Labor Market Frictions, Search and Schooling Investments*

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Abstract

Schooling investments have a persistent impact on future labor market trajectories therefore expectations about the labor market environment have an impact on present schooling decisions. However, since workers must invest in schooling before finding a job, part of the payoff of the schooling investment can be appropriated by firms and hence agents may held up their schooling investment. This may be especially the case in labor markets in developing countries that are usually characterized by substantial frictions (e.g. high informality rates). We propose a search-matching-bargaining model of the labor market in which individuals permanently choose (i) whether to become self-employed or remaining unemployed prior to searching for a job as employees and (ii) to acquire productivity-enhancing schooling prior to labor market entry. Potential employees are randomly matched with firms offering either legal or illegal wage contracts. Estimation of the model using Mexican micro-data enables us to quantify the sensitivity of educational investment with respect to the labor market parameters and evaluate the impacts of alternative labor market policies on the returns to schooling.

Keywords: Labor market search, Nash bargaining, Hold-up, Informality; Schooling decisions;
JEL Codes: J24, J3, J64, O17

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1 Introduction

Over the last two decades, the virtuous interactions between demand-side human capital interventions and sustained growth have spurred a dramatic increase in school participation, leading to almost universal enrollment in primary school in most developing countries. Yet, major differences with respect to high income countries persist at the secondary level: average enrollment is still significantly lower, with extremely low and barely improving school participation rates at the bottom of the income distribution.

Why secondary enrollment has not catch up and why education inequality persists at the secondary level? It is widely acknowledged that school availability and accessibility impose binding constraints on children's ability to attend school in developing countries (e.g. Duflo (2001); Filmer (2007), Kazianga, Levy, Linden and Sloan (2013)). Moreover, there is considerable evidence that children's school enrollment is responsive to variations in the costs and the quality of schooling (e.g. Burke and Beegle (2004); Banerjee, Cole, Duflo and Linden (2007)).

This paper takes a different stand. We argue that the presence of labor market "frictions" (essentially the inability to costlessly and instantaneously move between jobs) generates substantial distortions in the returns to human capital investments, thereby eventually leading to inadequate incentives to acquire education. A focus on the labor market is promising for two reasons. First, from a theoretical point of view, the labor market is the market where schooling investments are rewarded. Therefore any policy interventions aimed at altering the equilibrium in the labor market may affect these rewards and have potentially significant impacts on schooling decisions (e.g. Jensen (2012), Abramitzky and Lavy (2011)). Second, scholars and policy makers alike have recently argued in favor of complementary (or supply-side) policies in order to further enhance the effectiveness of demand-side policies (Levy, 2008). Yet, we know surprisingly little about the impacts of those alternative interventions and their potential synergies with demand-side incentives.

The standard environment in modeling labor markets dynamic acknowledges that the presence of "frictions" generates markets that are not perfectly competitive and leads to equilibrium unemployment. This class of *search model of the labor market* has been massively employed to study labor markets of high income economies[1] but has been scarcely used to study labor markets in developing countries' contexts.[2]

[1]For a survey of search-theoretic models and their applications, see Rogerson, Shimer and Wright (2005). For a recent survey focusing on empirical search model, see Eckstein and van den Berg (2007). A classic book reference is Pissarides (2000) while Mortensen (2003) is a book focusing on search and wage inequality

[2]Notable exceptions include: Albrecht, Navarro and Vroman (2009), a theoretical contribution calibrated on an average of large Latin American economies; Bosch and Esteban-Pretel (2012) focusing on Brazil and the economic cycle; Robalino, Zylberstajn and Robalino (2011) also looking at Brazil but focusing on the unemployment benefit system; and Tejada (2012) focusing on Chile and the difference between term and open-ended labor contracts. Finally, Meghir, Narita, Robin (2012) is the most recent and complete application to date on Brazil

One disadvantage of the search framework is that schooling decisions are usually taken as given. This is due to the theoretical complexity of embedding endogenous schooling decisions in a framework already comprising a fairly rich labor market decision process. Adding this ingredient, however, is essential to satisfy the objective of our research agenda since we want to study the impact of labor market conditions on schooling decisions and not only the returns to skills once these decisions have been taken.[3] Moreover, a quantitative assessment of the extent of the hold up problem in human capital investments requires a framework with endogenous schooling decisions. Since workers must invest in schooling *before* finding a job and since, in a non-competitive labor market, part of the payoff of the schooling investment can be appropriated by firms, agents may *held up* their schooling investment. The resulting inefficiencies are larger the larger the frictions in the labor market.[4]

