Assessing the Impact of Informal Sector Employment on Young Less-Educated Workers*

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Abstract

In this paper, we develop a search and matching model that allows for two important channels through which participation in the informal sector may benefit low-skill workers: (i) human capital accumulation, and (ii) employer screening. We calibrate our model using the ENOE, a Mexican household survey on income and labor dynamics. We consider a set of counterfactual policy experiments where the rate of human capital accumulation and employer screening are reduced from their calibrated levels and assess the effect these changes have on key equilibrium outcomes. The results highlight the importance of both roles of informal jobs in the determination of unemployment and the size of the informal sector. We also conduct a second set of counterfactual policy experiments to assess how labor market reforms designed to limit the informal sector impact the workers in question. Our results favor reducing regulations in the formal sector rather than increasing the likelihood of punishment in the informal sector, as the latter set of policies is found to adversely affect employment and vacancy creation.

Keywords: Informal Sector, Labor Search, Employer Screening, Human Capital Formation.

JEL Classification: J46, J64, J68, O17

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1 Introduction

In developing countries a substantial fraction of workers are employed through irregular *under-the-table* jobs. Jobs such as these are typically referred to as "informal jobs," and taken together, constitute the informal sector. Traditionally, the informal sector carries negative connotations such as poor working conditions, low pay, lack of basic benefits, and lower productivity. It has been argued that the existence of a large informal sector can negatively affect growth by congesting public services (e.g., Loayza, 1996). However, other studies have considered the possible benefits of informal sector participation, arguing that jobs in the informal sector provide young low-skilled workers with employment and worker-training opportunities outside of those offered in the formal sector or by the government (Hemmer and Mannel, 1989).

In the spirit of this last argument, our study examines the extent to which informal sector employment provides young less-educated workers with opportunities to advance their career and transition into formal-sector jobs. We focus on two possible channels through which informal-sector jobs may benefit these workers: (i) informality may provide workers with the opportunity to accumulate human capital and gain the skills required by formal-sector employers, and (ii) informality may provide firms with a cost effective way to screen employees and determine their specific skill level. While the existing literature provides empirical support for each of these mechanisms, our paper is the first to consider their combined effect within a calibrated labor market search model.[1]

Our focus on the beneficial role of informal labor market participation is motivated by the labor market experience of young less-educated workers in Mexico. Figure 1 describes the distribution of less-educated workers by sector of employment and age in Mexico. Inspection of Figure 1 clearly shows that the youngest less-educated workers are predominantly employed in the informal sector. Furthermore, moving across age cohorts, we find that the proportion of workers employed in the informal (formal) sector decreases (increases) monotonically with age. This pattern of employment adjustment continues until workers reach their mid-twenties, at which point sectoral employment shares remain more or less constant. This pattern is consistent with the idea that informal-sector jobs can serve as a "port of entry" into the labor market for young less-educated workers (Arias and Maloney, 2007), and it supports the notion that informal positions have lower barriers to entry than their formal-sector counterparts (Fields, 2009). If these are true, and if the formal sector offers better

[1] Cano-Urbina (2016) finds evidence which suggest that informal jobs facilitate the accumulation of general human capital among less-educated workers, while Cano-Urbina (2015) finds evidence that suggests informal jobs serve as a screening device used by firms to reduce the information problems associated with hiring workers with limited work histories.

Figure 1: Distribution of Less-Educated Workers by Sector of Employment in Mexico by Age

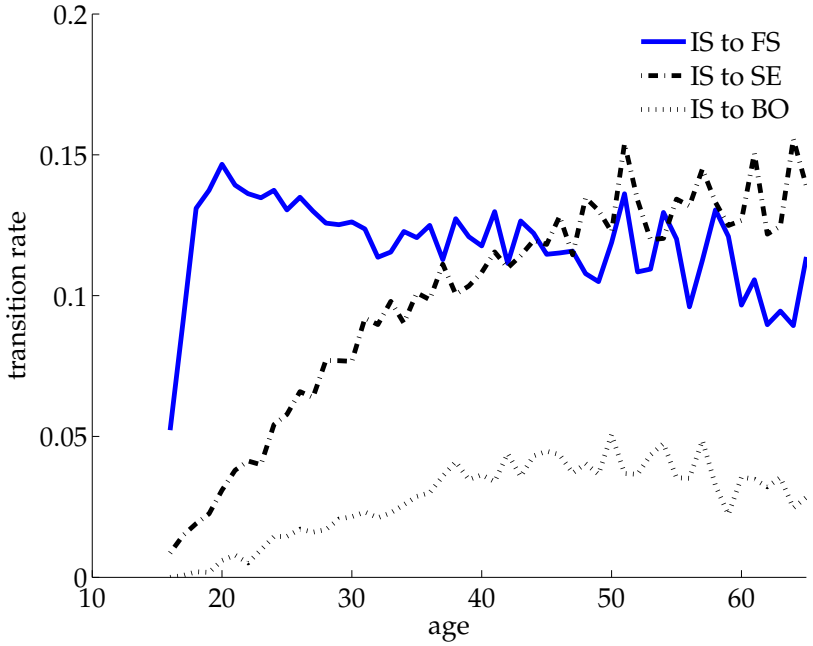
Notes: Male workers with less than 12 years of education. The lines correspond to the proportion of workers employed in each sector by age. Data obtained from the Mexican survey ENOE (*Encuesta Nacional de Empleo Urbano*) for years 2005-2010. Figure taken from Cano-Urbina (2015).

job opportunities than the informal sector, then the distribution of less-educated workers in the formal and informal sector presented in Figure 1 is consistent with the possibility that informal-sector jobs offer less-educated workers some opportunities that facilitate their entry into the formal sector.[2]

Given the empirical evidence discussed above, we consider two possible channels through which employment within informal jobs may facilitate transitions into formal employment for young less-educated workers: human capital accumulation and employer screening. Both of these mechanisms have been considered in the existing literature (see Cano-Urbina, 2015). However, while previous work has modeled each mechanism independently, we develop a model which allows both mechanisms to operate within the same equilibrium model. The importance of introducing both mechanisms within a single model environment can be seen in Figure 2. Notice that the adjustment from informal to formal employment occurs at a

[2]Note that Figure 1 makes clear that we are treating informal-sector workers separately from self-employed workers. That is, when we refer to the informal sector, we refer to those salaried workers. Some studies pool informal salaried and self-employed in the same category. Our reason to separate informal salaried from self-employed corresponds to our interest in human capital accumulation and screening of workers skills, which might not be very relevant, specially screening, for a self-employed worker.

Figure 2: Transition Rate of Less-Educated Workers in Mexico by Age



Notes: Male workers with less than 12 years of education. Number of transitions as a fraction of the number of workers in the informal sector. IS = Informal Sector, FS = Formal Sector, SE = Self-employed, BO = Boss/Employer. Data obtained from the Mexican survey ENOE (*Encuesta Nacional de Empleo Urbano*) for years 2005-2010. Figure taken from Cano-Urbina (2015).

non-linear rate. The transitions increase very fast for the first few years, say from ages 16 to 19. Then the rate of transition starts slowing down around age 20 and continues gradually decreasing over the following decades. This pattern of adjustment is consistent with rapid employer screening during individuals' first few working years, followed by a gradual rate of human capital accumulation. This suggests that including both mechanisms is needed to account for the dynamics observed in the data.[3]

We introduce both employer screening and human capital accumulation within a two-sector labor search model. In our model, firms create vacancies in either the formal or the informal sector. Positions in the formal sector benefit from higher average productivity and, as a consequence, offer higher wages on average. However, firms operating formally are required to pay firing costs whenever a worker separates from the firm. These firing

[3]The way we model both mechanisms in this paper is very general and can account for other more elaborate or specific mechanisms that give an important role to informal jobs in the early careers of less-educated workers. It becomes clear below that the employer screening mechanism also involves workers learning about their skills (and interests). These mechanisms can also interact so that human capital accumulation can work both as a screening mechanism and to help some workers accumulate skills. We discuss these possibilities below when present the theoretical model.

costs stand in for all of the regulatory burdens present in the formal sector and will be parameterized accordingly. Positions created informally are not subject to firing costs, but are on average less productive and generally offer lower wages. Also, there is a central authority (or government) that monitors informal activity. If a firm is caught operating informally, its position is destroyed and the firm faces a fine or penalty.

Workers in our model differ in terms of their skill level (high or low). However, while agents are endowed with a specific skill level at birth, we assume that all workers enter the labor market with an unknown/unobserved skill level that is revealed randomly while working in either sector. Therefore, workers in our model exist in one of three states related to their skills: unknown, high or low. If a worker is revealed as being low-skilled, they can become high-skilled over time by working in either sector. Once a worker becomes high-skilled, they remain high-skilled until they permanently exit the labor market. The processes by which workers' skill levels are revealed and low-skilled workers transition to high-skilled correspond to the employer screening and human capital accumulation mechanisms, respectively.

Workers and firms meet through a standard matching process where unemployed workers search for employment randomly across both sectors, regardless of their skill level. Once a worker and firm meet, they draw a match-specific productivity from a known distribution and only meetings with match-specific productivity larger than a hiring standard result in the creation of a job. If the match-specific productivity is lower than the hiring standard, both workers and firms keep searching for better matches. As a consequence, endogenous hiring cutoff rules will be formed to determine the minimum match-specific productivity needed before forming a productive match (e.g., hiring the worker). Given that workers may exist in one of three skill states (unknown, high, or low) and that employment may occur in one of two sectors (formal and informal), our model will endogenously generate six different hiring cutoff rules. Variation across these cutoff rules in our baseline model can be used to provide evidence in support of the "port-of-entry" role for informal employment. Finally, once a workers find a job in the informal sector, we assume that they keep searching for formal employment.[4]

Our paper contributes to the literature in the following four ways. First, we develop a multi-sector search and matching model that allows for both employer screening and human capital accumulation. As discussed above, the dynamics of informal to formal employment transitions observed in the data are suggestive of multiple mechanisms operating simultane-

[4]This type of on-the-job search is necessary for our model to be able to capture the large rate of direct transition between informal and formal employment. While there is also empirical justification to allow for some level of on-the-job search within sectors and from formal to informal jobs, we abstract from these within-sector transitions and only consider transitions from informal to formal jobs to focus on understanding the role of the informal sector in the careers of less-educated workers.

ously (e.g., rapid employer screening and gradual human capital accumulation). Second, we use both aggregate data and individual-level survey data to calibrate our baseline model to replicate features of the Mexican labor market. Of key interest are the parameters governing the rate of employer screening and human capital accumulation. We estimate these parameters using data on the duration between large wage adjustments for both the very young (age 16-20) and the relatively old (age 25-30) within our sample.[5] Third, we use the results of our baseline calibrated model to provide evidence in support of the "port-of-entry" role of informal employment. Specifically, we find that the endogenous hiring cutoff for agents with unknown skill level differs substantially across sectors, with the informal sector cutoff being substantively less restrictive than the cutoff for the formal sector. As a consequence, our model suggests that new labor market entrants are more likely to flow from unemployment into temporary informal sector employment until they have their skill-type revealed and gain human capital. And lastly, we use our calibrated model to conduct two sets of counterfactual experiments.

The first set of experiments adjust the rates of employer screening and human capital accumulation from their calibrated levels and assesses how these adjustments effect equilibrium outcomes such as the size of the informal sector and the unemployment rate, both at the aggregate and skill-specific levels. The changes in equilibrium outcomes are then used to assess the relative importance of each channel in determining the labor market outcomes of young less-educated workers. The results indicate that reducing either the rate of human capital accumulation or the rate of employer learning results in higher unemployment and a larger fraction of workers employed in the informal sector. These results suggest that both employer learning and human capital are important roles played by the informal sector making it a stepping stone for workers to get access to better formal-sector jobs.

The second set of experiments are used to determine the labor market implications of two contrasting policies that both attempt to restrict the size of the informal sector. Policies that attempt to restrict informal-sector participation typically focus on firm behavior by either (i) increasing the punishment for non-compliance, or (ii) reducing the regulatory burden associated with formal-sector participation. We consider the impact of both types of polices within our model environment. For the first type of policy, we consider an exogenous increase in the probability of being detected when operating informally (e.g., an increase in the expected cost of creating jobs in the informal sector). As for the second type of policy, we consider an exogenous reduction in the firing costs faced by formal sector firms, thereby reducing the expected cost of creating jobs in the formal sector. To ensure comparability across policy experiments, the policy variables are adjusted to the point where the share

[5] A detailed description of our full calibration process is presented below.

of employment in the informal sector reaches a predefined target. Our fundings support reducing firing costs as this policy change is associated with a relaxation in hiring standards in the economy and a modest reduction in the unemployment rate.

The rest of the paper is organized as follows. Section 2 presents the model, while Section 3 describes the survey data we use for our calibration and Section 4 describes our calibration strategy. Section 5 discusses the results of our baseline calibration and the policy experiments. Section 5 concludes.

2 The Model

We consider a labor market with two sectors, one formal and one informal. Firms in the formal sector are on average more productive than firms in the informal sector. This difference in average productivity between sectors could be a result of formal-sector firms having access to better outside financing and more investment in physical capital than informal-sector firms (as modeled in Amaral and Quintin, 2006). The institutional differences between formal and informal firms are: (i) formal-sector firms are subject to a firing cost incurred when matches are destroyed whereas informal-sector firms do not incur this cost, and (ii) informal-sector firms are subject to a penalty if they are caught by the authorities in which case the job is destroyed whereas formal-sector firms do not incur this penalty.[6]

Workers possess one of two skill levels: low or high. However when workers first enter the labor market their skill level is unknown. We assume that neither the worker nor the firm know the worker's skill level, so that information about the new worker's skill level is symmetric, and all that is known is that a fraction ν of these new workers are low skilled. We refer to new workers with unknown skill level as "newcomers." All newcomers enter the labor market through unemployment where they search for jobs in both the formal and informal sectors. When workers find a job in the formal or informal sector their skill level can be revealed. Skills cannot be revealed while the newcomer is unemployed. Workers' skills are revealed according to a stochastic process such that at every moment a worker's skill level can be revealed with probability σ_F if the worker is employed in the formal sector and σ_I if employed in the informal sector. High-skilled workers are on average more productive than low-skilled workers.

