Tax Policies and Informality in South Africa

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Abstract

We apply a new micro-macro simulation approach in order to evaluate the effects of labor income tax policies in South Africa. In particular, we consider the introduction of a proportional tax system and a lump-sum tax system instead of the current progressive taxation. We quantify the effects of these tax policies on individual's labor supply choices (formal/informal employment, work/leisure), as well as on the level of GDP, equilibrium wages, and the size of the informal sector. In all, our results suggest that the proportional tax system is inappropriate as it decreases labor participation, increases employment in the informal sector, produces a negative effect on GDP and increases inequality and poverty. On the contrary, the lump-sum tax system, although difficult to implement, has a positive effect on participation, reduces the size of the informal sector, increases GDP, but also increases income inequality and poverty.

JEL Classification: J22; H24; O17; C68

Key-words: Tax Reform; Informal Sector; Labor Supply; CGE Model; Microsimulation

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1 Introduction

Unlike the advanced countries, the developing countries have a large informal sector that fails to comply with tax authorities. In this context, it is interesting to study the way a tax change modifies the behavior of persons on the labor market, the amount of government revenues and the level of poverty and inequality. Developing countries face difficult challenges when they attempt to establish efficient tax systems given their weak direct and indirect tax capacity. The tax revenue-GDP ratio is a good measure for direct taxation efficiency. This ratio is usually higher in developed countries than in poor countries (McLaren, 1998).[1]

The fundamental distinction between the formal and the informal sector is related to tax payment, where the informal sector is the tax free option. Informality has a direct impact on public revenues, thus it accounts for fiscal policy analysis. Informality was traditionally viewed as a low-productive and low-paid activity sector, an option for workers who cannot find a formal job. But recent economic analysis suggests that informal employment may be voluntary. Maloney (1999) considers that workers are self-selected into the informal sector because of the various benefits and opportunities that it can offer implying the existence of comparative advantages in the informal sector. Subject to job availability, workers choose the sector of activity that maximizes their utility. Obviously wages are important determinants of the utility. However there are non-monetary advantages, like autonomy, flexibility, distance to work and working hours, which affect utility, determine job satisfaction and make desirable the informal employment.[2] Thus, depending on their characteristics, some workers choose the informal sector (Günther and Launov, 2012). Using data from Argentina, Pratap and Quintin (2006) conclude, after controlling for individual and firm characteristics, on the absence of a formal sector wage premium and thus reject the segmentation hypothesis in the labor market. El Badaoui *et al.* (2008) find similar results for South Africa. Evidence from Mexico (Gong and van Soest, 2002; Gong *et al.*, 2004) is also consistent with such view of the informal activity as an attractive option.

In countries where the labor market is characterized by the existence of a large informal sector, the tax policy plays a significant role as it modifies the relative (formal/informal) wage and thus affects the individual's labor supply decision (Fugazza and Jacques, 2004; Johnson *et al.*, 1998) and the size of the informal sector in the economy. In the literature,

[1] For instance, this ratio is equal to 37.9% for OECD countries and 18.2% for developing countries over the period 1995-1997 (Tanzi and Zee, 2000). Tanzi (1987) focuses on the high reliance of low-income countries on indirect taxation (61% of total tax revenue on average) while indirect taxation represents 36.4% of total tax revenue in high-income countries.

[2] See, for instance, Mulinge and Mueller (1998) and Saavedra and Chong (1999).

several studies attempt to analyze the link between the informal sector and taxation. According to Gutmann (1977), higher taxes increase the size of the informal economy.[3] Using a simple AK-type endogenous growth model, Loayza (1996) shows that the informal sector arises when governments with weak enforcement capacity/technology impose excessive taxes and regulations. As the AK framework does not generate the transitional dynamics of the informal sector perceived in actual economies, Ihrig and Moe (2004) propose a simple dynamic model consistent with the empirical observation. The model captures the negative and convex relationship between the size of the informal sector and the real GDP per capita. Moreover, the study shows that a reduction in tax rates plays a significant role in attracting people out of the informal sector and thus improves the standard of living in the economy. The authors show for Sri Lanka that simply raising the tax rate from 9.3% to 10%, holding enforcement constant, generates more than a 2.3% increase in the informal employment in steady state.[4] Saracoglu (2008) proposes a dynamic general equilibrium model with heterogeneous goods and an endogenous price for the informal sector good. The model shows that the informal sector diminishes over time as the economy grows and, more importantly, a lower tax on employment in the formal sector reduces the size of the informal sector. For high-income countries, Fugazza and Jacques (2004) show that lower taxation stimulate participation in the formal sector. In Lemieux *et al.* (1994), an increase in the tax rate drives people to reallocate labor from the formal to the informal sector. Using a data set collected in Québec City in Canada, they found that this relation is significant for particular groups of the population such as social-welfare claimants.

In this paper, we analyze the impact of two tax policies in South Africa using a Micro-Macro simulation approach that combines a Microsimulation model and a CGE (Computable General Equilibrium) model. The integration of these two types of models, widely used in policy analysis, allows to benefit from their respective advantages. In particular, it allows to evaluate the individual and the macro effects by taking into account both the individual heterogeneity present in a micro data-set and the general equilibrium effects. Our analysis is carried out using a new Micro-Macro simulation approach developed by Magnani and Mercenier (2009). This approach is based on the exact aggregation theory of Anderson *et al.* (1992) according to which individuals, who have to make a choice among a set of discrete alternatives, may be aggregated in a representative agent with CES preferences. In our paper, we assume that individuals face a discrete choice problem and have to choose among three alternatives: not working, working in the formal sector and working

[3]Even though reducing tax rates is not the only policy that may discourage tax evasion, it allows to evaluate some alternative tax policies.

[4]The authors define the size of the informal sector as the fraction of total labor hours devoted to informal work.

in the informal sector. We assume that workers compare the costs and benefits of each alternative and choose the option that maximizes their utility given their preferences and job characteristics. The exact aggregation procedure allows us to aggregate individual preferences into explicit labor supply functions that we introduce in a CGE model. The CGE model is then used to evaluate the macro effects of different tax policies and, in particular at the national and sectoral levels and on the equilibrium prices and wages. These results are then introduced in the Microsimulation model in order to evaluate the individual behavior on the labor market and the effects on the income distribution, inequalities and poverty.

South Africa is an interesting case study. The South African government has been particularly successful in collecting direct taxes - through a progressive tax system - in the form of corporate and personal income taxes. The tax represents, over the period 1997-2002, 25% of the South African GDP, the highest among middle-income countries for which the average ratio is 15%. However taxing the informal sector remains much less successful mainly because the cost of collections is too high. Thus there are still many South Africans who remain outside the tax net. According to the 2007 Labour Force Survey, 19.5% of employed workers operate in the informal sector in South Africa.[5]

The paper is organized as follows. In Section 2, we specify the individual discrete choice problem and present the micro analysis results. The CGE model used in this paper is presented in Section 3. Section 4 is a short description of the South African tax system. In Section 5, we analyze the micro and macro effects of tax reforms on the labor market participation and the formal/informal employment decisions. Conclusions are given in Section 6.

2 The Individual Discrete Choice Problem

2.1 Model Specification

In this paper we estimate a discrete choice labor supply model in which individuals are assumed to choose among three options of economic activity: (1) to work in the formal sector, (2) to work in the informal sector, and (3) not to work. We specify a nested logit model (McFadden, 1981) with two nests B_k.

The decision concerning labor market status is based on utility comparisons. Individual

[5] At the enterprize level, several studies consider that the high entry costs into the formal economy explain the presence of a large informal sector in developing countries. Djankov *et al.* (2002) report that becoming formal in South Africa requires the completion of 7 procedures that take 30 business days, the cost of which represents 36.7% of the 1997 GDP per capita. Kugler and Kugler (2009) show that a 10% increase in payroll taxes in Columbia reduces formal employment by between 4% and 5%.

preferences are described by the following utility function:

$$u_{hjk} = U_{hjk} + V_{hk} + \epsilon_{hjk} \tag{1}$$

where h indexes individuals, $k \in \{l, L\}$ denotes the labor (l) and the leisure (L) status and $j \in \{1, 2, 3\}$ indexes, respectively, formal/informal employment activity and not to work. Thus, each labor market option is uniquely identified by a double index jk. V_{hk} represents the upper nest specific component, U_{hjk} the alternative specific component, and ϵ_{hjk} the error term that is assumed to follow a generalized extreme value (GEV) distribution.

We assume that choices depend on annual wages. For each alternative jk, the alternative specific component U_{hjk} is defined as follows:

$$\begin{aligned} U_{hjk} &= \ln W_{hjk}\beta + y_h\delta_{jk} \quad \text{if } j \in B_l \\ &= 0 \qquad\qquad\qquad\quad \text{if } j \in B_L \end{aligned} \tag{2}$$

where W_{hjk} represents the net annual wage of individual h in the formal and informal sector, and y_h is a vector of individual characteristics.

