



The formal sector wage premium and firm size

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ABSTRACT

We show theoretically that when larger firms pay higher wages and are more likely to be caught defaulting on labor taxes, then large-high wage firms will be in the formal and small-low wage firms will be in the informal sector. The formal sector wage premium is thus just a firm size wage differential. Using data from Ecuador we illustrate that firm size is indeed the key variable determining whether a formal sector premium exists.

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1. Introduction

One of the main differences between labor markets in developing compared to developed economies is the existence of large informal sectors. For example, in Latin America the informal sector is estimated to absorb over half of the urban labor force.¹ Importantly in this regard, it is generally assumed and empirically substantiated by much of the literature that workers in the informal sector are paid less than their formal sector counterparts.² However, theoretically it is not clear why this should be the case. While a tax wedge would explain differences in gross wages, if workers can move between sectors then net wages should surely be equalized. Earlier papers in the literature, such as Lewis (1954) or Harris and Todaro (1970), attempted to explain this phenomena by assuming a dual labor market structure where workers earned rents in the primary sector and secondary sector workers queued for good jobs. There are of course many other models that could also be used to justify why workers in particular sectors would earn wage premiums—as, for example, variants of the efficiency wage model or union models—but applying these to explain a wage premium for formal sector employees would still mean arbitrarily assuming that formal sector workers earn rents because of some exogenously imposed feature that for some reason is more relevant to the formal rather than the informal sector.

In this paper we start off by demonstrating that in essentially any labor market model where in equilibrium larger firms pay higher wages, if larger firms are more likely to be caught defaulting on labor taxes, then large-high wage firms will be in the formal and small-low wage firms will be in the informal sector. The formal sector premium is thus just a firm size premium. In order to solve for the wage distribution explicitly in the case where the firm size wage premium emerges endogenously, we then incorporate taxes on labor income and an enforcement technology into the equilibrium search model of Burdett and Mortensen (1998). More specifically, firms post wages and workers may work in the formal sector or may opt for a tax free outside option, which could be viewed as informal sector employment, as discussed by Albrecht et al. (2005). We find that in this set-up formal sector employees do indeed earn rents relative to their informal counterparts in the model. However, this is not because they are formal sector employees, but because in our model large firms will pay higher wages and have the incentive to stay in the formal sector. In this regard, it arguably makes intuitive sense that small firms would be the most difficult for the government to find and the most likely to stay in the informal sector. Indeed, a number of theoretical models [Fortin et al. (1997) and Rauch (1991), for example] impose this assumption. Moreover, many empirical studies seem to confirm that informal sector workers are concentrated in small firms.³ As a matter of fact, small enterprise size is part of the ILO definition of the informal sector and has been used in a number of papers as a proxy for such.

A search model where it is difficult for workers and firms to find each other seems like a natural way to model the labor market with an informal sector in developing countries, where it is often argued that

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¹ See ILO (2002).

² See, for example, Mazumdar (1981), Heckman and Hotz (1986), Pradhan and van Soest (1995), Tansel (1999), and Gong and van Soest (2002).

³ See, for instance, Tybout (2000).

there are no clear channels for the exchange of labor market information and search costs are high.⁴ As a matter of fact, there have been other papers in the literature that use a search-matching framework to model the informal labor market. For instance, [Albrecht et al. \(2005\)](#) extend the [Mortensen and Pissarides \(1994\)](#) matching model to incorporate a self-employed informal sector where there is heterogeneity in workers' productivity in that more productive workers may opt to wait for a formal sector job, while others may select into the informal sector. Also, [Boeri and Garibaldi \(2006\)](#) develop a matching model with supervision where workers in the informal sector cannot avail of unemployment benefits, and show that matches found not paying tax are dissolved. Their model suggests that policies aimed at reducing the size of the shadow economy may increase unemployment. Alternatively, [Fugazza and Jacques \(2004\)](#) incorporate psychic costs as part of the costs of being in the informal economy in a matching model where workers direct their search at informal sector firms. However, it is important to emphasize that while all of these papers use the matching framework, they only focus on exogenously given worker heterogeneity. In the equilibrium search framework we adopt here the firm size premium and the informal sector emerge endogenously without arbitrarily imposing any differences between the two sectors other than that larger firms are more likely to be caught defaulting on their tax.⁵

A key prediction of the equilibrium search framework is that large firms pay more even when there is no heterogeneity amongst either workers or firms *ex ante*. It is only in the case where there are no search frictions that the labor market is competitive and the formal/large-firm premium disappears. There is already some evidence that suggests that firm size may be a driving factor behind the often observed formal sector wage premium. For example, [Pratap and Quintin \(2006\)](#) find, using Argentinean data and semi-parametric techniques to deal with the selectivity issue inherent in estimating the possibility of a formal sector wage premium, that there is no difference in gross (i.e., before tax deduction) wages between informal workers and their formal sector counterparts and that the employer's size is crucial in making the gross wage premium "disappear".^{6,7} Here we use the case of Ecuador to confirm that firm size can explain away the formal sector wage premium if one assumes that informal sector jobs are not taxed.⁸ More precisely, we use the same data source with which [Maclsaac and Rama \(1997\)](#) previously demonstrated with standard econometric techniques and without explicitly controlling for firm size, that workers in Ecuador in firms that complied with labor market regulation were paid about 18% higher net wages. We show that using the aforementioned arguably more appropriate semi-parametric estimation technique and allowing for firm size can make this formal sector net wage premium disappear.⁹

⁴ See, for example, [Husmanns \(1994\)](#) or [Byrne and Strobl \(2004\)](#).

⁵ In our paper we interpret informality to mean tax avoidance rather than any other illegal activity. [Schneider and Enste \(2000\)](#) provide a survey of the general literature on shadow economies and its various definitions.

⁶ However, the [Pratap and Quintin \(2006\)](#) do not provide any results for wages net of taxes.

⁷ [Amaral and Quintin \(2006\)](#) outline a theoretical framework where the only difference between informal and formal sector firms is that informal sector firms are seen as more likely to default on loans, have difficulty accessing credit and, because of this, rely on self financing. Because of the complementarity between skill and capital, high skill capital intensive firms enter the formal sector and hire high skill workers. Thus, in contrast to our model, labor markets are competitive and wage differentials can be explained by differences in ability.

⁸ In earlier version of the paper we demonstrated the same for South Africa, although arguably its labor market may not be as applicable as that of Ecuador in our context. See <http://repec.iza.org/RePEc/Discussionpaper/dp3145.pdf>.

⁹ One should note that in referring to findings in [Maclsaac and Rama \(1997\)](#) we will use the term formal sector to refer to what the authors called employers complying with labor market regulation. While the authors also used the terminology formal/informal in their study, these were reserved to describe job characteristics other than labor legislation compliance.

Our equilibrium search framework also allows us to do comparative static analysis on the policy parameters and predict the long run change in the equilibrium wage distribution accounting for firm entry and exit. We find that an increase in the enforcement/punishment parameter tends to reduce the share of the informal sector as one would expect. Somewhat surprisingly one also discovers that in the long run, when one accounts for the impact of firm exit on the shape of the distribution, an increase in the tax rate may reduce the share of the informal sector for plausible parameter values. Given the amount of structure we impose to solve the equilibrium search model explicitly, we view these comparative static results as examples that illustrate interesting possibilities in a reasonable framework.

The remainder of the paper is organized as follows. In the next section we present our model. In [Section 3](#) we outline the institutional setting that may be driving a formal/informal segmentation of Ecuador's labor market. A description of the data set that we use for our empirical analysis as well as summary statistics are provided in [Section 4](#). Empirical evidence in support of the results derived from our model are shown in [Section 5](#). Concluding remarks are given in the final section.