Once a worker's skill level is revealed, those workers who are found to be low skilled can accumulate human capital and become high skilled while employed in the formal or

[6]It should be mentioned that the regulatory costs of formality extend well beyond that of firing costs and include additional costs ranging from paid sick leave and vacation days, to employer-paid tax bills. To simplify our model environment we summarize these costs into an aggregate term that we call "firing costs."

the informal sector, but not while unemployed. Similar to the skill-revelation process, the process of human capital accumulation is also a stochastic process such that at every moment a low-skilled worker accumulates human capital and becomes high skilled with probability κ_F if employed in the formal sector and with probability κ_I if employed in the informal sector.

All unemployed workers search for jobs in both the formal and informal sectors, irrespective of their skill level and of whether their skill level is known. Given this job-search behavior, unemployed workers contact firms in the informal sector according to the function:

$$(1) \quad m_I(u, v_I) = \gamma_1^I u^{\gamma_2^I} v_I^{1-\gamma_2^I}$$

where u is the total unemployment rate across all skill types, and v_I is the number of vacant informal-sector jobs as a fraction of the labor force. The total unemployment rate is defined as $u = u_N + u_H + u_L$, where u_N, u_H, and u_L are the unemployment rate of newcomers, high-skilled, and low-skilled workers, respectively. The function $m_I(\cdot, \cdot)$ is increasing in both its arguments, concave, and homogenous of degree one. As a result, informal-sector firms contact unemployed workers at rate $q_I = m_I(u, v_I)/v_I = \gamma_1^I \theta_I^{-\gamma_2^I}$, where $\theta_I = v_I/u$ is the labor-market tightness in the informal sector. Similarly, unemployed workers contact informal-sector firms at rate $f_I = m_I(u, v_I)/u = \gamma_1^I \theta_I^{1-\gamma_2^I}$.

When workers find a job in the informal sector, these workers keep searching for jobs in the formal sector and move to a formal-sector job whenever it is optimal for them to do so. The search effort of informal-sector workers is not equally efficient as that of unemployed workers. Workers who find a job in the formal sector do not search for jobs in the informal sector. We abstract from on-the-job search within sector. Given this job-search behavior, unemployed and informal-sector workers contact formal-sector firms according to the function:

$$(2) \quad m_F(u + n_I, v_F) = \gamma_1^F (u + n_I)^{\gamma_2^F} v_F^{1-\gamma_2^F}$$

where n_I is the total number of workers employed in the informal sector across all skill types as a fraction of the labor force and v_F is the number of vacant formal-sector jobs as a fraction of the labor force. Similar to u, n_I is defined as $n_I = n_{IN} + n_{IH} + n_{IL}$, where n_{IN}, n_{IH}, and n_{IL} are the number of informal workers who are newcomers, high-skilled, and low-skilled, respectively, as a fraction of the labor force. The function $m_F(\cdot, \cdot)$ is increasing in both its arguments, concave, and homogenous of degree one. Following Bosch and Esteban-Pretel (2012) we allow for the possibility that unemployed and informal-sector workers are not equally efficient in their job search efforts. Then, formal-sector firms contact unemployed

individuals at rate $q_F = m_F(u + n_I, v_F)/v_F = \gamma_1^F \theta_F^{-\gamma_2^F}$ where $\theta_F = v_F/(u + n_I)$ is the labor-market tightness in the formal sector, and contact informal-sector workers at rate ηq_F, where η is the parameter that summarizes the relative efficiency in job search behavior between unemployed and informal-sector workers. Similarly, unemployed individuals contact formal-sector firms with unfilled vacancies at rate $f_F = m_F(u + n_I, v_F)/(u + n_I) = \gamma_1^F \theta_F^{1-\gamma_2^F}$, and informal-sector workers at rate ηf_F.[7]

Not all contacts between job seekers and firms result in a match being created. We assume that matches in the formal and informal sectors are created according to a stochastic job matching process as in chapter 6 of Pissarides (2000). That is, when a firm and a job seeker make contact they draw a match quality x from a distribution $G(x)$ with support on $[0, 1]$. Then, only those contacts with a match quality higher than a hiring standard end up in a match being created. Once the match quality is drawn it stays constant, if the match is created, until the match is destroyed. As we show below, hiring standards depend on the sector of employment (formal or informal), on the worker's skill level, and whether the skill level has been revealed yet. We denote the hiring standards in sector $j \in \{F, I\}$ as C_{jN}, C_{jH}, and C_{jL} for newcomers, high-skilled, and low-skilled workers, respectively, where $j = F$ corresponds to the formal sector and $j = I$ to the informal sector. We do not impose any ordering on these cut-offs but instead their ordering is an equilibrium outcome. As a result, it is possible that a match between a newcomer and a firm is destroyed once the newcomer's skill level is revealed if the current match quality is lower than the hiring standard for the revealed skill level of the worker.[8]

We assume that formal-sector matches are exogenously destroyed at a Poisson rate λ_F and that informal-sector matches are exogenously destroyed at Poisson rate λ_I. Formal-sector firms incur cost $D > 0$ when a match is exogenously destroyed. Formal-sector job destruction after the newcomer's skill is revealed is also subject to the firing costs D. Additionally, jobs in the informal sector can be exogenously destroyed when informal-sector firms are caught by the authorities, which happens with probability π. Informal-sector firms incur cost $T > 0$ when caught by the authorities.

Finally, we assume that workers exit the labor market permanently at an exogenous rate τ regardless of their current employment state and regardless of their skill level. Since work-

[7]Bosch and Esteban-Pretel assume that $\eta < 1$ so that informal-sector workers are less efficient in their search efforts than unemployed workers (see first paragraph of page 277 of Bosch and Esteban-Pretel, 2012). Recent work by Faberman et al. (2017) suggests that on-the-job search in the US labor market is more efficient than search while unemployed which would imply that $\eta > 1$. We follow Bosch and Esteban-Pretel in our calibration exercise below.

[8]That is, suppose that the current match quality between a newcomer and a formal-sector firm is $\tilde{x}$, then, if the worker is revealed low skilled and $\tilde{x} < C_{FL}$ the match is destroyed, or if the worker is revealed high skilled and $\tilde{x} < C_{FH}$ the match is destroyed.

ers exit permanently regardless of their employment state, job matches are also destroyed when the worker permanently exits the labor market, however this job destruction does not generate firing costs for firms. We assume that every worker that exits the labor market permanently is replaced by a newcomer that enters the labor market through unemployment and that is low-skilled with probability ν regardless of the skill level of the worker that permanently exited the labor market.

2.1 Steady-State Worker Flows

This section presents and describes the steady-state worker flows in our model. The equations for the worker flows represent the first block of equations in the definition of equilibrium. Figure 3 presents a graphical diagram of the equilibrium worker flows in our model. Each box in the figure represents a state in which a worker can be. There are nine states in the labor market which correspond to every combination of the three worker's employment status (unemployment, formal-sector employment, and informal-sector employment) with the three worker's skill-level situations (newcomer, low-skilled, and high-skilled). To avoid cluttering the picture more than necessary we do not specify the transition probabilities between these states but we discuss them next. For the same reason, the picture does not include transitions of workers permanently exiting the labor market which would be depicted as arrows out of each of the boxes in the picture.

First, all workers enter the labor market as newcomers through unemployment in the far left side of the diagram in box U_N. While unemployed, newcomers search for jobs in both formal and informal sectors. Unemployed newcomers, in box U_N, can move out of this state in three ways. With probability $f_F\bar{G}(C_{FN})$ a newcomer gets a formal-sector job moving to box FS_N, where $\bar{G}(\cdot) = 1 - G(\cdot)$. With probability $f_I\bar{G}(C_{IN})$ gets an informal-sector job moving to box IS_N. With probability τ exits the labor market permanently (the arrow is not shown in the picture).

A newcomer employed in the formal sector, in box FS_N, can move out of this state in three different ways. Loose job due to exogenous job destruction with probability λ_F and move back to box U_N. Have his type revealed with probability σ_F and move to boxes FS_H or FS_L, if the current match quality is good enough to keep the job, or move to boxes U_H or U_L, if the match quality is not good enough. Exit the labor market permanently with probability τ (the arrow is not shown in the picture).

A newcomer employed in the informal sector, in box IS_N, can move out of this state in the three similar ways as formal-sector newcomers moving to: (i) box U_N if the job is exogenously destroyed, (ii) to boxes IS_H, IS_L, U_H, or U_L if his skill is revealed, which

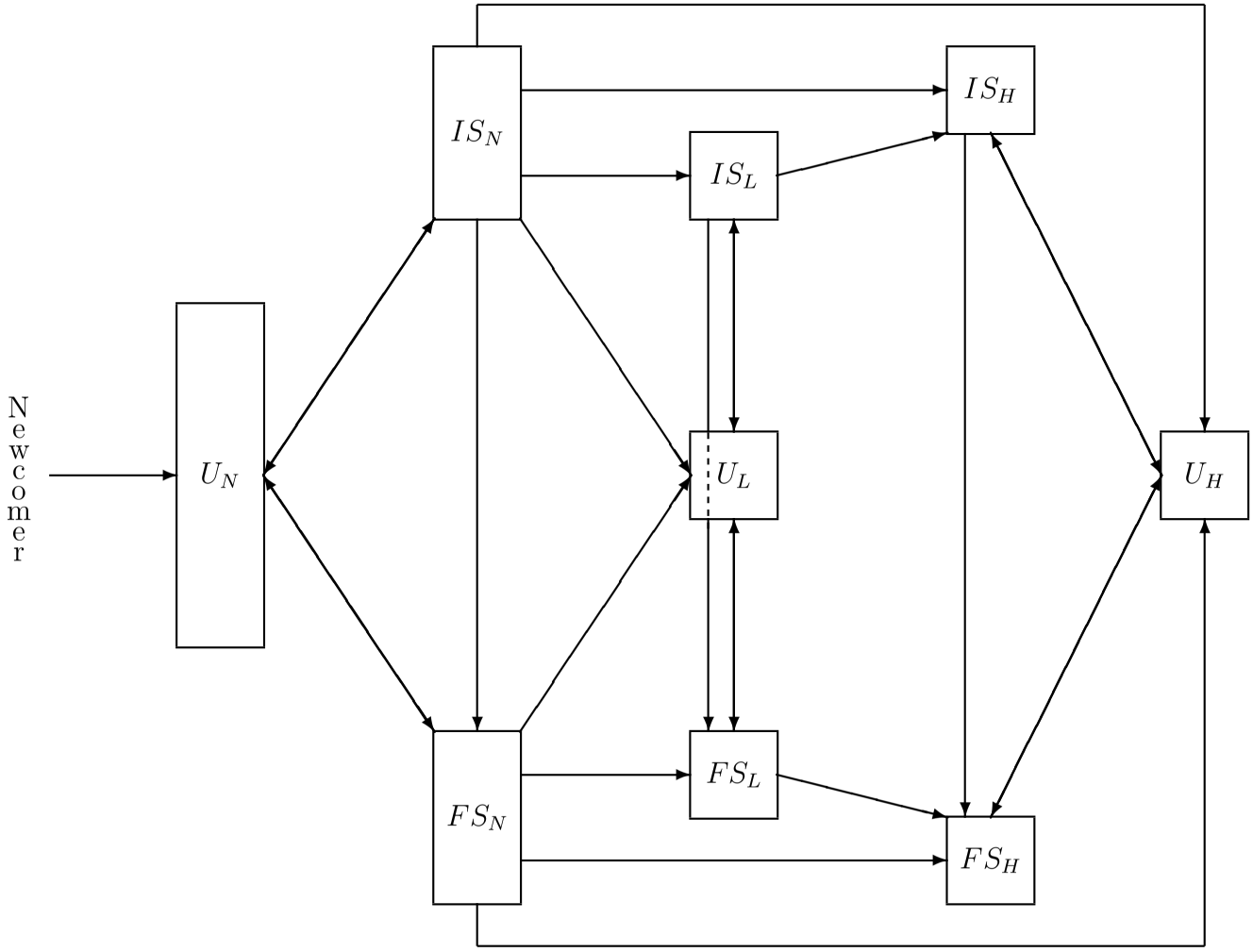
happens with probability σ_I, or (iii) permanently out of the labor market with probability τ. In addition, informal sector newcomers can move out of this state through two other channels: (i) with probability $\eta f_F \bar{G}(C_{FN})$ they get a formal-sector job moving to box FS_N, and (ii) with probability π the informal job is detected by authorities and destroyed moving to box U_N.

Workers whose skill level is revealed as high while working in either the formal or informal sector, keep moving between boxes FS_H, IS_H, and U_H until they permanently leave the labor market which happens with probability τ. Unemployed high-skilled workers in box U_N find a formal job with probability $f_F \bar{G}(C_{FH})$ and an informal job with probability $f_I \bar{G}(C_{IH})$ moving to boxes FS_H and IS_H, respectively. Once employed they can become unemployed if their job is exogenously destroyed with probability λ_F if employed in a formal job and with probability λ_I if employed in an informal job. Those workers employed in an informal job can also loose their job if detected by the authorities with probability π and can also move to the formal sector with probability $\eta f_F \bar{G}(C_{FH})$.