The upper nest specific component V_{hk} is defined as follows:

$$V_{hk} = z_h\gamma_k \tag{3}$$

where z_h is a vector of characteristics affecting the labor/leisure options.

The micro data give information on wages earned by individuals who are employed - in the formal sector or the informal sector - and obviously wages of non-working individuals are not observed. Moreover, since a worker is perceived in one option (employment sector) we observe at most one wage for each person. Thus, we have to impute the unobserved wages for all non-chosen options.

The wage equations for formal and informal workers can be represented as follows:

$$\ln w_{hjk} = x_{hjk}\alpha_{jk} + u_{hjk} \qquad \text{if } j \in B_l \tag{4}$$

where w_{hjk} is the net hourly wage determined by observable personal and job characteristics x_{hjk} and a zero-mean normally distributed error term u_{hjk}. Equation (4) is a censored regression as we observe w_{hjk} only if individual h is employed in the formal or the informal sector.

In order to take into consideration the possible correlation between u_{hjk} and ϵ_{hjk}, we

estimate the wage equations using the Lee's (1983) method to correct for selection bias - selection being specified as a nested logit.[6] To do this, we first estimate the nested model (Equation 1) without considering the wage as an explanatory variable. Then, we compute for each individual the probability of choosing alternative j in nest B_l and then the value of the sample selection correction variables $\frac{-\phi(\Phi^{-1}(\widetilde{P}_{hjk}))}{\widetilde{P}_{hjk}}$, where Φ^{-1} represents the inverse of the standard normal distribution and ϕ is the standard normal pdf. Next, we write the conditional mean of the wage equations as follows (Lee, 1983):

$$\ln w_{hjk} = x_{hjk}\alpha_{jk} + \sigma_{hjk}\rho_{jk}\Big(- \frac{\phi(\Phi^{-1}(\widetilde{P}_{hjk}))}{\widetilde{P}_{hjk}}\Big) \tag{5}$$

We estimate Equation (5) separately for formal and informal workers. Note that negative values of the coefficients of the selection correction variables imply positive selectivity, i.e. persons who choose to work in a sector obtain - *ceteris paribus* - a higher wage than the average of total population. Once we get the parameter estimates of the wage equations, we can impute wages for each individual in the non-chosen options. More precisely, for workers in the formal (informal) sector we calculate a predicted wage in the informal (formal) sector, and for those persons who do not work, we compute potential wages in both the formal and the informal sectors.

In the final step, we reestimate Equation (1) including the individual annual wage - observed for the chosen option and imputed for non-chosen options.

We denote by P_{hjk} the probability of choosing alternative j in nest B_l. Since $P_{hjk} = P_{hj|B_l}.P_{hB_l}$, after McFadden we can write, respectively, the probability of choosing alternative j (formal/informal sector employment) given that an alternative in nest B_l is chosen, and the marginal probability of choosing one alternative in nest B_l:

$$P_{hj|B_l} = \frac{W_{hjk}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_h\delta_{jk}}{\lambda}\right)}{\sum_{j'\in B_l} W_{hj'k}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_h\delta_{j'k}}{\lambda}\right)} \tag{6}$$

$$P_{hB_l} = \frac{\exp\left(z_h\gamma_l + \lambda I_{hl}\right)}{\exp\left(z_h\gamma_L\right) + \exp\left(z_h\gamma_l + \lambda I_{hl}\right)} \tag{7}$$

[6] Lee (1983) proposes a consistent two-step procedure based on the conditional logit model. His approach is a generalization of the two-step selection bias correction method introduced by Heckman (1979) and an extension to the case where selectivity is modelled as a multinomial logit. Since it is likely that there will be unobserved similarities among subsets, a generalization of the Lee's approach to a less restrictive nested logit is appropriate (Falaris, 1987).

where $I_{hl} = \ln \sum_{j \in B_l} \left[W_{hjk}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_h \delta_{jk}}{\lambda}\right) \right]$ is the *Inclusive Value* (IV) of nest B_l, i.e. the quantity that links the upper and the lower nests. This IV enters in the upper nest as an explanatory variable. The parameter λ is a measure of the degree of independence in unobserved utility among the alternatives in nest B_l. Note that a higher value of λ means greater independence and lower correlation. In particular, $\lambda = 1$ implies a complete independence within the nest and the absence of correlation. Moreover, λI_{hl} represents the expected utility that individual i receives from choosing to work, i.e. nest B_l.

2.2 Data and Descriptive Statistics

We apply the theoretical framework presented above using data from the South African Labour Force Survey (LFS). It is a biannual household survey conducted in South Africa from February 2000 to September 2007, and designed to measure the dynamics of employment and unemployment in the country. It measures a variety of issues related to the labor market, and most importantly enables us to obtain a good measure of the informal sector. Among the different available surveys, we adopt the September 2000 LFS for several reasons. First, the input-output table we use to build the macro CGE model is available for the year 2000. Second, the information on the amount of household non-labor income, not provided by the LFS although necessary to perform income distribution, inequality and poverty analysis, is available from the September 2000 Income and Expenditure Survey (IES) that uses the same sample of persons with the same identifiers as the 2000 LFS. In addition, the September 2000 LFS contains information we are able to use as proxy for the person's wealth.

The 2000 LFS includes a population base of 105,371 on a sample of 26,648 households. Since we are interested in the outcome associated to employment status (formal and informal), an important information required from our data is that concerning remuneration. All persons in paid employment are explicitly asked for the salary amount in their main job in the week preceding the survey. More precisely, the survey provides a worker's weekly, monthly or annual income and hours worked in the previous week in their main activity. These information allow us to compute hourly wage rates.[7] Another important information needed for our study is that associated to the distinction between formal and informal employment. The LFS asks workers explicitly whether their main job is in the formal or the informal sector. We use this information to define the informal employment dummy. Moreover, the survey gives further information related to the employment status

[7] We note however that for about 2.6% of paid workers - salaried and self-employed - reported their salary in income categories rather than exact values. For these, we use the midpoints of the intervals and the minimum of the open-ended interval.

that allow us to better identify the activity sector of workers. Among these information and besides the worker's answer, we control for whether the worker has a written contract, the company where he/she works is registered or not, and deduces unemployment contributions for him/her. However, only earnings from the formal sector are considered as being taxable. Income tax is computed on the individual level by applying the official tax rates for the year 2000 from the South African Revenue Service (SARS). The tax system is progressive and tax rates range from 18% to 42%. We reduce our sample to paid non self-employed workers aged 16-64 if males and 16-60 if females. After controlling for missing values, we remain with a total of 47,948 observations.

Basic summary statistics show that 30.7% of men and 21.5% of women are engaged in a salaried activity. In the selected sample, 80% are Black and 56% of people live in urban area. The average number of hours worked per week in the main job is 46.8 hours. In the subsample of working people, 33.9% of women have an informal activity while only 13.3% of men are informally employed. As shown in Table 1, the log hourly net wage is on average higher in the formal than the informal sector, and men are more likely to be paid a higher wage than women.

2.3 Estimation Results

First, we estimate the individual's labor supply choice using the nested logit model presented in Equation 1. In our model formulation, we assume that individuals choose first whether to work on a full-time basis or not. Then, conditional on participation, they choose between the informal sector and the formal sector employment. The estimates are obtained in two stages and reported in Table 2. The parameter estimates of the formal-informal employment choice show that men are more likely to have a formal job than women. Moreover, the probability to get a job in the formal sector increases with age and education level. Blacks are less likely to obtain an employment in the formal sector and speaking English increases the likelihood to obtain a formal job. Importantly, if the household is owner of the dwelling then the worker is less likely to work and more likely to choose the informal sector. Moreover, being the head of the household affects positively the labor decision and negatively the formal employment choice. At the household level, the proportion of workers in the informal sector affects negatively the formal employment choice. Similarly, the number of workers per household - others than the person himself/herself - has a positive impact on the individual labor decision. Concerning the work-leisure decision, the existence of at least one person receiving pension benefits affects negatively the participation decision.

In the second step, we estimate the wage equations for the two sectors using OLS with correction for the selection bias using the Lee's method. Table 3 gives the estimation results. The dependent variable is the logarithm of the net hourly wage in the formal and the informal sector, respectively. The results are qualitatively similar for both regressions. In fact, wages increase with age and education. Moreover, men have on average higher wages than women and White people more than Blacks. Concerning the Lee's selection variables, computed from the probabilities obtained in the first step, the estimates give a negative parameter implying the existence of a positive selectivity.

