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Unemployment Insurance in High Informality Countries*

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Abstract

Providing unemployment insurance is particularly problematic in countries with high informality because workers can claim unemployment benefits and work in the informal sector at the same time. This paper proposes a method to evaluate alternative schemes to provide insurance for unemployed individuals. First, it presents an economy that can be calibrated to reproduce key features of the economy for which the reform will be evaluated. Then, it shows how the implementation of an unemployment insurance savings account (UISA) scheme can be evaluated. The method is applied to Mexico, and the results show how the UISA scheme would eliminate incentives for participation in the informal sector. The implementation of the UISA would imply large welfare gains from the ex-ante perspective.

Keywords: Unemployment, insurance, Mexico, informality.
JEL classification: D82, H55, I38, J65.

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1 Introduction

In Latin American countries, a large share of labor market relationships cannot be monitored by governments. The informal sector in these countries produces between 25 to 76 percent of gross domestic product (GDP) (Schneider and Enste, 2000). This feature of labor markets presents a challenge for the provision of unemployment insurance (UI) in the region. For instance, if individuals in Mexico could claim unemployment benefits whenever they are not formally working, more than half of the labor force would be qualified for UI. Since receiving UI would be compatible with working in the informal sector, this sector would be even more attractive and the government capacity to oversee labor markets would become even more impaired. Therefore, the goal of this paper, using a model calibrated to Mexico, is to study the design of optimal UI in economies with high informality.

Why is the design of a UI system important? According to Hansen and Imrohoroglu (1992), the design of this type of system has important implications for welfare. In a general equilibrium model calibrated to the U.S. economy, they show that "if there is moral hazard, and the replacement ratio is not set optimally, the economy can be much worse off than it would be without unemployment insurance." This raises the following key question: What is the optimal design of unemployment insurance if search effort cannot be monitored? Hopenhayn and Nicolini (1997) study the repeated moral hazard: "The optimal long-term scheme involves a replacement ratio that decreases throughout the unemployment spell and a wage tax after reemployment that (...) increases with the length of the unemployment spell."

One of the important assumptions in the work of Hopenhayn and Nicolini is that employment is an observable state. In particular, this assumption implies that workers cannot claim UI benefits and, at the same time, work in the informal sector. However, recent research has focused on studying the optimal UI if there is an informal sector that allows unemployed individuals to secretly work in the informal sector and, simultaneously, ask for unemployment benefits. In particular, Alvarez-Parra and Sanchez (2009) argue that the existence of a hidden labor market modifies the optimal UI in a nontrivial way. The optimal contract has two phases: (i) unemployment benefits decrease very slowly to encourage workers to search for a job instead of working in the informal sector, and (ii) after several months of unemployment, benefits decline abruptly to zero. Since the optimal design involves payments and taxes that depend on the history of workers' labor market decisions and earnings, an unemployment insurance saving account (UISA) seems a reasonable scheme to implement such a contract.

The analysis in this paper will focus on incentives and will not consider general equilibrium effects. In particular, the labor demand side will be omitted to simplify the analysis. In a recent study, D'Erasmo and Moscoso-Boedo (2012) propose a firm dynamics model with formal and informal sectors. Their model predicts that countries with high costs of formality are characterized by low allocative efficiency and large output shares produced by low-productivity firms in the informal sector. The design of UI has not been studied in that framework.

This paper introduces a lifecycle model with informality and heterogeneity in the disutility of search effort. The fact that individuals have different disutility of search effort or "types" is important because individuals must exert effort to find and keep jobs in the formal sector. As a consequence, in the economy calibrated to Mexico with labor income taxes and severance payments, resources are redistributed among individuals of different types.

The quantitative model is used to study the optimal UI scheme among the class of UISA parameterized by a replacement rate, which determines UI payments, an initial contribution to the saving account, a minimum level of savings at which the payment is suspended, and a maximum level of savings at which the contributions are suspended. The optimal UISA provides large welfare gains compared to the benchmark economy, of the order of 5 percent in terms of consumption equivalent units. To understand the sources of those gains, several quantitative exercises are performed. The main finding is that welfare gains are due to two sources. The first source is simple. The UISA provides liquidity to young individuals that are expecting their income to increase over the lifecycle. This allows them to flatten their lifecycle profile of consumption. To quantify the importance of this mechanism, consider a UISA economy in which the initial level of savings is set to zero. In that case, welfare increases about 2 percent. Thus, about a half of the welfare gains are due to the provision of liquidity.

The second source of welfare gains is the drastic reduction of the size of the informal sector. This benefit can be seen in an increase in the revenues collected by the government, which more than doubles in the UISA economy compared to the benchmark economy. This allows the government to reduce labor income taxes from 27 to 12 percent, increase individuals lifetime utility, and keep the same level of fiscal revenues as in the benchmark economy. This effect explains the other half of welfare gains.

2 Benchmark Economy

The economy is populated by large number of ex-ante identical individuals with names in the unit interval. Each of these agents has the following lifetime profile.

The first N periods are the so-called working periods. Agents can participate in labor markets and work. When an individual reaches age $N+1$, he or she retires from the labor market. Once retired, individuals survive to the next period with probability ρ. Before entering the labor market at age $n = 1$, the agent privately observes a preference shock, θ, that determines the disutility of search effort and is uniformly distributed on $[\underline{\theta}, \overline{\theta}]$. This margin of ex-post heterogeneity is key for the analysis herein, and it is discussed in more detail below.

Labor Market Decisions

At any working period, an individual of working age $n = 1, ..., N$ can either work in the formal sector, work in the informal sector, or be unemployed. The employment decision that an individual with working age n faces in those three different states are the following.

Suppose, first, that the worker enters the period with an offer in the formal sector. The worker's income will equal $\omega_n(1-\tau)$, where τ is the payroll tax and ω_n is his or her productivity in the formal sector. If the worker accepts the offer, he or she exerts unobservable effort e to keep this job in the next period in the formal sector with probability $q(e)$.

Suppose, now, that the worker enters the period with an offer in the informal sector. The worker's wage will equal his or her productivity in the informal sector, $\varpi_n < \omega_n$. This wage remains untaxed. Then, he or she decides how much unobservable effort e to exert to receive an offer in the formal sector next period, with probability $p(e)$.

Finally, suppose that the worker enters the period as unemployed; that is, he or she does not receive either a formal or an informal job offer. The worker decides how much unobservable effort e to exert to receive an offer in the formal sector next period, with probability $g(e)$. We assume that a worker can receive offers in both sectors at the same time and also $q(e) > p(e) > g(e)$ for all e.

Financial Decisions

Agents must also undertake consumption-savings decisions. That is, an agent must allocate his or her resources (which will include financial income, as detailed below) between consumption and savings. The individual can save at the gross interest rate R and, once retired (i.e., age $n \geq N+1$), this is the only decision he or she must make. We assume that both the momentary utility function u and the cost of effort function v satisfy standard assumptions. The agents' discount factor is $\beta \in (0,1)$. An active worker's employment status is denoted by $\{f, i, u\}$, which denote formal, informal, and unemployed states, respectively.