Workers whose skill level is revealed as low while working in either the formal or informal sector also keep moving between boxes FS_L, IS_L, and U_L as with those workers who are high skilled and with analogous probabilities or permanently exit the labor market with probability τ. Low-skilled workers have an additional transition which is moving from boxes FS_L to FS_H or from boxes IS_L to IS_H when they accumulate human capital and become high-skilled workers. Those currently in box FS_L accumulate skills with probability κ_F and those in box IS_L accumulate skills with probability κ_I.

Next, we turn these flows into the equilibrium equations that represent them. In these equilibrium flows, u_k, n_{Fk}, and n_{Ik} represent the number of workers who are unemployed, employed in the formal sector, and employed in the informal sector, respectively, as a fraction of the labor force, for skill level $k \in \{N, H, L\}$, where $k = N$ means that the worker's skill level is not known yet and so is a newcomer. Given the assumptions stated above and the job search and matching behavior we have the following equilibrium worker flows in the steady state:

Figure 3: Worker Flows



NOTES: Every box in the figure represents a particular worker's state. To avoid cluttering the figure even more we do not include the transition probabilities between these workers' states. These probabilities can be inferred from equations (3)-(11). Similarly, to avoid visual cluttering we do not include the probabilities of exiting the labor market permanently, which would be represented as an outward arrow from each box.

$$(3) \quad [\tau + f_F\bar{G}(C_{FN}) + f_I\bar{G}(C_{IN})]u_N = \lambda_F n_{FN} + \lambda_I n_{IN} + \pi n_{IN} + \tau$$

$$(4) \quad [\tau + \lambda_F + \sigma_F]n_{FN} = f_F\bar{G}(C_{FN})u_N + \eta f_F\bar{G}(C_{FN})n_{IN}$$

$$(5) \quad [\tau + \lambda_I + \eta f_F\bar{G}(C_{FN}) + \pi + \sigma_I]n_{IN} = f_I\bar{G}(C_{IN})u_N$$

$$(6) \quad [\tau + \lambda_F + \kappa_F]n_{FL} = f_F\bar{G}(C_{FL})u_L + \eta f_F\bar{G}(C_{FL})n_{IL} + \sigma_F\nu\bar{G}(C_{FL}|x \geq C_{FN})n_{FN}$$

$$(7) \quad [\tau + \lambda_I + \pi + \kappa_I + \eta f_F\bar{G}(C_{FL})]n_{IL} = f_I\bar{G}(C_{IL})u_L + \sigma_I\nu\bar{G}(C_{IL}|x \geq C_{IN})n_{IN}$$

$$(8) \quad [\tau + \lambda_F]n_{FH} = f_F\bar{G}(C_{FH})u_H + \eta f_F\bar{G}(C_{FH})n_{IH} + \kappa_F n_{FL} + \sigma_F(1-\nu)\bar{G}(C_{FH}|x \geq C_{FN})n_{FN}$$

$$(9) \quad [\tau + \lambda_I + \pi + \eta f_F\bar{G}(C_{FH})]n_{IH} = f_I\bar{G}(C_{IH})u_H + \kappa_I n_{IL} + \sigma_I(1-\nu)\bar{G}(C_{IH}|x \geq C_{IN})n_{IN}$$

$$(10) \quad [\tau + f_I\bar{G}(C_{IH}) + f_F\bar{G}(C_{FH})]u_H = \\ = (\lambda_I + \pi)n_{IH} + \lambda_F n_{FH} + \sigma_F(1-\nu)G(C_{FH}|x \geq C_{FN})n_{FN} + \sigma_I(1-\nu)G(C_{IH}|x \geq C_{IN})n_{IN}$$

$$(11) \quad [\tau + f_I\bar{G}(C_{IL}) + f_F\bar{G}(C_{FL})]u_L = \\ = (\lambda_I + \pi)n_{IL} + \lambda_F n_{FL} + \sigma_F\nu G(C_{FL}|x \geq C_{FN})n_{FN} + \sigma_I\nu G(C_{IL}|x \geq C_{IN})n_{IN}$$

where $\bar{G}(\cdot) = 1 - G(\cdot)$. Since all worker shares are represented as a fraction of the labor force we have that:

$$(12) \quad u_N + n_{IN} + n_{FN} + u_L + n_{IL} + n_{FL} + u_H + n_{IH} + n_{FH} = 1$$

The left-hand side of the flows in equations (3)-(11) represent all the worker flows out of a given state and the right-hand side represent all the worker flows into that particular state. For example, equation (3) is the equilibrium flow of newcomers into and out of unemployment. On the left-hand side we have the three channels out of the unemployment state for newcomers: they could exit the labor market permanently with probability τ, they could contact a formal-sector firm with probability f_F and with probability $\bar{G}(C_{FN})$ they create a match, or they could contact an informal-sector firm with probability f_I and with probability $\bar{G}(C_{IN})$ they create a match. Similarly, on the right-hand side we have the four channels into unemployment for newcomers. The first three channels into the newcomers' unemployment are: (i) a match can be exogenously destroyed while a worker is employed in the formal sector with probability λ_F, (ii) or destroyed with probability λ_I if employed in the informal sector, or (iii) destroyed with probability π if employed in the informal sector and the job is detected by authorities. The fourth channel into the newcomers' unemployment state is the replacement of workers who permanently exited the labor market and so a fraction τ of workers flow into unemployment when they enter the labor market for the first time.

All of these transitions are depicted in Figure 3 with the exception of the transitions out of the labor market which would be depicted as arrows pointing out from each of the nine boxes in the picture.

Similarly, equations (4) and (5) show that workers can leave the state of newcomer employment in the formal or informal sector, respectively, as either low- or high-skilled with probabilities σ_F and σ_I, respectively. Notice that equations (6) - (11) describe that when workers' skills are revealed, these workers can loose their jobs. We do not make any assumption about the relative size of the cut-offs C_{jN}, C_{jH}, and C_{jL}, for $j \in \{F, I\}$. Hence, it is possible that a newcomer is hired in the formal sector with match quality $\tilde{x}$ larger than C_{FN}, but that once the worker's skill level is revealed, the match quality $\tilde{x}$ is not larger than the hiring standard corresponding to his revealed type in the formal sector. Equations (8) and (6) indicate that only formal-sector workers with a match quality larger than the cut-off C_{Fk} for $k \in \{H, L\}$ would keep their job and renegotiate their wage with the firm given their revealed skill level. Those whose current match quality is lower than the cut-off would become unemployed and join the group of unemployed of skill level $k \in \{H, L\}$ as it is described in equations (10) and (11). Something similar occurs when skills are revealed in the informal sector as indicated by equations (7) and (9) for workers that keep their informal-sector job and by equations (10) and (11) for workers that loose their informal-sector job.

Finally, these equations show the worker flows when those workers revealed as low skilled accumulate human capital and become high skilled. These transitions are illustrated in equations (6) and (8) for workers who accumulate skills while employed in the formal sector. Similarly, equations (7) and (9) illustrate the worker transitions when low-skilled workers accumulate skills while employed in an informal-sector job.

2.2 Value Functions

In this section, we clearly delineate the differences among our agents by specifying their value functions. We describe the value functions for workers first and then form firms.

2.2.1 Workers

The value function for newcomers while they are unemployed is given by:

$$(13) \quad rU_N = z_N + f_I \int_{C_{IN}}^{1} [W_{IN}(x) - U_N] dG(x) + f_F \int_{C_{FN}}^{1} [W_{FN}(x) - U_N] dG(x) - \tau U_N$$

where z_N is the flow utility in unemployment for newcomers, r is the discount rate, U_N is the value of unemployment for a newcomer, $W_{jN}(x)$ is the value of employment in sector

$j \in \{F, I\}$ for a newcomer with a match quality equal to x. Only those contacts with firms in sector $j \in \{F, I\}$ with a match quality larger than C_{jN} result in a match being created. A successful match in sector $j \in \{F, I\}$ generates a gain equal to $[W_{jN}(x) - U_N]$, given that $x > C_{jN}$, which depends on the distribution $G(\cdot)$. Finally, with probability τ a newcomer who is currently unemployed exits the labor market permanently which results in a loss of U_N.

Once newcomers find a job in the formal or informal sector the value of holding those jobs is given by:

$$
\begin{aligned}
(14) \quad rW_{IN}(x) &= w_{IN}(x) + (\lambda_I + \pi)[U_N - W_{IN}(x)] + \eta f_F \int_{C_{FN}}^{1} [W_{FN}(x') - W_{IN}(x)] dG(x') \\
&+ \sigma_I \nu \Big(\Gamma_{IL}(x)[W_{IL}(x) - W_{IN}(x)] + (1 - \Gamma_{IL}(x))[U_L - W_{IN}(x)] \Big) \\
&+ \sigma_I (1 - \nu) \Big(\Gamma_{IH}(x)[W_{IH}(x) - W_{IN}(x)] + +(1 - \Gamma_{IH}(x))[U_H - W_{IN}(x)] \Big) - \tau W_{IN}(x)
\end{aligned}
$$

$$
\begin{aligned}
(15) \quad rW_{FN}(x) &= w_{FN}(x) + \lambda_F [U_N - W_{FN}(x)] \\
&+ \sigma_F \nu \Big(\Gamma_{FL}(x)[W_{FL}(x) - W_{FN}(x)] + (1 - \Gamma_{FL}(x))[U_L - W_{FN}(x)] \Big) \\
&+ \sigma_F (1 - \nu) \Big(\Gamma_{FH}(x)[W_{FH}(x) - W_{FN}(x)] + (1 - \Gamma_{FL}(x))[U_H - W_{FN}(x)] \Big) - \tau W_{FN}(x)
\end{aligned}
$$

Newcomers receive wage $w_{IN}(x)$ or $w_{FN}(x)$ when they get an informal or a formal job, respectively, and the wage depends on the match quality x drawn when the worker and the firm make contact for the first time. With probability λ_j, $j \in \{F, I\}$, the job is exogenously destroyed in which case newcomers become unemployed. Additionally, an informal-sector job can be exogenously destroyed if the firm is caught by the authorities which happens with probability π. Informal-sector workers keep searching for jobs in the formal sector and with probability ηf_F they contact a formal-sector firm with a vacancy; at this point the firm and the informal-sector worker draw a new match quality x' from distribution $G(\cdot)$ and if the match quality x' is larger than the cut-off for newcomers in the formal sector, C_{FN}, the newcomer quits the informal-sector job and moves into the formal-sector job.[9] When workers move from informal to formal sector they have a gain of $[W_{FN}(x') - W_{IN}(x)]$, given that $x' > C_{FN}$, which again depends on distribution $G(\cdot)$.

[9]Notice that both unemployed and informal newcomers have the same hiring standard, C_{FN}, regardless of their employment status. We follow Pissarides (1994) by assuming that once a match between a worker and a firm occurs the threat point of the worker is unemployment. This is based on the assumption that wage contracts are negotiated continuously. Dolado et al. (2009) and Bosch and Esteban-Pretel (2012) adopt this assumption in their matching models. See page 206 of Dolado et al. (2009) and footnote 20 of Bosch and Esteban-Pretel (2012).

The skill level of a newcomer can be revealed in the formal or informal sectors with probability σ_j, for $j \in \{F, I\}$, and depending on the current match quality the worker and the firm renegotiate their wage contract or separate.[10] This is reflected in the value function with the indicator function $\Gamma_{jk}(x) = \mathbf{1}\{x \geq C_{jk}\}$ for $j \in \{F, I\}$ and $k \in \{H, L\}$. If the current match quality is higher than the corresponding cut-off given the worker's skill level then the contract is renegotiated and the worker has a gain of $[W_{jk}(x) - W_{jN}(x)]$, $j \in \{F, I\}$ and $k \in \{H, L\}$. If the current match quality is lower than the corresponding cut-off the match is destroyed and the worker has negative gain of $[U_k - W_{jN}(x)]$, $j \in \{F, I\}$ and $k \in \{H, L\}$. Finally, if a worker permanently exits the labor market before their skill level is revealed that worker suffers a loss of $W_{jN}(x)$, $j \in \{F, I\}$.

Once a worker's skill level is revealed, workers who are found to be low skilled can accumulate human capital while employed in the formal or the informal sector. The value of employment in the formal or the informal sector for a worker of skill level $k \in \{H, L\}$ is given by:

$$(16) \quad rW_{Ik}(x) = w_{Ik}(x) + (\lambda_I + \pi)[U_k - W_{Ik}(x)] + \eta f_F \int_{C_{Fk}}^{1} [W_{Fk}(x') - W_{Ik}(x)]dG(x') + \kappa_I[W_{IH}(x) - W_{Ik}(x)] - \tau W_{Ik}(x)$$

$$(17) \quad rW_{Fk}(x) = w_{Fk}(x) + \lambda_F[U_k - W_{Fk}(x)] + \kappa_F[W_{FH}(x) - W_{Fk}(x)] - \tau W_{Fk}(x)$$

where the elements of the value functions are very similar to those of newcomers. The difference with the value functions for newcomers is that now that workers' skills have been revealed, low-skilled workers accumulate human capital with probability κ_F and κ_I when employed in the formal and informal sectors, respectively. Workers who accumulate human capital have a gain of $[W_{jH}(x) - W_{jL}(x)]$ for $j \in \{F, I\}$. Notice that the gain associated with human capital accumulation only enters the value function of low-skilled workers.

