exploiting the time-staggered entry across municipalities of the *Seguro Popular* program. *Seguro Popular* is a non-contributory social program providing virtually free health services to everyone but legal workers. In our model, it can be parametrized as a 25% increase (from 1.92 to 2.42) in the per-capita hourly extra-wage benefits for non-legal and unemployed workers (B_0).[18] By linking information on the roll-out of the program in the year 2005 with the municipality of residence of the workers in our sample, we find that roughly 60% of the non salaried belong to a 'treated' municipality – i.e. where the program was operating – while the remaining 40% reside in a 'control municipality' and hence receive the status quo benefits – i.e. without the additional services provided by the program.

Our strategy consists in assuming that all the structural parameters of the model (see expression (34)) do not differ across municipalities that were exposed to the program at an earlier or later point in time, and hence all the changes in the match-specific productivity reservation values $x_0^\star(y,h)$, $\tilde{x}(y,h)$ and in the equilibrium objects b_1 and $Q(y,h)$ can be attributed to changes in B_0 induced by the introduction of the program. Under this assumption, the sensitivity in labor market outcomes to the change in B_0 values is very sensitive to $\beta_{0,h}$. As a result, information on labor market moments computed on individuals belonging to the treated or the control municipalities allow for the identification of $\beta_{0,h}$.

We support the assumption that the structural parameters of the model do not systematically differ between the two groups of municipalities by looking at their labor market outcomes before the *Seguro Popular* program was introduced. We can do this thanks to a previous round of the labor market survey conducted in 2001. OLS coefficients on an indicator variable for whether workers reside in municipalities that received the program in 2005 are reported in Table B.1. The estimates are very small in magnitude and not statistically different from zero, suggesting balance between the two groups in the crucial labor market variables we use in estimation. These findings are consistent with evidence reported in Bosch and Campos-Vazquez [2014], which document that the roll-out of the *Seguro Popular* program was not correlated with prior labor market characteristics.

4.3 Matching Function and Demand Side Parameters

Assume to observe the vacancy rate v_h just as we observe the unemployment and self-employment rates u_h and s_h. Then we have to identify:

$$\{\psi_h, \iota_h, \nu_h\} \tag{36}$$

Since at this stage we have identified all the other labor market parameters, we can use the definition of the matching function (5) and the equations defining the endogenous arrival

[18] See Section 2 for a brief discussion of the program and Appendix C on the computation of the two values of B_0 with and without the benefits accruing to the *Seguro Popular* program.

rates to obtain:

$$\psi_h = \frac{\gamma_h}{\lambda_h} \tag{37}$$

$$\iota_h = \frac{\ln \omega_h - \ln \lambda_h}{\ln \omega_h} \tag{38}$$

Then, with knowledge of (ψ_h, ι_h), we can use the equilibrium equation (30) to obtain:

$$\nu_h = -\omega_h^{-\iota_h} \left[\frac{u_h}{u_h + \psi_h s_h} \Lambda(0,h) + \frac{\psi_h s_h}{u_h + \psi_h s_h} \Lambda(y,h) \right] \tag{39}$$

where:

$$\Lambda(0,h) = \frac{(1-\alpha)}{\rho + \eta_h} R(y^*(h)|h) \left\{ \begin{array}{c} \int_{x_0^*(0,h)}^{\tilde{x}(0,h)} [(1-c_h)x + \beta_{0,h} B_0 - \rho U(h) dG(x|h)] \\ + \int_{\tilde{x}(0,h)}^{\infty} [x - \phi_h(\rho U(h) - \beta_{1,h} b_1) dG(x|h)] \end{array} \right\}$$

$$\Lambda(y,h) = \frac{(1-\alpha)}{\rho + \eta_h} \int_{y^*(h)}^{\infty} \left\{ \begin{array}{c} \int_{x_0^*(y,h)}^{\tilde{x}(y,h)} [(1-c_h)x + \beta_{0,h} B_0 - \rho S(y,h) dG(x|h)] \\ + \int_{\tilde{x}(y,h)}^{\infty} [x - \phi_h(\rho S(y,h) - \beta_{1,h} b_1) dG(x|h)] \end{array} \right\} dR(y|h)$$

As we discuss in the data section, we are able to obtain schooling-specific vacancy rates from the Mexican Secretary of Labor *Portal del Empleo*.

4.4 Schooling Parameters

Finally, we are left with the identification of the last source of heterogeneity: The $T(\kappa)$ distribution for the cost of acquiring schooling. We do not have any direct information on schooling costs but we can exploit the threshold-crossing impact generated by the model's equilibrium: above a certain threshold – the κ^* defined in (15) – the individual will not acquire additional education, below she will. We can combine the one data point in the sample – the proportion of individuals with the high schooling level - with the equilibrium condition to identify a one-parameter distribution. Based on previous literature, we choose a negative exponential distribution and we denote its parameter with δ. Once this distributional assumption is made, the parameter is easily recoverd from the following equilibrium condition:

$$\bar{\Upsilon} = T(\kappa^*; \delta) \tag{40}$$

where $\bar{\Upsilon}$ denotes the proportion of high schooling individuals in the sample, δ is the only unkown in the equation and the unique solution is assured by the invertibility of the cdf.

