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Marginal Cost of Public Funds under the Presence of Informality

CEYHUN ELGIN*
ORHAN TORUL**
Bogazici University
TUGCE TURK***
University of Chicago

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Abstract

In this paper, we investigate the behavior of the marginal cost of public funds (MCF) for different taxes under the presence of informality. We build a dynamic general equilibrium model with formal and informal sectors and allow the government to use consumption, capital, and labor income taxes to raise revenue. Using country-level data on taxes, we calibrate and measure MCF for a cross-section of economies. Our results show that different taxes have distinct cost responses to changes in the informal sector size in each country: while MCF of the consumption tax decreases with the increase in the informal sector size, the MCF of the income taxes, capital and labor, display an opposite behavior. Moreover, omitting the informal sector results in an underestimation in the MCF of capital income tax and overestimation in that of the consumption tax.

Keywords: Informal economy, Taxation, Marginal cost of the public funds, Dynamic general equilibrium model.

JEL Classification: E26, H26.

1. Introduction

Raising tax revenue in order to finance government spending generally has distortionary consequences for the economy, unless financed exclusively by lump-sum taxes or lumpsum tax equivalents.[1] For instance, taxes on earnings typically distort labor supply choice of workers, and taxes on capital income gains disincentivize physical capital investment motivation

* ORCID ID: 0000-0001-8796-2429.
** ORCID ID: 0000-0002-1251-1022.
*** ORCID ID: 0000-0003-0791-0325.

of capital owners. Assuming the economy functions on the "correct side" of the Laffer curve, i. e., raising taxes does not actually result in less revenue collection, the concept of *marginal cost of public funds* (MCF) formalizes the measurement of economic distortion due to increasing taxes by calculating the loss incurred by the society in raising one dollar revenue in order to finance government expenditure.

Informality is an important fact that should be considered in taxation especially in developing countries where the degree of informality is well above the world average. When a country lacks strong enough institutions for firms having to operate formally, taxation may drive some firms to the informal sector. Thus, measuring the cost of taxation should be handled differently, especially in countries with sizeable informal sectors. Although not taking informality into account in the measurement of the cost of taxation can be misleading, there is not much literature about the cost of taxation in a setting with informality. An exception in this regard is Auriol and Warlters (2012) who investigate the MCF in the presence of informality using cross-country data. In particular, authors calculate MCF values of different taxes for several African countries in a basic static set-up. Their main result suggests that when the informal sector enlarges, the cost of taxation intensifies. Thus, it is possible to decrease MCF by increasing the tax base through reducing the size of the informal sector.

In this paper, we study MCF under the presence of informality within a dynamic general equilibrium framework. Studying MCF in a rich set-up incorporating the informal sector is critical, because an analysis that neglects informality has economy-wide incorrect predictions, therefore may reduce the quality of both policy recommendations and conclusions derived from economic theory. Ignoring dynamic aspects is also undesirable, as the behavior of capital accumulation is critical to achieve macroeconomic objectives, and static models fall short in addressing these key dynamics.

Our agenda in this paper is two-fold: First, we evaluate the effects of different types of taxes, in particular, capital and labor income, and consumption taxes, in a dynamic general equilibrium setting featuring an informal sector. We report the impacts of different tax rates for the comparability of the costs of financing. For this goal, we use the simulations of the model to evaluate how the MCF is associated with different levels of informal sector size. Then, using actual tax data from a large set of countries, we calibrate and measure MCF for a panel of developed and developing economies.

Our results first show that among the three tax instruments, the capital income tax is the most distortionary and the consumption tax is the least costly one. This finding is in accordance with the spirit of the Chamley-Judd result, since the capital income tax creates a direct intertemporal wedge in household's optimality conditions. Further, while the consumption tax distorts only the *intratemporal* wedge, the labor income tax distorts the *intratemporal* margin directly, and *intertemporal* margin indirectly via household's labor supply (and leisure) re-allocation between the formal and the informal sectors.

Second, our results suggest that the MCF of both capital and labor income taxes increase with the informality level in the country, which is in line with the findings by Auriol and

Warlters[2] (2012). However, our findings further indicate that MCF of the least distortionary consumption tax does not increase but instead *decreases* over the informality level, while also exhibiting sizeable cross-country differences.[3]

Third, our findings reveal that when quantifying MCF of different tax rates, the choice of models has critical first-order implications. In particular, when MCF of different taxes are quantified via a dynamic general equilibrium model that does *not* feature an informal sector, MCF of capital income tax is *underestimated*, and consumption tax is *overestimated*.[4,5] Thus, neglecting the role informality when coming up with model-based predictions of MCFs may lead to unintended sub-optimal tax policies. In addition, our findings further unveil that the relationship between informality and the measured MCF of the labor income tax not only differs in level, but also *reverts* direction when the informal sector is incorporated into the model.[6] Thus, using a model lacking the informal sector may induce an inaccurate interpretation of the relationship between MCF of labor income tax rate and the informal sector size.

The behavior of the MCF of different taxes is a well-known, fundamental and yet a crucial one, rooting all the way back to the analyses by Pigou (1947), later being enriched by Stiglitz and Dasgupta (1974), Diamond and Mirrlees (1971) and Atkinson and Stern (1974), among others. While the first attempt to formalize the measurement of MCF dates back to Browning (1976), the idea of applying the MCF concept to different environments with different priorities have started both empirical and theoretical and computational line of literature in public economics soon after Browning (1976). Dahlby (1998) presents a calculation method for MCF and examines the social costs of a progressive taxation system which affects the supply decision in the labor market. Sandmo (1998) claims that calculation of MCF under the representative-agent settings misses the redistributive role of taxation, thus he investigates MCF with heterogeneous households. Kleven and Kreiner (2006) study the labor force participation decision in an environment with fixed work cost and its effects on government revenue in an MCF context. They show that non-convexities created by fixed work cost have revenue effects which result in a higher marginal cost of funds. Hashimzade and Myles (2012) investigate MCF in a standard neoclassical growth model with a dynamic environment instead of a static one to compare MCF of capital and labor taxes. However, to the best of our knowledge, except for the paper by Auriol and Warlters (2012), the literature largely neglects the role informality plays in the calculation of the MCF.

The rest of the paper is organized as follows: In Section 2, we describe the environment of the two-sector model we use. Next, in Section 3, we give information about our dataset and explain how we calibrate the parameters of the model. In Section 4, we present simulation results as well as provide cross-country comparisons. Finally, we provide some concluding remarks in Section 5.

2. Model

In this section, we describe the two-sector dynamic general equilibrium model that we use for the calculation of the marginal cost of public funds of different taxes.

The infinitely-lived representative household is endowed with K_0 units of initial productive physical capital and a total of $T > 0$ units of time each period. The agent chooses how much time to allocate to leisure, as well as to the formal and informal employment. The formal sector, denoted by the subscript *F*, has a standard Cobb-Douglas production technology and is subject to full taxation. The informal sector, denoted by the subscript *I*, however, does not have access to capital and uses only labor as input. It is plausible to assume that the informal sector is more labor-intensive compared to the formal sector.[7] Furthermore, the informal sector is subject to taxation only when it is caught by the monitoring authorities. Accordingly, we introduce a tax enforcement parameter ρ, which captures the frequency of being caught, thereby resulting *de facto* tax payments at the same rate. We assume that the tax revenue collected by the government is resulting in wasteful spending[8], or in other words spent for unproductive activities.

