The shadow economy as a cause of taxes and inflation

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Abstract: In this paper, we test empirically the notion that a rational government should rely less on taxes and more on inflation to finance its expenditures as the size of the shadow economy increases. 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. The relation is not driven by reverse causality, and survives a series of robustness checks.

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1. Introduction

Little is known of the impact of the shadow economy on monetary and fiscal policies. Yet, the shadow economy reduces countries' tax base, and thus reduces the marginal benefit of levying taxes. Governments should therefore rationally rely less on taxes and more on inflation if the share of the shadow economy is larger. Koreshkova (2006) builds a calibrated model based on that argument, and produces reasonable estimates of inflation in a cross section of countries. However, she does not test the model's prediction.

The aim of this study is precisely to provide the first empirical test of the impact of the shadow economy on fiscal and monetary policies. We test the hypothesis that the shadow economy should tilt government finance from taxes to inflation on a large panel data set of 162 countries and for 9 years (1999-2007) using the shadow economy estimates of Schneider et al. (2010).

The empirical literature has identified both structural and institutional determinants of inflation. For example, inflation is found to be negatively associated with statutory independence of monetary authority (Cukierman et al., 1992), openness (Romer, 1993), per capita GDP and political stability (Campillo and Mirron, 1996). Those studies provide a natural baseline model that we complement by taking the shadow economy into account.

We report strong evidence that the shadow economy has significant and robust effects on both the inflation and the tax burden, even after controlling for major macroeconomic variables. More precisely, inflation increases with the size of the shadow economy while taxes decrease with it. Those findings are in line with our working hypothesis.

The rest of the paper is organized as follows. The next section describes a simple model explaining that a rational government should rely less on taxes and more on inflation to finance its budget when the size of the shadow economy in its economy is larger. Section 3 is devoted to our empirical strategy. Section 4 reports our baseline findings, while section 5 provides a series of robustness checks.

2. A simple theoretical framework

Following Mankiw (1987), we assume that the demand for money is described by the quantity equation:

$$\frac{M}{P} = kY \tag{1}$$

where *M* denotes outside money, *P* the price level, *Y* the exogenous level of real output, and *k* is a constant.

Rewritten in variations, the quantity equation implies:

$$\frac{\dot{M}}{M} = \pi + g \tag{2}$$

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

The real revenue raised from seigniorage:

$$\frac{\dot{M}}{P} = \frac{\dot{M}}{M} \cdot \frac{M}{P} = (\pi + g)kY \tag{3}$$

Besides seigniorage, the government can levy a flat tax τ on output. However, the shadow economy amounts to a share ϕ of total GDP. As shadow output cannot be taxed, the tax revenue is equal to $\tau(1 - \phi)Y$.

The government's revenue is therefore the sum of the receipts from both sources:

$$T = \tau(1-\phi)Y + (\pi + g)kY \tag{4}$$

We assume that the deadweight loss of taxes is $f(\tau)Y$, with $f' > 0$ and $f'' > 0$. Similarly, the deadweight loss of inflation is $h(\pi)Y$, with $h' > 0$ and $h'' > 0$.

The policymaker needs to finance expenses *G*, and wishes to minimize the total cost of levying *G*.

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

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 decreases the tax base. As a result, the marginal cost of raising a dollar of tax revenue increases, which gives the government an incentive to substitute revenues of the inflation tax to income tax revenues. Consequently, a larger shadow economy results both in a higher inflation rate and a smaller share of taxes in GDP. 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, taxes, and the informal sector

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

$$\pi_{it} = \alpha S_{it} + AX'_i + \epsilon_{it} \tag{8a}$$

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

where π_{it} is the measure of inflation, τ_{it} the measure of taxes, and S_{it} the estimate of the shadow economy. X'_i and Z'_i 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 annual percentage change in the consumer price index which is a standard gauge of price increases in economies. To measure taxes, we employ tax revenue as a percent of GDP, this is the exact empirical counterpart of taxes in the model of section 2. Both the consumer prices and tax revenue are taken from World Bank development indicators online database.