Given the estimates of the wage equations, we impute hourly net wages in the non-chosen options and we compute annual net wages for all individuals in both the formal (W_1) and informal (W_2) sectors.[8] Finally, we reestimate the formal-informal employment decision taking into account the individual formal-informal relative wage[9] and the leisure-work decision. Results are presented in Table 4. The main result of the estimates is that the relative wage (W_1/W_2) affects positively participation in the formal salaried sector. In other words, wages are significant determinants of sectoral choice in that the probability to choose a formal job increases (decreases) if wages in the formal (informal) sector increase. Moreover, men and more educated people are more likely to choose the formal employment sector. However, once we control for wages, the age dummy for those who are 40 years and more has a negative and significant parameter. The notable result in the second column of Table 4 is the parameter estimate of the inclusive value. This parameter is positive and significantly different from unity which is evidence that the nested model is a realistic way to present the labor market status analyzed in this paper.

2.4 The representative agent formulation

Our micro-macro simulation approach is based on the aggregation of preferences of individuals making discrete choices. In this context, we assume that the population is partitioned into $s = 1, ..., S$ cells according to some characteristics.[10] For each cell, we assume there is a large enough set N_s of statistically identical and independent individuals, each of them having a total time endowment normalized to one. This implies that all individuals belonging to the same cell have the same probability to choose option $j = (1, 2, 3)$.

The aggregate labor supplied by all individuals belonging to cell s for each option

[8] For non-working persons, we assume that total working hours per week is equal to the average weekly working hours of total salaried population.

[9] Observed wages are used for employed persons for the chosen option. For salaried formal (informal) workers, we consider potential informal (formal) wages.

[10] In our model, we consider $S = 32$ cells, according to the following characteristics: sex, race, age category, education, and area of residence (see Section 3.2).

$j = (1,2)$ ($L_{sj} = P_{sj} \cdot N_s$) is then:

$$L_{sj} = \frac{W_{sj}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_{sj}\delta_j}{\lambda}\right)}{\sum_{j\in\{1,2\}} W_{sj}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_{sj}\delta_j}{\lambda}\right)} \cdot \frac{\exp(z_s\gamma_l) \cdot \left[\sum_{j\in\{1,2\}} W_{sj}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_{sj}\delta_j}{\lambda}\right)\right]^{\lambda}}{\exp(z_s\gamma_L) + \exp(z_s\gamma_l) \cdot \left[\sum_{j\in\{1,2\}} W_{sj}^{\frac{\beta}{\lambda}} \cdot \exp\left(\frac{y_{sj}\delta_j}{\lambda}\right)\right]^{\lambda}} \cdot N_s \quad (8)$$

where W_{sj} represents the average within-cell annual wage for option j.

Equation 8 is the aggregate labor supply in each employment sector ($j = 1, 2$) for given wages W_{sj}. Thus, we can introduce these labor supply functions in the CGE model since they aggregate the preferences of individuals belonging to the same cell.[11].

3 The CGE model

The macro model used in our analysis is a static and multisectoral CGE model based on the South African input-output data-set of 2000 provided by the OECD. The input-output table, which includes 48 industries, is aggregated into 10 industries reported in Table A.1 in the Appendix.[12] The construction of the SAM (*Social Accounting Matrix*), necessary to calibrate our CGE model, is completed with data from national accounts concerning the balance of payments and the government account. The elasticities used in our CGE model come from the GTAP model.

The CGE model developed in this paper is quite standard, except for three elements: (i) we introduce informality by assuming that each industry produces a formal and an informal good, (ii) we use labor supply functions that aggregate individual preferences, and (iii) we introduce a non-linear relation between the income tax and labor income in order to approximate the existing progressive tax system.

In particular, the formal and informal goods produced by each industry differ in several aspects: the informal good is not subject to indirect taxation, it is produced without using intermediate goods and its production is entirely sold to private consumers. The formal and informal goods are assumed to be qualitatively different, implying the existence of two distinct markets and, thus, equilibrium prices. Labor units used to produce formal and informal goods are assumed not to be substitutes, implying that the wage for the formal

[11] Magnani and Mercenier (2009) show that the aggregate labor supply function of each cell can be derived from the resolution of the optimization problem of a representative agent from each cell.

[12] The aggregation of industries is done with respect to the ten industries we have in the micro dataset.

labor and for the informal labor are different. In particular, the difference between the two wage levels affects the individual labor participation choice in the formal and informal sectors.

The South African input-output table gives information on the remuneration of labor and capital used by each sector only in the formal sector.[13] Concerning the calibration of the informal sector, we determine the remuneration of the informal labor by applying, for each industry, the weight of the informality, expressed in terms of labor remuneration, observed in the micro data-set (see Table 2). The remuneration of informal capital by industry is determined by applying the same weights, i.e. by assuming that the weight of the informality is the same for labor and capital in each industry. Finally, given that GDP is equal to the remuneration of formal factors only, and given that in our model we also include the remuneration of informal factors, it is necessary to correspondingly increase the aggregate demand. We assume that the remunerations of the informal labor and capital, which are perceived by the representative agent, are entirely consumed.

In what follows, we present a detailed description of our CGE model.

3.1 Production side

Each industry $i = 1, ..., 10$ produces two different types of good: a formal ($j = 1$) and an informal good ($j = 2$). We denote by Y_{i1} the production level of the formal good in industry i which depends on the total quantity of intermediate goods Z_i, formal labor L_{i1} and formal capital K_{i1}. In contrast, the production level Y_{i2} of the informal good depends on the quantity of informal labor L_{i2} and informal capital K_{i2}.[14]

We use a CES production function as follows:

$$Y_{i1} = \left[(\alpha_i^Z)^{\frac{1}{\sigma_i}} \cdot Z_i^{\rho_i} + (\alpha_{i1}^L)^{\frac{1}{\sigma_i}} \cdot L_{i1}^{\rho_i} + (\alpha_{i1}^K)^{\frac{1}{\sigma_i}} \cdot K_{i1}^{\rho_i}\right]^{\frac{1}{\rho_i}} \quad (9)$$

$$Y_{i2} = \left[(\alpha_{i2}^L)^{\frac{1}{\sigma_i}} \cdot L_{i2}^{\rho_i} + (\alpha_{i2}^K)^{\frac{1}{\sigma_i}} \cdot K_{i2}^{\rho_i}\right]^{\frac{1}{\rho_i}} \quad (10)$$

Each industry i produces the quantity of formal and informal goods by choosing the optimal level of the production factors that maximizes its profit given the technological

[13] Concerning the sector 10 "Private households", no information are available about the labor and capital remuneration in the input-output data-set. We determine the factors' remunerations by taking into account that from the micro data-set the labor remuneration in sector 10 represents 0.56% of the total formal labor remuneration.

[14] Given the lack of data, we suppose that informal goods are produced without using intermediate inputs.

constraint. The first order conditions for industry i producing the formal good are:

$$Z_i = \alpha_i^Z \cdot \left[\frac{P_{i1}^Y \cdot (1-\tau_i^Y)}{P_i^Z}\right]^{\sigma_i} \cdot Y_{i1} \quad (11)$$

$$L_{i1} = \alpha_{i1}^L \cdot \left[\frac{P_{i1}^Y \cdot (1-\tau_i^Y)}{w_1}\right]^{\sigma_i} \cdot Y_{i1} \quad (12)$$

$$K_{i1} = \alpha_{i1}^K \cdot \left[\frac{P_{i1}^Y \cdot (1-\tau_i^Y)}{r+\delta_K}\right]^{\sigma_i} \cdot Y_{i1} \quad (13)$$

$$P_{i1}^Y \cdot (1-\tau_i^Y) \cdot Y_{i1} = P_{i1}^Z \cdot Z_i + w_1 \cdot L_{i1} + (r+\delta_K) \cdot K_{i1} \quad (14)$$

and, for industry i producing the informal good are:

$$L_{i2} = \alpha_{i2}^L \cdot \left[\frac{P_{i2}^Y}{w_2}\right]^{\sigma_i} \cdot Y_{i2} \quad (15)$$

$$K_{i2} = \alpha_{i2}^K \cdot \left[\frac{P_{i2}^Y}{r+\delta_K}\right]^{\sigma_i} \cdot Y_{i2} \quad (16)$$

$$P_{i2}^Y \cdot Y_{i2} = w_2 \cdot L_{i2} + (r+\delta_K) \cdot K_{i2} \quad (17)$$

P_{ij}^Y is the equilibrium price of the formal ($j=1$) or informal ($j=2$) good produced by industry i, w_j is the equilibrium wage per unit of effective labor for sector $j=1,2$, and $r+\delta_K$ is the equilibrium gross remuneration rate of a unit of capital, where δ_K is the depreciation rate. The parameter τ_i^Y represents the tax rate on the production of the formal good, and P_i^Z represents the aggregate price of the intermediate goods used by industry i in the formal sector. Capital is supposed to be perfectly mobile across sectors and industries, while formal and informal labor are assumed to be perfectly mobile across industries. These assumptions imply the existence of an equilibrium wage for the formal labor, an equilibrium wage for the informal labor and a unique equilibrium rate of remuneration of capital.

