Labor Market Policies in a Dual Economy *

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Abstract

A structural model of heterogeneous agents is built to account for the labor market dynamics of an economy with a large informal sector and to quantify effects of labor market policies on employment, worker flows, savings and welfare in a dual economy. The introduction of unemployment insurance has only a small impact on unemployment but induces a sectoral reallocation of formal labor into informality. Generous severance payments lower the wage of formal jobs and reduce flows from unemployment to formality. In financing expenditures, shifting a tax burden from labor income to consumption increases the size of a formal sector, enhancing productivity and welfare. Economic and welfare consequences of policy reform can significantly differ from those in a single-sector economy due to workers' incentives to avoid taxes and maximize transfers by moving across sectors.

Keywords: Informal sector, dual economy, unemployment insurance, severance payment.

J.E.L. classification codes: E6, J2, J6, O17.

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1 Introduction

The size of the shadow economy is large across the world. Medina and Schneider (2018) estimate that more than one-third of world GDP is produced in the underground economy.[1] In developing regions such as Latin America and Sub-Saharan Africa, over 40% of the economic activities take place informally, and in some countries two-thirds of the economy is underground.

Distinguishing between formality and informality is important in analyzing policies in such an economy. An informal sector, by definition, is characterized by lack of compliance with government regulations. Individuals pay no taxes and make no social security contribution on income earned informally. They are, however, disconnected from public provision of social insurance, despite the fact that workers in the informal sector face higher labor mobility and earnings volatilities and are in need of more insurance.[2] Mexico is a prime example of such issues, with a history of attempts to curb informality. Using the data of the Mexican Statistics and Geography National Institute (INEGI), we estimate that 43% percent of the working population is employed in the underground sector.[3]

Workers in the shadow economy face not only lower wages, but also higher risks of job loss and little protection from job dismissals. Policy makers are debating the implementation of an unemployment insurance system, which is far from comprehensive at present. Also debated is a reform of the tax system on consumption and labor income, two major sources of revenues besides oil in Mexico (OECD, 2019). Such changes in labor market and fiscal policies are likely to induce mobility of workers across sectors.

This paper builds a structural life-cycle model of heterogeneous agents in a dual-sector economy, in which workers move between formal and informal sectors and in and out of unemployment. Individuals are heterogeneous in the stage of life-cycle, human capital, wealth, uninsurable idiosyncratic labor productivity and the sector where they currently work. They face uncertainty in employment and productivity, but the market is incomplete and risk-averse individuals engage in life-cycle as well as precautionary savings of riskless assets to smooth consumption. The model is calibrated using various micro data, including the National Urban Employment Survey (ENEU) and the National Employment and Occupational Survey (ENOE) for wage and employment data and the

[1] Medina and Schneider (2018) estimate the size of the shadow economy for 158 countries from 1999 to 2007. They define the underground economy as all economic activities which are hidden from official authorities for monetary, regulatory and institutional reasons. It reflects mostly legal economic and productive activities that would contribute to national GDP, if recorded. They try to avoid illegal or criminal activities and other household activities.

[2] Binelli (2016) uses the ENEU data of Mexico and shows that most (60%) of wage inequality comes from wage inequality within informal jobs and the informal sector contributed to the rise in wage in inequality since the financial crisis of the mid-1990s.

[3] The average over 2000-2010. See section 3 for detailed description of the data and the statistics we computed from the INEGI database.

National Household Income and Expenditure Survey (ENIGH) for asset profile.

We then use the calibrated model to simulate debated labor market policies to quantify effects on wages, employment, savings, and welfare, as well as the reallocation of labor across sectors. We simulate two labor market policies: an introduction of unemployment insurance and the provision of more generous employment protection through higher severance payment.

We allow laid-off workers in the formal sector to collect unemployment benefits for a limited duration. The policy increases the unemployment rate, although the effects are quantitatively small. Hazard rates, however, into formality among insurance recipients decline and the unemployed are more likely to accept offers for informal jobs. Given the lack of monitoring of employment in the informal sector, unemployed individuals who accept a job in the informal sector can keep collecting benefits until the receiving period ends.

A higher severance payment reduces the likelihood of layoffs in the formal sector. The policy, however, also depresses equilibrium formal wages, leaving the unemployment rate and the share of formality almost unchanged. Hazard rates, both into formality and informality, decrease with more severance payments due to wealth effects through larger transfers.

To quantify fiscal costs of alternative policies, we simulate a model implementing the policies under alternative tax regimes, by shifting sources of taxation between labor income and consumption. While consumption taxes are less distortionary than labor income taxes, the change in employment due to higher labor taxes turns out to be surprisingly small. In our dual-sector economy, workers move from formal jobs to informal jobs that remain free of taxes. Such a sectoral reallocation involves a decline in overall productivity and average earnings as well as a sizeable welfare loss of individuals.

Our paper attempts to contribute to different lines of literature. Our model follows the tradition of dynamic structural models populated by heterogenous agents, who optimally choose consumption, saving and labor supply in an incomplete market.[4] The model is also a version of the life-cycle framework developed by Auerbach and Kotlikoff (1987), where individuals accumulate wealth for precautionary and retirement reasons. Using a life-cycle rather than an infinitely-lived agent model helps us approximate the earnings-wealth ratio that is consistent with data of a typical dual economy and the process of accumulating physical and human capital at stages of the life-cycle. We introduce stochastic aging, a modeling device developed by Blanchard (1985), which allows us to reduce the size of individual state space.

The literature has been also merged with and extended to incorporate labor market frictions and to study unemployment dynamics and various labor market policies. The search-island model of Lucas and Prescott (1974) captures search frictions to account

[4]The literature was pioneered by Bewley (1986), Huggett (1993) and Aiyagari (1994).

for short-run unemployment, which is adopted by papers such as Alvarez and Veracierto (2001) and Kitao et al. (2017). They assume that a worker who finds an island will be randomly matched with a firm and receives a job offer at the equilibrium wage in each island. Alvarez and Veracierto (2001) use the model to study effects of severance payments and Kitao et al. (2017) the roles of transfer policies that interact with decisions of human capital investment and career length in a life-cycle model. Our model also includes frictions in the labor market, as in Mortensen and Pissarides (1994). We let each firm create one job, while being subject to idiosyncratic productivity shocks and endogenous job destruction.

The papers mentioned above focus on a single sector of the economy and one of our major contributions is to extend it to a dual-sector economy in a tractable way. We analyze effects of labor market and fiscal policies in an economy where a large informal sector plays an important role in accounting for dynamics of the labor market, individuals' welfare and the aggregate economy. Alcaraz et al. (2015) show that although there exists some segmentation in the Mexican labor market, a large number of workers self-select into a particular sector, implying that a structural model needs to capture endogenous mobility of workers across sectors and analysis of policy reforms should take into account their effects on these margins.

Therefore our paper builds on another growing body of literature comprising theoretical and empirical studies on labor market dynamics and policies in an economy with dual sectors. In terms of more theoretical papers, Álvarez-Parra and Sánchez (2009) study the design of unemployment insurance when workers can participate in a hidden labor market and show that the optimal scheme differs significantly from the one prescribed in a market without dual sectors. Cirelli et al. (2019) study optimal design of an unemployment insurance saving accounts (UISA) system in a model with two sectors with savings and their model is perhaps closest to ours among models with informality.[5] They find that the optimal UISAs increase welfare, reduce unemployment and informality due to the incentives for keeping jobs in the formal sector. Both of these papers study optimal design of an unemployment system in more detail than ours, while our analysis has the advantage of incorporating general equilibrium effects.

Levy (2008) studies informality in Mexico and different policy reforms that took place to curb it. The author's proposal is to eliminate wage-based social security contributions and impose a progressive consumption tax. The results of our paper that lower income taxes and higher consumption taxes reduce informality are broadly consistent with Levy's

[5]Our model differs from Cirelli et al. (2019) in that we have richer dynamics of earnings where individuals accumulate human capital over the life-cycle and face stochastic productivity shocks in each sector. They focus on effects of introducing UISA and we study roles of unemployment insurance and severance payments and also consider effects of alternative financing schemes, using taxes on labor income and consumption. They show that the UISA, with additional contribution of the government to an individual's account, makes it more attractive to work in the formal sector and improves welfare.

proposal, although our experiments are not a perfect mapping to his proposal and therefore not directly comparable. Other authors at the Inter-American Development Bank have also done various empirical research on the effects of tax reforms in countries with high informally. Bernal et al. (2017) study the effect on employment and wages of the switch from payroll taxes to corporate income taxes in Colombia. Lora and Fajardo (2012) analyze the effects of payroll, corporate income and value-added taxes on the labor market for 15 Latin American countries.