Our workhorse estimate of the shadow economy is the estimate provided by Schneider et al. (2010). They constructed the largest available panel data set on shadow economic activity, covering 162 countries from 1999 to 2007. They estimated the size of the shadow economy relative to official GDP using the DYMIMIC (dynamic multiple causes, multiple indicators) method. 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 the technology for enforcing tax collection is likely to be more inefficient in less-developed countries. We should therefore expect less developed countries to use inflation more, and taxes less, to finance their budget. Development is proxied by the log of GDP per capita. The estimates of GDP per capita are taken from the World Development Indicators data base maintained by the World Bank.

Romer (1993) argues that openness reduces the incentive for policy makers to inflate ex post because imports increase as a share of total consumption. 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 import and exports to total GDP.

In the tax regressions, we control for the quality of the institutional framework using two indices. One is the index of regulation quality from World Governance Indicators maintained by Kaufmann et al (2010). This measure the perceptions about the government's ability to develop and implement sound policies that promote private sector development. Its values range from -2.5 to 2.5 with higher values indicating more conducive institutional environment for businesses. The second measure is taken from International Country Risk Guide (ICRG) index of government stability. It measures governments ability to carry out its policies and its ability to hold office. The motivation to control for institutional setup is that it influence the expectations of the businesses about the future policy outcomes. It is in line with the evidence that effective institutions permit a matrix for good policy implementation and thus invoke public confidence (e.g. North (1994) and Willamson (2000)).

Overall, we could gather data for a sample of up to 162 countries over the period 1999 to 2007. Table 1 provides descriptive statistics along with the estimates of variances across the sample and within and between cross sections. For most variables between variations dominate the other two sources of variations. This observation motivates us to focus on estimators which exploit this type of variation in a better way compared to fixed effects or within variation.

Table 1. Descriptive Statistics of Major Variables

Variable		Mean	Std. Dev.	Min	Max
Inflation	overall	5.58	6.74	-9.62	61.13
	between		5.90	-8.53	31.52
	within		4.31	-17.46	41.58
Shadow Eco.	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
Total 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
Regulation Quality	overall	0.38	0.92	-2.39	2.03
	between		0.90	-1.99	1.86
	within		0.14	-0.30	1.16

4. Findings

As a natural starting point, we estimate our equations using between least squares estimator for the entire sample to capture between variations which is our main interest as it allows generalization of results. However, one problem is the increased likelihood of heteroskedasticity for which we employ country specific cluster-robust standard errors. For each estimator, we report three specifications: base line with shadow economy as the sole regressor; second controlling for national income and third that controls for additional determinant(s) of our regressand.

An important issue in panel data analysis is the choice between random or fixed effects estimators. From the perspective of our study, the random effects estimator appears more relevant as our primary interest is to capture stochastic regularity associated with population rather than with single cross sections. Statistically, we are unable to find significant fixed effects in multivariate setting. More specifically, out of 151 cross sections dummies, only one come out as significant once we control for income per capita. Whereas, in the absence of any control variables, 62 out of 162 dummies come out significant. It implies that there are no omitted individual-specific effects once we control for national income per capita. This is true for both inflation and tax revenue equations. It leaves us with the random effects model as our model of choice.

We report Breush and Pagan’s LM test to check for the significance of random effects. In most of the cases, random effects are significant i.e. we can reject the null hypothesis that estimated variance component is equal to zero.

Table 2. Dependent Variable: CPI , Between and Random Effect Estimates

	(1) BE	(2) BE	(3) BE	(4) RE	(5) RE	(6) RE
Shadow Economy	0.221***	0.169***	0.156***	0.268***	0.204***	0.193***
	(0.0642)	(0.0458)	(0.0480)	(0.072)	(0.054)	(0.057)
Log GDP per capita		0.212	0.135		0.086	0.034
		(0.296)	(0.294)		(0.270)	(0.279)
Openness			-0.00907			-0.078
			(0.00868)			(0.095)
Constant	-0.437	-4.333	-1.213	-2.092	-2.465	-0.123
	(1.698)	(8.054)	(8.480)	(1.912)	(7.471)	(8.150)
Observations	1,310	1,291	1,291	1,310	1,291	1,291
Adj.R-sq	0.120	0.083	0.081	0.056	0.045	0.047
F-test(P-value)	0.003	0.002	0.000	0.000	0.000	0.000
RE (BP-Test)	n.a	n.a	n.a	0.000	0.000	0.000
Number of countries	154	151	151	154	151	151

