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The Marginal Cost of Public Funds and Tax Reform in Africa*

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Abstract: In this paper we propose estimates of the marginal cost of public funds (MCF) in 38 African countries. We develop a simple general equilibrium model that can handle taxes on five major tax classes, and can be calibrated with little more than national accounts data. Our base case estimate of the average MCF from marginal increases in all five tax instruments is 1.2. Focusing on the lowest cost tax instruments in each country, commonly the VAT but not always, the average MCF is 1.1. A key feature of our model is explicit recognition of the informal economy. The larger the informal economy, the higher MCFs tend to be. Extending the tax base to include sections of the informal economy by removing some tax exemptions offers the potential for a low MCF source of public funds, and a lowering of MCFs on other tax instruments.

JEL Classification Numbers: D43, H25, H26, H32, H60

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1 Introduction

Tax revenue as a proportion of GDP is typically about 20 percentage points lower in African countries than in rich OECD countries. Yet one of the salient features of African countries is an apparent under-provision of public goods in areas such as health, basic education or infrastructure. If there are unrealized benefits from public spending, why isn't taxation increased to enable more public projects to be undertaken? There are various possible responses to this question, and the answer may be different in different countries. Some African governments may not have the objective of maximizing social well-being, and so may under-provide public goods. Perhaps the assumption of high returns to public spending is false in practice, possibly because of inefficient or corrupt implementation of projects.[1] Or perhaps the cost of public funds is higher in African countries than in rich countries. The paper explores this last response. It examines the marginal cost of public funds (MCF) - the change in social welfare associated with raising an additional unit of tax revenue using a particular tax instrument - in 38 African countries.

The central role of the MCF in tax policy is well known. The literature on this topic dates back at least thirty years, but it is almost entirely focused on the tax systems of high income countries. We know of only one African country, Cameroon, for which MCF estimates have been published (see Table 1 in Section 2). MCF estimates are particularly hard to come by for African countries, given the paucity of data and the cost of building sophisticated computable general equilibrium (CGE) models to obtain these estimates.[2] Thus, the challenge as we have conceived it is to develop a simple CGE model that can be calibrated with little more than national accounts data, and can be used to provide consistent estimates comparable across African countries. We estimate the MCFs for the five key African tax instruments: domestic sales taxes, import and export taxes, and corporate and personal income taxes.

Discussion of our MCF estimates provides a lens through which many of the major issues of African tax reform can be viewed. Over the past 10-20 years, African countries have lowered trade taxes to improve competitiveness, and intro-

[1] A further possible explanation is that the benefits of risk-related public spending (e.g., social security, health insurance) are relatively greater in rich economies (see Devarajan & Hammer (2002)). Tanzi & Schuknecht (2000) show that the difference between OECD and developing countries' public expenditure is the OECD's expenditure on social security; expenditure on goods and services is about the same as a proportion of GDP.

[2] Substitution effects, which are at the heart of the dead-weight loss of taxation, are poorly captured by partial equilibrium analysis. CGEs are required because real tax systems are complex, and because it is necessary to take account of multiple interactions within tax systems.

duced VATs, in part to compensate for lost trade tax revenues. In our 38 countries, from the early 1990s to the mid 2000s, on average trade taxes fell from 35.2% of tax revenue to 29.6%, while total tax revenue rose on average from 13.7% to 17.1% of GDP.[3] The list of 30 countries that now have VATs is included in our data set in Appendix 2. Our model and MCF estimates suggest directions for further reform of tax structures. A given level of revenue can be obtained at lower welfare cost by increasing a tax with a low MCF and lowering a tax with a high MCF. Low values of MCF estimates indicate that in most countries additional revenue could be raised with relatively low efficiency cost, in most cases using higher VATs, but in some cases through higher trade taxes. We find no general rules that imports or exports should not be taxed, so that MCF estimates are needed in order to determine appropriate directions for change in trade taxes. Finally, we estimate low MCFs in the informal economy, indicating priorities for the removal of tax exemptions.

Our model deals explicitly with the informal economy, a key requirement for realism. As a by-product of our model's calibration, we have produced estimates of the untaxed economy based on official GDP data. Viewing GDP as the sum of all output, our calibration algorithm indicates untaxed goods represent an average of 35% of GDP. Viewing GDP as the sum of all income, untaxed factor payments constitute an average 56% of GDP. Our measures of the untaxed economy are not identical with efforts to measure the shadow economy, such as Schneider & Enste (2000). To the extent that the shadow economy includes activities that are not caught in measures of GDP, our measure is smaller. To the extent that we include legal activities that are captured in GDP and happen not to be taxed by one of our five taxes, our measure is larger. Nevertheless, there is overlap between these measures (see Table 11 in the Appendix), and we use the terms 'untaxed' and 'informal' interchangeably.

Inclusion of the informal sector in our model is important in two respects in the modeling of MCFs. We might suspect that in countries with larger informal sectors, it is easier for economic agents to shift from formal to informal activity. Greater substitutability would lead to higher marginal costs of taxation on formal activity. We find that larger informal sectors are typically associated with higher MCFs.[4] Inclusion of informal goods and factors also permits us to model taxes on

[3]These figures are based on data from IMF country report Statistical Annexes, using the earliest and most recent data available from reports available online. The periods covered differ for each country, with 1992/3 the median first year, and 2005 the median final year. Trade tax revenues as a proportion of GDP rose from 4.7% to 4.9% on average. The share of trade taxes in tax revenue rose in 15 countries, and tax revenue as a proportion of GDP fell in 9 countries.

[4]Fortin & Lacroix (1994) suggest the informal sector accounts for around 0.02-0.05 of their MCF estimates of 1.39-1.53 for labour taxation in Canada. They note that although small,

domestic goods and factor taxes using legally specified rates, rather than 'effective' tax rates which are commonly modeled in CGEs.[5]

After a brief review of the existing literature in Section 2, we present the model in Section 3. The model is inspired by the minimal data requirements of the '1-2-3 model' of Devarajan, Go, Lewis, Robinson, & Sinko (1994). The basic 1-2-3 model has one country with two producing sectors and three goods: a domestic good, exports and imports. This model is extended to include production of an informal good, an intermediate investment good, and four factors of production: formal capital, informal capital, formal labour and informal labour. Our definition of an informal good or factor is one on which no tax is paid.

In section 4 we apply the CGE model to produce estimates of MCFs for 5 taxes in 38 African countries, vastly increasing the number of developing countries for which MCF estimates exist. Our base case estimate of the average MCF from marginal increases in all five tax instruments is 1.21, with a plausible range of 1.19 to 1.29. These estimates provide a basic blueprint for tax reform in Africa, indicating the high cost taxes that are ripe for cutting, and the low cost taxes which could be increased. Sensitivity testing of the model reveals which elasticities are the most important in determining MCF magnitudes, and suggests that our base case estimates are reasonably robust for purposes of tax reform. We also estimate the impact of administrative costs on MCFs.

In Section 5 we examine two central aspects of tax reform – the reform of tax structures, and the priorities for extending the tax base – with particular attention to the implications of Africa's large informal sectors. We ask whether African policies of lowering trade taxes and expanding the application of VATs are appropriate. We find the VAT and import tariff are typically the key optimal tax instruments, but in some cases taxes on exports and factors are also optimal. The optimality of taxes on inputs follow from the presence of the informal economy. In respect of tax base broadening, we ask how much administrative cost should be spent in order to bring parts of the informal economy into the tax system. On average the administrative cost thresholds above which efforts to impose an existing tax on currently untaxed sectors becomes more costly than simply raising

the impact of the informal sector increases rapidly with the level of the marginal tax rate. The importance of the informal sector when analyzing taxation in developing countries is also emphasized in other settings by García Peñalosa & Turnovsky (2003) and Emran & Stiglitz (2005).

[5]We do, however, use effective tax rates for trade taxes. 'Effective' tax rates are calculated as tax revenues divided by sector size. They provide an average between taxpayers who pay tax at something like the legal rate, subject to some under-reporting, and informal producers or consumers who pay no tax. Effective tax rates underestimate the marginal tax rate incurred by those who actually pay tax and are thus likely to underestimate MCFs.

the existing tax rate are quite high.

We conclude in section 6 with a review of several issues in African tax reform, interpreted in the light of our results.

2 The Marginal Cost of Public Funds

The MCF measures the change in social welfare associated with raising an additional unit of tax revenue using a particular tax instrument:

$$MCF = -\frac{\Delta W}{\Delta R} \tag{1}$$

where ΔW is a monetary measure of the change in social welfare and ΔR is the change in tax revenue arising from a marginal change in a tax instrument. The change in social welfare is a measure such as the equivalent variation or change in consumer surplus. Table 1 sets out a selection of existing estimates. Additional estimates are reported by Dahlby (2008), who provides a comprehensive treatment of the existing MCF estimates.

Unfortunately, existing estimates are not all comparable. The literature is plagued by multiple definitions of the same concepts. Useful reviews of the theoretical and empirical literature on MCFs can be found in Ballard & Fullerton (1992) and Devarajan et al. (2001). Different measures of the MCF for the same tax instrument can be found according to the nature of the tax experiment conducted, the choice of numeraire, and the attribution of some general equilibrium effects between benefit and cost.

Ballard & Fullerton (1992) identify two broad classes of theoretical analysis: 'differential' and 'balanced budget.' In differential analysis, one tax is marginally increased and another is decreased sufficiently to maintain the budget balance. The usual experiment is to increase a distortionary tax, and to reduce a lump-sum tax (return the revenue to consumers as a lump-sum). The income effects of the two tax changes cancel, leaving only substitution effects. Estimates of the welfare change, ΔW, depend on compensated elasticities, while the change in revenue, ΔR, can be equated with the actual lump-sum transfer. In balanced-budget analysis, one tax is marginally increased and the revenue is spent on a public project. Income effects are included in the analysis, and MCF estimates are derived using uncompensated elasticities. These are not the only possible measures. Wildasin (1984) proposed a measure in which the compensated change in welfare is divided by the compensated change in tax revenue rather than the actual change in tax revenue.

Table 1: Selected MCF Estimates

Country	Tax type	Estimate	Source
Australia	Labour	1.19-1.24	Campbell & Bond (1997)
Australia	Labour	1.28-1.55	Findlay & Jones (1982)
Australia	Capital	1.21-1.48	Diewert & Lawrence (1998)
Australia	Capital	1.15-1.51	Benge (1999)
Bangladesh	Sales	0.95-1.07	Devarajan, Suthiwart-Narueput & Thierfelder (2001)
Bangladesh	Import	1.17-2.18	Devarajan et al. (2001)
Cameroon	Sales	0.48-0.96	Devarajan et al. (2001)
Cameroon	Import	1.05-1.37	Devarajan et al. (2001)
Canada	Commodity	1.25	Campbell (1975)
Canada	Labour	1.38	Dahlby (1994)
Canada	Labour	1.39-1.53	Fortin & Lacroix (1994)
China	Sales	2.31	Laffont & Senik-Leygonie (1997)
India	Excise	1.66-2.15	Ahmad & Stern (1987)
India	Sales	1.59-2.12	Ahmad & Stern (1987)
India	Import	1.54-2.17	Ahmad & Stern (1987)
Indonesia	Sales	0.97-1.11	Devarajan et al. (2001)
Indonesia	Import	0.99-1.18	Devarajan et al. (2001)
New Zealand	Labour	1.18	Diewert & Lawrence (1994)
Sweden	All taxes	1.69-2.29	Hansson & Stuart (1985)
United States	All taxes	1.17-1.33	Ballard, Shoven & Whalley (1985)
United States	Labour	1.21-1.24	Stuart (1984)
United States	Labour	1.32-1.47	Browning (1987)
United States	All taxes	1.47	Jorgenson & Yun (1990)
United States	Labour	1.08-1.14	Ahmed & Croushore (1994)

The choice of numeraire can also change estimates of the MCF. Håkonsen (1998) has proposed a measure derived from the dual of the government's optimal tax problem (maximize revenue subject to a given level of social welfare) that is invariant to the choice of numeraire.