2. The model

2.1. Exogenous firm size wage premium

We start with a general model where there is a positive and continuous relationship between a firm's employment n and the wage w , $n(w)$, in a stationary equilibrium, but initially do not specify why this positive relationship exists.¹⁰ More specifically, firms have production function $q(n)$ and p is the price of output. There is a tax rate t on wages. There is a Poisson arrival rate of negative shocks (δ) which will destroy the firm and also a Poisson arrival rate of tax inspectors, which is a positive function of the number of employees at the firm: $\Theta[n(w)]$. If firms are caught not paying their taxes they are punished and must pay a fine according to the function: $\Omega[wtn(w)]$. This function is increasing in the per period tax bill $wtn(w)$. The flow values of defaulting (d) and complying (c) firms in a stationary equilibrium at any wage w are:

$$\begin{aligned} rV^d &= pq[n(w)] - wn(w) - \Theta[n(w)]\Omega[wtn(w)] - \delta V^d \\ rV^c &= pq[n(w)] - w(1+t)n(w) - \delta V^c \end{aligned} \quad (1)$$

The flow value of the firm where r is the discount rate is the dividend stream (flow of profits) plus any capital gain/loss in the value of the firm. It is instructive to look at the difference in the value of complying and defaulting at any wage w :

$$(V^c - V^d) = \frac{\Theta[n(w)]\Omega[wtn(w)] - wtn(w)}{(r + \delta)} \quad (2)$$

We will denote the tax liability as $B = wtn(w)$ for shorthand. From (2) we can establish our first proposition:

Proposition one. *We assume that there is a stationary equilibrium where there is a continuous positive relationship between employment and the wage rate $n(w)$. If the elasticity of punishment with respect to the tax bill is greater than or equal to unity: $\frac{\partial \Omega(B)}{\partial B} \frac{B}{\Omega} \geq 1$ and there are some compliant and some non-compliant firms in equilibrium, then there will be a cut-off point in firm size below which all firms will default on their taxes, and above which firms will be compliant. In other words, we*

¹⁰ Workers are assumed to be identical in the model since the firm size and formal sector premiums that interest us in the empirical study remain after we control for worker characteristics.

will have a wage distribution with small-low wage firms in the informal sector and large-high wage firms in the formal sector.

The proof is given in [Appendix one](#).

Assuming that the elasticity of the punishment function with respect to the tax bill is greater than or equal to unity seems plausible. This just means that when a firm is caught defaulting on their tax the punishment they pay increases at least proportionately with the amount of tax they owe. It is worth noting at this stage that in Eq. (1) we assume that the punishment for non-payment of taxes is dependent on the current tax bill. Because we look at a stationary equilibrium it would be difficult to make the punishment depend on the total tax liability incurred by a firm since it began defaulting, which would be more plausible. While it would be difficult to model this formally, we might expect that if we did it would make it even more likely that the elasticity in [Proposition one](#) would exceed unity.

[Proposition one](#) shows that in a general setup where we have a distribution of firms, small firms pay low wages, and large firms pay high wages, then small low-wage firms will be in the informal and large-high wage firms in the formal sector. It is worth noting that when taxes are on labor income, we also expect the punishment function to be determined by labor income. In other words, a firm's decision on whether to be in the formal or informal sector depends only on the cost side of the firm's objective function. This makes [Proposition one](#) fairly general. Firms of different sizes may be in different markets, have different market structures, or have different production functions etc. But, the decision on whether to default depends only on comparing the tax bill with the expected punishment for a firm of a given size, and this depends only on the firm size and wage, which are jointly determined.

One should note that there exists an extensive literature showing a positive relationship between firm size and wages in both developing and developed countries.¹¹ While there are different models that seek to explain this premium, [Proposition One](#) implies that if we are in a country with weak enforcement and a sizeable informal sector, because the informal sector firms are small, the formal sector wage premium is determined by the firm size premium. In [Section 5](#) we show empirical support for this proposition.

2.2. Endogenous firm size wage premium

2.2.1. Burdett and Mortensen (1998) model

While the above proposition is very general, it may be useful to solve the model explicitly. One can think of different models that rationalize why firms would pay higher wages. In [Rebitzer and Taylor \(1995\)](#) the efficiency wage premium is increasing in firm size, while in recent decades dynamic monopsony models where firms pay higher wages to lower turnover or attract more workers have been prevalent in the literature [see [Manning \(2003\)](#)]. In these latter types of models firms that pay higher wages retain and attract more workers and so larger firms pay higher wages.¹² One obvious candidate in this regard is the equilibrium search framework outlined by [Burdett and Mortensen \(1998\)](#). As a matter of fact, [Mortensen \(2003\)](#) argues that this model is a convincing candidate to explain the firm size and industry wage differentials that are empirically widely documented. In this model the firm size premium emerges endogenously and we can solve for the equilibrium wage distribution explicitly.

We first derive the labor supply curve in a model where there are search frictions and workers receive on the job offers.¹³ There is a mass

of M identical employers and a mass L of identical workers in the economy. The non-employment outside option is b .¹⁴ Workers receive offers according to a Poisson arrival rate, λ , at each instant. There is random matching so that any offer is equally likely to come from any firm irrespective of the firm's size¹⁵. The distribution of wage offers which we will solve for is $F(w)$. We assume that the arrival rate of job offers is the same for employed and unemployed workers. [Burdett and Mortensen \(1998\)](#) assume $r=0$ in their derivation of the labor supply curve and we follow this assumption. The separation rate at any firm, $d(w)$, is just the sum of the job destruction rate δ plus the arrival rate of offers to each worker times the probability the offer comes from a higher wage firm: $\lambda[1 - F(w)]$:

$$d(w) = \delta + \lambda[1 - F(w)]. \tag{3}$$

In a stationary equilibrium inflows and outflows to unemployment are equal, implying the following relationship between the unemployment rate u and the arrival rates:

$$\frac{u}{1 - u} = \frac{\delta}{\lambda} \tag{4}$$

If $N(w)$ is aggregate employment at wage w or less, stationarity also ensures that the inflows to this stock (the number of offers less than w accepted by unemployed workers) and outflows (the separation rate times the stock) are equal:

$$\dot{N} = \lambda F(w)uL - \{\delta + \lambda[1 - F(w)]\}N(w) = 0 \tag{5}$$

$F(w)$ is the wage offer distribution, while we define $G(w)$ as the wage distribution of employed workers. Since the employment rate times the wage distribution equals the stock of workers working for a wage less than w , we can use (5) to define the relationship between the wage and wage offer distributions:

$$G(w) = \frac{N(w)}{1 - u} = \frac{\delta F(w)}{\delta + \lambda[1 - F(w)]} \tag{6}$$

The number of offers received by workers from any firm is the offer arrival rate times L/M . If we multiply this by the fraction unemployed plus the fraction of employed workers earning less than w , we get the number of offers accepted to a firm offering a wage w at any point in time:

$$h(w) = \lambda \frac{L}{M} [u + (1 - u)G(w)] \tag{7}$$

Next, recognizing that since the separation rate times employment must equal new hires [given in (7)] for a firm to be in a stationary equilibrium, we use (6) in (7) and divide by (3) to get the labor supply curve:¹⁶

$$n(w, F) = \frac{h(w)}{d(w)} = \frac{\delta \lambda L}{M\{\delta + \lambda[1 - F(w)]\}^2} \tag{8}$$

¹⁴ Traditionally this outside option b is viewed as unemployment benefits. In the context of developing countries it is perhaps more appropriately seen as self-employment or support for the non-employed by their family which is a relatively common feature of the developing world.

¹⁵ See [Manning \(2003\)](#) pp. 284-286 for a discussion on the matching technology.

¹⁶ We note here that the labor supply curve in [Burdett and Mortensen \(1998\)](#) allows for different arrival rates for unemployed (λ_0) and employed (λ_1) workers. The labor supply curve in this case, not normalizing the mass of workers L to unity is:

$$n(w, F) = \frac{\delta \lambda_1}{M\{\delta + \lambda_1[1 - F(w)]\}^2} \left[\frac{\lambda_0 (\delta + \lambda_1)}{\lambda_1 (\delta + \lambda_0)} L \right]$$

That is it is just the labor supply curve in (8) (with λ replaced by λ_1) times a constant.

¹¹ See [Idson and Oi \(1999\)](#), for instance, for a review of the literature on the firm size premium. Examples of studies of developing countries include [Schaffner \(1998\)](#), [Velenchik \(1997\)](#), and [Marcelle and Strobl \(2003\)](#).

¹² In more traditional monopsony models, such as the company town model, large firms have more monopsony power and pay lower wages [see [Boal and Ransom \(1997\)](#) for a survey].

¹³ See [Mortensen \(2003\)](#) and [Burdett and Mortensen \(1998\)](#) for a detailed derivation of the labor supply curve.

