Centre Emile Bernheim
Research Institute in Management Sciences

Solvay Brussels School
Economics & Management

Taxing the unobservable: The impact of the shadow economy on inflation and taxation

Ummad Mazhar and Pierre-Guillaume Méon

We test the notion that a government may rely less on taxes and more on inflation to finance its expenditures the larger the size of the shadow economy. In a sample of developed and developing countries over the 1999-2007 period, we indeed report a negative relation between the tax burden and the size of the shadow economy, and a positive relation between inflation and the size of the shadow economy. We provide evidence that both are conditional on central bank independence and the exchange rate regime. Both survive a series of robustness checks, controlling for reverse causality, simultaneity, level of development, and estimates of the shadow economy.

JEL Classifications: O17, E52, H26, H27.

Keywords: Shadow economy, Inflation, Taxes, Inflation tax.

CEB Working Paper N° 12/023
August 2012

Université Libre de Bruxelles - Solvay Brussels School of Economics and Management
Centre Emile Bernheim
ULB CP114/03 50, avenue F.D. Roosevelt 1050 Brussels BELGIUM
e-mail: ceb@admin.ulb.ac.be Tel. : +32 (0)2/650.48.64 Fax : +32 (0)2/650.41.88

ULB

Taxing the unobservable: The impact of the shadow economy on inflation and taxation

(August 2012)

Ummad Mazhar

Université libre de Bruxelles (U.L.B.)
Solvay Brussels School of Economics and Management
Centre Emile Bernheim
Université de Strasbourg, BETA Cournot
Pôle Européen d'Economie et de Gestion
61 avenue de la Forêt Noire
67000 Strasbourg, France
ummad.mazhar@etu.unistra.fr

Pierre-Guillaume Méon

Université libre de Bruxelles (U.L.B.)
Solvay Brussels School of Economics and Management
Centre Emile Bernheim, CP-114/03
avenue F.D. Roosevelt, 50
1050 Bruxelles, Belgium
pgmeon@ulb.ac.be

Abstract: We test the notion that a government may rely less on taxes and more on inflation to finance its expenditures the larger the size of the shadow economy. In a sample of developed and developing countries over the 1999-2007 period, we indeed report a negative relation between the tax burden and the size of the shadow economy, and a positive relation between inflation and the size of the shadow economy. We provide evidence that both are conditional on central bank independence and the exchange rate regime. Both survive a series of robustness checks, controlling for reverse causality, simultaneity, level of development, and estimates of the shadow economy.

Keywords: Shadow economy, Inflation, Taxes, Inflation tax.

JEL classification: O17, E52, H26, H27.

Acknowledgements: We are grateful to Camille Cornand, Peter Egger, and Ben Zissimos for useful comments. We also thank participants in the World Congress of the Public Choice Societies, the 13th Mediterranean Research Meeting's workshop on the Causes and Effects of Shadow Economy, the Silvaplana workshop in political economy, and seminar participants at the University of Strasbourg and the University of Mannheim.

1. Introduction

Estimates of the size of the informal sector, or shadow economy, routinely exceed 40 percent in developing economies (Schneider and Enste, 2000, Gërxhani, 2004, Schneider, 2005, 2007, La Porta and Shleifer, 2008). Those daunting figures imply that a large share of output can by definition simply not be taxed, because it remains undeclared and unrecorded. Such an erosion of the tax base is a major challenge to government finance. As a result, governments have to find alternative revenue sources to finance public expenditures. Inflation is one. Governments facing a large informal sector therefore face an incentive to shift revenue sources from taxes to inflation.

From a theoretical point of view, the notion that inflation can be used to tax the informal economy goes back at least to Canzoneri and Rogers (1991). Subsequently, Nicolini (1999), Cavalcanti and Villamil (2003), and Koreschkova (2006) applied the public finance motive of inflation put forward by Bailey (1956) and Phelps (1973) to argue that using inflation to finance public expenditures may be optimal in the presence of a large informal sector. Végh (1989), Roubini and Sala-i-Martin (1995), and Blackburn and Powell (2011) use similar arguments in the case of imperfect tax collection. The common feature of those contributions is that they apply to inflation the optimal taxation principle, which implies that the marginal welfare cost of inflation and the marginal welfare cost of taxes should be set equal to maximize welfare. In the presence of positive public expenditures and of an informal sector, that policy rule implies a positive inflation rate. Furthermore, it implies that the inflation rate increases with the size of the shadow economy, while taxes decrease with it.

Surprisingly, whether governments adjust inflation and taxation to the size of the shadow economy has never been tested empirically. Admittedly, Nicolini (1998), Cavalcanti and Villamil (2004), and Koreschkova (2006) provide quantitative assessments of the relevance of the public finance argument. They calibrate their models, and provide estimates of the optimal levels of inflation and taxes implied by a given size of the informal sector. Koreschkova (2006) can even replicate the inflation gap between the US and Peru by focusing on the difference in the sizes of their shadow economies. However, quantitative estimates either rest on the comparison of two countries, like Koreschkova (2006), or are provided with no reference to real world examples, like Nicolini (1998) and Cavalcanti and Villamil (2004). Most of all, those estimates

are purely normative. They describe what the relation between the size of the informal sector and the levels of inflation and taxes should be. They do not describe the actual relation between them. Because there is no reason to *a priori* believe that governments maximize welfare, actual policies are likely to depart from the optimum, and those estimates cannot be used to predict inflation and taxes.

The present paper precisely aims at addressing this caveat by performing a systematic empirical test of the impact of the size of the informal sector on both inflation and taxes in a large sample of countries, using several econometric techniques. More precisely, we test the hypothesis that the shadow economy should tilt government finance from taxes to inflation on a panel data set of 162 countries for 9 years (1999-2007). By doing so, we provide quantitative estimates of the magnitude of the actual reaction of inflation and taxes to the size of the informal sector. We thus perform a positive analysis of the impact of the informal sector on inflation and taxes.

In line with our hypothesis, we find strong evidence that the shadow economy has significant and robust effects on both inflation and taxes, even after controlling for major macroeconomic variables. More precisely, we observe that inflation increases with the size of the shadow economy whereas taxation decreases with it. We then refine the analysis, and show that both relations are conditional on central bank independence, and on the exchange rate regime. We also provide evidence that the relations are causal.

Besides extending our understanding of the macroeconomic effects of the informal sector, those findings touch upon several more general strands of literature. Firstly, they complement our knowledge of the relation between taxation and the shadow economy. Theoretical and empirical research, such as Ihrig and Moe (2004) or Dabla-Norris et al. (2008), commonly assumes and documents that taxes drive firms out of the formal sector. The results of the present paper imply that the reverse effect exists. Secondly, by showing that a larger shadow economy results in a reduction in taxation, the present paper contributes to our knowledge of the political economy of taxation and the tax burden, such as Acemoglu (2005) or Acemoglu et al. (2011). Thirdly, the paper contributes to the empirical research on the structural determinants of inflation and seigniorage, such as Edwards and Tabellini (1991), Cukierman et al. (1992), or Aisen and Veiga (2008a, b). That literature has documented a robust relation between political instability and inflation. One explanation of the relation provided by Cukierman et al. (1992) is that

political instability gives governments an incentive to delay the reforms that would improve the efficiency of the tax system. Huang and Wei (2006) also relate inflation to the efficiency of the tax system in a model of endogenous monetary policy with time inconsistency. However, neither Cukierman et al. (1992) nor Huang and Wei (2006) provide evidence of a relation between the efficiency of the tax system and inflation. By doing so, we document the key relation on which their models rest.

To reach those results, the rest of the paper is organized as follows. The next section recalls the basic public finance argument relating inflation and taxes to the informal sector, using a simple but general model that emphasizes that the relation does not rest on the assumption of a welfare-maximizing government. Section 3 describes the data and the econometric strategy that we use. Section 4 provides the baseline results, and section 5 takes them to a series of robustness checks. Section 6 concludes.