The value of unemployment for a worker of skill level $k \in \{H, L\}$ is given by:

$$(18) \quad rU_k = z_k + f_I \int_{C_{Ik}}^{1} [W_{Ik}(x) - U_k]dG(x) + f_F \int_{C_{Fk}}^{1} [W_{Fk}(x) - U_k]dG(x) - \tau U_k$$

where only those contacts between an unemployed worker of skill level $k \in \{H, L\}$ and a firm in sector $j \in \{F, I\}$ that draw a match quality x larger than the cut-off C_{jk} result in a match. Notice that human capital accumulation can only happen when low-skilled workers

[10] Intuitively this stochastic process can be understood considering that it takes on average $(1/\sigma_j)$ periods to learn the skill level of a newcomer employed in sector $j \in \{F, I\}$.

are employed in the formal or informal sector but not while unemployed.

2.2.2 Firms

The value of a vacancy for firm in sector $j \in \{F, I\}$ is given by:

$$(19)\quad rV_j = -h_j + q_j\varphi_{jL}\int_{C_{jL}}^{1}[J_{jL}(x) - V_j]dG(x) + q_j\varphi_{jH}\int_{C_{jH}}^{1}[J_{jH}(x) - V_j]dG(x) + q_j(1 - \varphi_{jL} - \varphi_{jH})\int_{C_{jN}}^{1}[J_{jN}(x) - V_j]dG(x)$$

where h_j is the recruitment cost in sector $j \in \{F, I\}$. V_j is the value of a vacancy in sector $j \in \{F, I\}$, and $J_{jL}(x)$, $J_{jH}(x)$, and $J_{jN}(x)$ are the values of a match with a low-skilled, a high-skilled, and a newcomer, respectively, with match quality x for a firm in sector $j \in \{F, I\}$. The φ_{jk} represents the fraction of job seekers of skill level $k \in \{H, L\}$ that contact firms in sector $j \in \{F, I\}$. For example, $\varphi_{IL} = u_L/(u_N + u_L + u_H)$ since only unemployed workers search for informal-sector jobs, but $\varphi_{FL} = (u_L+n_{IL})/(u_N+u_L+u_H+n_{IN}+n_{IL}+n_{IH})$ since both unemployed and informal-sector workers search for formal-sector jobs. Notice that firms do not open skill-specific vacancies. Instead, firms open a vacancy and adjusts their hiring standard depending on the skill level of the worker they meet.

The values of a match for an informal-sector firm with a newcomer or with a worker with skill level $k \in \{H, L\}$ are given by:

$$(20)\quad rJ_{IN}(x) = p_{IN}x - w_{IN}(x) + (\lambda_I + \eta f_F\bar{G}(C_{FN}) + \tau)[V_I - J_{IN}(x)] + \pi[V_I - T - J_{IN}(x)] + \sigma_I\nu\Big(\Gamma_{IL}(x)[J_{IL}(x) - J_{IN}(x)] + (1 - \Gamma_{IL}(x))[V_I - J_{IN}(x)]\Big) + \sigma_I(1 - \nu)\Big(\Gamma_{IH}(x)[J_{IH}(x) - J_{IN}(x)] + (1 - \Gamma_{IH}(x))[V_I - J_{IN}(x)]\Big)$$

$$(21)\quad rJ_{Ik}(x) = p_{Ik}x - w_{Ik}(x) + (\lambda_I + \eta f_F\bar{G}(C_{Fk}) + \tau)[V_I - J_{Ik}(x)] + \kappa_I[J_{IH}(x) - J_{Ik}(x)] + \pi[V_I - T - J_{Ik}(x)]$$

where p_{Ik}, $k \in \{N, H, L\}$, are the worker productivity for newcomers, high-skilled, and low-skilled workers, respectively, when employed in the informal sector, and x is the match-specific quality. Therefore, the output from an informal-sector match is given by $p_{Ik}x$, $k \in \{N, H, L\}$. Notice that these value functions indicate four reasons for termination of informal-sector jobs. The first three are: (i) exogenous job destruction, (ii) the worker finds a formal-sector job and quits, and (iii) the worker permanently exits the labor market. In

these three cases, the firm has a negative gain of $[V_I(x) - J_{Ik}(x)]$ for $k \in \{N, H, L\}$. The fourth reason is if the job is terminated because the authorities caught the informal-sector firm in which case the firm incurs a penalty of T. Notice that the value function for a match with a low-skilled worker ($k = L$) in the informal sector reflects the possibility that the worker accumulates human capital and so the firm has a gain of $[J_{IH}(x) - J_{IL}(x)]$ and this happens with probability κ_I.

The value function for a match with a newcomer in the informal sector reflects the possibility that the worker's skill level is revealed, which happens with probability σ_I. If the worker's skill level is revealed, the firm has a gain of $[J_{IL}(x) - J_{IN}(x)]$ with probability ν and a gain of $[J_{IH}(x) - J_{IN}(x)]$ with probability $(1-\nu)$ given that the current match quality x is higher than the cut-off for low- and high-skilled workers in the informal sector, respectively, which is denoted by the indicator functions $\Gamma_{Ik}(x) = \mathbf{1}\{x > C_{Ik}\}$ for $k \in \{H, L\}$. If the current match quality x is smaller than the cut-off corresponding to the worker's skill level then the firm has a negative gain of $[V_I - J_{IN}(x)]$.

The values of a match for a formal-sector firm with a newcomer or with a worker with skill level $k \in \{H, L\}$ are given by:

$$
\begin{aligned}
(22)\quad rJ_{FN}(x) = {} & p_{FN}x - w_{FN}(x) + \lambda_F[V_F - D - J_{FN}(x)] \\
& + \sigma_F\nu\Big(\Gamma_{FL}(x)[J_{FL}(x) - J_{FN}(x)] + (1 - \Gamma_{FL}(x))[V_F - D - J_{FN}(x)]\Big) \\
& + \sigma_F(1-\nu)\Big(\Gamma_{FH}(x)[J_{FH}(x) - J_{FN}(x)] + (1 - \Gamma_{FH}(x))[V_F - D - J_{FN}(x)]\Big) \\
& + \tau[V_F - J_{FN}(x)]
\end{aligned}
$$

$$
(23)\quad rJ_{Fk}(x) = p_{Fk}x - w_{Fk}(x) + \lambda_F[V_F - D - J_{Fk}(x)] + \kappa_F[J_{FH}(x) - J_{Fk}(x)] + \tau[V_F - J_{Fk}(x)]
$$

where p_{Fk}, $k \in \{N, H, L\}$, are the worker productivity for newcomers, high-skilled, and low-skilled workers, respectively, when employed in the formal sector, and x is the match-specific quality. Notice that, in the formal sector, when jobs are exogenously destroyed the firm incurs a firing cost D and this happens with probability λ_F. However, if the worker permanently exits the labor market the firm does not incur the firing costs D and this happens with probability τ.

The value of a match with a newcomer in the formal sector reflects the possibility that the wage contract with the worker could be renegotiated after the worker's skill level is revealed given that the current match quality x is higher than the cut-off for the corresponding

worker skill level, or that the job is destroyed if the match quality is lower than that cut-off. If the match is destroyed after the worker's skill level is revealed the firm incurs firing cost D. Therefore, if $x > C_{Fk}$ wage contracts get renegotiated and the firm has a gain of $[J_{Fk}(x) - J_{FN}(x)]$ for $k \in \{H, L\}$. If $x < C_{Fk}$ the job is destroyed and the firm has a negative gain of $[V_F - D - J_{FN}(x)]$, $k \in \{H, L\}$.

Finally, notice that the value of a match with a low-skilled worker reflects the possibility of the worker accumulating human capital. If a worker accumulates human capital the firm and the worker renegotiate their contract and the firm has a gain of $[J_{FH}(x) - J_{FL}(x)]$ and this happens with probability κ_F.

Wages for all workers in the labor market are determined according to a surplus-sharing rule that entitles workers to a fraction β of the match surplus. In equilibrium, free entry implies that the profit from one more vacancy in the formal and the informal sectors is zero, and so in equilibrium it is the case that $V_F = V_I = 0$. The surpluses from matches of a firm in sector $j \in \{F, I\}$ and a worker are given by $S_{jk}(x) = W_{jk}(x) - U_k + J_{jk}(x) - V_j$ for $k \in \{N, H, L\}$, and so the surplus-sharing rule dictates that $[W_{jk}(x) - U_k] = \beta S_{jk}(x)$. The wage equations for each combination of worker skill level and employment sector are presented in Appendix A.

2.3 Endogenous Hiring Standards

When workers and firms meet they create a working relationship if and only if they draw a match quality that is higher than a given cutoff. To solve for these endogenous hiring cutoffs, we evaluate the firms' value functions (equations (20) - (23) above) at the specific match quality which brings their value to zero. We denote the hiring standard for a firm in sector $j \in \{F, I\}$ as C_{jk} for $k \in \{N, H, L\}$ when the firm meets a newcomer, a high-skilled, or a low-skilled worker, respectively.

The three hiring standards for the informal sector are given by:

$$p_{IH}C_{IH} = w_{IH}(C_{IH}) + \pi T \tag{24}$$

$$p_{IL}C_{IL} = w_{IL}(C_{IL}) + \pi T - \kappa_I J_{IH}(C_{IL}) \tag{25}$$

$$p_{IN}C_{IN} = w_{IN}(C_{IN}) + \pi T - \sigma\nu\Gamma_{IL}(C_{IN})J_{IL}(C_{IN}) - \sigma(1-\nu)\Gamma_{IH}(C_{IN})J_{IH}(C_{IN}) \tag{26}$$

where $w_{Ik}(C_{Ik})$ for $k \in \{N, H, L\}$ represent the reservation wage in the informal sector for newcomers, high-skilled, and low-skilled workers because those are the wages corresponding to a match quality of $x = C_{Ik}$.[11] The right-hand side of equation (24) shows that the

[11] The reservation wages follow from the steady state wage equations presented in Appendix A, but eval-

hiring standard for high-skilled informal workers depends on the high-skilled reservation wage paid in that sector and the likelihood the firm will be detected and punished for operating informally.[12] Intuitively, increases in either the reservation wage or the likelihood and size of punishment results in firms becoming more selective in hiring, leading to an increase in C_{IH}. Similar mechanisms are also present in equations (25) and (26). However, these expressions must also account for human capital accumulation and employer learning. Specifically, the last term in equation (25) represents the gain to firms when workers transition from low to high skill. The last two terms in equation (26) represent the gain to firms when a newcomer's type is revealed. Therefore, increases in the rate of human capital accumulation and employer learning can be seen to relax hiring standards in the informal sector.

The three hiring standards for the formal sector are given by:

$$(27)\quad p_{FH}C_{FH} = w_{FH}(C_{FH}) + \lambda_F D$$

$$(28)\quad p_{FL}C_{FL} = w_{FL}(C_{FL}) + \lambda_F D - \kappa_F J_{FH}(C_F L)$$

$$(29)\quad p_{FN}C_{FN} = w_{FN}(C_{FN}) + \left[\lambda_F + \sigma\nu(1-\Gamma_{FL}(C_{FN})) + \sigma(1-\nu)(1-\Gamma_{FH}(C_{FN}))\right] D - \sigma\nu\Gamma_{FL}(C_{FN})J_{FL}(C_{FN}) - \sigma(1-\nu)\Gamma_{FH}(C_{FN})J_{FH}(C_{FN})$$

The right-hand side of equation (27) shows that the hiring cutoff for high-skilled formal workers depends on the high-skilled reservation wage in that sector, as well as the expected firing costs the firm must pay. Increases in either the reservation wage or expected firing costs will result in tighter hiring standards and an increase in C_{FH}. Similar mechanisms operate for low-skilled workers and newcomers, but for these workers we must consider the impact of human capital accumulation and employer screening. The last term in equation (28) captures the benefit firms receive when low-skilled workers gain human capital and become high-skilled. Therefore, increases in the rate of human capital accumulation in the formal sector, κ_F, will relax hiring standards and lead to a reduction in C_{FL}. Equation (29) shows that type revelation may either tighten or relax hiring standards depending on the values of $\Gamma_{FL}(C_{FN})$ and $\Gamma_{FH}(C_{FN})$ and on the distribution of workers across types, ν. Specifically, if having a worker's type revealed is likely to lead to a job separation, then this will tighten hiring standards among newcomers in the formal sector and lead to an increase in C_{FN}. If workers are very likely to maintain their employment relationship after having their type revealed, then increases in this rate are likely to relax hiring standards and reduce C_{FN}.

uated at $x = C_{Ik}$ for $k \in \{N, H, L\}$.

[12] To ease exposition, the equations for hiring standards presented in the main text of the paper, equations (24) - (29), are not reduced. See Appendix B for reduced (closed-firm) versions of the hiring standards.

2.4 Job Creation Conditions

The last two equilibrium conditions are determined by the job creation conditions. In equilibrium, free entry in both the formal and informal sectors imply that all gains from an additional vacancy are exploited, so that $V_F = V_I = 0$. Then from equation (19) the job creation condition for firms in sector $j \in \{F, I\}$ is given by:

$$(30) \quad \frac{h_j}{q_j} = \varphi_{jL} \int_{C_{jL}}^{1} J_{jL}(x) dG(x) + \varphi_{jH} \int_{C_{jH}}^{1} J_{jH}(x) dG(x) + (1 - \varphi_{jL} - \varphi_{jH}) \int_{C_{jN}}^{1} J_{jN}(x) dG(x)$$

which indicates that the expected recruitment cost in both sectors should equal the expected profit of a match given the distribution of workers in the labor market and the distribution of match quality $G(\cdot)$.

2.5 Core Steady-State System

The equilibrium of the model is represented by three blocks of equations:

1. Steady state worker flows: equations (3)-(11).
2. Hiring standards: equations (24)-(29).
3. Job creation conditions: equation (30) for $j \in \{F, I\}$.