Given that employed and unemployed workers have the same arrival rate of job offers, the reservation wage is just the benefit level b . The employment levels of firms paying the reservation wage and the highest wage \bar{w} are:

$$n(b, F) = \frac{\delta\lambda}{M(\delta + \lambda)^2} \quad \text{and} \quad n(\bar{w}, F) = \frac{\lambda}{M\delta} \quad (9)$$

The derivation of the labor supply curve shows that when there are search frictions and an equilibrium where some firms wish to be larger than others, we will have wage dispersion and large firms will pay higher wages even when workers are identical. [Burdett and Mortensen \(1998\)](#) made an important contribution to this literature by solving for the unique stationary wage equilibrium in a model with constant productivity. Our next step is to use the Burdett and Mortensen model to illustrate [Proposition one](#). One should note that while the model imposes a lot of structure, it allows us to explicitly solve for the wage distribution of formal/informal firms.

2.2.2. [Burdett and Mortensen \(1998\)](#) model with formal and informal firms

We normalize the mass of workers to unity for simplicity. [Burdett and Mortensen \(1998\)](#) assume firms are identical ex-ante and workers have a constant productivity p at any firm. Here we modify the Burdett and Mortensen model by introducing a tax rate t on wage income that is paid by firms. Labor supply is given by (8) once we solve for the wage distribution. We assume the Poisson arrival rate of tax inspectors is a constant μ times employment to the power of a constant β so that large firms are more visible and more likely to be caught defaulting: $\Theta[n(w)] = \mu n(w)^\beta$. We specify the penalty for defaulting as x times the firm's per period tax bill: $\Omega[wtn(w)] = xwtn(w)$. To save on notation we define $s = x\mu$ as the parameter that when multiplied by employment to the power of $\sigma = \beta + 1$ the expected punishment for defaulters at any point in time. We can rewrite Eq. (1), i.e., the value of complying and defaulting firms as:

$$V^d = \frac{(p - w)n(w) - swtn(w)^\sigma}{\delta} \quad (10)$$

$$V^c = \frac{[p - w(1 + t)]n(w)}{\delta}$$

We note that the two policy instruments the government has are the tax rate t and the degree of punishment/enforcement s . While [Proposition one](#) makes no assumption about firm entry, to solve the model explicitly we assume free entry. This ensures that in equilibrium the value of all firms along the wage distribution, compliant and non-compliant, will be equalized. Using this condition in (10) gives us the level of employment below which firms will default:

$$V^d > V^c \quad \text{if} \quad \frac{1}{s} > n^{\sigma-1} \quad \text{and} \quad V^d < V^c \quad \text{if} \quad \frac{1}{s} < n^{\sigma-1} \quad (11)$$

We can use the expression for labor supply (8) in (11) to calculate the cut-off value of the wage offer distribution below which firms will be defaulting:¹⁷

$$F^* = \frac{\delta + \lambda}{\lambda} - \sqrt{\frac{s^{\frac{1}{\sigma-1}}\delta}{M\lambda}} \quad (12)$$

Free entry ensures that $V^d = V^c = k$. Imposing this free entry condition using (10) for the value of firms and (8) for labor supply,

¹⁷ It is worth noting from (10) that even with a general production function $y = y(n)$, where y is output, Eq. (11) will hold.

with $L = 1$, we can calculate the relationship between the wage and offer distribution for defaulting and compliant firms:

$$w^d = \left\{ p - \frac{kM}{\lambda} [\delta + \lambda(1-F)]^2 \right\} \left\{ \frac{M^{\sigma-1} [\delta + \lambda(1-F)]^{2(\sigma-1)}}{M^{\sigma-1} [\delta + \lambda(1-F)]^{2(\sigma-1)} + st(\lambda\delta)^{\sigma-1}} \right\} \quad (13)$$

$$w^c = \frac{p}{1+t} - \frac{kM}{\lambda} \frac{[\delta + \lambda(1-F)]^2}{1+t} \quad (14)$$

The wage in the lowest wage firm is b and, since all other firms pay higher wages, the value of the wage offer distribution will be zero at a wage b . Using $w = b$ and $F = 0$ in (10) and setting the value of the lowest wage firm equal to entry costs k , we can solve for the relationship between entry costs and the mass of firms in terms of the exogenous parameters:

$$k = \frac{(p - b)n(b) - bstn^\sigma(b)}{\delta} = \frac{(p - b)\lambda}{M(\delta + \lambda)^2} - \frac{stb\delta^{\sigma-1}\lambda^\sigma}{M^\sigma(\delta + \lambda)^{2\sigma}} \quad (15)$$

In [Fig. 1](#) we graphically depict the inverse wage offer distribution of our model for two different tax rates, 10% and 30%, using (13) for values of F between zero and F^* and (14) for values of F between F^* and unity under assumed values of the exogenous parameters. The graph illustrates a wage offer distribution which is consistent with many of the stylized facts. Small low wage firms are in the informal sector and large high wage firms in the formal sector. While we will do some comparative static analysis later where both arrival rates of job offers (λ) and entry costs (k) are dependent on the mass of firms in equilibrium, [Fig. 1](#) plots the response to a tax change under the simpler assumption that these parameters are fixed when the mass of firms changes in accordance with (15). Accordingly, the wage distribution becomes more compressed in response to the higher tax rate as we would expect. Firms paying high wages must adjust their wage downwards in response to the tax, while the lowest wage firms are already paying the reservation wage and cannot lower the wage any further.

One should note that the basic Burdett and Mortensen model with homogeneous productivity across firms predicts a wage distribution with a lot of weight on the upper tail of the distribution, whereas empirically it has been observed that the wage distribution generally has a long right hand tail. [Mortensen \(2003\)](#) discusses this issue and outlines

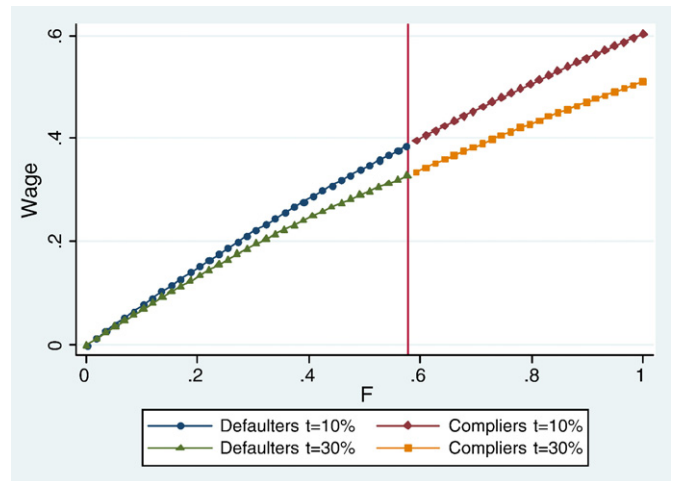


Fig. 1. Defaulters and compliers inverse wage offer distributions for tax rates of 10% and 30% and exogenous productivity. Notes: For both graphs we assume $s = 0.2$, $b = 0$, $p = 1$, and $k = 1$, and follow [Mortensen \(2003\)](#) and assume $\lambda = 0.287$ and $\delta = 0.207$. One should note in particular that the assumption $b = 0$ simplifies the derivation of M and causes the equilibrium mass of firms and cut-off value of F to be constant when t changes in both graphs.

a number of generalizations to the basic Burdett and Mortensen model where productivity varies across firms. These generalizations generate wage distributions that are more in keeping with empirically observed wage distributions. This can be where there is exogenous variation in firms' productivity and firms can choose the number of contacts with workers, or, alternatively, where firms may be allowed to invest in costly match specific or general capital, which generates differences in productivity. We will take the case where firms invest in match specific capital and apply our model of the informal sector to this set-up.

Within this framework we look at the model analyzed earlier where the risk of detection for defaulters rises with firm size so that small low wage firms are in the informal sector. We will set up the profit function in general terms before distinguishing between the defaulting and compliant sectors. We assume that $j \in [d, c]$ so that $w_j = w$ when $j = d$ and $w_j = w(1 + t)$ when $j = c$.