Country-cluster-robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

First three columns of Table 2 show the results of between estimates. 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[1]. As they comprise just a minuscule (16 observations in total) of our data we consider it safe to ignore them. The baseline model is significant statistically and indicates a notable economic influence of unobserved economy on inflation outcome. More precisely, a one percent increase in the share of shadow sector output increases the inflation by 0.22 percent, ceteris peribus. Adding controls have decreased the value of R-square but neither affects the models' significance nor the coefficient of our interest. Given the large and diverse cross-sectional nature of our data set the fall in the value of R-square is not an issue (Wooldridge, 2004).

[1] 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).

The last three columns of Table 2 report the random effects estimates. The influence of shadow sector remains significant and positive; standard errors of our coefficient of interest become sharper with controls although the controls themselves are insignificant. The p-value of Breusch and Pagan test in the lower panel indicate that we can reject the null hypothesis of no random effects at a high significant level. It justifies our use of random effects model.

Hitherto, we are dealing with inflation as dependant variable, now we turned towards the second variable, tax burden. Where we use tax revenue as a percentage of GDP as a proxy for tax burden. The results are shown in Tables 3. Overall the models are significant and we cannot accept the null hypothesis of no random effects. For most of the regressions, shadow sector has a significant negative effect on the tax revenue as predicted by our theoretical argument. For example, an increase of one percent in the size of shadow sector causes a decrease of 0.35 percent in our base line random effects model. The interpretation is that higher tax burden is inconsistent with larger share of the shadow economy. It is because greater size of the shadow economy weakens the institutes and thus government's capacity to implement and collect taxes.

In both tables 2 and 3 we could not employ Hausman test to choose among fixed or random effects because of the presence of heteroskedasticity which makes Hausman test inappropriate (Baltagi, 2011)[2].

[2]To test for heteroskedasticity in panel data context we use likelihood ratio test. A generalized least squares model (which we used as unrestricted model) is estimated by iterative method and is compared with a restricted model. For both our dependent variables we can reject the null hypothesis of homoskedasticity at a p-value of zero up to 4 decimal places. The results of the test are same for both the base line model and for the general model.

Table 3. Dependent Variable: Tax Revenue , Between and Random Effect Estimates

	(1) BE	(2) BE	(3) BE	(4) RE	(5) RE	(6) RE
Shadow economy	-0.169***	-0.197***	-0.0749	-0.348***	-0.294***	-0.305***
	(0.0400)	(0.0432)	(0.0601)	(0.056)	(0.056)	(0.068)
Log GDP per capita		-0.602*	-0.924***		0.532	0.527
		(0.323)	(0.354)		(0.440)	(0.405)
regulation quality			3.235***			0.033
			(0.931)			(0.752)
Constant	21.90***	37.85***	41.52***	27.642	12.773	13.337
	(1.709)	(8.916)	(9.996)	(2.162)	(11.696)	(11.132)
Observations	756	741	678	756	741	678
Adj.R-sq	0.0944	0.101	0.202	n.a	n.a	n.a
Overall R-sq	0.11	0.13	0.22	0.11	0.08	0.07
RE (BP-test) P-value	n.a	n.a	n.a	0.000	0.000	0.000
Number of countries	123	121	116	123	121	116

Country-cluster-robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1;

5. Robustness Checks

In this section, we screen our findings through several modifications to check their robustness. We first consider the issue of endogeneity and simultaneity of the errors associated with our equations. Second, we take into account the issue of omitted variables or correlation between error term and the regressors. Third, we consider a different dataset of the shadow economy. Fourthly, we segregate our sample to distinguish developed and developing countries. Finally, we also attempt to go beyond the realm of conditional mean prediction because of its alleged limitations.