Finally, the attribution of some effects of public spending can also affect the size of MCF estimates. Consider a marginal tax increase that increases revenue by one dollar, before public spending occurs. Public spending could increase the tax base in a second round effect (for example, building highways increases petrol tax revenue). If this second round effect is attributed to the MCF, the increase in revenue is greater than one dollar, and the MCF is accordingly reduced. But the second round effect could equally well be attributed to a measure of the marginal benefit of public spending. Mayshar (1991) proposed that all revenue effects of public spending should be incorporated in the benefits measure (MBF), rather than the MCF.

Fortunately, Schöb (1994) has shown that standard MCF measures provide a valid basis for revenue-neutral tax reform, provided they are prepared using consistent methodologies. The levels of MCF estimates will depend on the estimation methodology, but these levels are not important in deciding directions for reform. What is important is which tax instruments have high MCFs and which have low MCFs. For tax reform, MCFs can be thought of as an ordinal measure. For our tax reform analysis, estimates of the MCF for different tax instruments are prepared using common methodologies. By virtue of Schöb's (1994) result, our estimates indicate priorities for the reform of African tax structures.

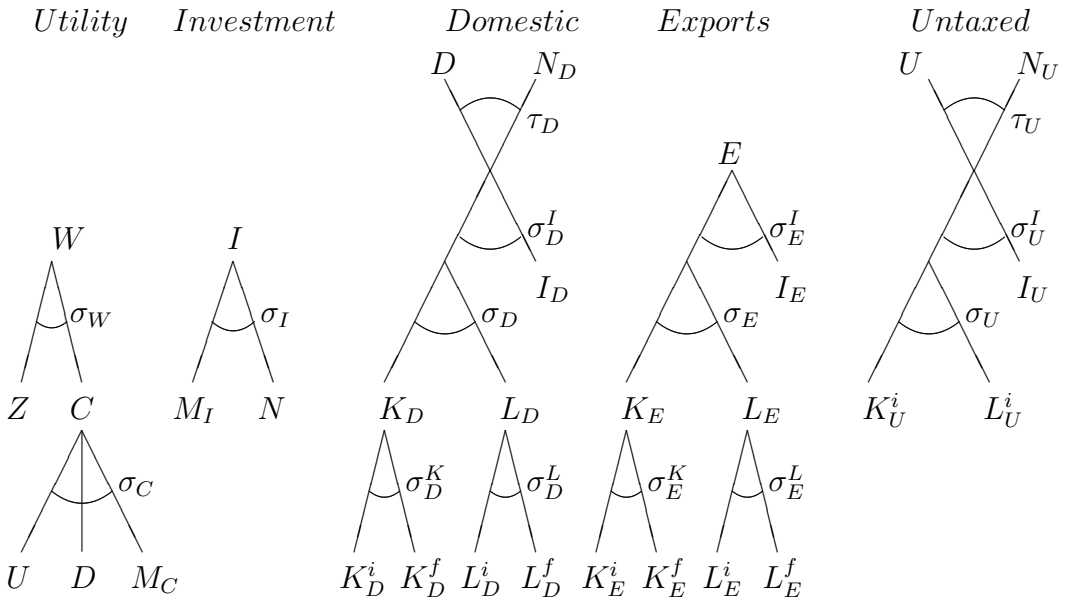
3 The Model

Our model is formally set out in Appendix 1. Four goods are consumed in the economy: *untaxed* (U), *domestic* (D), *imports* (M), and *leisure* (Z).[6] The representative consumer has endowments of leisure (which may be converted into labour), capital, and foreign exchange, which is used to purchase imports from the rest of the world.[7]

[6]Leisure is included only to permit robustness testing of the elasticity of labour supply. In our base case, this elasticity is set to zero, and there is no leisure. Leisure differs from informal labour in that it enters directly into the consumer's welfare function, and is not used as an input into production.

[7]The endowment of foreign exchange represents the trade balance. In Africa, this is financed by borrowing and foreign aid. In a static model borrowing has no purpose, and the endowment can be thought of as foreign aid.

Figure 1: Utility and Production Functions



On the production side of the economy, three final goods are produced in the country: *untaxed* (U), *domestic* (D), and *exports* (E). Exports are used to purchase foreign exchange (at a constant exchange rate), which is used to purchase *imports* (M) from the rest of the world. In addition *investment* (I) is modeled as an intermediate good, which is used as an input into each of *untaxed*, *domestic*, and *exports*.

The production goods use four factors of production: *formal capital* (K^f), *informal capital* (K^i), *formal labour* (L^f) and *informal labour* (L^i).[8] Taxation of a fixed endowment will not alter its supply and so will not result in a deadweight loss. Dividing factors into formal and informal introduces substitution possibilities, and so permits the possibility of deadweight losses associated with factor taxation. The inclusion of informal factors is thus critical for the estimation of factor MCFs. It is assumed that production is competitive, so that all funds received by firms are paid out to factors.

Nested constant elasticity of substitution (CES) functions are used in all production and utility functions. The structure of these functions is set out in Figure 1, with σ denoting elasticities of substitution between inputs, and τ denoting elasticities of transformation between outputs.

[8]The *informal* good uses only *informal capital* and *informal labour*.

The first panel in the diagram is the consumer's utility function, where utility (W) is a function of *leisure* Z, and a consumption good C, and C is a composite good derived from a CES function of *untaxed*, *domestic*, and *imports*. The endowment of time can be adjusted to determine the elasticity of labor supply.

The second panel illustrates the *investment* good CES function, combining inputs of *imports* and domestically produced inputs (N). The treatment of investment is driven by its role in the national accounts, where investment is defined as capital goods with a life greater than one year. Some of these capital goods are produced domestically, and some are imported. The model captures a static snapshot of the ongoing process of capital accumulation, with long-lived capital a necessary input into the production process: *investment* is itself an input into the final good production functions.[9] The domestically produced investment inputs, N, consist of *domestic* and *untaxed* goods. Goods that are exported cannot serve as an input.

The last three panels are the production functions for *domestic*, *export* and *untaxed*. The top parts of *domestic* and *untaxed* production functions are constant elasticity of transformation (CET) functions, where N is produced jointly with the main good. We keep these CET elasticities at 1 in our model, keeping production of long-lived capital assets at a constant share of the value of total output. The bottom parts of the three production function diagrams represent the nested CES functions over the factors of production, including capital/labour substitution, and formal/informal substitution. These factors are in turn combined with inputs of *investment*, in further CES functions, with elasticities σ_D^I, σ_E^I, and σ_U^I.

Even though the production technology is the same, we separate production of investment inputs, N, from production of *domestic* and *untaxed* goods to permit different tax treatment. We apply a zero tax rate to domestically produced investment inputs. This corresponds to cases where investment inputs are produced within the investing enterprise and so escape taxation, or where taxation permits full deduction of the costs of business inputs. On the public side of the economy taxes are thus imposed on *domestic*, *exports*, *imports*, *formal capital*, and *formal labour*. There are no untaxed traded exports or imports. This is not meant to imply that no smuggling occurs in African countries. Rather, the official figures for trade are based on customs data, which typically reflects taxed goods. An implication is that the *untaxed* good is produced and consumed purely domestically.

Tax revenue received by the Government is transferred lump-sum to consumers.

[9]Use of final good outputs as inputs into an intermediate good is standard in static CGE models, and can be considered to represent a long-run steady state (see Sue Wing (2004)).

The experiment of increasing a distortionary tax rate and returning the revenue lump-sum can be interpreted in terms of both 'differential' and 'balanced-budget' analysis. As emphasized in Section 2, for purposes of MCF estimates the realism of the modeled public expenditure is not as important as the fact that a consistent experiment is conducted across tax instruments.

The data are given in Appendix 2. Country-specific data comprise values of exports, imports, investment, and tax revenues for each of the five taxes, and legal tax rates for domestic goods, capital and labour. These data were obtained from IMF country report Statistical Annexes.

Data for tax revenue from sales of *domestic* are derived from tax revenues from domestic VATs or sales taxes. Corporate income tax revenues are interpreted as tax revenues from *formal capital*. Personal income tax revenues are equated with revenues from *formal labour*. Data for tax revenues from *exports* and *imports* are taken directly from the national accounts.

On average, in the countries that we examine, taxes on domestic goods, imports, exports, personal income tax, and corporate income tax represent respectively 20%, 38%, 2%, 13%, and 16% of tax revenue, with the remaining 11% coming from other sources. Twenty countries in our sample do not use export taxes. Among the eighteen countries that do use them, export taxes constitute 4% of tax revenue. We ignore classes of tax revenue that do not fall into any of the five tax revenue classes of the model. We assume that these other tax revenues are unaffected by shocks to the model's five tax rates, implicitly treating them as lump-sum taxes.

The calibration process is described in Appendix 3. The sizes of the *exports*, *imports* and *investment* are taken directly from the national accounts data. The size of the *domestic* good is determined by dividing *domestic* tax revenues by the legal tax rate. The size of the *untaxed* sector is the remainder of GDP after *domestic*, *exports*, and goods taxes are accounted for. Formal factor payments are similarly determined by dividing tax revenues by legal tax rates. Total payments to informal factors are the residual of GDP after formal factors and investment are accounted for, with their allocation between production goods and between capital and labor determined in proportion to the production of the relevant formal goods and factors, and for the *untaxed* good using an assumed labour-output ratio of 52%.[10] Imports are separated into consumption and investment goods, reflecting the ratio of consumption to investment in the national accounts. Domestic production of investment inputs (N) is the national accounts figure for investment, less imported investment goods.

[10]The figure is based on data derived from five African countries, as indicated in Appendix 2.

Calibration of the model is completed with specification of the elasticities in the utility and production functions. In our base case, we set all CES and CET elasticities at unity.

Setting the elasticity of substitution between leisure and consumption at unity, the elasticity of labour supply can be calibrated by changing the endowment of time. In our base case we set this endowment to achieve a zero elasticity of labour supply, and cover the possibility of positive elasticity in robustness testing.

We are unaware of estimates of the consumption function's elasticity of substitution between our aggregate informal and taxed goods, but there is evidence on the economy's price elasticity of import demand (which includes demand for both consumption and investment goods). Shocking the import price in our base case model reveals an average price elasticity of import demand of -0.76. Emran & Shilpi (2007) provide estimates for India and Sri Lanka in the range -0.63 to -0.79, with a mean of -0.72, which supports our base case elasticities. Other evidence suggests unitary import price elasticities (see, eg. Senhadji (1998)), and we deal with this possibility in robustness testing of the model.

On the production side of the economy, Cobb-Douglas production functions, with unitary elasticity of factor substitution, have long been a modeling workhorse, and we have continued in this tradition. Tybout (2000) surveys the empirical literature on production in developing countries, reporting returns to scale close to unity in all industries covered by the literature, in India, Indonesia and Africa. This evidence supports the assumption of Cobb-Douglas production. However, Chirinko (2008) provides a survey which suggests that long-run elasticities of substitution between capital and labour are in the range of 0.4 to 0.6 in OECD countries. We deal with this possibility in robustness testing of the model, testing an elasticity of 0.5.