2. A simple theoretical framework

To describe the impact of the shadow economy on the government budget, let us consider a government that has to finance a given level of public spending G with two instruments, a flat tax on output with rate τ, and seigniorage. However, the shadow economy amounts to a share ϕ of total GDP.[1] As shadow output cannot be taxed, the output tax revenue is equal to $\tau(1-\phi)Y$. If we denote Q the seigniorage revenue, then the government's budget constraint reads:

$$G = \tau(1-\phi)Y + Q \tag{1}$$

Variants of that budget constraint can be found in Cukierman et al. (1992), Edwards and Tabellini (1992), De Cavalcanti and Villamil (2003), Koreschkova (2006), or Prado (2011). Their common feature is that they all assume that the shadow economy erodes the tax base.

To model seigniorage, we now follow Mankiw (1987), and assume that the demand for money is described by the quantity equation:

[1] We consider ϕ as exogenous here. The size of the shadow economy may be affected by the tax burden and the inflation rate, but there are numerous other determinants that may affect that size, and make it partly exogenous to taxes and inflation. La Porta and Shleifer (2008) recall that the size of the shadow economy is determined jointly by the benefits of being formal, the costs of becoming formal, and the costs of staying formal. While taxes and inflation may affect the latter, they have little impact on the benefits of being formal and the costs of becoming formal. Recent contributions, such as Feld and Larsen (2005), Torgler and Schneider (2007), and D'Hernoncourt and Méon (2012), also emphasize the role of norms and culture in determining the size of the shadow economy. That suggests that the size of the shadow economy may be determined by deeper factors than simply taxes and inflation. In any case, we will explicitly take into account the possible endogeneity of the size of the shadow economy in the empirical part of the paper.

$$\frac{M}{P} = kY \tag{2}$$

where M denotes outside money, P the price level, and k is a constant.

Rewritten in variations, the quantity equation implies:

$$\frac{\Delta M}{M} = \pi + g \tag{3}$$

where π stands for the inflation rate, and g for the growth rate of output.

From (2) and (3), the real revenue raised from seigniorage can then be rewritten as:

$$\frac{\Delta M}{P} = \frac{\Delta M}{M} \cdot \frac{M}{P} = (\pi + g)kY \tag{4}$$

We assume that the costs of taxes and inflation both increase with their level, and that the marginal costs are increasing. The loss associated with taxes is given by $f(\tau)Y$, with $f' > 0$ and $f'' > 0$. Similarly, the loss associated with inflation is given by $h(\pi)Y$, with $h' > 0$ and $h'' > 0$. The government needs to finance expenses G, but wishes to minimize the total loss of financing it. Note that we refer to losses in general as opposed to deadweight or welfare losses so as to remain as general as possible. The model may thus apply as well to a benevolent social planner who minimizes welfare losses as to a corrupt dictator who tries to minimize the cost to his regime of levying taxes and seigniorage. For the same reason, we do not specify the destination of public expenditures, which may finance a public good as well as the dictator's private consumption. In doing so, we stress that the mechanism at work is more general than the mechanism assumed by Nicolini (1998), Cavalcanti and Villamil (2004), or Koreschkova (2006), who all assume a benevolent social planner. What matters to the argument is that the loss that the government perceives be increasing and convex in both the tax rate and inflation, be it because of the shape of the social welfare function, of the dictator's tax technology and own utility function, or because raising taxes and inflation reduces the government's popularity and increase the probability that it will be overthrown.

Replacing seigniorage as given by (4) by its value in equation (1), the government's program reads:

$$\begin{cases} Min \quad f(\tau)Y + h(\pi)Y \\ s.t. \quad G = \tau(1-\phi)Y + (\pi + g)kY \end{cases} \tag{5}$$

The first-order condition of that optimization problem implies:

$$kf'(\tau)-(1-\phi)h'(\pi)=0 \tag{6}$$

Applying the implicit-function theorem to the above condition, and recalling the assumption concerning the second derivatives of *f* and *h* yields:

$$\frac{\partial \pi}{\partial \phi} > 0 \tag{7a}$$

$$\frac{\partial \tau}{\partial \phi} < 0 \tag{7b}$$

Accordingly, the inflation rate is an increasing function of the share of the shadow economy, while the share of taxes in GDP is a decreasing function of the share of the shadow economy. The intuition of this result is that increasing the share of the shadow economy erodes the tax base. As a result, the marginal loss of raising a dollar of tax revenue increases, which gives the government an incentive to substitute revenues from seigniorage to income tax revenues. Consequently, a larger shadow economy results both in a higher inflation rate and a smaller share of taxes in GDP. The result is very general. It rests on the assumptions that the marginal loss of both inflation and taxes to be positive and increasing, and that the government be sufficiently rational to minimize losses.[2] We test this presumption in the rest of the paper.

3. Data and Econometric Methodology

To measure the impact of the shadow economy on inflation and taxes, we use standard specifications of the determinants of the two variables, and complement them by a measure of the size of the informal sector in the economy.

3.1. Inflation, taxation, and the informal sector

The previous section shows that inflation and taxes should both be treated as a function of the share of the shadow economy in GDP. To test this presumption, we must therefore estimate the two following relations:

$$\pi_{it} = \alpha S_{it} + AX'_{it} + \varepsilon_{it} \tag{8a}$$

$$\tau_{it} = \beta S_{it} + BZ'_{it} + \zeta_{it} \tag{8b}$$

[2] Note, in particular, that the result would hold even if *G* was endogenously determined, as long as the conditions on *f* and *h* hold.

where π_{it} is the measure of inflation, τ_{it} the measure of taxes, and S_{it} the estimate of the shadow economy. X'_{it} and Z'_{it} are vectors containing relevant control variables. α and β measure the marginal impact of the shadow economy on inflation and taxes. A and B are the vectors of coefficients of the control variables. ε_{it} and ζ_{it} are error terms.

To measure inflation, we use the annual percentage change in the consumer price index. To measure taxes, we employ tax revenue as a percent of GDP, which is the exact empirical counterpart of taxes in the model of section 2. One should note that the denominator of the tax revenue ratio is official GDP. Therefore, observing a relation between the shadow economy and that ratio cannot be only due to the mechanic reduction of the tax base. Instead, such a relation implies that the authorities indeed react to the shadow economy by adjusting fiscal policy. Both the consumer price index and tax revenue are taken from the World Bank development indicators database.

Our workhorse estimate of the shadow economy is the estimate provided by Schneider et al. (2010).[3] They provide the largest available panel data set on shadow economic activity, covering 162 countries from 1999 to 2007. They estimate the size of the shadow economy relative to official GDP using the DYMIMIC (dynamic multiple causes, multiple indicators) method.[4] That method infers the size of the shadow economy from variables such as direct and indirect taxation, custom duties, government regulations, the rate of unemployment, growth rate of real GDP, and currency circulation. In order to calibrate absolute figures of the size of the shadow economies from the relative DYMIMIC estimation results, they used previous estimates derived using the currency demand method.

3.2. Control variables

In both regressions, we control for the level of development. Cukierman et al. (1992) argue that tax collection is likely to be inefficient in less-developed countries. We should therefore expect less developed countries to use inflation more, and taxes less, to finance their budgets. Development is proxied by the log of GDP per capita. The GDP per capita data is also taken

[3] Schneider et al. (2010) employ various econometric specifications in terms of causal and indicator variables to estimate the size of the shadow economy. With reference to Table 3.1 in their paper, we use specification (6) which neither include GDP per capita nor tax burden in the set of causal or indicator variables.

[4] As a result, S_{it} is not exactly equal to ϕ, because ϕ measures the size of the shadow economy as a share of total output, as opposed to official GDP. However, the two are directly related by $S = \phi/(1 - \phi)$.

from the World Development Indicators database. We expect that variable to correlate positively with inflation and negatively with the tax burden.

Romer (1993) argues that openness reduces the incentive for policy makers to inflate ex post if they fear the exchange rate depreciation that would follow suit. Moreover, both Romer (1993) and Campillo and Miron (1997) find openness to be an important determinant of inflation across countries. We therefore control for openness. We take the measure of openness from the Penn World Table database (version 7), which defines openness as the ratio of imports and exports to total GDP.