Flinn (2011) extends the standard search and matching framework to allow for endogenous schooling decisions and it is therefore a promising environment to proceed in our research agenda. He proposes a labor market characterized by search frictions and by firms and workers deciding not only about the job relation but also about investment decisions prior to market entry. Specifically, the flow productivity of a match between a worker and a firm depends on: 1) a worker-specific component, which is affected by schooling decisions; 2) a firm-specific component, which is affected by investment decisions; and 3) a match-specific component, which captures residual idiosyncratic components. Once a match is created, rents are split using a standard Nash bargaining solution. Interestingly, after appropriate distributional assumptions are imposed, the model is tractable enough to be estimated using standard labor market dynamics data. This is a very attractive feature for our purposes since we want to provide a quantitative evaluations of policy interventions in specific labor markets. The conclusion of Flinn's paper confirms the claim we made at the beginning of this section: schooling decisions prior to market entry are responsive to labor market parameters and policy interventions.

2 Model

A model of labor market search with matching and bargaining in the presence of formal and informal labor market opportunities is presented. When a potential employee and a firm meet, the productive value of the match is immediately observed by both the applicant and the firm. At

[3]Eckstein and Wolpin (1995) is a classic reference in this respect, showing how returns to schooling change when we are looking at offered wages as opposed to (incorrectly) accepted wages. Flabbi and Tejada (2012) is a more recent contribution in this vein, evaluating the equilibrium impact of discrimination on wage offers distributions by gender and education.

[4]Acemoglu and Shimer (1999) study under what conditions these inefficiencies can be alleviated or eliminated. Flinn (2011) estimates that, in the context of the US labor market, the extent of the hold up inefficiency is very sensitive to the workers' bargaining power parameter.

this point a division of the match value and the legal status of the job is proposed using a Nash-bargaining framework. We first characterize the equilibrium conditions under which firms and workers agree on a match and whether a legal or illegal job is formed. We then extend the basic framework by allowing individuals to permanently choose (i) whether to become self-employed or remaining unemployed prior to searching for a job as employees and (ii) to acquire productivity-enhancing schooling prior to labor market entry.

2.1 Environment

The model is formulated in continuos time and assumes stationarity of the labor market environment. Unemployed individuals search for a job as employees and they receive an instantaneous utility (or disutility) flow ξ which is assumed constant in the population. The arrival of job offers follows a Poisson process at instantaneous rates λ. Once an employer and a worker meet, they observe a match-specific productivity value x, modeled as a draw from an exogenous distribution denoted by the cdf G. Once a match is formed, it can be terminated following a Poisson process at instantaneous rate η. There are no offers while the individual is working as an employee, and the instantaneous common discount rate is ρ. Workers' utility when employed is

$$v(x, f) = w(x, f) + f\beta_1 B_1 + (1 - f)\beta_0 B_0, \tag{1}$$

where w is the wage, B_1 represents the monetary value of the bundle of contributory social-security insurance (CSI) of working as a legal employee $(f = 1)$, B_0 is the monetary value of the lump-sum transfer that both illegal employees $(f = 0)$ and unemployed individuals receive through non-contributory social-security insurance (NCSI). In this framework, β_1 (β_0) defines the marginal willingness to pay for CSI (NCSI), which is assumed constant in the population.

The corresponding value functions for the potential worker in the states of employment and unemployment is:

$$V(x, f) = \frac{w(x, f) + f\beta_1 B_1 + (1 - f)\beta_0 B_0 + \eta Z}{\rho + \eta}, \tag{2}$$

where Z is the value of searching, which is defined by the following expression:

$$Z = \frac{\xi + \beta_0 B_0 + \lambda \int \max\{V(x, f), Z\}\, dG(x)}{\rho + \lambda}. \tag{3}$$

Firms' instantaneous profits from a filled job are:

$$p(x, f) = x - w(x, f) - f\tau w(x, f) - (1 - f)cx,$$

where c is the expected value of the per-worker penalty the firm has to pay if discovered employing an informal worker and τ is the withdrawal at the source operated by firms on their formal employees' wages. The cost of informality cx is proportional to the potential match-specific productivity value. The corresponding value functions for a job filled at the firm are:

$$P(x, f) = \frac{[1 - (1 - f)c]\, x - (1 + f\tau)w(x, f)}{\rho + \eta}, \tag{4}$$

where the value of the alternative state, an unfilled vacancy, is zero because we assume free-entry of firms in the market (or alternatively that posting a vacancy costs nothing).