4 MCF Estimates

We calculated the MCFs associated with six different shocks to tax rates. In the first five experiments we increased each tax rate individually by adding one-ten-thousandth of a percentage point to the existing tax rate (eg. from 10% to 10.0001%). The small increment is intended to capture the essence of a marginal change to the tax rate. In the sixth experiment we increased all five tax rates simultaneously by one-ten-thousandth of a percentage point.[11] In each case the

[11] In the sixth experiment, any zero export tax rates are left unchanged, under the assumption that in these countries increased export taxes are not a policy option.

additional tax revenue, ΔR, was redistributed to consumers as a lump sum transfer. The new equilibrium was established using a computable general equilibrium model written using GAMS MPSGE. The welfare change induced by the combined tax and spend experiment was measured in terms of the numeraire using the equivalent variation, denoted EV. The MCF of the experiment was calculated as:

$$MCF = \frac{EV}{\Delta R}. \tag{2}$$

4.1 Base Case Results

Our MCF estimates are presented in Table 2. On average, the MCF associated with a marginal increase in all five tax instruments is 1.21, indicating a required rate of return of 21% for African public projects. Studying marginal increase of specific tax intrument, the estimates provide a basic blueprint for tax reform in each country. For any pair of tax instruments, the same total revenue could be achieved for lower deadweight loss by lowering tax rates associated with a high MCF and increasing low-MCF tax rates.

On average, taxes on the two taxed consumption goods (*domestic* and *imports*) have low MCFs, while taxes on the two taxed factors (*formal labour* and *formal capital*) have high MCFs.[12] Looking at the lowest MCF in each country, the mean is 1.087. On average, African countries could raise additional tax revenue with an efficiency cost of just 8.7%. Outside of concessional donor funds, this is likely to be among the cheapest potential sources of finance available in most African countries.

The *exports MCFs* exhibit wide variation, to the point where the simple average across countries yields little information. In seven cases, MCF(E) is negative, because increasing the exports tax rate lowers total revenue ($dR/dT_E < 0$).[13] These cases can be grouped with high MCF values, in the sense that they indicate that the exports tax is not an effective revenue-raising instrument. Examining the 30 countries where ($dR/dT_E > 0$), the average $MCF(E)$ is 1.42. For the 15 countries with both strictly positive export tax rates and positive MCF(E), the average MCF(E) is 1.54, but the maximum is 3.35 (Uganda) and the minimum

[12] In 26 countries, the *domestic* tax has the lowest MCF, in 9 countries the lowest is the *imports* tax, and in 3 countries it is the *exports* tax. In making this comparison we ignore cases where a marginal increase in the export tax reduces total revenue, resulting in MCF(E)$<$0.

[13] In Eritrea, a marginal increase in T_E reduces tax revenue, but this in turn increases welfare, resulting in $0 < MCF(E) < 1$.

Table 2: MCF Estimates

Country	D	M	E	L	K	All
Congo, Dem. Rep.	1.08	1.07	1.11	1.30	1.60	1.10
Burundi	1.10	1.09	-0.37	1.74	1.57	1.18
Malawi*	1.19	1.18	1.65	1.65	1.68	1.26
Guinea Bissau	1.08	1.12	1.20	1.22	1.71	1.17
Ethiopia*	1.17	1.22	3.12	1.91	2.00	1.28
Niger	1.18	1.48	1.78	2.09	2.05	1.47
Eritrea*	1.15	1.13	0.58	1.99	1.65	1.21
Central African Rep.	1.17	1.13	1.37	1.79	1.62	1.22
Madagascar*	1.14	1.12	1.22	1.33	1.62	1.15
Rwanda*	1.23	1.27	-0.33	2.28	2.47	1.37
Togo*	1.07	1.09	1.16	1.47	1.58	1.12
Burkina Faso*	1.17	1.23	-2.91	1.68	1.59	1.27
Uganda	1.08	1.53	3.35	1.49	1.67	1.42
Ghana	1.05	1.12	1.30	1.38	1.36	1.17
Chad	1.09	1.05	1.02	1.26	1.18	1.06
Mali	1.09	1.27	1.59	1.62	1.84	1.29
Mozambique	1.14	1.06	1.11	1.35	1.54	1.12
Tanzania*	1.18	1.19	1.53	1.57	1.83	1.25
Gambia*	1.04	1.14	1.22	1.27	1.47	1.17
Benin	1.15	1.57	-1.24	2.55	2.55	1.72
Zambia*	1.13	1.09	1.48	1.23	1.58	1.16
Sudan	1.09	1.25	2.01	1.73	1.86	1.29
Guinea	1.14	1.12	1.19	1.45	1.64	1.16
Kenya*	1.11	1.16	1.42	1.32	1.44	1.18
Nigeria*	1.04	1.09	1.10	1.20	1.18	1.11
Mauritania*	1.06	1.08	1.14	1.31	1.31	1.11
Senegal*	1.08	1.19	1.50	1.48	1.70	1.19
Zimbabwe*	1.22	1.23	-0.06	1.50	1.71	1.31
Côte d'Ivoire	1.09	1.18	1.18	1.65	1.61	1.19
Cameroon*	1.04	1.06	1.15	1.22	1.29	1.08
Congo, Rep.*	1.11	1.05	1.03	1.33	1.41	1.09
Cape Verde*	1.09	1.17	-1.59	1.51	1.26	1.17
Swaziland	0.87	1.19	1.26	1.36	1.54	1.23
Namibia*	1.00	1.23	1.35	1.34	1.41	1.19
South Africa*	1.08	1.15	-0.25	1.22	1.21	1.13
Gabon	1.05	1.13	1.08	1.32	1.45	1.11
Botswana*	0.95	1.24	1.19	1.18	1.22	1.10
Equatorial Guinea	1.34	1.03	1.01	1.27	1.20	1.05
Average	1.11	1.18	0.96	1.51	1.60	1.21
Maximum	1.34	1.57	3.35	2.55	2.55	1.72
Minimum	0.87	1.03	-2.91	1.18	1.18	1.05
Std. Dev.	0.08	0.12	1.13	0.32	0.31	0.13

In this and subsequent tables, countries are ordered by GDP per capita in constant 2000 US$, for the year from which the relevant data are drawn. * indicates countries with zero export taxes.

is 1.01 (Equatorial Guinea). The variability of MCF(E) can be understood by noting that *exports* is an input into *imports*, so that the total tax on imports is the product of both the exports and imports taxes.[14]

4.2 Robustness of Results

We tested the robustness of our MCF estimates to changes in various parameters, focusing particularly on the elasticities of substitution in the demand and production functions. The results of robustness testing are set out in Table 3. The notation for the relevant elasticities is set out in Figure 1. For each experiment, any unmentioned elasticity is the same as in our base case (that is, all CES and CET function elasticities of substitution are 1, and the elasticity of labour supply is 0).

In experiments 1-9 we lowered specific elasticities of substitution to values of 0.5, and in experiments 10-18 we increased the same elasticities to 2. In experiments 6-9 and 15-18, changes in the consumer's elasticity of substitution (σ_C) between the three consumption goods (U, D, and M) resulted in large variation of MCF(All), ranging from 1.11 to 1.53. Changes in production CES elasticities resulted in little change in our base case estimates, with MCF(All) ranging from 1.19 to 1.24.

In experiments 19 and 20 we also tested the possibility of positive elasticity of labor supply, notwithstanding evidence from developed countries that the elasticity is zero.[15] A small labor supply elasticity of 0.05 induced a negligible change in our estimated MCFs. An implausibly large elasticity of labour supply of 1.0 increased average $MCF(All)$ to 1.27, and increased average $MCF(L)$ to 1.75 (compared with 1.51 in the base case).

Our choice of marginal tax rate for labour was in places arbitrary, choosing from multiple rates in personal income tax schedules. In experiments 21 and 22 we tested the effect of increasing and decreasing the marginal labour tax rate by 5 percentage points. The resulting average $MCF(L)$ values were 1.60 and 1.43. Other MCF estimates were little changed.

A check on the reasonableness of each experiment's parameter changes is provided in the column listing the absolute value of the resulting elasticity of import demand (ϵ_M). Emran & Shilpi (2007) find that a mean estimate of ϵ_M is 0.72, and our base case is close to this. However, Senhadji (1998) suggests $\epsilon_M = 1$. We

[14]The level of import tariffs appears to have a stronger influence on MCF(E) than the export tax rate. Among the 15 countries with strictly positive export taxes and positive MCF(E), linear regression of MCF(E) on the import tariff gave $MCF(E) = 0.7 + 0.044T_M$ with $R^2 = 0.58$, while regression on the export tax rate gave $MCF(E) = 1.5 - 0.02T_E$, with $R^2 = 0.004$.

[15]The elasticity of labor supply is varied by changing the endowment of time, while keeping constant the consumer's CES elasticity of substitution between leisure and consumption goods ($\sigma_W = 1$).

Table 3: Sensitivity Testing

	Experiment	D	M	E	L	K	All	ϵ_M	(1)	(2)	(3)
1	$\sigma_D = \sigma_E = \sigma_U = 0.5$	1.10	1.17	0.96	1.52	1.59	1.20	0.76	38	35	38
2	$\sigma_D^K = \sigma_D^L = \sigma_E^K = \sigma_E^L = 0.5$	1.11	1.18	0.97	1.36	1.40	1.19	0.76	28	20	27
3	$\sigma_D, \sigma_E, \sigma_U, \sigma_D^K, \sigma_D^L, \sigma_E^K, \sigma_E^L = 0.5$	1.10	1.17	0.96	1.37	1.40	1.19	0.76	28	18	27
4	$\sigma_D^L = \sigma_E^L = 0.5$	1.11	1.18	0.97	1.36	1.59	1.20	0.76	31	19	33
5	$\sigma_I = 0.5$	1.11	1.15	0.72	1.50	1.58	1.19	0.67	33	30	36
6	$\sigma_C = 0.5$	1.04	1.11	0.77	1.32	1.40	1.12	0.51	25	21	31
7	$\sigma_I = \sigma_C = 0.5$	1.05	1.08	1.76	1.28	1.38	1.11	0.42	33	29	34
8	$\sigma_C = \sigma_D = \sigma_E = \sigma_U = 0.5$	1.04	1.11	0.76	1.33	1.40	1.12	0.51	25	21	31
9	$\sigma_I = \sigma_C = \sigma_D = \sigma_E = \sigma_U = 0.5$	1.05	1.08	1.74	1.28	1.38	1.11	0.42	33	29	34
10	$\sigma_D = \sigma_E = \sigma_U = 2$	1.11	1.18	0.97	1.50	1.59	1.21	0.76	35	35	37
11	$\sigma_D^K = \sigma_D^L = \sigma_E^K = \sigma_E^L = 2$	1.11	1.18	0.97	1.99	2.29	1.24	0.76	33	29	34
12	$\sigma_D, \sigma_E, \sigma_U, \sigma_D^K, \sigma_D^L, \sigma_E^K, \sigma_E^L = 2$	1.11	1.18	0.97	1.98	2.29	1.24	0.76	32	28	34
13	$\sigma_D^L = \sigma_E^L = 2$	1.11	1.18	0.97	1.99	1.59	1.22	0.76	20	16	31
14	$\sigma_I = 2$	1.10	1.23	1.31	1.57	1.67	1.24	0.91	30	24	31
15	$\sigma_C = 2$	1.26	1.37	0.99	3.18	3.50	1.44	1.24	30	24	31
16	$\sigma_I = \sigma_C = 2$	1.25	1.49	1.83	1.08	2.05	1.52	1.42	27	20	31
17	$\sigma_C = \sigma_D = \sigma_E = \sigma_U = 2$	1.27	1.37	1.08	2.94	3.67	1.45	1.24	30	24	29
18	$\sigma_I = \sigma_C = \sigma_D = \sigma_E = \sigma_U = 2$	1.26	1.49	14.42	173.32	12.53	1.53	1.43	31	26	31
19	labor elasticity=0.05	1.11	1.18	0.98	1.53	1.59	1.21	0.77	27	16	26
20	labor elasticity=1	1.16	1.23	1.19	1.75	1.61	1.27	0.87	37	35	37
21	$T_L + 0.05$	1.11	1.18	1.05	1.60	1.60	1.21	0.76	26	19	27
22	$T_L - 0.05$	1.10	1.17	0.83	1.43	1.59	1.20	0.76	36	29	34
23	$\sigma_I = \sigma_C = 1.367$	1.16	1.26	2.29	1.74	1.86	1.29	1.00	29	25	28
24	$\sigma_I = \sigma_C = 1.375$; $\sigma_D, \sigma_E, \sigma_U, \sigma_D^K, \sigma_D^L, \sigma_E^K, \sigma_E^L = 0.5$	1.15	1.26	2.51	1.56	1.62	1.27	1.00	34	31	34

