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Designing Unemployment Insurance for Developing Countries

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Abstract

The high incidence of informality in the labor markets of middle-income economies challenges the provision of unemployment protection. We show that, despite informational frictions, the introduction of an unemployment insurance savings account (UISA) system may provide substantial benefits. This system improves welfare by providing insurance to the unemployed and creating incentives to work in the formal sector. The optimal scheme generates a reduction in unemployment (from 4 to 3 percent), an increase in formality (from 68 to 72 percent) and a rise in total output (by 4 percent). Overall, individuals obtain welfare gains equivalent to a 2.4 percent increase in consumption in every period.

JEL classification: D82, H55, I38, J65.

Keywords: Unemployment Insurance, Informality, Moral Hazard, Saving Accounts, UISA, Mexico, Incomplete Markets, Job Search.

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1 Introduction

We evaluate the benefits of implementing an optimal scheme of unemployment protection in an economy with key characteristics of middle-income developing countries. Despite the challenges posed by informational frictions, the results show that a system of unemployment insurance saving accounts (UISA) fully subsidized by the government can provide substantial benefits by reducing unemployment, increasing formality, and raising total output.

In a system of UISAs, workers have individual accounts to which they contribute in periods of employment and from which they can withdraw funds when they are not formally employed. Interest payments are credited or debited to this account, depending on its balance. If a balance exists at retirement age, it is available to the worker. If the balance is negative at retirement, most systems forgive the debt. A typical design specifies the following features: rates of contribution to the system, limits and rules for withdrawing funds, limits on total liability, and the interest rate applied to balances. The advantage of UISAs is that incentives are considerably improved when the cost of becoming or remaining not working formally is internalized. Consider an unemployment insurance system in which a worker who loses a formal job receives unemployment compensations for a number of periods that it is independent of her (formal) employment history. Our proposed scheme improves upon this system in two ways: first, by making the payments history dependent it provides incentives to search and retain formal jobs; secondly, personalized accounts make withdraws costly for the agents and prevents long periods of unemployment.[1]

This system is analyzed in the context of three informational frictions that hinder the implementation of unemployment insurance in developing countries. First, there is moral hazard because the government cannot directly observe the job search effort of unemployed individuals. Although this is also important in the developed world, countries with better information about firms and workers in the economy can usually mitigate this friction with agencies that schedule and monitor job interviews for unemployed individuals.[2] Second, we assume unemployment insurance cannot be conditional on the wealth of the unemployed. By allowing the agents to save part of the unemployment benefits, this assumption gives

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[1] The unemployment system analyzed in this paper consist on a particular version of the Unemployment Insurance Saving Account first suggested by Feldstein and Altman (1998).

[2] According to Marinescu (2017), "the standard level of monitoring may require the unemployed to contact about two employers per week, and report this to the unemployment agency, as in the US state of Maryland, or in Switzerland. A reinforced job search monitoring regime requires more job applications, and/or frequent meetings with the case worker who checks on the recipient's job search progress, e.g. every two weeks as under the British Jobseeker's Allowance program (JSA)."

the ability to undo government attempts to provide search incentives using a traditional decreasing profile, like in Hopenhayn and Nicolini (1997).[3] Finally, and key to capture the essence of labor markets in middle-income developing countries, there is an informal labor market that allows individuals outside of the formal labor market to work while still collecting unemployment insurance because their employment status is unobservable. Informality is widespread across developing countries. For example, the informal sector in Latin American countries produces between 25 to 76 percent of output (Schneider and Enste, 2000; Jensen, 2016).

We incorporate these frictions into a life-cycle model with incomplete markets and job search. In this model, individuals protect themselves against unemployment risk with their own savings and borrowing up to the natural borrowing limit. On top of these savings, since the benchmark is calibrated to Mexico, the model has a severance payment system financed with payroll taxes. The model features informality in a way that is meant to capture observed facts of this phenomenon in Latin America. According to Infante and Sunkel (2012), the persistence of a large portion of the labor force working in sectors of low productivity explains the informality of employment in Latin America (see also Infante, 2016). Similarly, CEPAL (2009) analyzes informality as a product of heterogeneity in the productive structure. They consider two sectors: one "formal," of medium or high productivity and having active social protection; and another "informal," of low productivity and having a low level of social protection. Our modeling approach is consistent with this characterization of informality. It considers two types of workers: (i) High-productivity workers with also higher efficiency to find formal jobs and (ii) low-productivity workers who are also relatively inefficient at finding formal jobs.

Why can a UISA system improve welfare even when individuals have access to borrowing/savings? By borrowing/saving individuals can move consumption across time perfectly. However, they are restricted by the inter-temporal budget constraint: the discounted sum of consumption must be equal to the discounted sum of income. With unemployment risk, unlucky individuals who spend more time in unemployment will have a discounted sum of income that is lower than lucky individuals. Unemployment insurance is about transferring income from lucky individuals to unlucky individuals. Of course, since individuals can pretend to be unlucky, the design of unemployment insurance must deal with moral hazard. That friction is at the center of our analysis. We show that a UISA system can provide insurance while at the same time minimizing distortions on incentives to work formally.

For the calibration of the model, we estimated life-cycle profiles of formal and informal wages using data for Mexico. In addition, we targeted key statistics about formal employment

[3] For a detail description of a role of hidden savings see Kocherlakota (2004).

and unemployment among young individuals, as well as quarterly transition rates between formality, informality, and unemployment. Our results indicate that the optimal design of a UISA has some features of the schemes implemented in Latin America and discussed by Ferrer and Riddell (2011). For example, during formal employment, the optimal scheme has a contribution of 12 percent to the worker's savings account, which is within the range the contribution rate in the system existing in Argentina for workers in the construction sector (about 8-12 percent).

In our optimal system, an individual with no initial funds in her UISA must work in the formal sector for about 8 quarters to qualify for a full formal wage during unemployment (i.e. this is a direct implication of a contribution rate of 12 percent). These contributions are fully subsidized and so made directly by the government. Whenever the account reaches a maximum (equivalent to one year of earnings in the formal sector), no more contributions are credited. An upper bound to the contributions is a feature similar to the system implemented in Chile in 2002. There, the employee contributions are limited to 11 years in each employment. In our optimal scheme, if a worker with a maxed account transitions to unemployment, she will receive unemployment payments equal to a full formal salary until she runs out of money in the account—which would happen after almost 1 year—or finds a job, whatever happens first. However, note that if a worker loses her job when the account is only half full, the duration of unemployment insurance payments is approximately 2 quarters. In the Chilean system, the length of the benefits also depends on the worker's contributions, and these payments also stop if the individual initiates a job. Both in our optimal scheme and in Chile, workers that retire with resources in the savings account receive those funds. Moreover, in our setup, it is optimal for contributions to be made by the government and not by individuals. This is because individuals already save optimally, and so the only possible improvement is through insurance against unemployment risk. That is, individuals that spend a larger share of their lifetime unemployed receive transfers from individuals that spent less time unemployed. Again, Chile similarly incorporates contributions from the government, although most UISA programs in Latin America do not (employers and the employees make contributions).

The government's contribution to the savings account provides incentives to keep jobs in the formal sector, and the limited duration of unemployment insurance benefits provides extra incentives to search for formal jobs. Overall, optimal UISAs produce welfare gains of 2.4 percent in consumption equivalent units. Formality increases by more than 3 percentage points, with the most significant increase happening for young individuals. The optimal system also helps in reducing unemployment, which decreases from almost 4 percent to 3 percent.

This article provides some policy recommendations that should be relevant for countries with the features included in the model. In particular, we have in mind countries with both (a) sufficient wage employment and (b) large incidence of informality. As a reference, it may be useful to consider the classification of the employment structure in Jensen (2016)'s analysis of the rise of the modern tax system. In that classification, our "formal employment" is called employee-job based. The key for this definition is that these are jobs that generate an information trail relevant for tax enforcement. Jensen (2016) also have a category, referred to as self-employment, which is quite similar to what we and ILO (2009) call informality. Figure 2 in Jensen (2016) shows the share of workers that are "employees" (formal workers) and "self-employed" (informal workers) for "average countries" with different levels of income per capita. There, countries with income per capita between $1065 and $2226 have the great majority of workers (between 80 and 90 percent) working informally. As a consequence, these countries may struggle implementing a UISA system as the one proposed here that is financed by taxing employment. On the other extreme, the same figure shows that "the average country" with income per capita $27960 and above have very low rates of informality (15 percent or less) and may find only small benefits of implementing an UISA system tailored to deal with informality. Thus, we believe that with the classification in Jensen (2016) countries with both sufficient wage employment and large incidence of informality are countries with incomes per capita roughly between $3,000 and $25,000 in PPPs dollars of 2011.

The rest of the paper is organized as follows. The next section describes the related literature. Section 2 introduces the environment. Section 3 presents the calibration results. Section 4 describes the optimal systems and Section 6 analyzes the sources of welfare gains derived from the optimal system. The appendix contains more details on the calibration and quantitative exercises.

1.1 Related Literature

The concern of moral hazard when designing unemployment insurance schemes was introduced in the seminal works of Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997). This literature focuses on the problem where agents are assumed to exert costly unobservable effort to find a job. In order to circumvent the associated moral hazard, this literature proposes monotonically decreasing benefits throughout the unemployment spell, replacement rates during unemployment, and taxes during employment that depend on the entire employment history of the worker. The last feature suggests that individual-specific unemployment accounts that provide information about individual employment history may be desirable and motivate the evaluation of introducing UISAs.

In our setup there is heterogeneity in productivity and in search effort productivities across workers. Fuller (2014) considers an environment where the utility cost of exerting effort to find a job varies across agents so that adverse selection problems arise. In his setup the optimal unemployment contract does not necessarily imply decreasing payments over the unemployment spell. Wang and Williamson (2002) also studied heterogeneity across workers, in their case across different industries, and found that the optimal unemployment insurance benefit schedule is non-monotonic. In our model, individuals have productivities of exerting search effort to find a formal job that differ, which creates heterogeneity similar to Fuller (2014).

