

# Unemployment Benefits and the Informal Sector

by

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(Under the Direction of)

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May 2, 2016

## **Abstract**

This paper extends the equilibrium search and match model of Albrecht et al. (2009), by including a government sector that collects and distributes tax revenues. Tax revenues are used to provide unemployment insurance (UI) benefits to workers laid off from formal sector jobs. I perform two labor market experiments, changing the severance and payroll taxes, to understand how UI benefits affect the flow of the labor market in an economy with a large informal sector. I find that benefits decrease labor market tightness, increase the size of the informal sector, and increase total unemployment.

Unemployment Benefits, Informal Sector, Latin America, Search and Matching, Labor Market, Policy

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A Thesis Submitted to the Graduate Faculty  
of The University of Georgia in Partial Fulfillment  
of the  
Requirements for the Degree

MASTER OF ARTS

ATHENS, GEORGIA

2016

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# UNEMPLOYMENT BENEFITS AND THE INFORMAL SECTOR

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# 1 Introduction

The informal sector is defined as an unregulated sector and in which the workers are therefore indirectly affected by labor market policies. The informal sector makes up a significant portion of the economy in many developing countries. Maloney (2004) estimated 30-70 percent of urban workers in Latin American countries are located in the informal sector. Schneider and Enste (2000) estimate informal workers represent 10-30 percent of the labor force in OECD countries, 20-40 percent of the labor force in former Soviet Union countries, and 60 percent of the labor force of developing countries in Asia and Africa.

Studying the effects of benefits in the informal sector is important for several reasons. First, workers are typically left out of or are only indirectly affected by the effects of labor market policy. Bosch and Pretel (2015) find that about 75 percent of workers in the world are without any type of unemployment insurance. This model views the informal sector as unregulated self-employment and workers do, in fact, select into the informal sector based on their productivity. However, it is important to distinguish that simply because workers select into the informal sector, does not imply they are well off. Rather, they are simply better off than they would be had they selected into the formal sector.

Finally, these workers are more susceptible to job loss while comprising a larger portion of the flows into unemployment. Bosch and Maloney (2008) measure the increases in unemployment in response to a one percent decrease in output. They split informal workers into salaried and self-employed. They find the separation rate for workers in the informal salaried group is 4.1 and 5.7 percent in Mexico and Brazil, respectively. These rates for the informal self-employed are 3.2 and 3.5 percent. For the formal sector, they are only

1.4 and 0.6 percent. Taking into account that the informal sector accounts for less than the amount of workers, this shows that informal workers are disproportionately affected by falls in output.

Some Latin American countries are looking to introduce or expand unemployment insurance benefits. However, there is limited research on the effects of introducing or expanding unemployment programs into developing economies with large informal sectors. There are already other programs that are aimed at protecting worker's formal sector jobs, such as the severance tax. These, along with benefits, increase the costs of dismissal of workers. It is helpful to analyze how these policies will interact in these economies with such large informal sectors.

There are two main mechanisms which could come into play with the introduction of these benefits. The first is a moral hazard issue in which workers choose to work in the informal sector or to be unemployed so as to take advantage of the system and to be able to collect benefits. (Hopenhayn and Nicolini 1999). This is similar to findings for advanced economies with unemployment benefits (Acemoglu and Shimer 1999). The second mechanism is an income effect that leads workers to spend less time in informal jobs and more time searching for formal employment.

I study quantitatively how the dispersion of workers into each sector changes in response to tax changes when unemployment benefits are included in the economy. I do so by constructing a search and match model. It is based off of Albrecht, Navarro, and Vroman, ANV hereafter, which is constructed in the form of a Mortensen and Pissarides, MP hereafter, search model. ANV's model extends MP to include an informal sector, so as to represent the economies of less-developed countries more accurately. I extend the model further to include a government sector that collects severance and payroll taxes from the firms and distributes them to unemployed and informally employed workers.

The workers in this model are heterogeneous in their productivity capabilities in the formal sector. Workers select into only the formal sector if their productivity is high enough

to qualify for the endogenous wage solved for in this model. If workers are of a medium productivity level, they will have the option to select into either sector. Workers with a low productivity capability will work in the informal sector only. I create thresholds between the sectors based upon worker's productivities to track how workers move and therefore be able to compare the percent of the labor force in each sector when policies change. The compositional changes give insight into how policies change the worker's incentives to select into either sector.

I perform two experiments that resemble typical labor market policies enacted by governments. The first changes the severance tax levied on firms. The second changes the payroll tax levied on firms. I analyze how the equilibrium labor-market tightness, productivity thresholds, reservation productivities, and total unemployment respond to these changes.

In summary, the direction of change for the equilibrium endogenous variables are similar to the ANV model where there are no benefits. However, the magnitudes are different. Compared to an economy with no unemployment benefits, this model finds labor market tightness is lower, thresholds are higher, reservation productivities are higher, and total unemployment is slightly higher.

## 2 Literature Review

### 2.1 Workhorse Model

The workhorse model in this literature is "Job Creation and Job Destruction in the Theory of Unemployment" by Dale T. Mortensen and Christopher Pissarides (1994). Their paper explains why job creation and job destruction flows coexist in the business cycle. MP build a model of endogenous creation and destruction and integrate it into a matching approach so as to solve for unemployment and vacancies. Their path of equilibrium is the number of matches created with their matching function and workers' rational behaviors.