The features of the UI scheme in the benchmark economy is taken as given to capture the current conditions in the economy under analysis. In our exercises, an individual who has been working in the formal sector at age n, and losses his or her job at age $n+1$, receives a severance payment as unemployment protection, denoted by $b_n = b\,\omega_n$. The replacement ratio in the benchmark economy will be refered to as b. Otherwise, the worker receives nothing during his or her working periods. When the worker retires, the government provides a retirement payment of d.

2.1 Workers' Problem

2.1.1 Retired Workers

We solve the workers' problem backwards, and so we begin by studying the problem of a retired agent with age $n \geq N+1$. While the worker is retired, he or she receives d as retirement payments. Let $H(m)$ denote the maximum expected utility attained by a retired agent with m asset holdings. This agent survives with probability ρ, and so H must solve

$$H(m) = \max_{m' \geq 0} \left[u(d + mR - m') + \beta\rho \; H(m') \right]$$

where m' denote next period asset holdings.

2.1.2 Active Workers

Consider a worker who has received a preference shock θ. In our exercises, θ represents how much the worker dislikes the effort exerted to find a job in the formal sector in the next period. The (exogenous) conditional probability of having an offer in the informal sector next period if the worker has been working informally during the current period is $(1-\delta_n)$; that is, δ_n is the informal separation rate. The conditional probability of having an offer in the informal sector next period if the worker has been unemployed in the current period is γ_n. Finally, η_n is the conditional probability of having an offer in the informal sector next period if the worker has been working in the formal sector during the current period. We assume that $(1-\delta_n) > \gamma_n > \eta_n$ for all n.

Suppose that the worker with working age $n < N$ receives an offer in the informal sector. The worker must decide whether to accept the offer (a, accept) or not (r, reject). The worker's maximized lifetime utility of entering the period with a wage offer in the informal sector at age n, $V_n^i(\theta, m)$ solves

$$V_n^i(\theta, m) = \max\left\{V_n^{i,a}(\theta, m), V_n^{i,r}(\theta, m)\right\}$$

The policy function that defines this discrete choice is

$$\begin{aligned} a_n^i(\theta, m) &= 1 \text{ if } V_n^i(\theta, m) = V_n^{i,a}(\theta, m) \\ &= 0 \text{ o.w.} \end{aligned}$$

Here, $V_n^{i,a}$ denotes the value of accepting the informal job offer and it satisfies

$$\begin{aligned} V_n^{i,a}(\theta, m) &= \max_{a,m'} u\left(mR - m' + \varpi_i\right) - v(\theta e) + \\ &\beta\left\{(1 - p(e))\left[(1 - \delta_n)V_{n+1}^i(\theta, m') + \delta_n V_{n+1}^u(\theta, m')\right] + \right. \\ &\left. p(e)\left[(1 - \delta_n)V_{n+1}^b(\theta, m') + \delta_n V_{n+1}^f(\theta, m')\right]\right\} \end{aligned}$$

where the corresponding policy functions for effort levels and savings are given by $e_n^{i,a}(\theta, m)$ and $m_n^{i,a}(\theta, m)$, respectively.

The value of rejecting the informal job offer, $V_n^{i,r}$, satisfies

$$\begin{aligned} V_n^{i,r}(\theta, m) &= \max_{a,m'} \{u\left(mR - m'\right) - v(\theta e) + \\ &\beta\left[(1 - g(e))\left(\gamma_n V_{n+1}^i(\theta, m') + (1 - \gamma_n)V_{n+1}^u(\theta, m')\right) + \right. \\ &\left. g(e)\left(\gamma_n V_{n+1}^b(\theta, m') + (1 - \gamma_n)V_{n+1}^f(\theta, m')\right)\right]\} \end{aligned}$$

where the corresponding policy functions for effort levels and savings are given by $e_n^{i,r}(\theta, m)$ and $m_n^{i,r}(\theta, m)$, respectively.

Suppose, on the other hand, that the worker with working age $n < N$ receives an offer in the formal sector. If the worker enters the period with m assets, his or her maximized lifetime utility, $V_n^f(\theta, m)$, must solve

$$V_n^f(\theta, m) = \max\left\{V_n^{f,a}(\theta, m), V_n^{f,r}(\theta, m)\right\}$$

where $V_n^{f,a}(\theta, m)$ and $V_n^{f,r}(\theta, m)$ denote the value of accepting or rejecting the offer, respectively. The policy function that defines this choice is

$$\begin{aligned} a_n^f(\theta, m) &= 1 \text{ if } V_n^f(\theta, m) = V_n^{f,a}(\theta, m) \\ &= 0 \text{ o.w.} \end{aligned}$$

Here $V_n^{f,a}$ must solve

$$\begin{aligned} V_n^{f,a}(\theta,m) &= \max_{a,m'} \{u(mR - m' + \omega_n(1-\tau)) - v(\theta e + \widehat{e}) + \\ & \beta \left\{(1-q(e)) \left(\eta_n V_{n+1}^i(\theta, m'+b_n) + (1-\eta_n) V_{n+1}^u(\theta, m'+b_n)\right) + \right. \\ & \left. q(e) \left(\eta_n V_{n+1}^b(\theta,m') + (1-\eta_n) V_{n+1}^f(\theta,m')\right)\right\}. \end{aligned}$$

The corresponding policy functions for effort levels and savings are given by $e = e_n^{f,a}(\theta,m)$ and $m' = m_n^{f,a}(\theta,m)$, respectively.

Observe that

$$V_n^{f,r}(\theta,m) = V_n^{i,r}(\theta,m),$$

and evidently the corresponding policy functions coincide.

Suppose, now, that the worker with working age $n < N$ receives offers in both the formal and informal sectors. If the worker enters the period with m assets, his or her maximized lifetime utility, $V_n^b(\theta,m)$, must solve

$$V_n^b(\theta,m) = \max\left\{V_n^{f,a}(\theta,m), V_n^{i,a}(\theta,m), V_n^u(\theta,m)\right\}.$$

In this case, the employment choice decision is given by the policy functions

$$\begin{aligned} a_n^b(\theta,m,f) &= 1 \text{ if } V_n^b(\theta,m) = V_n^{f,a}(\theta,m), \\ &= 0 \text{ o.w.} \end{aligned}$$

$$\begin{aligned} a_n^b(\theta,m,i) &= 1 \text{ if } V_n^b(\theta,m) = V_n^{i,a}(\theta,m), \\ &= 0 \text{ o.w.} \end{aligned}$$

$$a_n^b(\theta,m,0) = 1 - a_n^b(\theta,m,f) - a_n^b(\theta,m,i)$$

.