5 Estimation

5.1 Method

We estimate the parameters of the model using the Method of Simulated Moments (MSM). Given the vector of parameters for each schooling group:

$$\theta_h \equiv \{\mu_h, \sigma_h, \mu_h^y, \sigma_h^y, \beta_{1,h}, c_h, \xi_h, \lambda_h, \eta_h, \gamma_h\}\,, \tag{41}$$

the joint estimator $\hat{\theta} \equiv [\hat{\theta}_0|\hat{\theta}_1]$ is defined as:

$$\theta = \underset{\theta}{\operatorname{argmin}}\ \Psi(\theta, V)' W \Psi(\theta, V), \tag{42}$$

where $\Psi(\theta, V) = \left[\Gamma_R(\theta|\widehat{x_0^\star(y)}, \widehat{\tilde{x}(y)}) - \Gamma_N(V)\right]$ with Γ_N being the vector of the sample moments obtained by our sample of dimension N and $\Gamma_R(\theta|\widehat{x_0^\star(y)}, \widehat{\tilde{x}(y)})$ the vector of the corresponding moments obtained from a simulated sample of size R conditional on the estimated productivity reservation values. The function (42) is minimized using the Nelder-Mead Simplex Algorithm. The weighting matrix W is a diagonal matrix with elements equal to the inverse of the bootstrapped variances of the sample moments. The schooling cost parameter, δ, is obtained at the end of the procedure by exploiting the optimal decision rule in equation (15). Given our parametric assumption, it is an equation in one unknown which unique solution is the estimator for δ. Finally, the institutional parameters $\{B_0, \tau, t\}$ are set to the values determined by the Mexican legislation. See Appendix C for details.

The moments we match follow our identification strategy and they are extracted from the proportion of workers over labor market states, from the unemployment and self-employment durations, from the accepted wages distributions at legal and illegal jobs and from the accepted self-employed earning distributions. For the durations, we compute mean and standard deviation in unemployment and self-employment. For the wage distributions, we need to capture - on top of the location and scale of the distribution as captured by mean and standard deviation - also the extent and location of the overlap between legal and illegal employee wages. To capture the overlap, we use the following moments, in line with the procedure implemented by Flabbi and Moro [2012]. We compute quintiles over the legal workers' accepted wage distribution. For each interval, we compute the mean wage of legal and illegal employees earning a wage in the interval. We also compute the proportion of workers in illegal jobs among all employees earning a wage in the interval. These means and proportions by quintiles are the additional moments we use to capture the overlap in the two distributions.

5.2 Results

Most of the parameters of the model are schooling-specific. The implicit assumption is that the labor market is segmented along observable workers' characteristics so that the two education groups do not compete for the same jobs. However, the transfer to legal employees, b_1, is in common across the two schooling markets. This creates not only redistribution within schooling groups but also some externalities across schooling groups, which is the reason why the model is jointly estimated for all individuals regardless of their educational attainment.

Estimated parameters are reported in Table 2. The parameters governing the rates of job arrival and termination differ across schooling sub-markets, with lower arrival and termination rates for individuals who did not complete a high-school degree. Important differences between the two schooling groups are observed in the parameters of the match specific productivity distribution $G(x)$ and the self-employed earning distribution $R(y)$. As reported in the bottom panel, average productivity in the High Schooling group is about 5% higher than in the Low Schooling group.

The preference parameters denote a higher valuation for non-contributory benefits than for contributory benefits. We speculate that the result may related to the contributory nature of the benefit itself. The cost of illegality parameter c seems reasonable: about 10% of productivity is set asided to cover the probability and penality of getting caught.

5.3 Fit of the Model

Table 3 reports the full set of simulated moments computed at the estimated parameters and compare them with the corresponding moments computed from the ENOE sample. Notice that we report here moments aggregated over the individuals belonging to treated and control municipalities in order to give an idea of the overall fit of the model. The Appendix reports the moments separately since those are the moments used in the quadratic form (42). The Table reports a good fit across the board, including at the quantile levels. The worse fit is on the unemployment rate which we estimate too low. While this is a concern, unemployment is the least important state in this labor market since both the rates and the durations are relatively low. We also underestimate the average accepted wages of legal employees.

Table 2: Estimates of the Model Parameters

	Low Schooling		High Schooling	
	Coeff.	Std. Error	Coeff.	Std. Error
Parameters:				
γ	0.0279	0.0005	0.0354	0.0009
λ	0.2890	0.0162	0.3597	0.0083
η	0.0071	0.0004	0.0102	0.0008
μ_x	2.8114	0.0095	2.6116	0.0087
μ_y	2.2615	0.0145	2.4129	0.0125
σ_x	0.8359	0.0172	1.1051	0.0120
σ_y	0.7120	0.0072	0.7338	0.0107
β_1	0.5615	0.0034	0.6705	0.0101
β_0	0.9166	0.0055	0.9082	0.0081
c	0.1089	0.0026	0.0856	0.0014
α	0.4813	0.0135	0.4813	0.0135
ξ	-17.5092	0.6445	-20.1412	0.7263
δ	0.0073	0.0011	0.0073	0.0011
ψ	0.0965	0.0061	0.0983	0.0038
ι	0.3157	0.0494	0.4218	0.0365
ζ	1.7730	0.1721	2.1080	0.1857
ν	-79.6492	4.8504	-100.7496	9.4442
Predicted Values:				
$E(x)$	23.5888	0.4607	25.0845	0.3271
$SD(x)$	23.7192	1.1345	38.7912	1.1453
$E(y)$	12.3663	0.1879	14.6167	0.1845
$SD(y)$	10.0486	0.2254	12.3450	0.3151
$E(k)$	137.6188	17.0615	137.6188	17.0615

NOTE: Bootstrap standard errors reported.