Given the diverse nature of CSI, we parametrize B_1 as following:

$$B_1 = \gamma\tau w(x, f) + b_1, \tag{5}$$

where γ denotes the relative share of the bundle which is assumed to be returned one-to-one to the workers through proportional extra-wage benefits (e.g. pensions) and b_1 is the lump-sum transfer that formal workers receive in equilibrium once all firms' withdrawals have been collected (e.g. health insurance).

Potential employees and firms bargain over the surplus. We assume that the outcome of the bargaining game is the pair (w, f) described by the axiomatic Generalized Nash Bargaining Solution, using the value of unemployment (3) and zero, respectively, as threat points, and $(\alpha, 1 - \alpha)$ as the workers and the firm's bargaining power parameters.

2.2 Equilibrium

Using the expressions for the value functions (2), (3) and (4), we define the surplus Σ of the match as the weighted product of the worker's and firm's net return from the match with weights $(\alpha, 1 - \alpha)$:

$$\begin{aligned}\Sigma(x, f) &\equiv [V(x, f) - Z]^{\alpha} \times [P(x, f)]^{1-\alpha} \\ &= \frac{1}{\rho + \eta} [(1 + f\beta_1\gamma\tau)w(x, f) + f\beta_1 b_1 + (1 - f)\beta_0 B_0 - \rho Z]^{\alpha} \\ &\times [x - w(x, f) - f\tau w(x, f) - (1 - f)cx]^{1-\alpha}.\end{aligned}$$

Nash Bargaining implies the following equilibrium wage schedules:

$$w(x, f) = \frac{\alpha\, [1 - (1 - f)c]}{1 + f\tau} x + \frac{1 - \alpha}{1 + f\beta_1\gamma\tau} [\rho Z - f\beta_1 b_1 - (1 - f)\beta_0 B_0] \tag{6}$$

Equations (2) and (4) show that the values of being employed are monotone increasing in the match-specific productivity values and wages. Equation (3) shows that the value of unemployment is constant with respect to match-specific productivity values and wages. As a result and under mild regularity conditions, the optimal decisions rules are characterized by the following reservation match-specific productivity value:

$$x^*(f) = \frac{1 + f\tau}{(1 + f\beta_1\gamma\tau)\left[1 - (1-f)c\right]}\left[\rho Z - f\beta_1 b_1 - (1-f)\beta_0 B_0\right]. \tag{7}$$

Potential employees only accept matches with productivity higher than $x^*(f)$. An analogous decision rule holds for firms. Because of Nash Bargaining, the reservation value at which the worker is indifferent between accepting the firm's offer or keep searching for a better match is equal to the reservation value at which the firm is indifferent to the option of holding a vacancy or hiring the worker. Equation (7) states that job legal status f has two opposite effects on the reservation productivity value at which the match is formed. It decreases the reservation value because employees receive a valuable job amenity B_1 (B_0), but it also increases the reservation value because the firm pays costs τ (c) to provide the amenity.

By substituting the equilibrium wage schedule (6) into the value function (2), we obtain the match-specific productivity value such that both employees and firms will be indifferent between a legal and an illegal job:

$$\tilde{x} = \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1\gamma)\tau}{1+\tau}}. \tag{8}$$

Expression (8) has an intuitive economic interpretation. The numerator is the difference between the total utility value that individuals assign to NCSI and the lump-sum component of CSI. Graphically, it is the difference in the intercepts of the workers' value functions (2) in the two states of salaried employment. The denominator implicitly defines the penalty threshold that generates different labor market equilibria. This threshold is not binding in the case in which individuals fully value social-security benefits ($\beta_1 = 1$) and the bundle is fully proportional to the worker's wage ($\gamma = 1$). In the opposite case where the whole bundle is distributed in a lump-sum fashion ($\gamma = 0$), the penalty threshold reaches its maximum value at $\frac{\tau}{1+\tau}$. Graphically, the sign of the denominator determines which of the two workers' value functions (2) is steeper with respect to to the match-specific productivity value.