Columns D, E, M, K, L, and All report average MCFs for the 38 countries. Column ϵ_M reports the average elasticity of import demand resulting from the assumed elasticities of substitution. Columns (1), (2) and (3) indicate the number of countries that give recommendations for tax reform that are 'close' to those of the base case, in the following senses. In column (1) the tax instruments found to have the highest and lowest MCFs are the same as in the base case. In column (2) all five individual MCFs are ranked in the same order as in the base case. In column (3) at most one pairwise comparison of MCFs gives a different recommendation from the base case estimates.

calibrated the model to achieve average $\epsilon_M = 1$ by varying σ_C and σ_I, in experiments 23 and 24. Assuming values of $0.72 \leq \epsilon_M \leq 1.00$, a reasonable range for estimates of $MCF(All)$ is 1.19 to 1.29, with our preferred estimates in the range 1.19 to 1.21.

For partial revenue-neutral tax reform, it is the ordering of MCF estimates that is important, not their magnitudes. For such reform, the aim is to compare two tax instruments, increase the tax rate on the low MCF tax, and decrease the tax rate on the high MCF tax. Table 3 reports the number of countries in which the ordering of MCFs is robust to changes in parameters. Three measures of robustness are used. The first measure supposes that reform is concentrated on the most extreme MCFs. The two tax instruments with the highest and lowest MCFs are identified. If these two instruments are the same as in the base case, the ordering is considered robust. Among the five tax instruments there are ten pairwise comparisons that are possible, identifying for each pair the high and low MCF instruments. The second measure of robustness requires that all ten such comparisons report the same pairwise ordering. This implies that all five instruments follow the same order as in the base case. The third measure of robustness permits just one pairwise comparison to give a different ordering from the base case.

On the basis of the first measure the ordering of MCF estimates was robust to variations in parameters on average in 30 out of 38 countries with a minimum of 20. The ordering of MCFs was fully robust to the tested parameter changes on average in 25 countries with a minimum of 16. And on average in 31 countries, the ordering of MCFs was unchanged for 9 out of 10 pairwise comparisons, with a minimum of 26 countries. These results suggest that the MCF orders implied by the base case are reasonably robust to changes in the parameters. However, for any particular revenue-neutral reform it would be necessary to examine the results for the country in question.

4.3 Costs of Tax Administration

One of the features of taxation in Africa is relatively high administrative costs. Table 4 provides an international comparison of administrative costs, measured by dividing the expenses of tax collection agencies by the revenue collected. The average for rich countries is 1.36%, 1.88% for Latin American countries, and 2.35% for African countries.[16]

A taxpayer paying a dollar of taxes suffers the same loss of utility regardless of whether the administration has paid 2 cents or 50 cents to enforce the collection. Further, the administration costs are not lost to society. They are paid to civil

[16]Not all of the tax agencies represented in these figures collect all types of taxes. Since the collection costs vary by tax type, this may give a distorted impression of some agencies efficiency.

Table 4: Tax Administration Costs

Country	Year(s)	Cost/Collections
Australia	2001-2002	1.2%
Canada	2001-2002	2.3%
New Zealand	2001-2002	1.2%
UK	2001-2002	1.6%
US	2002	0.5%
Guatemala	1999-2001	1.9%
Mexico	1995, 1997-98	1.7%
Peru	1996-1998	1.9%
Venezuela	1995-1998	2.0%
Ghana	1993	2.8%
Kenya	1995-2000	1.2%
Namibia	2001-2002	1.3%
South Africa	1998-2001	1.1%
Tanzania	1996-1997	3.0%
Uganda	1991-2000	3.6%

The cost/collections ratio reports the annual cost of tax collection agencies divided by the amount of money collected. For data sources, see Appendix 6.

servants and other providers of goods and services. Thus, tax administration costs do not alter ΔW in our MCF formula (1).[17] Administration costs do, however, alter ΔR, by reducing the net revenue available for government spending. If we suppose that administration costs constitute $\mu\%$ of tax revenue collected, a tax shock that changes gross revenue by ΔR changes net revenue by $\Delta R(1-\mu)\%$. Incorporating administrative costs in our MCF estimates is thus a simple matter of multiplying our existing estimates by $\frac{1}{1-\mu}$.[18]

Table 4 indicates that on average $\mu = 2.35\%$ in Africa. On this evidence, our base case results should be multiplied by 1.024. Table 5 reports the resulting adjusted average MCFs from Table 2. Although Africa has more costly tax administrations than other regions, this alone is unlikely to result in substantially higher marginal costs of public funds.

If administrative costs of tax instruments differ, they could alter the MCF rankings. One of the arguments against the introduction of VATs, for example, is their high administrative cost.[19] Assuming that the taxes on imports, labour, and capital have administrative costs of 2.35%, the adjusted MCF for domestic taxation would exceed the adjusted MCFs for imports, labour, and capital, on

[17] We treat as negligibly small the marginal change in consumer surplus forgone on goods that could have been produced using the factors of production involved in tax administration.

[18] See Ahmad & Stern (1987), Slemrod & Yitzhaki (1996).

[19] Munk (2008) shows that the level of administrative costs has a bearing on the optimality of border taxes, in the presence of an informal sector.

Table 5: Average MCFs Incorporating Administration Costs

Domestic	Imports	Exports	Labour	Capital	All
1.13	1.20	0.99	1.55	1.63	1.23

average, if the administrative cost of domestic taxation exceeded the following thresholds: 8% for imports, 28% for labour, and 32% for capital.[20] That is, almost one-third of the revenue from a VAT could be consumed in administration cost before its adjusted MCF would exceed the adjusted MCF of the corporate income tax. These are wide margins, and help to explain why 30 countries in our sample have introduced VATs, notwithstanding the administrative costs they impose on the economy.

5 Tax Reform

The two most basic topics of tax reform are the structure of existing tax rates, and the bases on which taxes are levied. Our model can be applied to shed light on recent reforms of tax structures, and to suggest the level of resources which should be devoted to extending existing taxes into the informal economy.

5.1 Reforming Tax Structures

We noted in the introduction that African economies have in recent years been reducing trade taxes, and introducing VATs. Piggott & Whalley (2001), Emran & Stiglitz (2005), and Munk (2008) illustrate cases where in the presence of an informal sector, elimination of trade taxes and their replacement with a VAT reduces welfare. To assess the strength of such effects in the African context, we derived optimal taxes to achieve each country's existing revenue. Starting from zero tax rates for all five taxes, we iteratively and incrementally increased the tax with the lowest MCF until the revenue target was achieved.[21] The resulting tax structures are set out in Table 6.

In all countries, optimal taxation includes a tax on *domestic*, and a tax on one of either *imports* or *exports*. The mutual exclusivity of optimal taxes on *imports* and *exports* can be understood by noting that in our model *exports* are the sole inputs into *imports*, so that taxing either imports or exports reduces both, in equal proportions. The effect of an *exports* tax on the quantity of *exports* could be

[20] And dealing with the average MCF for *exports* in countries where MCF(E)>0, the threshold would be 23%

[21] We did not increase taxes when doing so would lower total revenue (ie $dR/dt < 0$). We conducted several iterations of tax-raising, starting with zero factor taxes and rates of goods taxation that were progressively higher but still less than required to generate the revenue target.

Table 6: Optimal Tax Structures

	t_D (%)	t_M (%)	t_E (%)	t_L (%)	t_K (%)	*Optimal MCF*	$\Delta W(1)$ (%)	$\Delta W(2)$ (%)	η (%)
Congo, Dem. Rep.	13.1	14.1	0	0	0	1.07	0.3	0.5	48
Burundi	18.0	20.6	0	0	0	1.07	0.7	1.2	61
Malawi	22.0	26.8	0	0	0	1.13	1.0	1.8	54
Guinea Bissau	16.8	18.9	0	0	0	1.10	0.4	0.9	48
Ethiopia	20.5	23.1	0	0	0	1.16	0.7	1.4	49
Niger	25.2	0	42.5	0	0	1.21	0.9	2.4	39
Eritrea	16.3	17.4	0	0	0	1.07	1.0	1.4	72
Central African Rep.	16.9	19.7	0	0	0	1.12	0.4	0.8	50
Madagascar	18.4	19.6	0	0	0	1.12	0.3	0.9	29
Rwanda	22.8	26.8	0	0	0	1.17	1.2	2.0	57
Togo	19.0	21.7	0	0	0	1.09	0.4	0.9	40
Burkina Faso	22.0	25.9	0	0	0	1.17	0.5	1.3	39
Uganda	28.1	0	47.0	0	0	1.20	1.2	3.0	40
Ghana	21.0	21.1	0	0	0	1.08	0.8	1.5	51
Chad	3.8	0	6.9	0.3	0.9	1.02	0.9	1.0	92
Mali	26.4	31.0	0	0	0	1.17	0.8	2.2	39
Mozambique	14.8	15.6	0	0	0	1.08	0.4	0.8	54
Tanzania	22.4	26.3	0	0	0	1.16	0.5	1.3	38
Gambia	24.6	27.3	0	1.0	0	1.13	0.6	1.9	34
Benin	31.7	41.4	0	0	0	1.27	1.8	3.7	49
Zambia	22.8	24.1	0	0	0	1.10	0.7	1.5	48
Sudan	18.5	21.3	0	0	0	1.15	0.4	0.8	48
Guinea	17.2	19.7	0	0	0	1.12	0.2	0.7	34
Kenya	24.6	29.2	0	0	0	1.12	0.7	1.7	39
Nigeria	17.1	0	19.2	0	4.3	1.06	0.7	1.3	51
Mauritania	18.9	18.6	0	0.9	0.7	1.07	0.5	1.1	46
Senegal	25.5	28.5	0	0	0	1.13	0.8	2.0	41
Zimbabwe	25.6	32.9	0	0	0	1.15	1.2	2.3	53
Côte d'Ivoire	19.3	0	28.6	0	0	1.08	1.1	1.9	56
Cameroon	19.4	20.2	0	3.2	3.3	1.05	0.5	1.0	51
Congo, Rep.	9.6	0	9.6	2.1	2.0	1.03	1.0	1.3	80
Cape Verde	24	23.1	0	0	0	1.10	0.7	1.8	42
Swaziland	30.7	0	44.3	1.3	0	1.07	2.0	4.2	47
Namibia	30.0	0	37.1	3.3	0	1.09	1.9	4.0	47
South Africa	28.4	32.5	0	0	0	1.08	0.8	1.8	3
Gabon	14.2	0	16.7	4.6	5.6	1.04	1.4	1.9	70
Botswana	20.5	0	17.2	3.7	3.9	1.04	1.9	2.6	74
Equatorial Guinea	7.8	0	9.9	0.2	5.6	1.04	4.6	5.9	79
Average	20.5	23.8	23.4	2.3	3.0	1.11	0.9	1.8	51

Averages of tax rates are calculated using only non-zero tax rates.

reproduced with a VAT applied to both domestic and imported goods, combined with an appropriately calibrated additional import tariff. But where the taxes are levied makes a difference to the marginal cost of public funds.[22] Accordingly, depending on the elasticities of the entire general equilibrium system, exports taxes may be required for optimal taxation.