MP's model takes place in an economy with a continuum of jobs that produce unique product varieties and sell for a unique market price. The price is a function of the idiosyncratic productivity shocks that each job faces. The basis of their model is understanding the value functions of firms and workers. Firms can either be in a state of creating a job vacancy and searching for a worker or be producing output from an employed worker. Workers can either be unemployed and searching for a firm, or employed and producing output for the firm. Wages are determined via a Nash bargaining strategy that splits the surplus from the creation of a job. They are renegotiated in response to productivity shocks.

From the value functions, they solve for a reservation productivity, a job-creation condition, and a Beveridge curve. From the intersection of the Beveridge curve and the job-creation curve, they can solve for equilibrium unemployment and vacancies. They analyze how unemployment and vacancies change when shocks to variables such as productivity occur.

## 2.2 Base Model

The model I extend is from "The Effects of Labour Market Policies in an Economy with an Informal Sector" by ANV. Their paper builds an equilibrium search and match model with an informal sector. They allow for a continuum of heterogeneity in workers formal-sector productivity to make the assumption of different sectors an interesting one. They calibrate their model to data for a compiled economy of the major Latin American countries and run two different simulations.

They provide several contributions to the literature. Their first contribution is the addition of and the approach they take in modeling the informal sector. Some literature views the informal sector as a disadvantaged sector in a segmented labor market framework. This view implies workers in the informal sector are there involuntarily and are queuing up for formal sector jobs. This paper, however, provides a second view of the informal sector. They model the informal sector as an unregulated micro-entrepreneurial sector. Informal workers select into this sector voluntarily based upon their productivity level in the formal sector.

The second major contribution is the assumption that workers' formal-sector productivities lie on a distribution. If all workers were identical, they would all select into one sector, making the inclusion of multiple sectors irrelevant. By including this extension, they are able to look at compositional effects of labor policies.

They perform a numerical analysis and demonstrate the empirical results of several different simulations. They use these simulations, changes in the payroll and severance taxes, to analyze the effects on labor market attributes such as output, composition, and wages. They find that an increase in the severance tax causes unemployment to fall, increases the average duration of a match, and decreases the number of workers who accept an offer. It also causes productivity to decrease and net output to fall. On the other hand, an increase in the payroll tax causes unemployment to rise, more people to shift into the

informal market, and decreases the duration of matches. It increases productivity, but net output falls.

## 2.3 Relevant Literature

Several other papers provide guidance on this topic and composition of this model. The most relevant papers to this model and my extension are Bosch and Pretel (2015), Bardey et al. (2014), and Satchi and Temple (2008).

Bosch and Pretel (2015), BP hereafter, look at the effects of implementing an unemployment benefits program in an economy with a large informal sector. They analyze policy changes implemented simultaneously with the benefits program, such as increases in firing costs, employment taxes, and government monitoring. The main mechanisms BP study are an increase in the size of the formal sector due to an increase in benefits and conversely a decrease in the formal sector due to the fact the workers can collect benefits while working in the informal sector.

BP's model is a search and match model in the form of MP. However, they allow for a third sector, the government, in addition to workers and firms, to model the collection and distribution of taxes in the form of unemployment benefits. There are two job types, formal and informal, that are decided based on the productivity of the match between a firm and worker. The formal sector faces paying the unemployment benefit as well as employment taxes, whereas the informal sector faces monitoring and penalty costs from the government. In addition to the taxes, workers must contribute to their unemployment accounts. Workers are allowed to directly transition (i.e., on-the-job search) between the sectors without having to go through a period of unemployment. In addition, informal workers are treated as salaried workers without benefits, meaning there is no ex-ante heterogeneity among workers and therefore, no self-employment.

The main contributions of BP's paper are, first, that they take into account the moral hazard issue of being able to collect unemployment benefits while in the informal sector and

second, that they analyze the interaction of the unemployment system with other policy changes.

The results depend upon the amount of benefits paid-in by and paid-out to workers. The amount of workers in the formal sector and in unemployment are positively related to the replacement rate, but have inverse relationships with the contribution rates. If the replacement rate is large, its affects will overshadow the effects of the contribution rates. When they introduce benefits in combination with lower firing costs, informality decreases. In combination with lower employment taxes, formality increases. A simultaneous increase in government monitoring increases unemployment and formality.

Bardey et al. (2014) look at the effect of unemployment insurance on the amount of effort workers exude in securing a formal job and the resulting amount of labor they supply in the informal sector. They analyze a moral hazard channel and an income effect channel. The first causes workers to flow out of the formal sector, where as the latter leads workers to spend less time in the informal sector and spend more time searching for jobs in the formal sector.

They build a continuous time model, in the manner of Fredriksson and Holmlund (2001), to look at the partial equilibrium effects. Because it is not a general equilibrium model, they are unable to analyze macroeconomic consequences, but they are able to derive analytical, not just computational, results.

Bardey et al. classify workers as either long-run and short-run unemployed based on their duration of collecting unemployment insurance. During unemployment, workers split their time between searching for a formal job, working in the informal sector, or enjoying leisure. Once steady-state equations are found, comparative statics are used to generate propositions.

