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Abstract

This paper studies how informality reacts to fiscal policy instruments. We develop an analytical framework with a dual labor market with frictions, where the formal sector, in contrast to the informal sector, produces with technology using capital and pay taxes. We calibrate the model for the Colombian economy and quantify to what extent a decrease in payroll taxes is effective to create formal jobs in a context where government compensates for the reduction in revenues by using other fiscal instruments, such as reducing expenditure or increasing other taxes, e.g., consumption or capital income taxes.

Keywords: Informality, occupational choice, payroll taxes, fiscal policy.

JEL Classification: E24, E62, J01, J21, J32.

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1 Introduction

Informal workers are an essential component of total employment, mainly in developing countries. In most Latin American and Caribbean countries, more than half of total employment is informal. In the case of Colombia, although the recent decreasing trend, the informal sector accounts for around 48% of total employment. The magnitude of this phenomenon makes it relevant to assess the interaction of this sector with output and welfare and to incorporate direct and indirect impacts of policy intervention on the informality rate. This discussion becomes particularly crucial in fiscal policy analysis as firms and workers react to relative prices by reallocating formal and informal activities. The classical economic theory predicts that in a dynamic model, income taxes are more distorting than consumption and labor (payroll) taxes. Likewise, consumption taxes are the less disturbing ones. However, Emram & Stiglitz (2005) show that consumption taxes can be very distorting in the context of an economy where the informal sector is significant.

This paper studies the effect of tax policy on employment and outcome in a dual labor market framework. In particular, we analyze how the informal sector is an important channel to understand how variations in payroll taxes, consumption taxes, or capital taxes impact output and welfare in Colombia. We build a dynamic model with capital accumulation and dual labor market and introduce unemployment and informality to the Ramsey-Cass-Koopmans growth model with taxes in consumption, labor, and capital. We also model labor market frictions a la Mortensen & Pissarides (1994) considering two productive sectors, named, formal and informal. We propose a particular segmentation of the labor market, defining the formal sector as the labor that assumes search costs and pays taxes, but with higher wages. Moreover, the informal sector exhibits a lower productivity level, and then lower wages. Our analysis focuses on the effect of the tax policy's mechanisms, reducing the hiring cost as an instrument of job creation.

While the definition of informality can be approached from different points of view, its consequences on economic activity are not controversial[1]. The Informal sector is widely characterized by productive units that use labor intensively, but low levels of

[1]In section 2, we discuss the existing definitions of informality, and we will explain with what definition of informality we work.

capital. These workers do not have stable jobs, and wages and non-wage benefits are considerably low with respect to formal workers. Therefore, the size of the informal sector is strongly related to inequality and poverty. On the other hand, the presence of informality reflects the misallocation of productive factors. Informal enterprises have lower investment rates, which affect the long-run growth path. So, it is essential to assess the informality nature and its relation to economic activity to design and implement an economic policy aimed to revert this phenomenon and generate employment and welfare.

The economic distortions that increase informality also reduce output and employment in the most productive enterprises (Ulyssea, 2018). These firms also tend to be more capital-intensive. Consequently, informality depends not only on distortions in the labor market but also on distortions affecting capital accumulation. The increase in capital and productivity in the formal sector magnifies economic growth and reduces informality in countries with high informality (La Porta and Shleifer, 2008; La Porta and Shleifer, 2014).

In this context, it is crucial to understand the connection between capital accumulation, formal labor demand, and the tax system in an economy with informality. Tax policies would be relatively simple if countries did not need public spending to finance social policies, public goods, and the security of their citizens. Furthermore, financing the public sector without distortions could be possible if the governments could establish lump-sum taxes. Nevertheless, if society requires a certain amount of public goods, and it is impossible to establish lump-sum taxes, then the effect of individual taxes on informality must be carefully assessed. Furthermore, it is also essential to consider the effect of such policies on capital accumulation, economic growth, and long-term production.

Mortensen and Pissarides's modern labor market theory of search and matching incorporates the flow of workers between employed and unemployed as a critical element of the analysis (Mortensen and Pissarides, 1994). This theory overcomes some of the limitations of the traditional employment approach. For instance, in contrast to traditional theories, the Mortensen and Pissarides model allows for an adequate assessment of the temporary effect of economic policy on employment and worker welfare. Indeed, some policies, such as unemployment benefits, initially affect employment flows, and only over time, do they affect the level of employment

(Mortensen and Pissarides, 1999). Our paper takes this type of analysis as a framework, adding the formal-informal transitions to incorporate the essential characteristics of an economy with an informal labor market.

In recent years, emerged noteworthy literature applying the models of search and matching of Mortensen and Pissarides to an economy with informality. Some examples of this class of literature are Satchi and Temple (2009), Albrecht et al. (2009), Bosch and Esteban-Pretel (2012, 2015), Charlot et al. (2015) Dix-Carneiro et al. (2019), and Meghir et al. (2005), among others. The framework of Albrecht et al. (2009) has been used in Colombia by Florez (2014) to analyze the effect of unemployment benefits, formal lump-sum taxes, and a job creation subsidy on the unemployment rates, formal employment, and informal employment[2]. In sum, this branch of literature has focused on estimating the impact of labor market regulations on worker allocation between the formal and informal sectors. For instance, non-wage labor cost increases the informal sector's relative size that results in a segmented market labor market. The interaction between payroll taxes and informality is crucial for policy design to improve the labor market outcome and reduce informality. In fact, in many countries, including Colombia, non-wage labor costs such as payroll taxes have been used as an active policy to foster formal employment.