Table 3: Model Fit: Conditional Moments

	Low Schooling		High Schooling	
Moment	Model	Data	Model	Data
% Self-employed	0.254	0.235	0.241	0.238
% Legally Employed	0.512	0.500	0.546	0.523
% Illegally Employed	0.220	0.223	0.182	0.193
% Unemployed	0.014	0.042	0.030	0.045
Mean Illegal Wages	17.396	18.138	21.253	21.792
SD Illegal Wages	8.810	9.908	10.746	15.291
Mean Legal Wages	21.442	24.001	27.636	30.355
SD legal Wages	12.742	11.926	19.555	18.309
Mean Self-empl Income	19.652	21.591	25.438	24.054
SD Self-empl Income	13.077	12.683	14.659	15.448
U Duration (months)	5.063	2.387	5.695	3.708
SE Duration (months)	113.172	133.741	112.470	122.883
% Illegally Employed - Q1	0.421	0.412	0.356	0.448
% Illegally Employed - Q2	0.151	0.243	0.277	0.233
% Illegally Employed - Q3	0.158	0.141	0.130	0.123
% Illegally Employed - Q4	0.155	0.123	0.137	0.096
% Illegally Employed - Q5	0.116	0.080	0.100	0.101
Mean Illegal Wages - Q1	11.132	10.463	14.537	11.359
Mean Illegal Wages - Q2	14.159	16.509	16.700	19.070
Mean Illegal Wages - Q3	17.728	21.104	21.648	25.696
Mean Illegal Wages - Q4	22.916	27.529	28.598	33.767
Mean Illegal Wages - Q5	36.599	42.773	47.266	58.317
Mean Legal Wages - Q1	11.250	11.207	14.008	12.528
Mean Legal Wages - Q2	14.196	16.901	17.212	19.070
Mean Legal Wages - Q3	17.735	21.432	21.441	25.696
Mean Legal Wages - Q4	23.162	27.506	28.637	33.767
Mean Legal Wages - Q5	40.858	42.930	56.843	58.317
Aggregate Labor Share	0.415	0.419		

NOTE: Data extracted from the 4 quarters of 2005 of the Mexican labor force survey (ENOE). Sample size is 9,199 observations in the low schooling group and 6,013 observations in the high schooling group. Simulated data obtained using a sample of 10,000 individuals in each schooling group.

6 Policy Experiments

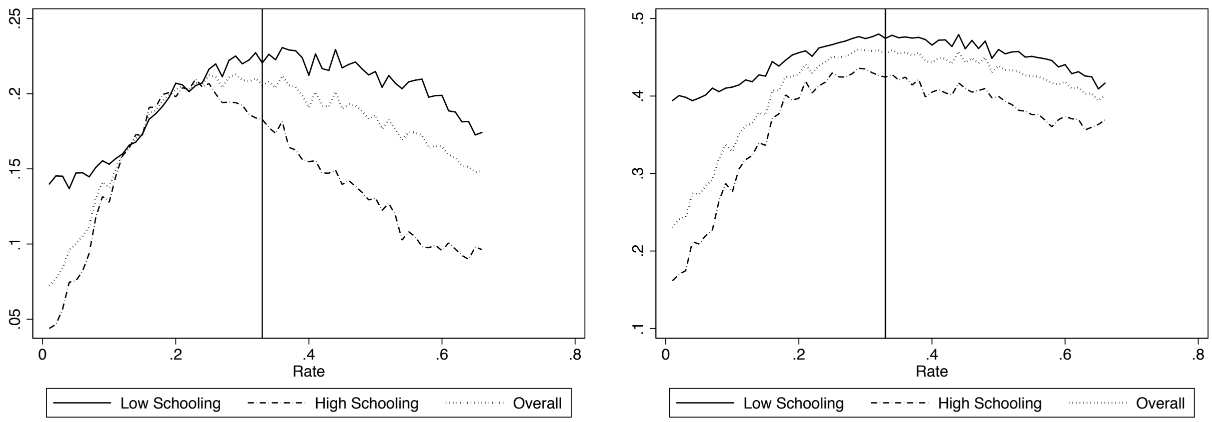
6.1 Labor Market Outcomes

We assess the equilibrium impacts on labor market outcomes and schooling levels of two policies:

1. Changes in the social security contribution rate t;
2. Changes in the non-contributory social benefit level B_0.

To evaluate the policy impact we proceed as follow. At each different value of the policy parameter, we find and compute the new equilibrium. We then simulate 480 months of labor market careers for 5,000 individuals in these counterfactual labor markets. We finally compute the relevant statistics on these simulated data. Simulation results on the equilibrium shares of illegal employment (left panel) and informal employment (right panel) – defined as the sum of illegal employees and self-employed workers – by schooling group are reported in Figures 6 and 7. As expected, increasing tax rates increase informality, although this relationship is far from being monotonic. This is because part of the social security contributions that are retained at the source by firms are equally redistributed among formal employees. To the extent that this redistributive component depends on the contribution rate, there exist a value of t such that this creates incentives at the margin to work as an illegal employee, thereby generating the hump-shape relationship observed in Figure 6. On the other hand, the relationship between non-contributory benefits and illegality and informality rates is monotonically increasing (See Figure 7).

Figure 6: Social Security Contribution Rate (t)