We note from Eq. (8) that the labor supply curve is:

$$\pi^j(w, F^j) = \frac{h^j(w)}{d^j(w)} \quad (16)$$

In this section the ability to distinguish between the separation and offer acceptance rates will be important. Firms invest in match specific human capital T , which also costs the firm T . These sunk costs will be incurred every time an offer is accepted and a new worker is hired. Human capital enhances the productivity of a match according to the concave function $p(T)$, but the productivity gain of the investment is lost as soon as the worker leaves this firm. The cost of the investment T is multiplied by the number of matches but is unaffected by the separation rate. The profit function in this case is:

$$\begin{aligned} \pi^j(w_j, F^j) &= h^j(w) \left[\frac{p(T) - w_j}{d^j(w)} - T \right] \\ &= \frac{\lambda \delta}{M \{ \delta + \lambda [1 - F^j(w)] \}} \left[\frac{p(T) - w_j}{\delta + \lambda [1 - F^j(w)]} - T \right] \end{aligned} \quad (17)$$

We assume that $p(T) = pT^\alpha$ and from the first order condition for the optimal choice of training T :

$$T = (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda [1 - F^j(w)] \}^{\frac{1}{\alpha-1}} \quad (18)$$

Substituting (18) into the profit function one obtains:

$$\begin{aligned} \pi_j(w_j, F^j) &= \frac{\lambda \delta}{M} \left[\left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda [1 - F^j(w)] \}^{\frac{2-\alpha}{\alpha-1}} \right. \\ &\quad \left. - w_j \{ \delta + \lambda [1 - F^j(w)] \}^{-2} \right] \end{aligned} \quad (19)$$

Eq. (10) can be amended to:

$$\begin{aligned} V^d &= \frac{\pi_c(w) - swtn(w)^\sigma}{\delta} \\ V^c &= \frac{\pi_d(w)}{\delta} \end{aligned} \quad (20)$$

Using (19) in (20) the value of defaulting and complying firms respectively can be written as:

$$\begin{aligned} V^d &= \frac{\lambda}{M} \left[\left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda [1 - F^d(w)] \}^{\frac{2-\alpha}{\alpha-1}} \right. \\ &\quad \left. - w \{ \delta + \lambda [1 - F^d(w)] \}^{-2} \right] \\ &\quad - \frac{swt \lambda^\sigma \delta^{\sigma-1} \{ \delta + \lambda [1 - F^d(w)] \}^{-2\sigma}}{M^\sigma} \end{aligned} \quad (21)$$

$$\begin{aligned} V^c &= \frac{\lambda}{M} \left[\left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda [1 - F^c(w)] \}^{\frac{2-\alpha}{\alpha-1}} \right. \\ &\quad \left. - w(1+t) \{ \delta + \lambda [1 - F^c(w)] \}^{-2} \right] \end{aligned} \quad (22)$$

One can see by comparing (21) and (22) that in equilibrium at a given wage and value of the distribution Eq. (11) still gives the condition that determines whether a firm can profit from moving to the defaulting from the compliant sector or vice-versa. Firms below the critical level of employment will default and firms above the critical level will comply. Given that (11) still holds, Eq. (12) continues to give the fraction of wage offers in the defaulting sector. The equilibrium value of firms is given by solving (21) for the lowest wage firm where $F=0$ and $w=b$.

$$\begin{aligned} k &= \frac{\lambda}{M} \left[\left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} (\delta + \lambda)^{\frac{2-\alpha}{\alpha-1}} - b(\delta + \lambda)^{-2} \right] \\ &\quad - \frac{sbt \lambda^\sigma \delta^{\sigma-1} (\delta + \lambda)^{-2\sigma}}{M^\sigma} \end{aligned} \quad (23)$$

Next one can equate $V^c = V^d = k$ to solve for the equilibrium relationship between the wage and the wage distribution for both firm types:

$$w = \frac{M^{\sigma-1} \left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda (1 - F^d) \}^{\frac{\alpha + 2(\sigma-1)(\alpha-1)}{\alpha-1}} - k \lambda^{-1} M^\sigma \{ \delta + \lambda (1 - F^d) \}^{2\sigma}}{M^{\sigma-1} \{ \delta + \lambda (1 - F^d) \}^{2(\sigma-1)} + st(\lambda \delta)^{\sigma-1}} \quad (24)$$

$$w(1+t) = \left(\frac{1-\alpha}{\alpha} \right) (p\alpha)^{\frac{1}{1-\alpha}} \{ \delta + \lambda (1 - F^c) \}^{\frac{\alpha}{\alpha-1}} - \frac{kM}{\lambda} \{ \delta + \lambda (1 - F^c) \}^2 \quad (25)$$

One can also solve for the highest wage by setting $F=1$ in (25).

We plot the distribution for the same assumed parameter values of Fig. 1 in Fig. 2 at two different tax rates. Once again the graph illustrates a wage distribution that is consistent with the stylized facts. Low wage small firms are informal, and large high wage firms are

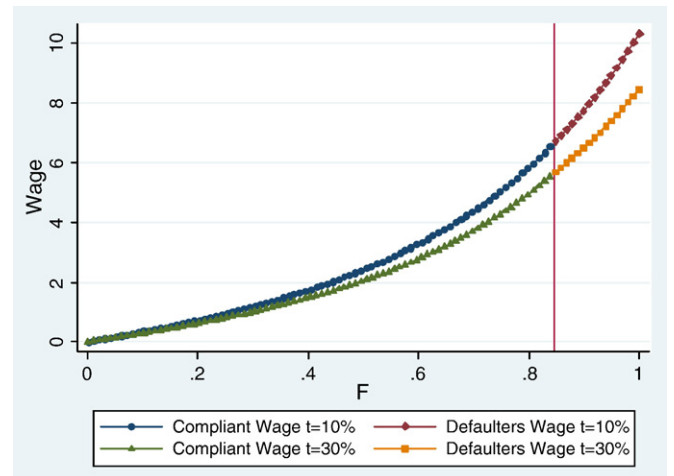


Fig. 2. Defaulters and compliers inverse wage offer distributions for tax rates of 10% and 30% and endogenous productivity. Notes: We make the additional assumption that $\sigma=2$ for this graph.

formal. In this case the inverse wage offer distribution is convex, indicating a small amount of weight in the upper tails, which is more in keeping with empirically observed wage distributions. The higher tax rate compresses the wage distribution as in Fig. 1.

2.2.3. Comparative statics

Next we investigate the effect of changes in the policy variables on the percentage of employed workers who will be in the informal sector. An increase in the tax rate or the punishment/enforcement parameters may have a direct effect, but may also affect the size of the formal sector by causing firm exit.¹⁸ The mass of firms M may in turn also plausibly affect entry costs and the arrival rate of job offers to workers which, in turn, will also determine the size of the informal sector. Specifically, we assume that $\frac{\partial k[M(z)]}{\partial M} \geq 0$ and $\frac{\partial \lambda[M(z)]}{\partial M} \geq 0$. Before making our next proposition, we define $\frac{\partial \lambda}{\partial M} \frac{M}{\lambda} = \varepsilon_{\lambda M}$ as the elasticity of the arrival rate with respect to the mass of firms and define the following condition:

Condition one. $p > b(1 + t\sigma)$

Proposition two. When productivity is exogenously given, then if $\varepsilon_{\lambda M} < 1$ and Condition one holds, this ensures that:

$$\frac{dG^*}{ds} < 0$$

and

$$\frac{dG^*}{dt} < 0.$$

The proof is given in Appendices two and three.

Proposition two shows conditions under which we can unambiguously say that an increase in punishment/enforcement rate reduces the fraction of employed workers in the informal sector. More surprisingly, it shows that the same conditions are sufficient for an increase in the tax rate to reduce the fraction of employed workers in the informal sector.

As we noted earlier, we would not argue that the comparative static results here, in particular the result that a higher tax rate reduces the share of the informal sector, is a general result. It is nevertheless informative. If we look at Eq. (10), we see that the reason that the tax rate cancels out in Eq. (12) is because the tax bill enters the costs of complying firms and the punishment of defaulting firms linearly. If the tax rate in (10) had an exponent greater than unity, for example, we would expect t to enter (12) and an increase in the tax rate to directly increase the size of the informal sector offsetting the impact of firm exit in increasing the size of this sector. We could think of the comparative static results as illustrating that for plausible parameter values higher tax and enforcement rates typically cause firm exit which in the long run changes the shape of the distribution in a way that increases the share of the informal sector. If there is no direct effect where the higher tax rate reduces the share of the informal sector, the impact of firm exit can dominate and the share of the informal sector will increase.¹⁹

3. Ecuador as a case study of the formal sector wage premium

An important result of our theoretical model is that, even when there is no heterogeneity amongst either workers or firms ex ante, large firms will operate in the formal sector and will pay higher wages than smaller firms, which are predicted to conduct business in the informal sector.

¹⁸ This is shown for the enforcement parameters in Eq. (12). In fact, the tax rate does not have a direct effect on (12) but, as we discuss below, this is possibly because of the structure we impose on the model rather than a general result.