Consider an unemployed worker (i.e., an individual with no offer), with working age n and savings m (which could include severance payments). Notice that

$$V_n^u(\theta,m) = V_n^{f,r}(\theta,m) = V_n^{i,r}(\theta,m).$$

In this case, the corresponding policy functions are given by

$$\begin{aligned} e_n^{f,r}(\theta,m) &= e_n^{i,r}(\theta,m) = e_n^u(\theta,m) \\ m_n^{f,a}(\theta,m) &= m_n^{i,r}(\theta,m) = m_n^u(\theta,m). \end{aligned}$$

Consider now the problem faced by an agent at working age $n = N$ (i.e., the period just before retirement). If employed in the formal sector, the worker solves

$$V_N^f(m) = \max\left\{V_N^{f,a}(m), V_N^{f,r}(m)\right\}$$

where

$$V_N^{f,a}(m) = \max_{m'}\left\{u(\omega_N(1-\tau) + mR - m') + \beta H(m')\right\},$$

$$V_N^{f,r}(m) = \max_{m'}\left\{u(mR - m') + \beta H(m')\right\}.$$

If employed in the informal sector, the worker solves

$$V_N^i(m) = \max\left\{V_N^{i,a}(m), V_N^{i,r}(m)\right\},$$

where

$$V_N^{i,a}(m) = \max_{m'}\left\{u(\varpi_N + mR - m') + \beta H(m')\right\},$$

$$V_N^{i,r}(m) = V_N^{f,r}(m) = \max_{m'}\left\{u(mR - m') + \beta H(m')\right\}.$$

Notice that during the last period of working age, the worker does not exert any effort to find a job in the formal sector since, in the next period, he or she will be retired. That is, the worker only decides how much to consume and save, and so θ is immaterial.

2.2 Characterization: Benchmark Economy

This section sheds light on some properties of the policy functions. First, consider the problem faced by retired workers; that is, the standard income fluctuation problem with discount factor $\beta\rho \in (0,1)$, for which the optimal decision rule (interior solution) $m'(m)$ is characterized by

$$u(b + mR - m'(m)) = \beta\rho\ H'(m'(m)),$$

where standard envelope conditions imply that

$$H'(m) = R\ u'(b + Rm - m'(m)).$$

The optimal effort level when the worker accepts the informal job offer is

$$\theta = \beta\ p'(e_n^{i,a}(\theta, m)) \left[(1-\delta_n)\left(V_{n+1}^b(\theta, m') - V_{n+1}^i(\theta, m')\right) + \delta_n \left(V_{n+1}^f(\theta, m') - V_{n+1}^u(\theta, m')\right)\right].$$

The optimal effort level when the worker rejects the informal job offer is

$$\theta = \beta\ g'(e_n^{i,r}(\theta, m)) \left[(1-\gamma_n)\ \left(V_{n+1}^f(\theta, m') - V_{n+1}^u(\theta, m')\right) + \gamma_n\ \left(V_{n+1}^b(\theta, m') - V_{n+1}^i(\theta, m')\right)\right].$$

The optimal effort level when the worker accepts the formal job offer is

$$\theta = \beta\ q'(e_n^{f,a}(\theta, m)) \left[\eta_n \left(V_{n+1}^b(\theta, m') - V_{n+1}^i(\theta, m')\right) + (1-\eta_n) \left(V_{n+1}^f(\theta, m') - V_{n+1}^u(\theta, m')\right)\right].$$

Finally, the optimal effort levels when the worker rejects the formal job offer and he is unemployed are

$$e_n^{f,r}(\theta, s)) = e_n^u(\theta, s) = e_n^{i,r}(\theta, s, r))$$

since

$$V_n^{f,r}(\theta, s) = V_n^{i,r}(\theta, s) = V_n^u(\theta, s).$$

3 The UISA Economy

This section evaluates policy reforms aimed at protecting unemployed workers. In particular, the analysis considers the implementation of alternative savings accounts systems in this framework.

We assume that agents do not have access to credit markets or, equivalently, that the government can decide their levels of financial wealth.[1] The UISA system considered herein can be characterized by six parameters.

[1]This assumption is common in most of the literature on optimal allocation with private information. Two notable exceptions are Cole and Kocherlakota (2001) and Abraham and Pavoni (2008).

- A lower bound for active savings in the worker's account, $\underline{s}$; that is, an agent that is not working in the formal sector can withdraw resources from his or her savings account only if the current savings balance is above $\underline{s}$.
- An upper bound for savings in the worker's account, $\overline{s}$; that is, an agent working in the formal sector must contribute to his or her savings account if the current savings balance is below $\overline{s}$.
- A contribution made to the worker's saving account during employment in the formal sector if the total savings balance is smaller than $\overline{s}$, ψ, as a proportion of his wage.
- A replacement ratio (on the age specific wage), b.
- An initial transfer to the saving account made by the government, s_0.
- A general tax paid in the formal market, $\widetilde{\tau}$.

Funds accumulated by the government on behalf of the workers are invested at the gross interest rate $\widetilde{R}$. Here, $\widetilde{}$ denotes functions and variables for the UISA economy.

3.1 Active Workers

In the UISA economy, the major change with respect to the benchmark economy is that, basically, the government will provide funds to the agents when they just enter the job market, while requiring them to deposit a fraction of their wages into a savings account. Agents can later withdraw from these accounts while not working in the formal market, as long as they have available funds.

Suppose, first, that the worker with working age $n < N$ receives an offer in the informal sector. His maximized lifetime utility, $\widetilde{V}_n^i$, must solve

$$\widetilde{V}_n^i(\theta, s) = \max\left\{\widetilde{V}_n^{i,a}(\theta, s), \widetilde{V}_n^{i,r}(\theta, s)\right\}.$$

The policy function that defines this choice is

$$
\begin{aligned}
\widetilde{a}_n^i(\theta, m) &= 1 \text{ if } \widetilde{V}_n^i(\theta, m) = \widetilde{V}_n^{i,a}(\theta, m) \\
&= 0 \text{ o.w.}
\end{aligned}
$$

$\widetilde{V}_n^{i,a}$ denotes the value of accepting the informal job offer in this setting and it satisfies

$$
\begin{aligned}
\widetilde{V}_n^{i,a}(\theta, s) &= \max_e u\left(\varpi_n + b\ \omega_n\ I(s > \underline{s})\right) - v(\theta e) + \\
&\beta \left\{ (1 - p(e)) \left[(1 - \delta_n) \widetilde{V}_{n+1}^i(\theta, s') + \delta_n \widetilde{V}_{n+1}^u(\theta, s') \right] + \right. \\
&\left. p(e) \left[(1 - \delta_n) \widetilde{V}_{n+1}^b(\theta, s') + \delta_n \widetilde{V}_{n+1}^f(\theta, s') \right] \right\},
\end{aligned}
$$

where

$$
s' = \widetilde{R}\ \max\left\{ s - b\omega_n I(s > \underline{s}), 0 \right\},
$$

and the corresponding policy function for effort levels is $\widetilde{e}_n^{i,a}(\theta, m)$. Here $I(s > \underline{s})$ is an indicator function that takes values equal to 1 if $s > \underline{s}$ and 0 otherwise.

Alternatively, $\widetilde{V}_n^{i,r}$ denotes the value of rejecting the informal job offer and it satisfies

$$
\begin{aligned}
\widetilde{V}_n^{i,r}(\theta, s) &= \max_e u\left(b\ \omega_n\ I(s > \underline{s})\right) - v(\theta e) + \\
&\beta \left\{ (1 - g(e)) \left[\gamma_n\ \widetilde{V}_{n+1}^i(\theta, s') + (1 - \gamma_n)\ \widetilde{V}_{n+1}^u(\theta, s') \right] + \right. \\
&\left. g(e) \left[\gamma_n\ \widetilde{V}_{n+1}^b(\theta, s') + (1 - \gamma_n)\ \widetilde{V}_{n+1}^f(\theta, s') \right] \right\},
\end{aligned}
$$

where

$$
s' = \widetilde{R}\ \max\left\{ s - b\omega_n I(s > \underline{s}), 0 \right\}
$$

and the corresponding policy function for effort levels is $\widetilde{e}_n^{i,r}(\theta, m)$.