The problem with this literature is that it does not incorporate the accumulation of capital. Consequently, it can not analyze the effect of replacing payroll taxes with capital and consumption taxes on capital accumulation, economic growth, and long-term production. This kind of intervention must be studied in a dynamic general equilibrium framework that incorporates the government financing balance, as we propose in our paper.

There is abundant literature analyzing the role of fiscal and labor policies in economies

[2]Many studies have analyzed the effect of taxes and labor regulations on informality in Colombia. In this introduction, we will focus on general equilibrium models. An extensive empirical literature has been devoted to investigating the link between taxes and labor regulations and informal sector size (Nuñez, 2002; Kugler & Kugler, 2008; Cardenas, 2008. In particular, Núñez (2002) considered a micro-structured model and econometric estimations, obtaining that income tax encourages participation in the informal sector to avoid the fiscal burden. In turn, Kugler & Kugler (2008), using data from the Annual Survey of Manufacture Activity, measure the effect of labor income taxes on labor market composition for the period 1982-1996, inferring that reducing labor income tax by 10% enhances the ratio informal/formal workers in 1.4%. There are also studies relate to minimum wage. For instance, Mondragon et al. (2010) with the same data for the period 1984-2006 explore also the effect of the minimum wage informal sector size, concluding that wage rigidities increase the probability of being an informal worker.

with informality with computable general equilibrium (CGE) models (Fortin et al. 1997; Agenor and Aizenman, 1999; Bourguignon and Savard). In Colombian, several articles have analyzed the effect of taxes and external shocks on the size of the informal sector (Alm and Lopez, 2002; Arguello, 2016; Hernández,2020). This brand of literature helps to analyze the effect of different kinds of taxes on the sectoral assignment of factors in a static context. Even if some of these models introduce are dynamics (recursive dynamic CGE models), the evolution of the capital is the consequence of an ad-hoc investment function that is not justified by reference to modern economic theory. Because of the ad-hoc nature of the saving and investment decisions in the CGE models, they are not anymore the dominant paradigm in the modelization of the general equilibrium for policy analyses.

The dynamic general equilibrium models with rational expectations have taken this place in modern macroeconomics. In Fiess et al. (2010), for example, the intertemporal decisions of formal and informal agents and enterprises are determined by the maximization of an intertemporal utility function. Using a Dynamic Stochastic General Equilibrium (DSGE) model, they analyze the dynamic adjustment of investment, stock of capital, and informal labor to shocks in productivity and demand. In Colombia, authors like Botero et al. (2014), Osorio-Copete (2016), and Granda (2015) analyze the effect of income transfers taxes, and taxes on the level and the dynamic of informality. Granda and Hammann show that the saving patterns of workers and firms and their influence on aggregate savings and inequality are important to understand occupation choice and human capital accumulation (Granda, 2015; Granda and Hammann 2015; Granda et al., 2019).

We complement this literature by introducing the modern labor theory of searching and matching issues in a DSGE model with formal and informal sectors. Our contribution is twofold. First, we build a quantitative model allowing us to assess the dynamic of taxes on the flows and stocks of formal and informal workers, vacancies, job-finding rates, and unemployment. Second, we calibrate the model for the case of Colombia and calculate the effect of reductions of payroll taxes on the dynamic of labor the market outcomes, capital accumulation, and GDP. Under this framework, we can analyze labor market variables' interaction with the accumulation of capital in the short and long term.

The effect of a reduction in payroll taxes depends on the financing mechanism. When

this policy is financed with a decline in transfers, there is a reduction in informality and an increase in GDP and welfare. I the long term transfers increases, since the economy become more formal. When the reduction in payroll taxes is financed with consumption or profit taxes, the long-term effect on employment, output and welfare will depend on the magnitude of the increase on these taxes.

When the reduction in payroll taxes is financed with an increase in consumption taxes (this increase is such that the government expenditure remains constant and the present value of transfers does not change), informal employment decreases, and formal employment, investment, and output increase. Transfers initially decrease. In the long run, however, as the economy becomes more formal, and therefore the tax base increases, tranfers increase. On the other side, when the reduction in payroll taxes is financed with capital income taxes, the effect of this policy on reducing the size of the informal sector and promoting the creation of formal jobs is much lower than in the previous two policies. This is because, the increase in capital income taxes decreases investment and capital accumulation, which in turn disincentivizes the creation of formal jobs.

The rest of the paper is organized as follows. The second section presents the model set-up. The third section provides the methods and main assumption of the calibration. Fourth shows the main results, while Sixth summarizes our concluding remarks.

2 The Model

We propose a DSGE model with labor frictions incorporated through a matching process in a dual labor market with informality. We consider homogeneous agents and assume complete capital markets so that households can perfectly share risk.[3].Our economy consists of a close economy with households, government, and two types of firms, formal and informal. The representative household maximizes the utility by choosing consumption and leisure. In turn, consumption is a composite good

[3]Risk-sharing can also be a result of informal mechanisms. There is a wide literature showing that there is a high level, although not perfect, of risk-sharing among households in developing countries (see c.f. Townsend, 1995).

that combines formal and informal goods. Formal firms combine labor and capital to produce a good that can be used for consumption and investment. Wages in this sector, are determined by a Nash bargaining game. On the other hand, informal firms produce using labor-intensive technology with marginal decreasing returns. Wages in this sector equal the workers' marginal productivity. Finally, the government collects taxes from households and formal firms, makes transfers to households, and has an unproductive expenditure.