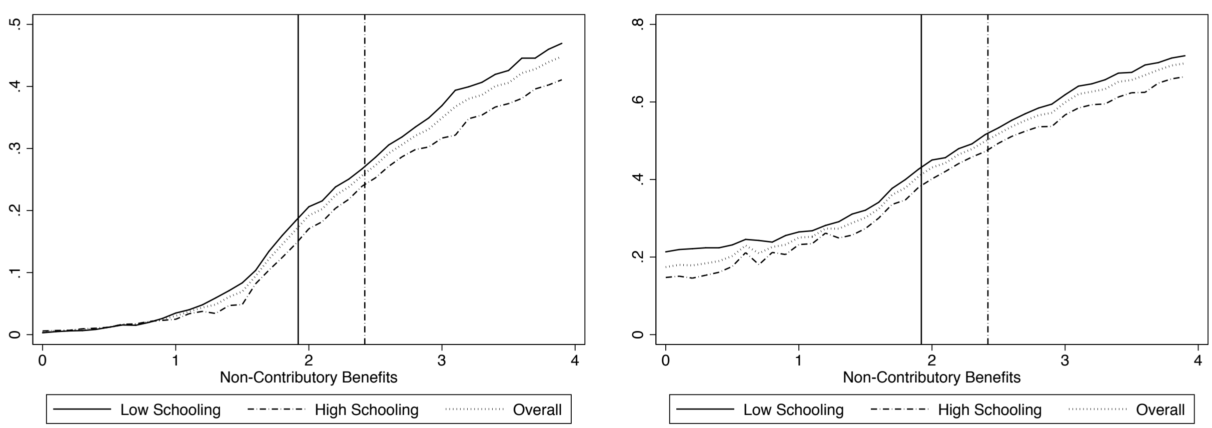


(a) Illegality Rate

(b) Informality Rate

NOTE: The vertical line represents the institutional value for the rate of retention at the source on legal employees' earnings. See Appendix C for details

Figure 7: Non-Contributory Social Benefits (B_0)



(a) Illegality Rate

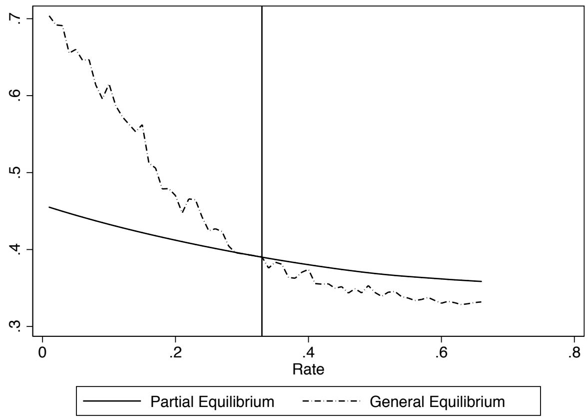
(b) Informality Rate

NOTE: The vertical lines represent the institutional monetary values of the per-capita benefits in non-contributory social programs excluding the *Seguro Popular* (continuos line) and including the *Seguro Popular*(dashed line). See Appendix C for details.

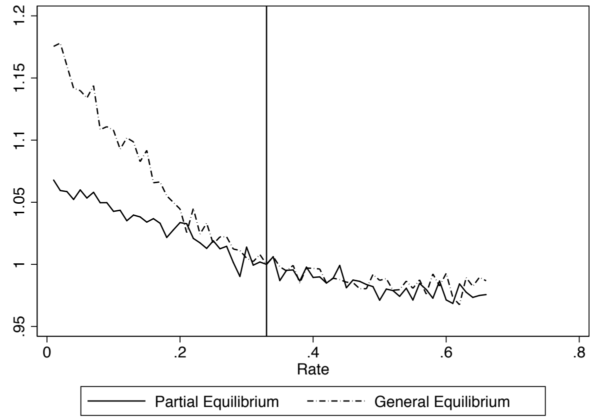
6.2 Schooling and Welfare Outcomes

We next evaluate the impact of the same policy variables considered in the previous section on two final outcomes: the share of individuals who choose to complete secondary education and the total value of production in our simulated economy (one measure of welfare). Simulation results are reported in Figures 8 and 9, separately for two equilibrium cases. In the first case (continuos lines in panels a and b) we consider the arrival rates of job offers as exogenous, whereas in the other case (dashed lines in panels a and b) we allow firms to react to the endogenous proportions of job seekers (unemployed and self-employed) in each schooling group by adjusting the vacancy rates. A striking pattern emerges from these simulations. Notably, in the partial equilibrium setting both schooling investments and welfare do not seem very much responsive to the two policy levers considered here. However, allowing firms to respond generates a fundamental discrepancy in the arrival rates by schooling group (see panels c and d in the Figures) that translates into a large elasticity of schooling investments and, as a consequence, in the value of production.

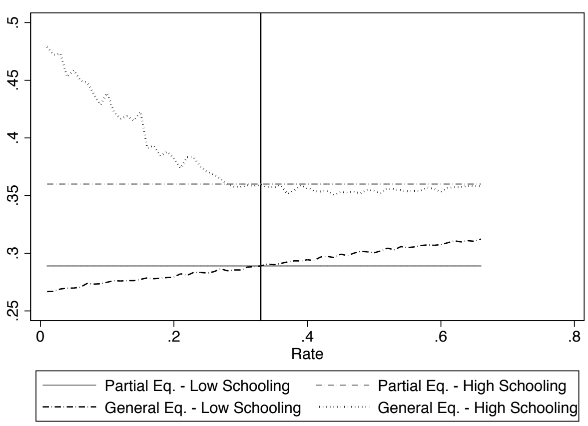
Figure 8: Social Security Contribution Rate (t)