Formally, the problem by the representative household is as follows:

$$\max_{\{C_t, K_{t+1}, L_t, N_{It}, N_{Ft}\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

$$\text{subject to} \quad (1+\tau_c)C_t + K_{t+1} - (1-\delta)K_t = (1-\tau_k)r_t K_t +$$

$$(1-\tau_n)w_{Ft}N_{Ft} + (1-\rho\tau_i)(w_{It}N_{It} + \pi_{It}^*)$$

$$N_{It} + N_{Ft} + L_t = T$$

In this setup, the representative household receives utility, discounted at the rate β, from aggregate consumption C_t and leisure L_t. The household has a fixed time endowment T and can use it for leisure, formal labor N_F and informal labor N_I. Moreover, the household's income comes from three sources: Rental income on physical capital $r_t K_t$, formal labor income $w_{Ft}N_{Ft}$ and income from the informal sector. Income from the informal sector is imperfectly taxed at a rate $\rho\tau_i$, where $\rho \in [0,1]$ denotes the extent of the tax enforcement. As there will be positive profits in equilibrium from the informal sector, these profits, π_{It}^*, are also added as an additional source of household income. Finally, τ_C, τ_k, and τ_n denote marginal tax rate on consumption, capital and formal labor, respectively.

Next, on the production side, we assume that each period, a representative firm operates a constant-returns-to-scale (CRS) technology[9] in the formal sector and and a decreasing-returns-to-scale (DRS) technology in the informal sector, represented by the following production functions, respectively:

$$Y_{Ft} = \theta_{F_t} K_t^{\alpha} N_{Ft}^{1-\alpha}$$

$$Y_{It} = \theta_{I_t} N_{It}^{\gamma}$$

where $\gamma < 1$. As before, the firm's optimization problem simplifies to a period-by-period profit maximization problem. Assuming that the competitive firm is a price-taker, each period $t = 0,1,...,T$ the firm solves the following profit maximization problem:

$$\begin{aligned} \max_{\{K_t, N_{Ft}\}} \quad & \pi_{Ft} = Y_{Ft} - r_t K_t - w_{Ft} N_{Ft} \\ \text{subject to} \quad & K_t \geq 0, N_{Ft} \geq 0. \end{aligned} \tag{1}$$

and

$$\begin{aligned} \max_{\{N_{It}\}} \quad & \pi_{It} = Y_{It} - w_{It} N_{It} \\ \text{subject to} \quad & N_{It} \geq 0. \end{aligned} \tag{2}$$

Simple optimization procedures give the first-order conditions that solve the profit maximization problems; as before, the marginal products should equal their price for each $t = 0,1,...,T$:

$$\frac{\partial Y_{Ft}}{\partial K_t} - r_t = 0$$

$$\frac{\partial Y_{Ft}}{\partial N_{Ft}} - w_{Ft} = 0$$

$$\frac{\partial Y_{It}}{\partial N_{It}} - w_{It} = 0$$

The CRS technology for the formal sector implies zero optimal profit whereas the DRS technology in the informal sector leads to positive profits in this sector, i.e. $\pi_{it}^* = (1-\gamma)\theta_{It} N_{It}^{\gamma} > 0$. Next, we proceed to characterize the competitive equilibrium (CE) below:

Definition: Given the government policy variables $\{\tau_c, \tau_i, \tau_k, \tau_n, \rho\}$, a competitive equilibrium of the above-described two-sector model is a set of sequences of allocations $\{C_t, L_t, K_{t+1}, N_{It}, N_{Ft}\}_{t=0}^{\infty}$ and prices $\{w_{Ft}, w_{It}, r_t\}_{t=0}^{\infty}$ such that

1. Given the prices and policy, $\{C_t, L_t, K_{t+1}, N_{It}, N_{Ft}\}_{t=0}^{\infty}$ maximizes the representative agent's present-discounted life-time utility.

2. Given the prices, $\{N_{It}, N_{Ft}, K_t\}_{t=0}^{\infty}$ solve the profit maximization problems of the firms.

3. All markets clear.

4. Government budget is balanced, thereby satisfying: $R = \tau_c C + \tau_k \alpha Y_f + \tau_n (1-\alpha) Y_f + \rho \tau Y_i$.

Assuming logarithmic utility[10] (i.e. $U(C_t L_t) = \log(C_t) + \varphi \log(L_t)$), the maximization problem of the household yields the following Euler equation:

$$\frac{C_{t+1}}{C_t} = \beta[(1-\tau_k)\theta_F \alpha K_{t+1}^{\alpha-1} N_{Ft+1}^{1-\alpha} + 1 - \delta]$$

Since in equilibrium marginal products of labor in both sectors must be equal, we have:

$$(1-\tau_n)\theta_F(1-\alpha)K_t^{\alpha}N_{Ft}^{-\alpha} = (1-\rho\tau)\theta_{I\gamma}N_{It}^{\gamma-1}$$

By rearranging the Euler equation, one can rewrite K_t as a function of N_{Ft}:

$$K_{t+1} = N_{Ft+1}\left[\frac{(1-\tau_k)\theta_{F\alpha}}{(1+g_c)/\beta - 1 + \delta}\right]^{\frac{1}{1-\alpha}}$$

Moreover, the time spent on informal labor can be obtained now using the marginal product equality:

$$N_{It+1} = \left\{\frac{(1-\rho\tau)\gamma\theta_I}{(1-\tau_n)(1-\alpha)\theta_F}\left[\frac{(1+g_c)/\beta - 1 + \delta}{\alpha(1-\tau_k)\theta_F}\right]^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{1-\gamma}}$$

So at the steady state (i. e. when $g_c = 0$), the informal and formal labor become:

$$N_I = \left\{\frac{(1-\rho\tau)\gamma\theta_I}{(1-\tau_n)(1-\alpha)\theta_F}\left[\frac{1/\beta - 1 + \delta}{\alpha(1-\tau_k)\theta_F}\right]^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{1-\gamma}}$$

$$N_F = \frac{(T-N_I)\gamma(1-\rho\tau)\theta_I N_I^{\gamma-1} - \phi(1-\rho\tau)\theta_I N_I^{\gamma}}{\gamma(1-\rho\tau)\theta_I N_I^{\gamma-1} + \phi\left[\big(\alpha(1-\tau_K) + (1-\alpha)(1-\tau_n)\big)\theta_F\left(\frac{\alpha(1-\tau)\theta_F}{1/\beta - 1 + \delta}\right)^{\frac{\alpha}{1-\alpha}} - \delta\left(\frac{\alpha(1-\tau_k)\theta_F}{1/\beta - 1 + \delta}\right)^{\frac{1}{1-\alpha}}\right]}$$

Once we have the steady-state expressions for N_I and N_F, we can obtain

$$K = N_F\left[\frac{(1-\tau_k)\theta_{F\alpha}}{1/\beta - 1 + \delta}\right]^{\frac{1}{1-\alpha}}$$

$$(1+\tau_c)C = (1-\tau_k)\alpha Y_F + (1-\tau_n)(1-\alpha)Y_F + (1-\rho\tau)Y_i - \delta K$$

$$R = \tau_c C + \tau_k \alpha Y_f + \tau_n(1-\alpha)Y_f + \rho\tau Y_i$$

Finally, given the indirect utility function V originating from the above-defined problem we can define the marginal cost of public funds for three different taxes as follows:

$$MCF_{\tau_k} = -\frac{\partial V/\partial\tau_k}{\partial R/\partial\tau_k}$$

$$MCF_{\tau_c} = -\frac{\partial V/\partial\tau_c}{\partial R/\partial\tau_c}$$

$$MCF_{\tau_n} = -\frac{\partial V/\partial\tau_n}{\partial R/\partial\tau_n}$$

The marginal cost of public funds shows the trade-off between the welfare loss and the revenue gain from the increase in taxes. It is higher when the marginal loss in the welfare

is more than the additional revenue gain of the government. Moreover, it is possible for the government to obtain less revenue when it increases the tax rate. Therefore, for a given tax, if the government is on the wrong side of the Laffer curve, then the MCF can also be negative.