¹⁹ In the case of an increase in punishment/enforcement parameter s both the direct and indirect effects go in the same direction.

Thus our model implies that any formal sector wage premium is actually just due to firm size wage differentials. Here we use the case of Ecuador to confirm these theoretical findings. More precisely, we use the same data source (the 1994 Living Standards Measurement Survey) with which Maclsaac and Rama (1997) previously demonstrated a non-negligible wage difference between formal and informal sector workers, but show that employing an arguably more appropriate econometric technique and explicitly controlling for firm size results in the disappearance of any observed formal sector premium.

Arguably the Ecuadorian labor market in 1994 is a particular suitable case study for the task at hand.²⁰ As noted by Maclsaac and Rama (1997), at the time of their study Ecuador had some of the most cumbersome labor legislation in Latin America. In particular, there were three main legislative aspects through which the government interfered with wage setting in the private economy and which were potentially important in terms of segmentation of the labor market. The first was through the setting of minimum wages, which differed across industries and occupations. However, enforcement of these was relatively weak given the few available labor inspectors and low penalties for non-compliance and thus arguably minimum wages were relatively unimportant. Secondly, legislation in Ecuador required a vast array of mandated benefits that were paid in addition to the base wage of a worker. These included cost-of-living, complementary, and transportation bonuses, as well as what are known as the “teen” salaries, i.e., the thirteenth, fourteenth, fifteenth, and sixteenth salaries, which depended on the base wage, the minimum wage, overtime pay etc. Finally, law required contributions to social security, which acted as a tax on labor in addition to payroll taxes. Such labor taxes amounted in total to 21.5% of the base wage in most cases.²¹ As noted by Maclsaac and Rama (1997), in general small firms were not targeted for inspection of compliance to tax payments.

In their empirical analysis using the 1994 Ecuador Living Standard Measurement Survey Maclsaac and Rama (1997) showed that formal sector employers were actually partly able to dampen the increase in labor costs due to the mandated benefits by reducing the base pay, although, an unexplained 18.8% in net wages remained. Employing the estimated coefficients Maclsaac and Rama (1997) then calculated that for a worker with net pay of about 50% of the average in their sample, the effect of compliance, including the impact of payroll tax payment and base pay reduction, would increase total labor costs by about 8%.

4. Data and summary statistics

Maclsaac and Rama (1997)'s data source is the 1994 Ecuador Living Standards Measurement Survey, which is a household survey covering 4391 households in urban and rural areas in Ecuador. The appeal of this dataset lies in its richness in detailed information regarding earnings, which allows one to construct exact measures of take home pay, and its vast array of other relevant information on employment. In constructing their base sample Maclsaac and Rama (1997) focus on paid employment (of the main occupation) other than agricultural jobs held by farmers working on their own land. Non-missing observations for all variables used in their analysis resulted in a total of 7281 workers in their base sample.

Two important components of Maclsaac and Rama (1997)'s analysis are the classification of workers according to compliance with labor market regulation and the measurement of earnings. In terms of classifying workers into those who have jobs that comply with labor market regulations—which we, following the standard in the current literature, call formal sector employees—and those that work in jobs where this is not the case, i.e., those we classify as working in the informal sector, we, following Maclsaac and Rama (1997), use the

²⁰ Unless indicated otherwise, background information regarding Ecuador is taken from Maclsaac and Rama (1997).

²¹ The mandated benefits are not subject to social security contribution and taxation.

Table 1
List of explanatory variables.

Variable name	Definition of the variable
Modern sector	Indicator variable of employment in modern sector (all professionals and workers in private firms with 6 or more employees)
Public sector	Indicator variable of employment in public sector
Urban sector	Indicator variable of location in urban area
Agricultural sector	Indicator variable of employment in agricultural sector
Schooling	Years of schooling
Experience	Years of work experience
Male	Indicator variable of male gender
Married	Indicator variable of being married
Indigenous	Indicator variable of fluency in Quichua or Shuar
Costa	Indicator variable of location in the Costa
Sierra	Indicator variable of location in the Sierra
Compliant	Indicator of compliance with labor regulations

information on whether the respondent is entitled to teen salaries as the distinction criteria. Conveniently the LSMS also provides exact measures of net take home pay, which is wages inclusive of bonuses, but net of payroll taxes and social security contributions.

Maclsaac and Rama (1997) also control for a large number of other worker characteristics in their analysis. In terms of sectoral classification the authors allocate workers into four groups: (1) the modern (private) sector, which consists of employees in privately owned firms of at least 6 employees and of professionals, (2) the public sector, (3) the agricultural sector, and (4) what they term as the informal (urban) sector. Additional controls included are whether an individual works in a place that is unionized, the years of schooling, the years of experience, a gender dummy, a marital status dummy, an indigenous dummy, and an urban dummy. Details regarding the exact definitions of these can be found in Table 1.

Given that our main focus is on investigating whether the data confirm the predictions of our theoretical framework in terms of a formal sector wage premium, in our empirical analysis we use a somewhat more restricted sample than Maclsaac and Rama (1997)'s constructed data. In particular, since public sector employees should essentially all by definition be in the formal sector we exclude these.²² We also, unlike Maclsaac and Rama (1997), exclude self-employed persons. While comparing self-employed informal sector workers to their formal sector counterparts may be of interest in its own right, one could argue that the decision of whether to register one's own enterprise is likely to be less constrained or at least determined by different criteria than attempting to get a formal sector job. Apart from this, self employed workers' earnings would be expected to have greater measurement error and incorporate returns to risk etc., that would not be included in wages of employees. More importantly for our purposes, of course, the theoretical predictions that we are trying to test here are based on the assumption that self-employment serves as the outside option.²³

An important component of our theoretical predictions is firm size. One should note in this regard that Maclsaac and Rama (1997) do not control for employer size except in the sense of identifying those that work in what they term the "modern" sector, which consists of professionals as well as those in firms with more than 6 employees. We thus also use information in the LSMS on employer size to create a set of firm size dummies indicating whether a worker works in a firm of 1, between 2 and 5, between 6 and 10, between 11 and 30, between 31 and 50, between 51 and 100, and at least 101 employee(s). Finally, since we are also interested in comparing results for gross and net of tax wages, we approximate gross wages for formal sector employees

²² Examining the raw data indicates that over 99% of workers in the public sector are in the formal sector, as defined by the receipt of teen salaries.

²³ One should note, however, that including public and self-employed workers gives us qualitatively the same results that we describe in Section V, details of which are available on request. We exclude them here solely to be consistent with what we are investigating in terms of the predictions of our theoretical model.

Table 2
General summary statistics.

		Formal	Informal
Log(net wage)	Mean	7.38	7.07
Log(gross wage)	Mean	7.47	7.07
1 employee	% of total	0.15	0.05
2–5 employees	% of total	0.26	0.48
6–10 employees	% of total	0.11	0.21
11–30 employees	% of total	0.15	0.14
31–50 employees	% of total	0.06	0.05
51–100 employees	% of total	0.07	0.03
101+ employees	% of total	0.20	0.04

by assuming that payroll taxes and social security contributions constitute 21.5% of the base wage, as is the case for most workers in the formal sector. In total non-missing observations on all variables used in our analysis resulted in a sub-sample of 3837 workers from the Maclsaac and Rama (1997) data, of which 46.7% are in the informal sector as defined by whether they are entitled to teen salaries.

Summary statistics for our sub-sample are provided in Table 2. As can be seen from the difference in gross log wages, formal sector workers earn on average about 40% more. When one allows for the income tax deductions from the earned income for those working in the formal sector, this discrepancy is reduced to about 31%. We also provide the distribution of the formal and informal sector workers by employer size categories in the same table. Accordingly, unsurprisingly the majority of informal workers are in smaller firms. In contrast, in the formal sector workers are much more evenly distributed across the given categories. We also calculated the difference in the formal relative to the informal log net wage rate within firm size categories in Table 3. Here it can be seen that there are large difference in the premium across categories. More precisely, the premium is greater in larger firms, where also the majority of formal sector employment tends to be located.

Finally, one should note that our sub-sample produces a somewhat larger estimate of the formal sector wage premium under standard OLS. More precisely, in the first row of Table 4, we show the estimated coefficient on the compliance dummy of using Maclsaac and Rama's (1997) sample of 7,281 workers and their base specification (using OLS), which, as found by the aforementioned authors, indicates a premium of 18.8% in log net wages for formal sector work. Using their specification but for our reduced sample²⁴, in contrast, we find an estimated premium of 27.8%, as shown in the second row of Table 4.