Alonso Ortiz and Leal Ordonez (2018) construct a search model of two sectors calibrated to the Mexican data and show that tax and transfer policies have a large impact on the size of the informal sector. Antón (2014) builds a model with endogenous choice of sectors calibrated to the data of Colombia and studies effects of tax reduction on the size of the formal sector. Bobba et al. (2018) estimate a search and matching model of formal and informal labor markets using Mexican data and show that raising taxes may or may not decrease the formal sector and that a comprehensive social security system will reduce the size of the informal sector and raise productivity. Leyva and Urrutia (2019) build a model with business cycles calibrated to the Mexican economy and study effects of informality and labor market regulations on volatility of macroeconomic variables.[6] Our innovation in this context is first to allow individuals to accumulate physical and human capital over their life-cycle, which interacts with an individual's decision about which sectors to work in. Savings of risk-averse individuals adds another key ingredient in evaluating the roles of government-provided insurance through unemployment benefits and severance payments. Second, we consider effects of alternative fiscal policies to finance policy expenditures on labor market dynamics and individuals' welfare.

The remainder of the paper is organized as follows. Section 2 presents the model and section 3 describes the data and calibration of the model parameters. Section 4 presents the results of the different policy experiments and section 5 concludes.

[6]The literature on informality is rapidly growing and papers describe above are examples of many contributions. Leal Ordonez (2014) analyzes the effect of tax enforcement in a model of entrepreneurial decisions and D'Erasmo and Moscoso Boedo (2012) build a dynamic firm model with endogenous formal and informal sectors to study the effects of capital market imperfections. Other papers in the literature include Kugler (1999), Fugazza and Jacques (2004), Boeri and Garibaldi (2005), Antunes and de V. Cavalcanti (2007), Zenou (2008), Albrecht et al. (2009), Bosch and Esteban-Pretel (2012), Margolis et al. (2012), Azuara and Marinescu (2013) and Bosch and Campos-Vazquez (2014). Papers such as Jung and Tran (2012) and Tkhir (2020) study effects of social security reform in an economy with an informal sector.

2 Model

2.1 Environment

There are two sectors of production in the economy: formal and informal. The main difference between the two sectors is that firms in the informal sector hide from the government to avoid regulations. Therefore, workers in the informal sector do not pay labor income taxes on their hidden earnings, and firms do not have to pay a severance cost when they fire the worker. However, in order to avoid detection from the government, firms operating in the informal sector incur a cost of continuously hiding from the authority, which negatively affects their productivity. They also face a cost associated with risks of being detected by the government and having to pay a penalty afterwards. We follow Bobba et al. (2018) and assume that the cost is proportional to the size of the firm, given the fact that such risks are higher for larger and more profitable firms.

There is no unemployment insurance in the baseline model, but we introduce it in section 4.2. In that extended version of the model, the formal sector also differs from the informal one in that working formally qualifies the worker to collect unemployment insurance if fired, but if re-hired in the formal sector, the worker has to give up those benefits. On the contrary, working informally does not entitle the worker to collect benefits, but if he was entitled to those benefits while unemployed, he can continue collecting them until expiration even after he is hired informally, since that type of job is hidden from the government.

In our model, there is a continuum of individuals born with uncertain life-spans. Each individual passes through two stages of life-cycle, working-age and retirement phases. A working-age individual faces probability ρ of transitioning to the retirement age. All individuals are subject to mortality risks every period and δ_w and δ_r denote the death probability in each period for working-age and retired individuals, respectively.

An unemployed individual finds a job offer with probability π_s^U in sector $s \in \{F.I\}$, which he chooses to accept or reject. An employed individual in sector s faces probability q_s every period that employment is terminated by an employer and becomes unemployed. With probability π_s^E, individuals employed in sector s will receive a job offer from the other sector, which they decide to accept or reject. Conditional on no separation that is exogenous to workers, all employed individuals have an option to quit the job and become unemployed or remain employed in the current sector. When a job is terminated by the employer in the formal sector, the worker receives a severance payment g_F from the firm that laid off the worker.

Earnings of an employed individual are determined by three components: human capital h, idiosyncratic labor productivity ε, and sector-specific market wage per efficiency unit w_s. Human capital grows at an average rate of γ_h while employed and depreciates at δ_h while unemployed. The evolution of the human capital is expressed by transition

matrices $H^E(h, h')$ and $H^U(h, h')$ for employed and unemployed individuals, respectively, which denote the probability of human capital h' in the next period conditional on the current human capital of h.

An individual in sector s draws a new idiosyncratic labor productivity ε' with probability $\Lambda_s(\varepsilon, \varepsilon')$ conditional on current productivity ε. When an individual is newly matched with a job in sector s, he will draw an idiosyncratic productivity ε from the stationary distribution of the productivity in each sector implied by the Markov transition matrices.

Individuals derive utility $u(c)$ from consumption c and incur disutility B_s from working in sector s. Future utility is discounted at rate β.

2.2 Production

A firm in sector $s \in \{F, I\}$ creates a job incurring a startup cost μ_s to produce output next period at productivity level $z = z_s^0$. The firm's productivity then follows a Markov process, $Z(z, z')$. More precisely, we assume that in each period, firms draw a new productivity with probability p^z from a uniform distribution with a support of $[0, \overline{z}]$, and calibrate the transition matrices accordingly.

The production functions of formal and informal firms denoted as F_F and F_I, respectively, are given as

$$\begin{aligned} F_F(z, k, n) &= zk^{\alpha}n^{1-\alpha} \\ F_I(z, k, n) &= (1-\phi)zk^{\alpha}n^{1-\alpha} \end{aligned}$$

where $\alpha \in (0, 1)$ denotes a capital share. z is the current job-specific productivity level, k is physical capital that depreciates at rate δ_k and n is efficiency units of labor εh supplied by the worker filling the job. ϕ represents the cost of operating in the informal sector, which reduces the productivity and output of an informal firm, as explained above.

The matching mechanism is based on the framework of Lucas and Prescott (1974), Alvarez and Veracierto (2001) and Kitao et al. (2017), extended to our multi-sector economy. Firms that enter each sector incur an entry cost and entries of new firms continue until the wage per efficiency unit clears the labor market and makes the expected profit of creating a new job be zero. A firm pays the competitively determined wage rate for each efficiency unit of a worker that it is randomly matched with in the centralized labor market. Each worker receives a payment, which is the market wage times the efficiency units of the worker filling the job in the current period. In a new period, all surviving and new firms are randomly matched with old and new workers of each sector.

2.3 Government

The government imposes tax on consumption at rate τ_c. In the labor market, it taxes workers' income in the formal sector at rate τ_l. In the benchmark model, there is no

unemployment insurance and we will introduce it in section 4.

The amount of revenues raised by these taxes in the benchmark economy is assumed to finance exogenous government expenditures that do not affect the decisions of individuals and workers. When we introduce different policies in section 4, we assume that the same amount of expenditures plus any additional expenses need to be financed and the tax rate is adjusted in a new equilibrium.

2.4 Timing of Events

At the beginning of each period, each incumbent firm observes its new productivity level z and decides whether to continue production or terminate the job. All firms in each sector have the same reservation productivity level $\tilde{z}_s$, below which jobs are terminated.[7] Formal firms terminating a job will incur a layoff cost g, which is paid to the laid off worker as a severance payment. As a result of job destructions initiated by firms, a fraction q_s of workers are laid off.

Conditional on no separation that is exogenous to workers, they may receive a job offer from the other sector, in which case they will decide among three options: to accept the offer and work in the other sector, to remain and work in the current sector or to quit the job and become unemployed. If a worker receives no job offer from the other sector, the choice is between staying in the current sector and quitting. All remaining jobs in each sector are randomly matched with workers in the centralized labor market, which include all existing and surviving workers and new entrants to the labor market.

Once matches are formed, firms observe the matched worker's efficiency units and choose the amount of capital to rent in the competitive market to maximize profit. Workers are paid the market wage w_s per efficiency unit and the wage rate is determined such that newly created jobs break even and generate no profit in expectation. The market wage adjusts to ensure that all workers in each sector are matched to a job.

2.5 Individuals' Problem

The state vector of an employed individual in sector $s \in \{F, I\}$ is given as $x_s^E = \{a, h, \varepsilon\}$, where a denotes assets carried from the previous period, h the level of human capital, and ε the idiosyncratic productivity in the current sector. The state vector of an unemployed individual is $x^U = \{a, h\}$. A retiree's state consists of assets only, $x^R = \{a\}$. We assume that individuals can accumulate riskless savings but they are not allowed to borrow, i.e. $a' \geq 0$. We let β_w and β_r denote discount factors inclusive of the survival probabilities, i.e. $\beta_w = \beta(1 - \delta_w)$ for working-age individuals and $\beta_r = \beta(1 - \delta_r)$ for retirees.