Suppose, on the other hand, that the agent with working age $n < N$ receives an offer in the formal sector. The worker's maximized lifetime utility, $\widetilde{V}_n^f$, must solve

$$
\widetilde{V}_n^f(\theta, s) = \max\left\{ \widetilde{V}_n^{f,a}(\theta, s), \widetilde{V}_n^{f,r}(\theta, s) \right\}.
$$

The policy function that defines this choice is

$$\begin{aligned}\widetilde{a}_n^f(\theta,m) &= 1 \text{ if } \widetilde{V}_n^f(\theta,m) = \widetilde{V}_n^{f,a}(\theta,m)\\ &= 0 \text{ o.w.}\end{aligned}$$

Let $\widetilde{V}_i^{f,a}$ and $\widetilde{V}_i^{f,r}$ denote the value of accepting or rejecting the formal job offer, respectively. $\widetilde{V}_i^{f,a}$ must solve

$$\begin{aligned}\widetilde{V}_n^{f,a}(\theta,s) &= \max_e u\left(\omega_n\left(1-\psi I(s<\overline{s})+\widetilde{\tau}\right)\right) - v(\theta e) + \\ &\quad \beta\left\{(1-q(e))\left[\eta_n\, \widetilde{V}_{n+1}^i(\theta,s') + (1-\eta_n)\, \widetilde{V}_{n+1}^u(\theta,s')\right] + \right.\\ &\quad \left. q(e)\left[\eta_n \widetilde{V}_{n+1}^b(\theta,s') + (1-\eta_n)\widetilde{V}_{n+1}^f(\theta,s')\right]\right\},\end{aligned}$$

where

$$s' = \widetilde{R}\ \left(s + \psi\omega_n I(s<\overline{s})\right)$$

and the corresponding policy function is $\widetilde{e}_n^{f,a}(\theta,m)$.

The rejection value must satisfy

$$\widetilde{V}_n^{f,r}(\theta,s) = \widetilde{V}_n^{i,r}(\theta,s).$$

Consider that an agent with working age $n<N$ receives an offer in both the formal and informal sector. If the worker enters the period with m assets, his or her maximized lifetime utility, $V_n^b(\theta,m)$, must solve

$$\widetilde{V}_n^b(\theta,m) = \max\left\{\widetilde{V}_n^{f,a}(\theta,m), \widetilde{V}_n^{i,a}(\theta,m), \widetilde{V}_n^u(\theta,m)\right\}.$$

In this case, the employment choice decision is given by the policy functions

$$\begin{aligned}\widetilde{a}_n^b(\theta,m,f) &= 1 \text{ if } \widetilde{V}_n^b(\theta,m) = \widetilde{V}_n^{f,a}(\theta,m),\\ &= 0 \text{ o.w.}\end{aligned}$$

$$\begin{aligned}\widetilde{a}_n^b(\theta,m,i) &= 1 \text{ if } \widetilde{V}_n^b(\theta,m) = \widetilde{V}_n^{i,a}(\theta,m),\\ &= 0 \text{ o.w.}\end{aligned}$$

$$\widetilde{a}_n^b(\theta,m,0) = 1 - \widetilde{a}_n^b(\theta,m,f) - \widetilde{a}_n^b(\theta,m,i).$$

Finally, consider an unemployed worker at working age n, with savings in the account S. If the individual has received a preference shock θ, his or her maximized lifetime utility is

$$\widetilde{V}_n^u(\theta, s) = \widetilde{V}_n^{f,r}(\theta, s) = \widetilde{V}_n^{i,r}(\theta, s).$$

Consider the problem faced by an individual at working age N (i.e., the period just before retirement). If the worker receives an job offer in the formal sector, he or she solves

$$\widetilde{V}_N^f(s) = \max\left\{\widetilde{V}_N^{f,a}(s), \widetilde{V}_N^{f,r}(s)\right\}.$$

If the worker accepts the job offer, $\widetilde{V}_N^{f,a}(s)$ solves

$$\widetilde{V}_N^{f,a}(s) = u(\omega_N\left(1 - \tau\ I(s < \overline{s})\right)) - v(\widehat{e}) + \beta H(s'),$$

where

$$s' = \widetilde{R}\left(s + \tau\omega_N I(s < \overline{s})\right).$$

Alternatively, if the worker rejects the formal job offer, $\widetilde{V}_N^{f,r}(S)$ solves

$$\widetilde{V}_N^{f,r}(S) = u(b\ \omega_n\ I(s > \underline{s})) + \beta H(s'),$$

where

$$s' = \widetilde{R}\ \max\left\{s - b\omega_N I(s > \underline{s}), 0\right\}.$$

Finally, if the worker receives an offer in the informal sector, he or she solves

$$\widetilde{V}_N^i(s) = \max\left\{\widetilde{V}_N^{i,a}(s), \widetilde{V}_N^{i,r}(s)\right\}.$$

If the worker accepts the job offer, $\widetilde{V}_N^{i,a}(s)$ solves

$$\widetilde{V}_N^{i,a}(S) = u(\varpi_N + b\omega_N I(s > s)) - v(\widehat{z}) + \beta H(s'),$$

where

$$s' = \widetilde{R}\ \max\left\{s - b\omega_N I(s > \underline{s}), 0\right\}.$$

On the other hand, if the worker rejects the offer, $\widetilde{V}_N^{i,r}(s)$ solves

$$\widetilde{V}_N^{i,r}(S) = \widetilde{V}_N^{f,r}(S) = u(\max\left\{b\omega_N I(s > \underline{s}), \underline{c}\right\})) + \beta R(s'),$$

where

$$s' = \widetilde{R}\ \max\left\{s - b\omega_N I(s > \underline{s}), 0\right\}.$$

3.2 Characterization: UISA Economy

This section sheds light on some properties of the policy functions for the UISA economy.

The optimal effort level when the worker accepts the informal job offer is

$$\theta = \beta\ p'(\widetilde{e}_n^{i,a}(\theta, s)) \left[(1-\delta_n) \left(\widetilde{V}_{n+1}^b(\theta, s') - \widetilde{V}_{n+1}^i(\theta, s')\right) + \delta_n \left(\widetilde{V}_{n+1}^f(\theta, s') - \widetilde{V}_{n+1}^u(\theta, s')\right)\right].$$

The optimal effort level when the worker rejects the informal job offer is

$$\theta = \beta\ g'(\widetilde{e}_n^{i,r}(\theta, s)) \left[(1-\gamma_n)\ \left(\widetilde{V}_{n+1}^f(\theta, s') - \widetilde{V}_{n+1}^u(\theta, s')\right) + \gamma_n\ \left(\widetilde{V}_{n+1}^b(\theta, s') - \widetilde{V}_{n+1}^i(\theta, s')\right)\right].$$

The optimal effort level when the worker accepts the formal job offer is

$$\theta = \beta\ q'(\widetilde{e}_n^{f,a}(\theta, s)) \left[\eta_n \left(\widetilde{V}_{n+1}^b(\theta, s') - \widetilde{V}_{n+1}^i(\theta, s')\right) + (1-\eta_n) \left(\widetilde{V}_{n+1}^f(\theta, s') - \widetilde{V}_{n+1}^u(\theta, s')\right)\right].$$

Finally, the optimal effort levels when the worker rejects the formal job offer and is unemployed are

$$\widetilde{e}_n^{f,r}(\theta, s)) = \widetilde{e}_n^u(\theta, s) = \widetilde{e}_n^{i,r}(\theta, s, r)),$$

since

$$\widetilde{V}_n^{f,r}(\theta, s) = \widetilde{V}_n^{i,r}(\theta, s) = \widetilde{V}_n^u(\theta, s).$$

4 Quantitative Targets

The goal herein is to evaluate the quantitative impact of a policy reform in which a UISA is implemented. In order to do that, we compare, in several dimensions described below, the performance of the reformed economy, after the implementation of the UISA, with a pre-reform economy as described in the benchmark setting.