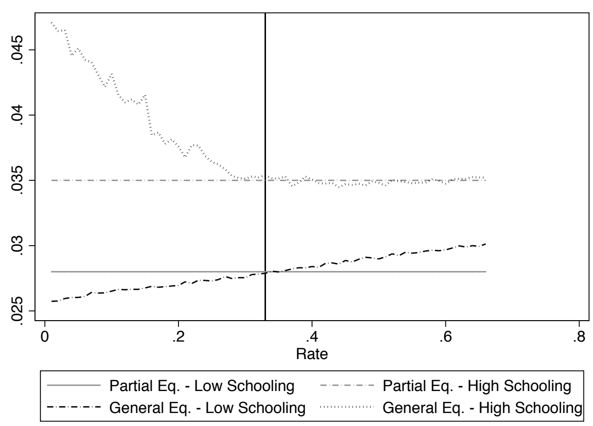
(a) % with High Schooling



(b) Value of Production



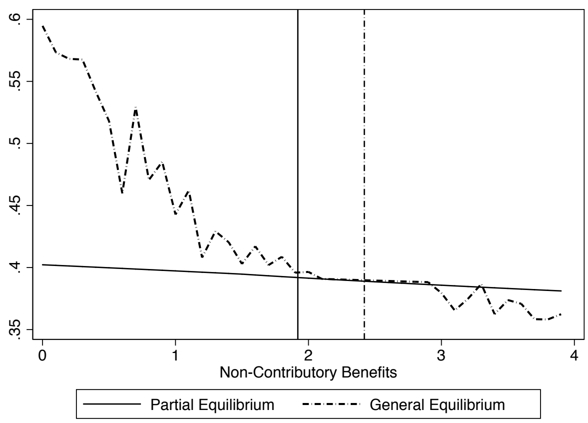
(c) Job Arrival Rate - Unempl.



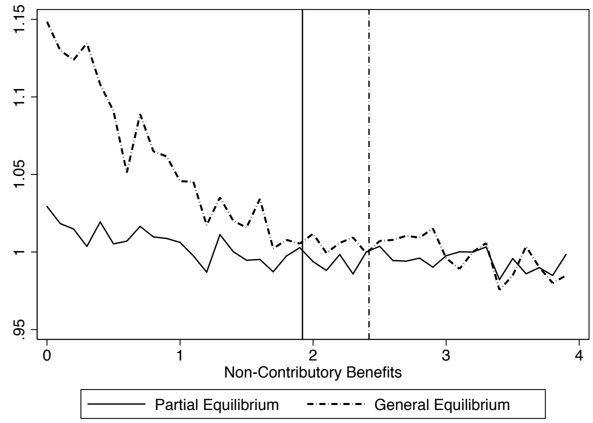
(d) Job Arrival Rate - Self-empl.

Note: The vertical line represents the institutional value for the rate of retention at the source on legal employees' earnings. See Appendix C for details.

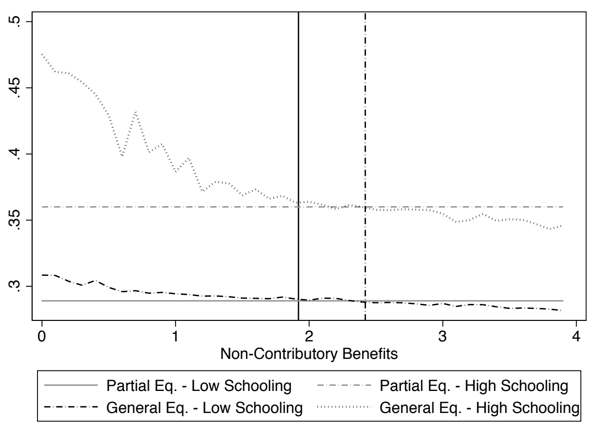
Figure 9: Non-Contributory Social Benefits (B_0)



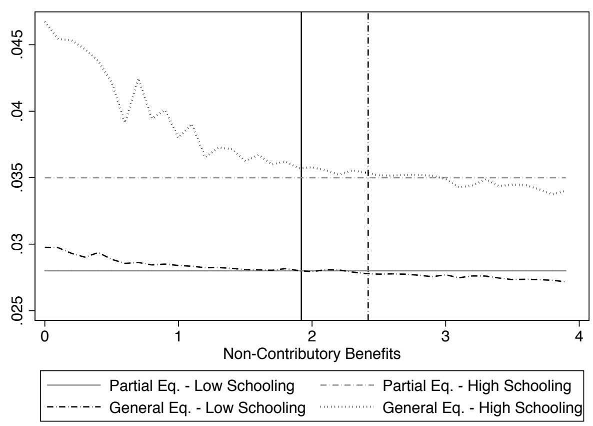
(a) % with High Schooling



(b) Value of Production



(c) Job Arrival Rate - Unempl.



(d) Job Arrival Rate - Self-empl.

NOTE: The vertical lines represent the institutional monetary values of the per-capita benefits in non-contributory social programs excluding the *Seguro Popular* (continuos line) and including the *Seguro Popular*(dashed line). See Appendix C for details.

7 Conclusion

In this paper, we nest some of the key features of informality in the context of a search model of the labor market in which schooling investments are endogenously determined. This modeling framework allows us to document how the presence of both illegal employment in firms and subsistence-level self-employment affect labor market outcomes and potentially distorts returns to schooling and individuals' decisions to acquire schooling. While the presence of informal labor market opportunities is not new in the empirical job search literature (see, e.g., Bosch and Esteban-Pretel [2012] and Meghir et al. [2015]), some key modeling features we introduce – e.g., the endogenous determination of the legal status of the job within the wage bargaining process – enable a better fit between the formal model and the institutional context. As a result, the experiments we performed based on our estimated model have the potential to generate more policy-relevant counterfactuals.