5. Econometric analysis

Our next task is to investigate whether the Ecuadorian data is supportive of the predictions of our theoretical model, i.e., whether incorporating tax payments and controlling for firm size makes the formal sector wage premium disappear. In terms of measuring the wage premium associated with the informal sector one may be tempted to simply run OLS on a standard Mincerian wage equation where one regresses logged wages on an indicator of formal sector employment while controlling for other relevant and available determinants of earnings. However, as recently shown by Pratap and Quintin (2006), not properly taking account of the selection bias in estimating such a parametric regression could bias the results. More specifically, the authors implement a semi-parametric propensity score matching estimator that allows one to explicitly deal with the problem of a lack of common support in standard OLS, where one may be comparing very dissimilar workers. As a matter of fact, under OLS Pratap and Quintin (2006) find evidence of a gross wage informal sector premium using Argentinean data, but no such gross earnings differential is detectable under the semi-parametric propensity score matching estimator. We thus follow Pratap and Quintin (2006) and resort to this semi-

²⁴ The only excluded variable is the public sector dummy.

Table 3
Difference in formal and informal log net wage rates by employer size.

Firm size	Difference
1 employee	0.11
2–5 employees	0.06
6–10 employees	0.09
11–30 employees	0.34
31–50 employees	0.71
51–100 employees	0.51
101+ employees	0.55

Table 4
Estimate of ATT of the formal sector wage premium.

Sample	Wage	Firm size DVs	Premium	Std. error	Obs.	Method
Total	Net	No	0.188**	0.027	7281	OLS
Total	Net	No	0.278**	0.026	3837	OLS
Total	Net	No	0.301**	0.069	2511	PSM
Total	Net	Yes	0.149	0.090	2234	PSM
Total	Gross	No	0.385**	0.070	2511	PSM
Total	Gross	Yes	0.238**	0.095	2234	PSM
1 employee	Net	–	–0.289	0.740	109	PSM
2–5 employees	Net	–	0.129	0.161	969	PSM
6–10 employees	Net	–	0.636	0.412	394	PSM
11–30 employees	Net	–	0.287	0.302	384	PSM
31–50 employees	Net	–	0.123	0.419	83	PSM
51–100 employees	Net	–	0.233	0.551	52	PSM
101+ employees	Net	–	0.742	0.437	97	PSM

Notes: (1) ** stands for 5% significance level.
(2) Standard errors generated via bootstrapping using 500 replications.
(3) Matching done separately for individual firm size categories.

parametric approach in investigating the formal sector wage premium in Ecuador.

Using a similar notation to Pratap and Quintin (2006) we define the average formal sector premium as what is in the matching literature known as the Average Treatment Effect on the Treated (ATT), where treatment refers to employment in the formal sector F:

$$ATT = E(\text{wage}^F | X, \text{sector} = F) - E(\text{wage}^I | X, \text{sector} = F) \quad (25)$$

where X are vector of observed individual and job related characteristics and worker i may be employed in the formal sector, $i \in F$, or in the informal sector, $i \in I$. If one assumes that the conditional independence assumption holds:

$$\text{wage}^F, \text{wage}^I \perp \text{sector} | X \quad (26)$$

i.e., that selection only occurs in terms of the observed characteristics, then (25) can be estimated by²⁵:

$$ATT = E(\text{wage}^F | X, \text{sector} = F) - E(\text{wage}^I | X, \text{sector} = I) \quad (27)$$

Rosenbaum and Rubin (1983, 1985) have shown that if the conditional independence assumption holds then conditioning on propensity scores, defined as $P(\text{sector} = F | X_i)$, is the same as conditioning on the covariates themselves. One can then use these propensity scores to create a sample of “matched” similar individuals, where matching is done via a chosen matching algorithm. In our case we use the caliper method, using a caliper δ of size 0.0001, although it must be noted that we obtained similar results also using nearest neighbor and kernel matching methods.²⁶ More specifically, each formal sector worker is matched with a set of informal sector workers whose propensity scores lie within 0.001 of the formal worker in question.

Assuming reasonable matches the ATT is then just:

$$ATT = \frac{1}{N^M} \left[\sum_{i \in F^M} \left(w_i^F - \sum_{i \in I^M} (n_{ij} w_i^I) \right) \right] \quad (28)$$

where F^M and I^M are the sets of matched formal and informal sector employees, respectively that could be matched, N^M is the total number of these, and for all $(i, j) \in F \times I$:

$$n_{ij} = \begin{cases} 0 & \text{if } |p_i - p_j| > \delta \\ \frac{1}{|p_i - p_j|} & \text{otherwise} \\ \frac{1}{\sum_{\{i,j: |p_i - p_j| \leq \delta\}} |p_i - p_j|} & \end{cases} \quad (29)$$

In order to generate the propensity score to match formal with informal sector workers we estimate a probit model of formal sector employment conditional on all characteristics as listed in Table 2, alternatively with and without the firm size dummies. Importantly for (28) to be an unbiased estimator of the formal sector wage premium, it must be emphasized that the conditional independence assumption must hold and thus that the set of covariates X that we use to generate the propensity scores captures all factors that determine both selection into formal sector employment and earnings. While it is not possible for us to test this, given the rich set of characteristics in the Ecuadorian data we feel reasonably confident that we are indeed likely to be satisfying the conditional independence assumption.

Matching on our set of covariates according to the algorithm above reduced our sample in the case with the firm size dummies to 2511. To assess our success in matching, we, as suggested by Rosenbaum and Rubin (1985), calculated and compared the standardized bias (SB) of the propensity scores for our overall and matched sample using:

$$SB = 100 * \frac{|\bar{p}_F - \bar{p}_I|}{\sqrt{0.5 * (V(p_F) + V(p_I))}} \quad (30)$$

where $p_{F,I}$ is the average propensity score and $V(p_{F,I})$ its variance for the two sectors. Using this we found that the percentage bias reduction was considerable from matching, around 80% when either including or excluding the firm size dummies. We also, as suggested by Sianesi (2004), compared the pseudo R-squared of our matching equation with the pseudo R-squared from re-estimating this on our matched sample. This was found to be reduced from 0.18 to 0.02 when we did not include firm size dummies, and from 0.29 to 0.03 when these were included. Thus the matching procedure was able to create a sample for which in terms of our explanatory variables much of the decision on participation in the formal sector remains random. In order to see if the matching can be substantially improved with a more restrictive caliper, we also experimented with $\delta = 0.00001$. While this further reduced the sample by about 24%, there was no noticeable reduction in the bias or in lower pseudo R-squared values.

Using our matched sample we first calculate the ATT as in (28) for the measure of net hourly take home pay given in the LSMS with all controls except the firm size dummies in the matching procedure, the results of which are given in the third row of Table 4.²⁷ Accordingly, the earnings premium associated with working in the informal sector is 30.1% and statistically significant, i.e., higher than when using standard OLS. However, once one conducts the matching not only with this base set of covariates but also includes the firm size dummies, the ATT on net wages, in line with our theoretical model, becomes insignificant, as shown in the subsequent row.

²⁵ See Rosenbaum and Rubin (1983).

²⁶ Details are available from the authors upon request.

²⁷ We also experimented with including more detailed occupation and industry dummies, but this produced qualitatively similar results in all specifications.

Our theoretical model emphasizes that some firms will remain small and in the informal sector in order to avoid paying taxes and it is thus of interest to investigate whether not taking account of taxes in the measurement of pay changes our results above on the formal sector wage premium. Applied to the Ecuadorian case the context is slightly more complicated in that labor market segmentation may, as argued above, be caused by both the required pay of mandatory benefits and the payment of payroll taxes (including social security contributions). In this regard one should note that mandatory benefits are not subject to taxation and, as shown by [Maclsaac and Rama \(1997\)](#), can be partially offset by lowering base wages. In contrast, (complying) employers cannot avoid paying taxes on a given base wage. To examine whether taking account of such tax payments is important in investigating the possible existence of a formal sector wage premium we re-calculated the ATT using our proxy of gross wage payments. Accordingly, in the matched sample without firm dummies the estimated premium is 8.5% points higher than for net wages. While including the firm size dummies in the matching procedure does reduce the size noticeably, the estimated premium remains, unlike for net wages, statistically significant and substantial. Thus it is important to take account of tax payments when investigating the possibility of a formal sector wage premium.