Case 1: $c > \frac{(1-\beta_1\gamma)\tau}{1+\tau}$. In this case, the value function (2) for legal jobs is steeper than the one for illegal jobs at any match-specific productivity value. Because the cost of providing the legal status is lower for highly productive matches, only relatively lower productivity matches will be associated with an illegal job status. The range of productivities over which illegal and legal jobs are accepted is directly related to the model parameters though the reservation values defined in (7) and (8). There are two possible rankings:

$$x^*(0) < x^*(1) < \tilde{x}, \tag{1.A}$$

$$\tilde{x} < x^*(1) < x^*(0). \tag{1.B}$$

The optimal decision rule in case (1.A) is to reject the match if $x < x^*(0)$, accept the match as an illegal worker if $x^*(0) < x < \tilde{x}$ and accept the match as a legal worker if $x > \tilde{x}$. The optimal decision rule in case (1.B) is to reject the match if $x < x^*(1)$ and accept the match as a legal worker if $x > x^*(1)$.

Case 2: $c < \frac{(1-\beta_1\gamma)\tau}{1+\tau}$**.** In this case the value function (2) for illegal jobs is steeper than the one for formal jobs at any match-specific productivity value. Hence, the range of productivities over which illegal and legal jobs are accepted is inverse with respect to Case 1:

$$x^*(1) < x^*(0) < \tilde{x}, \tag{2.A}$$

$$\tilde{x} < x^*(0) < x^*(1). \tag{2.B}$$

The optimal decision rule in case (2.A) is to reject the match if $x < x^*(1)$, accept the match as a formal worker if $x^*(1) < x < \tilde{x}$ and accept the match as an informal worker if $x > \tilde{x}$. The optimal decision rule in case (2.B) is to reject the match of $x < x^*(0)$ and accept the match as an informal worker if $x > x^*(0)$.

Using these decision rules and plugging the resulting equilibrium wage schedule (6) onto the value functions (2), we can express the value of unemployment (3) as an implicit function of the primitive parameters of the model. For instance, under case (1.A) we obtain the following expression for the value of unemployment

$$\begin{aligned}\rho Z_{1.A} = \xi + \beta_0 B_0 + \frac{\lambda\alpha}{\rho+\eta}\left\{\int_{\frac{\rho Z-\beta_0 B_0}{1-c}}^{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}} \left[x - \frac{\rho Z-\beta_0 B_0}{1-c}\right] dG(x)\right\} \\ + \frac{\lambda\alpha}{\rho+\eta}\left\{\int_{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}} \left[x - \frac{(1+\tau)(\rho Z-\beta_1 b_1)}{1+\beta_1\gamma\tau}\right] dG(x)\right\}.\end{aligned} \tag{9}$$

Given that $G(x)$ is an increasing function, this equation has a unique solution. We can therefore propose the following

Definition 1 *Given a vector of parameters* $\Gamma = (\xi, \lambda, \eta, \rho, \alpha, \beta_0, \beta_1, \tau, \gamma, c, B_0)$ *and one probabil-*

ity distribution function for the productivity of match values $G(x)$ a ***labor market equilibrium*** *is a value of unemployment Z that solves equation (9). The equilibrium value Z determines all the reservation values that constitute each agent's decision rules.*

2.3 Extensions

2.3.1 Self-employment Decisions

Self-employment decisions are assumed to be taken once and for all before searching for a job as an employee. In particular, we allow individuals to be heterogeneous in the potential earnings derived from their own business activity. The latter variable is modeled as a draw from an exogenous distribution denoted by the cdf Y which summarizes heterogeneity with respect to the monetary costs, ability-related returns and preference-related determinants of being self-employed. We further assume that when a potential employee and a firm bargain over the wage and the job status, the realized value (if any) of self-employment profits y is immediately observed by both the applicant and the firm. In this setting, the value of searching for a job as an employee under case (1.A) is