Given the total quantity of the intermediate good Z_i, each industry i producing a formal good chooses the optimal quantity to buy from industry i'. The first order conditions allowing to minimize the total cost are:

$$Z_{i'i} = \alpha_{Z_{i'i}} \cdot \left(\frac{P_i^Z}{P_{i'1}^C}\right)^{\sigma_i^Z} \cdot Z_i \quad (18)$$

$$P_i^Z \cdot Z_i = \sum_{i'} P_{i'1}^C \cdot Z_{i'i} \quad (19)$$

where P_{i1}^{C} is the average purchase price of the formal good in industry i, defined in subsection 3.5.

3.2 The representative agent

In our model individuals are grouped according to five characteristics: age, sex, education, race and area of residence. In particular, we consider two age groups (people aged less than 40 and people aged 40 and more), two education groups (high and low), two race groups (Black and non-Black), and two area of residence (urban and rural). Thus, we consider $s = 1, ..., S = 32$ cells.

Each cell earns a net labor income equal to $(1 - \tau_{sj}) \cdot w_j \cdot A_{sj}$, where w_j is the (equilibrium) wage per unit of effective labor in sector $j = 1, 2$, τ_{sj} is the tax rate, and A_{sj} is the productivity of the cell s in sector j. In particular, τ_{sj} is the average tax rate paid by formal workers belonging to cell s (see Equations 21 and 22), with $\tau_{sj} = 0$ for $j = 2$. $w_j \cdot A_{sj}$ represents the average wage earned in sector j by individuals belonging to cell s. This average wage is estimated from a wage equation using the age class, sex, education level, race, and area of residence as explanatory variables.

Each cell s supplies formal and informal labor according to the following labor supply functions:

$$\begin{aligned} L_{sj} &= \frac{\eta_{sj} \cdot \left[(1-\tau_{sj}) \cdot w_j \cdot A_{sj}\right]^{\frac{\beta}{\lambda}}}{\sum_{j'} \eta_{sj'} \cdot \left[(1-\tau_{sj'}) \cdot w_{j'} \cdot A_{sj'}\right]^{\frac{\beta}{\lambda}}} \\ &\cdot \frac{\phi^S \cdot \left[\sum_{j'} \eta_{sj'} \cdot \left[(1-\tau_{sj'}) \cdot w_{j'} \cdot A_{sj'}\right]^{\frac{\beta}{\lambda}}\right]^{\lambda}}{1 + \phi^S \cdot \left[\sum_{j'} \eta_{sj'} \cdot \left[(1-\tau_{sj'}) \cdot w_{j'} \cdot A_{sj'}\right]^{\frac{\beta}{\lambda}}\right]^{\lambda}} \cdot N_s \end{aligned} \tag{20}$$

where $j, j' = 1, 2$. L_{sj} is the number of individuals of cell s who work in sector j, while N_s is the total number of individuals belonging to the cell s. Note that the labor supply functions aggregate the preferences of individuals belonging to each cell s. In particular, Equations 20 and 8 coincide by posing $\eta_{sj} = \exp\left(\frac{y_s \delta_{jk}}{\lambda}\right)$, $(1 - \tau_{sj}) \cdot w_j \cdot A_{sj} = W_{sjk}$, $\phi^S = \exp(z_s \gamma_l)$, and $1 = \exp(z_s \gamma_L)$.

Income taxation is progressive in South-Africa. In order to take into account the progressivity of income taxation in the CGE model, we estimate, for each cell, a *taxation equation*, i.e. a nonlinear relation between income tax and labor income, as follows:

$$tax_{sj} = \alpha_s^0 + \alpha_s^1 \cdot w_j \cdot A_{sj} + \alpha_s^2 \cdot (w_j \cdot A_{sj})^2 + \alpha_s^3 \cdot (w_j \cdot A_{sj})^3 + \alpha_s^4 \cdot \ln(w_j \cdot A_{sj}) \tag{21}$$

where $j = 1$. The informal labor incomes are not taxed, thus $tax_{s2} = 0$. The coefficients are estimated separately for each cell s using the micro data-set. More concretely, we minimize the sum of the squared errors subject to the constraint that the predicted total taxation coincides with the observed value of taxation for each cell.

The income tax rate for each cell s is computed as follows:

$$\tau_{sj} = \frac{tax_{sj}}{w_j \cdot A_{sj}} \tag{22}$$

In our CGE model, we consider one representative household who perceives the net labor incomes (formal and informal) earned by the 32 cells. This representative household owns an exogenous wealth W remunerated at the rate r and receives exogenous transfers Γ from the government. His disposable income is then given by:

$$Y_{net} = \sum_{sj} (1 - \tau_{sj}) \cdot w_j \cdot A_{sj} \cdot L_{sj} + r \cdot W + \Gamma \tag{23}$$

An exogenous fraction s_{rate} of the disposable income is saved and the complementary fraction is consumed. The budget constraint is then:

$$P^C \cdot C = (1 - s_{rate}) \cdot Y_{net} \tag{24}$$

where C represents the aggregate consumption and P^C the consumer price index.

The choice consuming formal and informal goods produced by industry i (C_{ij}) is made in order to maximize a CES utility function. The first order conditions are:

$$C_{ij} = \alpha_{ij}^C \cdot \left(\frac{P^C}{P_{ij}^C} \right)^{\sigma^C} \cdot C \tag{25}$$

$$P^C \cdot C = \sum_{ij} P_{ij}^C \cdot C_{ij} \tag{26}$$

where P_{ij}^C is the consumer price of good i of sector j. The consumer price index is then equal to the weighted average of consumer prices of formal and informal goods produced by each industry i.

3.3 Government

Concerning the government, revenues are given by indirect taxes on the production of formal goods and direct taxation on formal labor incomes, while expenditures are given

by the public consumption of goods and services,[15] interests on the public debt (B) and transfers to families Γ. The difference determines the public savings (S_G). In particular, we assume that the ratio between public savings and GDP is kept constant, and the total public expenditure is endogenously determined by the following budget constraint:

$$S_G = \left[\sum_i \tau_i^Y \cdot P_{i1}^Y \cdot Y_{i1} + \sum_s tax_{s1}\right] - \left[\sum_i P_{i1}^C \cdot G_i + r \cdot B + \Gamma\right] \tag{27}$$

3.4 Investment

The aggregate investments, using a neoclassical closure, are determined by aggregate savings, i.e. the sum of private savings, public savings, and savings with respect to the rest of the world:

$$I = s_{rate} \cdot Y_{net} + S_G + S_{Row} \tag{28}$$

where savings with respect to the rest of the world (S_{Row}) are defined later.

The aggregate investment I must be the split out between different industries operating in the formal sector. The first order conditions in order to minimize the total investment cost are:

$$I_i = \alpha_i^I \cdot \left(\frac{P^I}{P_{i1}^C}\right)^{\sigma^I} \cdot I \tag{29}$$

$$P^I \cdot I = \sum_i P_{i1}^C \cdot I_i \tag{30}$$

where P^I is the average investment price of industry i in the formal sector.

3.5 International trade and the balance of payments

The formal production for each industry i can be sold in the domestic market or exported. Goods that are exported are supposed to be identical to those sold in the domestic market, implying that the selling price is the same. Exports are defined by a demand function that negatively depends on the relative price, i.e. the ratio between the foreign price expressed in domestic currency and the domestic price:

$$E_i = \alpha_i^E \cdot \left(\frac{\bar{P}_i \cdot \varepsilon}{P_{i1}^Y}\right)^{\sigma_i^E} \tag{31}$$

where $\bar{P}_i$ and ε are respectively the (exogenous) foreign price in industry i expressed in

[15] According to national accounts, the public consumption concerns only the industry 9 "Public administration". The public consumption of the other industries is then fixed to zero in the model.

foreign currency and the (endogenous) nominal exchange rate.

The informal production, in contrast, is supposed to be sold only on the domestic market.

The total demand for each industry i of the formal good is given by $\sum_{i'} Z_{ii'} + C_{i1} + G_i + I_i$. This total demand can be satisfied by domestic production or by imports.[16] We use an Armington formulation implying that domestic (X_i) and foreign (M_i) productions are supposed to be imperfectly substitutes due to the different origin of the products. The first order conditions in order to minimize the total cost are:

$$X_i = \alpha_i^X \cdot \left(\frac{P_{i1}^C}{P_{i1}^Y}\right)^{\sigma^M} \cdot \left[\sum_{i'} Z_{ii'} + C_{i1} + G_i + I_i\right] \quad (32)$$

$$M_i = \alpha_i^M \cdot \left(\frac{P_{i1}^C}{\bar{P}_i \cdot \varepsilon}\right)^{\sigma^M} \cdot \left[\sum_{i'} Z_{ii'} + C_{i1} + G_i + I_i\right] \quad (33)$$

$$P_{i1}^Y \cdot X_i + \bar{P}_i \cdot \varepsilon \cdot M_i = P_{i1}^C \cdot \left[\sum_{i'} Z_{ii'} + C_{i1} + G_i + I_i\right] \quad (34)$$

For the formal goods, the consumer price of industry i (P_{i1}^C) is then equal to a weighted average between the domestic price P_{i1}^Y and the foreign price $\bar{P}_i \cdot \varepsilon$.