Combining moral hazard with informality is the main contribution of Alvarez-Parra and Sánchez (2009). They explore the impact of a shadow economy on the design of unemployment insurance, which breaks the exact mapping between consumption and unemployment insurance payments. The non-observability of the participation in this market results in a flattening of the payments profile for some time to prevent individuals from joining the informal sector. After that time, optimality dictates that the unemployment insurance payments should drop to zero so that unemployed workers rely on the informal sector to obtain income. Our modeling of informality is similar to Alvarez-Parra and Sánchez (2009). However, we assume that finding a job in the informal sector is not always possible and calibrate that risk to transition rates in Mexico.

Another key difference between our model and theirs is the role of savings. This feature in the design of optimal contract with moral hazard was first pointed out by Rogerson (1985). The key insight there was that if a government tries to implement a contract similar to the one described by Hopenhayn and Nicolini (1997) or Alvarez-Parra and Sánchez (2009), agents will choose to save to offset the incentives provided by a declining profile of unemployment insurance payments.[4]

The papers mentioned above characterized the optimal unemployment insurance scheme in the presence of moral hazard and one additional friction. Note that in all cases these modifications are enough to alter the main prediction of the original model. Here, we include all these frictions to capture the economic environment in a developing country. The cost of our strategy is that analytic characterizations are hard to obtain. We overcome this difficulty through numerical optimization of the parameters describing UISAs to find what we call the optimal policy. Even when an analytic characterization of the constraint-efficient allocation is available, an approximation by a relatively simple system (e.g., UISAs) is always desirable to help guide policy. Thus, it is not surprising that approaches similar to ours have already

[4]See also Cole and Kocherlakota (2001), Kocherlakota (2004), and Abraham and Pavoni (2008).

been pursued. For instance, Feldstein and Altman (1998) evaluated the benefits of UISAs for the US. More related to our work is the contribution of Hopenhayn and Hatchondo (2011). They develop a simpler model than ours to examine the performance of alternative designs of UISAs in which contributions are made by the individuals taking into account private information through savings and effort. Since we will rely on the quantitative evaluation of alternative schemes, our model is quantitatively richer. Importantly, we also allowed for informality, which is arguably the most common labor markets difference between developing and developed countries.[5] More recently, Setty (2017) looks for the optimal parameters of a hybrid system that combines UISA with a traditional unemployment system that is used if the worker runs out of savings in the account. While his model is quantitatively richer than ours, the only informational friction in his setup is moral hazard.

Our work is also related to the analysis of labor market policies in a dual economy by Esteban-Pretel and Kitao (2020). While we focus on the details of a UISA system's design in partial equilibrium, they analyze much simpler policies but in a general equilibrium model. Extending the analysis to general equilibrium is an essential contribution of Esteban-Pretel and Kitao (2020) because, as they show, increasing the severance payment to provide higher protection to formal employees depresses the equilibrium wages in the formal sector. This margin of adjustment, which is not present in our analysis, would likely be smaller because, in our results, formality increases only moderately.

2 The Environment

In each period $t = 0, 1, 2, 3...$, a new ex-ante identical generation of N_t individuals is born. The new generation growth rate is constant at $x \geq 0$; i.e., $N_t = (1+x)^t$. Each of these households has the following lifetime profile: During the first N periods, agents can participate in labor markets and work (i.e., working periods). When an individual reaches age $N + 1$, she retires from the labor market. Once retired, individuals survive to the next period with probability ρ.

There are *only two types* of workers, whom we label low and high education (indexed by h, as in human capital). They differ in their productivity to find formal jobs θ_h (search productivity) and their productivity at formal jobs μ_h^f (work productivity). The fraction of workers with education h is ϕ_h. Both dimension of heterogeneity are exploited. Differences in work productivity are essential to allow the model to capture differences in earnings across workers in the formal sector. Heterogeneity in search productivity, on the other hand, helps

[5] Also, while our work emphasizes unemployment insurance dynamics in a developing country (Mexico), their work turns to a more developed labor market (Estonia).

account for the fact that individuals with lower education spend most of the time in the informal sector despite a significant premium in earnings for working formally. In other words, heterogeneity in search productivity allows the model to generate the persistence of a large portion of the labor force working in sectors of low productivity, as described by Infante and Sunkel (2012) and Infante (2016) for Latin America.

Both types of worker share the same productivity in the informal sector, μ^i. They also have the same life-cycle component of productivity, which differs by sector (formal or informal) and can be thought of as the returns to overall experience. We will denote the return of experience as in each sector as η_n^ℓ with $\ell \in \{f, i\}$, where n represents the working age or overall experience of the individual.

In each date t, the worker's utility at time t depends on consumption c_t and the corresponding search effort cost e_t , according to the utility function $u(c_t) - e_t$; $u : \mathbb{R} \to \mathbb{R}$ satisfies standard properties. Lifetime expected discounted utility is represented by

$$\mathbb{E}\left\{\sum_{t=1}^{\infty} \beta^t [u(c_t) - e_t]\right\},$$

where $\beta \in (0, 1)$ is the discount factor and $\mathbb{E}$ is the expectation operator.

2.1 Labor Market Decisions

Here we describe the labor market decisions faced by an individual during her working periods. An individual of working age $n = 1, ..., N$ can either work in the formal sector, work in the informal sector, or be unemployed.

Consider first a worker who has received an educational attainment $h \in \{L, H\}$. Suppose that she enters her working period n with an offer in the formal sector. The worker's earnings in the formal sector would be $\omega_{n,h}^f = \eta_n^f \mu_h^f$. If the offer is accepted, the worker exerts effort e to keep this job in the formal sector next period with a probability given by the increasing and concave function $q^f(\theta_h \times e)$. The probability of finding a job is increasing in θ_h, holding the level of effort constant, implies that more educated individuals are more likely to find jobs in the formal sector.

Second, suppose that an individual enters her working period n with an offer in the informal sector. Importantly, informal job offers are unobservable to third parties. The worker's informal earnings equal the productivity in the informal sector, $\omega_n^i = \eta_n^i \mu^i$. Note here that we allow the life-cycle component, η_n^i, to be different than the one in the formal sector. Also note that the sectorial component, μ^i, is assumed independent of education. This is because we found no return to education in our estimations for the informal sector.

If she accepts this offer, she must decide how much effort e to exert to receive an offer in the formal sector next period, with a probability given by the increasing and concave function $q^i(\theta_h \times e)$. As before, search effort productivity θ_h here increases the probability of finding a job holding the level of effort constant so that it is more likely that more educated individuals find jobs in the formal sector.

Finally, suppose that she enters her working period n without a formal or an informal job offer. The worker then decides how much effort e to exert to receive an offer in the formal sector next period, with a probability given by the increasing and concave function $q^u(\theta_h \times e)$. Again, search productivity increases the likelihood of finding a formal job holding constant the level of effort. Any rejected offer will make this worker unemployed immediately.

For simplicity, we assume that a worker cannot receive offers in both sectors at the same time. Therefore an active worker's opportunity status can be denoted by one of $\{f, i, u\}$, which denote formal, informal, and unemployed states, respectively.

The probabilities of any worker of age n finding a job in the informal sector are all exogenous (independent of search effort), but conditional upon the current employment status. Informal, formal, and unemployed workers in the current period will receive an offer in the informal sector next period with the respective probabilities p_i, p_f, and p_u.

2.2 Financial Markets

Agents have access to financial markets and undertake consumption-savings decisions. That is, an agent must allocate her resources (which will include financial income, as detailed below) between consumption and savings. While they are active, they have access to a risk-free one-period bond in which they can borrow and save (subject to a debt limit $\underline{m}$) at the gross interest rate R. Agents are endowed with $m_0 \geq 0$ when they are born.

The role of savings in this setting is key. First, once a worker knows her type, the only source of risk is unemployment risk. This means workers borrow and save for precautionary purposes. Second, workers face a life-cycle wage profile that is not flat, so borrowing and saving decisions are key to smooth consumption across ages.[6] Finally, they can also save for retirement.

Since agents have access to borrowing and saving of an uncontingent bond subject to a debt limit, it may be worth asking why they need any sort of unemployment insurance. The answer is that during their finite life span, two agents that exert exactly the same effort

[6] Borrowing is allowed to be able to focus the attention on the provision of unemployment insurance. For the same reason, this is an assumption that is usual in the optimal taxation literature (for a recent example, see Ndiaye, 2018). Without this assumption, unemployment insurance would be optimally designed to provide liquidity to agents to anticipate consumption in the life-cycle.

might have different life-time incomes due to the risk of unemployment. One agent could be unemployed more time than the other. Providing unemployment insurance to these two agents amounts to subtracting from the life-time income of the lucky individual (who was employed more often) and adding to the life-time income of the unlucky individual (who visited unemployment more often). This could be ex-ante beneficial to both agents. The issue is how to provide insurance in a way that individuals do not change their behavior to extract rents from the system. Next, we present a system that is sufficiently flexible to provide UI minimizing these distortions once optimized.

2.3 Unemployment Protection

We set up a general system of unemployment protection that nests the severance payment used in Mexico but it allows for flexibility such that under certain parameterizations it resembles UISA and experience rating.

Workers have personalized accounts to which the government contribute in periods of formal employment and from which they can choose to withdraw funds when they are out of formality. Interest payments are credited into these accounts and remaining balances may become available to the workers at retirement age. We argue that this system, when set optimally, not only provides insurance to the workers but also aligns incentives correctly.

The following parameters $\Gamma = (\overline{s}, \psi, b, \tau_w, \tau_r)$ fully describe the system. Notice that, in order to simplify the system, we assume that parameters do not depend on the education types h.

1. $\overline{s}$ is a proportion of current wages that provides an upper bound for contributions to the worker's account, determining the value above which the worker does not receive contributions to the system, i.e. when the balance in the worker account reaches $\overline{s}_{n,h} = \overline{s}\omega^f_{n,h}$ then the government stop crediting contributions. However, they continue to accumulate interest payments at the market rate.