The main propositions they derive are as follows. First, an increase in benefits has ambiguous effects on short and long run unemployed workers' allocation of time between the three activities. However, when an increase in benefits is temporary (similar to sever-

ance payments), the income effect dominates causing search efforts to increase and informal sector work to decrease. Second, an increase in unemployment benefits for short-run unemployed workers increases long-run unemployed workers' search efforts. Lastly, as the rate at which benefits expire increases, the search effort by unemployed workers increases in the short run but decreases in the long run.

Satchi and Temple (2007) analyze how productivity and labor markets interact in poorer countries. They are trying to use a match model to explain the size of the informal sector as well as analyze the equilibrium responses to experiments. They extend the basic MP model to include an endogenous opportunity in agriculture. Their model is simple enough to be solved analytically and includes rural-urban migration, endogenous capital stock in the formal sector, and variable search intensity.

Workers can be in the urban sector where they use labor and capital or in the rural sector where they use labor and land. Within the urban sector, there is a formal sector and an informal sector, which is equivalent to self-employment or unemployment. While in the informal sector, workers can look for formal sector jobs, but they will search with variable intensities. They can also migrate from the rural to the informal and subsequently to the formal sector. Firms face the typical profit maximization problem with rent for capital, severance payments, and corporate taxes included.

They conclude that the size of the informal market can be explained by matching frictions. They find two explanations that lead to large labor-market frictions. These are high recruitment costs or workers having a high bargaining power and therefore receive a large size of the match surplus relative to the firms. By shocking TFP in either sector, they are able to analyze equilibrium responses. An increase in TFP causes that sector to rise in size and output, but causes the other to contract.

### 3 Model

This model is based on the search model of MP and is an extension of the model in ANV. ANV extends MP by including an informal sector as well as having workers with heterogeneous levels of production in the formal sector. This paper extends ANV by including a government sector that utilizes the tax revenues collected. In congruence with MP and ANV, this model is done in continuous time. I use a standard matching function to model market frictions. A match is formed only if the surplus from the filled vacancy and employment is greater than the value the worker and firm would receive if they remained unmatched. As is typical, I use Nash bargaining to split the surplus between the workers and firm, using a set bargaining power,  $\beta$ , for workers.

This economy is comprised of three sectors: workers, firms, and the government. The workers supply labor to the firms, who in turn produce output. The government receives tax revenue from the firms and utilizes this revenue to supply unemployment benefits to workers that have involuntarily exited the formal sector. There are two sectors, formal and informal. Workers end up in either sector based on their level of productivity in relation to the distribution of workers.

Productivity shocks in the model arrive at an exogenous Poisson rate,  $\lambda$ , and are iid drawn from a continuous density,  $\frac{g(y')}{G(y)}$ . Shocks change a worker of type  $y$  from a productivity level of  $y$  to a new level  $y'$ , where  $y'$  is restricted to the range between 0 and  $y$ . After a shock, the new productivity level is compared to an endogenous reservation productivity,  $R(y)$ , which is dependent upon the worker's type. If the new level  $y'$  is higher than the reservation productivity, then the match continues and the worker and firm renegotiate

their wage from  $w(y)$  to  $w(y', y)$ . If the new productivity level is lower than the reservation productivity, the match will end and the worker returns to unemployment. Therefore, a match will end with probability  $\frac{G[R(y)]}{G(y)}$ , and will continue with probability  $1 - \frac{G[R(y)]}{G(y)}$ .

### 3.1 Workers

The workers in this model are risk neutral and infinitely lived. They can occupy four states in this model as opposed to two in MP. Workers are either unemployed, employed in the informal sector, newly employed in the formal sector, or insiders, after facing a productivity shock, in the formal sector. The residual state for workers is to be unemployed. Workers cannot directly transition between the formal and informal sector, but must pass through unemployment in between.

Workers are heterogeneous in their productivity level within the formal sector. This assumption is what makes including an informal sector relevant. Each worker's type is analogous to their productivity level in the formal sector, and these types are distributed on a unit measure according to a continuous density,  $f(y)$ , for the values  $0 \leq y \leq 1$ . There are two productivity thresholds within this distribution,  $y^*$  and  $y^{**}$ , that divide the workers into three categories. A worker can either be typed as a

- (i) High productivity worker with  $y^{**} < y \leq 1$ , and therefore they only choose to work in the formal sector,
- (ii) Medium productivity worker with  $y^* < y < y^{**}$ , and can choose to work in either the formal or informal sector,
- (iii) Low productivity worker with  $0 \leq y < y^*$ , and only work in the informal sector.

The high-productivity workers only choose to work in the formal sector because of the assumption restricting workers from directly transitioning between the informal and formal sectors. The opportunity cost of giving up the chance to find a formal job while working in the informal sector is too high.