The concept of informality was introduced by Hart (1970) in a study for Kenya. In this study, the informal sector was defined as the proportion of the employees excluded from the more productive activities, employed in low productivity activities, and earning low wages. Even though the informality is well defined, there is no consensus on how to identify the employment component uniquely. Usually, firm size (as an indicator of low productivity), and the absence of contribution to the social security system, are operational definitions to measure the size of the informal sector. For instance, Tokman (1982) makes no distinction between informal workers and self-employees, while De Soto (1989) considered the informal sector as the set of firms operating outside government regulations. On the other hand, in Levenson & Maloney (1998), the informal sector is conformed to firms with five or fewer workers. Likewise, ILO (2006) defines informal workers as those salaried workers whose labor relation is not attained to labor legislation, tax system, social security system, or other employee benefits (firing compensations, vacations, etc.). While the Delhi Group provides a framework to measure the size of the informal sector from household surveys. In this case, informal workers are salaried workers in small firms (less than five workers), self-employed in non-professional activities, and workers in other occupations (such as domestic services and unpaid family workers)[4]. For the proposes of our model, we use the ILO's definition.

2.1 Households

Household maximizes the following intertemporal utility function choosing consumption and leisure

[4]Existing literature aiming to understand the role of the informal sector has focused on very specific aspects of informality. In some cases, informality is measured by activities of low productivity, but, on the other hand, informality includes productive firms operating illegally. Other definition makes reference to workers without social security coverage (Guzmán, 2007).

$$\underset{k_{t-1},c_t}{max}\, E_t \sum_{t=1}^{\infty} \beta^t \left[\frac{(C_t)^{1-\frac{1}{\psi}} - 1}{1-\frac{1}{\psi}} L_t^* - \varsigma \left(L_t^i + L_t^f \right) - \left(d^f \left(e_t^f \right)^{\kappa^f} + d^i \left(e_t^i \right)^{\kappa^i} \right) L_t^u \right], \quad (1)$$

where β is the intertemporal discount rate, and ψ the intertemporal elasticity of substitution, ς measures the utility cost of working. Furthermore, the utility cost of searching for a work is

$$d^f \left(e_t^f \right)^{\kappa^f} + d^i \left(e_t^i \right)^{\kappa^i},$$

where, $\kappa^f > 1$, $\kappa^i > 1$.

where c^f is the consumption of formal goods, while c^i is the consumption of goods produced in the informal sector. Each household is given by a continuum of agents that can be unemployed or employed either in the formal or informal sector. We denote labor income in the formal and in the informal sector as w_t^f and w_t^i, respectively. Firms and capital are owned by households, so that households receive labor income, capital returns at the rate R_t and dividends Div_t at each period as well as transfers from the government that depends on the occupation status.

We assume that households pay consumption taxes τ_t^c for the consumption of formal goods and labor income taxes τ_t^w if employed in formal jobs, and capital taxes τ_t^π. Finally, households can trade free-risk bonds with a return of r_t. Therefore, household's problem consists in maximizing the intertemporal utility function (1) subject to the budget constraint and the law of motion of capital :

$$\begin{aligned} &(1-\tau_t^w) w_t^f l_t^f + w_t^i l_t^i + (1-\tau_t^\pi)(R_t k_t + Div_t) \\ &+ (1 + (1-\tau_t^\pi) r_{t-1})\, b_{t-1} + T = P_t C_t + (1 - si_t) p_t^f i_t + \varkappa_n b_t. \end{aligned} \quad (2)$$

$$\varkappa_n k_{t+1} = (1-\delta) k_t + i_t - \Psi_t k_t, \quad (3)$$

where

$$\Psi_t = \frac{\eta}{2} \left(\frac{i_t}{k_t} + (1-\delta) - \varkappa_n \right)^2$$

is the adjustment cost to capital, k_t is the stock capital level, i_t is investment level, δ denotes depreciation rate, b_t are bonds holdings, P_t is the general price index and p_t^f is the price of the formal good. T are fixed transfers from the government to the households.

The first order conditions can be written as follow

$$(c_t)^{-\frac{1}{\psi}} \varkappa_n = (1 + (1 - \tau_t^{\pi}) r_t) \beta E_t (c_{t+1})^{-\frac{1}{\psi}},$$

$$\frac{p_t^f \varkappa_n}{(1 - \Psi_t')} = \beta E_t \left(\frac{c_{t+1}}{c_t} \right)^{-\frac{1}{\psi}} \left[(1 - \tau_{t+1}^{\pi}) R_{t+1} + \frac{p_{t+1}^f}{(1 - \Psi_{t+1}')} \left((1 - \delta) - \left(\Psi_{t+1} - \Psi_{t+1}' \frac{i_{t+1}}{k_{t+1}} \right) \right) \right],$$

where $\Psi_t' = \eta \left(\frac{i_t}{k_t} + (1 - \delta) - \varkappa_n \right)$.

Additionally, the perfect risk sharing assumption implies

$$(C_t)^{-\frac{1}{\psi}} = (c_t^w)^{-\frac{1}{\psi}} = (c_t^u)^{-\frac{1}{\psi}},$$

As consequence, $c_t^w = c_t^u$. Aggregating among the household members, we have:

$$c_t^w (1 - u_t) + c_t^u u_t = C_t$$

Formal and informal goods are perfect substitutes. As a consequence:

$$P = 1 = p_t^i = (1 + \tau_t^c) p_t^f$$

$$p_t^f = \frac{1}{1 + \tau_t^c}$$

2.2 Search and Matching in a dual labor market

We assume a dual labor market economy, where households have an occupational choice over three alternatives: employed in the formal sector, employed in the informal sector, or unemployed. Total labor supply (L_t^*) is exogenous and equivalent to the total population that grows at a exogenous rate $\varkappa_n$. In equilibrium we have:

$$1 = l_t^i + l_t^f + l_t^u, \tag{4}$$

where

$$l_t^i = \frac{L_t^i}{L_t^*}, \quad l_t^f = \frac{L_t^f}{L_t^*}, \quad l_t^u = \frac{L_t^u}{L_t^*},$$

L_t^i is the number of workers in the informal sector, L_t^f the number of formal workers and L_t^u the number of unemployed.