2. ψ is the contribution rate made by the government during formal employment for a worker with wage $\omega^f_{n,h}$, where the total contribution to a account with savings s is given by $\psi_{n,h}(s) = \min\{\overline{s}_{n,h} - s, \psi\omega^f_{n,h}\}$;

3. b defines a replacement rate implying that someone without a formal job and a saving account with savings s receives $b_{n,h}(s) = \min\{s, b \times \omega^f_{n,h}\}$, as her (potential) wage is $\omega^f_{n,h}$;

4. τ_w is a general tax on formal labor income, where workers with wage $\omega^f_{n,h}$ in the formal sector pay $\tau_w \times \omega^f_{n,h}$;

5. τ_r sets a tax on balances at retirement, so that if the worker arrives at retirement with balance s she will only get $s \times (1 - \tau_r)$.

The system works as follows. If an individual is formally employed, the government makes a contribution given by the rate ψ to her saving account, up to the limit given by the rate $\overline{s}$. The individual pays payroll taxes τ_w. Funds accumulated by the government on behalf of the workers are invested at the market interest rate R. They can voluntary withdraw from their accounts while not working in the formal market, as long as they have funds available, at most at the rate b of their potential wage per period. If there are funds left at retirement, a share τ_r is taken by the government and the rest is credited to the individual.

2.4 Individuals Problem

We present the individuals problem going backward on age.

2.4.1 Retired Individuals

Retired workers always face the same problem at age $n \geq N + 1$ in which the only source of uncertainty is mortality. Suppose that this individual survives and reaches period n with m asset holdings. Denote m' as the amount of mortality-contingent securities that pay 1 unit of the consumption good in case of survival next period, with price μ.

Conditional on their education h, retired workers receive from the government a constant pension d_h while alive. Denote $H_h(m)$ as her expected lifetime utility and so, as retired agents survive with probability ρ, H must solve

$$H_h(m) = \max_{m' \geq \underline{m}} \left[u(m + d_h - \mu m') + \beta\rho \; H_h(m') \right]. \tag{1}$$

Notice that retired agents do not pay taxes and do not exert any effort; i.e., $e_t = 0$ for all $t \geq N + 1$.

2.4.2 Retirement Age ($n = N$)

The analysis at period N is similar to $n < N$, but the continuation is simpler because the worker will be retired next period $N + 1$, and therefore she does not exert any effort at age N. Any balance s_N in the savings account at the end of period N is partially transferred to $N + 1$ as follows: the worker keeps $s_N \times (1 - \tau_r)$, which cannot be negative because the balance cannot be negative.

Here we detail the case where a worker receives a formal offer. The other cases are similar.

Her maximized expected lifetime utility, V_N^f, must solve

$$V^f_{N,h}(s,m) = \max\left\{V^{f,a}_{N,h}(s,m), V^u_{N,h}(s,m)\right\}.$$

The value of accepting the formal job offer, $V^{f,a}_{N,h}$, must solve

$$V^{f,a}_{N,h}(s,m) \quad = \quad \max_{m'}\left\{u\left(mR + \omega^f_{N,h}\left(1-\tau_w\right) - m'\right) + \beta H_h\left(m' + s' \times (1-\tau_r)\right)\right\},$$

where $s' = R(s + \psi_{N,h}(s))$ denotes next period savings in the account. Alternatively, the value of rejecting the formal offer and remaining unemployed must satisfy

$$V^u_{N,h}(s,m) \quad = \quad \max_{m',\delta\in\{0,1\}}\left\{u\left(mR + \delta b_{N,h}(s) - m'\right) + \beta H_h\left(m' + s' \times (1-\tau_r)\right)\right\},$$

where $s' = R(s - \delta b_{N,h}(s))$ denotes next-period savings in the account. The discrete choice of accepting to withdraw from the saving account (when possible) is represented by $\delta = 1$, while $\delta = 0$ means that the worker does not execute this option.

In the case where they only receive an informal offer and decide to accept it, the lifetime utility is

$$V^{i,a}_{N,h}(s,m) \quad = \quad \max_{m',\delta\in\{0,1\}}\left\{u\left(mr + \omega^i_N + \delta b_{N,h}(s) - m'\right) + \beta H\left(m' + s' \times (1-\tau_r)\right)\right\},$$

where $s' = R(s - \delta b_{N,h}(s))$ denotes next-period savings in the account.

2.4.3 Individuals before retirement ($n < N$)

Here, we consider a worker with age $n < N$, education h, m personal assets, and s assets in her saving account.

Suppose that the individual receives an offer in the informal sector. Her maximized lifetime utility, V_n^i, must solve

$$V^i_{n,h}(s,m) = \max\left\{\underbrace{V^{i,a}_{n,h}(s,m)}_{\text{accept}}, \underbrace{V^u_{n,h}(s,m)}_{\text{reject}}\right\}.$$

The value of accepting the informal job offer satisfies

$$\begin{aligned} V^{i,a}_{n,h}(s,m) \;\; = \;\; & \max_{(e,m' \geq \underline{m}, \delta \in \{0,1\})} u\left(mR + \omega^i_n + \delta b_{n,h}(s) - m'\right) - e + \\ & \beta \left\{ (1 - q_i(\theta_h e)) \left[p_i V^i_{n+1,h}(s', m') + (1 - p_i) V^u_{n+1,h}(s', m') \right] \right. \\ & \left. + \; q_i(\theta_h e) V^f_{n+1,h}(s', m') \right\}, \end{aligned}$$

where $s' = R(s - \delta b_n(\theta, s))$ denotes next-period savings in the account.

Suppose that the worker receives an offer in the formal sector. Her maximized expected lifetime utility must solve

$$V^f_{n,h}(s,m) = \max \left\{ V^{f,a}_{n,h}(s,m), V^u_{n,h}(s,m) \right\}.$$

The value of accepting the formal job offer must solve

$$\begin{aligned} V^{f,a}_{n,h}(s,m) \;\; = \;\; & \max_{(e,m' \geq \underline{m})} u\left(mR + \omega^f_{n,h}\,(1 - \tau_w) - m'\right) - e + \\ & \beta \left\{ (1 - q_f(\theta_h e)) \left[p_f \; V^i_{n+1,h}(s', m') + (1 - p_f) \; V^u_{n+1,h}(s', m') \right] \right. \\ & \left. + \; q_f(\theta_h e) V^f_{n+1,h}(s', m') \right\}, \end{aligned}$$

where $s' = R(s + \psi_{n,h}(s))$ denotes next period savings in the account.

Finally, suppose that the worker receives no offer and is consequently unemployed. Her maximized expected lifetime utility is

$$\begin{aligned} V^u_{n,h}(s,m) \;\; = \;\; & \max_{(e,m' \geq \underline{m}, \delta \in \{0,1\})} \big\{ u\big(mR + \delta b_{n,h}(s) - m'\big) - e + \\ & \beta \big\{ (1 - q_u(\theta_h e)) \big[p_u \; V^i_{n+1,h}(s', m') + (1 - p_u) \; V^u_{n+1,h}(s', m') \big] \\ & q_u(\theta_h e) V^f_{n+1,h}(s', m') \big\}, \end{aligned}$$

where $s' = R(s - \delta b_{n,h}(s))$ denotes next-period savings in the account.

Ceteris paribus, the value of rejecting all the job offers available and of receiving none must necessarily coincide in equilibrium. The key difference is that in the first case the worker decides to be unemployed while in the second she is forced to be unemployed. In addition, observe that individuals working in the formal or informal sector will face different probabilities of finding a job, both formally and informally.

2.5 A Severance Payment System as the Benchmark

A simple way to provide protection to the unemployed is with a severance payment system. This section argues that the policy parameters described above can be chosen to approximate an economy using this system. This is relevant because such a system exists in Mexico, our benchmark economy used to calibrate the model. There, a formal worker that loses her job receives three months of the last wage she got.

The parameters must be set in the following way: $\overline{s} = 1/R, \psi = 1/R, b = 1, \tau_r = 1$ and τ_w such that there is balanced budget. With these values, workers receive three months of their last wage, independently of their tenure, in the quarter after losing a formal job. The saving account simply acts as an index to determine the right to receive payments during unemployment. Since there is a full tax at retirement, $\tau_r = 1$, they do not receive the money left in the account at retirement. Given $\psi = 1/R$ and $b = 1$, workers have the right to receive one quarterly wage after working just one period in formal employment.

This proposed system is an approximation of a severance payment economy because $\overline{s}$ only sets a threshold at which the contributions to the account stop. However, the stock of resources in the account can grow higher than this value because workers earn interest payments in the account: A worker who was formally employed for many periods would receive a quarterly salary after losing her job and, if she remains unemployed in the following period, additionally receive the interests earned in the account. For the value of the parameters in our calibration, we verified that this difference is actually very small.

2.6 How do We Choose the Optimal UI System?

Here we define how we select the parameters of what we define as *the optimal UI system*. The set of policy parameters is $\Gamma = (\overline{s}, \psi, b, \tau_w, \tau_r)$. Let $V^j_{0,h}(m_0 \mid \Gamma)$ be the utility of a type-h worker with initial private savings m_0, employment offer status j, and under the system Γ. Denote $v^j_{0,h}(m_0)$ as the initial fraction of workers with employment state j, private savings m_0, and type h. Similarly, let $F^j_{n,h}(m, s)$ denote the age-n fraction of individuals with type h that has accumulated m as private savings, a balance s in the saving account and employment status $j = \{f, i, u\}$. Finally, let $T(\Gamma)$ and $G(\Gamma)$ denote the resources collected and spent by the scheme Γ, respectively.