A worker of type  $y$  receives value  $U(y)$  in unemployment,  $N_0(y)$  in the informal sector, and  $N_1(y)$  when they enter into the formal sector. A formal sector worker of type  $y$  that has experienced a productivity shock and is now producing at  $y'$  has a value of  $N_1(y', y)$ . The workers gain leisure,  $b$ , and with probability  $\rho$  they will collect unemployment benefits, represented by  $z$ . At an exogenous Poisson rate,  $\alpha$ , the worker receives an opportunity to work in the informal sector. Workers' value of production is  $y_0$  in the informal sector. The informal match ends at the exogenous rate,  $\delta$ . Opportunities to work in the formal sector arrive at the endogenous rate of  $m(\theta)$ . Here,  $m(\theta)$  is the standard matching function. Workers discount the future at rate  $r$ .

The flow value of unemployment is

$$rU(y) = b + \rho z + \alpha \max[N_0(y) - U(y), 0] + m(\theta) \max[N_1(y) - U(y), 0]$$

The flow value function for a worker in the informal sector is

$$rN_0(y) = \rho z + y_0 + \delta[U(y) - N_0(y)]$$

The flow value function for a worker entering into the formal sector is

$$rN_1(y) = w(y) + \lambda \frac{G(R(y))}{G(y)} [U(y) - N_1(y)] + \lambda \int_{R(y)}^y [N_1(x, y) - N_1(y)] \frac{g(x)}{G(y)} dx$$

Finally, the flow value function for a worker already in the formal sector after facing a shock to productivity is

$$rN_1(y', y) = w(y', y) + \lambda \frac{G(R(y))}{G(y)} [U(y) - N_1(y', y)] + \lambda \int_{R(y)}^y [N_1(x, y) - N_1(y', y)] \frac{g(x)}{G(y)} dx$$

## 3.2 Firms

The firms problem stays the same as in ANV. Firms can either have a vacancy and be searching for a worker or have a created job that is filled by a worker producing output. The value of a vacancy for firm is given as  $V(y)$ . The value of a new job is given as  $J(y)$ . The value of job creation for the firm after a productivity shock is given as  $V(y'y)$ . Firms face costs of maintaining a vacancy,  $c$ , such as recruitment costs and more. Firms are also subject to a payroll tax,  $\tau$ , and a severance tax,  $s$ . New job creation pays wage of  $w(y)$ , while a firm that renegotiates a wage pays  $w(y', y)$ .

The flow value function of a vacancy is

$$rV = -c + \frac{m(\theta)}{\theta} Emax[J(y) - V, 0] \quad (1)$$

The flow value function for job creation for a new hire is

$$rJ(y) = y - w(y)(1 + \tau) + \lambda \frac{G(R(y))}{G(y)} (V - J(y) - s) + \lambda \int_{R(y)}^y [J(x, y) - J(y)] \frac{g(x)}{G(y)} dx$$

The flow value function for job creation for a worker after facing a productivity shock is

$$rJ(y', y) = y' - w(y', y)(1 + \tau) + \lambda \frac{G(R(y))}{G(y)} (V - J(y', y) - s) + \lambda \int_{R(y)}^y [J(x, y) - J(y', y)] \frac{g(x)}{G(y)} dx$$

## 3.3 Government

In ANV, the tax revenues collected are thrown into the ocean. I modify this assumption by including a government sector that collects taxes from firms and redistributes the revenues to workers in the form of unemployment benefits. Workers, therefore, are not funding their own benefits. Unemployment benefits can be collected by workers that have become unemployed after working for a specified period of time in the formal sector only. However, workers can continue to collect these benefits if they begin working in the informal sector.

Benefits expire when the worker re-enters the formal sector. These eligibility requirements are captured in the probability that unemployment benefits are received,  $\rho$ .

The government collects revenues from taxes imposed upon the firms. In this model, the taxes included are a payroll tax,  $\tau$ , and a severance tax,  $s$ . The revenues collected through these taxes are distributed to the workers through an unemployment benefit. Therefore, the amount collected must equal the amount paid-out, which implies the following budget constraint for the government. The firm's flow equation gives the amount of taxes collected, while  $z$  is the amount of benefits paid out.

The amount of taxes collected from a job-match is

$$z = \tau w(y) + \lambda \frac{R(y)}{y} s$$

I substitute the wage equation for a worker into the above equation to find

$$z = \tau \frac{\beta(y - \lambda s) + (1 - \beta)(1 + \tau)rU(y)}{1 + \tau} + \lambda \frac{R(y)}{y} s \quad (2)$$

### 3.4 Wages and Reservation Productivity

As is standard, the surplus from a match between a worker and a firm is split through Nash Bargaining. The worker has bargaining power,  $\beta$ , and therefore the firm has bargaining power of  $1 - \beta$ . The initial wage is determined by solving the following problem.

$$\max [N_1(y) - U(y)]^\beta [J(y) - V(y)]^{(1-\beta)}$$

Subject to total surplus, which is equal to

$$S(y) = N_1(y) - U(y) + J(y) - V(y)$$

As is typical, free-entry by firms into the market implies job creation will continue until all rents have been exhausted. This leads to the typical free-entry condition that  $V = 0$ .

For workers just entering the formal sector, the wage equation is found to be

$$w(y) = \frac{\beta(y - \lambda s) + (1 - \beta)(1 + \tau)rU(y)}{1 + \tau} \quad (3)$$

Unemployment benefits have a positive effect on  $rU(y)$ , and therefore affect wages through the value of unemployment. Wages are higher in an economy with unemployment benefits than in an economy without unemployment benefits. After a productivity shock changing a worker  $y$  to  $y'$ , the firm and worker will renegotiate the wage from  $w(y)$  to  $w(y', y)$ .