Employment in the formal sector is the result of a matching process. Firms post vacancies while an unemployed search for a job, after meeting they sign a contract. The matching process follows a constant return to scale given by:

$$\mathbb{N}_t = M\left(v_t\right)^{\mu}\left(e_t^f l_t^u\right)^{1-\mu}, \tag{5}$$

where v_t is the number of current vacancies in the formal sector, e_t^f is the effort level of a unemployed to search for a job in the formal sector, l_t^u is the number of unemployed, and M is a constant. In our context job-to-job transition is not possible. Informal workers might transit to a formal job through unemployment.

Firms fill a vacancy with probability q_t which is equal to the ratio between number of matched labor relations to the number of vacancies, i.e:

$$q_t = \frac{M\left(v_t\right)^{\mu}\left(e_t^f l_t^u\right)^{1-\mu}}{v_t} = M\left(\theta_t\right)^{\mu-1}, \tag{6}$$

where $\theta_t = \frac{v_t}{e_t^f l_t^u}$ measures the labor market tightness.

Following Frediksson & Holmlund (2003) and Cahuc & Lemman (2000), the probability that an unemployed j finds a job in the formal sector depends on the number of matched relations and the relative level of searching effort respect to the total effort exerted by all unemployed. That is:

$$\frac{e^f_{jt}}{e^f_t l^u_t} M v^\mu_t \left(e^f_t l^u_t\right)^{1-\mu} = e^f_{jt} q_t \theta_t.$$

There is not matching process in the formal sector; however, to find a job opportunity in this sector, the unemployed also must exert effort. The probability of finding a job in this sector is ξe^i_{jt}, where ξ is a positive parameter and e^i_{jt} is the effort level to find a job in the informal sector. We also assume that formal jobs are destroyed at an exogenous rate σ and that for an informal job is Ω. Then, the employment law of motion are:

$$\varkappa_n l^f_{t+1} = e^f_t q_t \theta_t l^u_t + (1-\sigma) l^f_t. \tag{7}$$

$$\varkappa_n l^i_{t+1} = e^i_t \xi l^u_t + (1-\Omega) l^i_t. \tag{8}$$

2.3 Firms

We consider two types of firms. They differ in production technology and tax payments. In particular, the formal firms use capital and pay capital (τ^π_t) and payroll (τ^{ew}) taxes. Informal firms can avoid taxation.

2.3.1 Informal firms

The informal sector has a competitive labor market with low productivity. At each period, l^i_t units of labor are hired to produce y^i_t units of informal goods. Under these assumptions, informal sector technology can be written as

$$y^i_t = z_t b^i \left(l^i_t\right)^\varphi, \tag{9}$$

where z_t is the technological progress of the economy and b^i is the relative productivity of informal sector respect to the formal sector, $\varphi \in (0,1)$. Wages in this sector are equal to the labor productivity, which is given by

$$w_t^i = p_t^i z_t b^i \left(l_t^i\right)^{\varphi-1}. \tag{10}$$

In equilibrium $y_t^i = c_t^i$.

2.3.2 Formal firms

Formal firms create vacancies with a fixed cost c_v per period. The value function of a vacancy J_t^v is

$$J_t^v = -(1-\tau_t^\pi)p_t^f c_v + E_t\left[\Gamma_{t+1}\left(q_t J_{t+1}^o + (1-q_t)J_{t+1}^v\right)\right],$$

where $p_t^f c_v$ represents the gross cost to create a vacancy. This cost reduces firm's profits by paying taxes $\tau_t^\pi p_t^f c_v$. Then, the net cost of a vacancy will be $(1-\tau_t^\pi)p_t^f c_v$. This value function also points out that the vacancy is not filled with probability $(1-q_t)$, and in this case, the continuing value is J_{t+1}^v. The free entry condition states that $J_t^v = 0$, implying that in equilibrium

$$(1-\tau_t^\pi)p_t^f c_v = E_t\left[\Gamma_{t+1}\left(q_t J_{t+1}^o\right)\right], \tag{11}$$

where Γ_{t+1} is the stochastic discount rate, given by $\Gamma_{t+1} = \beta\left(\frac{c_{t+1}}{c_t}\right)^{-\frac{1}{\psi}}$.

In turn, a filled vacancy produces y_{jt}^f units using the following technology

$$y_t^f = F(k_t, l_t^f) = z_t\left(\zeta\left(k_t\right)^{\frac{\gamma-1}{\gamma}} + (1-\zeta)\left(l_t^f\right)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}}, \tag{12}$$

$$\hat{y}_t^f = \frac{y_t^f}{l_t^f} = F(\hat{k}_{jt}, 1) = z_t\left(\zeta\left(\hat{k}_t\right)^{\frac{\gamma-1}{\gamma}} + (1-\zeta)\right)^{\frac{\gamma}{\gamma-1}}, \qquad \hat{k}_t = \frac{k_t}{l_t^f}.$$

Solving the firm's problem, we can deduce the capital demand from

$$R_t = p_t^f \frac{\partial F(\hat{k}_t, 1)}{\partial \hat{k}_t} = p_t^f \alpha_t \frac{\hat{y}_t^f}{\hat{k}_t} = p_t^f \alpha_t \frac{y_t^f}{k_t},$$

where

$$\alpha_t = \begin{cases} \zeta & if \;\; \gamma = 1 \\ \frac{\zeta (k_t)^{\frac{\gamma-1}{\gamma}}}{\zeta (k_t)^{\frac{\gamma-1}{\gamma}} + (1-\zeta)(l_t)^{\frac{\gamma-1}{\gamma}}} & if \;\; \gamma \neq 1 \end{cases} \tag{13}$$

where R_t is the rent cost of capital. Likewise, the average profit per worker, after capital rent costs, will be

$$\begin{aligned} \Pi_t = p_t^f F(\hat{k}_t, 1) - p_t^f \frac{\partial F(\hat{k}_t, 1)}{\partial \hat{k}_t} k_t - (1 + \tau^{ew})\, w_t^f \\ = (1 - \alpha_{jt})\, p_t^f \hat{y}_t^f - (1 + \tau^{ew})\, w_t^f, \end{aligned}$$

Regarding dividends, households receive profits net to gross vacancy cost given by $Div_t = \Pi_t l_t^f - p_t^f c_v v_t$.