3. Data and Calibration

The data that we use in our calculations and for the calibrations of our parameters are from 2010 and cover 45 countries across different regions. We calculate marginal tax rates following the methodology outlined by Conesa *et al*. (2007). For capital share α and depreciation rate δ, we use the country specific values reported by the Penn World Tables 9.0. Moreover, we calculate the discount factor β for each country separately by using the inter-temporal Euler equation. Again, for each country, we obtain the parameter estimates for the weight of leisure in the utility function (i. e. φ) by using intra-temporal condition between consumption and leisure. Finally, for formal output levels of countries, we use the estimates by Penn World Table 9.0 and we obtain cross-country panel estimates[11] of informal output and the ratio of informal/formal labor from Elgin and Oztunali (2012).

Productivity parameters in the production functions θ_F and θ_I, and labor share parameter in the informal sector γ are free parameters that are not explicitly fed into the model. Instead, we calibrate them to match desired values of specific variables in the model by their data counterparts. As the informality level in the economy is a crucial concern in this framework, formal and informal output levels and the ratio of informal/formal labor are the ones matched exactly with the data via θ_F , θ_I and γ. In the case of calculations of the model without informality, we use only θ_F and we match the formal output level in the data.[12]

In the simulation part, we calibrate the parameters so that their desired values are matched with the *averages* of the countries used in the cross-country analysis. In order to get different informality levels, we vary the tax enforcement parameter ρ.[13] In order to see if the results are driven by informality level or enforcement level, we perform a robustness check by changing the informality level via varying with the productivity of the informal sector θ_I.[14]

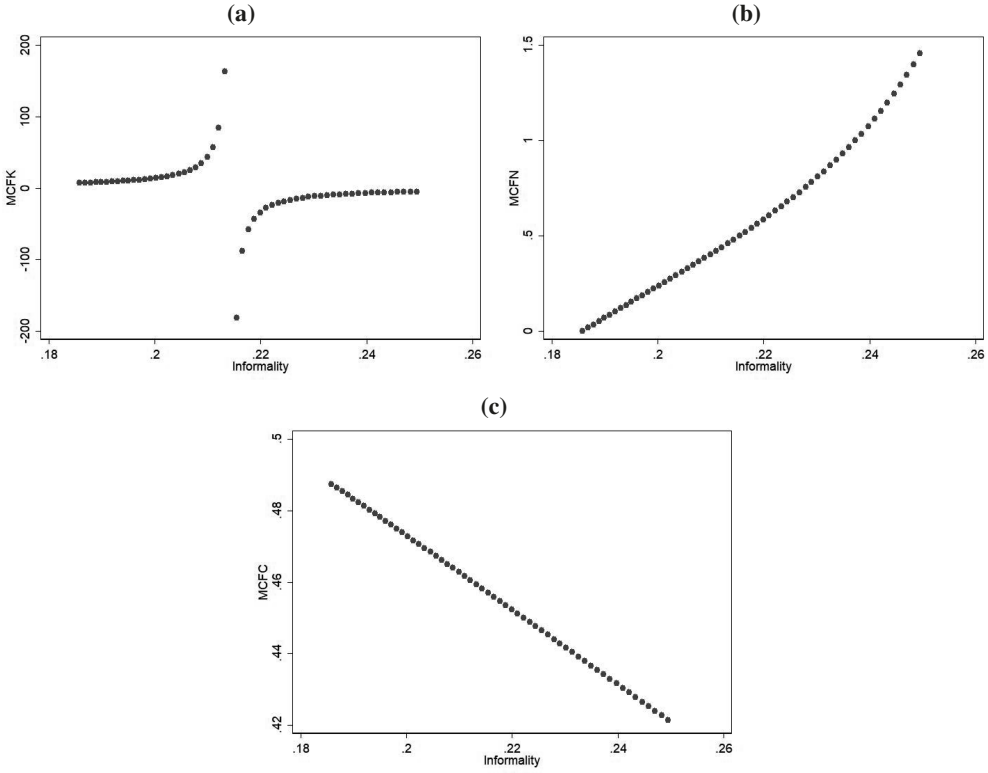
4. Results

4.1. Simulation Results

Before doing a cross-country analysis, we first conduct a simulation experiment to elicit how MCF of different taxes react to informality level for a representative country. For the values that are fed into the model of the representative country, we use the *average* values of our sample, and we calibrate the parameters the same way we described in the previous section. Next, we change the informality level via varying one of the free parameters, ρ, i. e. the tax enforcement rate on the informal sector. We observe how MCF of raising revenue for each tax instrument responses to those counter-factuals.

As it can be seen from the Figure 1a, MCF of capital income tax increases with the informal sector size. After a threshold, the representative country passes to the right (wrong) side of the Laffer curve, where increasing taxes start to reduce revenue. Thus, having a high level of informality obstructs the government from increasing its tax revenues with even higher tax rates. This threshold is illustrated by the discontinuity on the figure. When the degree of informality increases, the utility of the representative household starts to get affected less by the incremental increase in capital income tax rate, as the economy-capital levels already decreases notably. However, raising the revenue with the same amount of increase in the tax rate becomes harder, as the size of the informal sector becomes larger. Thus, the behavior of the cost is mostly determined by the revenue part, i. e. the denominator, of the MCF.

Figure 1
SIMULATION RESULT FOR MCF AND INFORMALITY

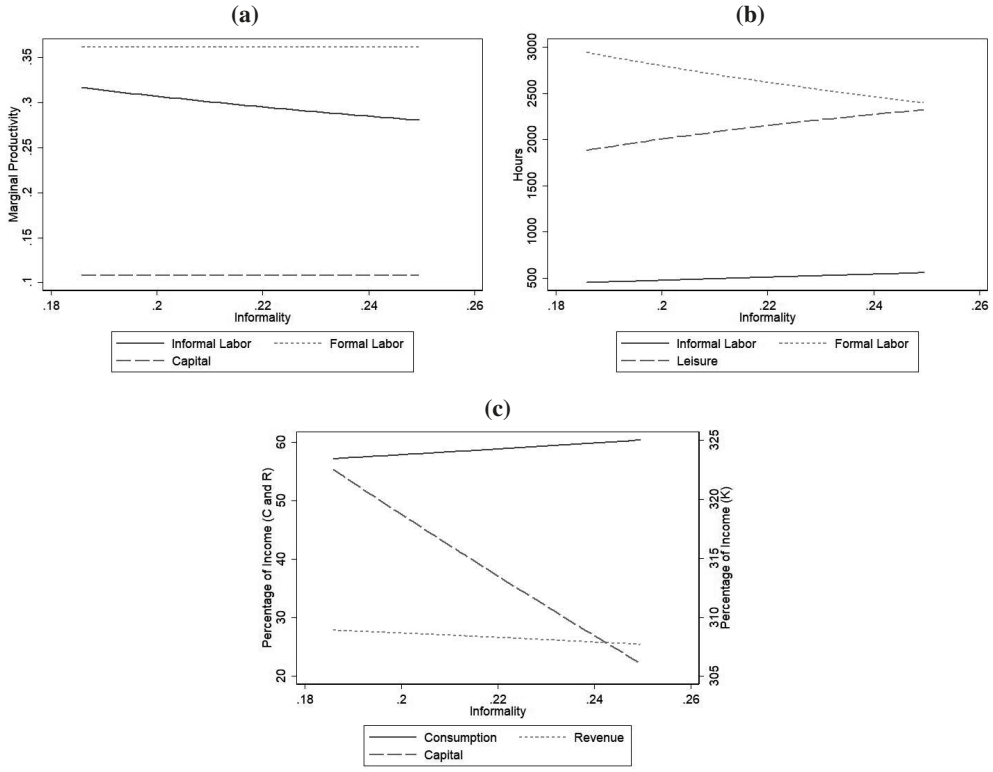


The MCF of labor income (Figure 1b) tax exhibits a behavior similar to that of the capital income tax, i.e. it also increases with the informal sector size. Notwithstanding, the driving force behind this pattern that determines the shape of the MCF graph is not the same as in the case of the capital income tax. Different from the former, the decline in the utility of households rises with the informal sector size. Although the average marginal tax rates on capital and labor income are similar, the MCF of capital income tax surpasses that of the labor in-