However, the core steady-state system for our model consists of equations (24)-(30), where (30) summarizes two conditions, and depends on the following endogenous variables: C_{FH}, C_{FL}, C_{FN}, C_{IH}, C_{IL}, C_{IN}, θ_F, and θ_I. The equilibrium worker flows and matching probabilities can be determined recursively given values for the sector-specific hiring standards and labor-market tightnesses. Given this core system, we calibrate our model to replicate key features of the Mexican labor market during the sample period 2005-2010, with a focus on young less educated workers. In the following sections we provide a detailed overview of the survey data used to determine our empirical targets and the methodology that we use to pin down key parameter values.

3 Data: The ENOE

We use a household survey from Mexico called the Occupation and Employment Survey, ENOE (*Encuesta Nacional de Ocupación y Empleo*). The ENOE is a rotating panel where

households are visited five times over the course of a year, one visit every three months.[13] As a result, the ENOE provides information quarterly. As the ENOE is a rotating panel, every three months 20% of the sample is replaced. Although information from each family member is recorded, this information is provided by only one member; the respondent is not necessarily the same individual on each visit.

The ENOE records the demographics of each family member (e.g. education, age, marital status), and information on the main and secondary jobs of family members older than 12 years of age. Job information includes working hours, earnings, fringe benefits, job position, firm size, industry, occupation and job tenure.[14] For further details about the ENOE see INEGI (2005, 2007).

To focus on the less-educated workers our sample only includes individuals not currently attending school and with less than 12 years of education.[15] To focus on young workers, our sample only includes workers between the ages of 16 and 30. Age 16 is the minimum age at which a worker can be hired according to Mexican Labor Law (see Congress, 1970), and age 30 seems to be the age at which transitions from the informal to the formal sector have reached a plateau (see Figure 2).[16] Our sample only includes male workers because women may have different reasons for joining the informal sector, e.g. job flexibility to balance work and child rearing (Arias and Maloney, 2007).

In Mexico when a worker is hired, it is the employer's responsibility to register the worker in the IMSS or the ISSSTE.[17] These institutions provide a bundle of benefits to their affiliates. For example, the bundle of services offered by IMSS include: health insurance,

[13]For example, a household visited for the first time in January 2005 will be visited a second time in April of 2005, a third time in July of 2005, a fourth time in October 2005, and a fifth time in January of 2006. Not all households are visited for the first time in January, they could be visited for the first time in any other month of the year.

[14]The ENOE has two formats: a long form and a short form. The job tenure information is only recorded in the long form of the ENOE, which is answered at least once during the five visits to the household.

[15]Grade 12 is the final year of secondary education in Mexico. Compared to the U.S., Mexico's educational system has three main blocks: (*i*) basic education (preK to grade 9), (*ii*) middle education (grades 10-12), and (*iii*) superior education (grades 13 and more). The U.S. system also has three levels: (*i*) elementary school (grades 1-6), (*ii*) secondary education (grades 7-12), and (*iii*) postsecondary education. So to put it in terms of the U.S. education system, grade 12 in Mexico is also the last year of secondary education.

[16]Presumably many individuals work in the informal sector at younger ages (below age 16), and so this left-censoring at age 16 could be perceived as loosing an important fraction of the informal sector. We restrict our sample to older than age 16 because we are mostly interested in how informal-sector jobs can be a stepping stone towards better jobs in the formal sector. However, since age 16 is lowest legal age to work in Mexico, the vast majority of informal worker younger than age 16 would not be eligible to make a transition to the formal sector even if the formal sector employer finds the worker suitable. And so these workers, even though they are part of the informal sector, do not contribute to our study because they are not "legally" allowed to make a transition from the formal to the informal sector.

[17]IMSS is the acronym in Spanish for the Mexican Institute of Social Security and ISSSTE is the acronym in Spanish for the Institute of Security and Social Services for the State's Workers.

day-care services for children, life insurance, disability pensions, work-risk pensions, sports and cultural facilities, retirement pensions, and housing loans (Levy, 2007). Both the worker and the employer must pay fees to fund these institutions, but the portion paid by the employer is much higher than that paid by the worker. If the firm is caught not complying with these regulations, it incurs a penalty.

The questionnaire of the ENOE does not ask the individual whether he is a formal or an informal worker. Instead, the survey asks the individual if he has access to medical services provided by the IMSS or the ISSSTE. We consider a worker to belong to the formal sector if he is salaried and has access to the IMSS or the ISSSTE, and to belong to the informal sector if he is salaried and does not have access to these services. Notice that the self-employed are not included in our definition of the informal sector as we restrict attention to salaried employees.

Finally, the sample is restricted to urban areas. In principle, we include all the cities that are statistically self-represented in the sample of the ENOE.[18] This includes 32 cities. All of the cities, except for one, have a population larger than 100,000 people.[19] We use data from the ENOE from the first quarter of 2005 to the fourth quarter of 2010.

Table 1 presents the summary statistics for the sample. As the table indicates formal sector workers are on average older, more educated, more likely to be married, and have higher hourly earnings than informal sector workers. Also formal sector workers tend to be concentrated in larger firms whereas informal sector workers tend to be concentrated in small firms. In terms of the industry of occupation, formal sector workers are mainly concentrated in manufacturing and services whereas informal sector workers tend to be concentrated in services and construction.

4 Calibration Strategy

We make use of our subsample from the ENOE and estimates from the existing literature to provide a detailed calibration of all model parameters. We start by focusing on the following parameters, σ_F, κ_F, σ_I, and κ_I, which determine the rate of employer screening and human capital accumulation across sectors, respectively. Once we have outlined our strategy to estimate these parameters from the data, we proceed to outline our calibration strategy for

[18] A city that is statistically self-represented means that the sample from the ENOE is large enough to draw inferences at the city level for this particular city.

[19] The one self-represented city that is not larger than 100,000 people is the city of Tlaxcala. It is classified as a city with a population between 15,000 and 99,999 people. According to the INEGI, the Statistics Bureau in Mexico in charge of the Census (and the ENOE), in 2010 the population of the city of Tlaxcala was 89,795 people (see http://www3.inegi.org.mx/sistemas/mexicocifras/default.aspx).

Table 1: Summary Statistics ENOE Q1:2005 - Q4:2010

	Formal Sector	Informal Sector
Age	24.34	23.02
Education	8.57	7.76
Married	0.36	0.23
Hourly earnings	20.19	17.81
Firm Size (%)		
1-5	8.27	66.31
6-50	39.74	28.84
51+	51.99	4.85
Industry (%)		
Construction	9.15	29.08
Manufacturing	35.34	20.1
Commerce	22.84	15.57
Services	32.67	35.25
Sample size	62,520	52,009

NOTES: Male with less than 12 years of education and not attending school, ages 16 to 30. Individual and job characteristics at the time of the first interview. Hourly earnings are in Mexican pesos as in the second half of December of 2010 (in this same period the exchange rate was on average 12.38 Mexican Pesos for 1 US Dollar). The sample size for formal sector workers is 62,520 and for informal sector workers is 52,009, but the statistics for hourly earnings, firm size, and industry are based in slightly smaller samples due to missing observations.

the remaining model parameters. The next few subsections provide a detailed description of this process.

4.1 Employer Screening and Human Capital Accumulation Rates

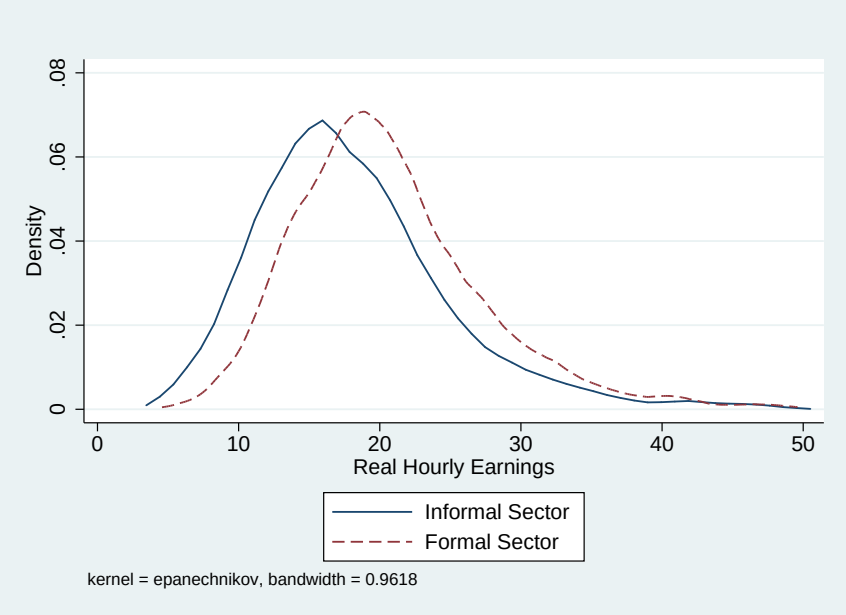
Perhaps the most important parameters in our model are σ_j and κ_j ($j \in \{F, I\}$), which govern the rate of employer screening and human capital accumulation, respectively. To estimate these parameters from the data we first assume that both rates are symmetric across sectors so that $\sigma_F = \sigma_I = \sigma$ and $\kappa_F = \kappa_I = \kappa$. We also assume that: (i) employer screening is more important for relatively younger individuals (those age 16-20), and (ii) human capital accumulation is more important for relatively older individuals (those age 25-30). Under these two assumptions, we estimate κ and σ using data on the duration of time between large wage changes observed in the ENOE.

According to the model developed in Section 2, wages can change for two reasons: (i) worker's skill level is revealed and the wage is adjusted up or down, and (ii) a L-skilled worker becomes H-skilled and the wage is increased. First, note that in our model, both the revelation of a worker's skill level and the accumulation of skills are Poisson processes and so they have durations that are exponentially distributed (Lancaster, 1990). The exponential duration distribution has a constant hazard rate that does not vary with the duration spent in a given state, which is the memoryless property of the exponential distribution (Cameron and Trivedi, 2005). In this section, we use these properties of the model to estimate σ and κ.

For this exercise, the duration variable of interest is the time that passes between the point in time in which an individual enters the survey and the point in time in which that individual experiences a wage change that could be attributed to either an employer learning the worker's skills or the worker accumulating human capital. In order to identify wage changes that would be the result of one of these processes we make use of our assumption that employer learning dominates the first years of the workers' careers (ages 16-20) and that human capital accumulation dominates the later years (ages 25-30). Then we use the distribution of wage changes in each of these two subgroups to determine which of these are wage changes that can be attributed to employer learning or the accumulation of skills.

First, for the case of employer learning, the model predicts that, in both sectors, wages of newcomers $w_{jN}(x)$, is greater than the wage of L-skilled workers $w_{jL}(x)$ and smaller than the wage of H-skilled workers $w_{jH}(x)$ for $j \in \{F, I\}$. That is, $w_{jL}(x) < w_{jN}(x) < w_{jH}(x)$ for $j \in \{F, I\}$. With this ordering in mind, we consider wage changes from the middle of the distribution to the top or bottom of the distribution as an adjustment in wages due to

Figure 4: Wage Distribution by Sector Ages 16-20

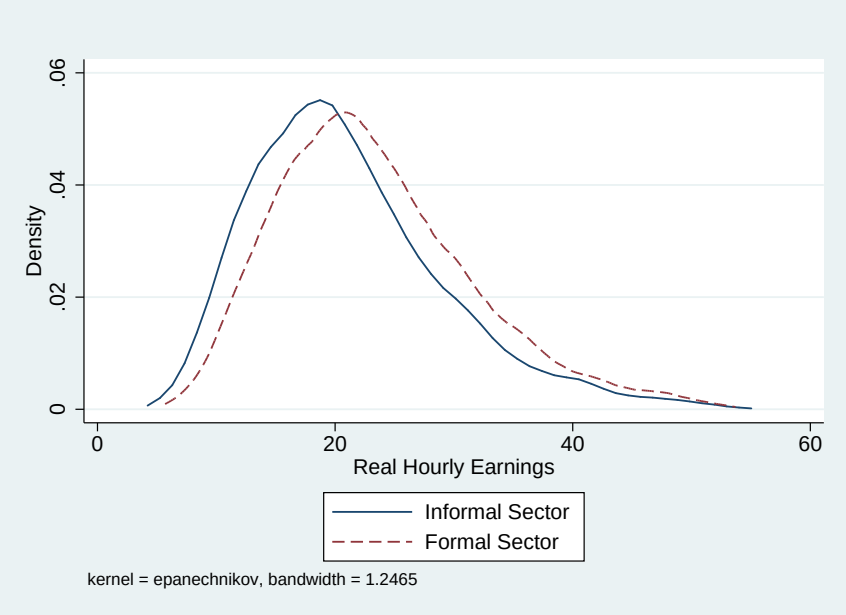


Notes: Data from the *Encuesta Nacional de Ocupacion y Empleo* (ENOE) from first quarter of 2005 to fourth quarter of 2010. The sample includes only males ages 16 - 20. We drop observations with wages above the top 0.5 percent or below the bottom 0.5 percent of the distribution of wages. Next, we only include individuals with five valid wage observations corresponding to the five interviews from the ENOE and that stayed in the same sector, formal or informal sector, over the five interviews.

worker's skill level being revealed as H-skilled or L-skilled, respectively. Figure 4 presents the distribution of hourly earnings for workers ages 16-20 in the formal and informal sectors. To identify wage changes due to employer learning we divide the distribution of hourly earnings in each sector into deciles. We focus on the subsample of workers whose wage is on the fifth or sixth decile at the first interview and measure the length of time that passes between the first interview and the interview in which their wage is located in the first or tenth deciles and use these duration measures to estimate an exponential hazard function as we explain below.