Denote $F_n(\theta, m, st)$ and $\widetilde{F}_n(\theta, m, st)$ as the number of individuals in the benchmark and UISA economy, respectively, with preference shock θ, asset holdings m, age n, and employment status $st \in \{f, i, u\}$ (i.e., formal employee, informal employee, unemployed). Define $c_n(\theta, m, st)$ and $\widetilde{c}_n(\theta, m, st)$ similarly for consumption.

It is useful to first compute the levels of formal employment, informal employment, and unemployment and, then, the welfare impact of a policy reform.

The level of employment in the formal sector for the benchmark and UISA economies, denoted by F and $\widetilde{F}$, are given by

$$\begin{aligned} F &= \sum_{n=1}^{N} \int_{\theta} \int_{m} F_n(\theta, m, f)\ d\theta\ dm, \\ \widetilde{F} &= \sum_{n=1}^{N} \int_{\theta} \int_{m} \widetilde{F}_n(\theta, m, f)\ d\theta\ dm. \end{aligned}$$

.

The corresponding level of employment in the informal sector, our measure of informality in the benchmark and UISA economies, is given by

$$\begin{aligned} I &= \sum_{n=1}^{N} \int_{\theta} \int_{m} F_n(\theta, m, i) d\theta dm, \\ \widetilde{I} &= \sum_{n=1}^{N} \int_{\theta} \int_{m} \widetilde{F}_n(\theta, m, i) d\theta dm. \end{aligned}$$

.

Finally, the unemployment level for each economy is defined as

$$\begin{aligned} U &= \sum_{n=1}^{N} \int_{\theta} \int_{m} F_n(\theta, m, u) d\theta dm, \\ \widetilde{U} &= \sum_{n=1}^{N} \int_{\theta} \int_{m} \widetilde{F}_n(\theta, m, u) d\theta dm, \end{aligned}$$

These represent total numbers of workers for each employment status. We can translate the numbers into shares by simply writing

$$\begin{aligned} S_f &= \frac{F}{F+I+U} \text{ and } \widetilde{S}_f = \frac{\widetilde{F}}{\widetilde{F}+\widetilde{I}+\widetilde{U}} \\ S_i &= \frac{I}{F+I+U} \text{ and } \widetilde{S}_i = \frac{\widetilde{I}}{\widetilde{F}+\widetilde{I}+\widetilde{U}} \\ u &= \frac{U}{F+I+U} \text{ and } \widetilde{u} = \frac{\widetilde{U}}{\widetilde{F}+\widetilde{I}+\widetilde{U}} \end{aligned}$$

where S_f ($\widetilde{S}_f$), S_f ($\widetilde{S}_i$), and u ($\widetilde{u}$) stand for the fraction of workers employed in the formal sector, the fraction of workers employed in the informal sector, and the unemployment rate, respectively, for the benchmark (UISA) economy.

To measure the impact of reforms on welfare, we concentrate on changes in active workers' consumption that make the workers indifferent in terms of allocation in the benchmark and UISA models. Importantly, this exercise leaves retired workers' consumption unchanged.

In order to carry out this measurement, consider a worker at age $n = 1$ with initial preference shock θ and m_0. Remember that all workers are assumed to receive a job offer in the formal sector as they enter the job market. Let $m_{N+1}(\theta)$ be the asset holdings at age $N + 1$ (i.e., the first period of retirement) generated by the policy functions that determine optimal savings. Similarly, let $s_{N+1}(\theta)$ be the asset accumulated in the individual account at age $N + 1$ generated by the optimal policy functions and the accumulation rule determined by the government in the UISA economy. These random variables depend on θ since optimal choices are contingent on the date-0 preference shock.

Let ν be the percentage change in consumption to make an ex-ante representative worker indifferent in terms of allocation in the benchmark and UISA economies. Since the utility function of the representative worker is homogeneous of degree $(1 - \sigma)$ with respect to consumption, ν is determined by

$$E_\theta(\widetilde{V}_1^f(\theta, m_0)) = (1+\nu)\left[E_\theta(V_1^f(\theta, m_0)) - \beta^{N+1}E_\theta(H(m_{N+1}(\theta))\right] + \beta^{N+1}E_\theta(H(m_{N+1}(\theta)),$$

and therefore

$$\nu = \frac{E_\theta(\widetilde{V}_1^f(\theta, m_0)) - \beta^{N+1}E_\theta(H(m_{N+1}(\theta))}{E_\theta(V_1^f(\theta, m_0)) - \beta^{N+1}E_\theta(H(m_{N+1}(\theta))} - 1$$

where E_θ denotes the expectation with respect to θ.

Now we compare the effect of a fiscal reform taking into account the impact on the fiscal budget. Total taxes collected by the government and its corresponding expenditures in the benchmark economy are

$$T = \sum_{n=1}^{N} \int_\theta \int_m F_n(\theta, m, f) w_n \, \tau \, d\theta dm,$$

$$G = \sum_{n=1}^{N} \int_\theta \int_m b \, F_n(\theta, m, f)(1 - q(e_n^f(\theta, m)))\tau d\theta dm,$$

since $F_n(\theta, m, f)(1 - q(e_n^f(\theta, m)))$ is the number of workers with formal jobs with working age n who were exerting effort $e_n^f(\theta, m)$, but were fired during the current period and so they collect unemployment benefits b.

Consider the UISA economy. Total taxes collected to finance transfers to workers entering the labor market are

$$\widetilde{T} = \sum_{n=1}^{N} \int_\theta \int_m \widetilde{F}_n(\theta, m, f) w_n \; \widetilde{\tau} \; d\theta \; dm,$$

while the expenditures needed to finance those transfers are

$$\widetilde{G} = \int_\theta \widetilde{F}_1(\theta, s_0) \; s_0 \; d\theta = s_0,$$

since s_0 is uncontingent with respect to θ.