In what follows, we detail how to compute the expenditures and revenues for each system to make them comparable. Agents retire after working for 160 quarters (from 25 to 65 years old) and during retirement they survive to the next period with probability ρ. We discount future revenues at the gross interest rate R which satisfies $\beta \times R = 1$. Consequently, since the fraction of surviving retired workers after j years is ρ^j, we discount payments to retirees using $\beta \times \rho$. We normalize the size of the initial population to one.

Expenditures

Let d_h denote the pension payment of type h. The total expenditure in pensions is given by:

$$Pensions = \sum_{h=L,H} d_h \frac{\beta^{159}}{1-\beta\rho} \phi_h.$$

Recall that $\psi_{n,h}(s)$ denotes the contribution made by the government to the account of a formally employed individual of type h, age n, and previous assets s in the saving account. The total expenditure in contributions to the saving accounts is given by

$$Contributions = \sum_{n=1}^{160} \beta^{(n-1)} \sum_{h=L,H} \phi_h \int_m \int_s \psi_{n,h}(s) F^f_{n,h}(m,s)\ ds\, dm.$$

Then, total expenditures for an scheme Γ are given by $G(\Gamma)=$ *Contributions + Pensions.*

Revenues

The government taxes at the rate τ_r the remaining savings in the Saving Account of the agents at retirement. The income from that source is

$$Revenues\ from\ Taxes\ at\ Retirement = \tau_r \beta^{160} \sum_{h=L,H} \phi_h \sum_j \int_m \int_s s^j_{161,h}(m,s) F^f_{160,h}(m,s)\, dsdm.$$

The main income source is labor taxes, which is given by

$$Payroll\ Tax\ Revenues = \tau_w \sum_{n=1}^{160} \beta^{(n-1)} \sum_{h=L,H} \phi_h w^f_{n,h} \int_m \int_s F^f_{n,h}(m,s)\ ds\, dm.$$

Therefore, total revenues for an scheme Γ are given by,

$$T(\Gamma) = Revenues\ from\ Taxes\ at\ Retirement + Payroll\ Tax\ Revenues.$$

Finally, a balanced budget for the government implies that

$$T(\Gamma) = G(\Gamma).$$

Optimality

Now denote Γ^S as the value of the policy parameters that implement the severance payments system. We define the optimal scheme, Γ^*, as the one that solves

$$\max_{\Gamma} \sum_{h=L,H} \phi_h \sum_{j=f,i,u} \int_{m_0} \int_{s_0} V_{0,h}^{j}(m_0 \mid \Gamma) dv_{0,h}^{j}(m_0, s_0),$$

subject to

$$T(\Gamma) = T(\Gamma^S), \tag{2}$$

$$G(\Gamma) = G(\Gamma^S). \tag{3}$$

We constrain our optimal scheme in two ways. Constraint (2) requires that the optimal system must generate the same level of revenues as in the benchmark economy while constraint (3) means that expenditures must also be equal to expenditures in the benchmark. Note that this is more restrictive than generating the same balance, which is zero in the benchmark. It is a way impose that *the generosity of the system must be the same* as that of the benchmark. This makes the comparison across systems cleaner and prevents the system from trying to mitigate other frictions that are present and perhaps more important than the risk of unemployment. Thus, what we present as our optimal scheme is purely a redesign of the existing system in order to quantify potential welfare improvements.

3 Calibration

We use Mexico as the benchmark economy because of the prevalence of the frictions included in our analysis. Another advantage of using Mexico is data availability, which is obtained from the National Institute of Statistics and Geography (INEGI).

As the goal of our exercise is to evaluate the quantitative impact of policy reforms, we must select the key parameters of the model. This section briefly explains these choices, describes the parameters, and compares the model with the data. In the calibration, the setting described in section 2.5 is employed to approximate the observed system of unemployment protection.

The value of the parameters are set using three strategies. First, there is a group of parameters that can be obtained directly from data or taken from previous literature. Whenever possible, we follow that strategy. For the rest of the parameters, we choose specific targets and search for values to minimize the distance to the targets.

3.1 Functional Forms

The utility function is the standard constant relative risk aversion (CRRA) form,

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma},$$

with relative risk aversion parameter $\sigma > 0$. The functions describing the probability of getting formal job offers are

$$q_i(\theta_h e) = 1 - \exp(\xi_I \theta_h e), \quad q_u(\theta_h e) = 1 - \exp(\xi_U \theta_h e), \text{ and } q_f(\theta_h e) = 1 - \exp(\xi_F \theta_h e).$$

This choice of functional forms for the probability of getting a job offers has a tradition in the literature going back to Hopenhayn and Nicolini (1997). One advantage is that the probability is zero when search effort is zero, and it approaches one as search effort goes to infinity. Another advantage is that the term multiplying search effort can be calibrated to match the average transition rates in the data.

3.2 Calibration Results

Several parameters were obtained directly from data or previous literature. The retirees survival probability, $\rho = 0.9875$, is set to match Mexican lifetime expectancy. The coefficient of relative risk aversion is set at $\sigma = 2$. The discount factor is set at $\beta = 0.96^{1/4}$, and the returns on savings for the workers is set at $R = \frac{1}{\beta}$.

To calibrate the remaining parameters, we construct statistics using Mexican data for the third quarter of 2017, a recent representative quarter. Unemployment, informality rates, labor transition probabilities, schooling years on each sector, and life-cycle profiles of wages were calculated from the National Employment and Occupation Survey (ENOE) from the INEGI. The survey is the largest continuum household survey performed by the national statistics authority quarterly to gather information about the labor force characteristics and their occupations in the entire country. The survey is a rotating panel with 20 percent of the households tracked for five quarters before being replaced by another with similar characteristics.

To get the unemployment and informality rates using the ENOE, we keep only residents between 25 and 65 years old, as in our model. Unemployment rates correspond to the sum of all unemployed people over active population, for every age group. Since in our model agents cannot be self employed or employers, we keep only workers that are employed and receive a salary for their job. We define a worker as informal following the methodology the

INEGI uses to characterize informality of the main job. This identification consists on two parts: First, we will label a worker as informal if it is employed by a company that operates in the informal sector, that is, a non-registered firm that does not have an office nor a formal accounting system. Secondly, a worker is also defined as informal if he or she does not have access to health insurance. We compute the informality rates as all the workers defined as informal over the total working population in our sample.

Another important set of moments correspond to quarterly transition probabilities, which were calculated between the third and fourth quarter of 2017. The ENOE allows us to identify agents that were interviewed in both quarters and the employment state that the person has at each date. To calculate transitions we keep only agents with both observations in one of the three states defined above: formal, informal or unemployed. Then, we calculate the number of people that move from one state to another and divide by the number of people in the departing state to get the transition probability. For instance, the transition rate from formal employment to unemployed is defined as all the people that move from formal employment to unemployed between 3Q-07 to 4Q-07 divided by the number of formal workers in 3Q-07.

To obtain the life-cycle profile of wages, η_n^f and η_n^i, we estimated the life-cycle profile of hourly wages using data from the ENOE. The estimation is subject to self selection bias arising from endogenous choices of unemployment, formality, and informality. The self-selection bias, we are considering is similar to the one raised in Heckman (1979) but generalized to include multiple discrete choices. A low productivity worker may prefer low search effort, creating a selection of high productivity workers into employment and biasing the estimated coefficients. Also, the same selection problem may be present in the choice of formal and informal sectors. This selection issue is critical for the consistent estimation of the intercept in the regression. In order to correct for self-selection bias we proceed as in Lee (1983) and Bourguignon et al. (2007).[7] The estimated profile for formal salaries is constructed using self-reported income, which corresponds to after-tax wage. In order to incorporate tax to our model, we increase the formal profile so that the one used as an input in the model after tax coincides with the estimated. Our estimation is performed with cross-sectional data and cannot distinguish between potential experience and birth-cohort effects due to co-linearity. However, our estimates for Mexico are similar to the profile estimated for Mexico in Lagakos et al. (2018).

Recall that wages also have sector-specific (formal or informal) shifters μ_H^f, μ_L^f, and μ^i. We obtain them directly from data using the estimated Mincer equation at age 25 (zero

[7] Treviño (2007) and Ordaz (2008) performed similar works for the case of Mexico. Details on the estimation of the Mincer equation are presented in Appendix A.

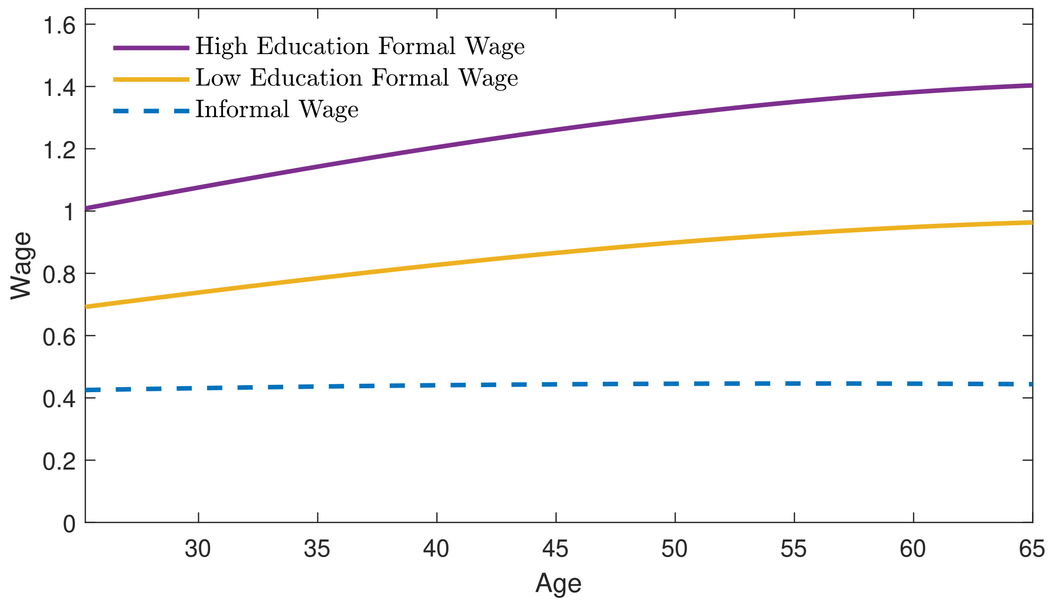
experience) using as an input the average education in each sector equal to what we observe in the data. However, the average education in each sector is endogenous in our model, since both types work formally and informally. Thus, we add to the set of targets that we want the model to reproduce the average education in each sector (more on this below).