For a renegotiated wage, the problem becomes

$$\max[N_1(y', y) - U(y)]^\beta [J(y', y) - V(y) - (-s)]^{(1-\beta)}$$

Thus for workers that are insiders to the formal sector, the wage equation is found to be

$$w(y', y) = \frac{\beta(y' + rs) + (1 - \beta)(1 + \tau)rU(y)}{1 + \tau} \quad (4)$$

The insider's wage is seen to be higher than a worker entering the formal sector. This difference occurs because of the added cost to a firm to pay a severance tax if a worker is fired. A higher severance tax makes keeping a worker more valuable and therefore a firm will pay more in wages. As in the new formal worker's wage, unemployment benefits have a positive relationship to wages. Therefore, the wages for insiders will also be higher when there are benefits available to workers. The inclusion of benefits increases the value of unemployment and working in the informal sector. This drives up the opportunity cost of working in the formal sector. Thus, workers would have a stronger bargaining position and would demand a higher wage.

As in MP, a job is destroyed when a productivity shock makes the surplus equal to zero. This is represented as

$$N_1[R(y)y] - U(y) + J[R(y), y] = -s$$

Applying the surplus sharing rule and substituting, I get

$$R(y) = \frac{(r + \lambda)G(y)[(1 + \tau)rU(y) - rs] - \lambda[\int_{R(y)}^y [1 - G(x)]dx - [1 - G(y)]y]}{rG(y) + \lambda} \quad (5)$$

This equation makes clear the effect the different types of taxes will have on the reservation productivity. An increase in the severance tax will shift the reservation productivity down, whereas an increase in the payroll tax will shift this value up.

### 3.5 Unemployment Values and Thresholds

In order to solve for  $y^*$  and  $y^{**}$ , I need to solve for  $rU(y^*)$  and  $rU(y^{**})$ . To start I use the general form of the flow value of unemployment evaluated at  $y^*$ .

$$rU(y^*) = b + \rho z + \alpha[N_0(y^*) - U(y^*)] + m(\theta)[N_1(y^*) - U(y^*)]$$

Now, as I have defined our workers, the workers below  $y^*$  are working in the informal sector only, and the workers directly above  $y^*$  (but still below  $y^{**}$ ) can choose to work in either the informal or formal sector. Based on this assumption, workers at  $y^*$  must be indifferent between working in the formal sector and unemployment. By this logic,  $N_1(y^*) = U(y^*)$ . Therefore, the last term in this equation is zero. I am left with

$$rU(y^*) = b + \rho z + \alpha[N_0(y^*) - U(y^*)]$$

Using substitution for  $N_0(y^*)$ ,

$$rU(y^*) = \frac{(r + \delta)(\rho z + b) + \alpha(\rho b + y_0)}{r + \delta + \alpha}$$

By setting  $U(y) = N_1(y)$ , and solving for  $y^*$ ,

$$y^* = (1 + \tau) \frac{(r + \delta)(\rho z + b) + \alpha(\rho z + y_0)}{r + \delta + \alpha} + \frac{\lambda}{G(y^*)} s - \frac{\lambda}{(r + \lambda)G(y^*)} \int_{R(y^*)}^{y^*} [1 - G(x)] dx \quad (6)$$

Next, I use similar logic to solve for  $y^{**}$

$$rU(y^{**}) = b + \rho z + \alpha[N_0(y^{**}) - U(y^{**})] + m(\theta)[N_1(y^{**}) - U(y^{**})]$$

Again, by how I have defined our worker levels, workers above  $y^{**}$  work in the formal sector only, and those below  $y^{**}$  (above  $y^*$ ) can work in either the informal or formal sector. Workers at  $y^{**}$  must be indifferent between working in the informal sector and unemployment. Therefore,  $N_0(y^{**}) = U(y^{**})$  and the middle term will drop out of the unemployment equation.

$$rU(y^{**}) = b + \rho z + m(\theta)[N_1(y^{**}) - U(y^{**})]$$

Also, by this assumption and substituting into the flow equation for the informal sector employment, I find that  $rU(y^{**}) = \rho z + y_0$ . Solving, I find,

$$N_1(y^{**}) = \frac{y_0(r + m(\theta)) - r(b + \rho z)}{rm(\theta)} \quad (7)$$

Solving for  $y^{**}$

$$y^{**} = \frac{(1 + \tau)[rG(y^{**}) + \lambda]}{\beta m(\theta)G(y)} (y_0 - b - \rho z) + (1 + \tau)y_0 + \frac{\lambda}{G(y^{**})} s - \frac{\lambda}{(r + \lambda)G(y^{**})} \int_{R(y^{**})}^{y^{**}} [1 - G(x)] dx \quad (8)$$

### 3.6 Steady-State Conditions

The Beveridge curve, or the steady-state condition for unemployment, is the final part of the model left to derive. I start by normalizing an individual's time to 1. They can split their time between unemployment,  $u(y)$ , working in the informal sector,  $n_0(y)$ , and working in the formal sector,  $n_1(y)$ . Therefore,

$$u(y) + n_0(y) + n_1(y) = 1$$

On each part of the Beveridge curve, the flows into unemployment must equal the flows out of unemployment. Thus, for each productivity category of worker, whether  $0 \leq y < y^*$ ,  $y^* < y < y^{**}$ , or  $y^{**} < y \leq 1$ , there are different steady-state conditions. From these steady-state conditions, I derive the unemployment rates for each group and then for the aggregate.