A filled vacancy generates $(1 - \tau^{\pi})\Pi_t$ at a given t. In the following period, either the job is destroyed and firms assume the vacancy cost or produce the value J_{t+1}^o with probability $(1 - \sigma)$. Therefore, the function value is:

$$J_t^o = (1 - \tau^{\pi})\,(\Pi_t) + E_t\left[\Gamma_{t+1}\left(\sigma J_{t+1}^v + (1-\sigma) J_{t+1}^o\right)\right], \tag{14}$$

In equilibrium, under $J^v = 0$, equation (14) reduces to

$$J_t^o = (1 - \tau^{\pi})\Pi_t + E_t\left[\Gamma_{t+1}(1-\sigma) J_{t+1}^o\right], \tag{15}$$

2.4 Workers

An unemployed can find a job in the informal sector with probability ξe_t^i, and in the formal sector with probability $e_t^f q_t \theta_t$. We assume that informal workers must become unemployed in order to look for a job in the formal sector. A hired worker in the formal sector received a wage equivalent to $(1 - \tau_t^w) w_t^f$. With probability $(1 - \sigma)$ the

worker keeps the job and obtain an expected value given by Q^f_{t+1}. Otherwise, the same worker becomes unemployed obtaining Q^u_{t+1}. Hence, the present discounted value of being employed in the formal sector is

$$Q^f_t = (1-\tau^w_t)w^f_t + T^f_t - \frac{\varsigma}{(C_t)^{-\frac{1}{\psi}}} + E_t\left[\Gamma_{t+1}\left(\sigma Q^u_{t+1} + (1-\sigma)Q^f_{t+1}\right)\right] \tag{16}$$

Analogously, in the informal sector, workers receive w^i_t. In the following period, she will obtain Q^u_{t+1} with probability Ω and Q^i_{t+1} with in case of stay as an informal worker with probability $(1-\Omega)$. Therefore:

$$Q^i_t = w^i_t + T^i_t - \frac{\varsigma}{(C_t)^{-\frac{1}{\psi}}} + E_t\left[\Gamma_{t+1}\left(\Omega Q^u_{t+1} + (1-\Omega)\, Q^i_{t+1}\right)\right]. \tag{17}$$

Similarly, the value function of the unemployed Q^u_t is given by:

$$\begin{aligned} Q^u_t = T^u_t - \frac{d^f\left(e^f_t\right)^{\kappa^f} + d^i\left(e^i_t\right)^{\kappa^i}}{(C_t)^{-\frac{1}{\psi}}} \\ + E_t\left[\Gamma_{t+1}\left(e^f_t q_t\theta_t Q^f_{t+1} + \xi e^i_t Q^i_{t+1} + \left(1 - e^f_t q_t\theta_t - \xi e^i_t\right) Q^u_{t+1}\right)\right] \end{aligned} \tag{18}$$

In this case, individuals obtain utility equal to ς from leisure and costs $\frac{d^f}{\kappa^f}\left(e^f_t\right)^{\kappa^f}$ and $\frac{d^i}{\kappa^i}\left(e^i_t\right)^{\kappa^i}$ related to job search in the formal and informal sector, respectively. In the period $t+1$, an individual finds a formal job with probability $e^f_t q_t\theta_t$, and an informal job with probability ξe^i_t. Each period, the effort levels e^f_t, e^i_t are chosen such that the present value of unemployed is maximized. As q_t and θ_t depend on the aggregated effort levels, $q_t\theta_t$ is taken as given by the individuals. Accordingly, the aggregate effort is such that the marginal cost and marginal benefits of searching for formal and informal jobs are equal. That is, the first order conditions of maximizing Q^u_t are:

$$-d^f\kappa^f\frac{\left(e^f_t\right)^{\kappa^f-1}}{(C_t)^{-\frac{1}{\psi}}} + E_t\left[\Gamma_{t+1}\left(Q^f_{t+1} - Q^u_{t+1}\right)q_t\theta_t\right] = 0$$

$$-d^i \kappa^i \frac{\left(e_t^i\right)^{\kappa^i - 1}}{\left(C_t\right)^{-\frac{1}{\psi}}} + E_t \left[\Gamma_{t+1} \left(Q_{t+1}^i - Q_{t+1}^u\right) \xi\right] = 0.$$

The marginal benefit of searching for a job in the formal sector depends on the difference between the value of being a formal worker and unemployed, i.e. $Q_{t+1}^f - Q_{t+1}^u$, and on the probability of finding a job. Analogously result is obtained for the case of the informal sector.

2.5 Formal wages

As a consequence of the labor market frictions, formal firms make monopolistic profits. Wages are determined by a Nash bargaining game. Defining ϕ as the worker's bargaining power, and given that $J_t^v = 0$, firms and workers choose w_t^f that solves the following optimization problem

$$\max_{w_t^f} \Phi = \left(J_t^o\right)^{1-\phi} \left(Q_t^o - Q_t^u\right)^{\phi}.$$

The solution to this problem is given by

$$\phi(1 - \tau_t^w) J_t^o = (1 - \phi)(1 - \tau_t^\pi)(1 + \tau_t^{ew})(Q_t^f - Q_t^u), \tag{19}$$

Interestingly, wages depend on labor income taxes and payroll taxes.