[7] The continuation decision is made before a firm is randomly matched with a worker and $\tilde{z}_s$ is the threshold productivity level below which profit is negative in expectation.

We now write value functions of individuals employed in sector s, $V_s(a,h,\varepsilon)$ and unemployed, $U(a,h)$, and value functions of retirees, $R(a)$.

Value Function of the Employed in the Formal Sector:

$$\begin{aligned} V_F(a,h,\varepsilon) &= \max_{c,a'} \{u(c) - B_F + \beta_w(1-\rho)\left[q_F EU(a',h')\right. \\ &\quad +(1-q_F)\pi_I^E E\max\{V_F(a',h',\varepsilon'),V_I(a',h',\tilde{\varepsilon}'),U(a',h')\} \\ &\quad \left.+(1-q_F)(1-\pi_I^E)E\max\{V_F(a',h',\varepsilon'),U(a',h')\}\right] \\ &\quad +\beta_w\rho R(a')\} \end{aligned} \tag{1}$$

subject to

$$\begin{aligned} a' &= (1-\tau_l)\varepsilon h w_F + (1+r)a + g - (1+\tau_c)c \\ a' &\geq 0 \end{aligned} \tag{2}$$

A formal worker chooses current consumption, c, and savings, a', to maximize his lifetime utility subject to the budget constraint. In the current period, he obtains utility $u(c)$ from consumption and disutility B_F from working.

In the following period, which is discounted at rate β_w, he may retire with probability ρ and obtain value $R(a')$. He may also get laid-off by the firm, which happens with probability q_F, in which case he will obtain a value $EU(a',h')$. If the worker does not get fired, he may get an offer from an informal firm with probability π_I^E and will have to choose among staying in the formal sector, moving to the informal sector (in which case he will draw a new idiosyncratic productivity $\tilde{\varepsilon}'$ in the informal sector), or becoming unemployed. Finally, if he does not get fired or receive an informal offer, he will choose between staying employed in the formal sector or becoming unemployed. As seen in the budget constraint (2), the formal worker receives income $\varepsilon h w_F$, which is the product of the formal wage, w_F, his current idiosyncratic productivity, ε, and human capital, h. Out of the earned income, the formal worker must pay a fraction τ_l in taxes. He will also receive interests on the saved assets, $(1+r)a$, and a severance payment g only if he is laid-off by the firm. All individuals pay a tax τ_c per unit of consumption.

Value Function of the Employed in the Informal Sector:

$$\begin{aligned} V_I(a,h,\varepsilon) &= \max_{c,a'} \{u(c) - B_I + \beta_w(1-\rho)\left[q_I EU(a',h')\right. \\ &\quad +(1-q_I)\pi_F^E E\max\{V_I(a',h',\varepsilon'),V_F(a',h',\tilde{\varepsilon}'),U(a',h')\} \\ &\quad \left.+(1-q_I)(1-\pi_F^E)E\max\{V_I(a',h',\varepsilon'),U(a',h')\}\right] \\ &\quad +\beta_w\rho R(a')\} \end{aligned} \tag{3}$$

subject to

$$\begin{aligned} a' &= \varepsilon h w_I + (1+r)a - (1+\tau_c)c \\ a' &\geq 0 \end{aligned} \tag{4}$$

The problem of an informal worker is similar to that of a formal worker, but differs in that because he is employed in the underground economy, he does not pay taxes on his earned income. Unlike a formal worker, an informal worker cannot collect a severance payment if fired by the firm.

Value Function of the Unemployed:

$$\begin{aligned} U(a,h) = \max_{c,a'} \{ & u(c) + \beta_w(1-\rho)\,[\\ & +\pi_F^U \pi_I^U E \max\{V_F(a',h',\varepsilon_F), V_I(a',h',\varepsilon_I), U(a',h')\} \\ & +\pi_F^U(1-\pi_I^U) E \max\{V_F(a',h',\varepsilon_F), U(a',h')\} \\ & +\pi_I^U(1-\pi_F^U) E \max\{V_I(a',h',\varepsilon_I), U(a',h')\} \qquad (5) \\ & +(1-\pi_F^U)(1-\pi_I^U) E U(a',h')\big] \\ & +\beta_w \rho R(a')\} \qquad (6) \end{aligned}$$

subject to

$$\begin{aligned} a' &= (1+r)a - (1+\tau_c)c \\ a' &\geq 0 \end{aligned} \tag{7}$$

Similar to employed workers, an unemployed individual chooses consumption and savings to maximize his life-time utility. The future value of being unemployed depends on his chances of getting job offers and retiring. He may get an offer from both sectors simultaneously with probability $\pi_F^U \pi_I^U$, and after drawing the idiosyncratic productivities, ε_F and ε_I, he will choose among a job in the formal sector, one in the informal sector, or remaining unemployed. He may get an offer only from one of the sectors, for instance from the formal sector with probability $\pi_F^U(1-\pi_I^U)$, and choose between taking the offer and moving to that sector or remaining unemployed. He may not get any offer, which happens with probability $(1-\pi_F^U)(1-\pi_I^U)$, and he will remain unemployed. Finally, he may retire with probability ρ.

Value Function of Retirees:

$$R(a) = \max_{c,a'} \{u(c) + \beta_r R(a')\} \tag{8}$$

subject to

$$\begin{aligned} a' &= (1+r)a - (1+\tau_c)c \\ a' &\geq 0 \end{aligned} \tag{9}$$

The problem of a retired worker is a simple one, where he chooses consumption and savings to maximize his utility, subject to the budget constraint. The problem remains the same until he exits the model upon death.

2.6 Firms' Problem

A firm with productivity z matched with a worker with efficiency units n will optimally choose the level of capital k used in production. Current profits for the firm are composed of the difference between revenues obtained from production, $zk^{\alpha}n^{1-\alpha}$ for formal firms and $(1-\phi)zk^{\alpha}n^{1-\alpha}$ for informal firms, and costs, both from hiring labor, $w_s n$, and renting capital, $(r+\delta_k)k$, where δ_k is the rate of depreciation of capital.[8] The value functions of an existing firm in each of the two sectors are given as follows.

Problem of the Formal Firm:

$$\begin{aligned} J_F(n,z) &= \max_k \left\{ zk^{\alpha}n^{1-\alpha} - w_F n - (r+\delta_k)k \right\} \\ &\quad + \frac{1}{1+r}\sum_{z'} Z(z,z')\tilde{J}_F(z'), \end{aligned} \tag{10}$$

where

$$\tilde{J}_F(z) = \max\left\{ E_n\left[J_F(n,z) \right], -g \right\} \tag{11}$$

is the continuation value for the formal firm, which must decide whether to remain operative or fire the worker and pay cost g.

Problem of the Informal Firm:

$$\begin{aligned} J_I(n,z) &= \max_k \left\{ (1-\phi)zk^{\alpha}n^{1-\alpha} - w_s n - (r+\delta_k)k \right\} \\ &\quad + \frac{1}{1+r}\sum_{z'} Z(z,z')\tilde{J}_I(z'), \end{aligned} \tag{12}$$

where

$$\tilde{J}_I(z) = \max\left\{ E_n\left[J_I(n,z) \right], 0 \right\}, \tag{13}$$

is the continuation value for the informal firm, which does not face a firing cost for dismissing the worker.

Associated with the solution to an existing firm's optimization problem is a reservation productivity $\tilde{z}_s$ for $s \in \{F, I\}$ that satisfies

[8] Note that firms optimally choose capital at a level where the marginal product is equated with the interest rate. The wage rate is determined to satisfy the free entry condition of firms, as explained in section 2.2, and not necessarily equal to the marginal product of labor for each job.

$$E_n\left[J_F(n,\tilde{z}_F)\right] = -g, \tag{14}$$

$$E_n\left[J_I(n,\tilde{z}_I)\right] = 0 \tag{15}$$

for formal and informal firms, respectively.

Firms who enter the marker face the break-even condition for starting a new firm in sector s which is

$$\mu_s = \frac{1}{1+r} E_n\left[J_s(n,z_s^0)\right]. \tag{16}$$

In a stationary equilibrium, firms that shut down operations are replaced by the entry of new firms, which possess the initial productivity level of z_s^0.

2.7 Stationary Equilibrium

Individual states are $x_s^E = \{a,h,\varepsilon\}$ for $s \in \{F,I\}$, $x^U = \{a,h\}$ and $x^R = \{a\}$ for the employed, unemployed, and retirees, respectively. Let the state space of three types of individuals be denoted as $\mathbb{X}_s^E$, $\mathbb{X}^U$ and $\mathbb{X}^R$, and the entire state space of all individuals as $\mathbb{X}$ with $X \in \mathbb{X}$ being the general state vector of an individual including the employment and retirement state $N \in \{E,U,R\}$.