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Appendix

A Algebraic and Computation Details

A.1 Proof of Proposition 1

Proof. The result is proved by observing that:

$$\frac{\partial F_1[x,y,h]}{\partial x} = \frac{1-\alpha_h}{\rho+\eta_h} \geq \frac{1-\alpha_h}{\rho+\eta_h}(1-c_h) = \frac{\partial F_0[x,y,h]}{\partial x} > 0$$

■

A.2 Formal Definition of the Equilibrium

TBD

A.3 Derivation of Per-Capita Social Security Benefits

Tax revenues from social security contributions in each schooling market h after taking out the proportional extra-wage benefits are:

$$sc_h = l_h \pi_h (1-\tau) t \int_y \int_{\bar{x}(y,h)} w_1(x;y,h) \frac{g_h(x)dx}{1-G_h(\bar{x}(y,h))} dR(y|h), \tag{A.1}$$

where l_h is the steady-state proportion of legal employees in each schooling group h, which value depends on the equilibrium case discussed in Proposition 1:

$$l_h = \left\{ \begin{array}{ll} \left[\frac{\gamma_h\eta_h(1-R_h(y_h^\star))}{\eta_h+\gamma_h(1-G_h(x_0^\star(0,h)))} + \frac{\lambda_h\eta_h R_h(y_h^\star)}{\eta_h+\lambda_h(1-G_h(x_0^\star(0,h)))}\right]\left[\frac{1-G_h(\tilde{x}(0,h))}{\eta_h}\right] & \text{if } \tilde{x}(0,h) > x_1^\star(0,h) \\ \left[\frac{\gamma_h\eta_h(1-R_h(y_h^\star))}{\eta+\gamma_h(1-G_h(x_1^\star(0,h)))} + \frac{\lambda_h\eta_h R_h(y_h^\star)}{\eta_h+\lambda_h(1-G_h(x_1^\star(0,h)))}\right]\left[\frac{1-G_h(x_1^\star(0,h)))}{\eta_h}\right] & \text{if } \tilde{x}(0,h) < x_1^\star(0,h)) \end{array} \right\},$$

π_h is the equilibrium share of workers in each schooling level ($\pi_1 = T(\kappa^\star)$ and $\pi_0 = 1 - T(\kappa^\star)$ according to expression 15), $\bar{x}(y,h) = \max\{\tilde{x}(y,h), x_1^\star(y,h)\}$ denotes the match-specific reservation value for legal employees with education h and outside option in self-employment y (see equations 24 and 26), and $w_1(x;y,h)$ is the corresponding equilibrium wage schedule.

We can thus obtain the per-capita transfer that each legal employee receives in equilibrium (b_1 in expression 2) by summing up the quantities in expression A.1 in the two schooling groups and dividing by the corresponding equilibrium shares:

$$b_1 = \frac{sc_0 + sc_1}{l_0\pi_0 + l_1\pi_1} \tag{A.2}$$

A.4 Computation of Total Wage Bills

The fact that $\bar{x}(0,h) = \bar{x}(y_h^\star, h) < \bar{x}(y,h)$, $\forall y > y_h^\star \, \forall h \in \{0,1\}$ (see equations 17, 24 and 26) implies that we can separate the two integrals in expression A.1 for those individuals with $y < y_h^\star$. Using the equilibrium wage schedule (expression 21), we obtain the total wage bills for those legal employees coming from unemployment:

$$W_h^u = R_h(y_h^\star)\left\{\frac{\alpha_h}{(1+t)(1-G_h(\bar{x}(0,h)))}\int_{\bar{x}(0,h)} x dG(x|h) + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)}\left[\rho U(h) - \beta_{1,h} b_1\right]\right\}, \tag{A.3}$$

For those coming from self-employment ($y > y_h^\star$), we discretize the support of $\rho S(y,h)$ into sufficiently small intervals, and approximate the total wage bills as follows:

$$W_h^{se} = \left\{\begin{array}{c} \sum_{y\in[y_h^\star,\tilde{y}_h]}\left[R_h(y+y/2) - R_h(y-y/2)\right]\frac{\alpha_h}{1+t}\left[\int_{\tilde{x}(y,h)} x\frac{dg_h(x)dx}{1-G_h(\tilde{x}(y,h))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)}(\rho S(y) - \beta_{1,h}b_1)\right] + \\ \sum_{y>\tilde{y}_h}\left[R_h(y+y/2) - R_h(y-y/2)\right]\frac{\alpha_h}{1+t}\left[\int_{x_1^\star(y,h)} x\frac{dg_h(x)dx}{1-G_h(x_1^\star(y,h))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)}(\rho S(y) - \beta_{1,h}b_1)\right] \text{ if } \tilde{x}(0,h) > x_1^\star(0,h) \\ \sum_{y>y_h^\star}\left[R_h(y+y/2) - R_h(y-y/2)\right]\frac{\alpha_h}{1+t}\left[\int_{x_1^\star(y,h)} x\frac{dg_h(x)dx}{1-G_h(x_1^\star(y,h))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)}(\rho S(y) - \beta_{1,h}b_1)\right] \text{ if } \tilde{x}(0,h) < x_1^\star(0,h) \end{array}\right\}. \tag{A.4}$$

where $\tilde{y}_h$ is the value of self-employed earnings such that $\tilde{x}(\tilde{y}_h, h) = x_1^\star(\tilde{y}_h, h)$. Hence, we can approximate the quantity in expression A.1 as follows:

$$sc_h \simeq l_h\pi_h(1-\tau)t(W_h^u + W_h^{se}). \tag{A.5}$$

A.5 Derivation of b_1 with two different values for B_0

Let $B_{0,d}$, where $d \in \{0,1\}$, denote whether or not non-formally employed individuals receive higher non-contributory benefits (e.g. due to the receipt of the *seguro popular* in their municipality of residence).

$$l_{h,d} = \left\{\begin{array}{ll} \left[\frac{\gamma_h\eta_h(1-R_h(y_{h,d}^\star))}{\eta_h+\gamma_h(1-G_h(x_0^\star(0,h,d)))} + \frac{\lambda_h\eta_h R_h(y_{h,d}^\star)}{\eta_h+\lambda_h(1-G_h(x_0^\star(0,h,d)))}\right]\left[\frac{1-G_h(\tilde{x}(0,h,d))}{\eta_h}\right] & \text{if } \tilde{x}(0,h,d) > x_1^\star(0,h,d) \\ \left[\frac{\gamma_h\eta_h(1-R_h(y_{h,d}^\star))}{\eta_h+\gamma_h(1-G_h(x_1^\star(0,h,d)))} + \frac{\lambda_h\eta_h R_h(y_{h,d}^\star)}{\eta_h+\lambda_h(1-G_h(x_1^\star(0,h,d)))}\right]\left[\frac{1-G_h(x_1^\star(0,h,d)))}{\eta_h}\right] & \text{if } \tilde{x}(0,h,d) < x_1^\star(0,h,d) \end{array}\right\}, \tag{A.6}$$