Foreign capital flows (S_{Row}) are fixed at the initial level, while the exchange rate ε is endogenously determined to equilibrate the balance of payments:

$$S_{Row} = \sum_i P_{i1}^Y \cdot E_i - \sum_i \bar{P}_i \cdot \varepsilon \cdot M_i \quad (35)$$

3.6 Equilibrium conditions

We assume that the domestic prices are perfectly flexible and guarantee the equilibrium in each market, i.e. the markets of formal and informal goods and services of the 10 industries, the two labor markets and the capital market.

For each industry i, the production level of the formal good must coincide with the domestic and foreign demand, while the production level of the informal good must coincide with private consumption:

$$Y_{i1} = X_i + E_i \quad (36)$$

$$Y_{i2} = C_{i2} \quad (37)$$

[16] Instead, we suppose that the total demand for each industry i of the informal good is satisfied only by domestic production.

These equations determine the domestic equilibrium price for the industry i in the sector j, P_{ij}^{Y}.

Concerning the two labor markets, the total quantity of effective units of formal and informal labor demanded by firms must coincide with the quantity supplied by individuals:

$$\sum_{i} L_{i1} = \sum_{s} L_{s1} \cdot A_{s1} \tag{38}$$

$$\sum_{i} L_{i2} = \sum_{s} L_{s2} \cdot A_{s2} \tag{39}$$

These equations determine the domestic equilibrium wage per unit of effective labor in the formal and informal sectors, w_1 and w_2.

Concerning the capital market, the (exogenous) quantity of capital supplied by individuals W must finance the total formal and informal capital demanded by firms and the public debt B:

$$\sum_{ij} K_{ij} + B = W \tag{40}$$

This equation determines the domestic equilibrium rate of remuneration of capital.

Finally, the *numéraire* chosen is the domestic producer price index computed as the weighted average of the domestic prices of industry i and sector j.

4 The South African Tax System

For the purpose of our study, we focus our analysis on the personal income taxation in South Africa. Here we summarize its most important features. Given the year in which the sample used is collected, we apply the 2000/2001 tax rates.[17] The South African tax system is progressive. The tax system consists of 6 brackets ranging from a rate of 18% applied to incomes less than or equal to R35,000 to 42% for incomes above R200,000 (Table A.2). The primary tax rebate, for which all taxpayers are eligible, amount for R3,800 in the 2000/01 tax year, thus the tax threshold for persons under 65 years is equal to R21,111.

The taxable unit is not the family, but the individual. In other words, the individual income tax rate structure is applicable to all persons irrespective of marital status.[18]

[17] The South African fiscal year goes from the first of March to the end of February.

[18] The earlier South African income tax system sustains the belief that households with two income earners are better off than households with one income earner, assuming that altruism prevails within the household. Thus, the second earner (i.e. the wife) was taxed more heavily. In 1994, the *Katz Commission*

However, this method implies that in the presence of a progressive tax system, a fiscal discrimination remains between a one income earner family and a family with two members earning together the same taxable income. Obviously, because of the tax progressivity, this discrimination increases with the total income of the family. The South African tax legislation aims to reduce the tax gap and increase tax collections. Although the child rebate was removed, the primary rebate continues to increase on an annual basis. The majority of registered individual taxpayers are men given that participation of men is higher than that of women and men are more likely to have a formal employment activity. In 2000/2001, the personal income tax accounts for R86,478 million (9.1% of GDP) and represents 39.2% of total tax revenue.

5 Tax Reforms: Macro and Micro Effects

In this section we analyze the effects of two tax reforms: in the first, noted *Reform 1*, the current progressive tax system is replaced by a proportional tax system; in the second, noted *Reform 2*, it is replaced by a lump-sum tax system. In order to guarantee that the pre-reform total amount of taxes remains unchanged, *Reform 1* stipulates that workers in the formal sector pay taxes on the basis of a tax rate equal to 12.4% and *Reform 2* considers that, all individuals, independently on the labor choice and the amount of the income earned, pay the same amount of taxes equal to R485.

We first analyze the macroeconomic effects and then the effects at the individual level.

5.1 Macroeconomic Effects

Tax policies produce important effects on the labor market and, consequently, on the whole economy. The mechanisms are the following. First, tax policies induce changes in the labor supply since they modify the opportunity-cost of working and choosing the employment sector. Labor choices, both at the individual level and at the macro level, depend on the yearly net (of direct taxes) wage. In particular, with *Reform 1* which considers a proportional tax system, poor cells pay on the basis of a greater tax rate, while rich cells pay on the basis of a lower tax rate. The amount of direct taxes becomes zero with *Reform 2*, implying that formal wages become more attractive for each cell, especially for the richest ones. Second, a general equilibrium effect on wages is observed.

was charged to evaluate the appropriateness of the tax system and make some recommendations to improve it. The main purpose of this commission was to establish equity between men and women. Following the recommendations of the Katz Commission, the South African government introduced several tax policy changes since 1994 among which the introduction of a unified structure for income tax rate for all individuals, the adjustments of the tax rates and income brackets, and the reduction of the number of income brackets.

In fact, the change in the labor supply may be absorbed by the demand of firms only through an adjustment in wages.

Table 5 shows the main macroeconomic results. At the national level, we find that the number of workers in the formal sector decreases with *Reform 1* by 3.1%, while it increases with *Reform 2* by 2.8%; the number of workers in the informal sector increases with *Reform 1* by 5% and decreases with *Reform 2* by 1.4%. The total number of workers decreases by 1.3% with *Reform 1* and increases by 1.8% with *Reform 2*. However, labor supply depends not only on the number of workers but also on their productivity. With *Reform 1*, the number of units of effective labor in the formal sector decreases by only 0.6%, while in the informal sector it increases by 3.7%, implying that people who decide to move from the formal to the informal sector are, on average, low productive. In contrast, with *Reform 2*, the number of units of effective labor in the formal sector increases by 4.5%, while in the informal sector it decreases by 3%, implying that people who decide to move from the informal to the formal sector are, on average, high productive.

Moreover, the wages in the formal and informal sectors adjust in order to guarantee the equilibrium in the two labor markets. In particular, given the changes in labor supplies expressed in terms of units of effective labor, the equilibrium wage per unit of effective labor in the formal sector increases by 0.3% with *Reform 1* and decreases by 1.9% with *Reform 2*, while the equilibrium wage per unit of effective labor in the informal sector decreases by 1.1% with *Reform 1* and increases by 1.6% with *Reform 2*.

The aggregate capital available in the economy is exogenous and fixed at the initial level. However, it is assumed to be perfectly mobile across industries and across formal and informal sectors. In particular, given the effects on the labor supply, capital shifts from the informal sector to the formal sector with *Reform 1*, and from the formal sector to the informal sector with *Reform 2*. The impact on the equilibrium rate of remuneration of capital is quite negligible with *Reform 1* while, with *Reform 2*, it is positive (+0.8%) given the important increase in the quantity of labor available in the economy and, thus, in the marginal productivity of capital.

The level of production at the national level in the formal sector, i.e. real GDP, decreases with *Reform 1* by 0.2% and increases by 2.2% with *Reform 2*, mainly due to the positive effect on the supply of formal labor. On the contrary, the production in the informal sector increases by 1.2% with *Reform 1* and decreases by 0.3% with *Reform 2*. Total production remains essentially unchanged with *Reform 1* and increases by 1.6% with *Reform 2*. Thus, the introduction of a lump-sum tax system, which implies the elimination of the distortions in the labor market, induces, as expected, a positive macroeconomic effect

on real GDP and total production.

The total amount of income taxes decreases by 0.3% with *Reform 1*. Remember that, with *Reform 1*, the proportional tax rate is fixed at 12.4% in order to guarantee that the *pre-reform* total amount of taxes remains unchanged. Given that the reform induces a reduction in the number of formal workers, the effect on the *ex-post* total amount of income taxes is negative. With *Reform 2*, the effect is clearly nil since, even if the number of formal workers increases, the total amount of income taxes is completely independent on the formal wages earned.

Table 6 shows the effect of the two tax policies on the size of the informal sector, measured in terms of (i) production, (ii) number of workers and (iii) number of units of effective labor. The results confirm that the size of the informal sector increases with *Reform 1* and decreases with *Reform 2*. In particular, with *Reform 1*, the size of the informal sector increases from 8.1% to 8.2% in terms of production, from 22.7% to 24.1% in terms of number of workers, and from 18.2% and to 18.8% in terms of number of units of effective labor. With *Reform 2*, the size of the informal sector decreases from 8.1% to 7.9% in terms of production, from 22.7% to 22% in terms of number of workers, and from 18.2% and to 17.1% in terms of number of units of effective labor.