The equilibrium is given by allocation functions of individuals in each state; labor income and consumption tax rates; layoff cost; a set of value functions $\{V_s(x_s^E)\}_{x_s^E \in \mathbb{X}_s^E}$, $\{U(x^U)\}_{x^U \in \mathbb{X}^U}$ and $\{R(x^R)\}_{x^R \in \mathbb{X}^R}$; and distribution of individuals over the state space given by $m(X)$, such that (1) individuals solve the problem described in section 2.5 and optimally choose consumption, wealth and labor supply, (2) firms solve the problem described in section 2.6 and optimally make entry and exit decisions and choose the level of capital used in production, and (3) the market wage w_s clears the labor market in sector s: $\sum_{x_s^E} \Psi_s^E(x_s^E) = \sum_z \Psi_s^F(z)$, where $\Psi_s^E(x_s^E)$ denotes the measure of employed workers in state x_s^E and $\Psi_s^F(z)$ denotes the measure of firms operating with productivity z in sector s.

3 Calibration

This section presents the parametrization of the model. The frequency of the model is quarterly. As we discuss in more detail below, we use different micro databases to calibrate parameters related to the labor market and asset holdings as well as various macroeconomic and fiscal data to calibrate other parameters.

Micro data used in the paper, which runs from 2000 to 2010, is obtained from the Mexican Statistics and Geography National Institute (INEGI). Employment related data, including unemployment rate, worker flows, and wages is obtained from the National Urban Employment Survey (ENEU) and its revised version, the National Employment

and Occupational Survey (ENOE). Data on assets is drawn from the National Household Income and Expenditures Survey (ENIGH). Inflation and interest rates are taken from the Bank of Mexico.[9] The annual interest rate is set at 4%, the short-term nominal government funding rate as reported by the Bank of Mexico adjusted by the CPI inflation rate during the same period.[10] Calibrated parameters of the model are summarized in Tables 2 and 3.

3.1 Demographics

We set the probability of retirement $\rho = 1/45$ on an annual basis, so that individuals remain in the labor force for 45 years on average, close to the average years of employment among individuals in the ENEU and ENOE data.[11] The death probabilities are $\delta_w = 0.0050$ and $\delta_r = 0.061$ on an annual basis for working-age individuals and retirees, respectively, based on the estimates of death probabilities by age reported by the National Population Council of Mexico in 2010.[12]

The population is constant and newborns replace those who die and leave the model in each period. We assume that newborns enter the economy with no assets and as unemployed.[13] We abstract from intergenerational linkage through bequest motives and transfers, and assume that accidental bequests are confiscated by the government ("thrown into the ocean"). We assume that individuals can accumulate riskless savings for precautionary and life-cycle/retirement purposes but they are not able to borrow.[14]

3.2 Labor Market Dynamics and Asset Holdings

To obtain employment statistics we concatenate the quarterly panels of ENEU from the first quarter of 2000 to the fourth quarter of 2004 with those of ENOE from the first quarter of 2005 to the fourth quarter of 2010. Both ENEU and ENOE are quarterly

[9] http://www.banxico.org.mx

[10] More precisely, it is computed as the average real interest rate on one-year government bonds in 2000-2010.

[11] Among our samples, the average working years of those attached to the labor force (around 65% of the population) is 42 years.

[12] The assumption of stochastic aging follows a modeling device developed by Blanchard (1985) and used more recently in life-cycle models with rich heterogeneity, such as Cagetti and De Nardi (2009) and Jeske and Kitao (2009), to mitigate computational burden.

[13] According to the age profile of saving that we compute with the ENIGH data, which we discuss in detail below, the saving of those aged 20 and below is almost zero. In the computation, we assume that the lowest possible asset is extremely small, but positive to avoid a computational problem.

[14] The level of household debt in Mexico is very low, at just a few percentage points of GDP. See, for example, studies by the IMF and BIS of household debt across different countries.
https://www.imf.org/external/datamapper/HH_LS@GDD/MEX/USA/DEU/JPN/CAN
https://www.bis.org/publ/qtrpdf/r_qt1712f.pdf

household surveys that track workers for five quarters, and provide detailed information on labor market participation, wages, work hours and other relevant variables. ENEU covered 48 major metropolitan areas,[15] and was redesigned and renamed ENOE in 2005, extending the interviews to rural areas. For the purpose of obtaining labor market data, we restrict our sample to workers between the ages of 16 and 65.

We divide employed workers into two categories, formal and informal, and classify them on the basis of compliance with labor legislation, following the definition of informality by the International Labor Organization (ILO). In particular, we use the lack of contributions by the employer to the social security agency, IMSS (or the equivalent for civil servants, IMSTS), as the distinguishing characteristic defining informal employment.[16]

Worker Flows: We follow the matching method used in Shimer (2012) to construct worker flow data. Given the survey structure of ENEU and ENOE that track workers for five quarters, 80 percent of the households interviewed in any given quarter are interviewed again in the following survey. This allows us to match individual records over two consecutive quarters, and record workers' transitions among the three states of employment: employed in formality (F), informality (I), and unemployed (U), and obtain nine types of transitions across three employment states.[17] We classify a worker as employed, formally or informally, if he/she also reports to have worked at least 1 hour per week.

Letting Ω_{it} be the sample weight of worker i at quarter t in the sample, and Λ_t^{XY} the number of workers who move from state $X \in \{F, I, U\}$ to state $Y \in \{F, I, U\}$ in quarter t, the gross flow from state X to Y is given by $\Gamma_t^{XY} = \sum_{i \in \Lambda_t^{XY}} \Omega_{it}$. The total number of workers in a particular state $X \in \{F, I, U\}$ is computed as $X_t = \sum_{Y \in \{E,U,I\}} \Gamma_t^{XY}$. The transition probability from state X to Y is derived as $p_t^{XY} = \frac{\Gamma_t^{XY}}{X_t}$.

The unemployment rate is calculated as $u_t = \frac{U_t}{F_t + I_t + U_t}$ and the share of formal employment among total employment is given as $\frac{F_t}{F_t + I_t}$.

The ENEU and ENOE surveys contain a question related to the reasons why unemployed workers separated from their previous employer. We use this information to calculate the fraction of separations which are due to quits and lay-offs.

Wage Dynamics: Data for nominal wages is obtained using variables on weekly labor earnings and hours worked in the ENEU and ENOE surveys. Real wages are calculated deflating wages by the Mexican CPI index. Given individual data for real hourly wages in two consecutive quarters we estimate the AR(1) process of log wages in the formal and

[15] 16 cities were dropped for the survey of 2004, reducing the number of surveyed metropolitan areas to 32 from that year and into ENOE.

[16] We exclude self-employed individuals from our samples since our model does not capture the decisions to start self-owned business and to hire workers and rent capital for their own firms.

[17] Remaining in formal (FF), moving from formal to informal (FI), from formal to unemployment (FU), IF, II, IU, UF, UI and UU.

informal sectors. We control for age and education of individuals, and use year dummies to control for macroeconomic changes.

The wage premium for the formal sector, defined as $\frac{w_F}{w_I}$, is calculated regressing real log wages on a formal sector dummy, and controlling for age and education of the individuals.

Asset Holdings: Asset data for Mexico is not readily available and we rely on the expenditures and capital earnings data reported in ENIGH to infer the asset profile. This survey, which is conducted every two years, records expenditures and earnings for households across the country. We use the surveys from 2000 to 2010 and convert the nominal values into real by using the CPI index.

Given the available data from ENIGH, we calculate the assets of individuals as the sum of residential and financial assets. The value of housing assets owned by an individual is not available as such. However, ENIGH contains a question about the market rent equivalence for a residence owned by the household. We use information on rent-to-value ratio for Mexico[18] to infer the value of the house.[19] As to the financial assets, we compute the values using reported data on capital income from different types of assets. These include, but are not limited to, stocks, bonds, savings accounts, loans, and land.[20] Given the lack of available data on the return of all different types of assets, we assume that on average they provide the same return as the 1-year bond issued by the government.[21] Hence, we sum the value of all capital income from the different sources and use the interest rate for each year to infer the value of the assets owned by individuals.[22] The ratio of the average assets to annual earnings among workers is 1.2 in 2000-2010.

[18] According to real state agency Numbeo.com, the annual rent-to-value ratio in Mexico is 15. http://www.numbeo.com/property-investment/rankings_by_country.jsp

[19] While ENIGH contains information about whether the house is fully owned or mortgage payments are still being made, it does not report what fraction of the house is equity. However, only about 10% of residential units owned by individuals have outstanding mortgages. A recent study of the Bank of Mexico reports that the loan-to-value ratio for new mortgages is 65-70 percent in 2009. In order to assess the impact of mortgages on the distribution of assets in Mexico, we tried calculating the value of residential assets using two different assumptions: (i) assign only 35% of the house value for those units with outstanding mortgages, or (ii) ignore outstanding mortgages and assign the full value of the house as residential assets. We find that the asset distribution does not change very much across these two assumptions. This may be due to the fact that only 10% of houses have outstanding mortgages. We therefore assume that individuals own the whole value of the house and count it as their residential assets.