5.1 Endogeneity and Simultaneity in variables

Unless we could able to separate out an exogenous influence of unofficial economy on the response variables, we cannot claim that size of the shadow economy has causal influence on our dependent variables. In fact, it is possible that shadow economy is endogenous in our analysis at least on two accounts: one due to omitted variables, and second due to errors in the measurement of shadow economy. The influence of both these factors could be captured by the error term making it correlated with the shadow economy. To check for the endogeneity of shadow economy in each of our equations we use C-test or GMM distance test (Hayashi, 2000), which follow chi-square distribution under the null hypothesis that a given regressor is exogenous to the equation concerned. In our case, we could not reject the null hypothesis for inflation equation while it is rejected in the case of tax revenue equation. In other words, in our general model, we can assume shadow economy as exogenous but only in inflation equation. Still, we report 2SLS results for both equations to maintain symmetry. Following Dreher and Schneider (2010) we have employed business costs and start up procedures related to new business to instrument shadow economy[3].

Table 3a and 3b report the instrumental variables results. For inflation equation the results are rather weak indicating the incapacity of instruments to capture the exogenous variation in the shadow economy other than that is unrelated to inflation. This is in line with our GMM distance test result that shadow economy is not endogenous in this equation.

Table 3a . Dependent Variable: CPI, IV/2SLS

	(1)	(2)	(3)	(4)	(5)	(6)
	BE	BE	BE	RE	RE	RE
VARIABLES						
shadow economy	0.224**	0.188	0.178	0.271*	0.220	0.246
	(0.0908)	(0.148)	(0.178)	(0.156)	(0.178)	(0.211)
Log GDP per capita		0.237	0.197		0.281	0.380
		(0.501)	(0.558)		(0.625)	(0.655)
Openness			-0.00335			0.00889
			(0.0148)			(0.0153)
Constant	-1.383	-6.057	-4.436	-2.906	-8.173	-12.29
	(2.842)	(17.03)	(20.58)	(4.887)	(21.00)	(23.89)
Observations	811	809	809	811	809	809
Number of countries	146	145	145	146	145	145

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Shadow Economy is instrumented by Business Costs and Start-up Procedures

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

On the contrary, for tax revenue equation we have significant results and correct signs with instruments. Moreover, the chi-square value of Sargan statistic at one degree of freedom is 0.479 which indicates no evidence of invalidity of instruments.

Table 3b. Dependent Variable: Tax Burden , IV/2SLS Estimator

	(1) BE	(2) BE	(3) BE	(4) RE	(5) RE	(6) RE
Shadow economy	-0.447***	-0.472***	-0.320	-1.011***	-1.250***	-1.415***
	(0.100)	(0.123)	(0.357)	(0.182)	(0.384)	(0.365)
Log GDP per capita		-1.541***	-1.412*		-3.293**	-3.274***
		(0.579)	(0.772)		(1.533)	(1.069)
regulation quality			1.564			-3.835*
			(3.036)			(2.124)
Constant	31.12***	70.54***	62.21**	48.83***	138.9***	144.4***
	(3.336)	(17.66)	(29.61)	(6.187)	(49.79)	(37.47)
Observations	509	507	507	509	507	507
Number of countries	107	106	106	107	106	106

Bootstrap Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

According to our theoretical argument, policymaker determines jointly the inflation and tax rates. Our dependent variables are therefore simultaneous. To take that simultaneity into account we start using SUR estimator that estimate two equations with contemporaneously correlated error structure. The results of SUR estimation are shown in table 4.

One message of table 4, in addition to buttressing the earlier results, is the greater precision in standard errors especially those of our coefficient of interests, namely, shadow economy. It clearly reflects the greater exploitation of relevant information by this estimator through incorporating possible correlation among cross sectional error variance. This supports our theoretical argument.

As we have seen above that in our sample, we cannot reject endogeneity hypothesis of shadow economy in taxes equation. It implies that a better strategy is to control both for simulataneity of response variables and the endogeneity of shadow economy in tax revenue equation. This possibility is accounted for in 3SLS estimator.