2.6 Government

We assume that government has balanced budget constraint at every period. It must be satisfied that:

$$p_t^f g_t + T + p_t^f i_t = \left(\tau_t^w + \tau_t^{ew}\right) w_t^f l_t^f + \tau_t^\pi (R_t k_t + Div_t) + \tau_t^c p_t^f c_t^f, \tag{20}$$

2.7 Equilibrium

The market clearing condition are the following

$$y_t^i = c_t^i, \tag{21}$$

$$y_t^f - c_v v_t = c_t^f + i_t + g_t \tag{22}$$

$$C_t = c_t^f + c_t^i \tag{23}$$

$$Output = y_t^f + y_t^i = c_v v_t + C_t + i_t + g_t$$

$$GDP_t = y_t^i + p_t^f y_t^f - p_t^f c_v v_t + \tau_t^c p_t^f c_t^f + \tau_t^c p_t^f g_t = C + g_t + p_t^f i_t$$

3 Calibration

This section briefly describes the main assumptions under which the model is calibrated. Some parameters, standard in the literature, are fixed based on previous studies for the Colombian economy and other developing countries. We set the intertemporal elasticity of substitution $\psi = 2/3$ as in Ojeda et al. (2016). The quarterly discount factor is set at $\beta = 0.986$ based in the estimations of Bonaldi et al. (2009). This implies a monthly discount factor of $\beta = 0.995$. Following Blanchard & Diamond (1989) we fix $\mu = 0.5$, and $\phi = 0.5$.

For the population growth, we use the monthly growth rate of the Economically Active Population from the household survey (GEIH for their acronyms in Spanish) for the year 2019, which is $\varkappa_n - 1 = 0.11\%$. We use the effective tax rates estimated in

Rincon (2018) for the Colombian economy. In order to account for the fact that taxes are only paid by the formal sector, the taxable base value is measure with respect to formal consumption, formal wage mass, and formal firms' profits. As a result, the effective tax rates are set equal to $\tau^c = 16.62\%$, $\tau_t^{ew} = 23.37\%$, $\tau_t^w = 9.12\%$, and $\tau_t^\pi = 13.9\%$. Based on Colombian household survey to characterize formal and informal labor markets monthly flows, we set

$$jfr_f = e_t^f q_t \theta_t = 4.80\%; \quad jfr_i = e_t^i \xi = 7.93\% \quad \sigma = 1.01\% \quad \Omega = 2.06\%$$

where jfr_f and jfr_i are the probability that an unemployed finds a formal an informal job, respectively. For simplicity, we set the parameter that measures the utility cost of working equal to zero $\varsigma = 0$.

Tabla 1. Parameters values

Parameter	**Symbol**	**Value**
Intertemporal elasticity of Substitution	ψ	2/3
Discount rate	β	0.995
Elasticity of matching function	μ	0.5
Workers' Bargaining power	ϕ	0.5
1+Population growth rate	$\varkappa_n$	1.0011
Consumption tax rate	τ^c	16.62%
Payroll tax rate	τ^{ew}	23.37%
Labor income tax rate	τ^w	9.12%
Capital income tax rate	τ^π	13.9%
Depreciation rate	δ	0.84%
Utility cost of working	ς	0

In addition, we use the steady state equations in order to match the value of a set of parameters. In particular, with information from the System of National Accounts (SNA), we define the following targets.

$$l^f = 47.8\%, \; l^i = 41\%, \; l^u = 11.2\%$$

$$\frac{G}{PIB} = 15.8\% \quad \frac{w^f}{w^i} = 1.391; \quad y_t^i + p_t^f y_t^f - p_t^f c_v v_t = 1; \quad e_t^f = 1 \quad e_t^i = 1$$

We also estimate the wage gap between formal and informal sector. Using data from 2008 to 2019, and using the same definition of informality used by the National Department of Statistics (DANE for their acronym in Spanish) we find that gap between formal and informal sector is 39.1%. Finally, base on Cardozo (2019), who estimate that the time to fill a vacancy in Colombia is 1.35 months, we set $q = 0.5232$. The rest of parameters of the model are calibrated in order to match these features of the Colombian economy.

Tabla 2. Calibrated parameters values

Parameter	**Symbol**	**Value**
Fixed probability to find an informal job	ξ	7.93%
Elasticity of substitution between capital and formal labor	γ	1.0863
Returns to scale of the informal production function	φ	0.84
Weight of capital in the formal production function	ζ	31.16%
Vacancy cost	c_v	11.41
Weight in the utility cost of searching for a formal job	d^f	0.531
Weight in the utility cost of searching for an informal job	d^i	0.176
Job destruction rate in the formal sector	σ	1.01%
Job destruction rate in the informal sector	Ω	2.06%
Scale factor matching function	M	0.158
Transfers to households	T	0.0872
Informal sector productivity	b_i	0.789
Total productivity	z	0.56