[20] A full list of capital assets can be found in the documentation for the various years of the survey.

[21] We obtain this rate from the Bank of Mexico website: http://www.banxico.org.mx

[22] Consistent with samples of the ENEU/ENOE surveys, we exclude self-employed individuals in computation of the asset profile. We note that not all adults own a bank account in Mexico and some individuals, especially informal workers may have difficulty making deposits at a financial institution. According to the report, Encuesta Naciaonal de Inclusion Financiera (ENIF 2015), more than one half of adults do not own a bank account and a smaller fraction of them have a formal job than those with a bank account.

Joint Calibration in Equilibrium: We use the moments described above as targets in calibrating the following 11 parameters: B_s that represents disutility of work in each sector s, π_s^E that denotes probability of getting an offer from sector s while working on the other sector, π_s^U for the probability of receiving a job offer from sector s while being unemployed, p_s^z for the probability of firms drawing a new productivity shock z in sector s, $\overline{z}$ that represents the scale of firms' productivity, the cost of operating in the informal sector ϕ, and finally subjective discount factor β. We use the method of Nelder and Mead (1965) to calibrate the 11 parameters using 11 targets as summarized in Table 1.

Table 1: Jointly calibrated parameters and target moments

Parameter description and values		**Target moments and values**	
Work disutility B_F	0.944	flow rate from F to U	1.9%
Work disutility B_I	0.890	flow rate from I to U	3.5%
Prob of job offers (emp) π_I^E	0.300	flow rate from F to I	9.5%
Prob of job offers (emp) π_F^E	0.231	flow rate from I to F	13.3%
Prob of job offers (unemp) π_F^U	0.457	average unemployment rate	3.7%
Prob of job offers (unemp) π_I^U	0.826	% of jobs that are formal	57%
Prob of z draw p_F^z	0.0256	separation due to layoff in F	1.22%
Prob of z draw p_I^z	0.0466	separation due to layoff in I	2.32%
Firm productivity scale $\overline{z}$	0.184	average earnings (normalization)	1.0
Cost of informal firms ϕ	0.147	wage ratio w_F/w_I	1.235
Discount factor β (annual)	0.901	avg asset-earnings ratio (annual)	1.2

3.3 Human Capital and Idiosyncratic Productivity

The transition matrix of human capital while employed $H^E(h, h')$ is calibrated to match the average growth rate of wages between ages 20 and 50 at 2.7%, based on the ENEU and ENOE individual data. While unemployed, we assume that human capital depreciates at a constant rate. Due to the lack of estimates based on Mexican data, we use estimates of skill depreciations based on U.S. data, and set an annual depreciation rate of 15%. The transition matrix $H^U(h, h')$ is calibrated accordingly. See, Pavoni and Violante (2007) for a survey of estimates. We assume that the human capital lies in the range of [0, 10] and that newborns enter the economy at the lowest level of human capital.

The transition matrix of idiosyncratic labor productivity $\Lambda_s(\varepsilon, \varepsilon')$ in sector s is based on the AR(1) wage process estimated using the ENEU and ENOE individual panel data. Unemployed individuals who receive a job offer make a draw of initial idiosyncratic productivity ε from the stationary distribution of the productivity in each sector.

3.4 Firms

Firing cost g in the formal sector corresponds to 16 weeks (4 months) of average earnings in the formal sector, based on a schedule of severance payments in Mexico according to tenure and average duration of employment in the formal sector. The amount of a severance payment varies by tenure. According to estimates of the World Bank's Doing Business project, it is earnings of 14.6 weeks for a worker with a tenure of 1 year, 21.4 weeks for a 5-year tenure and 30.0 weeks for a 10-year tenure.[23] As stated before, there is no severance payment in the informal sector. The entry cost μ_s is set at 50% of average monthly earnings in each sector. In the Cobb-Douglas production function, the capital share is set at 0.4 and the annual depreciation rate is 6%.

3.5 Government

The proportional labor income tax in the formal sector τ_l is set at 15%, which lies in the range of estimates of effective labor income taxes in Mexico (Sarabia, 2005).[24] There is no tax imposed on labor earnings in the informal sector. The consumption tax is set at 15%, the value-added tax rate in Mexico.

[23] See http://www.doingbusiness.org/data/exploreeconomies/mexico for more information on mandatory severance payments in Mexico.

[24] We compute tax revenues from the labor income tax in the benchmark economy and assume that they are government expenditures that are exogenous to the model. In experiments, we assume that the same amount of expenditures needs to be raised through taxes and compute the tax rate in equilibrium that would satisfy the budget constraints of the government.

Table 2: Functional forms and parameters (1): individuals

Param.	**Description**	**Value/Target**
Demographics		
δ_w	Death probability (working age)	0.0050 (annual)
δ_r	Death probability (retirees)	0.0613 (annual)
ρ	Retirement probability	1/45 (annual)
Preferences		
$u(c)$	Consumption utility	$\log(c)$
B_s	Disutility of work in sec. s	Separation rate from sector s to U
β	Discount factor	Avg. wealth to earnings at retirement
Human capital		
$H^E(h,h')$	Markov transition (employed)	Growth of wages over life-cycle
$H^U(h,h')$	Markov transition (unemployed)	Estimates of skill depreciation in the U.S.
Job offers		
π_s^E	Prob. of offer from sec. s while employed	Transition prob. between sectors
π_s^U	Prob. of offer from sec. s while unemployed	Job finding rates in sector s
Idiosyncratic productivity		
$\Gamma_s(\varepsilon,\varepsilon')$	Markov transition	AR(1) estimates for sector $s \in \{F, I\}$
r	Interest rate	4%

Table 3: Functional forms and parameters (2): firms, production, and government

Param.	**Description**	**Value/Target**
Firms' productivity		
p_s^z	Prob. of drawing new z in sec. s	Lay-offs in sector s
$\overline{z}$	Scale of productivity z	Normalization
Production function		
α	Share of capital	0.4
δ_k	Depreciation of capital	0.06
ϕ	Cost of operating in informal sec.	0.147, relative wage $w_1/w_2 = 1.235$
μ_s	Cost of opening job in sec. s	50% of monthly earnings in s
g	Firing cost in formal sec.	4 months of average earnings in formal sector
Government: taxes		
τ_l	Labor income tax in formal sec.	15%
τ_c	Consumption tax	15%

4 Numerical Results

4.1 Benchmark Model

Table 4 shows key statistics of the benchmark economy and outcomes of calibration. Marked with an asterisk are the variables used as target moments in the calibration of parameters as discussed in section 3. The unemployment rate is 3.7%, which matches the average value in Mexico from 2000 to 2010 based on the ENEU and ENOE data and the average duration of unemployment is about 3.5 months.

The wage rate in the formal sector is about 23% higher than in the informal sector, as we targeted in the joint calibration of labor market parameters. As shown in the middle part of the table, there is a high degree of mobility across sectors and between employment and unemployment. The mobility, however, is much higher among workers in the informal sector, who will exit the sector with probability 16.7% every quarter, as opposed to 11.4% in the formal sector. Out of the 16.7%, 13.3% move to the formal sector and 3.5% unemployment. From the formal sector, 9.5% move to the informal sector and 1.9% to unemployment. Probabilities of quit and layoff are both higher in the informal sector, but the difference is larger in the layoff probability due to firm-initiated job destruction, which stands at 2.3% in the informal sector, about twice as high as in the formal sector.

As explained in section 3.2, probabilities of receiving a job offer are not what we observe in the data and calibrated jointly with other parameters while using various realized flow rates as target moments. Unemployed individuals are much more likely to receive an offer from the informal sector, with probability 83% in each quarter period, than from the formal sector with probability 46%. Once on a job, formal workers face a higher probability of receiving an offer from the other sector than informal workers. Formal workers, however, are less likely to accept offers they receive and the intersectoral flow rate from formal to informal is 9.5% while it is 13.3% the other way.

Except when employed individuals are laid off by firms, all transitions of workers across sectors and between employment and unemployment are the result of individuals' optimal employment decisions. Formal jobs are associated with a higher wage and greater protection since employers must pay a severance payment to a worker that they lay off. At the same time, however, workers are subject to labor income tax on earnings only in the formal sector. Unemployed individuals who decide whether to accept a job in the formal sector versus informal sector also take into account the difference in expected duration of a job in each sector, as well as the likelihood of transitioning to another sector later when a new job offer arrives while working on the job. Although employment in the informal sector is subject to a higher probability of exogenous termination, they will receive an offer for a formal job about once in every four quarters, with probability 23.1% every period.