come tax for all informality levels prior to changing sides on the Laffer curve exhibited by the discontinuity at Figure 1a.

In contrast to income taxes, the MCF of consumption tax r (Figure 1c) reacts negatively to an increase in informality level. As we discuss in the next subsection, this result is in line with our findings from our cross-country estimations. Moreover, when we compare the MCF of consumption tax to those by the other two, we report that it emerges as the least costly one for most of the informality levels and also again ignoring the region of the MCFK in the wrong side of the Laffer curve.

Figure 2
STEADY-STATE VALUES FOR DIFFERENT INFORMALITY LEVELS



Our simulation exercise delivers valuable lessons on several fronts. First, when we vary the size of the informal sector via the tax enforcement parameter, we observe several implications of different tax enforcement policies. Enhancing auditing and enforcement of the informal sector raises the revenue of the government as expected (Figure 2c) , but its marginal cost differs across different taxes. The increase in the number of firms that comply with tax obligations (i. e. a reduction in the size of the informal sector) decreases the MCF of labor and capital income taxes, which is consistent with the results by Auriol and Warlters (2012). Un-

der the presence of a large and possibly less efficient informal sector, taxes do not only distort consumption-investment and labor-leisure tradeoffs, but also the tradeoff between formal and informal labor and therefore are more costly.

Second, it also induces an increase in the MCF of the consumption tax. To see why we need to first understand how steady state consumption changes with informal sector size. To this end, in Figure 2 we look at the steady-state values of some key variables in our simulation experiment to detect how the levels of such variables are affected by varying tax enforcement and informal sector size. We report that the steady-state capital level becomes higher when the informal sector size shrinks, due to the fact that the informal sector production function does not utilize capital as an input. However, a major drawback of having a smaller informal sector is consuming less at the steady-state (due to the fact that the optimality conditions between formal and informal labor being distorted reduces the extra income from the informal sector for the household), which emerges as a welfare loss from the representative-household's perspective. Another consequence of the decrease in the informal sector size is that the representative-household starts to work more in order to sustain her consumption level, which in turn lowers her overall utility. The former results is very much related to the decreasing MCF of the consumption tax with informal sector size. When informal sector size is larger, consumption is larger and as a result the denominator in the MCF of consumption tax, i.e. the change in revenue due to a change in consumption tax is also larger. However, at the same time the numerator increases more than the denominator, i.e. the reduction in the utility due to consumption taxes is less under the presence of a larger informal sector. This overall reduces the MCF of the consumption tax.

All these results can be attributed to a joint causal relationship between informality and MCF of different taxes. in a dynamic general equilibrium model all endogenous variables are linked to each other and are determined jointly. So, in that sense they all jointly cause each other (labeled as a causal chain by some economists).

4.2. Cross-Country Analysis

In this section, we report and discuss our model-based MCF measures for different taxes on a cross-country basis. As discussed before, we use the standard logarithmic utility of the following form[15] $U(C_t,L_t) = log(C_t) + \varphi log(L_t)$.

Table 1 shows both MCF values and the rankings of countries for each of the tax instrument. As some of the MCF values are negative, i. e. the country is on the wrong (right-hand) side of the Laffer curve, we also report their *rankings* to be able to make a comparison for each country. Here, rankings are assigned in a way that a country having least costly taxation is ranked lower than the others. Negative MCF values are treated to be costlier than the positive ones because being on the right-hand side of the Laffer curve means that increasing tax rates decreases both the utility of households as well as the revenue of the government and this is interpreted as worse than decreasing only the utility. In the graphs, the rankings are used again to provide a visual interpretation of our results. Regarding the model without

informality, we refer to a one-sector standard neoclassical growth model (without an informal sector), the details of which are presented in the Appendix.

We start our discussion with the MCF of the capital income tax and illustrate our findings in Figure 3a. The horizontal axes refer to the informal sector size (as % of GDP), while the vertical axis refers to the ranking of MCF of capital income tax for each country. The two ends of each vertical line display the resulting ranking of a country in the model with and without informality. Evidently, under both model settings there is a positive relationship between the informal sector size and the MCF of the capital income tax. Having a larger informal sector reduces the tax base of the government and leads to a higher MCF of capital taxation. We also analyze the effect of *tax rate* on MCF and report that MCF of capital income tax increases with the tax rate, as illustrated in Figure A.3.