As the shadow economy may correlate with the quality of the regulatory framework, it may indirectly capture the efficiency of the tax system. Because we want to capture its impact on the decision to tax, as opposed to the ability to tax, we control for the quality of the institutional framework in the tax regressions, using the quality of the regulatory framework index from the World Governance Indicators database constructed by Kaufmann et al. (2010). It measures the government's propensity to implement policies that promote private sector development. Its values range from -2.5 to 2.5 with higher values indicating more business-friendly environments. As a better regulatory environment is favorable to the collection of taxes, and should therefore result in larger tax revenues, the coefficient of that variable should be positive.

Given the wide divergence in inflation outcomes across countries, we restrict our sample to countries with inflation rates less than 100 percent on annual basis.[5] However, only 16 observations in total were deleted for that reason. Conditioned on the availability of covariates, and the problems of missing values and outliers, the sample's coverage varies from 106 to 151 countries over the 1999 to 2007 period.

4. Findings

Because our sample exhibits persistence and an unbalanced panel structure, the cross-section dimension of the sample contributes to most of the observed variation in our sample. Pooling observations, therefore, allows maximizing information for inference. As a starting point, we, consequently, estimate equations (8a) and (8b) using pooled ordinary least squares. As

[5] They are mostly from low income countries like Zimbabwe (with average inflation of more than 4000 percent), Democratic Republic of Congo (with average inflation of around 400 percent), and Angola (with average annual inflation of more than 200 percent).

successive observations of the same country cannot be considered independent, we employ country-specific cluster-robust standard errors.

For each of our dependent variables we report three specifications: the baseline specification with the shadow economy as the sole regressor, a specification controlling for national income, and a specification including all main control variables.

*** Insert Table 1 around here ***

The first three columns of Table 1 show the results when the inflation rate is the dependent variable. The last three columns show the results obtained with the tax revenue as the dependent variable. As shown in the bottom panel, Chi-squared tests strongly reject the hypothesis of model insignificance in each case. Control variables are either correctly signed or insignificant. In the inflation equation, the coefficient of openness is negative and significant at the one-percent level, in line with Romer's (1993) argument, while GDP per capita is statistically insignificant at standard level of significance. In the taxation equation, the coefficient of GDP per capita is negative, as predicted by Cukierman et al.'s (1992) argument. We also observe a positive and statistically significant effect of regulatory quality on the tax revenue.

More to the point, the first three regressions of Table 1 report a positive coefficient for the size of the shadow economy. The coefficient is moreover always significant beyond the one-percent level. The magnitude of the coefficient is stable across specifications. Moreover, it is economically significant. Thus, regression (1.1) implies that a one percentage point increase in the share of the shadow economy results in an increase in the inflation rate equal to 0.15 percentage points. For example, Brazil had an average 40.15 percent of its output produced in the shadow economy during the 1999-2007 period. Had it restricted the share of unofficial output to a quarter of its official GDP, Brazil's inflation rate would have been 4.95 percent, instead of 7.02 percent.

As regards the tax equation, the last three columns of Table 1 indicate a strong negative link between the tax burden and the shadow economy. Namely, all the regressions in Table 1 report a negative coefficient for the shadow economy. The coefficient is moreover always significant at the one-percent level or beyond. In economic terms, our baseline estimate (regression 1.4) implies that an increase in the shadow economy by one percentage point results

in a reduction of tax revenues as a share of official GDP equal to 0.141 percentage points. Specifically, our baseline model predicts that a country like Greece would have a tax revenue ratio 1.5 percentage points larger than its present level if the size of its shadow economy was 20 percent, the average for developed countries, instead of its current average size of 30 percent.

5. Robustness checks

In this section, we put our findings to several robustness checks. We firstly generalize the specification of our baseline model considering alternative specifications of the two equations. Secondly, we estimate the baseline model separately for developing and developed countries. We then address the issues of identification and simultaneity. Finally, we reproduce our results using two alternative measures of the shadow economy.

5.1. Alternative specifications

We consider three additional possible determinants of inflation and taxes. The first is the debt ratio, the second, central bank independence, and the third the exchange rate regime. [6]

The debt ratio

A relatively greater stock of public debt increases the incentive of the government to boost inflation, both to increase seigniorage revenues and to reduce the real value of debt. Moreover, Prinz and Beck (forthcoming) find that public debt is a function of the size of the shadow economy. Therefore, our estimates may confound the influence of the shadow economy on inflation with the impact of public debt. In Table 2, we ran previous regressions controlling for the public debt to GDP ratio, as provided by the World Development Indicators data base of the World Bank.

*** Insert Table 2 around here ***

As shown in Table 2, controlling for the stock of public debt does not alter the overall significance of the model neither with inflation nor with the tax burden as the dependent

[6] We only report the most important control variables here. We also controlled for year fixed effects, for corruption, measured by the ICRG corruption index, and for political stability as measured by the World Governance Indicators index of political stability. The results were robust to those additions.

variable. For inflation the coefficient of the shadow economy is little affected, both in terms of magnitude and significance (columns 2.1 to 2.3). Interestingly, the coefficient of the debt ratio never appears significantly in those estimations, suggesting that the stock of public debt is not systematically related to monetary policy. The regressions reported in columns 2.4 to 2.6 take the tax ratio as the dependent variable. In these regressions, the debt ratio exhibits a positive and significant coefficient, suggesting that indebted countries raise more taxes to repay their debt. Again, the coefficient of the shadow economy remains negative and statistically significant at the five-percent level or beyond, in line with previous results and the implications of the theoretical model. Overall, the results of Table 2 show that the results of Table 1 were not due to the omission of the stock of public debt.

Central bank independence

For the government to substitute seigniorage revenues for tax revenues, it must be able to set not only taxes, but also monetary policy. With an independent central bank, the mechanism on which the theoretical model rests breaks down, because the government can simply not control money creation. In other words, the marginal effect of the shadow economy on inflation and taxes should be conditional on central bank independence (CBI). More precisely, we expect the absolute marginal impact of the shadow economy on inflation and tax revenue to be decreasing in CBI.

To take that possibility into account, we interacted the size of the shadow economy with a measure of CBI in all our regressions, so as to let the marginal impact of the shadow economy be a linear function of CBI. We used the index of CBI developed by Cukierman et al. (1992) as updated by Crowe and Meade (2008). It is available for two years (1998 and 2006) and 90 countries in our sample.[7] The results are shown in Table 3. The implied marginal impact of the shadow economy and its significance are computed for the minimum, mean, and maximum values of the CBI index, and reported in the last three rows of the table.[8]

*** Insert Table 3 here ***

[7] Note that our sample start from year 1999 but we take the 1998 value of Crowe and Meade (2008) index for the year 1999 to increase the number of observations. Given the high persistence in CBI scores we believe that this does not affect our analysis.

[8] On the interpretation of models with interactive terms, one may refer to Brambor et al. (2006).

Columns 3.1 to 3.3 of Table 3 confirm that the marginal impact of the shadow economy on the inflation rate is positive, but show that it is a decreasing function of CBI. More precisely, we observe a positive and significant marginal effect of the shadow economy when CBI is equal to its minimum. As the coefficient of its interaction with CBI is negative, the marginal impact of the shadow economy goes down as CBI increases. It is still positive and significant when CBI takes its average value in the sample, but becomes insignificant at standard levels of significance when CBI takes its maximum value. The last three columns (3.4 to 3.6) lead to similar conclusions for the tax equation. The marginal impact of the shadow economy on taxes is significantly negative for all the values of the CBI index in the sample, at least in columns 3.4 and 3.5. The pattern of the interaction, however differs across the two columns. In column 3.4, the marginal impact of the shadow economy varies little with CBI. In column 3.5, however, the absolute marginal impact of the shadow economy indeed decreases when CBI increases, as expected.

Overall, the findings reported in Table 3 confirm that the shadow economy leads to higher inflation and lower taxes. They moreover suggest that CBI acts as a moderating factor.