For the case of human capital accumulation, the model predicts that, in both sectors, wages of L-skilled workers increase when they accumulate skills and become H-skilled, and so $w_{jL}(x) < w_{jH}(x)$ for $j \in \{F, I\}$. With this ordering in mind, we consider wage changes from the bottom to the top of the distribution as an adjustment in wages due to human capital accumulation, that is, a L-skilled worker becoming H-skilled. Figure 5 presents the distribution of hourly earnings for workers ages 25-30 in the formal and informal sectors. To identify wage changes due to human capital accumulation we divide the distribution of hourly earnings in each sector into deciles. We focus on the subsample of workers whose wage is on the first or second deciles at the first interview and measure the length of time

Figure 5: Wage Distribution by Sector Ages 25-30



Notes: Data from the *Encuesta Nacional de Ocupacion y Empleo* (ENOE) from first quarter of 2005 to fourth quarter of 2010. The sample includes only males ages 25 - 30. We drop observations with wages above the top 0.5 percent or below the bottom 0.5 percent of the distribution of wages. Next, we only include individuals with five valid wage observations corresponding to the five interviews from the ENOE and that stayed in the same sector, formal or informal sector, over the five interviews.

that passes between the first interview and the interview in which their wage is located in the ninth or tenth deciles and use these duration measures to estimate an exponential hazard function as we explain below.

In both cases, we restrict the sample to individuals who held a job during the five interviews. The duration of employment is measured in months, and given the sampling scheme of the ENOE all durations will be interval censored. More specifically, all durations will be contained in three-month intervals, $(0, 3]$, $(3, 6]$, $(6, 9]$, $(9, 12]$. The durations of individuals who did not experience a substantial wage change by the fifth interview are considered to be right-censored. Then, for individuals who did not have a substantial wage change by the fifth interview, all we know is that their duration of employment is in the interval $(12, \infty)$. Given this structure of the duration data, we estimate an exponential hazard function for two separate subsamples.

The exponential hazard function is a constant function of the form $h(t) = h$. For our purposes, when we estimate the hazard using the subsample of workers ages 16-20 we consider that the constant h is equal to σ so that the hazard function is $h(t) = \sigma$ for this group of workers. Similarly, when we estimate it using the subsample of workers ages 25-30 we consider that the constant h is equal to κ so that the hazard function is $h(t) = \kappa$ for this group of

workers. We parameterize these hazard functions using covariates for individual characteristics such as education and marital status and controls for job characteristics such as the size of the firm and the industry of occupation. We also include indicators for minimum-wage zones and survey year.[20] In particular, for the hazard for duration of employment before a worker's skill level is revealed we use:

$$\sigma = \exp(x_s' \rho_s), \tag{31}$$

and for the the hazard for duration of employment before a L-skilled worker becomes H-skilled we use:

$$\kappa = \exp(x_h' \rho_h). \tag{32}$$

Table 2 presents our estimates of the exponential hazard function using the parameterization in (31) and (32). The most relevant results from the table are the estimates of the employer learning and human capital accumulation parameters:

$$\hat{\sigma} = \exp(\bar{x}_s' \hat{\rho}_s)$$
$$\hat{\kappa} = \exp(\bar{x}_h' \hat{\rho}_h)$$

where $\bar{x}_s'$ is the vector of the means of the covariates for the subsample of workers ages 16-20 included in the estimation sample and $\bar{x}_h'$ is the corresponding vector for the subsample of workers ages 25-30. As indicated in Table 2, our estimates for σ and κ are 0.0499 and 0.0151, respectively. However, these estimates are at a monthly frequency and we use the quarterly values of 0.1498 and 0.0452 when solving for the steady state of our model.

4.2 Remaining Parameters

After pinning down the values for σ and κ using the procedure described above, we must still determine the values for the remaining 25 parameters of our model: r, τ, η, ν, β, γ_1^F, γ_2^F, γ_1^I, γ_2^I, λ_F, λ_I, D, z_N, z_H, z_L, h_F, h_I, p_{FH}, p_{FL}, p_{FN}, p_{IH}, p_{IL}, p_{IN}, π, T. To simplify this process, we assume that the utility value of unemployment is symmetric across worker types ($z_N = z_H = z_L$) and the parameters of the matching functions are symmetric across sectors ($\gamma_1^F = \gamma_1^I$ and $\gamma_2^F = \gamma_2^I$). This simplification reduces the number of parameters from 25 to 21. Of the 21 needed restrictions, 8 follow from the existing literature or by assumptions

[20] In Mexico, there are three different levels for minimum wage. Cities with the highest minimum wage are said to be in minimum-wage zone A. Cities with the lowest minimum wage are said to be in minimum-wage zone C. Minimum-wage zone B is for the middle minimum wage.

Table 2: Maximum Likelihood Estimates of Exponential and Weibull Models

	Employer Learning Ages 16 - 20	Human Capital Accumulation Ages 25 - 30
Graduate grade 6	0.7120*	-0.0938
	(0.4322)	(0.4118)
Graduate grade 9	0.0804	0.2801
	(0.1645)	(0.2358)
Married	0.0008	-0.0951
	(0.2928)	(0.1934)
Firm size		
6 - 20	0.2450	-0.1593
	(0.1821)	(0.2861)
21 +	0.0375	-0.1560
	(0.1887)	(0.2364)
Industry		
Commerce	0.4903**	-0.5676*
	(0.2244)	(0.3127)
Services	0.6116***	0.1791
	(0.1991)	(0.2391)
Construction	0.3909*	0.2148
	(0.2273)	(0.4624)
Constant	-4.0590***	-4.4944***
	(0.5312)	(0.5708)
Estimate of σ	0.0499	
Estimate of κ		0.0151
No. of subjects	429	646
No. of failures	198	114

The omitted firm size is 1-5 employees and the omitted industry is Manufactures. The educational dummies are: Graduate Grade 6 = $\mathbf{1}\{Edu \geq 6\}$ and Graduate Grade 9 = $\mathbf{1}\{Edu \geq 9\}$. The covariates also include: two dummies for the three different zones of the minimum wage, six dummies for the year (2005-2010). Standard errors in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.

Table 3: Quarterly Transition Probabilities ENOE Q1:2005 - Q4:2010

	Informal Sector	Formal Sector	Unemployed
Informal Sector	0.769	0.174	0.057
Formal Sector	0.129	0.833	0.037
Unemployed	0.385	0.282	0.333

regarding model timing. Given that data from the ENOE is quarterly, we adopt a quarterly frequency within our model and set the interest rate, r, to 0.01. This restriction implies an annualized rate of return of approximately 4%, consistent with existing estimates for Mexico. We also set the exit rate, τ, to 0.0179 in order to target an average duration of approximately 14 years. This ensures that the time horizon for agents in our model is consistent with that of subjects in our sample (e.g., individuals age 16 to 30).[21]

Following Bosch and Esteban-Pretel (2012), we set $\eta = 0.4$ implying that on-the-job search while employed in the informal sector is less efficient than traditional search from unemployment. Following the same authors we set the parameter governing informal detection $\pi = 0.005$. We set the penalty for informality $T = 10$ which is about 40% of firing costs D (explained below).[22] This is consistent with a monitoring authority that is only taking modest actions to monitor and punish firms who hire workers informally. We take an agnostic approach regarding the fraction of newcomers who are high- or low-type, setting ν to 0.5.[23] For our surplus sharing rule, we follow the literature and assume symmetric bargaining power between firms and workers, $\beta = 0.5$. We also follow Hosios (1990) and set the elasticity of matches with respect to vacancies in both markets equal to the firm's bargaining power, and so we set the matching function parameter $\gamma_2 = 0.5$.

After imposing the eight restrictions described above, we still need 13 additional restrictions to pin down our remaining parameter values. To this end, we turn our attention back to our sample from the ENOE. Table 3 presents the quarterly transition probabilities between informal employment, formal employment, and unemployment. The last elements in the first and second rows of Table 3 represent the flow of workers transitioning into unemployment from informal and formal employment respectively. We set the exogenous separation rates

[21] While τ is often interpreted as the probability of death, we are interpreting τ as the probability an agent transitions out of this segment of the labor market. That is out of the segment of age 16-30 workers in the labor market.

[22] According to Mexican laws the penalty imposed on a firm caught evading social security contributions is 150% of unpaid contributions (Antón et al., 2012). We set T to a fraction of firing costs D since in our model, firing costs account for all the costs of regulation associated with formality. One of these costs are the social security contributions.

[23] Our results are found to be robust to small variations in the value of ν.

in our model, λ_I and λ_F, equal to the observed transition rates into unemployment for their respective sector. The coefficients on both sectors' matching function, γ_1 is set to target an unemployment rate of 6.9%, consistent with our sample from ENOE. Next, we set firing costs in the formal sector, D, so that our model generates an employment share in the informal sector that matches that observed in our sample (approximately 44.5%).[24] Agent's flow utility from unemployment, z, is set to approximately 50% of the average wage in the formal sector. While Mexico does not have a comprehensive unemployment insurance program, our value of z should be interpreted as the total value or income received while unemployed, which includes, among other things, the value of home production. We also use the average wages to provide a sense of scale for vacancy posting costs across both sectors. Specifically, we set h_F to 50% of the average formal sector wage and h_I to 25% of the average informal sector wage.[25]

The final six parameters are the skill and sector-specific productivity values (the p's) in our model. These productivity values are determined using both ordinal and cardinal wage restrictions. Specifically, within each sector the productivity values are set to preserve the following ordering: $E\{w_{jL}\} < E\{w_{jN}\} < E\{w_{jH}\}$, $j \in \{F, I\}$. The productivities must be consistent with the following within skill-type ordering: $E\{w_{Fk}\} > E\{w_{Ik}\}$, $k \in \{N, H, L\}$. Along with preserving the two orderings of average wages described above, the magnitude of the skill and sector-specific productivity values is set so that the average wage in the formal sector is approximately 14% higher than the average wage in the informal sector, which is consistent with the ENOE data (see Table 1).

5 Results

Given our calibration strategy, we compute the steady state solution of our model economy and recover a set of baseline results. These baseline results are then compared to the data to assess our model's empirical fit and derive results regarding unobservables, such as the endogenous hiring cutoff rules and unemployment rates across sector of employment and skill level. These results are then used to determine if informal employment serves as a "port-of-entry" into the labor market for young less-educated workers. After assessing our baseline results, we consider two sets of counterfactual experiments. The first set of experiments

[24] This calibration target results in firing costs that are nearly 16.5 times as large as the average wage in the formal sector. While this value may seem high, it is important to remember that what we call firing costs in our model are actually standing in for all regulatory costs associated with formality. Therefore, we view costs of this magnitude to be of a reasonable size.

[25] The key point here is that vacancy costs should be relatively small and it should be cheaper to create a vacancy in the informal sector. Our results are not sensitive to small variations in these targets.

independently reduces the rate of human capital accumulation and worker screening and assesses the relative importance of each channel by comparing the equilibrium outcomes to the baseline specification. The second set of experiments considers two alternative policies designed to reduce the employment share of the informal sector by a fixed amount. These policies differ in the way they achieve this objective, with one policy deregulating the formal sector and the other policy increasing the likelihood a firm is caught when operating informally. The two policies are compared in terms of how they distort the baseline labor market outcomes in order to achieve the desired reduction in the informal sector employment share.

5.1 Baseline Results

Our baseline model is found to match the data reasonably well. Table 4 presents the list of moments used in our calibration. The model does a very good job in targeting the unemployment rate and the size of the informal sector. The model does also a good job in targeting the wage data. The third row of Table 4 indicates that our model predicts a larger wage premium for workers in the formal sector compared to those in the informal sector. On the other hand, the data suggest a higher premium for the top 20 percent of wages in both the formal and informal sectors compared to what the model predicts. While the data suggests a similar dispersion of wages across sectors, our model predicts that the informal sector has a larger wage dispersion in the informal sector but still very close to the data. As suggested in Figures 4 and 5, the distribution of wages in the formal and informal sectors is fairly smooth and single-peaked. The model has a harder time trying to reproduce this distribution because the wage distributions produced by the model are concentrated at the worker productivity parameters p_{jk}, $j \in \{F, I\}$, $k \in \{H, L\}$. The reason for this bunching is, as it is shown below, that the match-specific qualities x of created matches are concentrated on the top of the distribution $G(x)$. The last three rows of Table 4 involve the target value of theoretical targets that are anchored to observed moments in the data. These theoretical targets include the recruitment costs in both sectors and the value of leisure.

In addition to matching the unemployment rate and the proportion of informal-sector workers from the ENOE, Table 5 indicates that our baseline model also makes strong predictions regarding the composition of agents across skill levels. Specifically, the first column of the table indicates that 74.2% of agents are H-skilled in the steady state equilibrium, while only 12.9% and 13% are L-skilled and newcomers, respectively. Given that all agents are born as newcomers and half are initially revealed to be L-skilled, this result is suggestive of a substantial effect of both employer screening and human capital accumulation.