Table 1
SUMMARY OF THE RESULTS

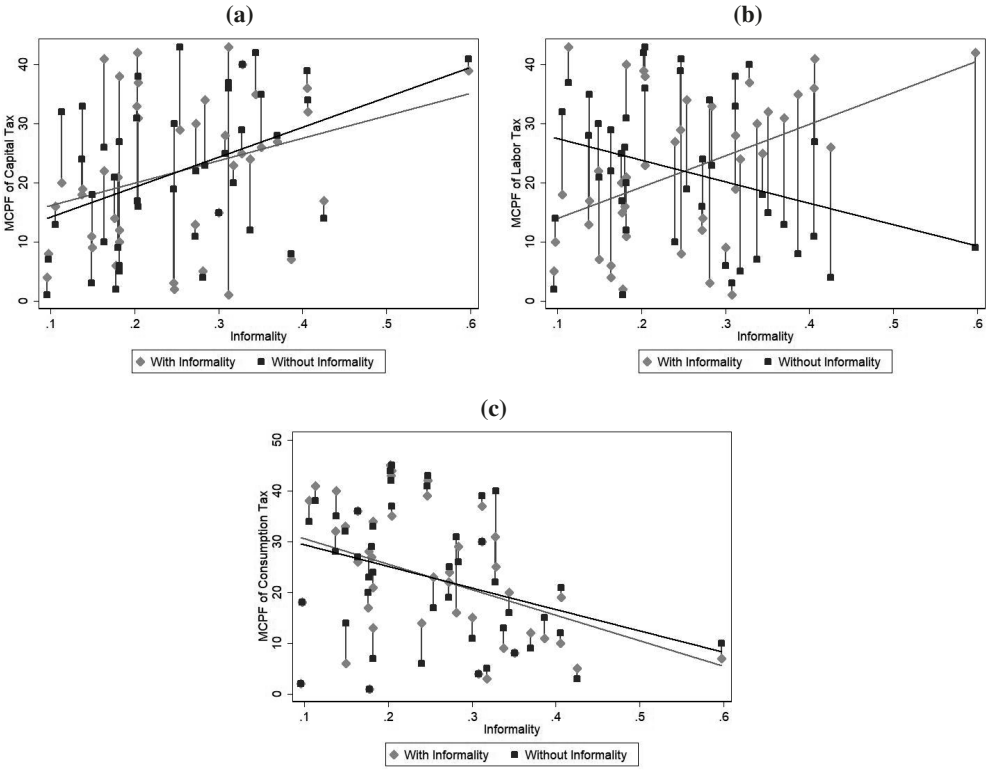
		With Informality						Without Informality					
Region	**Country**	**MCFK**	**Rank**	**MCFC**	**Rank**	**MCFN**	**Rank**	**MCFK**	**Rank**	**MCFC**	**Rank**	**MCFN**	**Rank**
East Asia & Pacific	Hong Kong	0.56	6	0.13	1	0.10	2	0.55	2	0.20	1	0.29	1
	Taiwan	-10.88	23	0.27	3	1.84	24	1.21	20	0.46	5	0.74	5
	Singapore	1.26	9	0.28	6	0.25	7	1.14	18	0.62	14	1.23	21
	Australia	-13.79	22	0.46	26	0.14	4	0.86	10	0.90	27	1.33	22
	New Zealand	4.76	18	0.51	32	0.38	13	1.36	24	0.91	28	1.51	28
	Japan	-0.31	41	0.56	36	0.22	6	1.38	26	1.06	36	1.57	29
	Korea	-8.14	24	0.32	9	-23.19	30	0.89	12	0.59	13	0.80	7
Average		-3.79	20	0.36	16	-2.89	12	1.05	16	0.68	18	1.07	16
Eastern Europe	Bulgaria	4.06	17	0.28	5	1.91	26	0.97	14	0.39	3	0.61	4
	Poland	3.27	15	0.34	15	0.28	9	0.99	15	0.55	11	0.76	6
	Romania	-5.77	27	0.32	12	-9.48	31	1.45	28	0.53	9	0.97	13
	Hungary	2.52	13	0.42	22	0.37	12	0.89	11	0.71	19	1.08	16
	Czech Republic	2.53	14	0.36	17	0.53	20	1.22	21	0.73	20	1.35	25
Average		1.32	17	0.35	14	-1.28	20	1.10	18	0.58	12	0.95	13
Latin America & Caribbean	Jamaica	-3.81	28	0.27	4	0.05	1	1.36	25	0.45	4	0.60	3
	Colombia	1.02	7	0.32	11	-1.39	35	0.78	8	0.64	15	0.81	8
	Peru	-0.53	29	0.29	7	-0.18	42	3.36	41	0.54	10	0.88	9
	Brazil	-0.84	36	0.32	10	-1.11	36	2.57	39	0.59	12	0.92	11
	Trinidad and Tobago	-6.20	26	0.31	8	-8.74	32	2.09	35	0.52	8	1.05	15
	Mexico	-0.84	35	0.42	20	1.89	25	4.27	42	0.67	16	1.15	18
	Argentina	-2.02	29	0.43	23	-2.18	34	5.29	43	0.68	17	1.20	19
	Venezuela	-0.50	40	0.45	25	-0.55	37	2.94	40	1.45	40	4.22	40
	Barbados	-6.98	25	0.50	31	-57.12*	-	1.46	29	0.78	22	1.03*	-
Average		-2.30	29	0.37	15	-1.11	30	2.68	34	0.68	15	1.30	15
Middle East	Israel	0.20	3	0.62	39	12.43	29	1.16	19	1.51	41	3.05	39
Average		0.20	3	0.62	39	12.43	29	1.16	19	1.51	41	3.05	39

(Continued)

		With Informality						Without Informality					
Region	**Country**	**MCFK**	**Rank**	**MCFC**	**Rank**	**MCFN**	**Rank**	**MCFK**	**Rank**	**MCFC**	**Rank**	**MCFN**	**Rank**
North America	United States	1.09	8	0.39	18	0.28	10	0.76	7	0.70	18	1.04	14
	Canada	1.54	10	0.42	21	0.32	11	0.69	5	0.82	24	1.22	20
Average		1.32	9	0.40	20	0.30	11	0.72	6	0.76	21	1.13	17
Northern Europe	Iceland	-0.78	38	0.54	34	-0.29	40	0.70	6	1.04	33	1.62	31
	Norway	-1.51	31	0.56	35	0.97	23	1.00	16	1.29	37	2.35	36
	Denmark	-0.91	33	0.92	45	-0.41	39	1.50	31	2.11	44	7.27	42
	Sweden	-0.81	37	0.84	44	-0.54	38	2.26	38	2.20	45	10.67	43
	Finland	-0.22	42	0.80	43	-38.46*	-	1.09	17	1.87	42	4.32*	-
Average		-0.85	36	0.73	40	-0.07	35	1.31	22	1.70	40	5.48	38
Southern Europe	Portugal	-0.85	34	0.48	29	-4.62	33	1.33	23	0.88	26	1.34	23
	Spain	-1.80	30	0.45	24	0.39	14	1.26	22	0.87	25	1.35	24
	Turkey	-1.37	32	0.41	19	-0.27	41	2.01	34	0.74	21	1.40	27
	Greece	0.01	1	0.49	30	2.30	28	2.13	36	0.97	30	1.84	33
	Cyprus	0.44	5	0.36	16	0.13	3	0.68	4	1.02	31	1.87	34
	Italy	-0.10	43	0.57	37	0.52	19	2.18	37	1.34	39	2.72	38
Average		-0.61	24	0.46	26	-0.26	23	1.60	26	0.97	29	1.75	30
Western Europe	Switzerland	0.31	4	0.22	2	0.20	5	0.31	1	0.38	2	0.49	2
	Ireland	2.48	12	0.32	13	0.57	21	1.43	27	0.49	7	0.93	12
	Germany	-26.47	21	0.46	27	0.43	16	0.80	9	0.91	29	1.36	26
	Netherlands	2.37	11	0.53	33	0.60	22	0.61	3	1.03	32	1.62	30
	Luxembourg	3.69	16	0.59	38	0.52	18	0.90	13	1.05	34	1.64	32
	United Kingdom	8.47	19	0.63	40	0.51	17	1.68	33	1.06	35	2.10	35
	Austria	20.12	20	0.75	41	-0.00	43	1.60	32	1.30	38	2.67	37
	Belgium	0.04	2	0.78	42	0.28	8	1.50	30	1.95	43	4.48	41
Average		1.38	13	0.53	29	0.39	18	1.10	19	1.00	27	1.82	26

Moreover, when the values of MCF of capital income taxes are investigated, the first observation we make is that the capital income tax is the most costly tax among others in most of the economies. Another pattern that can be inferred from the Table 1 is that when the MCF of the capital income tax is measured via a model with no informality, it generally underestimates the true cost, as illustrated when compared to the predictions by the two-sector model. The model with informality reveals that the real cost of taxation is higher and as it can be understood from the negative values, most of the countries are on the wrong side of the Laffer curve. Although policymakers are most of the time trying to optimize the tax revenues before implementing a new tax plan, we see that the existence of the informal sector shifts the optimal point on the Laffer curve. Thus, ignoring the informal sector in the economies when measuring their cost in taxation may result in drawing sub-optimal conclusions. Nevertheless, different regions have different patterns on the cost of taxation. Western Europe and North America rank better in the cost of the capital income tax and Northern Europe has the most costly capital income tax compared to other regions in our sample.