The exchange rate regime

CBI is not the only institutional factor that constrains monetary policy. The adoption of a fix exchange rate regime similarly takes the reins of monetary policy out of the hands of the government. As a result, the magnitude of the effects that we have so far observed is likely conditional on the exchange rate regime. That magnitude should increase with the flexibility of the regime. To test this contention, we need to interact the size of the shadow economy with the exchange rate regime of the country.

To this end, we employ the exchange rate data set of Ilzetzki, Reinhart, and Rogoff (2008), who classify *de facto* exchange rate regimes into four categories: pegged exchange rate regimes, crawling pegs, managed floats, and freely floating regimes. We interact the shadow economy with a dummy variable for each of exchange rate regime, taking fully flexible regimes as the reference category. The implied marginal impact of the shadow economy and its significance for pegged exchange rate regimes, crawling pegs, managed floats are

reported in the last three rows of Table 4. The marginal impact of the shadow economy in the reference category is directly given by the coefficient of the shadow economy in each regression.

*** Insert Table 4 around here ***

As shown in Table 4 (columns 4.1 to 4.3), the marginal effect of the shadow economy on inflation is always significantly positive or insignificant. It is in particular positively significant at the one-percent level in fully floating exchange rate regimes. Moreover, in line with our contention, the marginal impact of the shadow economy in that regime is larger than in any other regime. In general, the marginal impact of the shadow economy is also the smallest in pegged exchange rate regimes, which gives the contention additional support. The impact is also larger under a managed float than under a crawling peg or a fixed peg.

In the tax revenue equations reported in Table 4 (columns 4.4 to 4.6), the marginal effect of the shadow economy on taxes is either negative or insignificant in all exchange rate regimes.

However, the relation between the absolute magnitude of the marginal effect of the shadow economy and the flexibility of the exchange rate regime is less intuitive than for inflation. More precisely, the absolute marginal effect of the shadow economy is larger under a free float than under a managed float. However, it also appears that the largest effect is observed under either a crawling or a fixed peg. That surprising result may be due to the fact that governments have an incentive to resort more to fiscal policy to stabilize output in a fixed exchange rate regime, because fiscal policy is more efficient in that regime.

In any case, the main finding here is that the findings of previous section remain unchanged when the marginal effect of the shadow economy is allowed to differ across exchange rate regimes. Namely, a larger shadow economy remains positively correlated with inflation and negatively correlated with taxes.

5.2. Developing vs. developed countries

Our estimations have so far pooled together developed and developing countries. Yet, Gërxhani (2004) emphasizes that the relation between the formal and informal sectors likely differ across the two groups of countries. Dreher and Schneider (2010) similarly find that the relation between corruption and the shadow economy differs between developed and developing countries. Although the public finance argument of inflation is not conditioned on the level of

development of the country, the structural differences between developed and developing countries may result in the marginal impact of the shadow economy differing across the two groups of countries. We therefore re-estimate the regressions of previous section on two separate samples: one consisting of developing countries, the other including only developed countries. In Table 5a we consider the former while in Table 5b we consider the latter.[9]

*** Insert Table 5a around here ***

*** Insert Table 5b around here ***

By and large, splitting the sample between developed and developing countries does not affect our findings qualitatively. Overall the models are significant in both sub-samples with the only exception of univariate model (5a.1) in developing model. In both sub-samples, the marginal impact of the shadow economy on inflation is positive whenever it is significant, while it is negative in tax equations. Our results are therefore not driven by a particular subset of countries.

5.3. Endogeneity

Our main independent variable may be endogenous, at least, on two accounts. Firstly, higher taxes and inflation may drive agents out of the formal sector. The impact of inflation is suggested by Crane and Nourzad (1986), who report that inflation is positively correlated with tax evasion in the US. As the shadow economy is a form of tax evasion, one may suspect it to be also driven by inflation. If that is the case, the coefficient of the shadow economy in the inflation equation may have been overestimated. As Schneider and Enste (2000) underline, a high tax burden is considered as one of the main causes of the shadow economy. If that is true, then the coefficient of the shadow economy in the tax equation may have been underestimated in absolute terms, thereby running against the effect that we have so far reported. Secondly, inflation, taxes, and the shadow economy may all be caused by the same omitted variables. For instance, various dimensions of the quality of institutions have been found to affect both inflation, e.g. by Al-Marhubi (2000), and the shadow economy, e.g. by Choi and Thum (2005) or Dreher et

[9] Countries are classified according to the World Bank's income categories. The developing countries' group comprises of middle income (both upper middle income and lower middle income) and low income countries. Whereas, the developed countries' group contains countries falling in the World Bank's high income category.

al. (2009). Both reverse causality and omitted variables may result in the error term being correlated with the shadow economy, and bias our estimates and inferences.

We address the issue of endogeneity in two ways. Firstly, we take advantage of the panel structure of our data set, and use lagged values of the shadow economy to make it predetermined in our statistical model. Tables 6 reports the results of lagged variable estimation.[10] This change does not affect any of our results.

*** Insert Table 6 around here ***

Secondly, to capture exogenous variations of the shadow economy, we employ instrumental variables. Following Dreher and Schneider (2010), we employ business costs and start up procedures related to new businesses to instrument the shadow economy.[11] Those variables measure the cost of becoming formal. They should therefore affect the size of the shadow economy. Because they are at the same time unlikely to directly affect the dependent variables, they are suitable instruments. The results of IV regressions are displayed in Table 7.

*** Insert Table 7 around here ***

In the first three columns of Table 7 we have reported the results of two-stage GMM instrumental variable estimator for inflation and the last three columns (7.4 to 7.6) report the results for tax burden.[12] We have employed available diagnostics to check the validity of the instruments in the last 6 rows of Table 7. These results show that our estimated equations are neither weakly identified (the Craig-Donald statistic exceeds its critical value at the 10 percent level of significance in all but the last column) nor underidentified (the null of hypothesis of underidentification is convincingly rejected in all cases). The p-value of the Anderson-Rubin test shows that we cannot accept the null hypothesis that the instrumented shadow economy has no influence on the dependent variable. The last row reports the Hayashi or C test of exogeneity for

[10] Taking shadow economy as predetermined may cause the problem of autocorrelation in the error term. To tackle this issue we also estimated the equations of table 6 using Diskoll and Kraay (1997) standard errors that allow autocorrelation of more than one year in the error term. Our results remained unaffected by this change. Those results are available upon request.

[11] Both these variables have been taken from the World Development Indicators data base of the World Bank.

[12] More precisely our estimates use feasible efficient two stage GMM estimator, which is robust against heteroskedasticity.

the shadow economy (Hayashi, 2000). Under the null hypothesis that shadow economy can be treated as exogenous, the test statistic follows a chi-square distribution with one degree of freedom. As shown, the test is insignificant, indicating that endogeneity of the shadow economy is not a problem in our sample at least for the inflation equation.[13] This is also supported by the Hansen test, suggesting that the extra orthogonality conditions imposed by instruments are not significant. The results of OLS regressions are therefore unbiased. Accordingly, the estimated coefficient of the shadow economy in the inflation equations are similar to previous estimates.

For the tax revenue equation our results validate the assumptions of the instrumental variables. The coefficient of the (instrumented) shadow economy is significant and negative. Moreover, the magnitude of the coefficient increases in absolute terms as compared to previous results. As expected, previous results, if anything, underestimated the impact of the shadow economy on the tax burden. Controlling for endogeneity, not only confirms but also revises upwards the causal effect of the shadow economy on taxation.

5.4. Simultaneity

According to the public finance argument of inflation, policymakers jointly determine the inflation and tax rates. Our dependent variables are therefore simultaneously determined. To take that simultaneity into account, we estimate our two equations using the SUR estimator, which exploits the contemporaneous correlation of errors. For the SUR estimator to differ from OLS applied on individual equations, the sets of explanatory variables must differ across equations. We therefore focus on our most general specifications, which satisfy this condition. The results of the SUR estimation are shown in Table 8.