In Table A.3, we show the detailed effects at the industry level, in the formal and informal sectors, concerning the production, the labor and the capital demand.

5.2 Microeconomic Effects

We now present the micro effects of the two tax policies simulated. Starting from the estimation of the nested logit model of labor supply described in section 2.3, and after generating for each individual 300 GEV conditional error terms, we first evaluate the effects on the individual labor choices. It is important to note that in our micro analysis, we consider not only the change in the taxation rules but also the change in the equilibrium wages determined in the CGE model. Consequently, the individual effects are computed while taking into account the general equilibrium effects.

Table 7 reports the changes in the formal/informal employment and the work/leisure choices for the total sample as well as for the different groups, subsequent to the two tax reforms we simulate. The aggregate effect of the proportional tax (*Reform 1*) is a decrease in the fraction of people who decide to work from 25.7% to 25.3% and a decrease in the fraction of working people who choose the formal sector from 77.3% to 75.7%. Results by age, gender, education, race and living areas indicate sizable effects for those categories of poor or less productive. In particular, individuals who move out of employment are mainly

recorded for young adults, females, low-educated persons, Blacks and persons living in rural areas. These changes are explained by the fact that the categories above-mentioned face an increase in the tax rate. For instance, the pre-reform mean tax rate on personal income of low-educated, rural residents, Blacks, females and people aged 15-39 is 2.8%, 4.1%, 6.5%, 9.8% and 11.4%, respectively. Given this raise in taxation compared to the relatively low actual income taxation, people modify their choices by reducing their participation. The introduction of a proportional tax system implies that some categories avoid higher taxation and thus leave the formal sector. Only non-Blacks experience an increase in the labor market participation as they benefit, contrary to the other cells, from a significant decline in their average tax rate that goes from 17.3% to 12.4%. Similarly, the formal/informal employment decision is affected by tax changes.

The lump-sum tax (*Reform 2*) induces an overall increase in both the participation decision and the formal employment decision. Compared to the pre-reform situation, the fraction of people who decide to work passes from 25.7% to 26.1% and the fraction of workers who decide to join the formal sector raises from 77.3% to 77.8%. Concerning the results for the different categories, the elimination of the direct taxation makes employment more attractive and thus incites individuals to participate more, especially those belonging to the cells where the income level is relatively high, i.e. males, high-educated, non-Blacks and people living in urban areas. In addition, the participation to the formal employment increases for the same categories.

Table A.4 gives a deeper look into the results across the 32 cells. As a consequence to *Reform 1*, all low-educated non-Blacks participate less to the labor market as well as non-Black men and women who are high-educated, aged 15-39 and living in rural areas. Then, only some high-educated non-Blacks choose to work. Except high-educated men aged more than 40 and living in rural areas, all Black people work less as they experience a 12.4% tax rate higher than the rate currently applied to them. Moreover, the formal sector employment decision follows similar changes within these 32 cells to those noticed on the work decision. *Reform 2* generates different results compared to *Reform 1*. In particular, all non-Blacks, except low-educated persons living in rural areas, choose to work more. In addition, Blacks are more likely to increase their participation to the labor market. Concerning the formal employment decision, we observe that *Reform 2* increases the share of formal employment for urban workers and high-educated non-Blacks in rural areas.

In a final step, we proceed to an analysis in terms of income inequality and poverty. To do this, we first compute the post-reform individual annual net wage which depends on the labor market participation, the choice of the employment sector, the equilibrium level

of wages in the formal and informal sectors, and the taxation rule. Then, we compute, at the household level, the annual net labor income to which we add the amount of the total household non-labor income. The inequality and poverty analyses are carried out by computing equivalent incomes using the OECD equivalence scale.

In Table 8, we present the Gini index and the Theil index for the total sample and for the different cells before and after the tax reforms. We notice an overall increase of inequalities with both the proportional tax and the lump-sum tax. This increase is observed for all the categories (age, education, gender, race, residence area), particularly with *Reform 2*. This result is clearly related to the fact that high income workers are less taxed and low income workers are more taxed with the two tax reforms compared to the initial situation.

Table 9 reports the effects of the two reforms on poverty for the total sample and for the different categories. The results show that *Reform 1* is followed by an increase of poverty although the poverty gap goes down.[19] With *Reform 2*, in all, the fraction of poor families (headcount ratio) increases more intensively with respect to *Reform 1*, and we observe a 35% increase in the poverty gap compared to the pre-reform situation.[20]

6 Conclusions

In this paper, we apply a new micro-macro simulation approach to analyze the impact of different tax policies on the labor supply in developing countries characterized by a large informal sector and a low level of participation to the labor market. Our micro-macro model is built using the approach developed by Magnani and Mercenier (2009) based on the aggregation theory of Anderson *et al.* (1992) that permits to aggregate preferences of individuals facing discrete choices. We use data from South Africa and we assume that individuals have to decide whether not to work, to work in the formal sector or to work in the informal sector. We analyze two types of tax reform. The first consists of replacing the current progressive tax system by a proportional tax system and the second consists of introducing a lump-sum tax system.

We quantify the effects of these reforms at the macro level (on GDP, equilibrium prices and wages) and at the individual level (on the labor market choice of each individual, on income distribution, inequality and poverty). The main results are that the reform introducing a proportional tax system produces a negative effect at the macroeconomic

[19] A family is poor if its equivalent income is lower than the poverty line, defined as the half of the median equivalent income. The poverty gap is the mean distance separating the population from the poverty line.

[20] Table A.5 gives the effects of the tax reforms on income distribution, in particular, for the 10^{th}, 50^{th} and 90^{th} percentiles.

level in terms of GDP and total production, i.e. including informal activities, while the lump-sum system increases GDP and total production. In addition, the proportional tax system increases the size of the informal sector, whereas the lump-sum tax system reduces employment in the informal sector. The inequality analysis suggests an overall increase of inequalities with both reforms. This increase is observed for almost all the categories (age, education, gender, race, residence area), particularly with the lump-sum tax. As for poverty, the results show that a proportional tax is followed by an increase of poverty although the poverty gap goes down. With the lump-sum tax system, in all, we observe a 35% increase in the poverty gap compared to the pre-reform situation.

To conclude, our simulations show that a reform introducing a proportional tax system is clearly inappropriate given that it produces solely negative economic effects, both at the macro and the micro levels. Even though a lump-sum tax system produces some positive effects, it strongly increases inequalities and remains difficult to implement. Although the results of our simulation are qualitatively as expected, the approach used in this paper allows to quantify the changes in terms of individual participation to the labor market following a tax reform. In particular, these changes are evaluated starting from the estimation of individual behavior and by taking into account the general equilibrium effects on equilibrium wages provoked at the macro level.

This paper constitutes one possible application of this new micro-macro simulation approach which has also the advantage to be easier to implement compared to other micro-macro simulation techniques as it allows to aggregate individual choices into explicit functions that can be introduced in the macro model. Many other applications are certainly contemplated in the study of other discrete choices such as migration, education, profession.

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Table 1: Summary Statistics

	Men		Women	
	Mean	***SD***	***Mean***	***SD***
Age	30.396	(13.153)	30.613	(12.132)
White	0.050	(0.218)	0.050	(0.218)
Black	0.806	(0.395)	0.804	(0.397)
Asian	0.021	(0.142)	0.020	(0.140)
Coloured	0.112	(0.316)	0.112	(0.315)
English	0.055	(0.228)	0.054	(0.226)
Afrikaans	0.146	(0.353)	0.149	(0.356)
Single	0.296	(0.458)	0.339	(0.473)
Married	0.012	(0.110)	0.043	(0.203)
No education	0.073	(0.260)	0.079	(0.270)
Nursery	0.002	(0.046)	0.002	(0.044)
Primary	0.213	(0.409)	0.188	(0.391)
Secondary	0.663	(0.473)	0.689	(0.463)
NTC	0.008	(0.091)	0.003	(0.055)
Diploma	0.041	(0.198)	0.039	(0.193)
Urban area	0.563	(0.496)	0.562	(0.496)
Employment dummy	0.307	(0.461)	0.215	(0.411)
Informal dummy	0.133	(0.339)	0.339	(0.473)
Log hourly gross wage	1.704	(1.108)	1.342	(1.045)
Log hourly net wage	1.667	(1.048)	1.326	(1.011)
Formal (log) hourly wage	1.781	(1.021)	1.574	(1.006)
Informal (log) hourly wage	0.927	(0.910)	0.842	(0.832)
Weekly working hours	48.881	(14.519)	44.411	(15.922)