Figure 3
RANKINGS OF MCF AND INFORMALITY



Next, we concentrate on the behavior of MCF of labor income tax, and present our results in Figure 3b. In this regard, we notice that adding informal sector into the model drastically changes the relationship between the MCF and the informal sector size. In fact, while the cost increases with informal sector size in the model with informality, it decreases in the one-sector model without the informal sector. Thus, we cannot certainly argue that the model with no informality systematically overestimates or underestimates the MCF, as the effect varies by country. The model with informality predicts a positive association between the informal sector size in the country and the MCF of labor income tax, as expected. When the formal sector size gets smaller, raising the same amount of revenue requires a higher increase in the tax level, resulting in a higher distortion in the economy. However, the main determinant of the result of the model without informality is the relationship between labor income tax levels and the income level of the country.[16] Another stylized fact from the literature is that highincome countries have smaller informal sector sizes. Thus, the countries with larger informal sectors also happen to be the ones with lower labor income tax rates.[17] As a result, higher tax levels incentivize households to choose leisure over labor and create more distortions, meaning that an increase in taxation results in a higher decrease in utility of the household. The summary of the labor income tax and the distortion level in terms of

informality level can be found Table A.1 and A.2. Thus, the origin of the shape of the graph of informality and the cost of labor income tax in the model without informality is the distortionary nature of the labor income tax. In the model with informality, the distortionary effect is not dominant, as there is also an informal labor option for the household, one can choose over formal labor instead of leisure.[18]

Finally, we study the MCF of consumption tax and report our findings in Figure 3c. As expected, consumption tax is the least costly one among others. The relationship between the cost of consumption tax and the informal sector size exhibits a negative correlation, as in accordance with our model simulations. Considering this, in countries with larger informal sector sizes, financing government expenditures with consumption tax might be less costly.[19]

We also make several observations with respect to cross-regional differences in MCF values. For example, countries in Northern Europe face especially higher costs of consumption tax compared to other countries. This observation is not surprising, as these economies have both higher consumption tax rates and smaller informal sector sizes. Although Latin America seems to have less costly labor income tax compared to other regions if predicted by the one sector model, this result reverses when the informal sector is incorporated into the model setting. Additionally, we report that East Asia and Pacific countries have less costly labor income tax compared to other countries.

4.3. Possible Extensions of the Model

In this subsection we shortly discuss several potential extension of the model and how the results would be affected under such extension.

The first of these extensions concerns the deterministic nature of our general equilibrium model. Surely, a more general setup where certain parameters are subject to stochastic shock would be more realistic, however, at the same time, this would also require more country-level data to calibrate additional parameters regarding the distributional properties of these shocks. One such example could be making the tax enforcement parameter ρ subject to a shock such as specifying it as $\rho = \bar{\rho} + \epsilon$. Under this specification, all of our results with the deterministic model would still hold as long as exhibits a standard normal distribution. Surely, under different distributional assumptions and/or different shock mechanisms results could potentially differ.

Another extension would concern opening up the economy to include a foreign sector, since real exchange rate and access to international goods and capital markets can play an important role in the evolution of the informal sector (See Acosta *et al*. 2009 and Chatterjee and Turnovsky, 2018 for two examples) We leave a more detailed analysis to a future study here, but again, as long as the trade taxes (e. g. in the form of tariff barriers) are negligible as compared to the total tax revenue.

A third extension of the benchmark model that rests upon the representative agent assumption and therefore the lack of heterogeneity. This could be overcome by adding up a

hand-to-mouth agent to the Ricardian one already in the model, using an overlapping generations model or introducing heterogeneity in skills, income, preferences etc. One such heterogeneity could possibly be created through the introduction of productivity differences in labor, where (low) high productive labor will go (in)formal. More importantly, when heterogeneity is introduced there might also be room for a discussion of redistribution, through the extension of the tax base. This might have several repercussions on the marginal cost of public funds and depending on how this heterogeneity is introduced might affect the results particularly with respect to informality. Again, we leave a full-fledged analysis to future research.

A final possible extension would concern separating consumption in formal and informal sectors. We provide a short sketch of such a model in the Appendix and present a simulation result in Figure A.5. We observe from the figure that the result with respect to the MCFC is similar to the case without a separate informal consumption.

5. Conclusion

Keeping account of the distortions resulting from taxation is critical in the cost-benefit analysis of financing government spending and in this regard MCF is commonly used in literature to measure these distortions. Although most of the countries, especially the developing ones have large informal economies. There is not much precedent in the literature investigating the relationship between these two issues. In this paper, we aim to fill in this gap in the literature and take informality into consideration when measuring the MCF. To this aim, we use a two-sector model, with formal and informal sectors, in a dynamic general equilibrium framework. Each tax creates a different level of distortion in the economy and this allows us compare the marginal cost of capital and labor income and consumption taxes which are commonly used in financing the government spendings. First, a simulation exercise is done to see the effect of informality level on the cost of taxation. Then, by using cross-country data, the model is calibrated and MCF values are calculated for each country in our sample.

Our results generally show that among three main taxes the capital income tax is the most and the consumption tax is the least costly tax. This result sheds significant light on the tax policy design for policy-makers. Moreover, both the results of simulation and the cross-country analysis imply that informal sector size is positively related to MCF of income taxes and negatively related to MCF of the consumption tax. Yet another crucial result is that taking informality into account implies significant changes in the calculation of the MCF levels. Generally, the MCF estimates of the capital income tax obtained from the two-sector model that includes the informal sector are significantly higher than the ones obtained from the one-sector model. Additionally, we also report that a significant number of the countries are on the right-hand-side of the Laffer curve, meaning that the tax rate are not maximizing the tax revenue and reducing the taxes would increase the revenue. Moreover, for the labor income tax, mis-measurement is more severe than the other taxes. If the cost of taxation is calculated without the presence of informal sector, countries with higher tax levels have a higher cost as taxes result in more distortion in the economy. However, having a large infor-

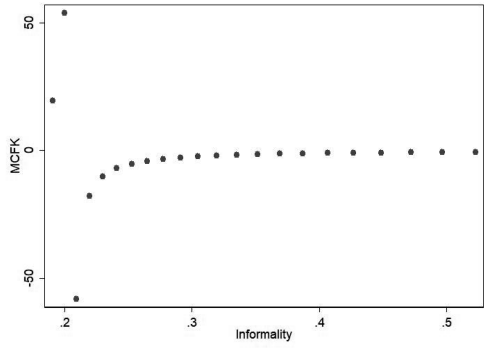
mal sector makes raising revenue harder which also increases the cost of taxation. Latter one outweighs the former one in our model. Thus, the relationship between informality and cost of labor income tax changes direction by including the informal sector. When we study the consumption tax, unlike the capital income tax the one-sector model overestimates the MCF. Thus, in general we argue that measuring MCF with a one-sector model results in a significant mis-measurement in the cost calculations.

However, one specific limitation of our model is that we use representative agent model and therefore do not take the redistributive effects and distortions of taxes into account. Moreover, the role of full insurance within the household in the calculation of the MCF due to the representative agent model might also be affecting our results. Another limitation is that we did not incorporate economic growth into account. We leave the study of these aspects to future research.