$$\rho Z(ys)_{1.A} = \xi + ys + \beta_0 B_0 + \frac{\lambda_s \alpha}{\rho + \eta} \left\{ \int_{\frac{\rho Z(ys) - \beta_0 B_0}{1-c}}^{\frac{(1+\tau)(\beta_0 B_0 - \beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}} \left[x - \frac{\rho Z(ys) - \beta_0 B_0}{1-c} \right] dG(x) \right\}$$
$$+ \frac{\lambda_s \alpha}{\rho + \eta} \left\{ \int_{\frac{(1+\tau)(\beta_0 B_0 - \beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}} \left[x - \frac{(1+\tau)(\rho Z(ys) - \beta_1 b_1)}{1+\beta_1\gamma\tau} \right] dG(x) \right\}. \quad (10)$$

where we have allowed the instantaneous rate of arrival job offers to vary (exogenously) according to the two regimes $s = 0$ and $s = 1$ of the search status.

Self-employment decisions are taken by comparing the value functions in expression (10) in the two regimes $s = 0$ and $s = 1$. The wage schedule, together with the value functions, implies that the optimal decision rule has a reservation value property. The value of unemployment $Z(0)$ is independent of the potential earnings accruing from starting-up a business, whereas the value of self-employment $Z(y)$ is increasing with respect to self-employment earnings. Hence, there exists a reservation value such that $Z(0) = Z(y^*)$[5], so that for equilibrium case (1.A) we have

$$y^*_{1.A} = \frac{\alpha}{\rho+\eta}\left\{\int_{\frac{\rho Z(ys)-\beta_0 B_0}{1-c}}^{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{\rho Z(ys)-\beta_0 B_0}{1-c}\right]dG(x)\right\}$$
$$+\frac{\alpha}{\rho+\eta}\left\{\int_{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{(1+\tau)(\rho Z(ys)-\beta_1 b_1)}{1+\beta_1\gamma\tau}\right]dG(x)\right\}(\lambda_0-\lambda_1). \quad (11)$$

Given that $G(x)$ is an increasing function, this equation has a unique solution which positively depends on the difference in the (exogenous) arrival rates of job offers between unemployed and self-employed searchers. This implies that in order to have a positive mass of unemployed individuals in equilibrium ($Y(y^*) > 0$), it must be that case that $\lambda_0 > \lambda_1$.

2.3.2 Schooling Decisions

We now introduce an additional dimension of heterogeneity across individuals: the stock of human capital they have accumulated prior to any occupational choice decision. For simplicity, we consider two levels of schooling: h_1 and h_2, where $h_2 > h_1$ and we allow the key labor market parameters of the model to vary along this dimension ($\eta_h, \lambda_{s,h}, G_h(x)$). The parameters $\rho, \xi, \beta_0, \beta_1$, being intrinsic characteristics of individual agents, are assumed to be homogeneous across schooling sub-markets, as are the monitoring technology parameter c, the bargaining power parameter α and the remaining parameters which characterize the structure of the extra-wage benefits (τ, B_0, γ). In terms of the labor market equilibrium described above, this implies that the value of searching in the equilibrium case (1.A) can be expressed as

$$\rho Z(ys,h)_{1.A} = \xi + ys + \beta_0 B_0 + \frac{\lambda_{s,h}\alpha}{\rho+\eta_h}\left\{\int_{\frac{\rho Z(ys,h)-\beta_0 B_0}{1-c}}^{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{\rho Z(ys,h)-\beta_0 B_0}{1-c}\right]dG_h(x)\right\}$$
$$+\frac{\lambda_{s,h}\alpha}{\rho+\eta_h}\left\{\int_{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{(1+\tau)(\rho Z(ys,h)-\beta_1 b_1)}{1+\beta_1\gamma\tau}\right]dG_h(x)\right\}. \quad (12)$$

Analogously, the reservation value of potential self-employment earnings in the presence of

[5] According to expression (7), this implies that the match-specific reservation productivity values at which a potential employee is indifferent between accepting or not a given job (legal or illegal) are equal for the individual who is indifferent between becoming self-employed or remaining unemployed: $x^*(f; y^*) = x^*(f; 0)$.