With these ingredients, our measure of the impact of a fiscal reform is

$$\Delta \equiv \left[(T - G) - \left(\widetilde{T} - \widetilde{G}\right)\right] + \nu_{st=\{f,i,u\}}{}_{n=1}^{N} \int_\theta \int_m F_n(\theta, m, st) c_n(\theta, m, st) d\theta dm. \tag{1}$$

5 Calibration to Mexico

The utility function is of 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

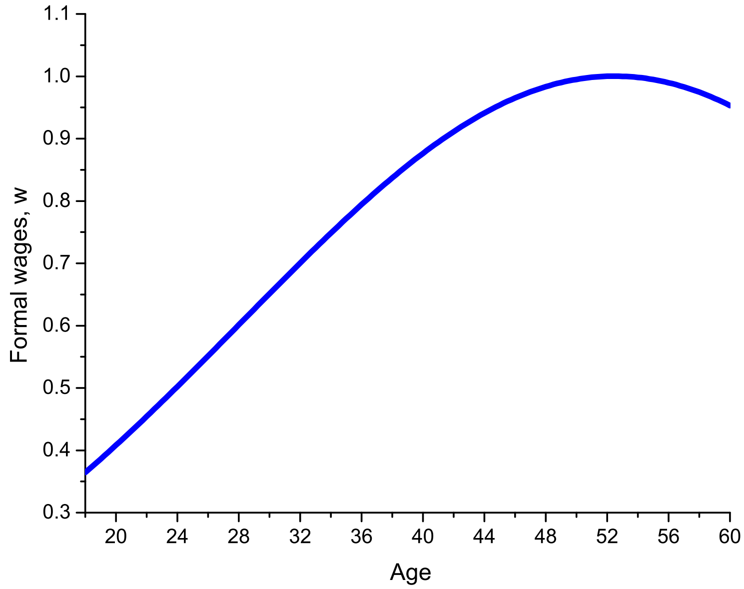
$$p(e) = 1 - \exp(-\xi_I e),$$

$$g(e) = 1 - \exp(-\xi_U e),$$

$$q(e) = 1 - \exp(-\chi e).$$

The model is calibrated to Mexico. The value of the parameters are set using two 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

Figure 1: Lifecycle Profile of Formal Wages



strategy. One example is the lifecycle profile of wages that is obtained from the estimations in Polachek (2007). The implied profile is depicted in Figure 1.

For the rest of the parameters, we search for values that imply that the model replicates specific targets as closely as possible. The artificial economy is generated by simulating various lifecycle profiles of individuals. Each profile starts with no assets. Additionally, in the initial period, we assume there is an equal number of individuals in each labor market sector (employment, unemployment, and informality). Table 1 presents the resulting parameters and the basis for the calibration. The parameters that cannot be determined ex-ante will be determined jointly in the calibration procedure. For those parameters, the reference in Table 1 is to the moment that is likely to be more affected by that parameter. Thus, the parameters that are important to determine the probability of transitions across labor market outcomes are associated with the size of the employment and unemployment sectors and the value of transition probabilities. For instance, the parameter in the function q determines the probability of keeping a job offer from the current employer χ; its associated statistic is the probability for a worker of making a transition from a formal job to unemployment.

TABLE 1: PARAMETERS VALUES

Parameter	Definition	Basis
$\sigma = 2$	Coefficient of relative risk aversion	Standard
$\beta = 0.96^{1/4}$	Discount factor	Standard
$d = 0.7$	Retirement payment	Standard
$\rho = 0.9875$	Retirees survival probability	Expected life after retirement
$\tau = 0.27$	Labor income tax rate	Mexican tax rate
$\vartheta = 1$	Severance payment is $b_n = \vartheta w_{n-1}$	Mexican severance payment
$\xi_U = 0.0030$	Parameter in fn g	Unemployment rate
$\xi_I = 0.0015$	Parameter in fn p	Size of informal sector
$\chi = 0.065$	Parameter in fn q	F-U transition rate
$\delta = 0.03$	Informal sector separation rate	I-U transition rate
$\eta = 0.50$	Prob. informal offer, given formal at t-1	F-I transition rate
$\gamma = 0.60$	Prob. informal offer, given unempl. at t-1	U-I transition rate
w : (see Figure 1)	Formal sector wage	Mexican profile, Polachek (2007)
$\frac{\varpi_n}{w_n} = 0.5$	Relative wage in the informal sector	Mexican relative wages
$R = 1.0$	Gross interest rate	No return asset
$\underline{\theta} = 0.001$	Minimum value of θ	Lifecycle profile of U,E,I
$\overline{\theta} = 0.031$	Maximum value of θ	Lifecycle profile of U,E,I

Table 2 shows that the predictions of our benchmark economy match closely with unemployment, informality, and employment rates at the aggregate level. For instance, the informality rate is 52.7 percent in the data and 52.9 percent in the model.

TABLE 2: MODEL AND AGGREGATE TARGETS

	Unemployment rate	Informality rate	Employment rate
Data	2.7%	52.7%	44.5%
Benchmark	3.6%	52.9%	43.4%

Table 3 compares the percentage of individuals, based on age group, in each employment sector calculated from the data and the model. The model can effectively reproduce the shape of the lifecycle profile of formal and informal employment. The key here is the dispersion in the disutility of search effort. If individuals were identical, there would be a sharply decreasing profile of formal employment, and thus an increasing profile of informal employment. More dispersion implies that individuals do not change between formal and informal sectors often, and the lifecycle profiles are flatter.

Table 3: Lifecycle Patterns, Model, and Data

	Unemployment rate		Informality rate		Employment rate	
	Model	Data	Model	Data	Model	Data
Less than 24	4.5%	4.8%	42.2%	46.3%	53.3%	48.9%
25-39	3.0%	2.2%	44.7%	48.4%	52.3%	49.4%
40 plus	3.7%	1.2%	65.0%	63.5%	31.3%	35.3%

In the model, the resulting probability of getting an offer is endogenously chosen equal to zero if the individual is in the informal sector. Table 4 shows the probability of having a formal job offer next period, conditional on age and labor market status. If the individual is currently working in the formal sector, the probability of getting a job offer from that sector next period is, on average, 98 percent. In the data, the probability of a transition from the formal sector to unemployment is 1.5 percent. Thus, the model is able to match this moment very well. The probability of getting a offer in the formal sector next period for an individual that is currently unemployed is, on average, 22 percent. Notice in Table 4 that these probabilities decrease with age, which occurs endogenously because individuals accumulate assets over their lifetime.

Table 4: Probability of Having a Job Offer

	Employed individual	Unemployed individual
All ages	97.7%	21.9%
Less than 24 years old	98.7%	32.9%
25-39 years old	97.8%	27.3%
40 years old and older	96.8%	11.7%