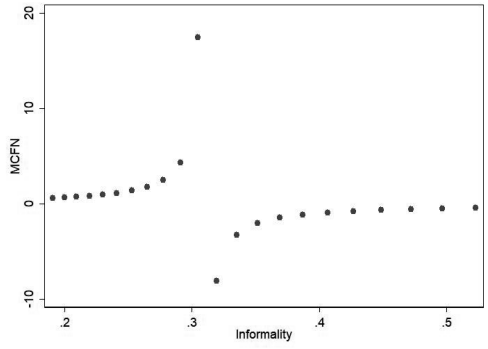
Appendix A. Figures and Tables

Figure A.1
SIMULATION RESULT FOR MCF AND INFORMALITY

(a)



(b)



(c)

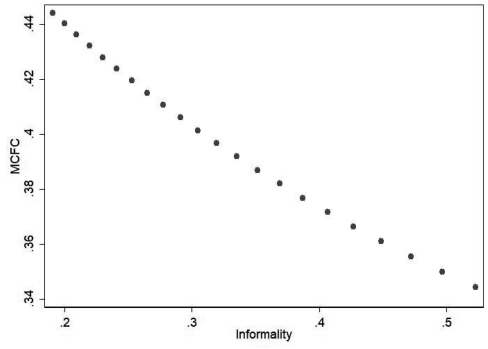
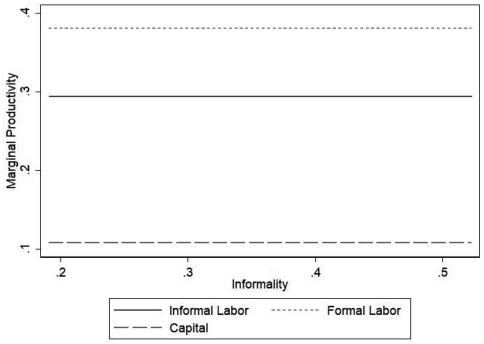
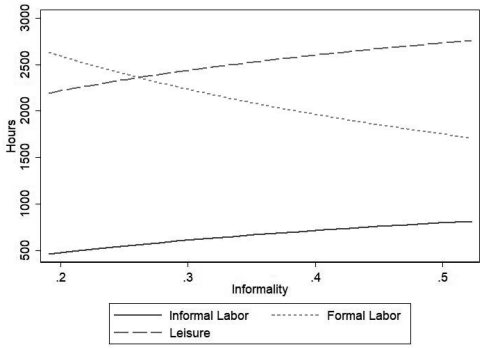


Figure A.2
STEADY-STATE VALUES FOR DIFFERENT INFORMALITY LEVELS

(a)



(b)



(c)

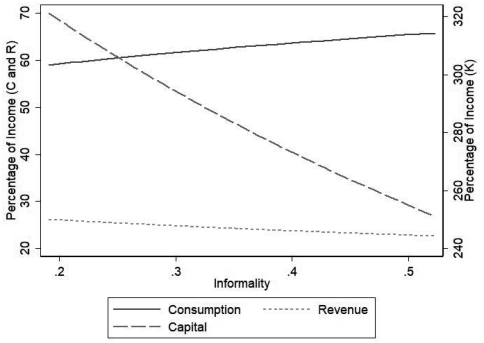
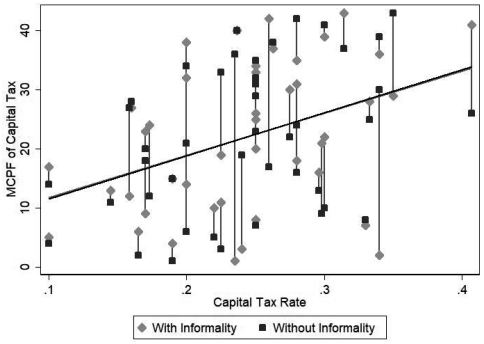
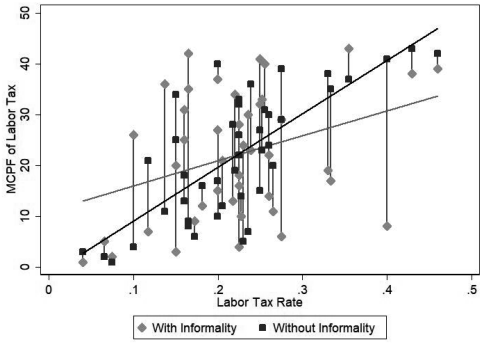


Figure A.3
RANKINGS OF MCF AND TAX RATES

(a)



(b)



(c)

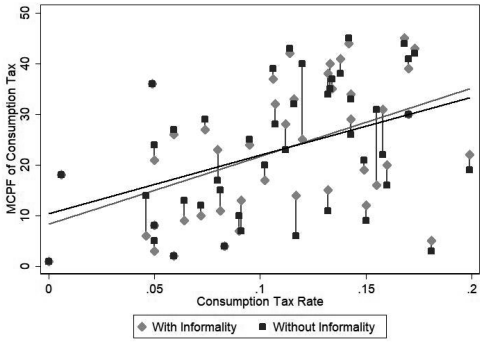


Figure A.4
LABOR INCOME TAX AND INFORMALITY RATE OF THE COUNTRIES IN THE SAMPLE

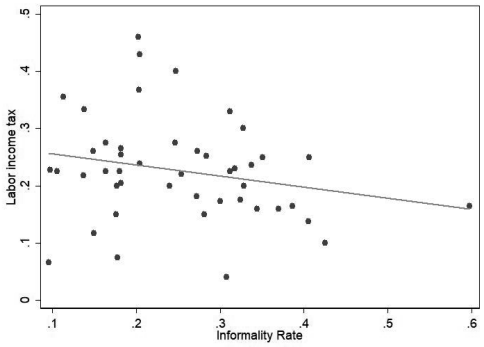


Table A.1
SUMMARY OF LABOR INCOME TAX

Informality		Mean	Std. Dev.	Freq.
	<0.2	0.216	0.079	17
0.2<	<0.3	0.286	0.103	12
0.3<		0.194	0.071	17
Total		0.226	0.089	46

Table A.2
SUMMARY OF $\partial U/\partial \tau_n$

Informality		Mean	Std. Dev.	Freq.
	<0.2	-1.391	0.207	17
0.2<	<0.3	-1.569	0.401	12
0.3<		-1.169	0.210	17
Total		-1.355	0.310	46

Appendix B. Model without Informality

In this Appendix, we present the details of the model without informality. This is a standard one-sector growth model with labor-leisure choice.

The representative household maximizes her present-discounted utility subject to her budget constraint:

$$\max_{\{C_t, K_{t+1}, L_t, N_{Ft}\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

$$\text{subject to} \quad (1+\tau_c)C_t + K_{t+1} - (1-\delta)K_t = (1-\tau_k)r_t K_t + (1-\tau_n)w_{Ft}N_{Ft}$$

$$N_{It} + L_t = T$$

The representative firm operating under a Cobb-Douglas production technology maximizes its profits taking prices as given:

$$Y_{Ft} = \theta_{F_t} K_t^{\alpha} N_{Ft}^{1-\alpha}$$

Accordingly, the factor prices are determined competitively:

$$\frac{\partial Y_{Ft}}{\partial K_t} - r_t = 0$$
$$\frac{\partial Y_{Ft}}{\partial N_{Ft}} - w_{Ft} = 0$$

Government runs a balanced budget, which it uses to finance wasteful government spending:

$$R = \tau_c C + \tau_k \alpha Y_f + \tau_n (1-\alpha) Y_f$$

Assuming the same logarithmic utility, $U(C_t, L_t) = log(C_t) + \varphi log(L_t)$, the maximization problem of the household yields the following intratemporal and intertemporal optionality conditions:

$$\frac{L_t}{\phi C_t} = \frac{1+\tau_c}{(1-\tau_n)w_t}$$
$$\frac{C_{t+1}}{C_t} = \beta[(1-\tau_k)r_{t+1} + 1 - \delta]$$

where the factor prices are determined competitively: $r_t = \alpha K_t^{\alpha-1} N_{Ft}^{1-\alpha}$ and $w_t = (1-\alpha)K_t^{\alpha} N_{Ft}^{-\alpha}$.