Table 1: Calibrated Parameters

Parameter	Description	Value	Source
ξ_U	Overall Search efficiency, u-to-f	0.029	Fit moments in Table 2
ξ_I	Overall Search efficiency, i-to-f	0.031	Fit moments in Table 2
ξ_F	Overall Search efficiency, f-to-f	0.359	Fit moments in Table 2
p_f	Prob. of i offer $t+1$ given f at t	0.75	Fit moments in Table 2
p_u	Prob, of i offer $t+1$ given i at t	0.59	Fit moments in Table 2
p_i	Prob, of i offer $t+1$ given u at t	0.96	Fit moments in Table 2
θ_H	High Education Search Efficiency	45.5	Fit moments in Table 2
θ_L	Low Education Search Efficiency	5.30	Fit moments in Table 2
ϕ_H	Share of High Education Individuals	0.75	Fit moments in Table 2
y_H	Years of Education for High Education Agents	11.8	Fit moments in Table 2
y_L	Years of Education for Low Education Agents	6.9	Fit moments in Table 2
μ^i	Informal Sector Productivity	0.44	Mincer eq. estimation
μ_L^f	Formal Sector Productivity, Low Education	0.7	Mincer eq. estimation
μ_H^f	Formal Sector Productivity, High Education	1.00	Normalization
d_H	Pensions for High Education Individuals	0.62	Directly from ENIGH
d_L	Pensions for Low Education Individuals	0.38	Directly from ENIGH
$\upsilon_{0,H}^f$	Initial Share of High-Edu in Formality	0.64	Directly from ENOE
$\upsilon_{0,L}^f$	Initial Share of Low-Edu in Formality	0.27	Directly from ENOE
$\upsilon_{0,H}^i$	Initial Share of High-Edu in Informality	0.31	Directly from ENOE
$\upsilon_{0,L}^i$	Initial Share of Low-Edu in Informality	0.68	Directly from ENOE

Figure 1 shows our estimated profiles of after-tax hourly wages using the average level of education conditional on each state. We normalized the initial wage in the formal sector for high education workers to 1.

Figure 1: Estimated Life-Cycle Profile of Before Tax Wages by Sectors



The retirement payment parameter d was calculated using the income survey of Mexico (ENIGH) for the year 2016.[8] Since our high education individuals have approximately 12 years of education, we pick agents with secondary school completed, whereas for low education individuals we consider only primary school. Our calculations using the average income at retirement gave us a $d_H = 0.62$ and $d_L = 0.38$; that is, respectively 62 percent and 38 percent of the average formal wage.

Starting probabilities across assets and labor status, $\upsilon^j_{0,h}(m_0, s_0)$, must be set as well. Since there is no direct evidence on the initial stocks of assets in Mexico and since young workers in the United States have very little savings, we set m_0 to 15 percent of an average formal wage for Mexico. The value of s_0 is set at zero because there is not currently a UISA in Mexico. Since the probability across m and s are degenerate, the probabilities across employment status are referred to as $\upsilon^j_{0,h}$. They are conditional on educational levels and taken directly from ENOE as the ratio of formal, informal and unemployed agents with primary and secondary school completed; the probability of starting with a formal offer is $\upsilon^f_{0,H} = 64$ percent for high education agents and $\upsilon^f_{0,L} = 27$ percent for low education individuals, whereas the probability of starting with an informal offer $\upsilon^i_{0,H} = 31$ percent and $\upsilon^i_{0,L} = 68$ percent for high and low education individuals, respectively. Finally, the labor tax is set to $\tau_w = 19.9$ percent in order to balance the budget in our benchmark economy.

[8]The reason of using a different survey is that the ENOE, the survey that allow us to distinguish between formal and informal employees, do not report income of retired people. Therefore we use the closest wage of the ENIGH, which is performed every two years.

The remaining 11 parameters, listed in top panel of Table 1, are jointly calibrated to minimize the distance to relevant data targets, which are presented in Table 2. To do this we performed a minimization of the distance between moments and targets with equal weights in each target. In Appendix C we argue that the choice of moments let us identify the value of the parameters by showing how the distance to each target varies when we vary one parameter at a time. As can be seen in Table 2, the model reproduces aggregate moments quite well. In particular, it reproduces almost exactly the transition probabilities among the alternative labor market statuses (formal job, informal job, and unemployment).

Table 2: Calibration Targets and Fit

Statistic	Model	Data
Unemployment Rate	3.9	3.5
25-30 years	4.3	5
Formality Rate	68	66
Quarterly Transition Matrix		
Formal to formal	88	89
Formal to informal	9	9
Informal to formal	21	20
Informal to informal	76	77
Unemployed to formal	38	38
Unemployed to informal	37	37
Education Level		
Average Schooling in formal sector	11.6	11.9
Average Schooling in informal sector	8.6	8.62

By construction, this benchmark economy is not able to reproduce data on consumption or wealth. Recall that to isolate the lack of insurance, in the benchmark economy we allow individuals to borrow against future income. This assumption implies a wealth distribution with a mean close to zero and flat life-cycle profiles, both at odds with the data.

Importantly, recall that the model captures differences in the earnings of formal and informal workers conditional on education because we estimate the life-cycle profiles directly from the data. A validation of the model is the overall gap between earnings in formal and informal labor markets. This will speak to the distribution of workers by education across labor market statuses. The average of informal workers' incomes is 47 percent of the average of formal workers' salaries in the model. In the data we use for Mexico, this ratio is 56 percent. The fact that this non-targeted moment is relatively close to the data is reassuring. The difference is due to the fact that in the model, there is too much selection by education across formality and informality.[9]

4 Optimal Unemployment Insurance

A key characteristic of our optimal system is that we keep the same level of revenues and expenditures as in the benchmark. So the main change in the design is not the generosity of the system but rather the implications on incentives and and risk-sharing stemming from how the government allocates resources across individuals. To achieve optimality the scheme minimize the distortions caused by payroll taxes and create incentives for individuals to work formally, all this while keeping the same level of expenditure.

The parameters maximizing ex-ante welfare are displayed in Table 3. The system is substantially different than a severance payment system, with the only similarity being that the replacement rate is equal to 1 in the period after transitioning from formality to unemployment.

4.1 Main Features of the Optimal Scheme

In our system, contributions are paid by the government. That is, if the formal employee has not reach the upper bound in her account, the government credits in her savings account a certain amount that will give the right to get unemployment compensation in the future. So, as one of these formal workers lose her formal job, she can execute the right to receive those compensations. Additionally, while she is formally employed, the government tax formal job wages independently of the worker's history, to finance compensation to other individuals. This sort of social contract audited and enforced by the government is the main source of insurance. Also, it is the key difference with self-insurance provided by precautionary savings where, in some way, workers diversify their individual unemployment risk across time (i.e. accumulate in good time, disaccumulate in bad times). In our system, on the other hand, unemployment risk is diversified across agents, where active formal workers contribute by means of taxes to a common pool fund that finances the payments of unemployment compensations.

In contrast with our results in which optimality dictates to fully subsidize workers' contribution, in most UISA systems implemented in Latin America the government contribution is nearly zero. So, this feature is a fundamental departure of the system we propose from standard UISA systems and indeed it is key to align correctly search incentives as these

[9]Note also that the ratio obtained in the model is similar in other countries of Latin America according to Gasparini and Tornarolli (2009): Argentina, 62 percent; Brazil, 46 percent; and Chile, 53 percent.

transfers are made only to those working formally, .

On the other hand, an important difference with the severance payment system is that the contribution rate is much smaller: 12 percent instead of almost 100 percent. This small contribution rate means that workers must stay in their formal jobs (approximately 8.3 quarters) to qualify for receiving a full quarter's salary. In contrast, the maximum stock of savings in the account increases from almost 1 (or $1/R$) to almost 4. This means that individuals can receive payments up to 4 quarters of unemployment, but only if they have been previously formally employed for long enough. All these features aligns incentives to increase formality.

Finally, as the new system increases formality, the tax burden decreases (i.e. the payroll tax goes down from 20 to less than 19 percent). This generates an extra equilibrium effect that benefits all formal workers equally and makes productive jobs even more attractive to everyone.

Table 3: Policy Parameters

	b	ψ	τ_w	$\overline{s}$	τ_r
Severance payment	1	$1/R$	0.2	$1/R$	1
Optimal UI	1	0.12	0.188	3.9	0

The aggregate implication of the optimal system are shown in Table 4. It shows that formality indeed increases by more than 3 percentage points, from 67.9 percent to 71.8 percent. The decline in unemployment is proportionally larger: it decreases from 3.9 percent to 3 percent, or about 25 percent. Given that there is more formal employment, which is more productive, total output per worker increases 4 percent. Finally, all of these changes together imply an increase in ex-ante welfare of about 2.4 percent in terms of consumption equivalent units. These gains are large, and we study the main forces behind them in the next section.