4 Simulations

We construct counterfactual scenarios to assess how the informal sector, output, and welfare vary with different fiscal policies. There is a wide discussion about the ef-

fect of payroll taxes as a barrier to creating formal jobs. In fact, Colombia and other developing countries have historically used this kind of policy as an instrument to promote formal jobs, which has motivated a number of papers to explore the general equilibrium effect of such policies (see for instance Granda, 2015 and Granda & Hamann, 2015). In particular, we focus the analysis on a reduction in payroll taxes but considering the trade-off faced by the government that requires fiscal balance either reducing transfers or increasing government revenue from other tax sources. This trade-off is crucial since payroll taxes are used for social investment such as family welfare funds, technical services training, early childhood protection so the government must find revenue sources. As a benchmark, we consider a reduction of 5 percentage points (pp.) in τ^{ew} that is financed by one of the following policies: i. reduction of transfers, keeping goverment expenditure constat, ii. Increase in consumption tax, such that Government expenditure G remains constant, and the present value of transfers is the same. and iii. increase on income capital taxes to keep G constant and the same present value of transfers. Our interest is to study how the use of different fiscal instruments determines the transition to the steady-state.0.241741- 0.05

Figure 1 shows the dynamics of employment, transfers, output, consumption, investment, and capital when the government finances a decrease on payroll income taxes of 5 pp (from 23.37% to 19.37%) by decreasing transfers. Under this policy, formal employment increases while informal employment decreases, and unemployment slightly increases. Notice that initially transfers decrease, but in the long run, due to the higher size of the formal sector and higher capital accumulation, transfers increase. On the other hand, output and welfare also increase. Table 3 shows that under this policy, at the steady-state, informal employment reduces 3.53 pp, and the formal sector increases by 3.15 pp. The increase of output at the steady-state is 4.28%, while transfers increase by 0.26%. Overall, this policy increases welfare by 7.11%.

Figure 1 Effect of a reduction in τ^{ew} financed with Transfers

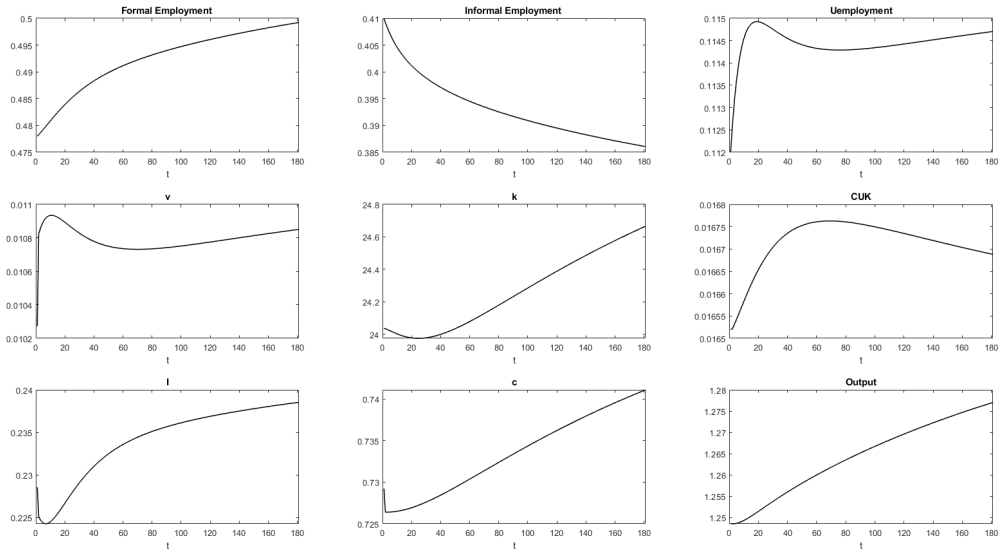

Table 3. Steady-state effect of a reduction in τ^{ew} financed with Transfers:

	Steady State
Informal sector (l^i)	-3.53 pp.
Formal sector (l^f)	3.15 pp.
Unemployment (l^u)	0.37 pp.
Output (△%)	4.28%
Transfers(△%)	0.26%
Welfare	**7.11%**

Source: Authors calculations. SS: Steady state.

Figure 2 shows the dynamics of employment, transfers, output, consumption, investment, and capital when the government finances a decrease of 5 pp on payroll income taxes, with an increase on consumption tax. The increase in the consumption tax is such that the government expenditure remains constant, and the present value of transfers does not change. We can observe that under this policy, informal employment decreases and formal employment, investment, and output increase.

At the Steady-State, informal employment increases by 1.70 pp, while formal employment increases by 1.52 pp (see table 4). Under this policy, welfare increases by 3.4%.

Figure 2 Effect of a reduction in τ^{ew} financed with consumption taxes τ^{c}

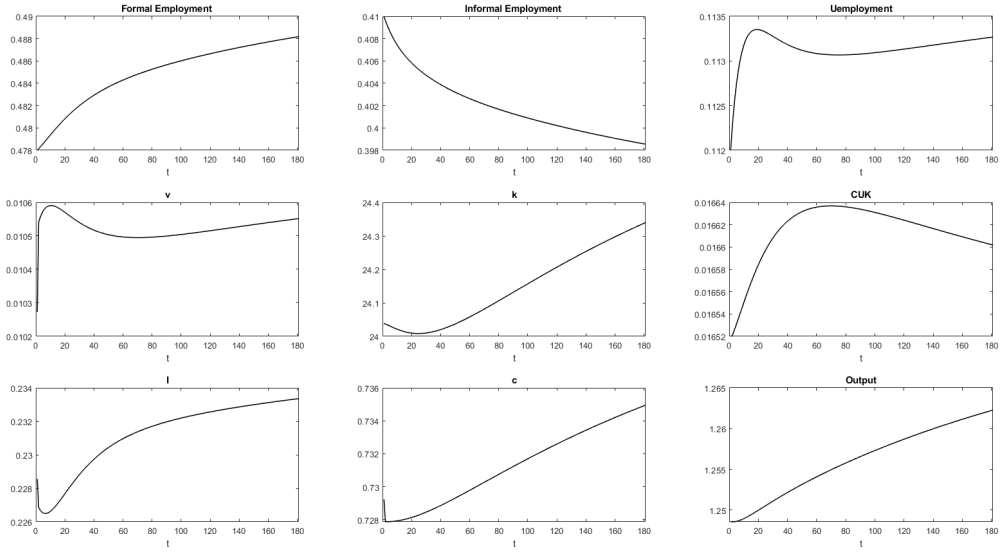

Table 4. Steady-state effect of a reduction in τ^{ew} financed with consumption taxes τ^{c}