The competitive equilibrium of this decentralized economy can be defined by the above household optimality conditions, factor prices, balanced budget of the government and the aggregate resource constraint: $C_t + K_{t+1} = (1-\delta)K_t + Y_{Ft}$.

Appendix C. Model with Formal and Informal Consumption

Here, we discuss the implications of an extension, where we separate formal and informal consumption. That is, the utility maximization problem now becomes as follows:

$$\max_{\{C_{ft},C_{it}K_{t+1},L_t,N_{It},N_{Ft}\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

$$\text{subject to} \quad (1+\tau_c)C_{ft} + (1+\rho\tau_c)C_{it} + K_{t+1} - (1-\delta)K_t = (1-\tau_k)r_t K_t +$$

$$(1-\tau_n)w_{Ft}N_{Ft} + (1-\rho_c\tau_i)(w_{It}N_{It} + \pi_{It}^*)$$

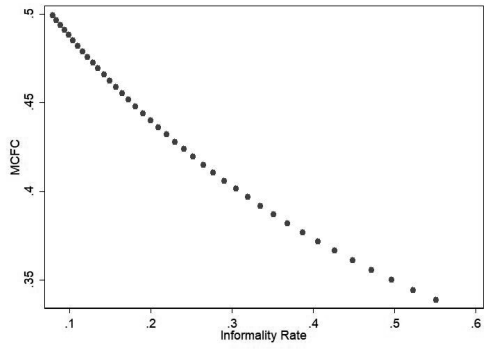
$$N_{It} + N_{Ft} + L_t = T$$

$$C_t = C_{ft}^{\mu} C_{it}^{1-\mu}$$

Here, different than the benchmark model we differentiate between formal (C_{ft}) and informal (C_{it}) consumption. This setup is essentially the same as the benchmark model in the main text if $\rho_c = 1$, where ρ_c denotes the enforcement level on consumption taxes in the informal sector. C_t is the aggregate consumption that is a function of both formal and informal consumption, where this aggregation is illustrated in the last equation.

Once we simulate the model following the exact same methodology and MCF definitions as before, we provide the behavior of the MCFC with respect to informality in Figure A.5. We observe from the figure that the result with respect to the MCFC is similar to the case without a separate informal consumption.

Figure A.5
LABOR INCOME TAX AND INFORMALITY RATE OF THE COUNTRIES IN THE SAMPLE



Notes

1. A proportional consumption tax on an inelastically demanded consumption good can *de facto* serve as lump-sum tax, hence is generally considered as a lump-sum tax equivalent.

2. As the authors in this paper solely focus on 38 African economies we report a quantitative comparison between their results and results of our paper; however we generally observe that the positive correlation between MCF of capital and labor income taxes and informal sector size is in line with the results of Auriol and Warlters (2012).

3. It is worthy to note that while the MCF of the consumption tax *does* increase over the consumption tax rate, the negative data-driven relationship between the MCF of consumption tax rate and the informality level is not independent of the negative correlation between economic development and informality. These results are robust to the choice of models.

4. In order to conduct these comparison exercises, regarding the model without informality, we rely on a standard one-sector neoclassical growth model, which we calibrate to match country-specific formal GDP and labor force figures while also feeding the model with actual country-specific tax rate estimates. We then plot the MCF of tax rates by the one-sector model along with *external estimates* of the informal sector size for the country-specific targets of interest so as to unveil the relationship between the two. Regarding the model featuring informality, as we discuss in the next section, we rely on a two-sector neoclassical growth model featuring the formal and the informal sectors, which we calibrate to match not only the formal GDP and labor estimates, but also the ratio of the informal-to-formal sector size and employment.

5. The underestimation of MCF of capital income tax refers to being on the wrong side of the Laffer curve for most countries in our working sample.

6. Note that high-income economies tend to exhibit i) low informality levels ii) high labor income tax rates, and iii) high productivity levels. Thus, when we measure MCF of country-specific labor income taxes via a model that does not feature informality, and plot these MCF predictions jointly with actual informality levels, we document a negative relationship between informality level and MCF of labor income taxes, which stems mainly from the higher productivity of the low-informal and high-tax developed economies. When we incorporate the informal sector into the model, we factor in the distortionary role of higher labor income taxes to the labor re-allocation from the formal to the informal sector (along with devoting higher time to leisure), as well as its adverse implications on capital accumulation (whose access is limited to the formal sector). When acknowledged, such distortionary consequences of higher labor income taxes overweigh the benefits of high productivity levels of high-tax developed economies, therefore reverts the relationship between MCF of labor income taxes and informality levels.

7. A possible interpretation of this assumption might be that the informal sector has a fixed amount of productive capital and cannot possibly accumulate physical capital. For further discussion, see Ihrig and Moe (2004), and Elgin and Oztunali (2012).

8. As in Elgin (2015), assuming that at least some fraction of tax revenue is spent for productive activities, e. g., in the form of productive public capital that can enter into the production function of the formal sector, would not qualitatively alter our results, even though the numerical simulations could potentially differ. Surely, as it will be mentioned in the last subsection of the next section, when the government revenue is used for redistributive purposes in a heterogeneous model, results can significantly change.

9. This is a standard way of introducing informal sector in a two-sector dynamic general equilibrium model.

   It has been used in various paper including but not limited to Ihrig and Moe (2004), Busato and Chiarini (2004), Elgin and Oztunali (2012), and Elgin (2015). The DRS assumption is needed for the co-existence of informal sector along with the formal one, as this assumption generates positive optimum profits for the informal sector.

10. Results of a sensitivity analysis using a CES utility are available upon request from the corresponding author.

11. Alternatively, using informal sector size estimates of Buehn and Schenider (2012) does not yield significantly different results.

12. See the Appendix for the detailed description of the one-sector neoclassical growth model without informality.
13. For the cross-country calibrations, we set ρ to zero. Results by other parametrization are available upon request.
14. Consequent results are qualitatively similar, and can be seen in Figure A.1.
15. Using a CES utility produces qualitatively similar results.
16. In the sample, there is a significant positive correlation between those two indicators.
17. Related graph can be found in Appendix (Figure A.4).
18. We also checked whether the MCF of the labor income tax rises with the particular tax rate or not and reported it in Figure A.3.
19. However, we should note that the (re)distributive aspects of taxation are not considered in this study.

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Resumen

En este trabajo se investiga el coste marginal de los fondos públicos (CMF) de los diferentes impuestos en presencia de informalidad. Se estima un modelo de equilibrio general dinámico con sectores formales e informales y se permite que el gobierno utilice impuestos sobre el consumo, el capital y la renta del trabajo para recaudar ingresos. Utilizando datos a nivel de país, se calibra el modelo y se calcula el CMF para un conjunto de sección cruzada de países. Los resultados muestran que los diferentes impuestos tienen distintas respuestas de coste ante cambios en el tamaño del sector informal en cada país: mientras que el CMF del impuesto sobre el consumo disminuye con el aumento del tamaño del sector informal, el CMF de los impuestos sobre la renta, el capital y el trabajo, muestran un comportamiento opuesto. Por otro lado, al omitir el sector informal produce una subestimación en el CMF del impuesto sobre la renta del capital y una sobreestimación en el del impuesto sobre el consumo.

Palabras clave: economía informal, fiscalidad, coste marginal de los fondos públicos, modelo dinámico de equilibrio general.

Clasificación JEL: E26, H26.