Also, for each couple $\{h,d\}$ we can derive expressions for the total wage bills for legal employees depending on their search status. In particular, for those legal employees coming from unemployment:

$$W^u_{h,d} = R_h(y^\star_{h,d}) \left\{ \frac{\alpha_h}{(1+t)(1-G_h(\bar{x}(0,h,d)))} \int_{\bar{x}(0,h,d)} x dG(x|h) + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)} \left[\rho U(h,d) - \beta_{1,h} b_1\right] \right\}, \tag{A.7}$$

where $\bar{x}(y,h,d) = \max\{\tilde{x}(y,h,d), x^\star_1(y,h,d)\}$. For those coming from self-employment ($y > y^\star_{h,d}$), we discretize the support of $\rho S(y,h,d)$ into sufficiently small intervals, and approximate the wage bills as follows:

$$W^{se}_{h,d} = \left\{ \begin{array}{ll} \sum_{y\in[y^\star_{h,d},\tilde{y}_{h,d}]} [R_h(y+y/2) - R_h(y-y/2)] \frac{\alpha_h}{1+t} \left[\int_{\tilde{x}(y,h,d)} x \frac{dg_h(x)dx}{1-G_h(\tilde{x}(y,h,d))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)} (\rho S(y,h,d) - \beta_{1,h} b_1)\right] + & \\ \sum_{y>\tilde{y}_{h,d}} [R_h(y+y/2) - R_h(y-y/2)] \frac{\alpha_h}{1+t} \left[\int_{x^\star_1(y,h,d)} x \frac{dg_h(x)dx}{1-G_h(x^\star_1(y,h,d))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)} (\rho S(y,h,d) - \beta_{1,h} b_1)\right] & \text{if } \tilde{x}(0,h,d) > x^\star_1(0,h,d) \\ \sum_{y>y^\star_{h,d}} [R_h(y+y/2) - R_h(y-y/2)] \frac{\alpha_h}{1+t} \left[\int_{x^\star_1(y,h,d)} x \frac{dg_h(x)dx}{1-G_h(x^\star_1(y,h,d))} + \frac{(1-\alpha_h)}{(1+\beta_{1,h}\tau t)} (\rho S(y,h,d) - \beta_{1,h} b_1)\right] & \text{if } \tilde{x}(0,h,d) < x^\star_1(0,h,d) \end{array} \right\} \tag{A.8}$$

where $\tilde{y}_{h,d}$ is the value of self-employed earnings such that $\tilde{x}(\tilde{y}_{h,d},h,d) = x^\star_1(\tilde{y}_{h,d},h,d)$.

Then, tax revenues from social security contributions in schooling group h after taking out the proportional extra-wage benefits can be written as:

$$sc_h \simeq (1-\tau)t \sum_{d\in\{0,1\}} \pi_{h,d} l_{h,d} (W^u_{h,d} + W^{se}_{h,d}), \tag{A.9}$$

where $\pi_{h,d}$ is the equilibrium share of workers in schooling group h with treatment status d.

B Additional Figures and Tables

Table B.1: SP Roll-out and Pre-determined Labor Market Characteristics (ENE, 2001)

	(1) $\ln(w_f)$	(2) $\ln(w_i)$	(3) $\ln(w_{se})$	(4) Legal	(5) Illegal	(6) Self-Empl	(7) Unempl
sp	0.014	0.083	0.043	-0.038	0.024	0.013	0.001
	(0.042)	(0.068)	(0.060)	(0.023)	(0.017)	(0.016)	(0.003)
educ	0.187***	0.182***	0.189***	-0.034***	-0.015**	0.048***	0.001
	(0.016)	(0.034)	(0.020)	(0.007)	(0.006)	(0.008)	(0.003)
Mean Dep. Var.				0.494	0.154	0.327	0.024
Number of Obs	10077	3061	6534	20803	20803	20803	20803
Number of Clusters	217	190	217	238	238	238	238

OLS estimates. Standard errors clustered at the municipality level.