*** Insert Table 8 around here ***

In Table 8, both equations are significant independently and the *p* value of the Breusch and Pagan (1980) test rejects the null hypothesis that the two equations are independent. Table 8, however, communicates the same message as previously: a larger informal sector increases inflation and reduces tax revenues even when the contemporaneous correlation of error terms is controlled for.

[13] It is significant in the simple case of one regressor only (column 7.1). As simple regression does not control for competing influences it has relatively lesser reliability as compared to regressions in columns 7.2 and 7.3.

Previous section suggested that the hypothesis of endogeneity of the shadow economy could not be rejected for the tax equation. We therefore complement the SUR estimator by the 3SLS estimator, which controls both for the simultaneity of dependent variables and the endogeneity of the shadow economy. We use the same instruments as in 2SLS regressions, namely business costs and start-up procedures.

*** Insert Table 9 around here ***

The results of 3SLS estimates are shown in Table 9. The results are same as in previous cases. Namely, the coefficient of the shadow economy is positive in inflation equations and negative in tax equations. They are in both cases statistically significant at the one-percent level in both series of equations. Accordingly, neither simultaneity nor endogeneity are driving our results.

5.5. Alternative measures of the size of the shadow economy

A possible concern with the size of the shadow economy is that it cannot be directly observed. One may consequently worry about the sensitivity of our results to the specific estimates of the shadow economy we used. Therefore, we verify our results employing alternative estimates of the size of the shadow economy.

Our first alternative is the Johnson et al.'s (1998) estimates. Johnson et al. (1998) provide a single estimate of the size of the shadow economy for 49 countries for various years around 1994. We therefore estimate the relations only with OLS and SUR estimators on a cross-section, using values of inflation and taxes for 1994 in our estimates. Table 10 reports the results using Johnson et al's estimates of the shadow economy.

*** Insert Table 10 around here ***

As is shown in the lower panel, we have to estimate our model on a sample of less than 40 countries, which does not allow us to tackle all the statistical issues discussed in the previous sections. Nonetheless, in the last two columns we estimate the system of two equations using the SUR estimator to take into account the simultaneity problem, as it directly relates to our theoretical model. As shown in the table, all of our models are statistically significant beyond the

one-percent level. Remarkably, most of our earlier results hold with this change in the measurement of the shadow economy as well as in the sample size and time period of estimation.

We complement Johnson et al.'s (1998) estimates by those of Elgin and Oztunali (2012), who use a general equilibrium approach to measure the size of the shadow economy. Those estimates are available for a large panel data set, which makes them readily substitutable in our empirical models. Therefore, we report, in Table 11, estimates using pooled OLS with panel corrected standard errors and the instrumental variable two step GMM estimator. The same estimates are reported for the inflation equation (columns 11.1 to 11.4) and the tax revenue equation (columns 11.5 to 11.8). As can be seen, the results in Table 11 are very similar to their corresponding estimates reported previously. Table 12 addresses simultaneity, and reports the SUR and 3SLS estimates obtained using Elgin and Oztunali's (2012) estimates. As in the previous case, here too, our results are unchanged.

In summary, the robustness checks bring home the point that our results are due neither to a misspecified model nor to endogeneity/simultaneity issues. Our results hold both for developing and developed countries, and are equally valid across different measures of the size of the shadow economy.[14]

6. Concluding remarks

In this paper, we jointly studied, in a large panel of countries, the relation between the size of the shadow economy and inflation, and the relation between the size of the shadow economy and the tax burden. We observed a positive relation between the size of the shadow economy and inflation, and a negative relation between the size of the shadow economy and the tax burden. For both relations we identified causal effects running from the size of the shadow economy to inflation and the tax burden. We found that both relations are robust to controlling for the debt ratio, for simultaneity, and to using alternative estimates of the shadow economy. In line with the logic of the public finance motive of inflation, we, moreover, found that they are conditional on central bank independence and on the exchange rate regime. Finally, we observed that they are not confined to a particular level of development.

[14] In addition to the results reported in the robustness section we also assessed the sensitivity of our results against influential observations in the main variables of interest using quantile regressions. We also used alternative measures of inflation and tax revenue. Namely, we used the inflation rate obtained from the GDP deflator and the Freedom House tax index. These changes did not change the nature of our findings. However, they are not reported to save space. They are available on request.

Put together, those results are first-time evidence that governments adjust their monetary and tax policies to the size of the shadow economy in a way that is in line with the public finance motive of inflation. They show that the erosion of the tax base by undeclared activities is a strong driver of monetary and tax policies. Governments facing large shadow economies indeed shift their financing from taxes to seigniorage. That behavior was assumed in previous work. This paper backs that assumption by econometric evidence. Our estimates suggest that a one-percentage point increase in the size of the shadow economy to GDP ratio results in a 0.15 point increase in the inflation rate, and in a decrease of up to 0.67 point in the tax burden to GDP ratio. Although these estimates imply that the shadow economy cannot be held as the sole cause of episodes of hyperinflation, they are not negligible for countries that are struggling to balance their budgets or have committed to setting a low inflation rate.

Another implication is that monetary arrangements limiting the availability of governments to boost inflation may cause a sizeable stress on governments that face a large shadow economy. This is in particular the case of monetary integration, be it through a fix exchange rate regime or through monetary union. The shadow economy may thus threaten the sustainability of the government's budget and/or undermine the credibility of its commitment to monetary integration. The shadow economy therefore not only affects domestic policies, but also the sustainability of international agreements. Determining how it interferes with international political and economic phenomena is an avenue for future research.

References

Acemoglu, D., 2005. "Politics and economics in weak and strong states", *Journal of Monetary Economics*, vol. 52 n°7, p. 1199–1226.

Acemoglu, D., D. Ticchi, and A. Vindigni, 2011. "Emergence and persistence of inefficient states", *Journal of the European Economic Association*, vol. 9 n°2, p. 177–208.

Aisen, A., and F.J. Veiga, 2008a. "The political economy of seigniorage", *Journal of Development Economics*, vol. 87 n°1, p. 29–50.

Aisen, A., and F.J. Veiga, 2008b. "Political instability and inflation volatility", *Public Choice*, vol. 135 n°3-4, p. 207–223.

Al-Marhubi, F.A., 2000. "Corruption and inflation", *Economics Letters*, vol. 66 n°2, p. 199–202.

Bailey, M.J., 1956. “The welfare cost of inflationary finance”, *Journal of Political Economy*, vol. 64 n°2, p. 93–110.

Blackburn, K., and J. Powell, 2011. “Corruption, inflation and growth”, *Economics Letters*, vol. 113 n°3, p. 225–227

Brambor T., W.R. Clark, and M. Golder, 2006. “Understanding interaction models: Improving empirical analyses”, *Political Analysis*, vol. 14 n°1, p. 63–82.

Campillo, M. and J.A. Mirron, 1997. “Why does inflation differ across countries?”, in D. Romer and C. Romer (eds) *Reducing Inflation: Motivation and strategy*, NBER 30, Chicago: University of Chicago Press, p. 335–362.

Canzoneri, M.B. and C.A. Rogers, 1990. “Is the European Community an optimal currency area? Optimal taxation versus the cost of multiple currencies”, *American Economic Review*, vol. 80 n°3, p. 419–433.

Cavalcanti, T.V. de V., and A.P. Villamil, 2003. “Optimal inflation tax and structural reform”, *Macroeconomic Dynamics*, vol. 7 n°3, p. 333–362.

Choi, J., and M. Thum, 2005. “Corruption and the shadow economy”, *International Economic Review*, vol. 46 n°3, p. 817–836.

Crane, S.E., and F. Nourzad, 1986. “Inflation and tax evasion: An empirical analysis”, *Review of Economics and Statistics*, vol. 68 n°2, p. 217–223.

Crowe, C., and E. E. Meade, 2008. “Central bank independence and transparency: Evolution and effectiveness”, *IMF Working Paper*, n°119.

Cukierman, A., S. Edwards, and G. Tabellini, 1992. “Seigniorage and political instability”, *American Economic Review*, vol. 82 n°3, p. 537–555.