Workers in the low-productivity group,  $0 \leq y < y^*$ , spend time in unemployment or in the informal sector. This means that  $n_1(y) = 0$ , and thus I can write  $u(y) = 1 - n_0(y)$ . Their steady-state condition is the flows into unemployment from the informal sector must equal flows into the formal sector from unemployment. This is given as

$$\alpha u(y) = \delta n_0(y)$$

Substituting for  $n_0(y)$ ,

$$\alpha u(y) = \delta [1 - u(y)]$$

Solving for the unemployment rate,  $u(y)$ , time spent in the informal sector,  $n_0(y)$ , and the formal sector,  $n_1(y)$

$$u(y) = \frac{\delta}{\delta + \alpha}$$

$$n_0(y) = \frac{\alpha}{\delta + \alpha}$$

$$n_1(y) = 0$$

Next, workers in the middle-productivity group, such that  $y^* < y < y^{**}$ , can spend time in all three sectors. Therefore, they have two steady-state conditions. The first steady-state condition is flows into the informal sector from unemployment must equal flows into unemployment from the informal sector. The second steady-state condition is flows into unemployment from the formal sector must equal flows into the formal sector from unemployment.

$$\alpha u(y) = \delta n_0(y)$$

$$m(\theta)u(y) = \lambda \frac{G[R(y)]}{G(y)} [1 - u(y) - n_0(y)]$$

Solving for the fraction of time the workers spend in each sector gives

$$u(y) = \frac{\delta \lambda G[R(y)]}{\lambda(\delta + \alpha)G[R(y)] + \delta m(\theta)G(y)}$$

$$n_0(y) = \frac{\alpha \lambda G[R(y)]}{\lambda(\delta + \alpha)G[R(y)] + \delta m(\theta)G(y)}$$

$$n_1(y) = \frac{\delta m(\theta)G(y)}{\lambda(\delta + \alpha)G[R(y)] + \delta m(\theta)G(y)}$$

Lastly, workers in the high-productivity group,  $y^{**} < y \leq 1$ , spend their time in either the formal sector or unemployment. Thus for this group,  $n_0(y) = 0$ , and  $n_1(y) = 1 - u(y)$ . Their only steady-state condition is the flows into unemployment from the formal sector must equal the flows into the formal sector from unemployment.

$$m(\theta)u(y) = n_1(y)\lambda \frac{G[R(y)]}{G(y)}$$

Subbing in for  $n_1(y)$ ,

$$m(\theta)u(y) = [1 - u(y)]\lambda \frac{G[R(y)]}{G(y)}$$

Finally, solving for the fraction of time the high-productivity workers spend in each sector

$$u(y) = \frac{\lambda G[R(y)]}{\lambda G[R(y)] + m(\theta)G(y)}$$

$$n_0(y) = 0$$

$$n_1(y) = \frac{m(\theta)G(y)}{\lambda G[R(y)] + m(\theta)G(y)}$$

After solving for the time each worker type spends in unemployment, I find total unemployment by aggregating across the economy,

$$u = \int_0^{y^*} u(y)f(y)dy + \int_{y^*}^{y^{**}} u(y)f(y)dy + \int_{y^{**}}^1 u(y)f(y)dy$$

### 3.7 Equilibrium

A steady-state equilibrium in this model includes the labor market tightness,  $\theta$ , the reservation productivity,  $R(y)$ , the thresholds,  $y^*$  and  $y^{**}$ , the unemployment rates,  $u(y)$ , and new, in my paper, are the unemployment benefits,  $z$ , so that

- (i.) the steady state conditions hold
- (ii.) the flow value of a vacancy for firms is zero, meaning all rents are exhausted
- (iii.) matches only end when the worker and firm find it mutually beneficial

The second condition of equilibrium implies that  $V = 0$ . This closes the model to get the free-entry condition

$$c = \frac{m(\theta)}{\theta} \int_{y^*}^1 (1 - \beta) \left[ \frac{y - R(y)}{r + \lambda} - s \right] \frac{u(y)}{u} f(y) dy \quad (9)$$

Using this equation, I can solve for the labor market-tightness,  $\theta$ , after I have solved all the other endogenous variables.

## 4 Experiments

This section is comprised of a discussion of the experiments I run, an interpretation of the results, and a comparison to findings in other literature. My experiments include changing the severance and payroll taxes. I analyze how these changes affect the composition of the workforce between the formal and informal sector by looking at how the unemployment rate, the threshold values and the other variables respond.

### 4.1 Calibration

I follow the values ANV utilize in their calibration. They pull numbers for a composite economy of Latin America, including Argentina, Brazil, Colombia, and Mexico. Outside of their model, I calibrate for  $\rho$ , or the probability an individual receives unemployment benefits. According to a report by the International Labour Organization, approximately seven percent of workers in Brazil qualify to receive unemployment benefits. Therefore, I use this number as my parameter in my experiments.