Table 4: Benchmark economy and labor market variables

Variables		
Unemployment rate*	3.71%	
% of jobs that are formal*	56.92%	
Avg. unemp. duration	3.56 months	
Avg. asset-earnings ratio (annual)*	1.22	
	Formal	Informal
Avg. earnings (annual)	1.0840	0.8880
Wage rate (annual)	0.3772	0.3056
Employment flows		
(1) remain in sector	88.59%	83.26%
(2) flow to the other sector*	9.52%	13.25%
(3) flow to unemp.*	1.89%	3.49%
− quit	0.67%	1.17%
− layoff*	1.22%	2.32%
Hazard rate: from unemp. to I or F	30.67%	54.17%
On-the-job offer prob. from the other sector	29.98%	23.09%
Job offer prob. when unemployed	45.68%	82.57%

* indicates a moment used as a calibration target.

We also emphasize that there is a significant overlap of both workers and firms across the formal and informal sectors. Our result that the two sectors are not entirely segmented is consistent with empirical evidence such as Maloney (2004), who demonstrates mobility of workers between formal and informal sectors and overlap of wages between the two in Latin American countries including Mexico. Meghir et al. (2015) use Brazilian data and show that there is no clear segmentation and that formal and informal firms overlap for a very large range of productivity, although a lower end of productivity distribution is occupied by informal firms.

Consistent with the data, workers in our model flow between formal and informal jobs as well as between employment and unemployment. Distribution of earned income of workers overlaps in the two sectors. Figure 1 plots the probability distributions of income earned by formal and informal workers and shows that they overlap over a wide range of support of earnings.

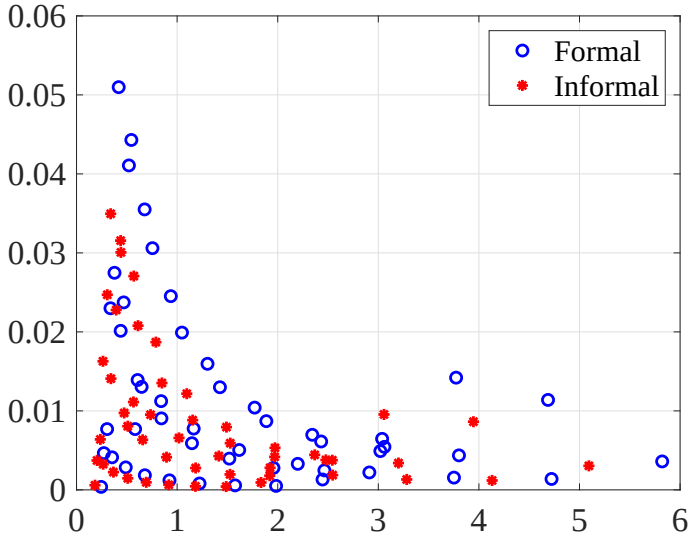

Figure 1: Distribution of Earnings

Note: This figure shows the probability distribution of earned income for formal and informal workers in the model. Earnings on the horizontal axis are normalized by the average earnings of all workers (average earnings=1.0).

Productivity of firms in our model also overlaps between the two sectors. The average productivity of firms operating in the formal sector is 0.115 with a standard deviation of 0.03, and the average productivity in the informal sector is 0.098 with a standard deviation of 0.026.[25] Firms overlap in a large range of productivities while there are more informal firms at the lower end of the distribution, consistent with empirical evidence.[26]

In terms of the saving of individuals, although we do not explicitly target heterogeneity in assets between the employed and unemployed, the model generates a large difference in wealth level between them. The average savings of the employed are 46,400 pesos and those of the unemployed are 25,500 pesos in our model. The asset holdings that we imputed from the ENIGH data following the method described in section 3.2 are 40,400 and 15,700 pesos, respectively. Our figure for the unemployed is higher than for the data, but the model performs decently well in accounting for the large difference in savings. Although the unemployed in our model own much less than the employed, they are highly attached to the labor force and quickly return to work, with an average duration of less than 4 months, but some in the data may be unemployed longer for reasons we do not have in our model.[27]

[25]The productivity level also includes the costs incurred by informal firms associated with hiding from the government.

[26]Note that the Diamond-Mortensen-Pissarides framework that is employed in this and other papers focuses on dynamics of matches between one worker and one firm. For recent studies that explore firms' decision in both extensive and intensive margins, see for example, Ulyssea (2018) and Haanwinckel and Soares (2016).

[27]For saving behavior of the unemployed in the context of the U.S. economy, see, for example, Gruber

4.2 Unemployment Insurance

In the benchmark economy, there is no unemployment insurance that helps alleviate shocks to incomes from exogenous job separations. In this section, we introduce unemployment insurance to the benchmark model. We assume that the government will provide benefits, which replace 50% of previous earnings $\varepsilon h w_F$ of formal workers over a given maximum duration.[28] These benefits are paid to unemployed individuals only when they are separated from a job exogenously due to job destruction initiated by firms. Workers are not entitled to benefits if they quit the job.

An economy with dual markets poses a challenge that is not present in single-sector models. The government is unable to identify market activities and wages earned in the informal sector. Therefore, we assume that, first, only those individuals who are laid off from a job in the formal sector are entitled to benefits, and second, individuals are able to "hide" and continue to receive benefits even after they accept a job in the informal sector as long as they have been unemployed for less than maximum duration of insurance and do not switch to a job in the formal sector. We consider the maximum benefit duration of 6 and 24 months as alternative scenarios. In the computation, we let the benefit expire with given probability each period so that the payment continues for 6 (or 24) months on average. We make the assumption that the unemployment insurance will lapse stochastically to economize on the computational time. As we discussed in section 4.4, we let the consumption tax adjust so that the government budget is balanced.

The introduction of unemployment insurance requires an additional state variable, which captures the amount of benefits that an unemployed or informal worker is entitled to. Note that the benefits are tied to earnings prior to job separation and do not necessarily reflect the wage that the unemployed individual would receive once finding and accepting a job offer. The value functions and individual problems in the economy with unemployment insurance are presented below. For conciseness, we do not show value functions of the employed in the formal and informal sector separately, but instead display it as $V_s(a, h, \varepsilon, b)$ and denote as $\pi_{\tilde{s}}^E$ the probability of receiving an offer from the sector in which the worker is not currently employed.

(2001).

[28] We chose to use a replacement rate of 50%, which is in the range of average gross replacement rates of public pensions in OECD countries. According to OECD Pension at a Glance (2019), the average gross replacement rate is 49.0%.

Employed Individuals:

$$\begin{aligned} V_s(a,h,\varepsilon,b) &= \max_{c,a'}\{u(c) - B_s + \beta_w(1-\rho)\left[q_s EU(a',h',b')\right. \qquad (17)\\ &\quad +(1-q_s)\pi^E_{\tilde{s}} E\max\{V_s(a',h',\varepsilon',b'), V_{\tilde{s}}(a',h',\tilde{\varepsilon}',b'), U(a',h',b')\}\\ &\quad \left.+(1-q_s)(1-\pi^E_{\tilde{s}})E\max\{V_s(a',h',\varepsilon',b'), U(a',h',b')\}\right]\\ &\quad +\beta_w\rho R(a')\} \qquad (18)\end{aligned}$$

subject to

$$\begin{aligned} a' &= (1-\tau_l)\varepsilon h w_s + (1+r)a + g + b - (1+\tau_c)c \qquad (19)\\ a' &\geq 0\end{aligned}$$

where τ_l is positive only if the worker is employed in the formal sector, and g is non-zero only if he is fired from a formal job.

Unemployed Individuals:

$$\begin{aligned} U(a,h,b) &= \max_{c,a'}\{u(c) + \beta_w(1-\rho)\left[\right. \qquad (20)\\ &\quad +\pi^U_F\pi^U_I E\max\{V_F(a',h',\varepsilon_F,0), V_I(a',h',\varepsilon_I,b'), U(a',h',b')\}\\ &\quad +\sum_{s\in\{F,I\}}\pi^U_s E\max\{V_s(a',h',\varepsilon_s,b'), U(a',h',b')\}\\ &\quad \left.+(1-\pi^U_F)(1-\pi^U_I)EU(a',h',b')\right]\\ &\quad +\beta_w\rho R(a')\} \qquad (21)\end{aligned}$$

subject to

$$\begin{aligned} a' &= (1+r)a + b - (1+\tau_c)c \qquad (22)\\ a' &\geq 0\end{aligned}$$

As shown in Table 5, unemployment insurance increases the average duration of unemployment and the number of unemployed individuals. The unemployment rate rises from 3.71% in the benchmark model to 3.84% when 6-month unemployment insurance is introduced, and to 4.12% as the maximum duration increases to 2 years. The second section of the table shows that the decline in the hazard rates is driven by a large drop in the flows from unemployment to formal employment. There is little change in the outflow into the informal sector since workers are able to keep these benefits while making earnings in the informal sector and there is no work disincentive associated with the insurance benefits.