Dabla-Norris, E., M. Gradstein, and G. Inchauste, 2008. “What causes firms to hide output? The determinants of informality”, *Journal of Development Economics*, vol.85 n°1-2, p. 1–27.

D’Hernoncourt, J., and P.-G. Méon, 2012. “The not so dark side of trust: Does trust increase the size of the shadow economy?”, *Journal of Economic Behavior & Organization*, vol. 81 n°1, p. 97–121.

Dreher, A., and F. Schneider, 2010. “Corruption and the shadow economy: An empirical analysis”, *Public Choice*, vol. 144 n°1, p. 215–238.

Dreher, A., C. Kotsogiannis, and S. McCorriston, 2009. “How do institutions affect corruption and the shadow economy?”, *International Tax and Public Finance*, vol. 16 n°6, p. 773–796.

Edwards, S., and G. Tabellini, 1991. “Explaining Fiscal Policies and Inflation in Developing Countries”, *Journal of International Money and Finance*, vol. 10, p. S16–S48.

Feld, L.P., and C. Larsen, 2005. *Black activities in Germany in 2001 and 2004. A comparison based on survey data*, Rockwool Foundation Research Unit.

Friedman, E., Johnson, S., Kaufman, D., and Zoido-Lobaton, P., 2000. “Dodging the grabbing hand: The determinants of unofficial activity in 69 countries”, *Journal of Public Economics*, vol. 76 n°3, p. 459–493.

Gërxhani, K., 2004a. “Tax evasion in transition: Outcome of an institutional clash? Testing Feige’s conjecture in Albania”, *European Economic Review*, vol.48 n°4, p.729–745.

Gërxhani, K., 2004b. “The Informal Sector in Developed and Less Developed Countries: A Literature Survey”, *Public Choice*, vol. 120 n°3-4, p. 267–300.

Hayashi, F. 2000. *Econometrics*. Princeton University Press, Princeton.

Huang, H., and S.-J. Wei, 2006. “Monetary policies for developing countries: The role of institutional quality”, *Journal of International Economics*, vol. 70 n°1, p. 239–252.

Ihrig, J., and K.S. Moe, 2004. “Lurking in the shadows: The informal sector and government policy”, *Journal of Development Economics*, vol. 73 n°2, p. 541–557.

Johnson, S., D. Kaufman, and P. Zoido-Lobaton, 1998. “Regulatory discretion and the unofficial economy”, *American Economic Review*, vol. 88 n° 2, p. 387–392.

Kaufman, D., A. Kraay, and M. Mastruzzi, 2010. “The worldwide governance indicators: Methodology and analytical issues”, *World Bank Policy Research Working Paper*, n°5430.

Koreshkova, A.T., 2006. “A quantitative analysis of inflation as a tax on the underground economy”, *Journal of Monetary Economics*, vol. 53 n° 4 p. 773–796.

La Porta, R., and A. Shleifer, 2008. “The Unofficial Economy and Economic Development”, *Brookings Papers on Economic Activity*, n° 2, p. 275–352.

Mankiw, N.G., 1987. “The optimal collection of seigniorage: Theory and evidence”, *Journal of Monetary Economics*, vol. 20 n° 2, p. 327–341.

Nicolini, J.P., 1998. “Tax Evasion and the Optimal Inflation Tax”, *Journal of Development Economics*, vol. 55 n°1, p. 215–232.

North, D., 1994, “Economic performance through time”, *American Economic Review*, vol. 84 n°3, p.359–368.

Phelps, E.S., 1973. “Inflation in the theory of public finance”, *Swedish Journal of Economics*, vol. 75 n°1, p. 67–82.

Prado, M., 2011. “Government policy in the formal and informal sectors”, *European Economic Review*, vol. 55 n°8, p. 1120–1136.

Prinz, A., and H. Beck (forthcoming). “In the shadow of public debt: Are there relations between public debt and the shadow economy?”, *Economic Analysis and Policy.*

Romer, D., 1993. “Openness and inflation: Theory and evidence”, *Quarterly Journal of Economics*, vol.108 n°4, p. 869–903.

Roubini, N., and X. Salai-i Martin, 1995. “A growth model of inflation, tax evasion, and financial repression”, *Journal of Monetary Economics*, vol. 35 n°2, p. 275–301.

Schneider, F., and D.H. Enste, 2000. “Shadow economies: size, causes, and consequences”, *Journal of Economic Literature*, vol. 38 n°1, p. 77–114.

Schneider, F., 2005. “Shadow Economies around the world: What do we really know?”, *European Journal of Political Economy*, vol. 21 n° 3, p. 598–642.

Schneider, F., 2007. “Shadow Economies and Corruption all over the World: New Estimates for 145 Countries”, *Economics: The Open Access, Open-Assessment E-Journal*, vol.1 2007-9 (Version 2).

Schneider, F., A. Buehn, and C.E. Montenegro, 2010. “Shadow Economies All over the World: New Estimates for 162 Countries from 1999 to 2007”, Working Papers wp322, University of Chile, Department of Economics.

Torgler, B. and F. Schneider, 2009. “The Impact of Tax Morale and Institutional Quality on the Shadow Economy”, *Journal of Economic Psychology*, vol. 30 n°2, p. 228–245.

Végh, C.A., 1989. “Government spending and inflationary finance: a public finance approach”, *International Monetary Fund Staff Papers*, vol. 36 n°3, p. 657–677.

Appendix

Appendix 1. Descriptive Statistics

**** Insert Table A1 around here ****

Appendix 2. Variable Definition and Sources

Shadow Economy. Schneider et al. (2010) estimates.

Inflation. Annual percentage change in Consumer Price Index (CPI). Source IMF.

National Income. GDP per capita in purchasing power parity dollars. Source IMF.

Opnness. Ratio of imports plus exports to GDP. Source Penn World Tables version 7.

Tax revenue. Tax revenue as a percentage of GDP. Source World Bank development indicators.

Central bank independence. Cukierman et al. (1992) index of central bank independence as updated by Crowe and Meade (2008). Data is available at http://www.imf.org/external/pubs/cat/longres.aspx?sk=21903

Exchange Rate Regime. Dataset from Ilzetzki, Reinhart and Rogoff (2008). Exchange rates regimes are classified into four categories ranging from 1 to 4 with 1 equals de factor peg, 2 crawling peg, 3 managed float, and 4 indicates freely float.

Debt Stock. The debt of the central government measured as percentage of GDP. Source World Bank development indicators.

Regulatory quality. Regulatory quality captures perceptions of the government's ability to formulate and implement sound policies and regulations that permit and promote private-sector development. Average 1996–2008. Source World Bank aggregate governance indicators, Kaufmann et al. (2010).

Tables

Table 1. Shadow economy's effect on CPI and Tax Revenue: Pooled regressions.

	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)	(1.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.150***	0.137***	0.120***	-0.141***	-0.176***	-0.039***
	(0.018)	(0.018)	(0.018)	(0.012)	(0.011)	(0.010)
Log GDP per capita		0.086	-0.007		-0.680***	-0.875***
		(0.097)	(0.093)		(0.156)	(0.133)
Openness			-0.012***			
			(0.002)			
Regulatory quality						3.465***
						(0.156)
Constant	1.196***	-0.587	3.302	21.834***	40.107***	39.252***
	(0.332)	(2.797)	(2.736)	(0.257)	(4.323)	(3.875)
Observations	1,230	1,218	1,218	732	723	723
R-squared	0.046	0.038	0.042	0.081	0.109	0.218
Number of countries	143	141	141	116	115	115
Model χ^2 (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Panel corrected standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2. Controlling for the stock of debt. Pooled regressions.