For the distributions of workers and productivity shocks, a standard uniform distribution was chosen. This was for computational convenience and it allows for a unique solution. The discount rate,  $r$ , is set to be 0.04. For unemployment parameters, the value of leisure is set,  $b = 0$ . For the informal sector, the parameters are set,  $y_0 = 0.2$ ,  $\alpha = 5$ , and  $\delta = 0.5$ . The formal sector parameters are set,  $c = 0.2$ ,  $\beta = 0.5$ , and  $\lambda = 0.5$ . Lastly, a Cobb-Douglas matching function is chosen so that  $m(\theta) = 4\theta^{1/2}$ .

In order to check my calibration, I compare my unemployment values as well as the size of my informal sector to other literature and research. First, I find unemployment

rates between 6.6 and 8 percent. This is well within the typical range for these Latin American economies as well as values used in other papers. Bosch and Maloney find that the unemployment rate for Mexico ranges from 2-7 percent, and for Brazil its 3-8 percent. The averages are about 5 and 6 percent, respectively. Mondragon and Pena (2008) estimate 13 percent for urban unemployment in Colombia.

Second, I find the informal sector to comprise between 30 and 50 percent of the labor force. Again, this is congruent with other research and findings. The ILO calculates the informal economy comprises 30-40 percent of these economies. Bosch-Pretel cite between 30-70 percent of workers in developing economies are in the informal sector. Pratap and Quintin (2004) estimate that 30 percent of workers in Buenos Aires are located in the informal sector. Thus, my calibration seems to fit an economy that resembles a developing economy.

## 4.2 Analysis

For the baseline case, I begin with the values of the payroll tax rate set to 0.5 and the severance tax rate equal to 0.3. The first experiment I look at is varying the severance tax. The results of this are located in Table 1. These results mean that when the severance tax is 0.3 and payroll tax is 0.5, 33.1 percent of workers are in the informal sector only and 59 percent are in the formal sector only.

I discover that as the severance tax increases, labor market tightness, the reservation productivities and overall unemployment decrease, whereas the threshold values increase. A higher severance tax makes it more costly to fire and hire. Therefore less vacancies will be opened by firms. When firms open less vacancies,  $\theta$  falls.

The threshold values,  $y^*$  and  $y^{**}$ , increase as the severance tax increases. When the severance tax increases to 0.5, with the payroll tax still at 0.5, 46.9 percent of workers are in the informal sector and 45.6 percent are in the formal sector. After comparing to the baseline case, the results show workers flow from the formal sector to the informal sector. As

only firms in the formal sector must pay these taxes on their workers it is relatively cheaper for firms to hire informal workers. Thus more jobs appear in the informal sector. Because it is relatively more expensive to hire formal sector workers, the threshold of productivity a worker must obtain increases.

The severance tax and reservation productivities display a negative relationship. As the severance tax increases, the reservation productivities decrease. A severance tax makes firing a worker more expensive, leading firms to keep on workers that are less productive. Finally, unemployment decreases from 7.5 percent to 7.2 percent as the severance tax increases. As the decrease in the reservation productivity causes jobs to end less frequently, unemployment falls.

The results of changing the payroll tax are in Table 2. The value of  $\theta$  ranges from 1.38 to 0.91. Just as the severance tax makes workers more expensive, the payroll tax makes hiring more expensive. So, again, less jobs are opened and labor market tightness decreases.

The threshold values,  $y^*$  and  $y^{**}$  increase as payroll taxes rise. This relationship can be explained the same way as the relationship between the severance tax and the threshold values was explained.

The taxes affect the reservation productivities differently. As the payroll tax increases, the reservation productivity increases as well. Due to the fact the payroll tax is calculated based on wages, if it increases, the current workers become more expensive to keep on payroll. Therefore, firms will desire workers to be more productive to be worth the additional costs.

The two taxes also have opposite effects on unemployment. Total unemployment increases as the payroll tax increases. This is due to the fact that it becomes expensive to employ workers. The reservation productivity has also increased so people are more likely to get fired after facing adverse shocks.

In comparison to ANV, labor tightness is lower, while the thresholds, reservation productivities, and unemployment are higher in my model. As the benefits are available to

unemployed workers, the value of unemployment is higher. Workers spend more time in unemployment and unemployment is higher. Therefore, the labor market tightness is lower in my model.

The threshold values in my results are higher. The inclusion of unemployment benefits increases the threshold values of productivity in which workers are valuable enough to select into in the formal sector. This result is congruent with the moral hazard mechanism as the unemployment benefits are paid out informal sector and unemployment. As the severance tax increases, the amount of tax revenue by the government increases and thus the benefits paid out increase. This is shown by the government budget equation, as  $s$  has a strictly positive relationship on  $z$ . Therefore, because more benefits are available and they can be collected in the informal sector, at the same time as their informal productivity value, we see moral hazard of people switching to the informal sector.

These reservation productivities are higher than ANV's model without benefits. This result is driven again by moral hazard by workers. They will incur the opportunity cost of collecting benefits if they were to choose to work in the informal sector. As the value of working in the informal sector has increased, workers must produce at a higher value after a shock in order to stay in the formal sector.