Table 4: Aggregate Implications

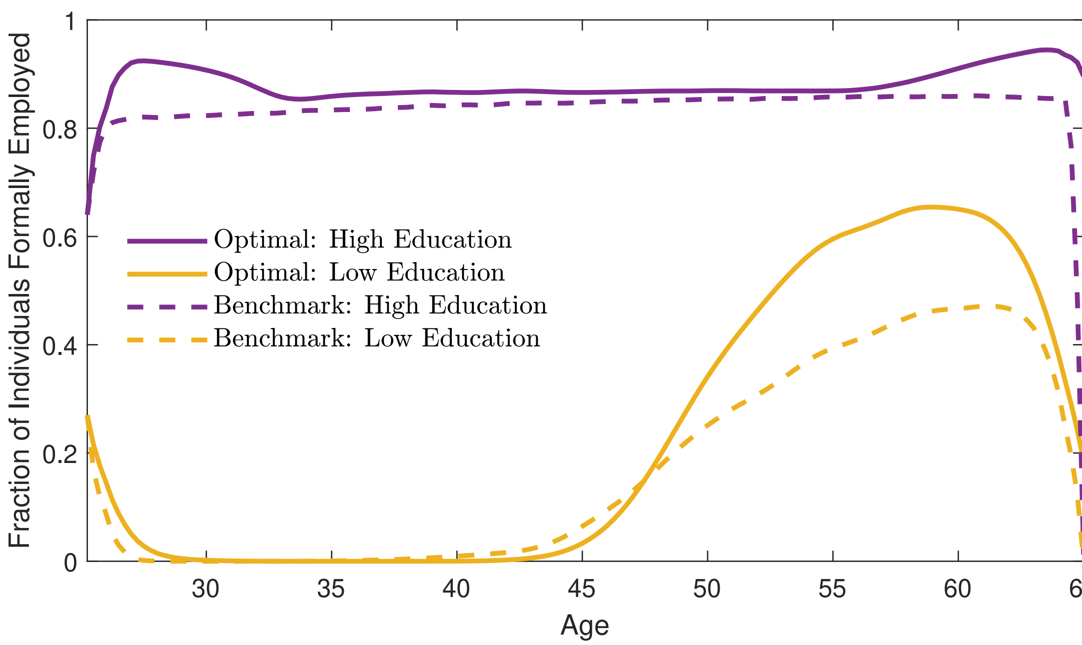
	Benchmark	Optimal
Formality	67.9	71.8
Unemployment	3.9	3.0
Production per-worker	0.906	0.94
Welfare Gains	-	2.37%

In the next figures, we explain the changes driven by the implementation of the optimal UI system. They show the life-cycle pattern of different variables with purple lines representing more educated individuals and yellow lines representing less educated individuals. Similarly, dashed lines represent the benchmark economy, while solid lines represent the optimal UI.

First, not surprisingly, more educated workers have a higher rate of a formality than less-educated workers regardless of their age or the system (see Figure 2). This pattern is a consequence of more-educated workers having: (i) higher formal-job-search productivity and (ii) more significant formal-to-informal wage gap (see Figure 1).

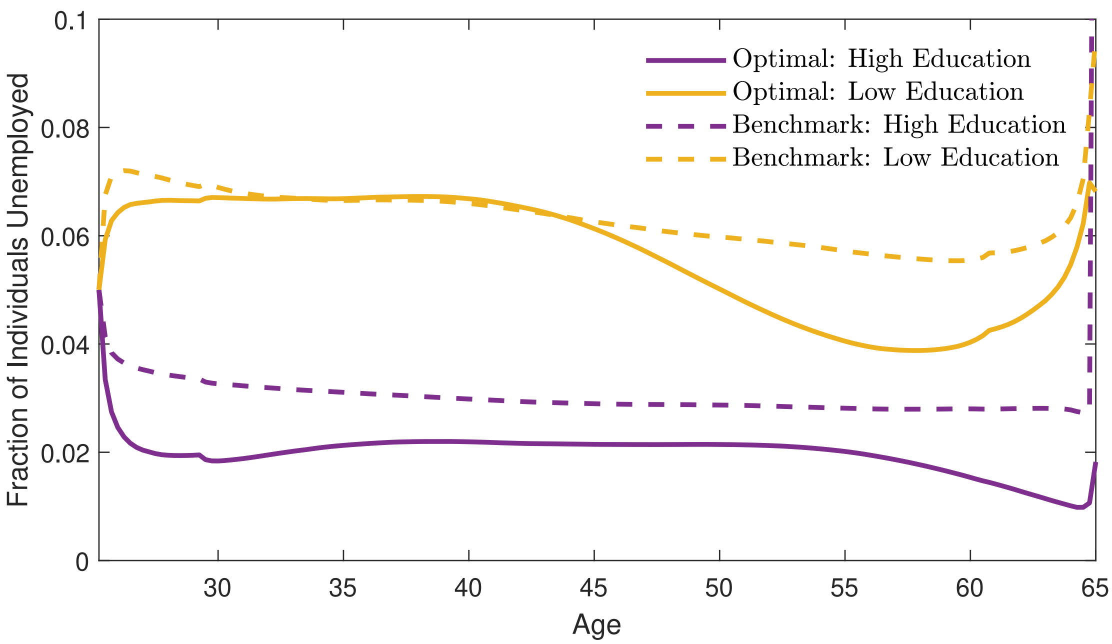
Second, low-education individuals aged between 25 and 40 have nearly zero participation in the formal sector (Figure 2). This fact occurs because the estimated wage gap between working in the formal and informal sectors (Figure 1) is relatively small for young, low-educated workers to justify exerting much effort looking for a formal job. For individuals in their early 40s, it becomes beneficial to look for a formal job. Consequently, the formality rate increases sharply, and in the benchmark economy, it reaches almost 50 percent near retirement.

Figure 2: Formal Employment



Since the life-cycle pattern of formality is due to wages' life-cycle profile, it carries over to the economy with the optimal UI system. The main difference is that individuals want to work more in the formal sector because they collect the right to file for unemployment compensation in case of unemployment. Note also that for 50-to-63 years of age, the impact on formal market participation is relatively more substantial for less-educated workers than for educated workers. This pattern is a consequence of low-education workers' incentives to obtain more fully subsidized funds in the UISA at retirement. Note in Figure 4 that both worker-types get close to the upper bound in the account of 3.9. Although the upper bound in the UISA is the same for both education types, it takes more years of formal employment for low-education education workers to reach it. Note also that, compared with the benchmark, low-education workers postpone for a few more years returning to the formal labor market. This result can be interpreted as an intertemporal labor substitution effect since they exert much more costly effort than the benchmark case.

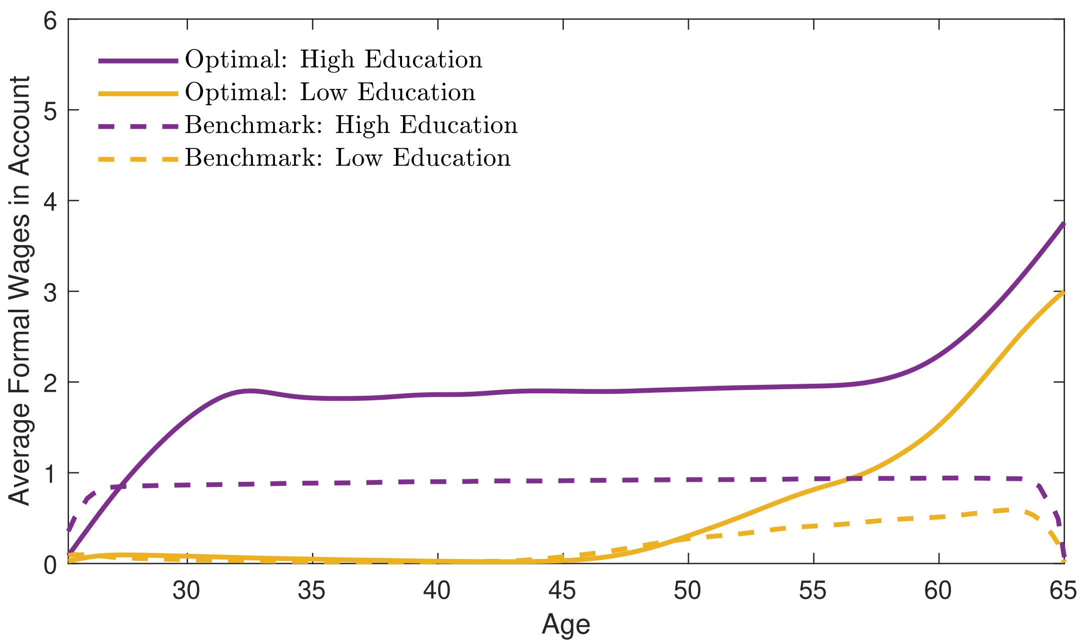
Figure 3: Unemployment



For more educated workers, the effect of implementing the optimal UI on formality is large for young workers and also for workers near retirement. Young individuals have incentives to work in the formal sector to accumulate resources in the saving account to accumulate rights to get unemployment compensations if needed. This can be seen by comparing Figures 2 and 4. After they reach some level of savings, the rate of formality returns to levels similar to the severance payment system. At this age the risk of unemployment remains significant but, as can be seen in Figure 3, is lower for the optimal UI. For ages 50 and older the formality rate is again higher for the optimal UI than for the severance payment system. This departures occurs because individuals have incentives to work formally to maximize the contributions made by the government that they will receive at retirement.

A similar pattern is followed by lower education individuals, although the difference for younger individuals is minimal but for older individuals is larger. Figure 2 shows that starting in the early 40s, there is an increase in the share of low education individuals working formally from close to zero to more than 40 percent in the case of the severance payment system, while it reaches more than 60 percent for the optimal UI system. This increase of more than 20 percent in formality induces a reduction of unemployment for this group of around 2 percentage points around the age of 40. Also, compared with the benchmark, they postpone some time their return to the formal labor market until the mid-forties due to an intertemporal labor substitution effect since they will exert much more costly effort later. Their participation when young is still relatively less intense than educated workers as their disutility costs are higher and then play a role. When older, on the other hand, the impact on formal market participation is relatively higher than educated workers as they want to appropriate as many rights as possible to collect fully subsidized funds at retirement.

Figure 4: Average Stock of Funds in Unemployment Accounts*



(*) Recall that the benchmark economy can be reinterpreted as a UISA economy in which agents accumulate one salary in the account after working one period and the contribution is fully subsided.