Table B.2: Unconditional Moments: Treated Sample

Moment	Low Schooling			High Schooling		
	Model	Data	Weight	Model	Data	Weight
% Self-employed	0.259	0.241	0.005	0.241	0.238	0.007
% Legally Employed	0.429	0.486	0.006	0.485	0.514	0.007
% Illegally Employed	0.297	0.236	0.006	0.245	0.206	0.006
% Unemployed	0.016	0.037	0.003	0.028	0.042	0.003
Mean Illegal Wages	5.043	4.252	0.114	5.074	4.480	0.179
SD Illegal Wages	8.873	9.009	0.182	10.141	11.119	0.380
Mean Legal Wages	9.860	11.651	0.183	14.681	15.690	0.309
SD legal Wages	14.195	14.615	0.168	21.229	20.294	0.348
Mean Self-empl Income	5.332	5.408	0.143	6.276	5.983	0.203
SD Self-empl Income	11.272	11.531	0.216	13.871	13.218	0.334
U Duration (months)	0.076	0.095	0.014	0.162	0.159	0.023
SE Duration (months)	30.965	33.017	0.996	27.432	29.786	1.116
% Illegally Employed - Q1	0.162	0.094	0.005	0.143	0.092	0.005
% Illegally Employed - Q2	0.037	0.061	0.005	0.033	0.046	0.004
% Illegally Employed - Q3	0.038	0.033	0.004	0.029	0.026	0.003
% Illegally Employed - Q4	0.034	0.029	0.003	0.025	0.020	0.003
% Illegally Employed - Q5	0.025	0.018	0.002	0.015	0.021	0.003
Mean Illegal Wages - Q1	1.950	0.973	0.054	2.204	1.049	0.071
Mean Illegal Wages - Q2	0.584	1.005	0.080	0.603	0.883	0.078
Mean Illegal Wages - Q3	0.739	0.695	0.074	0.700	0.669	0.075
Mean Illegal Wages - Q4	0.848	0.797	0.072	0.794	0.675	0.096
Mean Illegal Wages - Q5	0.921	0.781	0.081	0.773	1.204	0.143
Mean Legal Wages - Q1	1.116	1.063	0.023	1.525	1.220	0.043
Mean Legal Wages - Q2	1.358	1.626	0.046	1.823	1.969	0.095
Mean Legal Wages - Q3	1.645	2.046	0.044	2.277	2.707	0.075
Mean Legal Wages - Q4	2.140	2.715	0.070	3.049	3.534	0.085
Mean Legal Wages - Q5	3.601	4.201	0.089	6.007	6.260	0.166

Table B.3: Unconditional Moments: Control Sample

	Low Schooling			High Schooling		
Moment	Model	Data	Weight	Model	Data	Weight
% Self-employed	0.267	0.224	0.007	0.244	0.239	0.010
% Legally Employed	0.551	0.527	0.009	0.626	0.545	0.011
% Illegally Employed	0.171	0.198	0.007	0.100	0.165	0.009
% Unemployed	0.011	0.051	0.004	0.030	0.052	0.005
Mean Illegal Wages	3.281	3.632	0.152	2.422	3.607	0.243
SD Illegal Wages	8.245	8.609	0.274	8.317	10.425	0.635
Mean Legal Wages	11.555	12.675	0.259	16.187	16.320	0.455
SD Legal Wages	13.757	14.746	0.224	19.670	19.770	0.502
Mean Self-empl Income	5.452	4.440	0.177	5.886	5.193	0.266
SD Self-empl Income	11.699	9.951	0.293	12.486	11.556	0.468
U Duration (months)	0.066	0.109	0.012	0.182	0.186	0.033
SE Duration (months)	29.523	28.462	1.252	27.747	28.245	1.546
% Illegally Employed - Q1	0.052	0.085	0.006	0.011	0.078	0.007
% Illegally Employed - Q2	0.024	0.043	0.005	0.028	0.036	0.006
% Illegally Employed - Q3	0.034	0.027	0.004	0.018	0.020	0.004
% Illegally Employed - Q4	0.032	0.025	0.003	0.025	0.015	0.003
% Illegally Employed - Q5	0.029	0.017	0.003	0.018	0.015	0.003
Mean Illegal Wages - Q1	0.570	0.902	0.079	0.162	0.896	0.099
Mean Illegal Wages - Q2	0.338	0.727	0.082	0.413	0.690	0.105
Mean Illegal Wages - Q3	0.585	0.571	0.074	0.365	0.531	0.096
Mean Illegal Wages - Q4	0.744	0.693	0.094	0.665	0.531	0.114
Mean Illegal Wages - Q5	1.045	0.740	0.125	0.819	0.960	0.200
Mean Legal Wages - Q1	1.211	1.153	0.041	1.635	1.363	0.049
Mean Legal Wages - Q2	1.521	1.880	0.068	1.960	2.130	0.090
Mean Legal Wages - Q3	1.920	2.234	0.118	2.442	2.793	0.115
Mean Legal Wages - Q4	2.532	2.837	0.091	3.364	3.695	0.134
Mean Legal Wages - Q5	4.371	4.571	0.112	6.787	6.340	0.234

C Institutional Parameters

The parameters $\{B_0, \tau, t\}$ are set to the values determined by the institutional setting of the Mexican labor market. In particular:

$\boldsymbol{\tau} = \mathbf{0.55}$ In order to derive the share of the bundle of additional benefits for legal employees (τ), we follow calculations reported in Levy [2008], which are based on the current legislation in Mexico. Accordingly, for a worker who earns twice the minimum wage in 2007 (2,931 Pesos), social security contributions amount to 864.30 Pesos (almost 30% of the wage), of which 55% are attributable to spending categories that are proportional to the wage - notably, work-risk insurance (76.2 Pesos), disability and life insurance (69.6 Pesos), retirement pensions (184 Pesos) and housing fund (146.6 Pesos).

$\boldsymbol{t} = \mathbf{0.33}$ We rely on calculations reported in Anton et al. [2012], which are based on official statistics reported by the Mexican Social Security Institute (IMSS). The authors decompose the average tax rate on formal labor (38%) into government subsidies (5%) and firms and workers contributions (33%).

$\boldsymbol{B_{0,1}} = \mathbf{2.42}$ **and** $\boldsymbol{B_{0,0}} = \mathbf{1.92}$ Total spending in non-contributory social programs for the year 2005 amounted to 133,090,002,747 Pesos, of which 11,916,448,117 Pesos were devoted to the *Seguro Popular* program. For the same year, we compute the total number of informal workers (25,035,508) and unemployed (1,353,561) by applying sampling weights to the nationally-representative labor market survey used in our empirical analysis (ENOE). Assuming full time working hours over a period of one year (2,080 hours), we can compute the per-capita hourly monetary benefits extended to the part of the labor force that is non-legally employed, separately for those who reside in municipalities with ($B_{0,1}$) and without ($B_{0,0}$) the *Seguro Popular* program.