Figure 2: Share of Informality, Employment, and Unemployment by Types

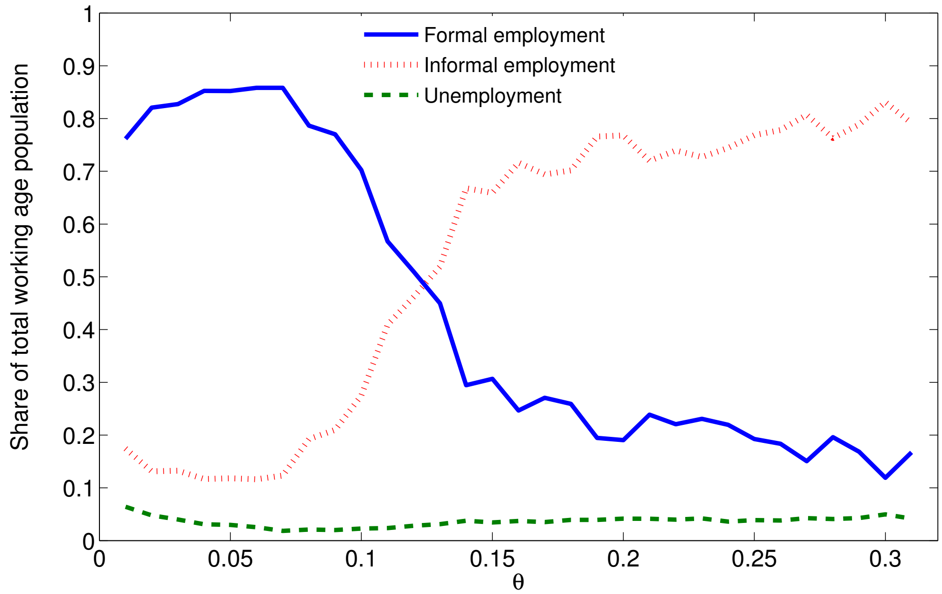
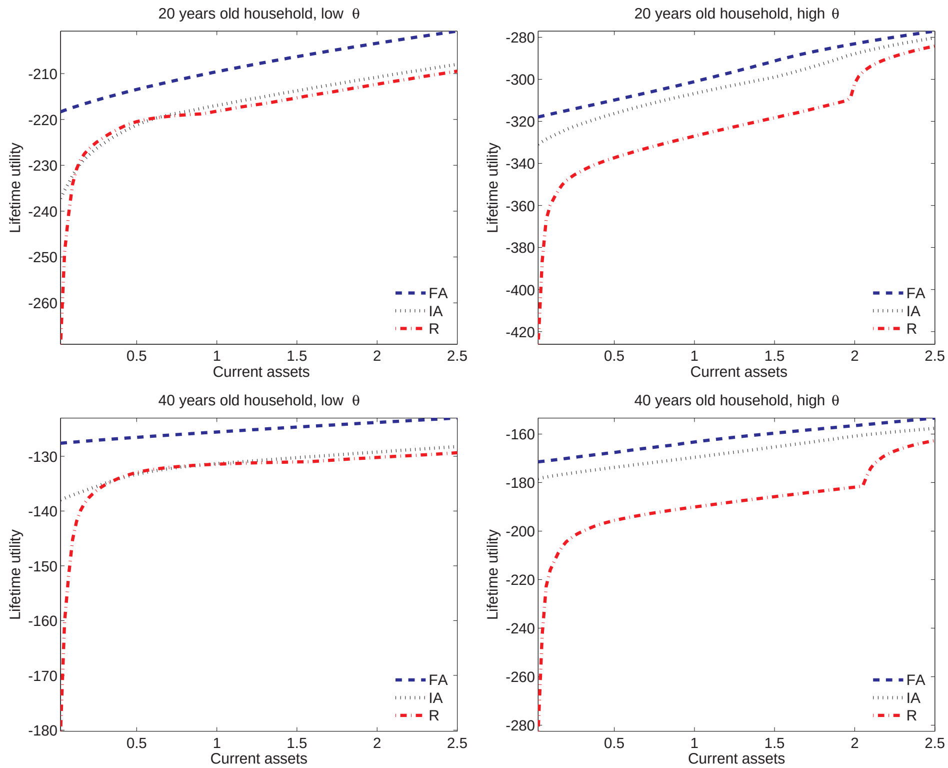


Figure 2 shows the share of the population based on employment status—employment (solid blue line), unemployment (green dashed line), and informality (red dotted line)—as a function of the disutility of search effort (θ). The key feature is that individuals with low disutility of search effort work mainly in the formal sector, while those with high disutility of search effort work mostly in the informal sector.

Figure 3 displays the expected discounted lifetime utility of individuals based on the labor market status—working in the formal sector (blue dashed line), working in the informal sector (black dotted line), and unemployed (red dot-dashed line). The four panels present these function for younger and older individuals, with low and high disutility of search effort. Focus, for instance, on the top left panel. For any level of assets, working in the formal sector is preferred. Individuals with very low and very high savings prefer working in the informal sector to unemployment. However, for a range of assets between 0.1 and 0.5, individuals prefer unemployment to informality. This happens because unemployed individu-

Figure 3: Informality, Employment, and Unemployment by Types



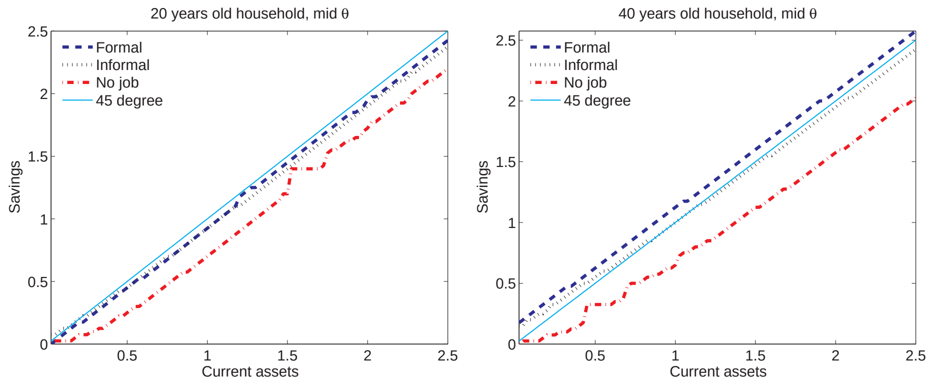
als have higher probability of getting an offer from the formal sector than workers in the informal sector (given the same search effort).

Finally, Figure 4 shows the chosen stock of savings for the next period as a function of the current stock of savings. Notice that young individuals actually consume part of their savings regardless of their labor market status. In contrast, older individuals save while they have a job and consume part of their savings during unemployment.

6 Design of the UISA

This section presents the quantitative implications of implementing the optimally designed UISA. The optimality criterion is the following. The set of alternative policy reform that we consider belongs to unemployment protection schemes that

Figure 4: Savings and Labor Market Status



can be parametrized by $(\underline{s}, \overline{s}, \psi, b, s_0, \widetilde{\tau})$. Within this set, we define the optimal UISA scheme as the one that maximizes (1).

The first set of results, presented in Table 4 as optimal UISA, are obtained choosing the values for $(\underline{s}, \overline{s}, \psi, b)$ while assuming labor income taxes have not changed, so that $\tau = \widetilde{\tau}$ and $s_0 = 2$. The optimal UISA system has $\underline{s} = 0.4$, $\overline{s} = 2$, $\psi = 0.25$, and $b = 0.4$. Table 5 compares unemployment, informality, and formal employment in the benchmark and UISA economies. Although the unemployment rate is lowered after the reform, the most significant impact is in the composition of employment. The size of the informal sector shrinks drastically from 52.9 percent to 0.01 percent, while employment in the formal sector increases from about 43.4 percent to about 97 percent. So this policy reform has its main impact on the labor market.

Table 5: Labor Market Status: Benchmark versus UISA

	Benchmark	UISA
Employment	43.4%	97.1%
Unemployment	3.6%	2.9%
Informality	52.9%	0.0%

Table 6 shows the implications of the reform in terms of welfare. To do that, the tax rate in the economy is dropped from 27 to 12 percent such that the government budget is unchanged. The reform has total positive impact of 4.9 percent in terms of consumption equivalent units. Why can the government surplus be unchanged if taxes are less than half that in the benchmark economy? The intuition for the positive impact on government surplus can be grasped as follows. On one hand, formal employment increases so much so that collected taxes increase as well. On the other hand, government expenditures are limited under this policy because they provide the initial level of savings, which is equal to about six months of earning in the formal sector at age 40.