Figure 4 shows the life-cycle evolution of the average stock of funds that individuals accumulated in their accounts. In the case of the benchmark economy, formal workers qualify for one salary, so that is the amount account. Thus, the dashed lines follow very closely the share of workers in the formal sector. In the optimal UISA system, workers accumulate resources more slowly, but they can accumulate up to 3.9 salaries.

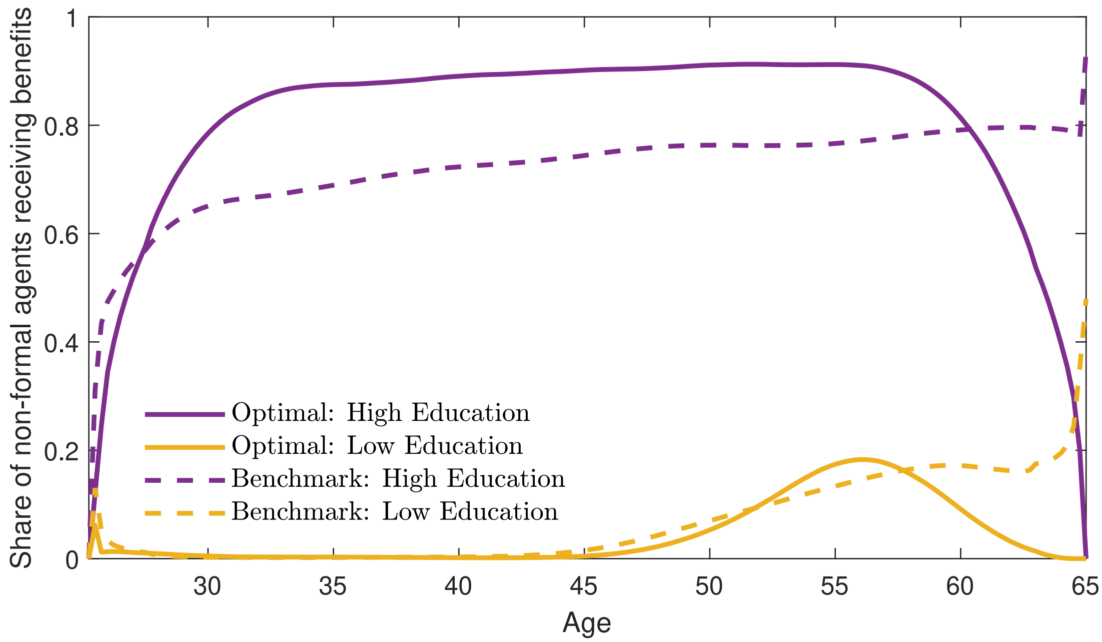
For highly educated workers, transfers from the government to the account provide extra incentives to make more effort and so search more for formal jobs. Since this extra reward lasts longer in the optimal UISA, as it takes 8 quarters to full the account, they increase their effort for approximately that amount of time relative to the benchmark and reduce it when their account has substantial balances.

For low educated workers, in both systems, funds available are zero up to age 45. This pattern is explained by the fact that they find it optimal not to work in the formal sector when young (see Figure 2 above); consequently, they are not entitled to receive benefits. As less-educated workers get older and start working formally, savings increase sharply during these years before retirement, reaching three formal salaries at the end of their working age in the optimal UI, while converging to zero in the benchmark case. In the benchmark case, workers close to retirement have incentives to leave formal employment to receive the funds before retirement (as these funds are not distributed in retirement). On the contrary, in the optimal UI, funds in their account are distributed to agents in retirement, generating incentives for formal employment near retirement for both types of workers. Consequently, the funds in the account increase sharply near retirement.

Finally, it is important to compare the coverage to workers without a formal job across systems. Figure 5 pictures the share of non-formally employed workers receiving benefits. The most important difference is for more educated workers, for whom there is a clear advantage of implementing the optimal UI. Except for very young individuals and those very close to retirement, the coverage in the optimal UI scheme is close to 90 percent while it is about 70 percent for the severance payment system. This occurs because in the new system individuals who transition into unemployment are covered more periods.

Near retirement, differences in incentives under both schemes generates another discrepancy. When workers get closer to retire, there are more individuals filling for unemployment compensations in the severance payments because they want to make sure that they receive this benefit before retirement, since at that point those benefits become unavailable. On the hand, in the optimal UI, since they receive the amount in the account at the time of retirement, non-formally-employed individuals are indifferent between withdrawing the benefits or waiting until retirement.

Figure 5: Share of Non-Formally Employed Workers Receiving Benefits



4.2 Disentangling the Sources of Welfare Gains

This section decomposes the sources of the welfare gains obtained after implementing the optimal UI system. To do so, we present in Table 5 the *changes* in the main variables of interest between the severance payment system and the optimal UI for different groups of the population.

Table 5: Changes in Key Variables After the Implementation of the Optimal UI

	Education	
	High	Low
(1) Welfare	4.1%	0%
(2) Formality rate	3.7%	4.1%
(3) Unemployment rate	-1.1%	-0.4%
(4) Output	3.6%	4.3%
(5) Avg. Worker Consumption:	3.9%	2%
During formality	3.9%	3.9%
During informality	3.7%	2.1%
During unemployment	3.6%	0.6%
(6) Duration of Formality, quarters	2.8	5.3

The first row in Table 5 shows that, after the implementation of the optimal UI, newborn welfare increases 4.1 percent for individuals with more education but does not change for individuals with less education. So the implementation of a reform is Pareto improving but with a large distributional impact. The rest of the statistics will shed light on why that is the case.

The second row of Table 5 shows that formal employment increases for both types of individuals, and especially for less-educated individuals. As the last row (6) shows, these workers also increase substantially their duration of formal jobs; i.e. on average less educated individuals work formally 5.3 quarters longer during their lifetime. This increase in formal work comes despite having a worse technology to find and keep these jobs with the consequent higher disutility. They produce 4.3 percent more, as shown in the fourth column. Increased production, in turn, translates into higher consumption for all three possible labor market states, although their output increases more than their consumption, implying that they are contributing more to the economy. Even though they consume more than in the severance payments system, their ex-ante welfare does not increase because to implement such a large increment in the participation in the formal labor market, they must exert a much larger amount of effort. So even though their consumption increases 2 percent on average, this is compensated by the burden (in terms of disutility) of exerting such an amount of effort to look for and keep formal jobs and so get the right to unemployment compensations.

Importantly, Table 5 shows that there is a significant difference in the impact of implementing the optimal scheme between low and high education types. As mentioned, more productive educated workers are the winners of the reform while the welfare of the less educated, less productive remains unchanged. More educated workers have welfare gains around

4 percent while working more formally (and so exerting more effort), staying less time unemployed, and consuming almost 4 percent more on average. They produce 3.6 percent more while their consumption increases even more; i.e., 3.9 percent. While they stay working formally 2.8 quarters longer, and these implies more effort, this disutility is offset by the utility of higher consumption.

4.3 The Role of Key Policy Parameters

Here we analyze the implications of changing some of the policy parameters in comparison with the optimal UI. This exercise is important to understand the role played by the instruments of the optimal UI.

The first exercise reduces the replacement ratio and quantifies the implications. Table 6 compares the optimal scheme with replacement ratio of 100 percent (first column) and reduces this rate to 80 percent and 70 percent (second and third columns, respectively). In order to keep revenue constant, labor taxes need to be slightly increased, while to keep expenditures constant, the scheme can now finance unemployed workers who left formality for more time; i.e., $\overline{s}$ increases from 3.9 to 6. So regarding the amount of insurance against unemployment risk, there is tension between two forces. On one hand, the increment in $\overline{s}$ translates into potentially more time being able to withdraw compensations. But, one the other hand, the generosity of the compensation is lower as b decreases. In our exercises, the second (effect) dominates and then these alternative schemes make working formally (the mechanism to gain rights to compensations) less attractive. Consequently, formality decreases monotonically, increasing informality at the same rate, while leaving unemployment unchanged. As the replacement rate moves from 100 percent to 80 and 70 percent, the costs in terms of welfare gains lost are significant; they go down from 100 percent of the optimal UI, to 93 percent and 91 percent, respectively.

Table 6: Would Lower Replacement Rates Help?

	Optimal UI	Lower replacement	
b, replacement rate	100%	80%	70%
ψ, contribution	12%	12%	12%
$\overline{s}$, threshold in UISA	3.9	4.9	6.0
τ_w, payroll tax	18.8%	18.9%	19.1%
Formality rate	71.8%	71.1%	70.8%
Informality rate	28.2%	28.9%	29.2%
Unemployment rate	3%	3%	3%
Avg Consumption	0.85	0.84	0.84
Welfare Gains	2.37%	2.21%	2.17%
Share of total gains	100%	93%	91%

The second exercise consists of increasing the contribution rate. We compare the optimal UI (first column in Table 4.3) with alternative schemes so that we increase the contribution rate from 12 percent to 20 percent and 30 percent (second and third columns, respectively). Labor taxes are slightly increased to sustain revenues while $\overline{s}$, and so the maximum time that unemployed workers can receive compensations, is reduced to maintain the same level of expenditures (from almost four quarters to a bit more than one quarter and a half, and then to a bit less than one quarter and a half). Here, as the amount of time that unemployed workers receive compensations decreases, this unambiguously reduces the amount of insurance in the system. This implies that working formally becomes less attractive and so formality decreases monotonically, informality increases slightly, and unemployment increases between 20 and almost 30 percent (from 3 percent to 3.6 and 3.8 percent, respectively). As the contribution rate moves from 12 percent to 20 percent, welfare losses are large, dropping by more than 66 percent of the original welfare gains (from 2.37 percent to 1.04 percent). Then, as the contribution rate moves from 12 percent to 30 percent, welfare decreases by almost 70 percent to 0.72 percent. These losses are mostly explained by the significant reduction of time receiving unemployment compensation discussed above, and so the less insurance against unemployment risk.

Table 7: Would Higher Contribution Rates Help?