Table 5: Unemployment insurance: financed by consumption taxes

UI duration	0m	6m	24m
Unemp. rate	3.71%	3.84%	4.12%
Formal share	56.93%	56.63%	54.73%
Avg. unemp. duration (months)	3.56	3.65	4.06
Hazard rates	84.84%	83.19%	78.42%
- U to F	30.67%	28.25%	22.83%
- no benefits	–	30.58%	30.96%
- with benefits	–	18.68%	3.70%
- U to I	54.17%	54.94%	55.59%
Job separation rates			
- F to U	1.89%	1.89%	1.76%
- I to U	3.49%	3.61%	3.80%
Intersectoral flow rates			
- F to I	9.52%	9.51%	9.52%
- I to F	13.25%	13.18%	12.31%
- no benefits	–	13.25%	13.27%
- with benefits	–	7.49%	1.74%
UI recipients (% of labor force)	–	1.26%	4.86%
- Unemployed (% of all UI)	–	59.87%	25.34%
- Informal workers (% of all UI)	–	40.13%	74.66%
Aggregate savings	–	+0.77%	+2.17%
Aggregate consumption	–	−0.13%	−1.99%
Consumption tax	15.00%	15.71%	18.78%
Welfare effect	–	−0.01%	−0.74%

We also highlight the finding that with unemployment insurance, the share of formal employment drops from 56.93% in the benchmark economy to 56.63% and 54.73% in the two scenarios. The drop in formality may be surprising given some of the debates that have taken place in countries such as Mexico, where the introduction of unemployment insurance is seen as a way to fight informality and provide incentives for workers to move into the formal sector (Anton et al., 2013). Our simulations suggest that the benefit of additional insurance with formal jobs is not large enough to raise the size of the formal sector and that the opposite change could happen. Given the relatively small chance of qualifying for benefits through layoffs, a positive effect on formality share is offset by the fact that benefits can still be collected while working informally, and many more workers choose to take a job in the informal sector until the expiration of benefits.

The incentive effects of unemployment insurance are clearly identified by studying the

flow rates from unemployment or informality to formality, conditional on being eligible to receive unemployment benefits. As shown in Table 5, when 6-month benefits are introduced, the flow rate from unemployment to formality falls from 30.67% in the benchmark to 28.25%, by just about 2.4 percentage points. However, this seemingly small decline hides the massive heterogeneity between those without benefits, who move to formality with probability 30.58% and those receiving benefits, whose likelihood of moving to formality is less than 19%. The large difference is also observed in the intersectoral flow rates from informality to formality between those with and without benefits.

The number of unemployment insurance recipients, as well as its decomposition by employment status, are reported in Table 5. A large number of recipients are in fact employed in the informal sector. Furthermore, when benefits are available for as long as two years, three quarters of recipients have a job in the informal sector.

Finally, as the anticipated duration of unemployment increases, individuals allocate more of their disposable income to savings than consumption. In addition, expenditures incurred by the government to finance the unemployment insurance program lead to a rise in consumption tax rate, from 15% in the benchmark economy to 15.71% and 18.78%, respectively. The increase in consumption tax also contributes to a decline in aggregate consumption. Given the drop in consumption, welfare deteriorates as the unemployment insurance is introduced and becomes more generous, as shown in the last row of Table 5.

Up until now, the results presented assumed that expenditures associated with unemployment insurance are financed by raising taxation on consumption. Table 6 presents the results of a simulation where unemployment insurance policies are financed by labor income taxes, leaving constant the consumption tax rate at the benchmark level of 15%. Qualitative results of unemployment insurance policy are similar to the ones presented above. In particular, when unemployment insurance is introduced and as the duration of benefits increases, we find that unemployment increases and formality drops, both of which are driven by a sharp decline in the hazard rates into formality, and welfare deteriorates. However, we find quantitatively that labor income taxes are more distortionary and have a greater impact on sectoral allocations and welfare than in the case of financing the benefits with consumption taxes. Furthermore, when the duration of benefits increases up to two years, the taxes necessary to finance the system start to explode and the formal sector shrinks, rendering the system unsustainable.

Table 6: Unemployment insurance: financed by labor income taxes

UI maximum duration	0m	6m	12m
Unemp. rate	3.71%	3.77%	3.92%
Formal share	56.93%	56.45%	54.94%
Avg. unemp. duration (months)	3.56	3.61	3.72
Hazard rates	84.84%	83.88%	82.21%
- U to F	30.67%	28.10%	24.80%
- U to I	54.17%	55.78%	57.41%
Job separation rates			
- F to U	1.89%	1.88%	1.82%
- I to U	3.49%	3.54%	3.69%
UI recipients (% of labor force)	–	1.26%	2.48%
- Unemployed (% of all UI)	–	59.61%	35.83%
- Informal workers (% of all UI)	–	40.39%	64.17%
Aggregate savings	–	−0.24%	−0.85%
Aggregate consumption	–	−0.31%	−1.27%
Labor income tax	15.00%	16.25%	17.90%
Welfare effect	–	−0.09%	−0.37%

4.3 Severance Payment

In the benchmark model, firms in the formal sector are required to make a severance payment equivalent to the four-months average earnings upon dismissal of a worker. More generous severance payments provide workers with protection against income fluctuations associated with exogenous layoffs initiated by employers. Workers receive such protection also through unemployment insurance, but the two policies differ in two key aspects. For the severance payment, benefits are paid by employers and in a one-time lump-sum fashion upon dismissal, but the unemployment insurance is provided by the government, financed through taxes. Benefits are paid conditionally on the worker remaining unemployed or working but not in the formal sector. Both policies provide benefits only for workers dismissed in the formal sector.

In order to understand the effects of the severance payment on individuals' behavior and the responses of firms to the additional costs of layoffs, we simulate the model with alternative levels of severance payments in two steps. First, we allow only individuals to respond and reoptimize. We shut down the effects through the interaction between individuals and firms by holding wage rates, w_s, and rates of job destruction initiated by firms, q_s, in each sector fixed at the benchmark levels. Table 7 shows the results of these simulations. The partial equilibrium analysis helps us identify the effects associated with

a different level of severance payment on workers' labor supply decisions. In the second step, we let firms respond to changes in the layoff cost and solve for full equilibrium, in which the wage rates and job destruction rates are determined in the market. These results are displayed in Table 8.

Table 7: Severance payments: partial equilibrium (with fixed wage and layoff rates)

Severance pay	0m	4m	12m
Unemp. rate	3.75%	3.71%	3.83%
Formal share	55.21%	56.93%	57.20%
Hazard rates	84.91%	84.84%	82.61%
- U to F	29.35%	30.67%	30.29%
- U to I	55.56%	54.17%	52.32%
Job separation rates			
- F to U	1.80%	1.89%	1.82%
- I to U	3.64%	3.49%	3.63%
Aggregate savings	−1.00%	–	+3.47%
Aggregate consumption	−1.84%	–	+2.31%
Consumption tax	15.63%	15.00%	14.77%
Welfare effect	−0.69%	–	+0.85%

Table 8: Severance payments: full equilibrium

Severance pay	0m	4m	12m
Unemp. rate	3.71%	3.71%	3.76%
Formal share	56.83%	56.93%	57.02%
Hazard rates	85.31%	84.84%	83.03%
- U to F	30.83%	30.67%	29.96%
- U to I	54.48%	54.17%	53.07%
Job separation rates			
- F to U	1.93%	1.89%	1.80%
- I to U	3.48%	3.49%	3.56%
Formal worker layoff rate (q_F)	1.27%	1.22%	1.13%
Formal wage w_F rel. to bnch	+1.63%	–	−2.97%
Aggregate savings	−0.03%	–	+1.77%
Aggregate consumption	−0.54%	–	+0.30%
Consumption tax	15.20%	15.00%	15.23%
Welfare effect	−0.21%	–	−0.12%

First, we will examine the partial equilibrium results reported in Table 7. As the

severance payment increases from 0 to 4 months of earnings as in the benchmark and to 12 months, risks associated with layoffs decline. This benefit, however, occurs only with jobs in the formal sector. Unemployed individuals find a job offer from the formal sector with the added insurance benefit more attractive relative to that of the informal sector. The flow rate from unemployment to employment in the informal sector falls from 55.6% with no severance payment to 52.3% when the severance payment is raised to 12 months of earnings. The flow rate from unemployment to formality shows little change, in a range between 29.4% and 30.7%. The decline in total hazard rates is partly due to a rise in wealth since laid off workers receive a larger severance transfer payment. In the benchmark model, as discussed in section 4.1, about two-thirds of the transitions from formal employment to unemployment are due to exogenous layoffs. When all of these laid off workers receive transfers from firms, the wealth effect reduces the incentive to accept job offers.