As a further robustness check we also redid our matching within firm size categories and then calculated out the net wage premium associated with working in the formal sector in the final six rows of [Table 4](#). One should note that this meant matching on small samples, particularly for the very small and the very large categories where there were not many formal and informal sector workers, respectively. Our results show that even within firm size categories there is no significant (net) wage premium. Thus, once one reduces our sample to more homogenous sub-samples in terms of the size of the employer there is also no earnings premium for working in the formal sector.

6. Concluding remarks

The presence of a firm size wage premium in developing countries is well documented in the literature, as is the prevalence of a large informal sector where workers tend to be concentrated in small-low wage firms. In this paper we have drawn these two strands of the literature together to re-examine the possible existence of wage premiums for workers in the formal sector. We have shown in a fairly general framework that if there is a firm size wage premium and if large firms are more likely to be caught defaulting on labor taxes, then theory predicts what one observes: informal sector firms will be small and thus have low wages, while large firms will pay higher wages and be in the formal sector. In this model the formal sector wage premium is then just a firm size premium. Using Ecuadorian data we find empirical support for this result.

We also use the equilibrium search model, which in the literature has already been proposed as a natural framework in which firm size wage premiums may arise endogenously, in our formal/informal sector context and show again that the formal sector wage premium is just a firm size wage differential. One should note that we additionally find for this example that, because of the impact of firm exit on the shape of the wage distribution, a higher tax rate can reduce the fraction of informal workers in the long run. Less surprisingly, an increase in enforcement or punishment of defaulters is found to reduce the size of the informal sector for a wide range of parameter values.

Appendix A. Proof of proposition one

We take the derivative of the difference in the value of firms in [Eq. \(2\)](#) to get:

$$\frac{\partial (V^c - V^d)}{\partial w} = \frac{\Omega(B) \frac{\partial \Theta[n(w)]}{\partial n(w)} \frac{\partial n(w)}{\partial w}}{r + \delta} + \left(tn(w) + wt \frac{\partial n(w)}{\partial w} \right) \left(\Theta[n(w)] \frac{\partial \Omega(B)}{\partial B} - 1 \right) \tag{A.1.1}$$

As long as $\frac{1}{\frac{\partial \Omega(B)}{\partial B}} < \Theta[n(w)]$, then [\(A.1.1\)](#) will be positive since $\frac{\partial \Theta[n(w)]}{\partial n(w)}$ and $\frac{\partial n(w)}{\partial w}$ are positive by assumption. From [Eq. \(2\)](#) in the text, we see that a firm will comply if $(V^c - V^d) > 0$, which implies:

$$\Theta[n(w)] > \frac{B}{\Omega(B)} \tag{A.1.2}$$

We also note that if the elasticity of punishment with respect to the tax bill is greater than or equal to unity, i.e., $\frac{\partial \Omega(B)}{\partial B} \frac{B}{\Omega(B)} \geq 1$, then using [\(A.1.2\)](#) and this elasticity we see that if $(V^c - V^d) > 0$ the following inequality holds:

$$\frac{1}{\frac{\partial \Omega(B)}{\partial B}} \leq \frac{\Omega(B)}{B} < \Theta[n(w)]. \tag{A.1.3}$$

Next we assume that in equilibrium there are some defaulting and some compliant firms. Now we find the smallest firm where $(V^c - V^d) > 0$ and call it firm*. Since inequality [\(A.1.3\)](#) holds for firm* then the derivative in [\(A.1.1\)](#) is positive for firm*. This implies that the firm that is just bigger than firm* will also choose the formal sector, and so on, for all larger firms up to the largest firm. All firms below firm* must be defaulters since firm* is the smallest compliant firm by assumption.

Appendix B. The impact of a change in t or s on the mass of firms when productivity is exogenous

While the [Section 2.2.2](#) derives the wage offer distribution, one generally observes the wage distribution in the data, i.e., the fraction of workers paid different wages or the fraction of workers in the informal sector etc. In [Eqs. \(5\) and \(6\)](#), we derived the relationship between the wage distribution and wage offer distribution as in the [Burdett and Mortensen \(1998\)](#) model. This relationship will continue to hold when we incorporate taxes and enforcement in [Section 2.2.2](#) except that the wage offer distribution will also depend on the enforcement parameters, s, and the tax, t.

$$G(w, s, t) = \frac{N(w)}{1 - u} = \frac{\delta F(w, s, t)}{\delta + \lambda [1 - F(w, s, t)]} \tag{A.2.1}$$

For $z \in (s, t)$ we evaluate the derivative of [\(A.2.1\)](#) at F^* which is the cut-off value of the wage offer distribution below which firms will be defaulting²⁸:

$$\frac{dG^*}{dz} = \frac{\delta \frac{dF^*}{dz} [\delta + \lambda (1 - F^*)] + \delta F^* \left[-\frac{d\lambda}{dM} \frac{dM}{dz} (1 - F^*) + \frac{dF^*}{dz} \lambda \right]}{[\delta + \lambda (1 - F^*)]^2} \tag{A.2.2}$$

From [\(A.2.2\)](#) we see that when λ is fixed, the sign of the derivative of the wage distribution is the same as the sign of the derivative of the wage offer distribution. Moreover, if λ is increasing in the mass of firms, then $\frac{dM}{dz} < 0$ is a sufficient condition for:

$$\text{sgn} \frac{dG^*}{dz} = \text{sgn} \frac{dF^*}{dz} \tag{A.2.3}$$

This means comparative static results given for the wage offer distribution below will also apply to the wage distribution when: $\frac{dM}{dz} < 0$. In the remainder of this appendix we will determine conditions where $\frac{dM}{dz} < 0$, which in turn ensures [\(A.2.3\)](#) holds even if λ depends on the mass of firms.

²⁸ F^* is calculated in [Eq. \(12\)](#) in the text.

We define two conditions which we will use in the comparative static analysis:

Condition one. $p > b(1 + \sigma t)$

Condition two. $\frac{\lambda}{\delta} > \frac{\varepsilon_{\lambda M} - 1}{1 + \varepsilon_{\lambda M}}$

Totally differentiating (15) with respect to t and M and setting the derivative equal to zero, we get the following expression:

$$\left\{ \frac{\partial k}{\partial M} + \left[\frac{(p-b)n(b)}{\delta} - \sigma \frac{bstn^\sigma(b)}{\delta} \right] \frac{1}{M} + \left[\frac{(p-b)n(b)}{\delta} - \sigma \frac{bstn^\sigma(b)}{\delta} \right] \left[\frac{(\lambda - \delta)}{\delta + \lambda} \right] \frac{\partial \lambda}{\partial M} \right\} dM + \frac{bstn^\sigma(b)}{\delta} dt = 0 \quad (A.2.4)$$

The first line constitutes the change in fixed entry costs from a change in the mass of firms, the second term is the direct impact of a change in the mass of firms, the third line is the derivative from a change in offer arrival rates resulting from a change in firm entry, and the fourth line provides the derivative with respect to a change in the tax rate t . One should note that if one totally differentiates (15) with respect to the punishment/enforcement rate s and M one would get the same expression as (A.2.4), except that the final term would be: $\frac{bstn^\sigma(b)}{\delta} ds$. Also, we assume that $\frac{\partial k}{\partial M} \geq 0$ and $\frac{\partial \lambda}{\partial M} \geq 0$ and define $\frac{\partial \lambda}{\partial M} \frac{M}{\lambda} = \varepsilon_{\lambda M}$ as the elasticity of the arrival rate with respect to the mass of firms. We can multiply (A.2.4) by M and rewrite it as:

$$\left\{ \frac{\partial k}{\partial M} M + \left(\frac{(p-b)n(b)}{\delta} - \sigma \frac{bstn^\sigma(b)}{\delta} \right) \left(\frac{\lambda(1 + \varepsilon_{\lambda M}) + \delta(1 - \varepsilon_{\lambda M})}{\delta + \lambda} \right) \right\} dM + \frac{bstn^\sigma(b)}{\delta} dt = 0 \quad (A.2.5)$$

First we will take the left hand side term in square brackets from the second line of (A.2.5):

$$\frac{(p-b)n(b)}{\delta} - \sigma \frac{bstn^\sigma(b)}{\delta} \quad (A.2.6)$$

We note from (12) that in any equilibrium there are some defaulting firms $s < \frac{1}{n\sigma - 1/b}$. Substituting the right hand side in for s in (A.2.6) we see **Condition one** is a sufficient condition for this expression to be positive. Next we see that the second term in squared brackets in (A.2.5) is positive if **Condition two** holds. We can conclude that $\frac{dM}{dt} < 0$ if **Conditions one** and **two** hold.