Table 4. Dependent Variables: Inflation and Tax Revenue, SUR Estimator

	(1)	(2)	(3)	(4)	(5)	(6)
	Model SUR1		Model SUR2		Model SUR3	
	CPI	Tax	CPI	Tax	CPI	Tax
shadow economy	0.159***	-0.176***	0.143***	-0.207***	0.128***	-0.0680***
	(0.0175)	(0.0181)	(0.0184)	(0.0197)	(0.0199)	(0.0255)
Log GDP per capita			-0.0516	-0.718***	-0.0817	-0.987***
			(0.134)	(0.143)	(0.143)	(0.144)
Openness					-0.00602	
					(0.00455)	
regulation quality						3.329***
						(0.363)
Constant	0.745	22.52***	2.464	41.63***	4.116	43.00***
	(0.578)	(0.600)	(3.631)	(3.892)	(4.110)	(3.883)
Observations	756	756	741	741	678	678
R-squared	0.099	0.111	0.093	0.130	0.093	0.220

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The 3SLS estimator permits endogeneity of regressors and allows greater efficiency, in asymptotic terms, then 2SLS under correct specification. To safeguard our analysis against the misspecification issues we also run a system 3SLS regression with one additional variable in each of the equation. Thus, we add lag inflation as regressor in the inflation equation while political stability as regressor in tax revenue. For lagged equation, the inertial nature of inflation suggests that its past values have a significant influence on present values. While, for political stability, it can be argued that tax burden can be considered more sustainable in the presence of political stability then without it (Friedman et al., 2000).

The results of 3SLS specification are largely the same as those with earlier specifications except the coefficient of openness which has come out as positive. It is not serious, however, because openness is measured as a ratio of imports and exports to total GDP. Therefore, an exogenous shock that increased the demand or price of a crucial import globally caused the openness index to go up while impacting the inflation positively, ceteris paribus.

Table 5. Dependent Variables: Inflation and Tax Revenue, 3SLS Estimates

	(1)	(2)	(3)	(4)
	Model I		Model II	
	Inflation	Tax	Inflation	Tax
shadow economy	0.402***	-0.0818***	0.105**	-0.0525**
	(0.0836)	(0.0256)	(0.0530)	(0.0263)
Log GDP per capita	0.621	-0.961***	0.458	-0.754***
	(0.604)	(0.144)	(0.380)	(0.152)
Openness	0.0866***		0.0500***	
	(0.0189)		(0.0118)	
regulation quality		3.036***		2.082***
		(0.362)		(0.459)
Lag Inflation			0.663***	
			(0.0202)	
Political Stability				1.482***
				(0.414)
Constant	-28.88*	42.87***	-17.58	36.96***
	(17.35)	(3.889)	(10.91)	(4.144)
Observations	681	681	674	674
R-squared	0.054	0.222	0.636	0.238

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.2 Alternative Control Variables

One worry with our results is that they may be due to unobserved or omitted variables. The usual procedure to control the unobserved or omitted variables is to control for fixed country effects. We tried to estimate our model using fixed effects (FE) but could not find significant FE in our sample. In other words, it means that there are no non-random influences correlated with the error term of our model[4]. Therefore, we circumvent that issue by relying on difference

[4] An unfortunate aspect of taxonomy in panel data analysis is the use of fixed and random effects for different error component structures. In both models the individual specific effects are fixed. The difference is that in one model we assume them correlated with the regressors over time (and call them fixed effects) while in the other model we assume that effects are uncorrelated with the regressors (and call them random over time).

estimator which estimate coefficients of time varying regressors consistently while eliminate the issue of omitted effects.

Results in Table 6a indicate a robust positive effect of the rate of change in informal sector on the inflationary outcome. For example, in itself, a one percent increase in the rate of change in the share of unofficial output (as a percent of national output) causes an increase in the rate of inflation of 1.32 percent. The effects reduce to less than one percent once we control for openness and national output but remain significant.

Table 6a. Dependent Variable: Inflation, First-Difference Estimates

	(1)	(2)	(3)
D.Shadow Eco	1.316***	0.790**	0.887**
	(0.382)	(0.395)	(0.418)
D.Log GDP per capita		-6.318	-11.32
		(4.541)	(7.521)
D.Openness			0.245
			(0.183)
Observations	1,160	1,144	1,144
R-squared	0.005	0.006	0.032

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

Table 6b repeats the same analysis for tax burden. The results indicate a hemorrhage on government revenues due to an increase in shadow sector, of the magnitude of around half a percentage point. Adding control variables reduce the effect of change in shadow economy on change in tax revenue but it remains significant.