The presence of significant optimal trade taxes appears to validate criticisms of general policies of lowering trade taxes. But as Keen (2008) stresses, the VAT also applies to imported goods. In our sample, the average optimal tax on *domestic* is 20.5%, while the average optimal tax on imports is 23.8%. If a VAT of 20.5% is levied on all *domestic* and *imports*, then an ad valorem import tariff of 2.7% is required to achieve the average optimal *imports* tax rate. That is, in countries with VATs, these results support low rates of tax on imports.[23]

A VAT does not, however, serve as a replacement for an optimal export tax. In particular, exports are frequently zero-rated, meaning that no VAT is paid on sales, but credit is given for tax paid on inputs. In the 11 countries where optimal taxation recommends positive exports taxes, welfare would be reduced by the elimination of exports taxes combined with revenue-neutral increases in the VAT, confirming the point made by Emran & Stiglitz (2005).[24] The importance of this result can be measured. We calculated welfare under optimal taxes in the 11 countries, and then recalculated optimal taxes under the constraint of zero taxes on *exports*. Unconstrained, a movement from existing tax structures to optimal taxes increases welfare by an average of 1.61% across the 11 countries. With the constraint of zero export taxes, the welfare gain is 1.03%.

Summarizing these findings, in most countries an optimal structure would include a VAT, a small imports tariff, and a zero exports tax. But there are some countries where taxes on imports should be zero (including a zero VAT for imports), and exports taxes should be relatively large.

Several further observations follow from our calculation of optimal taxes. The presence of factor taxes in 11 countries contrasts with the common belief that these taxes play no efficiency role in optimal taxation, and should be included in the tax system only to address equity goals. In conjunction with optimal taxes on *exports*, the results serve as a reminder that the Diamond & Mirrlees (1971) production efficiency result (ie. optimal taxes should be levied only on final goods, and not on inputs) does not necessarily hold when not all final goods can be taxed (see, for example, Dasgupta & Stiglitz (1974)). The optimality of factor taxes may be related to the size of the informal sector. The *untaxed* good represents an average

[22]For example, in Niger, with optimal tax rates of $T_D = 25.2\%$, $T_E = 42.5\%$, and $T_M = 0\%$, the corresponding costs of funds are $MCF(D) = 1.21$, $MCF(E) = 1.21$, and $MCF(M) = 1.39$.

[23]The limits of lowering import tariffs may have been reached. The average tax rate on *imports* in our calibrated data (which includes revenue derived from VATs) is 21.4%, which is less than the average optimal imports tariff.

[24]The average rate of taxes on exports in these 11 countries is 1.3% in our data, much lower than the average 23.4% recommended by optimal taxation.

of 28% of GDP in countries where optimal factor taxes are strictly positive, and 7% of GDP in countries where optimal factor tax rates are zero.

Moving to optimal taxes results in a single MCF for all non-zero taxes. Across the 38 countries, the average of these optimal MCFs is 1.11, much lower than the average MCF(All)=1.21 reported in Table 2. A lower cost of public funds would permit a wider range of public projects. These additional public projects could, in a dynamic setting, augment the static gains reported here.

We define three measures of the potential benefits of reform: $\Delta W(1)$ is the welfare improvement resulting from a revenue-neutral move from existing tax structures to optimal tax structures, measured as a percentage of the consumer's initial level of income; $\Delta W(2)$ is the welfare improvement resulting from the elimination of all taxes; and $\eta = \frac{\Delta W(1)}{\Delta W(2)} \times 100$ reports the first measure as a proportion of the second, reflecting the relative importance of the revenue target and the tax structure in terms of efficiency cost. On average, $\Delta W(1) = 0.9\%$, $\Delta W(2) = 1.8\%$, and $\eta = 51\%$: reforming tax structures would achieve just over half of the gains of entirely eliminating distorting taxes. There is, however, wide variation in the potential impact of revenue-neutral reform of tax structures: η ranges from a minimum of 34% to a maximum of 92%, with higher values indicating greater potential benefits. Reform of tax structures should be on the reform agenda in countries with high η.

5.2 Expanding the Tax Base

Perhaps the key distinguishing feature of African tax systems is the importance of the informal sector. At the heart of the dead-weight loss of taxation is the substitution effect. This effect is presumably greater when it is easier to escape taxation. This suggests that economies with large informal sectors are likely to have high MCFs associated with their existing taxes. Figure 2 plots our base case estimates of $MCF(All)$ against the calibrated value of *untaxed*, suggesting the strength of this intuition. The Figure holds out the prospect that expanding the tax base to include currently untaxed sectors could lower the MCFs of existing taxes and offers the potential for additional revenue at low marginal cost: all else equal, economic activities that are more lightly taxed than others will have lower MCFs.

Pursuing the implications of Figure 2, we calculate the MCFs associated with different parts of the informal sector. The detailed results of these experiments are reported in Table 12 in the Appendix. Marginal taxes were imposed on: production of the *untaxed* good (U); *informal capital* used anywhere in the economy (K^i); *informal capital* used to produce *domestic* or *export* goods (K^i_{DE}); *informal labour* used anywhere in the economy (L^i); and *informal labour* used to produce *domestic* or *export* goods (L^i_{DE}). We distinguished between taxing a factor wherever it is used and taxing a factor when it is used to produce *domestic* or *export*

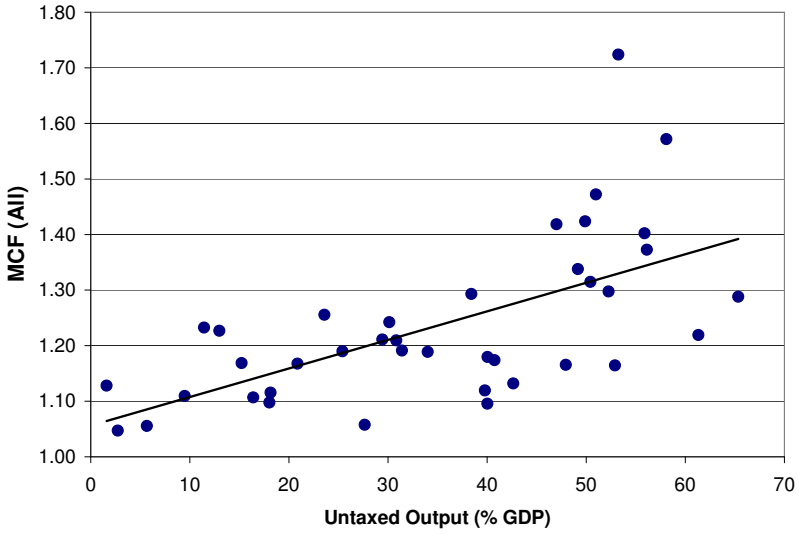


Figure 2: MCF(All) as a Function of the Value of the Untaxed Good

goods because the latter seems more plausible. It seems more likely that the administration will be able to tax a firm's accounting profits (returns to capital) and labour inputs in cases where the firm's output is already taxed.[25]

The average MCF values for the new tax instruments are reported in the last line (MCF^i) of Table 7. Among the different tax instruments for taxing the informal sectors, the least cost way of raising money is by increasing taxes on *untaxed* goods. The average $MCF(U)$ is 0.85, lower than the average MCF elsewhere in the informal economy.[26] But governments may hesitate to increase taxes of informal goods if they care about distributional issues and poor households are concentrated in production of *untaxed* goods or they consume a lot of *untaxed* goods.

When distributional issues are considered, a promising part of the untaxed economy is *informal capital* used to produce taxed goods: average $MCF(K^i_{DE})$ is 0.9. That is, imposing taxes on companies that produce taxed goods but do not pay company tax generally offers a lower cost of public funds than increasing

[25]This is a second best policy. When taxation of informal factors is restricted to inputs to *domestic* and *export* goods, the MCF is higher than when informal factors are taxed wherever they are used: $MCF(K^i_{DE}) > MCF(K^i)$ and $MCF(L^i_{DE}) > MCF(L^i)$.

[26]In all countries the MCF of a tax on the *untaxed* good is less than 1 (see Table 12). The negative welfare shock suffered by households (before the revenue is returned lump-sum) is smaller than the increase in government revenue. Once lump-sum redistribution of the revenue occurs, households are better off than before the tax shock. Increasing taxes in the informal sector helps to counteract existing taxes in other sectors.

Table 7: Administrative Cost Thresholds for Informal Taxes

	U	K^i	K^i_{DE}	L^i	L^i_{DE}	MCF^f
Domestic	0.25	0.21	0.20	0.21	0.08	1.11
Imports	0.29	0.26	0.25	0.25	0.13	1.18
Exports	0.40	0.38	0.37	0.37	0.27	1.40
Labour	0.45	0.43	0.42	0.42	0.33	1.51
Capital	0.48	0.46	0.45	0.45	0.36	1.60
All	0.31	0.28	0.27	0.27	0.16	1.21
MCF^i	0.85	0.89	0.90	0.90	1.04	

existing taxes elsewhere in the formal economy. In many cases such companies have legal tax exemptions, which can be removed with low administrative expense.[27] Removing such exemptions has the potential for a low marginal cost of taxation, without obvious major effects on the poorest households.

Finally, we calculate the threshold levels of administrative costs for taxes in the informal sector, as a proportion of revenue raised. Table 7 reports the thresholds at which the average MCFs of informal sector taxes from Table 12 adjusted to include administration costs, would be equal to our average base case formal sector MCFs (Table 2) adjusted to include uniform 2.35% administration costs.[28]

Policy-makers considering a reform which would extend taxation into an untaxed sector could compare the estimated administrative costs of the new tax against these thresholds. For example, extending the VAT (tax on *domestic*) to a currently exempt firm's sales (U), the relevant administrative cost threshold is 25% of the revenue raised. If it costs \$600 to bring the firm into the tax system, the revenue generated should be at least \$2400. If the VAT has a 15% rate, and value-added represents 35% of sales, then the appropriate threshold for application of the VAT is sales greater than $\frac{2400}{0.35 \times 0.15} = \$45,714$.[29]

[27] In a survey of 197 businesses in Cameroon, Gauthier & Gersovitz (1997) report that 4 were legally exempt from sales tax, while 30 were legally exempt from the business profits tax. In Gauthier & Reinikka (2001) a similar survey of 158 businesses in Uganda reports 17 exemptions from sales tax and 41 exemptions from the corporate income tax. Both studies found that exemptions tended to be granted to large firms, while smaller firms were more likely to evade tax illegally. Legal tax exemptions may be the result of corruption. Fjeldstad (2002) reports that in the mid 1990s senior Tanzanian officials accepted bribes in return for tax exemptions: "within the Ministry of Finance, the *Revenue Department* went under the nickname of the 'Tax Exemption Department.' "

[28] The exports MCF used is the average only for countries for which $MCF(E) > 0$ and existing exports taxes are non-zero.