Table 2: Nested Logit Model of Labor Participation

	Formal Dummy		***Work Dummy***	
Male dummy	1.270	(0.071)	0.144	(0.058)
Age	0.056	(0.016)	0.362	(0.007)
Age squared	-0.001	(0.000)	-0.004	(0.000)
White	1.360	(0.250)	-0.196	(0.089)
Black	-0.733	(0.173)	-0.069	(0.104)
English	0.805	(0.216)	0.199	(0.113)
Afrikaans	-0.326	(0.172)	0.228	(0.100)
Single	0.218	(0.055)	0.183	(0.031)
Married	0.046	(0.116)	-0.281	(0.071)
Nursery	0.576	(0.445)	0.163	(0.255)
Primary	0.120	(0.080)	0.053	(0.049)
Secondary	0.808	(0.081)	-0.097	(0.055)
NTC	2.707	(1.022)	-0.502	(0.211)
Diploma	2.409	(0.254)	0.001	(0.125)
Region	0.175	(0.069)	0.165	(0.037)
Urban area	-0.317	(0.055)	-0.196	(0.031)
House owner	-0.386	(0.053)	-0.857	(0.031)
Children 0-3 years	0.092	(0.042)	-0.149	(0.021)
Children 4-6 years	0.058	(0.048)	-0.116	(0.024)
Children 7-12 years	0.083	(0.031)	-0.167	(0.016)
Household head	-0.322	(0.059)	1.554	(0.034)
Province unemployment rate	-0.037	(0.008)	-0.024	(0.004)
Household informal workers	-4.135	(0.196)	–	–
Household workers number	–	–	0.406	(0.017)
Pension dummy	–	–	-0.239	(0.042)
Inclusive Value	–	–	0.078	(0.048)
Constant	1.157	(0.412)	-6.929	(0.218)
Observations	**12,309**		**47,948**	

(i) The second and third columns give estimates of the binary choice models with the formal employment dummy and the work dummy as dependent variables, respectively; (ii) Standard errors are in parentheses; (iii) The "household informal workers" variable indicates the proportion of informal workers among employed persons within the household.

Table 3: Estimates of the Wage Equations with Sample Bias Correction

	Formal Sector		***Informal Sector***	
Male dummy	0.279	(0.019)	0.120	(0.034)
Age	0.078	(0.006)	0.064	(0.010)
Age squared	-0.001	(0.000)	-0.001	(0.000)
White	0.657	(0.031)	0.922	(0.199)
Black	-0.234	(0.054)	-0.138	(0.109)
English	0.300	(0.057)	0.158	(0.134)
Afrikaans	-0.126	(0.054)	-0.168	(0.107)
Nursery	0.101	(0.154)	-0.014	(0.284)
Primary	0.198	(0.031)	0.077	(0.046)
Secondary	0.552	(0.030)	0.173	(0.048)
NTC	1.004	(0.093)	0.643	(0.800)
Diploma	1.128	(0.043)	0.369	(0.200)
Region	0.237	(0.018)	0.533	(0.039)
Urban area	0.549	(0.018)	0.117	(0.033)
Selection Correction	-0.033	(0.023)	-0.132	(0.042)
Constant	-1.019	(0.143)	-0.900	(0.259)
R^2	**0.46**		**0.14**	
Observations	**9,516**		**2,793**	

(i) The dependent variables are the logarithm of the net hourly wage in the formal and informal sector, respectively; (ii) Standard errors are in parentheses.

Table 4: Nested Logit Model of Labor Participation Including Wages

	Formal Dummy		***Work Dummy***	
Male dummy	1.242	(0.070)	-0.354	(0.043)
Age dummy	-0.229	(0.056)	-0.011	(0.032)
Education dummy	0.664	(0.056)	-0.408	(0.034)
Black	-0.918	(0.175)	0.299	(0.098)
Urban area	-0.495	(0.057)	-0.046	(0.028)
English	0.941	(0.218)	-0.091	(0.105)
Afrikaans	-0.304	(0.175)	0.297	(0.096)
Single	0.264	(0.053)	0.640	(0.029)
Married	0.030	(0.117)	-0.145	(0.068)
Region	0.335	(0.069)	0.140	(0.097)
House owner	-0.369	(0.053)	-0.800	(0.028)
Children 0-3 years	0.069	(0.042)	-0.169	(0.020)
Children 4-6 years	0.048	(0.049)	-0.099	(0.023)
Children 7-12 years	0.086	(0.031)	-0.157	(0.015)
Household head	-0.313	(0.057)	1.902	(0.031)
Province unemployment rate	-0.023	(0.008)	-0.022	(0.004)
Household informal workers	-4.358	(0.199)	–	–
$Ln(W_1/W_2)$	0.517	(0.032)	–	–
Household workers number	–	–	0.371	(0.016)
Pension dummy	–	–	-0.052	(0.041)
Inclusive Value	–	–	0.298	(0.025)
Constant	1.604	(0.472)	-2.086	(0.284)
Observations	**12,309**		**47,948**	

(i) The second and third columns give estimates of the binary choice models with the formal employment dummy and the work dummy as dependent variables, respectively; (ii) Standard errors are in parentheses; (iii) Age dummy equals one for those people aged 40 and more; (iv) The education dummy indicates whether people are high educated (secondary education and more).

Table 5: Main Macroeconomic Effects of Tax Reforms

	Total Economy			Formal Sector			Informal Sector		
	Initial	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
Value added	1,003,186	-0.1%	1.6%	922,147	-0.2%	2.2%	81,039	1.2%	-0.3%
Units of labor (labor force normalized to 100)	25.67	-1.3%	1.8%	19.85	-3.1%	2.8%	5.83	5.0%	-1.4%
Units of effective labor (normalized to 100)	100.00	0.2%	3.1%	81.84	-0.6%	4.5%	18.16	3.7%	-3.0%
Real wage	–	–	–	105.33	0.3%	-1.9%	45.69	-1.1%	1.6%
Capital (labor force normalized to 100)	100.00	0.0%	0.0%	90.71	0.2%	-0.3%	9.29	-1.6%	2.6%
Gross capital remuneration rate	15.0%	-0.1%	0.8%	–	–	–	–	–	–
Income tax	83,915	-0.3%	0.0%	–	–	–	–	–	–
Net labor incomes	430,107	0.0%	2.8%	387,529	-0.3%	17.4%	42,578	2.5%	-1.1%
–									

(i) The macro effects of *Reform 1* and *Reform 2* are percentage change from initial values.

Table 6: Size of the Informal Sector

	Initial Value	***Reform 1***	***Reform 2***
% of production	8.1%	8.2%	7.9%
% of workers	22.7%	24.1%	22.0%
% of units of effective labor	18.2%	18.8%	17.1%

Table 7: Effects of Tax Reforms on Individual Labor Market Choices

		% Formal Employment			% Work		
		Initial	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
All		77.3	75.7	77.8	25.7	25.3	26.1
Age	15-39	80.2	78.5	80.5	20.9	20.5	21.3
	> 40	72.7	71.3	73.5	40.2	40.0	41.0
Sex	Females	66.1	63.8	66.6	21.5	21.2	21.8
	Males	86.7	85.6	87.2	30.7	30.3	31.3
Education	Low education	66.5	63.6	66.4	31.8	31.1	31.9
	High education	83.0	82.1	83.8	23.3	23.1	23.9
Race	Non black	90.4	90.2	91.3	39.8	40.0	41.2
	Black	71.7	69.4	72.0	22.3	21.8	22.5
Zone	Rural	75.9	73.2	75.6	22.9	22.3	23.0
	Urban	78.2	77.3	79.2	27.9	27.7	28.6

Table 8: Inequality Indexes

		Gini Index			Theil Index		
		Initial	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
All		0.646	0.659	0.693	0.843	0.899	0.860
Age	15-39	0.637	0.649	0.691	0.777	0.829	0.799
	> 40	0.651	0.664	0.684	0.931	0.981	0.929
Sex	Females	0.659	0.671	0.708	0.942	0.999	0.961
	Males	0.629	0.642	0.674	0.735	0.789	0.751
Education	Low education	0.559	0.561	0.632	0.493	0.509	0.507
	High education	0.654	0.666	0.693	0.874	0.926	0.880
Race	Non black	0.563	0.565	0.562	0.670	0.707	0.670
	Black	0.596	0.598	0.662	0.648	0.670	0.660
Zone	Rural	0.654	0.661	0.741	1.116	1.188	1.187
	Urban	0.599	0.611	0.628	0.657	0.705	0.669

Table 9: Poverty Analysis

		Headcount ratio (%)			Poverty gap (%)		
		Initial	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
All		35.8	36.2	39.2	23.4	23.1	31.6
Age	15-39	37.6	38.3	41.5	24.5	24.4	33.7
	> 40	30.2	29.9	31.9	20.0	18.9	25.2
Sex	Females	37.5	38.1	41.1	24.5	24.2	33.1
	Males	33.7	34.0	36.8	22.2	21.7	30.0
Education	Low education	38.6	39.5	43.4	25.3	25.3	35.8
	High education	34.7	34.9	37.5	22.7	22.2	30.0
Race	Non black	16.8	15.4	14.3	12.3	9.7	9.7
	Black	40.2	41.1	45.0	26.0	26.2	36.8
Zone	Rural	45.6	47.3	51.9	29.1	29.4	42.7
	Urban	28.0	27.5	29.1	18.9	18.0	22.9