To better understand the role played by the informal sector, we can look into the com-

Table 4: Summary of Targeted Moments

Moment	Notatio	Data	Model
Unemployment rate	u	0.0690	0.0692
Fraction of IS workers	n_I	0.4500	0.4458
Ratio of wages	$\bar{w}_F/\bar{w}_I$	1.1408	1.1876
Ratio of top 20% wages - FS	$\bar{w}_F^{20}/\bar{w}_F$	1.5949	1.1533
Ratio of top 20% wages - IS	$\bar{w}_I^{20}/\bar{w}_I$	1.4593	1.3478
Ratio of Std Dev of wages	s_w^F/s_w^I	1.0176	0.8322
Recruitment costs FS	$h_F/\bar{w}_F$	0.5000	0.5001
Recruitment costs IS	$h_I/\bar{w}_I$	0.2500	0.2501
Value leisure	$z/\bar{w}_F$	0.5000	0.5001

Table 5: Distribution of Workers in Baseline Model

	Fraction of Workers		
	Labor Market	Formal Sector	Informal Sector
H-skilled	0.7415	0.8634	0.6433
L-skilled	0.1288	0.0991	0.1643
Newcomer	0.1297	0.0375	0.1925

NOTES: Each column presents the fraction of workers within a particular sector or the total labor market. Therefore the numbers on each column add to one.

position of agents across skill-type within each sector of employment in the second and third columns of Table 5. Here we find that the vast majority of workers employed in the formal sector, 86.3%, are H-skilled. Furthermore, only 3.8% of workers employed in the formal sector are newcomers. This is in stark contrast with the skill composition found in the informal sector, where 64.3% are H-skilled and 19.3% are newcomers. The relatively high concentration of newcomers in the informal sector suggests that the informal sector in our calibrated model serves as a "port of entry" for young less educated workers.

Table 6 breaks down unemployment by skill level in our baseline model. The results are intuitive as the H-skilled workers are those with the lowest unemployment rate of 4.85%. Newcomers whose skill level has not been learned by the labor market participants suffer from the higher rate of unemployment of almost 20%.

Table 6: Unemployment Rate by Skill Level in Baseline Model

	Unemployment Rate
H-skilled	0.0485
L-skilled	0.0585
Newcomer	0.1982

Table 7: Hiring Standards in Baseline Model

	Formal Sector	Informal Sector
H-skilled	0.8787	0.7693
L-skilled	0.9120	0.7702
Newcomer	0.9417	0.7524

To further investigate whether the informal sector is serving as a "port of entry" for young less educated workers, we must turn to the equilibrium hiring standards that are derived from our baseline model. Table 7 presents these cutoffs across both sectors and for each skill-type for our baseline specification. Inspection of the table indicates that the cutoffs are in fact substantively lower for the informal sector than for the formal sector. This finding is in line with the hypothesis that formal sector employment carries with it more stringent barriers to entry which may not be present with informal sector employment. This fact is most evident when comparing the hiring cutoff for newcomers across sectors. Specifically, this hiring cutoff in the informal sector is 0.7524, which is substantively lower than 0.9417, the cutoff in the formal sector. As a consequence, newcomers in our model will more naturally flow into informal employment until they have their skill-type revealed and gain human capital. This is consistent with an informal sector that serves as a "port of entry" for formal sector employment.

5.2 Lowering σ and κ

While the baseline results presented above provide evidence in support of the "port of entry" role of informal employment, we are also interested in assessing the relative importance of both human capital accumulation and worker screening in generating our equilibrium outcomes. To this end, we consider a set of counterfactual experiments in which we independently lower the rate of human capital accumulation, κ, and employer screening, σ, from their estimated levels by 25%, while holding all other parameters fixed.[26] The change in equilibrium outcomes that result from these single parameter adjustments are used to provide some evidence of the relative strength of each channel in generating our baseline equilibrium outcomes

Table 8 presents the aggregate results of our baseline calibrated model along with the results from the two counterfactual experiments where the rates of human capital accumulation, κ, and employer screening, σ, are lowered by 25%. Comparing across columns, we see that reducing either rate increases the employment share in the informal sector and the

[26]In the baseline model, $\kappa = 0.0452$ and $\sigma = 0.1498$. So, in these experiments we first lower κ to 0.0339 and then we lower σ to 0.1123.

Table 8: Counterfactual from Reducing κ and σ by 25%: Aggregate Effects

	Data	Baseline	Reduce κ	Reduce σ
Size of Informal Sector	0.445	0.446	0.456	0.474
Unemployment Rate	0.069	0.069	0.073	0.072
Fraction of workers:				
H-skilled	-	0.742	0.712	0.713
L-skilled	-	0.129	0.157	0.124
Newcomer	-	0.130	0.131	0.163

Table 9: Counterfactual from Reducing κ and σ by 25%: Distribution of Workers

	Baseline	Reduce κ	Reduce σ
Fraction of Formal Workers			
H-skilled	0.8634	0.8427	0.8596
L-skilled	0.0991	0.1209	0.0958
Newcomer	0.0375	0.0365	0.0446
Fraction of Informal Workers			
H-skilled	0.6433	0.6133	0.6068
L-skilled	0.1643	0.1966	0.1544
Newcomer	0.1925	0.1902	0.2388

unemployment rate in equilibrium. While adjusting either κ or σ has a roughly equal effect on the unemployment rate (6.9% to 7.2-7.3%), it should be noted that reducing σ increases the informal sector share by more (44.6% to 47.4%) than reducing κ (44.6% to 45.6%). The larger increase in the share of informal sector when σ is reduced follows from a larger share of newcomers in equilibrium as indicated by the last column of Table 8 since it is the informal sector that is the main recipient of these workers in the labor market.

Specifically, Table 8 shows how the skill composition is affected when κ or σ are reduced. Reducing κ leaves the fraction of newcomers roughly constant but results in a more L-skilled (12.9% to 15.7%) and fewer H-skilled (74.2% to 71.2%) in equilibrium. In contrast, reducing σ leaves the number of L-skilled roughly constant but results in more newcomers (13% to 16.3%) and fewer H-skilled (74.2% to 71.3%) in equilibrium. These effects are intuitive given how κ and σ influence the skill revelation and accumulation processes within our model.

Table 9 breaks down the effects on the distribution of workers in these counterfactual experiments. In particular, reducing the rate of human capital accumulation κ, results in more L-skilled workers in equilibrium in both the formal and informal sectors. Similarly, reducing the rate of employer learning σ results in more newcomers in equilibrium in both the formal and the informal sector, where the informal sector is the main recipient of these workers.

Table 10: Counterfactual from Reducing κ and σ by 25%: Unemployment Rate by Skill Level

	Baseline	Reduce κ	Reduce σ
H-skilled	0.0485	0.0493	0.0491
L-skilled	0.0585	0.0661	0.0573
Newcomer	0.1982	0.2075	0.1828

Next, we can consider how these rate adjustments impact the unemployment rates across skill levels. The results, presented in Table 10, make clear that while there is a strong aggregate unemployment rate effect resulting from these rate changes, changing κ or σ does not significantly alter the unemployment rates at the individual skill level. Together, these results suggest that both mechanisms are important for the transition of workers from informal to formal employment and the determination of the steady state unemployment rate.

Lastly, Table 11 shows that reducing either κ or σ primarily results in an increase in hiring standards across all sectors for L-skilled and newcomers, who are the main groups affected by the changes in these rates. As described in Section 2.3, decreases in κ would reduce the expected benefit of hiring a L-skilled worker because it would take longer for that worker to accumulate enough human capital to become H-skilled. Since workers and firms share the match surplus, reducing κ reduces the surplus of matching with a L-skilled worker and results in a higher hiring standard for these workers in both the formal and informal sectors. As it is also described in Section 2.3, decreases in σ would increase the hiring standard in the informal sector because when it takes longer to find the worker's skill level the surplus for matches with newcomers in the informal sector is reduced, which in turn results in a larger hiring standard for newcomers in the informal sector. The effect of a decrease in σ on the hiring standard for newcomers in the formal sector depends on whether skill revelation can result on the worker being fired, as we described in Section 2.3. However, given the equilibrium values for the formal cut-offs when a worker's skill level is revealed, it is guaranteed that the match-specific quality x will be larger than both C_{FH} and C_{FL}, and so it would not lead to job destruction. And so the only effect of reducing σ is extending the length of time it takes for an employer to learn the worker's skill level, reducing the match surplus and resulting in larger hiring standards for the formal sector as well. Since both policy experiments result in larger informal sectors and larger fractions of L-skilled or newcomers, these results suggest that both employer learning and human capital are important roles played by the informal sector making it a stepping stone for workers to get access to better formal-sector jobs. Reducing the strength of either of these two channels

Table 11: Counterfactual from Reducing κ and σ by 25%: Hiring Standards

	Baseline	Reduce κ	Reduce σ
Formal Sector			
H-skilled	0.879	0.877	0.878
L-skilled	0.912	0.921	0.912
Newcomer	0.942	0.945	0.955
Informal Sector			
H-skilled	0.769	0.767	0.770
L-skilled	0.770	0.786	0.771
Newcomer	0.752	0.758	0.766

prolongs the workers' wait for a better formal job.

5.3 Reducing Informal Sector

Next, we consider two policy experiments that attempt to reduce the informal-sector employment share to approximately 25%. The first policy achieves this objective by reducing firing costs, D, present in the formal sector. As such, this policy experiment can be thought of as a type of "deregulation" within the formal sector. The second policy works by increasing the likelihood of being caught operating informally, π. As such, we interpret the second policy as "cracking down" on informal participation. When conducting these counterfactual experiments, we fix all model parameters and simply adjust the parameter of interest (either D or π) until the model implied informal-sector employment share reaches the target of 25%. We then compare both polices to determine if one policy dominates the other in terms of equilibrium outcomes within the labor market (e.g., the effect on aggregate unemployment, hiring cutoff rules, etc).

Table 12 presents the effects of the policy changes on aggregate outcomes such as the size of the informal sector, the unemployment rate, and the fraction of workers of each skill level present in equilibrium. Inspection of the first row of Table 12 shows that we are able to reach our informal sector employment share target by adjusting either D or π. Moving down the rows of Table 12, we can also consider how these policies impact other equilibrium outcomes. Recall that we calibrated our baseline steady state to replicate the unemployment rate in our sample: 6.9%. However, the unemployment rate is free to vary during our policy experiments. From Table 12 we see that reducing firing costs results in the unemployment rate falling from its baseline value of 6.9% to 5.8%. In contrast, when we increase the likelihood of being caught operating informally, the unemployment rate increases considerably to 7.5%. Table 12 also shows how the skill composition of the economy changes

Table 12: Reducing Informality: Aggregate Effects

	Data	Baseline	Reduce D	Increase π
Size of Informal Sector	0.445	0.446	0.250	0.250
Unemployment Rate	0.069	0.069	0.058	0.075
Fraction of workers:				
H-skilled	-	0.742	0.746	0.739
L-skilled	-	0.129	0.129	0.131
Newcomer	-	0.130	0.125	0.130

across the policy scenarios. Comparing across columns of the second panel of Table 12, we see that neither policy has a very large impact on the skill composition in the economy. However, reducing firing costs does lead to a reduction in the number of newcomers in equilibrium from 13% to 12.5%. On the one hand, our aggregate results indicate that while both policies can achieve the objective of lowering the informal sector employment share to 25%, reducing firing costs will also result in lower unemployment and fewer newcomers in steady state. On the other hand, increasing the probability of penalizing informal firms results in higher unemployment and fewer H-skilled workers.

Table 13 breaks further down the composition of employment. Reducing firing costs allows more L-skilled and newcomers to access jobs in the formal sector. As Table 15 suggests this follows from a reduction in the hiring standards for all three types of workers. As discussed in Section 2.3 reducing the firing costs directly reduces the formal-sector hiring standards for the three types of workers which is the effect we observe in the model. Interestingly, reducing firing costs also reduces hiring standards in the informal sector. These effect can be understood for two reasons. First, the reduction in firing costs increases the match surplus for all formal-sector jobs. Second, the reduction in formal-sector hiring standards makes the transition of informal-sector workers to the formal sector more likely. Both of these effects increase the surplus of informal-sector matches and as a consequence reduces the hiring standards in the informal sector as well.

As the hiring standards are reduced in both sectors, the unemployment rate goes down for all three worker types as indicated in Table 14. Specifically, reducing firing costs causes the unemployment rate for newcomers to fall from 19.8% to 16.4%, the unemployment rate for H-skilled to fall from 4.9% to 4.2%, and the unemployment rate of L-skilled to fall from 5.9% to 5.1%. This policy mainly benefits newcomers who have better access to both formal and informal jobs.

Similarly, Table 13 shows how increasing the probability of detection affects the composition of workers within each sector. While this policy is only intended to affect informal-sector jobs, we see that in equilibrium, we have a lower fraction of H-skilled workers in both the

Table 13: Reducing Informality: Distribution of Workers

	Baseline	Reduce D	Increase π
Fraction of Formal Workers			
H-skilled	0.8634	0.8170	0.8169
L-skilled	0.0991	0.1210	0.1214
Newcomer	0.0375	0.0619	0.0617
Fraction of Informal Workers			
H-skilled	0.6433	0.5989	0.5969
L-skilled	0.1643	0.1541	0.1542
Newcomer	0.1925	0.2470	0.2489

formal and informal sector and a higher fraction of newcomers in both sectors. The fraction of L-skilled workers increases in the formal sector but decreases in the informal sector. Table 15 shows that only the hiring standard of L-skilled workers in the informal sector increases after the increase in the probability of detection π. While the analytical results in Section 2.3 indicate that after increasing π all hiring standards in the informal sector should increase, the probability of detection (π) and the size of the penalty (T) are still too low, and so the effect on the hiring standards come from different channels. The reason for the differential effect on the hiring standards in the informal sector follows from the reduction in the surplus of informal-sector matches. When the match surplus falls in the informal-sector this induce informal-sector firms to focus on H-skilled workers who have larger productivity on average and a higher change to move to the formal sector and on the newcomers who carry the promise of being revealed as H-skilled with probability $\nu = 0.5$. As a result informal-sector firms would increase the hiring standard of L-skilled workers while reducing the hiring standard of both H-skilled and newcomers.