While **Condition two** may not hold, for reasonable parameter values the indication is that it will hold unless $\varepsilon_{\lambda M}$ is very large. For example if $\lambda > \delta$ **Condition two** certainly holds, or, taking the values $\lambda = 0.207$ and $\delta = 0.287$ used by Mortensen (2003) in his simulations, **Condition two** will hold as long as $\varepsilon_{\lambda M} < 6.17$. One should also note that this is a sufficient condition, so there is a range of parameter values where **Conditions one** or **two** fail, but $\frac{dM}{dt} < 0$ continues to hold. We also remark that in the simpler case where $\frac{\partial \lambda}{\partial M} = 0$ **Condition two** always holds so that **Condition one** is sufficient for $\frac{dM}{dt} < 0$.

Appendix C. Comparative static results

The sign of $\frac{dC^*}{ds}$ and $\frac{dC^*}{dt}$ when productivity is exogenous. The derivatives of (12) are:

$$\frac{dF^*}{dt} = \frac{\partial F^*}{\partial M} \frac{dM}{dt} = \frac{1}{M} \left\{ \frac{1}{2} \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} \left[1 + \frac{d\lambda}{dM} \frac{M}{\lambda} \right] - \frac{\delta}{\lambda} \frac{M}{\lambda} \frac{d\lambda}{dM} \right\} \frac{dM}{dt} \quad (A.3.1)$$

$$= \frac{1}{M} \left\{ \frac{1}{2} \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} [1 + \varepsilon_{\lambda M}] - \frac{\delta}{\lambda} \varepsilon_{\lambda M} \right\} \frac{dM}{dt}$$

One should also note from (12):

$$1 - F^* = \frac{-\delta}{\lambda} + \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} \quad (A.3.2)$$

Using this (A.3.1) can be written:

$$\frac{dF^*}{dt} = \frac{\partial F^*}{\partial M} \frac{dM}{dt} = \frac{1}{M} \left\{ \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} \left(\frac{1 - \varepsilon_{\lambda M}}{2} \right) + (1 - F^*) \varepsilon_{\lambda M} \right\} \frac{dM}{dt} \quad (A.3.3)$$

We note that if λ is inelastic with respect to firm entry, i.e. $\varepsilon_{\lambda M} < 1$, this ensures that $\text{sgn} \frac{dF^*}{dt} = \text{sgn} \frac{dM}{dt}$. Since $\varepsilon_{\lambda M} < 1$ ensures that **Condition two** is satisfied, this means that $\varepsilon_{\lambda M} < 1$ and **Condition one** are sufficient for $\frac{dM}{dt} < 0$ and by implication $\frac{dF^*}{dt} < 0$ and $\frac{dC^*}{dt} < 0$ when productivity is exogenous.

$$\frac{dF^*}{ds} = \frac{\partial F^*}{\partial s} + \frac{\partial F^*}{\partial M} \frac{dM}{ds} = \frac{1}{M} \left\{ (1 - F^*) \varepsilon_{\lambda M} + \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} \left[\frac{1 - \varepsilon_{\lambda M}}{2} \right] \right\} \frac{dM}{ds} - \frac{1}{2s(\sigma-1)} \sqrt{\frac{s^{\sigma-1}\delta}{\lambda M}} \quad (A.3.4)$$

If $\varepsilon_{\lambda M} < 1$ and **Condition one** holds, this ensure that both terms in (A.3.4) are negative and $\frac{dF^*}{ds} < 0$ and $\frac{dC^*}{ds} < 0$ when productivity is exogenous.

References

- Albrecht, J., Navarro, L., Vroman, S., 2005. Modeling the effects of Labor Market reform in a Developing Economy. Mimeo; 2005.
- Amaral, P.S., Quintin, E., 2006. A competitive model of the informal sector. Journal of Monetary Economics 53, 1541–1553.
- Boal, W., Ransom, M., 1997. Monopsony in the labor market. Journal of Economic Literature 35, 86–112.
- Boeri, T., Garibaldi, P., 2006. Shadow sorting. CEPR Discussion Paper No. 5487.
- Burdett, K., Mortensen, D.T., 1998. Wage differentials, employer size, and unemployment. International Economic Review 39, 257–273.
- Byrne, D., Strobl, E., 2004. Defining unemployment in developing countries: evidence from Trinidad and Tobago. Journal of Development Economics 73, 465–476.
- Fortin, B., Marceau, N., Savard, L., 1997. Taxation, wages control and the informal sector. Journal of Public Economics 66, 293–312.
- Fugazza, M., Jacques, J.F., 2004. Labor market institutions, taxation and the underground economy. Journal of Public Economics 88, 395–418.
- Gong, X., van Soest, A., 2002. Wage differentials and mobility in the urban labor market: a panel data analysis for Mexico. Labour Economics 9, 513–529.
- Harris, J., Todaro, M., 1970. Migration, unemployment and development: a two-sector analysis. American Economic Review 40, 126–142.
- Heckman, J.J., Hotz, V.J., 1986. An investigation of the labor market earnings of Panamanian males: evaluating the sources of inequality. Journal of Human Resources 21, 507–542.
- Husmanns, R., 1994. International standards on the measurement of economic activity, employment, unemployment and underemployment. Bulletin of Labour Statistics, International Labour Organisation.
- Idson, T.L., Oi, W.Y., 1999. Workers are more productive in large firms. The American Economic Review 89, 104–108.
- ILO Employment Sector, 2002. Women and Men in the Informal Economy: A Statistical Picture. International Labour Office, Geneva.
- Lewis, W.A., 1954. Economic development with unlimited supplies of labor. The Manchester School 22, 139–191.
- Maclsaac, D., Rama, M., 1997. Determinants of hourly earnings in Ecuador: the role of labor market regulations. Journal of Labor Economics 15, 136–165.
- Manning, A., 2003. Monopsony in Motion, Imperfect Competition in Labor Markets. Princeton University Press.
- Marcelle, M., Strobl, E., 2003. Do smaller firms pay less in the Caribbean? The case of Trinidad and Tobago. The Journal of Development Studies 39, 181–198.
- Mazumdar, D., 1981. The Urban Labor Market And Income Distribution: A study of Malaysia. Oxford University Press for the World Bank, Oxford.
- Mortensen, D.T., 2003. Wage Dispersion: Why are Similar Workers paid differently? MIT Press.
- Mortensen, D.T., Pissarides, C.A., 1994. Job creation and job destruction in the theory of unemployment. Review of Economic Studies 61, 397–415.
- Pradhan, M., van Soest, A., 1995. Formal and informal sector employment in urban areas of Bolivia. Labour Economics 2, 275–297.
- Pratap, S., Quintin, E., 2006. Are labor markets segmented in developing countries? A semiparametric approach. European Economic Review 50, 1817–1841.

- Rauch, J.E., 1991. Modelling the informal sector formally. *Journal of Development Economics* 35, 33–47.
- Rebitzer, J., Taylor, L., 1995. The consequences of minimum wage laws: some new theoretical ideas. *Journal of Public Economics* 56, 245–255.
- Rosenbaum, P., Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70, 41–55.
- Rosenbaum, P., Rubin, D.B., 1985. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician* 39, 33–38.
- Sianesi, B., 2004. An evaluation of the active labor market programmes in Sweden. *The Review of Economics and Statistics* 86, 133–155.
- Schaffner, J.A., 1998. Premiums to employment in larger establishments: evidence from Peru. *Journal of Development Economics* 55, 81–113.
- Schneider, F., Enste, D.H., 2000. Shadow economies: size, causes, and consequences. *Journal of Economic Literature* 38, 77–131.
- Tansel, A., 1999. Formal versus informal sector choice of wage earners and their wages in Turkey. *Economic Research Forum Working Paper No. 9927*.
- Tybout, J., 2000. Manufacturing firms in developing countries: how well do they do and why? *Journal of Economic Literature* 38, 11–44.
- Velenchik, A.D., 1997. Government intervention, efficiency wages and the employer-size wage effect in Zimbabwe. *Journal of Development Economics* 53, 305–338.