	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.156***	0.147***	0.141***	-0.171***	-0.175***	-0.019**
	(0.025)	(0.026)	(0.029)	(0.018)	(0.013)	(0.009)
Log GDP per capita		-0.189**	-0.237**		-0.079	-0.314**
		(0.086)	(0.102)		(0.189)	(0.147)
Openness			-0.004*			
			(0.002)			
Regulatory quality						4.500***
						(0.285)
Debt (% of GDP)	0.004	0.003	0.003	0.032***	0.031***	0.035***
	(0.009)	(0.008)	(0.008)	(0.004)	(0.004)	(0.005)
Constant	0.013	5.191**	6.983**	21.186***	23.378***	20.341***
	(0.327)	(2.322)	(2.944)	(0.266)	(5.025)	(4.203)
Observations	442	438	438	428	424	424
R-squared	0.163	0.166	0.168	0.157	0.157	0.313
Number of countries	81	80	80	75	74	74
Model χ^2 (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Panel corrected standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Interacting the shadow economy with central bank independence (CBI). Pooled regressions.

	(3.1)	(3.2)	(3.3)	(3.4)	(3.5)	(3.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.360*	0.198	0.166	-0.155**	-0.235***	-0.081
	(0.199)	(0.129)	(0.126)	(0.072)	(0.080)	(0.074)
CBI (Crowe-Meade)	3.282	-1.823	-1.150	-1.877	-3.238	-4.748
	(7.120)	(5.249)	(5.159)	(4.102)	(4.195)	(4.272)
Shadow econ.*CBI	-0.276	-0.028	-0.049	-0.002	0.034	0.045
	(0.329)	(0.235)	(0.228)	(0.111)	(0.120)	(0.121)
Log GDP per capita		0.098	-0.306		-1.186***	-1.039***
		(0.413)	(0.416)		(0.344)	(0.316)
Openness			-0.028***			
			(0.010)			
Regulatory quality						3.567***
						(0.613)
Observations	150	147	147	107	105	105
R-squared	0.123	0.083	0.107	0.136	0.216	0.365
Number of countries	91	89	89	73	72	72
Model $\chi 2$ (p-value)	0.001	0.000	0.000	0.000	0.000	0.000
Marginal effect of the shadow economy:						
at min. CBI	0.332**	0.195*	0.161	-0.155***	-0.230***	-0.074
	(0.167)	(0.108)	(0.106)	(0.057)	(0.063)	(0.059)
at mean CBI	0.220***	0.183***	0.141***	-0.156***	-0.217***	-0.057
	(0.056)	(0.049)	(0.049)	(0.034)	(0.036)	(0.039)
at maximum CBI	0.106	0.172	0.120	-0.157***	-0.204***	-0.040
	(0.121)	(0.108)	(0.106)	(0.051)	(0.053)	(0.062)

Panel corrected standard errors in parentheses; constant is included but not reported;
*** p<0.01, ** p<0.05, * p<0.1.

Table 4. Interacting the shadow economy with the exchange rate regime. Pooled regressions.

	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)
	Dependent Variable: CPI			Dependent Variable: Tax Rev.		
Shadow economy	0.174***	0.127***	0.118***	-0.145***	-0.181***	-0.056*
	(0.014)	(0.027)	(0.027)	(0.026)	(0.028)	(0.031)
Log GDP per capita		-0.064	-0.160		-0.677***	-0.818***
		(0.158)	(0.161)		(0.187)	(0.174)
Openness			-0.013***			
			(0.004)			
Peg	-0.053	-0.099	0.787	2.586*	2.942**	1.022
	(1.160)	(0.795)	(0.855)	(1.442)	(1.428)	(1.379)
Crawling peg	8.152**	6.289*	6.500**	4.517	3.979	5.449*
	(3.236)	(3.310)	(3.291)	(3.363)	(3.356)	(3.061)
Managed Float	5.160***	3.971***	4.597***	-3.446**	-4.052***	-0.615
	(1.357)	(1.350)	(1.372)	(1.588)	(1.558)	(1.516)
Shadow econ.*Peg	-0.051	-0.073**	-0.093***	-0.023	-0.044	0.029
	(0.049)	(0.030)	(0.031)	(0.041)	(0.041)	(0.040)
Shadow econ.*Crawling peg	-0.176**	-0.130	-0.129	-0.032	-0.017	-0.045
	(0.081)	(0.082)	(0.082)	(0.065)	(0.066)	(0.064)
Shadow econ.*Managed float	-0.057	-0.032	-0.044	0.082**	0.099**	0.032
	(0.047)	(0.045)	(0.046)	(0.040)	(0.040)	(0.039)
Regulatory quality						3.372***
						(0.376)
Observations	1,230	1,218	1,218	732	723	723
R-squared	0.364	0.095	0.100	0.118	0.146	0.236
Number of countries	143	141	141	116	115	115
Model χ^2 square (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Marginal effect of the shadow economy:						
in pegged ERRs	0.123***	0.054**	0.026	-0.168***	-0.225***	-0.027
	(0.047)	(0.027)	(0.030)	(0.029)	(0.031)	(0.485)
in crawling ERRs	-0.002	-0.003	-0.011	-0.177***	-0.198***	-0.101*
	(0.080)	(0.078)	(0.079)	(0.060)	(0.061)	(0.060)
in managed float ERRs	0.117***	0.095**	0.075*	-0.063**	-0.082***	-0.024
	(0.044)	(0.038)	(0.039)	(0.028)	(0.028)	(0.027)

Panel corrected standard errors in parentheses; constant is included but not reported;
*** p<0.01, ** p<0.05, * p<0.1.

Table 5a. Developing countries. Pooled regressions.

	(5a.1)	(5a.2)	(5a.3)	(5a.4)	(5a.5)	(5a.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.026	0.008	0.230**	-0.050***	-0.071***	-0.069***
	(0.018)	(0.015)	(0.102)	(0.011)	(0.013)	(0.011)
Log GDP per capita		0.381***	1.318***		-0.941***	-0.967***
		(0.124)	(0.447)		(0.107)	(0.092)
Openness			0.248***			
			(0.082)			
Regulatory Quality						2.889***
						(0.267)
Constant	7.070***	-1.637	-49.691***	17.222***	41.193***	42.563***
	(0.484)	(3.118)	(18.222)	(0.738)	(3.381)	(4.882)
Observations	817	814	814	393	393	393
R-squared	0.001	0.004	0.140	0.008	0.070	0.127
Number of countries	96	95	95	74	74	74
Model χ^2 (p-value)	0.153	0.004	0.019	0.000	0.000	0.000

Panel corrected standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5b. Developed Countries. Pooled regressions.

	(5b.1)	(5b.2)	(5b.3)	(5b.4)	(5b.5)	(5b.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.095***	0.094***	0.086***	-0.028***	-0.060***	-0.130**
	(0.006)	(0.096)	(0.010)	(0.009)	(0.015)	(0.030)
Log GDP per capita		0.027	-0.103**		-0.613***	-0.680***
		(0.056)	(0.053)		(0.215)	(0.188)
Openness			-0.004***			
			(0.001)			
Regulatory quality						6.212***
						(0.626)
Constant	0.520***	1.283	3.799**	20.557***	37.219***	27.310***
	(0.143)	(1.679)	(1.616)	(0.277)	(5.952)	(5.559)
Observations	413	404	404	339	330	330
R-squared	0.122	0.126	0.138	0.001	0.021	0.123
Number of countries	47	46	46	42	41	41
Model χ^2 (p-value)	0.000	0.000	0.000	0.003	0.000	0.000

Panel corrected standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Taking the Shadow economy as predetermined. Pooled regressions.

	(6.1)	(6.2)	(6.3)	(6.4)	(6.5)	(6.6)
	Dependent Variable : CPI			Dependent Variable: Tax Revenue.		
Lagged Shadow economy	0.143***	0.129***	0.115***	-0.143***	-0.185***	-0.045***
	(0.018)	(0.015)	(0.015)	(0.012)	(0.010)	(0.009)
Log GDP per capita		0.032	-0.046		-0.789***	-0.968***
		(0.066)	(0.067)		(0.128)	(0.114)
Openness			-0.010***			
			(0.002)			
Regulatory quality						3.418***
						(0.156)
Constant	1.309***	0.894	4.193**	21.953***	43.194***	41.892***
	(0.360)	(1.967)	(2.119)	(0.230)	(3.475)	(3.315)
Observations	1,104	1,094	1,094	673	665	665
R-squared	0.051	0.044	0.048	0.080	0.116	0.218
Number of countries	143	141	141	112	111	111
Model χ^2 (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Panel corrected standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Instrumental variable regressions.