different schooling sub-markets becomes:

$$y^*(h)_{1.A} = \frac{\alpha}{\rho+\eta_h}\left\{\int_{\frac{\rho Z(ys,h)-\beta_0 B_0}{1-c}}^{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{\rho Z(ys,h)-\beta_0 B_0}{1-c}\right]dG_h(x)\right\}$$
$$+\frac{\alpha}{\rho+\eta_h}\left\{\int_{\frac{(1+\tau)(\beta_0 B_0-\beta_1 b_1)}{c(1+\tau)-(1-\beta_1\gamma)\tau}}\left[x-\frac{(1+\tau)(\rho Z(ys,h)-\beta_1 b_1)}{1+\beta_1\gamma\tau}\right]dG_h(x)\right\}(\lambda_{0,h}-\lambda_{1,h}). \tag{13}$$

Individuals are characterized by an individual-specific cost $\kappa \sim K(\kappa)$ which summarizes any monetary cost, ability-related cost and preference-related cost in acquiring a schooling level h_2 with respect to a schooling level h_1. The discounted equilibrium value of unemployment corresponds by definition to the present discounted value of participating in a labor market characterized by $\langle \Gamma', Y(\cdot), G_h(\cdot)\rangle$. This is the value individuals will look at ex-ante when deciding the optimal level of schooling. If $Z(ys,h_1) > Z(ys,h_2)$ the decision is trivial and no one will acquire education level h_2. If $Z(ys,h_1) < Z(ys,h_2)$ then there will exist a reservation cost value $\kappa^*(y)$ such that

$$\kappa^*(y) = Z(ys,h_2) - Z(ys,h_1). \tag{14}$$

By combining this with equation (13), we can write the fraction of individuals who will acquire education level h_2

$$K(\kappa^*) = K(\kappa^*(0))\,Y(y^*) + \int_{y^*} K(\kappa^*(y))\,dY(y). \tag{15}$$

3 Identification

3.1 Baseline Model

We hereby consider identification of the model's primitive parameters $\Theta = \langle \Gamma, G(x)\rangle$ in the baseline environment with no self-employment and homogenous schooling markets under the equilibrium case (1.A) based on data containing the following information: accepted wages (w_i), unemployment durations (t_i) and an indicator of the legal status of the job (f_i). The separate identification of the bargaining power parameter is difficult without demand side information; therefore, we resort to a common assumption in the literature, which is to assume symmetric bargaining, or $\alpha = \frac{1}{2}$. We further fix some of the parameters in order to closely replicate the structure of the extra-monetary benefits currently in place in the mexican labor market. In particular, we set $\gamma = 0.55, B_0 = 1.27, \tau = 0.33$. We then proceed by steps so as to sequentially identify the remaining parameters. First, following Flinn and Heckman (1982) we identify non-parametrically the reservation wages by using the minimum observed wage for both legal and illegal employees as a strongly consistent estimator:

$$w^{min}(0) \equiv \min_{\{i:f_i=0\}} \{w_i\} = \widehat{w^*(0)}, \tag{16}$$

$$w^{min}(1) \equiv \min_{\{i:f_i=1\}} \{w_i\} = \widehat{\tilde{w}(1)}, \tag{17}$$

where

$$w^*(0) = w(x^*(0)) = \rho Z(ys) - \beta_0 B_0, \tag{18}$$

$$\tilde{w}(1) = w(\tilde{x}, 1) = \frac{\alpha(\beta_0 B_0 - \beta_1 b_1)}{c(1+\tau) - (1-\beta_1\gamma)\tau} + \frac{(1-\alpha)(\rho Z(ys) - \beta_1 b_1)}{1+\beta_1\gamma\tau}. \tag{19}$$

Second, we impose a standard distributional assumption on the match distribution in order to identify the wage offers distribution from the accepted wage distributions. In particular, we assume that $G(x)$ is log-normal with parameters (μ, σ). This recoverability condition together with knowledge of reservation wages allow us jointly identifying the sampling distribution of $G(x)$, along with the preferences for job status β_0 and β_1 and the cost of signing illegal job contracts c by inverting the mapping wage-productivity implied by Nash bargaining[6]

$$\begin{aligned} F(w_i|f_i = 1) &= P\left[w(x,1) \leq w_i | f_i = 1\right] \\ &= G\left\{\frac{1+\tau}{\alpha}\left[w_i - w^{min}(1)\right] + \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1\gamma)\tau}{1+\tau}}\right\}, \end{aligned} \tag{20}$$

$$\begin{aligned} F(w_i|f_i = 0) &= P\left[w(x,0) \leq w_i | f_i = 0\right] \\ &= G\left\{\frac{1}{\alpha(1-c)}\left[w_i - (1-\alpha)w^{min}(0)\right]\right\}. \end{aligned} \tag{21}$$