[29] The example is a modified version of an example given by Keen & Mintz (2004), who uses a different methodology and different assumption concerning the benchmark MCF to find a VAT threshold of \$40,000.

6 Conclusion

We conclude by applying our findings to a series of issues in African tax policy.

First, we find little evidence that African taxation is more costly than in other regions. Our preferred estimates in robustness testing, based on plausibility, are in the range of 1.19 to 1.21 for MCF(All), suggesting low average MCFs in Africa, associated with raising taxes on all five taxes simultaneously. While comparison with MCF estimates produced using different methodologies is problematic, these estimates are well within the range of other studies given in Table 1.[30] Focusing on the lowest MCF tax instrument in each country, the average MCF in our base case estimates is 1.087, which is a low cost source of finance. Low MCF estimates suggest there is scope for increasing total tax revenue in most African countries.

Second, our estimates provide support for the emphasis that reformers have placed on VATs, with low MCFs indicating the efficiency of taxes on domestic and imported goods. In our dataset, 30 countries have implemented VATs. This has been part of a global tax reform wave over the past twenty years, documented in Ebrill, Keen, Bodin & Summers (2002). Average MCF(D) is 1.11 and average MCF(M) is 1.18. Benefits of VATs include the elimination of cascading of multiple sales taxes, and a tendency to broaden the tax base through VAT reporting requirements. Cascading of taxes raises the average and marginal tax rates applied to goods that go through multiple intermediate steps in the production chain, so we would expect the introduction of VATs to have lowered average MCFs. And bringing untaxed goods into the tax base is associated with a very low average MCF(U) of 0.85, indicating that it actually increases welfare. One of the concerns in the introduction of VATs is the administrative cost involved. In very poor countries, these administrative costs could be large relative to the revenue raised. We find, however, that there is typically a wide margin for error. On average, in order for the marginal cost of a VAT to exceed the marginal cost of other taxes, the VAT's administrative costs would need to exceed at least 23% of the revenue raised, compared with African evidence that the costs of administering existing taxes are less than 2.4%.

Third, our results suggest that Africa has perhaps reached the limits of the process of lowering import tariffs, at least in respect of average import tariff rates. In our data, the average tax rate applied to *imports* is 17%, compared with 16% for domestic goods, an average margin of 1 percentage point. In the presence of VATs applied to both domestic and imported goods, the import tariff can be interpreted as a supplementary consumption tax applying only to imports. In an

[30] It is beyond the scope of this paper to estimate the MCF in rich countries to provide directly comparable results. There are several difficulties in adapting our model to rich countries. For example, the European customs union must be modelled to examine import tariffs, and in the United States, state level taxes complicate the analysis. Social security taxes also need to be taken into account. These difficulties are not insurmountable, but we leave them for future research.

optimal tax structure, the supplementary import tariff is small. In countries with optimal domestic and imports taxes, the tax rate on *imports* exceeded the tax rate on *domestic* by an average of 2.8 percentage points. This suggests that the reduction in import tariffs may have gone too far. Moving away from the ideal of optimal taxation, the average MCF(M) associated with imports taxes is, at 1.18, the second-lowest average MCF[31] suggesting that it is a candidate for potential increase if additional revenue is sought.

Fourth, our model does not support a general conclusion of zero rates of export tax. In our sample data, 21 countries have eliminated export taxes entirely, and the average *exports* tax rate in the remaining 17 countries is 1.6%. There appears to be a growing consensus that export taxes are inappropriate. But our MCF results reveal widely varying values of MCF(E), sometimes very low, sometimes very high, and sometimes the instrument performs so poorly that it reduces total revenue resulting in a negative MCF(E). The variability of MCF(E) carries over into the optimal tax rates, where it is optimal to have either an imports tax or an exports tax, but never both. There are 12 countries for which strictly positive export taxes are optimal, of which 5 currently have zero export taxes. Where export taxes are optimal, our results suggest that replacing them with consumption taxes would induce an average welfare loss of around 0.5% (measured in terms of the equivalent variation in the consumer's income). These findings suggest that caution is warranted in reducing export tariffs in countries where MCF(E) is positive but small.

Fifth, estimates of the MCF in informal sectors provide guidance concerning the social cost of tax exemptions. Some African countries have offered tax exemptions to large companies with the aim of encouraging investment. Our MCF estimates suggest the cost of such policies. The corporate income tax, for example, is typically associated with a high MCF (average $MCF(K) = 1.6$). But there is a low MCF associated with the imposition of a marginal tax on companies that produce taxed goods but are exempt from the corporate income tax (average $MCF(K^i_{DE}) = 0.9$). The removal of exemptions from goods taxation has an even lower marginal cost (average MCF(U)=0.85), and from an efficiency point of view should be the first priority when consideration turns to increasing revenue.

Sixth, our MCF estimates provide guidance for reformers about the level of resources that should be devoted to extending taxes into informal sectors. Large informal sectors are associated with high MCFs in the formal economy. Expanding the tax base will help to lower the cost of public funds. While there may be equity concerns associated with taxing some parts of the informal economy, the existence of MCFs less than one in the informal economy suggests scope for increasing welfare and tax revenue simultaneously. In turn, higher welfare and tax revenue suggests the possibility of compensating the losers from tax base expansion. For example, efforts to tax informal agriculture could be accompanied by increased roads main-

[31] Excluding negative MCF(E) for which $dR/dT_E < 0$.

tenance in rural areas. Measures to bring currently informal activities within the tax base would be justified even if a large proportion of the additional revenue were consumed in enforcement and administration (eg 25% or more in the case of currently untaxed goods). Non-tax measures to reduce the informal economy could also be effective tools in improving the efficiency of the tax system. Auriol & Warlters (2005) suggest that governments could reduce substantially the size of their informal sectors by reducing red tape barriers to business entry into the formal sector. Such a policy would not only help to enhance revenue by enlarging the tax base, but would also reduce the marginal cost of public funds.

Finally, we find that corporate and personal income taxes have high average MCFs, suggesting that they should be reduced. In our data, average corporate tax rates (33%) and MCF(K)= 1.6 are slightly higher than average personal income tax rates (27%) and MCF(L) = 1.51. The role of factor taxes is sometimes understood in terms of equity objectives, with progressive personal income tax serving a purely distributional purpose, and the corporate income tax serving as a backstop to prevent easy avoidance of the personal income tax. It is thus interesting to note that instances of strictly positive factor taxes occur under optimal taxation in our model, and that this appears to be related to the size of the informal sector.

Our model and MCF estimates provide tools for examining important issues in tax policy. We are making our CGE model available on the editor's website, in the hope that it can be more widely applied to generate insights into the tax systems of additional countries. The model runs on the free demonstration version of the GAMS software.

APPENDIX 1: Model Specification

The single representative consumer maximizes a CES utility function with four goods: *leisure* (Z), *untaxed* (U), *domestic* (D), and *imports* (M_C) subject to the income constraint.

$$Max\ W = W(Z, U, D, M_C)\ subject\ to\ P_L Z + \tilde{p}_u U + \tilde{P}_D D + \tilde{P}_M M \leq Y$$

A tilde over a price indicates that it is tax-inclusive:

$$\tilde{P}_j = (1 + T_j)P_j, \forall j \in \{D, E, M, I, N, K_D^f, K_E^f, L_D^f, L_E^f\}$$

Consumer income is the value of the endowments of foreign exchange ($\bar{a}$), time ($\bar{T}$), and capital ($\bar{K}$) plus the transfer received from the government (R).

$$Y = \bar{a} + P_L \bar{T} + P_K \bar{K} + R$$

Leisure plus labour supply equals the time endowment.

$$Z + L = \bar{T}$$

The consumer's first order conditions are:

$$\frac{\partial W/\partial Z}{P_L} = \frac{\partial W/\partial U}{\tilde{P}_U} = \frac{\partial W/\partial D}{\tilde{P}_D} = \frac{\partial W/\partial M}{\tilde{P}_M}$$

Factors and investment are combined by CES production functions to produce intermediate goods for *untaxed* (ψ_U), *domestic* (ψ_D), and a final good *exports* (ψ_E). The factors used are capital and labour, each of which may be formal (taxed) or informal (untaxed). The notation for factors is s_r^q : the amount of factor $s \in \{K, L\}$ used to produce good $r \in \{U, D, E\}$, where $q \in \{i, f\}$ indicates whether the factor is informal or formal.

$$\psi_U = \gamma_U(K_U^i, L_U^i, I_U)$$

$$\psi_D = \gamma_D(K_D^i, K_D^f, L_D^i, L_D^f, I_D)$$

$$X_E = \gamma_E(K_E^i, K_E^f, L_E^i, L_E^f, I_E)$$

The first order conditions determining factor usage in production, investment usage in production, and investment inputs in production are given by:

$$\frac{\partial \psi_r}{\partial s_r^q} = \frac{\tilde{P}_{s_r^q}}{P_r}$$

$$\frac{\partial I}{\partial N} = \frac{\tilde{P}_N}{P_I}$$

$$\frac{\partial \psi_I}{\partial x} = \frac{\tilde{P}_x}{P_I}, for x \in \{M, N\}$$

Investment inputs are combined to produce investment:

$$I = \psi_E(M, N)$$

The intermediate goods are divided between final goods and investment inputs using CET production functions.

$$\psi_U = \delta_U(X_U, N_U)$$

$$\psi_D = \delta_D(X_D, N_D)$$

The value of imports is equal to the value of exports plus the endowment of foreign exchange.

$$\tilde{P}_M X_M = \tilde{P}_E X_E + \bar{A}$$

Factor demand equals factor supply:

$$K_U^i + K_D^i + K_E^i + K_D^f + K_E^f = \bar{K}$$

$$L_U^i + L_D^i + L_E^i + L_D^f + L_E^f = L$$

Factors receive the same after-tax return wherever employed:

$$P_{s_r^q} = P_s, \forall s \in \{K, L\}, \forall q \in \{i, f\}, \forall r \in \{U, D, E\}$$

Taxes are zero for the informal good, informal factors, domestically produced investment inputs, and investment:

$$T_j = 0 \ \forall j \in \{U, \{s_r^i\}, N, I\}, \forall s \in \{K, L\}, \forall r \in \{U, D, E\}.$$

Formal factors face the same tax rates whether producing *exports* or *formal* goods. This permits simpler notation:

$$T_K \equiv T_{K_r^f}, \ T_L \equiv T_{L_r^f}, \forall r \in \{D, E\}$$

The numeraire is foreign exchange:

$$P_M^w = 1$$

Goods supply equals demand.

$$X_U = U$$

$$X_D = D$$
$$X_M = M = M_C + M_I$$
$$I_U + I_D + I_E = I$$
$$N = N_U + N_D$$

The transfer to the consumer is equal to tax revenue.

$$R = T_E P_E X_E + T_M P_M X_M + T_D P_D X_D + T_L P_L (L_D^f + L_E^f) + T_K P_K (K_D^f + K_E^f)$$

Parameters in the model are: production and utility function parameters; endowments of time, capital and foreign exchange; and tax rates. Parameter values are determined by the calibration process.