	(7.1)	(7.2)	(7.3)	(7.4)	(7.5)	(7.6)
	Dependent Variable: CPI			Dependent Variable: Tax Revenue		
Shadow economy	0.186***	0.129***	0.102*	-0.406***	-0.462***	-0.511***
	(0.046)	(0.047)	(0.056)	(0.048)	(0.053)	(0.168)
Log GDP per capita		0.079	-0.039		-1.987***	-1.998***
		(0.188)	(0.220)		(0.299)	(0.393)
Openness			-0.010**			
			(0.005)			
Regulatory quality						-0.856
						(1.698)
Constant	-0.875	-1.018	3.738	30.804***	83.064***	85.248***
	(1.451)	(6.083)	(7.526)	(1.601)	(8.885)	(15.249)
Observations	768	766	766	499	497	497
Number of countries	137	136	136	104	103	103
C-D Statistic	72.138	63.959	47.232	75.561	79.469	12.026
C-D critical value	19.93	19.93	19.93	19.93	19.93	19.93
A-R Test (p-value)	0.000	0.000	0.004	0.000	0.000	0.000
Under id test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Over id test (p-value)	0.000	0.000	0.000	0.547	0.575	0.312
Endogeneity test (p-value)	0.040	0.397	0.662	0.000	0.000	0.000

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Shadow Economy is instrumented by business costs and start-up procedures, as provided by World Bank Doing Business Survey.
Test Statistics and p-values shown in the lower panel (last 6 rows) of the table are, respectively:
C-D Statistics: Cragg-Donald statistic (H0: Equation is weakly identified).
C-D critical value is from Stock and Yogo (2002).
A-R test: Anderson-Rubin test of significance of shadow economy (F-test version).
Under id test: It tests the null hypothesis that instrumental variable regression is under identified. (That is, it is rank deficient).
Hansen overid test: Null hypothesis that all instruments are valid instruments. (For GMM estimations it is the p-value of Hansen J's statistic).
Endogeneity test: H0 that endogenous regressor can actually be treated as exogenous.

Table 8. SURE regressions.

	(8.1) CPI	(8.2) Tax Revenue
Shadow economy	0.402***	-0.043*
	(0.084)	(0.022)
Log GDP per capita	0.445	-0.852***
	(0.656)	(0.139)
Openness	0.097***	
	(0.020)	
Regulatory quality		3.378***
		(0.341)
Constant	-25.321	38.825***
	(18.679)	(3.737)
Observations	728	728
R-squared	0.054	0.220
Number of countries	115	115
Breusch Pagan test of independence	0.080	

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 9. 3SLS regressions. Dependent variables: Inflation and Tax Revenue. 3SLS.

	(9.1)		(9.2)		(9.3)	
	CPI	Tax Revenue	CPI	Tax Revenue	CPI	Tax Revenue
Shadow economy	0.204***	-0.406***	0.189***	-0.460***	0.278***	-0.524***
	(0.039)	(0.055)	(0.043)	(0.058)	(0.037)	(0.136)
Log GDP per capita			0.216	-1.949***	0.550***	-1.952***
			(0.204)	(0.278)	(0.208)	(0.306)
Openness					0.003	
					(0.006)	
Regulatory quality						-1.121
						(1.304)
Constant	-1.409	30.856***	-6.386	81.996***	-18.042***	84.605***
	(1.320)	(1.865)	(6.309)	(8.583)	(6.442)	(11.985)
Observations	497	497	497	497	497	497
Number of countries	104	104	103	103	103	103

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 10. Regressions using Johnson et al.'s (1998) estimates

	(10.1)	(10.2)	(10.3)	(10.4)	(10.5)	(10.6)
	PCSE	PCSE	PCSE	PCSE	SUR estimates	
	Dependent var.: CPI		Dependent var.: Tax Revenue		CPI	Tax Revenue
Shadow economy	1.109***	-0.167	-0.808***	-0.816***	0.793*	-0.608***
	(0.323)	(0.348)	(0.123)	(0.198)	(0.476)	(0.209)
Log GDP per cap		-0.984***		-0.00686	-0.865***	-0.239*
		(0.153)		(0.133)	(0.274)	(0.139)
Openness					-0.00915	
					(0.00882)	
Regulation (WEF)						0.439***
						(0.145)
Observations	39	39	34	34	34	34
R-squared	0.29	0.62	0.46	0.46	0.61	0.58
Model F(p-value)	0.001	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Constant is included but not reported.

Table 11. Regressions using Elgin-Oztunali's (2012) estimates

	(11.1)	(11.2)	(11.3)	(11.4)	(11.5)	(11.6)	(11.7)	(11.8)
	Dependent Variable: CPI				Dependent Variable: Tax Revenue			
	PCSE		IV/GMM		PCSE		IV/GMM	
Shadow economy	0.153***	0.124***	0.201***	0.122*	-0.165***	-0.074***	-0.438***	-0.667***
	(0.016)	(0.015)	(0.048)	(0.065)	(0.008)	(0.011)	(0.049)	(0.213)
Log GDP per capita		0.041		0.043		-0.903***		-2.145***
		(0.089)		(0.245)		(0.129)		(0.425)
Openness		-0.011***		-0.009*				
		(0.002)		(0.005)				
Regulatory quality						3.179***		-1.799
						(0.184)		(1.967)
Constant	1.367***	2.200	-0.813	1.324	22.213***	40.959***	30.604***	92.415***
	(0.342)	(2.593)	(1.460)	(8.354)	(0.233)	(3.650)	(1.515)	(16.983)
Observations	1,329	1,316	832	830	758	749	516	514
R-squared	0.045	0.040	0.027	0.049	0.097	0.130	0.188	0.326
Number of countries	153	151	149	148	122	121	122	121

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Shadow economy is instrumented by business costs and start-up procedures, as provided by World Bank Doing Business

Table 12. SURE regressions using Elgin-Oztunali's (2012) estimates of the shadow economy

	(12.1)	(12.2)	(12.3)	(12.4)	(12.5)	(12.6)
	SURE Estimates		3SLS Estimates			
	CPI	Tax Revenue	CPI	Tax Revenue	CPI	Tax Revenue
Shadow economy	0.119***	-0.066***	0.212***	-0.437***	0.311***	-0.524***
	(0.020)	(0.024)	(0.041)	(0.056)	(0.041)	(0.142)
Log GDP per capita	-0.164	-0.914***			0.638***	-1.879***
	(0.144)	(0.137)			(0.211)	(0.296)
Openness	-0.009*				0.006	
	(0.005)				(0.006)	
Regulatory quality		3.381***				-0.682
		(0.336)				(1.255)
Observations	749	749	516	516	514	514
Number of countries	121	121	108	108	107	107

Robust standard errors in parentheses ; *** p<0.01, ** p<0.05, * p<0.1; For 3 stage least squares shadow economy is instrumented by business costs and start-up procedures, as provided by World Bank Doing Business Survey. Constant is included but not reported.

Table A1. Descriptive Statistics of Major Variables

Variable		Mean	Std. Dev.	Min	Max
CPI	overall	5.58	6.74	-9.62	61.13
	between		5.90	-8.53	31.52
	within		4.31	-17.46	41.58
Shadow economy	overall	30.31	13.34	8.10	68.30
	between		12.95	8.54	65.80
	within		0.95	25.77	34.21
Log GDP per capita	overall	25.11	1.84	20.94	30.28
	between		1.91	21.09	30.11
	within		0.18	24.62	25.83
Tax Revenue	overall	17.17	7.05	0.82	57.49
	between		6.85	0.99	44.05
	within		1.68	8.72	30.62
Openness	overall	91.23	53.20	14.27	441.17
	between		49.58	15.28	383.03
	within		10.21	28.62	149.37
Regulatory quality	overall	0.38	0.92	-2.39	2.03
	between		0.90	-1.99	1.86
	within		0.14	-0.30	1.16