[6]Equilibrium wages implied by Nash-Bargaining for legal and illegal workers are

$$w(x,1) = \frac{\alpha}{1+\tau}x + (1-\alpha)w(x^*(1)),$$
$$w(x,0) = \alpha(1-c)x + (1-\alpha)w(x^*(0)).$$

Given equilibrium case (1.A) discussed in the main text, the reservation wage for legal employees is

$$w(\tilde{x},1) = \frac{\alpha}{1+\tau}\tilde{x} + (1-\alpha)w(x^*(1)).$$

Hence

$$w(x^*(1)) = \frac{1}{1-\alpha}\left[w(\tilde{x},1) - \frac{\alpha}{(1+\tau)}\tilde{x}\right].$$

After imposing (16) and (17) and plugging this onto the equilibrium wage for legal employees and solving for the respective productivity values we get the arguments of the distribution functions (20)-(21).

Third, given that the arrival rate of matches follows a Poisson process with parameter λ, it can be shown that the hazard rate out of unemployment is constant over time and equal to

$$r = \lambda \tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\}. \tag{22}$$

It can also be shown that the expected duration in unemployment is equal to the inverse of the hazard rate. Hence, knowledge of unemployment durations in the sample together with equation (22) allows to identify the parameter λ, while by plugging (22) into the steady state flows of workers in and out of unemployment

$$U = \frac{\eta}{\eta + r}, \tag{23}$$

together with knowledge of the unemployment rate, allows to identify η.

Finally, note that the parameters ξ and ρ can only be jointly identified using the equilibrium equation (9)

$$\begin{aligned} w^{min}(0) = \frac{\xi}{1-c} &+ \frac{\lambda\alpha}{(1-c)(\rho+\eta)} \left\{ \int_{\frac{w^{min}(0)}{1-c}}^{\alpha(1-c)\tilde{x}+(1-\alpha)w^{min}(0)} \left[w - \frac{w^{min}(0)}{1-c} \right] dF(w) \right\} \\ &+ \frac{\lambda\alpha}{(1-c)(\rho+\eta)} \left\{ \int_{w^{min}(1)} \left[w - (1+\tau) w^{min}(1) \right] dF(w) \right\}. \end{aligned} \tag{24}$$

Likelihood contributions. The likelihood of a sample extracted from this steady state equilibrium is given by the contribution of unemployed and employed individuals. In order to obtain the contribution of unemployed individuals, we assume that (on-going) unemployment durations are exponential with parameter equal to the hazard rate

$$d(t_i | i \in U) = \lambda \tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\} \exp \left[-\lambda \tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\} t_i \right], t_i > 0. \tag{25}$$

Weighting this density by the relative steady-state probability we obtain

$$f_u(t_i, i \in U) = \frac{\eta}{\eta + r} \lambda \tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\} \exp \left[-\lambda \tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\} t_i \right], t_i > 0. \tag{26}$$

The contribution of employed individuals is based on the mapping between wages and match values reported in equations (20)-(21). We first write the corresponding densities conditional on agent i accepting a (legal or illegal) wage offer

$$f[w_i|w_i > w^{min}(1), f_i = 1] = \frac{\frac{1+\tau}{\alpha} g \left\{ \frac{1+\tau}{\alpha} \left[w_i - w^{min}(1) \right] + \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\}}{\tilde{G} \left\{ \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\}}, \quad (27)$$

$$f[w_i|w_i > w^{min}(0), f_i = 0] = \frac{\frac{1}{\alpha(1-c)} g \left\{ \frac{1}{\alpha(1-c)} \left[w_i - (1-\alpha) w^{min}(0) \right] \right\}}{\tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\}}. \quad (28)$$