Table 6: Labor Market Status: Benchmark vs UISA

	Benchmark	UISA ($\tau = 12\%$)
Employment	43.4%	97.2%
Unemployment	3.6%	2.8%
Informality	52.9%	0.0%
Tax revenue per capita	0.087	0.092
Expenditures per capita	0.007	0.012
Balance per capita	0.081	0.081
Ex-ante utility	-270.8	-252.4
Welfare gains, CE units		4.9%

The big impact of the UISA is in the size of the formal labor market. To understand this result, Table 7 illustrates how the probability of getting a job offer increases after the reform. The biggest increase is the probability of getting a job offer during unemployment. When analyzing all ages, this probability increases from 22 to 71 percent. The rise is even more dramatic for individuals over 40 years old, for whom this probability increases from 12 to 86 percent. Thus, the increase in formal employment is driven by the fact that the value of finding a formal job is magnified with this scheme. In particular, formal jobs not only offer higher salaries but also let the worker contribute to his or her savings account. Informal jobs are not only poorly paid, but they also make it harder to find formal jobs (as in the benchmark economy) and prevent informal workers from accumulating savings in a UISA.

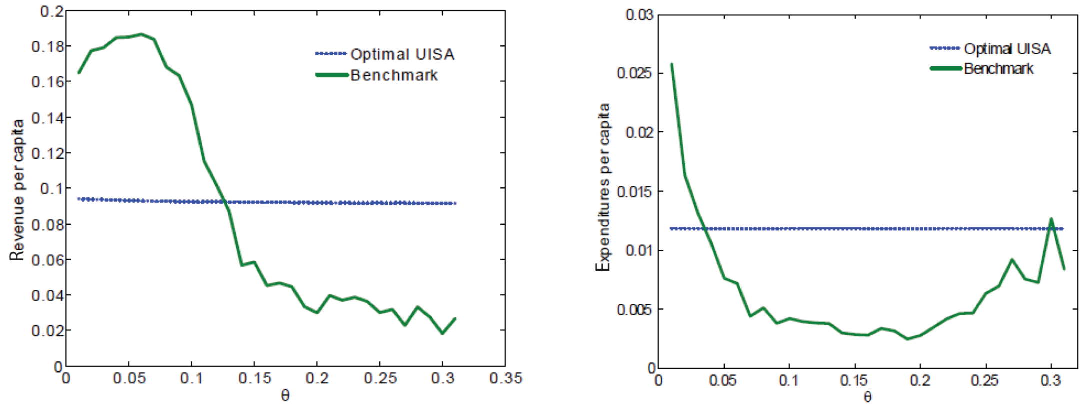
Table 7: Probability of Having a Job Offer

	Benchmark		Optimal UISA ($\tau = 12\%$)	
	Employed	Unemployed	Employed	Unemployed
All ages	97.7%	21.9%	97.8%	70.6%
Less than 24 years old	98.7%	32.9%	98.3%	60.2%
25-39 years old	97.8%	27.3%	98.3%	71.5%
40 years old and over	96.8%	11.7%	97.0%	85.9%

Figure 5 shows the expenditures per capita for individuals with different disutility of search effort. Here, the level of taxes is changed in the optimal UISA, such that the government balance is unchanged. This figure evidences that while the benchmark economy revenues (left panel) are higher for individuals that search more for formal jobs—revenue is increasing with the disutility of effort—in the optimal UISA, they are almost independent of θ. A similar pattern is observed in terms of expenditures (right panel). Thus, the benchmark economy provides incentives for lower effort.

Table 8 presents an exercise that was designed to capture how much of the welfare gains are due to the fact that the initial level of savings was higher in the UISA than in the benchmark economy: the liquidity effect. The first and second columns present the benchmark and optimal UISA economy described previously. The third column contains the statistics for an optimal UISA conditional on the initial level of savings being zero ($s_0 = 0$). Notice that in this economy the tax rate was also decreased to keep the government budget unchanged. Also, formal

Figure 5: Revenues and Expenditures by Types



employment is even higher and unemployment is even lower. The welfare gains are reduced to 2.3 percent, which occurs because individuals cannot smooth their lifecycle profile of consumption. The remaining gains are due to the increase in formal employment that is generated by the increase in search effort. This makes it possible to reduce the tax rate from 27 to 10 percent and keep the balance unchanged. This effect explains about half of the total welfare gains.

Finally, the last column isolates the impact of liquidity provision itself. Agents are provided with financial assets, as in the UISA economy, at date 0; that is $s_0 = 0$. However, in this exercise, agents have access to credit markets for savings, and they are allowed to make optimal consumption/saving decisions by themselves. Of course, since one of the portfolio options replicates the UISA, this scenario will deliver larger utility in general. Indeed, in our example, welfare gains are 8.5 percent. This option reduces the shadow value of working in the formal sector in the UISA economy, in which the formal market gives access to savings.

In the last exercise, agents are provided with liquidity that allows them to smooth their lifecycle profile of consumption, which explains why the impact on employment is small: formal employment increases less than 3 percent, unemployment remains basically unchanged, and informality reduces just over 2 percent.

This last exercise shows that, in this setting, pure liquidity provision can play a key role in terms of welfare, but it does not have a significant impact on reducing informality.

Table 8: The Role of Liquidity

	Benchmark	UISA		Pure liquidity
		($s_0 = 2$, $\tau = 12.0\%$)	($s_0 = 0$, $\tau = 10.4\%$)	($s_0 = 2$, $\tau = 12.0\%$)
Employment	43.4%	97.2%	98.7%	46.2%
Unemployment	3.6%	2.8%	1.3%	3.4%
Informality	52.9%	0.0%	0.0%	50.33
Tax revenue per capita	0.087	0.092	0.081	0.092
Expenditures per capita	0.007	0.012	0.000	0.011
Balance per capita	0.081	0.081	0.081	0.081
Ex-ante utility	-270.8	-252.4	-264.7	-248.2
Welfare gains, CE units		4.9%	2.3%	8.5%

7 Conclusions

The framework introduced herein, perhaps with minor modifications, can be used to study the design of unemployment insurance in different countries with high informality. The main changes should be introduced into the benchmark economy to reproduce the economy under consideration. Then, the parameters of that benchmark economy should be calibrated to reproduce statistics available for the country of interest. The rest of the analysis would be similar: simply look for the best design of the UISA system. However, the optimal design of UISA and the associated welfare gains of the reform may be different.

It would be interesting to extend the model to incorporate human capital, which can be done following the work of Pavoni and Violante (2009). A model with human capital will be able to capture at least two features that are not present herein. First, the levels of education completed by individuals working in the informal sector usually differ substantially from those of workers in the formal sector. Reproducing this observation may be important to quantify the gains and losses associated with changes in the size of the informal sector. Second, it has been argued that the rate at which workers accumulate human capital in the informal sector is lower than in the formal sector. Capturing this potential loss associated with the informal sector may affect the optimal design of policy. Lastly, the theoretical characterization of optimal unemployment insurance in economies with unobserved heterogeneity and moral hazard seems an interesting topic for future research.

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