Welfare of individuals improves with the rise in severance payments, as shown in the last row of the table. Since the experiments in Table 7 ignore the cost of the additional transfers that firms bear with the increase in firing costs, it is not surprising that individuals are better off as the generosity increases.

Once we allow for full equilibrium, letting the market determine wages and firms terminate jobs, a large response from firms is observed as shown in Table 8. In this case, a higher severance payment affects behavior of labor market agents in several additional ways. First, higher protection for formal workers implies a lower lay-off rate, which drops from 1.22% in the benchmark economy to 1.13% when severance payments are equivalent to 12 months of wages. Second, a higher firing cost increases the cost of employing formal workers and the equilibrium wage rate falls by 3% as the severance payment rises from 4 to 12 months of earnings. Third, as already explained in the partial equilibrium analysis, the more generous severance payment produces an increase in the wealth of individuals (even after the drop in formal wages), which renders workers more selective about the jobs they take, reducing the hazard rate both into formality and informality, as the severance payment increases. Note, however, that the flow rate from unemployment to formality falls more sharply with the level of the severance payments in Table 8 than in Table 7, reflecting the impact of a decline in the wage rate.

In general, the overall effect of layoff costs on unemployment depends on the relative strength of the lower separation rate and the lower job finding rate. Ljungqvist (2002) and Kitao et al. (2017) show that a higher layoff cost tends to decrease unemployment in a model with a frictional labor market. Their results, however, are derived in a single labor market. In the case of our dual economy calibrated to the Mexican economy, we find that the drop in the layoff rate is not enough to compensate for the decline in the hazard rates into both sectors due to increased wealth, and the increase in the separation rate from the informal sector. The net effect is a small increase, not a decrease, in the

unemployment rate, from 3.71% in the benchmark economy to 3.76% when the severance payment is 12 months of earnings. The welfare effects are also very small, on the order of 0.12% in consumption equivalence with a severance payment of 12 months of earnings.

4.4 Tax Policy

In this section, we analyze the effects of shifting the tax burden between consumption and earnings, and quantify their impact on labor supply and sectoral allocations. In Mexico, consumption and labor income are the two major sources of the government's revenues beside oil (OECD, 2019). Direct taxation alleviates the problem of tax evasion and enforcement, a serious issue in an economy with a large informal sector. Anton et al. (2013), for example, suggest the use of consumption taxes, rather than labor income taxes, to cover expenditures for social insurance programs.

Table 9 summarizes the simulation results under alternative labor income tax rates. In each scenario, the consumption tax rate is adjusted so that the government budget remains balanced. More precisely, in the benchmark model, we had exogenously set the tax rates on labor income and consumption in the benchmark model at 15%, respectively. The amount of revenues raised by these taxes in the benchmark economy is kept fixed as exogenous government expenditures need to be financed under alternative tax policies. As tax revenues go up or down with a change in both the tax rate and tax base, some component of the government budget has to be adjusted to balance the budget. We let the consumption tax play the role of clearing the budget.

Table 9: Labor income and consumption taxes

Labor income tax	5.00%	15.00%	25.00%
Consumption tax	19.59%	15.00%	17.65%
Unemp. rate	3.26%	3.71%	4.32%
Formal share	78.52%	56.93%	30.87%
Hazard rates	84.49%	84.84%	84.27%
- U to F	37.54%	30.67%	20.24%
- U to I	46.95%	54.17%	64.03%
Intersectoral flow rates			
- F to I	4.24%	9.52%	16.69%
- I to F	17.75%	13.25%	7.51%
Aggregate savings	+9.68%	–	−7.29%
Aggregate consumption	+6.10%	–	−10.09%
Welfare effect	+1.05%	–	−3.05%

As shown in Table 9, unemployment rises as the labor income tax increases. This is

as expected given the effect of distortionary taxation on work incentives. The magnitude, however, of the change in unemployment is surprisingly small. The unemployment rate remains in a narrow range between 3.3% and 4.3% when the tax rate shifts from 5% to 25%.

Unlike in a single-sector model, changes in labor income taxes only affect net earnings in the formal one, since the government is unable to capture earnings in the informal sector and the labor income of informal workers is tax free. As a result, after-tax wages in the formal sector become increasingly less attractive relative to those in the informal sector as taxes rise. With high labor income taxation, the impact of the greater disincentive to work among formal employees is partially offset by a rise in the number of workers in the informal sector. This sectoral shift is apparent in the sharp decline in the share of formal employment from 79% to 31% when the labor income tax rate rises from 5% to 25%. As shown in Table 9, the intersectoral flow rate from formal to informal sector increases from about 4% to 17%.

When the labor income tax is below the benchmark level of 15%, tax revenues from labor income decline and the consumption tax has to increase. This occurs despite the rise in the share of formal workers. An increase in the labor tax induces a sharper drop in the share of formal sector employment and reduces the labor income tax base, and the consumption tax has to rise to cover the given government expenditures.

Higher levels of the labor income tax produce a drop in total earnings of the individual. As explained above, higher taxes increase unemployment, which in turn reduces the time to accumulate human capital, and makes workers face the risk of skill depreciation while out of work. In addition, the average efficiency units of informal workers decline sharply with a drop in the reservation wage, as informal jobs become relatively more attractive compared to formal ones that are subject to high labor income taxes. As a result, a higher labor tax reduces disposable income and drives down both average savings and consumption. The latter is also hit by a rise in consumption taxes. As shown in Table 9, aggregate consumption declines by about 10% when the labor income tax is raised from 15% to 25%.

To quantify the welfare effects of alternative tax policies, we compute the change in welfare as a percentage adjustment of consumption given to the individual at every state in the economy under an alternative policy so that a newborn individual will be just as well off as in the benchmark economy. The rise in labor taxes from 15% to 25% would lead to a significant welfare loss on the order of 3% in consumption equivalence, while individuals enjoy a welfare gain of 1% in consumption equivalence when the labor income tax is reduced to 5%.

In what follows, we simulate various labor market policies that affect labor participation and sectoral allocation of employment. To finance expenditures of such policies, alternative financing methods may be considered to balance the government budget. As

shown above, if a program is financed by labor income taxation, a relative change in after-tax earnings can cause a shift in the labor force between informal and formal sectors. A rise in the labor tax, for example, can reduce the tax base, requiring a further rise in the tax rate and exacerbate distortions in sectoral allocation. This is an unintended and undesirable consequence of a policy both economically and politically. For these reasons, we use consumption tax as the principal way to balance the government budget in the baseline simulations, although we also present some results under an alternative assumption that policy expenditures are financed by labor income taxes.

5 Conclusion

This paper builds a structural life-cycle model of equilibrium unemployment with a dual economy and simulates different labor market and fiscal policies. The model is calibrated to Mexico, where a majority of workers reside in the informal sector. Given that any government policy based on official work records in the formal sector fails to reach half of the workforce, policies are shown to bring about consequences that would not emerge in single-sector models.

Unemployment insurance is intended to help smooth consumption and possibly induce more workers to choose formality. The policy, however, is found to do the opposite. The unemployment rate rises with the generosity of benefits and the share of the formal sector declines. The unintended outcome is driven by the inability of the government to detect economic activities in the informal sector, giving unemployed individuals incentives to accept informal jobs and continue to receive benefits. Such effects are exacerbated if the benefits are financed by labor income taxes on formal workers rather than by consumption taxes. Severance payments do not create such a moral hazard problem in accepting formal job offers. However, the layoff costs imposed on firms in the formal sector lead to a lower wage, making jobs in the formal sector less attractive than those in the informal sector. This effect offsets the lower layoff probability in the formal sector and the net effect is a marginal increase in the unemployment rate and deterioration of welfare.

The decline in employment due to higher labor taxes is surprisingly small in our dual-sector economy. As the after-tax wage in the formal sector declines, workers move to informal jobs that remain free of taxes, leading to a decline in productivity and consumption at the aggregate level and a sizeable welfare loss of individuals.

Our experiments also suggest that policies that would remove distortions in the formal sector are most effective in encouraging workers to undertake a job in formality. Given the higher productivity and wages in the formal sector, such shifts increase output of the economy, raise net income of individuals, and enhance welfare. Consumption tax appears to be a better choice than labor taxes when additional revenues must be raised to cover expenditures.

Recently, economists as well as policy makers in countries with a large informal sector are debating comprehensive reform of the social insurance system, including social security and health insurance programs. An obvious challenge, as highlighted in our study, is how to identify workers in the informal sector and provide necessary social insurance to the population without generating unintended disincentives. Our framework as appropriately extended will serve as a basis for quantitative analysis of such policies and we leave these topics for our future research.

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