APPENDIX 2: DATA

The data required for the model are:

E	exports (% of GDP)
M	imports (% of GDP)
I	investment (% of GDP)
R_D	tax revenue from VATs and sales taxes (%GDP)
R_E	tax revenue from export taxes (% GDP)
R_M	tax revenue from import taxes (% GDP)
R_K	tax revenue from capital taxes (% GDP)
R_L	tax revenue from labour taxes (% GDP)
T_D	tax rate on domestic goods and services
T_K	tax rate on capital (corporate tax rate)
T_L	tax rate on labour
α_U	labour-output ratio in production of *untaxed*

Country-specific data are set out in Table 8. All country-specific data were obtained from IMF Statistical Annexes to country reports, available on the internet at www.imf.org. Table 8 also reports the year for which the data apply, and whether the country had a VAT in that year.

Countries which separately report the VAT/sales tax on imported goods are: Eritrea, Gabon, Ghana, Guinea-Bissau, Malawi, Mali, Mozambique, São Tomé and Principe, Senegal, Tanzania, Uganda, Zambia. In other countries, the tax revenue data do not distinguish between VAT/sales tax on domestic goods and VAT/sales tax on imported goods. This distinction is important for the calibration of our model, so we estimate the VAT on domestic goods (Rd), according to the following procedure: Rd = R x N/(N+Mc) where R = reported revenue from VAT/sales tax; Mc = Imports x consumption/(consumption+investment) = share

Table 8: Country-Specific Data

	Year	E	M	I	R_D	R_E	R_M	R_K	R_L	Rev	T_D	T_K	T_L	$GDPpc$
Congo, Dem. Rep.	2005	34.0	45.7	13.9	2.0	0.3	4.4	0.8	0.7	8.2	0.13	0.4	0.2	89
Burundi	2005	11.4	45.3	10.8	6.0	0.0	6.0	2.9	1.4	16.3	0.17	0.35	0.35	100
Malawi	2002	25.3	43.8	9.9	2.8	0.0	6.5	2.3	3.4	15.0	0.175	0.3	0.32	129
Guinea-Bissau	2005	37.6	55.1	14.6	0.9	1.3	6.4	1.2	0.8	10.6	0.15	0.3	0.22	134
Ethiopia*	2007	12.8	32.2	25.0	1.7	0.0	5.4	1.3	1.1	9.5	0.15	0.3	0.25	146
Niger*	2003	15.8	16.3	25.8	1.9	1.0	4.5	1.1	0.7	9.2	0.19	0.35	0.32	167
Eritrea	2001	2.5	55.5	19.9	3.8	0.0	5.3	5.0	1.8	15.8	0.12	0.3	0.25	181
Central African Rep.*	2006	13.9	21.7	8.8	2.8	0.4	2.2	1.0	0.7	7.2	0.19	0.3	0.35	223
Madagascar*	2004	31.7	48.0	27.5	1.9	0.0	6.8	0.9	0.8	10.3	0.2	0.3	0.15	229
Rwanda*	2003	8.3	27.6	18.4	3.0	0.0	5.0	1.9	1.8	11.8	0.18	0.35	0.3	239
Togo*	2006	40.5	60.1	13.0	1.6	0.0	9.6	1.7	0.2	13.1	0.18	0.37	0.22	240
Burkina Faso*	2003	8.9	21.7	17.0	3.2	0.0	4.2	1.5	1.0	10.0	0.18	0.2	0.2	241
Uganda*	2001	15.7	18.6	16.6	3.4	0.0	7.3	1.5	1.1	13.4	0.17	0.3	0.2	244
Ghana*	2004	37.0	57.7	27.9	3.2	1.2	7.5	2.9	2.7	17.5	0.125	0.28	0.275	272
Chad*	2005	54.9	21.0	20.2	0.6	0.1	1.5	0.8	1.1	4.0	0.18	0.4	0.4	274
Mali*	2004	24.6	32.0	20.7	3.4	0.3	8.1	1.2	1.5	14.5	0.18	0.35	0.28	276
Mozambique*	2004	30.0	39.3	20.1	2.5	0.1	3.1	0.8	1.8	8.3	0.17	0.32	0.25	295
Tanzania*	2003	17.8	26.7	18.6	2.7	0.0	4.7	0.8	1.7	9.9	0.2	0.3	0.25	299
Gambia	2007	54.0	69.9	25.0	1.4	0.0	12.4	3.0	2.2	19.0	0.15	0.35	0.2	320
Benin*	2006	11.3	22.6	18.1	3.2	0.0	8.3	2.1	1.4	15.0	0.18	0.38	0.33	324
Zambia*	2003	24.7	45.9	25.6	4.3	0.0	5.1	1.2	6.7	17.3	0.175	0.35	0.25	333
Sudan*	1999	8.1	15.1	16.7	1.1	0.1	3.0	0.9	0.1	5.2	0.1	0.4	0.25	350
Guinea*	2004	21.0	25.4	11.4	2.7	0.0	3.5	0.8	0.6	7.4	0.18	0.35	0.23	397
Kenya*	2002	26.0	31.4	13.4	5.2	0.0	5.8	3.5	2.6	17.1	0.18	0.3	0.2	403
Nigeria*	2004	49.7	41.5	23.9	1.0	0.0	3.9	7.3	1.8	14.1	0.05	0.3	0.2	409
Mauritania*	2002	40.0	52.6	26.8	3.4	0.0	6.5	2.1	2.5	14.5	0.14	0.25	0.26	413
Senegal*	2003	28.5	41.5	23.4	4.1	0.0	9.0	1.5	2.7	17.2	0.18	0.33	0.28	471
Zimbabwe	2001	14.8	25.7	5.6	4.0	0.0	3.7	2.5	7.5	17.7	0.15	0.3	0.35	564
Cote d'Ivoire*	2001	40.6	32.9	9.7	2.9	2.5	5.3	1.5	2.3	14.5	0.18	0.35	0.4	599
Cameroon*	2005	23.5	28.8	18.1	6.9	0.0	4.7	1.7	1.3	14.6	0.175	0.35	0.3	678
Congo, Rep.*	2004	84.4	57.3	24.2	0.7	0.0	4.9	1.8	1.3	8.7	0.18	0.38	0.3	1046
Cape Verde*	2005	16.9	50.9	37.9	4.7	0.0	8.7	3.8	2.9	20.0	0.15	0.2	0.275	1343
Swaziland	2007	76.9	87.2	16.2	0.8	0.2	28.4	2.7	5.1	37.2	0.14	0.3	0.26	1401
Namibia*	2005	52.2	52.5	26.0	3.1	0.0	13.7	3.8	6.5	27.1	0.15	0.35	0.345	2133
South Africa*	2005	21.5	25.9	18.2	6.1	0.0	4.3	6.0	8.3	24.6	0.14	0.3	0.35	3429
Gabon*	2003	54.2	30.1	26.4	3.1	0.8	4.9	1.8	1.7	12.3	0.18	0.35	0.25	4235
Botswana*	2005	49.8	35.1	34.8	2.6	0.0	8.4	2.4	1.8	15.2	0.1	0.25	0.2	4382
Equatorial Guinea*	2006	86.8	33.1	32.5	0.2	0.1	0.5	8.6	0.7	10.1	0.15	0.35	0.25	7470
Average		31.8	38.8	20.1	2.9	0.2	6.4	2.3	2.2	14.0	0.16	0.32	0.27	907

* indicates countries with a VAT. *Rev* is the sum of revenues from the five taxes considered, not total tax revenue. GDP per capita is expressed in constant 2000 US$, for the relevant year for each country. GDP per capita is taken from the World Bank's World Development Indicators. All other data are drawn from IMF Country Report Statistical Annexes.

Table 9: Labour-Output Ratios in *Untaxed* Goods (%)

Malawi	South Africa	Tanzania	Zambia	Zimbabwe	Average
58.66	53.99	43.79	53.15	49.70	51.86

of imported goods that are consumed rather than invested; N = Consumption - Mc = consumption of non-imported goods. We add (R-Rd) to the revenue from import taxes.

The countries of the Southern African Customs Union (Botswana, Lesotho, Namibia, South Africa and Swaziland) share imports tax revenue according to a formula that gives a reduced share of the revenue to South Africa. Our calibration method is inaccurate to the extent that the formula differs from the share of regional imports that is consumed by each country.

In the absence of data on the labour-output ratio in the informal economy, the model uses the average ratio for the five countries of Table 9, supposing that the ratio is constant across all countries. These data are derived from social accounting matrices prepared by the International Food Policy Research Institute. Among other data, the SAMs provide for each commodity: the value-added by each factor; exports of each commodity; domestic demand for the commodity; and goods taxes paid. We classified commodities as *untaxed* if the taxes paid on the commodity constituted less than 5% of the value of domestic output of the commodity. Let L_i denote the labour share of value added for each commodity i. Let U be the set of *untaxed* goods, and U_i be the value-added of each untaxed good i. The labour-output ratio for *untaxed* is then calculated as $\frac{\sum_i (L_i \times U_i)}{\sum_i U_i} \forall i \in U$. For comparison, the average labour-output ratio for *exports* is 36.86%, and for *domestic* is 43.28%.

The administrative costs of tax collection presented in Table 4 are derived from various sources. For the United States: IRS Data Book, FY2002, available at: www.irs.gov/pub/irs-soi/02db30cs.xls; For other OECD countries – authors' calculations based on the following tax agency annual reports: Australia – ATO Annual Report 2002, available at www.ato.gov.au; United Kingdom – Inland Revenue, Annual Report for the year ending 31st March 2002, available at www.inlandrevenue.gov.uk/pdfs/report2002.pdf; New Zealand – Inland Revenue Annual Report 2001-2002, available at: www.ird.govt. nz/aboutir/reports/annual-02.pdf; and Canada: Canada Customs and Revenue Agency, 2001-2002 Annual Report to Parliament, Financial Statements, available at www.cra-arc.gc.ca/agency/annual/2001-2002/. For Guatemala: simple average of adjusted figures from Mann (2002). Ghana: revenue-weighted average of figures cited by Terkper (1995). Namibia: statistics provided by Klaus Schade of the Namibian Economic Policy Research Unit. Tanzania: statistics provided by Odd-Helge Fjeldstad of the Chr. Michelsen Institute. Remaining countries: Taliercio (2004). We are very grateful to Klaus Schade, Odd-Helge Fjeldstad and Robert Taliercio for their assistance in obtaining these data.

APPENDIX 3: Model Calibration

The economic relationships in the model can be represented by a rectangular SAM such as Table 10. The entries in the SAM are expressed as percentages of GDP at market value. All rows and columns sum to zero, reflecting a Walrasian

Table 10: SAM for Guinea-Bissau 2005

	Consumer	Untaxed	Domestic	Exports	Imports	Investment	Foreign	Govt
Untaxed	-47.97	47.97						
Domestic	-6.65		5.79					0.87
Exports				36.38			-37.65	1.27
Imports	-48.26				48.69	-6.83		6.41
Foreign Exchange	11.04				-48.69		37.65	
Inv. inputs (I^N)		6.90	0.83			-7.73		
Investment Good		-8.17	-0.98	-5.42		14.57		
Informal Capital	26.51	-11.67	-2.34	-12.51				
Formal Capital	4.14		-0.65	-3.49				
Informal Labour	46.73	-35.03	-1.75	-9.95				
Formal Labor	3.83		-0.57	-3.26				
Capital Taxes			-0.20	-1.05				1.24
Labour Taxes			-0.13	-0.72				0.84
Transfers	10.62							-10.62

Figures represent a percentage of GDP at market value. The tax inclusive value of production of all goods except imports sums to 100.

equilibrium in which incomes equal expenditures. In the consumer's column positive entries are endowments or factor incomes, negative figures are expenditures on goods, including investment. In the production columns, positive entries are the receipt of sales revenue or investment, and negative entries are payments to factors or factor taxes. In the government's column, positive figures are tax revenues, the negative figure is the transfer to consumers. The 'Foreign' column represents the purchase of exports and the sale of imports by the rest of the world, using foreign exchange.