	Optimal UI	Higher contribution	
ψ, contribution	12%	20%	30%
b, replacement rate	100%	100%	100%
$\overline{s}$, threshold in UISA	3.9	1.6	1.3
τ_w, payroll tax	18.8%	19.5%	19.7%
Formality rate	71.8%	69.5%	68.9%
Informality rate	28.2%	30.5%	31.1%
Unemployment rate	3%	3.6%	3.8%
Avg Consumption	0.85	0.83	0.83
Welfare Gains	2.37%	1.04%	0.72%
Share of total gains	100%	43.8%	30.3%

5 Conclusion

We study how to provide unemployment protection in an economy with features resembling middle-income developing countries. Departing from a benchmark severance payment system, we show that welfare can increase substantially with a system similar to an UISA with contributions into the accounts made directly by the government. Since workers get these transfers from the government to their UI saving accounts while working formally, the optimal system improves incentives to work formally. As a consequence, formality increases from 67.9 percent to 71.8 percent. The new system also reduces unemployment, from 4 to 3 percent, and raises output by 3 percent.

While we focused on unemployment and informality, three other important questions could be studied in this framework. First, the UI system is financed here with labor taxes. One interesting issue is the potential advantage of taxing consumption in an economy with informality. Since both formal and informal workers consume a similar basket of goods, consumption taxes are more likely to affect workers in these two sectors more evenly, reducing incentives to participate in the informal sector (see Antón et al., 2012; Levy, 2019).

Second, although our framework features two types of workers with substantial productivity differences when working in the formal sector, we did not analyze how to redistribute resources across agents optimally. Extending the model to consider redistribution would be exciting and challenging because, with a technological representation of labor markets similar to ours, any optimal scheme favoring more formal sector participation would tend to favor high-education workers.[10]

Finally, it would be great to understand why a system like this one is not more widely implemented. Based on Argentina's anecdotal evidence, we conjecture that it would be essential to capture how unions are involved in the current system and how their influence would change with the system proposed here.

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[10]Our optimal scheme favors more formal sector participation by providing more unemployment payments conditional on past participation in the formal sector and reducing taxes. As a consequence, only high-education workers, which have high formal sector participation (both in the benchmark and in the optimal system), obtain significant welfare gains with the new system.

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A Estimation of the Mincer Equation

We estimated the life-cycle profile of hourly wages using data from the ENOE following a methodology similar to Huber and Rahimov (2017) and Tansel and Kan (2012). Bourguignon et al. (2007) provide a detailed description of Lee (1983)'s method. To estimate the wage we assume that each worker j can choose between any of the three states k: unemployment, informality or formality. Each state is associated with earnings given by a classical Mincer equation

$$ln\left(w_{j,k}\right) = \alpha_k + \beta_{1,k} exp_j + \beta_{2,k} exp_j^2 + \beta_{3,k} educ_k + \varepsilon_{j,k} \tag{4}$$

where $w_{j,k}$ represents the declared hourly wage in sector k of agent j, exp_j the experience of agent j calculated as $age_j - 25$, $educ_k$ is the years of schooling and $\varepsilon_{j,k}$ is a random component.

The problem with the previous equation is that it does not consider the endogenous decision of whether or not to accept a job and in which sector. The variable $w_{j,k}$ is observed only if the utility of participating in that sector is greater than all the others:

$$u_{j,k} > \underset{h \neq k}{max}\, u_{j,h}.$$

To resolve this issue, we assume that the utility $u_{j,k}$ is linear on observables,

$$u_{j,k} = z_j \gamma_k + \eta_j,$$

where z_j is a vector containing the same explationary variables as in (4) plus some extra selection variables commonly used in the literature: marital status, number of children, gender, and whether he or she is the head of the household.

We then perform selection bias correction using the method proposed by Lee (1983). The results of the two step estimation are:

	log of formal wage	log of informal wage
exp	0.01428^{***}	0.00316^{***}
exp^2	-0.00015^{***}	-0.00005^{*}
$educ$	0.07637^{***}	0.00038
constant	2.55^{***}	2.81^{***}
observations	$37,684$	$26,999$

The estimated profile for formal salaries is constructed using self reported income, which is after-tax wage. In order to incorporate tax to our model, we adjust the formal profile so that the one used as input in the model after tax coincides with the estimated value. That is,

$$w_{f,t} = \frac{exp\left(2.55 + 0.01428exp_t - 0.00015exp_t^2 + 0.07637educ_t\right)}{1-\tau_{w,b}}$$
$$w_{i,t} = exp\left(2.81 + 0.00316exp_t - 0.00005exp_t^2 - 0educ_t\right)$$

is the wage profile used in our models, where $\tau_{w,b}$ is the formal income tax in our benchmark economy. Also, in order to ease the interpretation of our policy coefficients, we will normalize wages by the average formal salary before taxes across time.

B Welfare Comparison

Let $gain(A, B)$ be the percentage change in consumption needed to make an ex-ante representative worker indifferent between the allocations in the economies with policy parameters Γ^A and Γ^B, which deliver ex-ante expected utilities $\mathbf{V}^A$ and $\mathbf{V}^B$. For $d \in \{A, B\}$ we have that the ex-ante utility is

$$\mathbf{V}^d = \sum_h \phi_h \sum_{j\in\{f,i,u\}} \int_{m_0} \int_{s_0} V_{0,h}^j(m_0, s_0 \mid \Gamma^d) dv_{0,h}^j(m_0, s_0).$$

As the utility function of the representative worker is assumed to be homogeneous of degree $(1-\sigma)$ with respect to consumption for $\sigma > 0$ (i.e., CRRA preferences), $\nu(A, B)$ can be directly computed as follows

$$\nu(A,B) \;=\; \left[\frac{\mathbf{V}^B + \sum_h \phi_h \int_m \int_s \mathbf{V}_h^{A,e}(m,s)\, ds\, dm}{\sum_h \phi_h \int_m \int_s \left(\mathbf{V}_h^{A,c}(m,s) + \beta^N H_h(m, s \mid \Gamma^A)\right)\, ds\, dm}\right]^{\frac{1}{(1-\sigma)}},$$

where

$$\mathbf{V}_h^{A,e}(m,s) \;=\; \sum_{n=1}^{N} \beta^{n-1} \sum_{j\in\{f,i,u\}} F_{n,h}^j(m, s \mid \Gamma^A) e_{n,h}^j(m, s \mid \Gamma^A)$$
$$\mathbf{V}_h^{A,c}(m,s) \;=\; \sum_{n=1}^{N} \beta^{n-1} \sum_{j\in\{f,i,u\}} F_{n,h}^j(m, s \mid \Gamma^A) u(c_{n,h}^j(m, s \mid \Gamma^A)).$$

C Sensitivity of Estimation to Moments

In order to improve the transparency of our structural estimation we follow the approach proposed by Andrews et al. (2017). Authors showed that in order to obtain the sensitivity of estimated parameters to a perturbation of moments it is sufficient to calculate the Jacobian of moments with respect to parameters. This calculation should help the reader to understand which features of the data are driving the results.

The elasticity of moments with respect to parameters can be calculated numerically at a negligible cost. We solve the model perturbing each parameter θ_i at a time. That is, we solve the model once for $\theta \times \exp(\iota_i \varepsilon)$ and another for $\theta \times \exp(-\iota_i \varepsilon)$ where ι_i is a selector vector at position ith and ε is a positive perturbation. Table 8 reports the numerically calculated elasticities.

We organized parameters and targets such that the diagonal of the matrix shows, for each parameter, the parameter that affects that moment the most (excluding some parameters that have the largest impact on more than one moment). For instance, the first column and first row shows how the probability of receiving an informal job offer during unemployment, p_U, changes the transition probability from unemployment to informality. The other values in the first column show how the transition probability from unemployment to informality changes after changing the value of p_U. In the case of the second column, we highlight the change in the transition probability from formality to informality after a change in the parameter determining the probability of receiving an informal offer during formality. As in the first column, the link between between targets and moments is quite close. Although the link is not as direct for each parameter and each moment, in general this table shows that the selection of moments allow us to identify the value of the parameter of interest.

Table 8: Elasticity of Moments to Changes in Parameters

	U-to-I prob	F-to-I prob	I-to-I prob	U-to-F prob	I-to-F prob	F-to-F prob	Schooling F	Schooling I	FR	UR	UR young
p_u	**1.302**	0.080	-0.021	-0.164	0.093	-0.010	0.002	0.016	-0.025	-0.253	-0.316
p_f	0.062	**1.770**	-0.215	-0.109	0.946	-0.093	-0.015	0.161	-0.135	-2.444	-2.366
p_i	-0.258	0.454	**0.129**	0.182	-0.566	-0.059	0.080	0.023	-0.329	0.071	0.335
ξ_U	-0.777	0.367	-0.041	**0.598**	0.182	-0.047	-0.005	0.036	-0.030	0.154	0.071
ξ_I	0.498	1.303	-0.272	-0.356	**1.198**	-0.171	-0.035	0.124	-0.047	1.347	1.075
ξ_F	0.113	-1.305	0.087	-0.089	-0.383	**0.170**	-0.039	-0.105	0.294	-0.961	-0.995
y_H	0.000	0.000	0.000	0.000	0.000	0.000	**0.987**	0.433	0.000	0.000	0.000
y_L	0.000	0.000	0.000	0.000	0.000	0.000	0.013	**0.567**	0.000	0.000	0.000
ψ_H	-0.560	-0.175	-0.572	0.289	2.510	0.010	0.039	0.496	**0.911**	1.059	0.089
θ_L	-0.293	-0.078	0.160	0.165	-0.703	0.010	0.078	-0.068	-0.197	**-0.277**	-0.011
θ_H	0.496	-0.301	0.067	-0.390	-0.296	0.040	0.000	0.016	-0.017	-0.217	**-0.214**

Note: "Schooling F" means average years of schooling of workers in the formal sector, "Schooling I" means average years of schooling of workers in the informal sector, "FR" means formality rate and "UR" means unemployment rate.