Weighting these expressions by the relative steady-state probabilities of legal and illegal employment, we obtain

$$f_{w1}(w_i, f_i = 1|w_i > w^{min}(1)) = \left[\frac{r(1)}{\eta + r(1) + r(0)} \right] \frac{\frac{1+\tau}{\alpha} g \left\{ \frac{1+\tau}{\alpha} \left[w_i - w^{min}(1) \right] + \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\}}{\tilde{G} \left\{ \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\}}, , \quad (29)$$

$$f_{w0}[w_i, f_i = 0|w_i > w^{min}(0)] = \left[\frac{r(0)}{\eta + r(1) + r(0)} \right] \frac{\frac{1}{\alpha(1-c)} g \left\{ \frac{1}{\alpha(1-c)} \left[w_i - (1-\alpha) w^{min}(0) \right] \right\}}{\tilde{G} \left\{ \frac{w^{min}(0)}{1-c} \right\}}, , \quad (30)$$

where the hazard rates out of unemployment into the legal and illegal employment status are

$$r(1) = \lambda \tilde{G} \left\{ \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\}, \quad (31)$$

$$r(0) = \lambda \left[G \left\{ \frac{\beta_0 B_0 - \beta_1 b_1}{c - \frac{(1-\beta_1 \gamma)\tau}{1+\tau}} \right\} - G \left(\frac{w^{min}(0)}{1-c} \right) \right]. \quad (32)$$

Identification results. The preference parameters (β_0 and β_1) and the cost of signing illegal job contracts (c) are specific to our model and not commonly found in the literature. Those parameters enter into the distribution functions (20)-(21) and hence they are identified using the log likelihood function of wages (29)-(30).

Identification of c relies on the functional form of the per-worker penalty the firm has to pay if discovered employing an informal worker. In the value function for a job filled at the firm (4), we have assumed that the cost of informality is proportional to the match-specific productivity value. We believe this a natural assumption given that the legal authorities may find it easier to inspect more productive firms, and that fines are actually increasing with illegal workers' wage (which, in turn, depends positively on firms' productivity).

Identification of β_0 and β_1 stems directly from the bargaining equilibrium discussed in Section 2. Insofar as employers and job seekers bargain over both the wage and the legal status of the job, workers' valuations of the relative extra-wage benefits not only affect equilibrium wages (6) but they also determine the level of the match-specific productivity value at which both employees and firms are indifferent between a legal and an illegal job (8). Under equilibrium case 1.A, the cost of providing a legal job is lower for highly productive matches and hence only relatively lower productivity matches will be associated with illegal jobs. Hence, the resulting reservation wage of working as a legal employee (19) embeds a positive premium which compensates the worker for not having an illegal job that depends on workers' valuation over the extra-wage benefits implied by the two job contracts.

4 Data

For identification purposes, we need a data set reporting accepted wages and an indicator for the legal status of the job (defined according to whether employees are registered or not in the social-security payrolls), self-employment and unemployment durations and information regarding the latest level of schooling attained.

The data is extracted from Mexico's national labor force survey (ENOE, by its spanish acronym) for the first quarter of the year 2013. We restrict the sample to nonagricultural male workers between the ages of 35 and 55 who reside in urban areas. We further drop those who did not complete primary schooling 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 (h_2) or not (h_1). In order to obtain a more homogenous population of self-employed individuals, we drop those who report having paid employees (roughly 30%). Table 1 reports descriptive statistics for the final sample we use in the empirical analysis.

5 Results

To be added..

Table 1. Descriptive Statistics - ENOE 2013:Q1

Education group	Incomplete Secondary			Complete Secondary		
Labor market state	Formal	Informal	Self-Empl.	Formal	Informal	Self-Empl.
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Hourly Wage	30.29	24.61	31.87	38.64	28.25	35.89
SD Hourly Wage	16.45	13.94	21.03	22.35	18.76	25.66
Employment Rates	0.46	0.29	0.21	0.60	0.18	0.18
Mean Unempl. Duration (months)		2.23			2.72	
Mean Self-Empl. Duration (years)		12.47			11.17	
Number of Observations	5396	3389	2445	2937	862	882

NOTE: The definition of earnings in the publicly available version of the ENOE refers to monthly ”equivalent” earnings from the main job after taxes and Social Security contributions, including overtime premia and bonuses. For those paid by the week, the survey transforms weekly earnings into monthly earnings by multiplying the former by 4.3. Similar adjustments are used for workers paid by the day or every two weeks.

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