Benchmark quantities of goods and factors (entries in the SAM) are calculated using the following equations:

$X_D = \frac{R_D}{T_D}$	production of *domestic*
$X_E = E - R_E$	production of *exports*
$X_M = M - R_M$	quantity of *imports*
$\bar{A} = X_M - E$	endowment of foreign exchange
$C = 100 - I - (E - M)$	aggregate consumption
$M_C = M \times \frac{C}{C+I}$	share of imports that is consumed
$X_U = C - M_C - X_D - R_D$	production of *untaxed*
$M_I = M \times \frac{I}{C+I}$	*imports* input into investment good
$I_U^N = (I - M_I) \times \frac{X_U}{X_U+X_D}$	*untaxed* input into investment good
$I_D^N = (I - M_I) \times \frac{X_D}{X_U+X_D}$	*domestic* input into investment good
$I_U = I \times \frac{X_U+I_U^N}{X_U+I_U^N+X_D+I_D^N+X_E}$	investment in *untaxed* production

$I_{DE} = I \times \frac{X_D+I_D^N+X_E}{X_U+I_U^N+X_D+I_D^N+X_E}$	investment in other production
$K_D^f = \frac{X_D+I_D^N}{X_D+I_D^N+X_E}\frac{R_K}{T_K}$	*formal capital* used to produce *domestic*
$K_E^f = \frac{X_E}{X_D+I_D^N+X_E}\frac{R_K}{T_K}$	*formal capital* used to produce *exports*
$L_D^f = \frac{X_D+I_D^N}{X_D+I_D^N+X_E}\frac{R_L}{T_L}$	*formal labour* used to produce *domestic*
$L_E^f = \frac{X_E}{X_D+I_D^N+X_E}\frac{R_L}{T_L}$	*formal labour* used to produce *exports*
$FF = K_D^f + K_E^f + L_D^f + L_E^f$	Cost of formal factors
$FS = X_D + I_D^N + X_E - I_{DE}$	Sales of formal output, less investment costs
$AF = FS - FF - R_K - R_L$	Funds distributed to informal factors in formal sector
$K_D^i = AF \times \frac{K_D^f}{FF}$	*informal capital* used to produce *domestic*
$K_E^i = AF \times \frac{K_E^f}{FF}$	*informal capital* used to produce *exports*
$L_D^i = AF \times \frac{L_D^f}{FF}$	*informal labour* used to produce *domestic*
$L_E^i = AF \times \frac{L_E^f}{FF}$	*informal labour* used to produce *exports*
$K_U^i = (1-\alpha_U)(X_U + I_U^N - I_U)$	*informal capital* used to produce *untaxed*
$L_U^i = \alpha_U(X_U + I_U^N - I_U)$	*informal labour* used to produce *untaxed*
$I_D = X_D + I_D^N - (K_D^f + K_D^i + L_D^f + L_D^i + \frac{X_D+I_D^N}{X_D+I_D^N+X_E}R_K + \frac{X_D+I_D^N}{X_D+I_D^N+X_E}R_L)$	investment in *domestic*
$I_E = X_E - (K_E^f + K_E^i + L_E^f + L_E^i + \frac{X_E}{X_D+I_D^N+X_E}R_K + \frac{X_E}{X_D+I_D^N+X_E}R_L)$	investment in *exports*
$\bar{K} = K_E^f + K_D^f + K_E^i + K_D^i + K_U^i$	total capital endowment
$L = L_E^f + L_D^f + L_E^i + L_D^i + L_U^i$	total labour supply
$\bar{T} = \epsilon_L L$	endowment of time, where ϵ_L is elasticity of labour supply

Tax rates on *exports* and *imports* are calibrated, rather than being drawn directly from the legal tax rates:

$T_E = \frac{R_E}{X_E}$	tax rate on *exports*
$T_M = \frac{R_M}{X_M}$	tax rate on *imports*

We do not observe price or quantities of goods, but we do observe the total

amount of money spent on each good (values as a percentage of GDP). Following the Harberger convention we choose units of the aggregate goods such that quantities equal values. This implies that initial prices equal one. Where goods are taxed, goods units can be chosen such that either the gross of tax or net of tax price equals one. We chose units such that the agent supplying the good or factor received a price of one, with remaining prices implied by tax rates:

$P_M^w = 1$	world price of imports (and foreign exchange)
$P_I = 1$	price of *investment*
$P_U = 1$	price of *untaxed*
$P_L = 1$	wage received by labour (formal or informal); also the wage paid by producers for *informal labour*
$P_K = 1$	wage received by capital (formal or informal); also the wage paid by producers for informal capital
$P_D = 1$	producer price of *domestic*
$P_E = 1$	producer price of *exports*

An n-factor CES production function, $F = A(\sum_{j=1}^{n} \theta_j X_j^{\rho})^{\frac{1}{\rho}}$, with factors X_j, share parameters θ_j, scale parameter A, and elasticity of substitution $\sigma = \frac{1}{1-\rho}$, can be rewritten in calibrated form as

$$F = \bar{F}\left[\sum_{i=1}^{n}\left(\frac{\bar{p}_i\bar{X}_i}{\sum_{j=1}^{n}\bar{p}_j\bar{X}_j}\right)\left(\frac{X_i}{\bar{X}_i}\right)^{\rho}\right]^{\frac{1}{\rho}}$$

where a bar over a variable indicates the observed benchmark level. The benchmark factor demands, factor prices and product outputs, combined with the elasticities of substitution fully specify the three production functions. The Cobb-Douglas coefficient in the base case are $\theta_j = \frac{\bar{p}_i\bar{X}_i}{\sum_{j=1}^{n}\bar{p}_j\bar{X}_j}$ $j = 1, ..., n$. The same methodology can be used for the CES utility function, where the X_is represent goods consumed, the p_is are goods prices, and the benchmark utility level is normalized to unity.

The calibration process is completed with the selection of substitution elasticities for production and utility functions. In our base case we chose unitary elasticities.

The calibration process provides estimates of the untaxed economy, which we treat as synonymous with the informal economy. There is overlap between our measures of the untaxed economy, and measures of the 'shadow' economy, as suggested in Table 11. As discussed in the main text, however, our estimates are larger to the extent that they include legal untaxed activities (eg informal agriculture), and smaller to the extent that they do not include illegal activities that are not caught by official GDP statistics. The coefficient of correlation with Schneider's (2005) measure of the shadow economy is 0.29 in the case of untaxed goods, and 0.17 in the case of untaxed factors.

Table 11: Size of the Informal Sector (% GDP)

	U	$K^i + L^i$	Shadow
	Untaxed good sales	Informal factors	Economy
Congo, Dem. Rep.	40.0	76.7	49.7
Burundi	40.0	66.7	38.7
Malawi	50.4	63.4	42.1
Guinea Bissau	47.9	69.6	
Ethiopia	55.9	62.1	42.1
Niger	51.0	64.1	43.8
Eritrea	49.2	45.8	
Central African Rep.	61.3	81.0	46.1
Madagascar	40.7	61.2	41.6
Rwanda	58.1	63.3	42.2
Togo	42.6	77.9	40.4
Burkina Faso	56.1	64.8	43.3
Uganda	47.0	66.6	45.4
Ghana	20.9	41.8	43.6
Chad	27.7	72.6	48.0
Mali	38.4	63.9	44.7
Mozambique	39.8	65.1	42.4
Tanzania	52.3	66.5	60.2
Gambia	25.4	48.6	
Benin	53.3	65.4	49.1
Zambia	31.4	32.2	50.8
Sudan	65.3	78.4	
Guinea	52.9	80.0	41.3
Kenya	30.8	50.6	36.0
Nigeria	16.4	32.3	59.4
Mauritania	18.1	47.4	37.9
Senegal	30.1	54.1	47.5
Zimbabwe	49.9	50.8	63.2
Cote d'Ivoire	34.0	71.1	45.2
Cameroon	18.0	63.0	34.9
Congo, Rep.	5.7	62.7	50.1
Cape Verde	23.6	21.4	
Swaziland	13.0	46.4	
Namibia	11.4	31.1	33.4
South Africa	15.2	18.1	29.5
Gabon	9.5	54.3	
Botswana	1.6	39.5	34.6
Equatorial Guinea	2.7	30.6	
Average	34.9	56.6	44.2

Values of untaxed good sales and informal factors used to produce formal goods are from our calibration algorithm. Values of the 'shadow' economy are from Schneider (2005).

Table 12: MCFs in the Informal Sector

Country	U	K^i	K^i_{DE}	L^i	L^i_{DE}
Congo, Dem. Rep.	0.92	0.97	1.06	0.98	1.05
Burundi	0.86	0.91	1.02	0.93	1.11
Malawi	0.86	0.89	1.10	0.87	1.06
Guinea Bissau	0.90	0.93	1.09	0.96	1.08
Ethiopia	0.90	0.92	1.26	0.93	1.29
Niger	0.90	0.94	1.24	0.96	1.30
Eritrea	0.84	0.76	1.02	0.87	1.27
Central African Rep.	0.93	0.96	1.13	0.97	1.17
Madagascar	0.90	0.95	1.12	0.96	1.10
Rwanda	0.88	0.89	1.32	0.89	1.33
Togo	0.90	0.95	1.04	0.98	1.18
Burkina Faso	0.90	0.91	1.19	0.93	1.26
Uganda	0.86	0.91	1.13	0.92	1.16
Ghana	0.82	0.86	0.96	0.86	0.97
Chad	0.94	0.96	0.98	0.96	0.98
Mali	0.86	0.93	1.15	0.93	1.11
Mozambique	0.92	0.96	1.07	0.95	1.02
Tanzania	0.90	0.95	1.22	0.93	1.13
Gambia	0.82	0.84	0.94	0.89	0.98
Benin	0.85	0.89	1.29	0.91	1.39
Zambia	0.83	0.86	-0.26	0.73	0.69
Sudan	0.95	0.97	1.15	0.99	1.26
Sao Tome	0.82	0.73	0.98	0.69	0.96
Guinea	0.92	0.97	1.10	0.98	1.11
Kenya	0.82	0.85	0.98	0.88	1.02
Nigeria	0.85	0.80	0.83	0.87	0.93
Mauritania	0.85	0.90	0.97	0.90	0.97
Senegal	0.83	0.90	1.09	0.89	1.02
Zimbabwe	0.82	0.86	-3.10	0.77	0.35
Cote d'Ivoire	0.86	0.94	1.06	0.93	1.03
Cameroon	0.82	0.92	0.97	0.93	0.98
Congo, Rep.	0.89	0.94	0.96	0.96	0.97
Cape Verde	0.79	0.72	0.94	0.73	1.00
Swaziland	0.68	0.81	0.95	0.82	0.90
Namibia	0.70	0.75	0.85	0.74	0.82
South Africa	0.72	0.70	0.82	0.67	0.77
Gabon	0.83	0.92	0.97	0.94	0.98
Botswana	0.75	0.89	0.90	0.91	0.92
Equatorial Guinea	0.87	0.82	0.83	0.89	0.98
Average	0.85	0.89	0.90	0.90	1.04
Maximum	0.95	0.97	1.32	0.99	1.39
Minimum	0.68	0.70	-3.10	0.67	0.35
Std. Dev.	0.06	0.07	0.71	0.08	0.19

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