	SS
Informal sector (l^i)	- 1.70 pp.
Formal sector (l^f)	1.52 pp.
Unemployment (l^u)	0.18 pp.
Output ($\triangle\%$)	2.07 pp.
Tansfers($\triangle\%$)	0.43 pp
Consumption tax τ^{c}	2.52 pp
Welfare	**3.4%**

Source: Authors calculations. SS: Steady state.

Finally, Figure 3 shows the dynamics of employment, transfers, output, consumption, investment, and capital when the government finance a decrease of 5 pp on payroll income taxes, with an increase in capital income taxes. As in the previous exercise, the increase in capital taxes is such that the government expenditure remains constant and the present value of transfers does not change. The effect of this policy on promoting the creation of formal jobs is lower than in the previous case. The increase in capital income taxes decreases investment, capital accumulation and output. Table 5 shows that, under this policy, at the steady-state informal employment decreases by only 034 pp. and formal employment increases by 0.29 pp. Finally, we have that under this policy, welfare increases by 0.42%.

Figure 3 Effect of a reduction in τ^{ew} financed with capital income taxes τ^{π}

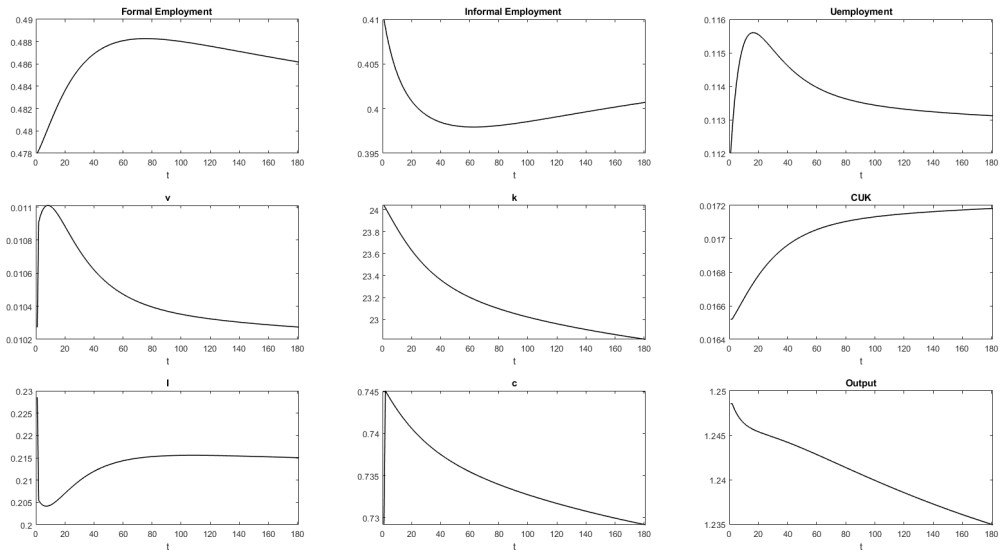

Table 5. Steady-state effect of a reduction in τ^{ew} financed with capital income taxes τ^{π}

	SS
Informal sector (l^i)	-0.34 pp.
Formal sector (l^f)	0.29 pp.
Unemployment (l^u)	0.06 pp.
Output (△%)	-2.08 pp.
Tansfers (△%)	-0.40 pp.
Capital income tax τ^π	3.75 pp
Welfare	**0.42%**

Source: Authors calculations. SS: Steady state.

5 Concluding remarks

The informal sector has become an important source of employment in developing countries. This sector is characterized by small production units with low productivity, where workers usually do not contribute to the social security system. In the last decades, it has been discussed to what extent labor costs, such as minimum wage or payroll taxes are causing higher informality rates. We propose an analytical framework that enables us to understand how fiscal policy, as a reduction in payroll taxes, might play a role in the reduction of informal sector size. The proposed model considers that an individual chooses between being either a formal worker, informal worker, or unemployed in a labor market with search frictions. We include capital accumulation and taxes to distinguish between the formal and informal sectors.

We calibrate the model for the Colombian economy. Since payroll taxes are used to finance social programs, the government faces a trade-off to keep fiscal balance. Therefore, our simulations consist of studying how labor composition, output, and welfare are adjusted in the short run and the steady-state when government promotes the reduction of payroll taxes as a labor formalization instrument, considering possible alternatives to compensate for the reduction in government revenues.

Results suggest there are general equilibrium effects related to fiscal instruments and their impact on output and informality rate. In particular, when the government exchanges payroll taxes by consumption or capital income taxes, there is a smaller impact on output and employment, in the long run. In the case of increasing capital income tax to keep fiscal balance, although hiring formal workers is less costly,

the impact on capital accumulation results in a lower increase on output formal employment. These results are crucial for labor policy design showing that informality is not the only consequence of direct labor cost, but also depends on labor market frictions and aggregate productivity level of the economy.

Colombia managed to reduce the informality rate in the last years as a result of combining payroll taxes cutting and reductions in capital taxes to promote capital accumulation. This has coincided with an increase in the tax rate on high-income salaried workers. A natural extension of our model consists of incorporating the trade-offs in the human capital accumulation and the redistributive effects of the fiscal instruments to explain the changes in informality patterns.

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