These unemployment values are higher than in ANV because the value of unemployment has increased, leading more people to stay unemployed. Workers are willing to wait longer in a state of unemployment and hold out for a better job.

However, these are not completely congruent with some of the literature. BP find that formality increases when the benefit amounts increase. They too find, though that unemployment increases when the benefits increase.

## 5 Conclusion

In my paper, I extend a search and match model that was utilized by ANV and is based on the MP original model. I have added into the model the possibility for workers that have been fired from the formal sector to collect unemployment benefits. These unemployment benefits are financed from payroll and severance taxes raised on firms in the economy. The taxes are collected and distributed through the newly-added government sector.

I examine how labor market characteristics such as the composition, unemployment and tightness change in response to changes in the severance and payroll taxes when these benefits are available. In changing either tax, I found that the labor market tightness is lower, whereas the thresholds, reservation productivities, and total unemployment are higher than in a model without unemployment benefits. This interprets to more workers choosing to stay unemployed, and workers flowing into the informal sector when there are unemployment benefits available.

These findings are congruent with the proposed mechanisms of moral hazard: workers do not have as much incentive to be employed at all because they can take advantage of collecting benefits in unemployment. Also, more workers would select into the informal sector, because they could still collect benefits in the informal sector while collecting their value of productivity. It appears that these forces outweigh the possible income effect that causes workers to spend less time in the informal sector and to become formal to be eligible to collect benefits.

## 6 Further Research

Working through this project, there are several assumptions that I would like to relax going forward. First off, I would like to allow for workers in the informal sector to differ in their productivity capabilities. Along with this, I would like to make the rate at which workers find informal sector jobs endogenous and subject to the matching function as they are for the formal sector. Second, I would like to relax the assumption that workers cannot flow directly between the formal and informal sector.

# Figures

Table 6.1: Effects of Varying  $s$

| $s$ | $\tau$ | $\theta$ | $y^*$ | $y^{**}$ | $R(y^*)$ | $R(y^{**})$ | $u$   |
|-----|--------|----------|-------|----------|----------|-------------|-------|
| 0.1 | 0.5    | 1.51     | 0.331 | 0.410    | 0.277    | 0.297       | 0.075 |
| 0.3 | 0.5    | 1.15     | 0.410 | 0.490    | 0.248    | 0.259       | 0.074 |
| 0.5 | 0.5    | 0.89     | 0.469 | 0.544    | 0.199    | 0.199       | 0.072 |

Table 6.2: Effects of Varying  $\tau$

| $s$ | $\tau$ | $\theta$ | $y^*$ | $y^{**}$ | $R(y^*)$ | $R(y^{**})$ | $u$   |
|-----|--------|----------|-------|----------|----------|-------------|-------|
| 0.3 | 0      | 1.38     | 0.294 | 0.341    | 0.132    | 0.134       | 0.066 |
| 0.3 | 0.5    | 1.15     | 0.410 | 0.490    | 0.248    | 0.259       | 0.074 |
| 0.3 | 1      | 0.91     | 0.530 | 0.635    | 0.368    | 0.389       | 0.080 |

## Works Cited

- Acemoglu, D., Shimer, R. 1999. Efficient Unemployment Insurance. *Journal of Political Economy*. Vol 107(5), 893-928.
- Albrecht, J.W., Navarro, L., Vroman, S.B., 2009. The effects of labor market policies in an economy with an informal sector. *Economic Journal*, Royal Economic Society 119 (539), 1105-1129.
- Bardey, D., Jaramillo, F., Pena, X. 2014. Unemployment Insurance in the Presence of an Informal Sector.
- Bosch, M. 2007. Job Creation and Job Destruction in the Presence of Informal Markets. CEP discussion Paper No. 0761.
- Bosch, M. and Esteban-Pretel, J. 2015. The labor market effects of introducing unemployment benefits in an economy with high informality. *European Economic Review* 75, pp.1-17.
- Bosch, M., Maloney, W.F. 2008. Cyclical Movements in Unemployment and Informality in Developing Countries. IZA Discussion Paper, No. 3514.
- Gong, X. and van Soest, A. 2002. Wage differentials and mobility in the urban labor market: a panel data analysis of Mexico. *Labour Economics*, vol 9(4) September., pp 513-29.
- Gong, X., van Soest, A. and Villagomez, E. (2004). Mobility in the urban labour market: a panel data analysts for Mexico. *Economic Development and Cultural Change*, vol 53(1) October. pp 1-36.
- Mortensen, D. and Pissarides, C. 1994. Job creation and job destruction in the theory of unemployment., *Review of Economic Studies*, vol. 61(3) (July), pp. 397-415
- Pratap, S., Rogerson, R. and Wright, R. 2006. Are labor markets segmented in developing countries? A semiparametric approach. *European Economic Review*. vol 50(7). October pp 1817-1841.

Satchi, M., Temple, J. 2008. Labor markets and productivity in developing countries.  
Review of Economic Dynamics.

Shimer, R. 2005. The Cyclical Behavior of Equilibrium Unemployment and Vacancies.  
The American Economic Review, vol 95(1), pp. 25-49.