Appendix

Table A.1: Proportion of Informal Sector Remuneration by Industry

1	Agriculture, hunting, forestry and fishing	4.02%
2	Mining and quarrying	0.07%
3	Manufacturing	0.59%
4	Electricity, gas and water supply	0.02%
5	Construction	13.15%
6	Wholesale and retail trade	1.47%
7	Transport and communication	4.43%
8	Financial intermediation, insurance, real estate	0.12%
9	Public administration	0.19%
10	Private households	71.91%

Table A.2: Tax Rates for Individuals - 2000/2001

Taxable Income	**Rates of Tax**	**Proportion**
R1 - R35 000	18% of each R1	78.56%
R35 001 - R45 000	R6 300 + 26% of the amount above R35 000	5.99%
R45 001 - R60 000	R8 900 + 32% of the amount above R45 000	6.30%
R60 001 - R70 000	R13 700 + 37% of the amount above R60 000	2.00%
R70 001 - R200 000	R17 400 + 40% of the amount above R70 000	6.47%
R200 001 - and above	R69 400 + 42% of the amount above R200 000	0.71%
Individual Primary Rebates	R3 800	
Tax Threshold under 65 years	R21 111	

Source: South African Revenue Service (*SARS*).
Among the 78.56%, 62.59% does not pay taxes due to rebates and tax threshold.
We note that the tax brackets and tax thresholds are adjusted on an annual basis.

Table A.3: Macroeconomic Effects of Tax Reforms by Industries

	Formal Sector			Informal Sector		
	Initial Value	***Reform 1***	***Reform 2***	***Initial Value***	***Reform 1***	***Reform 2***
Value Added						
Agriculture, hunting, forestry and fishing	39,049	-0.1%	1.2%	4,818	0.8%	0.1%
Mining and quarrying	63,193	-0.2%	2.1%	148	1.1%	-0.2%
Manufacturing	238,431	-0.2%	2.0%	4,173	1.2%	-0.4%
Electricity, gas and water supply	27,750	-0.1%	1.5%	22	0.8%	0.1%
Construction	24,335	-0.3%	1.7%	12,522	1.4%	-0.5%
Wholesale and retail trade	120,620	-0.2%	2.2%	5,759	1.1%	-0.3%
Transport and communication	76,942	-0.2%	1.8%	10,833	1.0%	-0.1%
Financial intermediation, insurance, real estate	154,491	-0.1%	1.7%	624	0.8%	0.1%
Public administration	172,743	-0.4%	3.4%	897	1.9%	-1.1%
Private households	4,592	-0.4%	3.5%	41,244	1.2%	-0.4%
Total	922,147	-0.2%	2.2%	81,039	1.2%	-0.3%
Units of Effective Labor						
Agriculture, hunting, forestry and fishing	115	-0.6%	4.5%	37	4.3%	-3.6%
Mining and quarrying	267	-0.6%	4.7%	2	3.9%	-3.2%
Manufacturing	1,023	-0.6%	4.4%	49	3.7%	-3.0%
Electricity, gas and water supply	87	-0.6%	4.7%	0	4.3%	-3.6%
Construction	128	-0.6%	3.8%	165	3.5%	-2.8%
Wholesale and retail trade	523	-0.6%	4.7%	63	3.8%	-3.1%
Transport and communication	250	-0.6%	4.6%	105	4.0%	-3.3%
Financial intermediation, insurance, real estate	486	-0.6%	4.8%	5	4.3%	-3.6%
Public administration	1,298	-0.5%	4.2%	17	2.7%	-1.9%
Private households	24	-0.7%	5.8%	489	3.7%	-3.0%
Total	4,201	-0.6%	4.5%	932	3.7%	-3.0%

	Formal Sector			Informal Sector		
	Initial Value	***Reform 1***	***Reform 2***	***Initial Value***	***Reform 1***	***Reform 2***
Capital						
Agriculture, hunting, forestry and fishing	151,284	0.2%	-0.4%	20,873	-1.1%	2.0%
Mining and quarrying	201,804	0.1%	-0.2%	510	-1.5%	2.5%
Manufacturing	607,622	0.2%	-0.4%	12,732	-1.7%	2.7%
Electricity, gas and water supply	113,118	0.1%	-0.2%	95	-1.1%	2.1%
Construction	59,453	0.2%	-1.1%	33,149	-1.9%	2.9%
Wholesale and retail trade	362,959	0.2%	-0.2%	19,061	-1.5%	2.6%
Transport and communication	220,399	0.2%	-0.3%	40,115	-1.4%	2.4%
Financial intermediation, insurance, real estate	608,398	0.1%	-0.1%	2,659	-1.1%	2.1%
PUBLIC administration	157,972	0.3%	-0.6%	883	-2.6%	3.8%
Private households	13,977	0.1%	0.9%	125,523	-1.7%	2.7%
Total	2,496,986	0.2%	-0.3%	255,600	-1.6%	2.6%

Table A.4: Effects of Tax Reforms on Labor Market Choices

					% Formal Employment			% Work		
Education	***Zone***	***Race***	***Sex***	***Age***	***Initial***	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
Black	Low education	Rural	Females	15-39	60.8	56.3	59.8	17.6	17.0	17.6
				>40	51.7	47.3	50.9	28.5	27.8	28.5
			Males	15-39	78.8	75.6	78.2	28.0	27.0	28.0
				>40	78.0	75.4	78.0	45.4	44.4	45.5
		Urban	Females	15-39	36.7	33.2	36.4	20.8	20.5	20.9
				>40	33.2	30.8	33.9	40.0	39.6	40.3
			Males	15-39	73.4	70.6	73.5	23.6	23.0	23.8
				>40	76.1	74.3	76.9	44.2	43.5	44.6
	High education	Rural	Females	15-39	70.2	66.2	69.3	9.0	8.7	9.0
				>40	56.8	53.0	56.6	29.1	28.5	29.3
			Males	15-39	82.0	79.4	81.7	14.4	13.9	14.5
				>40	80.0	79.0	81.3	38.5	38.0	39.1
		Urban	Females	15-39	66.4	63.9	67.2	16.6	16.3	16.8
				>40	60.6	59.6	63.0	41.2	40.8	41.8
			Males	15-39	89.6	89.0	90.3	22.9	22.5	23.5
				>40	91.5	91.7	92.7	47.2	47.2	48.5
Non-Black	Low education	Rural	Females	15-39	80.6	77.3	79.7	51.8	50.5	51.7
				>40	69.1	64.7	67.9	49.2	48.1	49.2
			Males	15-39	94.7	93,6	94.4	80.4	79.4	80.3
				>40	94.7	93.6	94.4	84.6	83.8	84.6
		Urban	Females	15-39	55.6	52.5	56.0	25.4	24.9	25.6
				>40	43.2	41.1	44.6	25.4	25.0	25.7
			Males	15-39	81.0	78.8	81.1	30.9	30.1	31.1
				>40	75.4	73.7	76.4	34.8	34.3	35.3
	High education	Rural	Females	15-39	88.0	87.7	89.1	40.1	39.8	41.0
				>40	87.7	89.1	90.4	33.5	34.2	35.4
			Males	15-39	94.2	94.3	95.0	59.2	59.1	60.4
				>40	95.2	95.6	96.1	70.9	71.3	72.4
		Urban	Females	15-39	93.3	93.5	94.4	29.5	29.6	30.8
				>40	91.6	92.7	93.6	29.5	30.2	31.4
			Males	15-39	95.6	96.0	96.5	40.3	41.0	42.3
				>40	95.8	96.7	97.2	52.9	54.6	55.9

Table A.5: Effects of Tax Reforms on Income Distribution

		10^{th} percentile			50^{th} percentile			90^{th} percentile		
		Initial	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***	***Initial***	***Reform 1***	***Reform 2***
All		184	227	-229	4149	3808	3648	19556	18821	20684
Age	15-39	156	198	-249	3727	3437	3227	17799	16999	18604
	> 40	261	352	-98	5619	5122	5264	25512	26530	28998
Sex	Females	156	208	-232	3720	3454	3232	17854	17342	18759
	Males	210	265	-221	4659	4274	4224	21300	20855	22693
Education	Low education	194	209	-293	3382	3108	2831	11985	10843	11750
	High education	180	240	-199	4540	4181	4147	22756	22884	24812
Race	Non black	607	1009	991	13527	13674	14777	41199	44620	47965
	Black	150	151	-291	3194	2962	2652	13179	12121	13241
Zone	Rural	134	141	-355	2490	2272	1887	10230	8906	9655
	Urban	229	324	-23	6710	6128	6418	25974	26790	29110