Notice that Table 15 also indicates that formal-sector hiring standards also decrease following the increase in the probability of detection of an informal-sector firm. When the probability of detection is increased this leads to a reduction in the creation of informal-sector vacancies. Given that the size of the labor market does not change, this would mean that formal-sector firms can increase their rate of contacts with job seekers and filling up vacancies faster which will increase the surplus of formal-sector matches and reduce the hiring standards in that sector. Finally, Table 14 indicates that the unemployment rate increases for all worker skill levels but it is mainly L-skilled workers who suffer from larger unemployment rates, which is the result of higher hiring standards in the informal sector.

Both of the policies that we consider result in relatively fewer informal vacancies being created in equilibrium. So, why do our results suggest that reducing firing costs will have a more positive effect on the labor market outcomes in our economy? The answer to this

Table 14: Reducing Informality: Unemployment Rate by Skill Level

	Baseline	Reduce D	Increase π
H-skilled	0.0485	0.0415	0.0517
L-skilled	0.0585	0.0506	0.0765
Newcomer	0.1982	0.1640	0.2025

Table 15: Reducing Informality: Hiring Standards

	Baseline	Reduce D	Increase π
Fraction of Formal Workers			
H-skilled	0.8790	0.8495	0.8528
L-skilled	0.9120	0.8659	0.8770
Newcomer	0.9420	0.8896	0.8978
Fraction of Informal Workers			
H-skilled	0.7690	0.7541	0.7623
L-skilled	0.7700	0.7510	0.7940
Newcomer	0.7520	0.6862	0.7093

question is that the two policies reduce informal vacancies in very different ways. When we reduce firing costs in the formal sector, we are lowering the expected cost of creating a formal vacancy. As such, we are incentivizing additional formal vacancies to be created. In contrast, when we increase the probability of being caught operating informally, we are increasing the expected cost of creating an informal vacancy. So, in this case, we are providing a disincentive to create informal vacancies.

6 Conclusion

The empirical evidence suggests that informal labor participation may play an important and transient role for young, less-educated workers in Mexico. To analyze this issue, we develop a two sector labor market model with heterogeneity in workers' initial skill levels. Firms post vacancies in both formal and informal labor markets and workers are free to search for employment opportunities across both sectors. While all workers are born with an unknown level of skill, their skill-level is revealed probabilistically while working in either sector. Similarly, a low skilled worker will probabilistically gain human capital and become high skilled while working in either sector.

We calibrate our model using the ENOE, a household survey in Mexico that collects detailed income and employment information. To focus on young less educated workers, we restrict our sample to individuals between the ages of 16 and 30 with less than 12 years of education. Using our calibrated model, we find that hiring standards are substantially

higher in the formal sector relative to the informal sector. This serves as evidence that the informal sector is operating as a "port of entry" for formal employment.

We also consider two sets of counterfactual experiments. The first set of experiments independently reduces the rates of human capital accumulation and worker screening, holding all other parameters fixed. We find that reducing either of these rates increases the informal employment share and unemployment rate in the economy. Thus, both channels are found to have a sizable impact on our model's equilibrium outcomes. The second set of experiments attempt to reduce the informal sector employment share to 35% by either lowering firing costs in the formal sector or by lowering the likelihood a firm is caught and punished for operating informally. While both policies are able to reduce the informal sector employment share to its desired level, lowering firing costs also results in lower unemployment and fewer newcomers in equilibrium while increasing the likelihood of punishment for informal firms raises these values.

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Technical Appendix: Assessing the Impact of Informal Sector Employment on Young Less-Educated Workers

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In this appendix we provide details regarding the steady-state of our two sector labor search model...

A Wages

Wages for all workers in the labor market are determined according to a surplus-sharing rule that entitles workers to a fraction β of the match surplus. In equilibrium, free entry implies that the profit from one more vacancy in the formal and the informal sectors is zero, and so in equilibrium it is the case that $V_F = V_I = 0$. Matches of a firm in sector $j \in \{F, I\}$ and a worker are given by $S_{jk}(x) = W_{jk}(x) - U_k + J_{jk}(x) - V_j$ for $k \in \{N, H, L\}$, and so the surplus-sharing rule dictates that $[W_{jk}(x) - U_k] = \beta S_{jk}(x)$. In equilibrium, free entry and the surplus sharing rule result in formal- and informal-sector wages for workers with known skill level given by:

$$\text{(1a)} \quad w_{FH}(x) = \beta p_{FH} x + (1-\beta)(r+\tau)U_H - \beta\lambda_F D$$

$$\text{(2a)} \quad w_{FL}(x) = \beta p_{FL} x + (1-\beta)(r+\tau)U_L - \beta\lambda_F D - (1-\beta)\kappa_F[U_H - U_L]$$

$$\text{(3a)} \quad w_{IH}(x) = \beta p_{IH} x + (1-\beta)(r+\tau)U_H - \beta\pi T - (1-\beta)\eta f_F \int_{C_{FH}}^{1} [W_{FH}(x) - U_H] dG(x)$$

$$\text{(4a)} \quad w_{IL}(x) = \beta p_{IL} x + (1-\beta)(r+\tau)U_L - \beta\pi T - (1-\beta)\eta f_F \int_{C_{FL}}^{1} [W_{FL}(x') - U_L] dG(x') - (1-\beta)\kappa_I[U_H - U_L]$$

where all wage contracts are functions of the match quality. If the job is destroyed in the formal sector the firm incurs a firing cost D and since the firm and worker are sharing the match surplus the worker's wage in this sector is reduced by a fraction β of the expected firing cost. Similarly, if authorities catch an informal-sector job the firm incurs a penalty of T and given the surplus sharing rule the worker's wage is reduced by a fraction β of the expected penalty. A low-skilled worker that accumulates skills and become high skilled experiences a gain in lifetime utility of $[U_H - U_L]$; given the surplus sharing rule the worker shares this gain with the firm and so the wage for low-skilled workers is additionally reduced by a fraction $(1-\beta)$ of the gain. Finally, an informal-sector worker that moves to the formal

sector experiences a gain of $E[W_{FL}(x') - U_k | x' > C_{Fk}]$ and this gain is shared with the firm, and so wages in the informal sector are reduced by the expected gain from such movement.

Similarly, free entry and the corresponding surplus-sharing rule result in wages for newcomers given by:

$$\begin{aligned}(5a)\quad w_{FN}(x) &= \beta p_{FN} x + (1-\beta)(r+\tau)U_N - \beta\lambda_F D - (1-\beta)\sigma_F[\nu U_L + (1-\nu)U_H - U_N] \\ &\quad - \beta\sigma_F\nu(1-\Gamma_{FL}(x))D - \beta\sigma_F(1-\nu)(1-\Gamma_{FH}(x))D \\ (6a)\quad w_{IN}(x) &= \beta p_{IN} x + (1-\beta)(r+\tau)U_N - \beta\pi T - (1-\beta)\eta f_F \int_{C_{FN}}^{1} [W_{FN}(x) - U_N] dG(x) \\ &\quad - (1-\beta)\sigma_I[\nu U_L + (1-\nu)U_H - U_N]\end{aligned}$$

where now wage contracts for newcomers account for the possible gain associated with having their skill level revealed given by $[\nu U_L + (1-\nu)U_H - U]$. In the formal sector, wage contracts also account for the possibility that once the worker's skill level is revealed, the match might have to be destroyed and the firm incur firing cost, D. Wages in the formal sector for newcomers account for the possibility that the match may be exogenously destroyed before the worker's type is revealed. This possibility is also accounted for in the expression for the informal sector wage, but this wage must also account for the possibility the worker might quit and move to the formal sector before having their skill level revealed.

In this model, reservation wages w_{jk}^R for $j \in \{F, I\}$ and $k \in \{N, H, L\}$ are obtained when we substitute match quality x with the corresponding hiring standard C_{jk}. So that the reservation wage is given by:

$$w_{jk}^R = w_{jk}(C_{jk})$$

for $j \in \{F, I\}$ and $k \in \{N, H, L\}$, where $w_{jk}(\cdot)$ is given by the equations (1a)-(6a).

B Simplified (Closed-Form) Hiring Standards

Contacts between job seekers and firms in both sectors result in a match if and only if the match quality drawn when they make contact is higher than a reservation match quality. The reservation match quality depends on the sector of employment, and whether the worker is a newcomer, high-skilled, or low-skilled. The reservation match quality C_{jk} is such that $J_{jk}(C_{jk}) = V_j$, for $j \in \{F, I\}$ and $k \in \{N, H, L\}$. In equilibrium, free entry implies that

$V_j = 0$ and so the cut-offs for high-skilled workers C_{FH} and C_{IH} solve:

$$\text{(1b)}\quad p_{FH}C_{FH} = (r+\tau)U_H + \lambda_F D$$

$$\text{(2b)}\quad p_{IH}C_{IH} = (r+\tau)U_H + \pi T - \beta\frac{\eta f_F}{r+\tau+\lambda_F}p_{FH}\left[\hat{x}_{FH} - \bar{G}(C_{FH})C_{FH}\right]$$

where $\hat{x}_{FH} = \int_{C_{FH}}^{1} x dG(x)$ is the average match quality in the formal sector for high-skilled workers.

For low-skilled workers C_{FL} and C_{IL} solve:

$$\text{(3b)}\quad p_{FL}C_{FL} = (r+\tau)U_L + \lambda_F D - \kappa_F[U_H - U_L] - \left(\frac{\kappa_F}{r+\tau+\lambda_F}\right)p_{FH}(C_{FL} - C_{FH})$$

$$\begin{aligned}\text{(4b)}\quad p_{IL}C_{IL} = {} & (r+\tau)U_L + \pi T - \kappa_I[U_H - U_L] - \left(\frac{\kappa_I}{r+\tau+\lambda_I+\pi+\mu_{FH}}\right)p_{IH}(C_{IL} - C_{IH}) \\ & - \beta\frac{\eta f_F}{r+\tau+\lambda_F+\kappa_F}\left(p_{FL} + \frac{\kappa_F}{r+\tau+\lambda_F}p_{FH}\right)\left[\hat{x}_{FL} - \bar{G}(C_{FL})C_{FL}\right]\end{aligned}$$

where $\hat{x}_{FL} = \int_{C_{FL}}^{1} x dG(x)$ is the average match quality in the formal sector for low-skilled workers.

The value of unemployment increases all measures of reservation match quality since unemployment is the outside option when considering taking a job. Note that firing costs and penalty costs increase the reservation match quality in the formal and informal sectors, respectively, for both high- and low-skilled workers. For low-skilled workers, the third and fourth terms in (3b) and (4b) indicate that the reservation match quality for these workers is reduced by the possibility of accumulating skills. Similarly, for informal-sector workers, the last terms in (2b) and (4b) indicate that the reservation match quality of these workers is reduced by the possibility of making a transition to the formal sector.

For newcomers, the reservation match qualities C_{FN} and C_{IN} solve:

$$\begin{aligned}\text{(5b)}\quad p_{FN}C_{FN} = {} & (r+\tau)U_N + \lambda_F D - \sigma_F[\nu U_L + (1-\nu)U_H - U_N] \\ & - \Gamma_{FL}(C_{FN})\,\frac{\sigma_F\nu}{r+\tau+\lambda_F+\kappa_F}\left(p_{FL} + \frac{\kappa_F}{r+\tau+\lambda_F}p_{FH}\right)(C_{FN} - C_{FL}) \\ & - \Gamma_{FH}(C_{FN})\,\frac{\sigma_F(1-\nu)}{r+\tau+\lambda_F}\,p_{FH}(C_{FN} - C_{FH}) \\ & + (1 - \Gamma_{FL}(C_{FN}))\nu\sigma_F D + (1 - \Gamma_{FH}(C_{FN}))(1-\nu)\sigma_F D\end{aligned}$$

$$
\begin{aligned}
(6b)\quad p_{IN}C_{IN} = {} & (r+\tau)U_N + \pi T - \sigma_I[\nu U_L + (1-\nu)U_H - U_N] \\
& - \Gamma_{IL}(C_{IN})\frac{\sigma_I \nu}{r+\tau+\lambda_I+\pi+\mu_{FL}+\kappa_I}\left(p_{IL} + \frac{\kappa_I}{r+\tau+\lambda_I+\pi+\mu_{FH}}p_{IH}\right)(C_{IN}-C_{IL}) \\
& - \Gamma_{IH}(C_{IN})\frac{\sigma_I(1-\nu)}{r+\tau+\lambda_I+\pi+\mu_{FH}}p_{IH}(C_{IN}-C_{IH}) \\
& - \eta f_F \int_{C_{FN}}^{1} [W_{FN}(x') - U_N]dG(x')
\end{aligned}
$$

As in the case of high- and low-skilled workers, the reservation match quality for newcomers depends on the value of unemployment, the firing costs, and the penalty costs. However, for these workers the reservation match quality also depends on the gains associated with the process of the revelation of skills. Gains associated with the revelation of skills reduce the reservation match quality and these are the gains for both the worker and the firm and are represented by the third, fourth, and fifth terms in equations (5b) and (6b). In the case of the formal sector, there are also costs associated with the revelation of skills. These are the costs incurred if the match has to be destroyed once the worker skill level is revealed and it is indicated in the last two terms in the equation (5b). In all cases, the gains and costs associated with the revelation of skills depend on the value of C_{jN} with respect to C_{jH} and C_{jL} as indicated by the indicator functions $\Gamma_{jk}(x)$ for $j \in \{F, I\}$ $k \in \{H, L\}$. Finally, the reservation match quality in the informal sector also depends on the gains associated with the possibility that the newcomer moves from the informal to the formal sector before the skill level is revealed. This gain is represented by the last term in equation (6b).