Table 6b. Dependent Variable: Tax Revenue , First-Difference Estimates

	(1)	(2)	(3)
D.Shadow Economy	-0.439***	-0.290**	-0.307**
	(0.0931)	(0.122)	(0.131)
D.Log GDP per capita		1.694*	1.755*
		(0.915)	(1.004)
D.Regulation Quality			0.0462
			(0.387)
Observations	635	622	565
R-squared	0.041	0.048	0.054

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

We further employ different regressors to verify the resilience of our results. In Table 7, we attempt to control for past inflation, which is generally considered as a potent determinant of inflation (Campillo and Miron, 1997), while also replace the GDP per capita with GNI. For tax equation we have changed the regulation quality with ICRG measure of Government Stability which is an assessment both of the government's ability to carry out its declared program(s), and its likelihood of staying in office. Its values range from 0 to 12 with higher values signifying greater stability. As our results show, these changes do not change the earlier message of our findings. The proportion of unofficial sector still has significant coefficient both with pooled least squares and SUR techniques. Similarly, for tax equation, the inclusion of government stability does not go against our working hypothesis.

Table 7. Alternative Regressors

	(1)	(2)	(3)	(4)
	Pool-OLS	Pool-OLS	SUR Estimates	
VARIABLES	CPI	Tax	CPI	Tax
Shadow economy	0.0507**	-0.204***	0.0682***	-0.203***
	(0.0202)	(0.0191)	(0.0245)	(0.0203)
Gross National Income in Logs	-0.454**		-1.249***	
	(0.176)		(0.271)	
Openness	-0.00343		-0.00418	
	(0.00304)		(0.00439)	
Lagged CPI	0.318***			
	(0.119)			
Log GDP per capita		-0.763***		-0.756***
		(0.160)		(0.157)
Government Stab. ICRG		-0.464***		-0.482***
		(0.158)		(0.171)
Constant	6.463***	46.91***	15.14***	46.86***
	(1.826)	(4.677)	(2.961)	(4.783)
Observations	1,132	642	640	640
R-squared	0.419	0.138	0.138	0.137

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

5.3. Alternative estimates of Shadow economy

A possible concern with the size of the shadow economy is its being an imperfect estimate of phenomena which in itself unobserved. One may consequently worry about the sensitivity of our results to the specific estimate of the shadow economy we used. Therefore, in Table 8 we report the results of analysis employing Johnson et al (1997) measure of unofficial economy for 49 countries during 1990s. The estimates of Johnson et al. provide only single values rather than time series so we are confined to OLS estimator.

The results obtained with the alternative measure of the shadow economy are displayed in table 8. Although the sample size shrink to 39 observations, the general picture displayed in that table is consistent with our previous results. In other words, inflation is still positively correlated with the size of the shadow economy, with a different estimate of the shadow economy and on a different period of estimation.

Table 8. Estimation using Johnson's et al. 1997 Shadow Eco Estimates

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	SUR Estimates	
	CPI	CPI	CPI	CPI	Tax burden
Shadow Eco	0.0373**	-0.0267	-0.0266**	0.0379*	-0.0388***
	(0.0166)	(0.0159)	(0.0131)	(0.0225)	(0.0116)
Log GDP per capita		-1.167***	-1.203***	-0.849***	0.0691
		(0.155)	(0.143)	(0.279)	(0.161)
Openness			-0.00724	-0.0102	
			(0.00451)	(0.00849)	
Regulation (Heritage)					-0.0423
					(0.0532)
Constant	1.078***	12.71***	13.46***	9.388***	3.356**
	(0.396)	(1.617)	(1.483)	(3.032)	(1.475)
Observations	39	39	39	34	34
R-squared	0.178	0.660	0.681	0.609	0.436

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

Table 12. Dependent Variable: Tax Burden; Johnson's et al 1997 Shadow Eco Estimates

	(1)	(2)	(3)
Shadow Eco.	-0.0363***	-0.0390***	-0.0390***
	(0.00656)	(0.0108)	(0.0108)
Log GDP per capita (1994)		0.0722	0.0722
		(0.153)	(0.153)
Fraser Institute (Tax Rule Index)		-0.0442	-0.0442
		(0.0407)	(0.0407)
Constant	3.678***	3.343**	3.343**
	(0.204)	(1.455)	(1.455)
Observations	34	34	34
R-squared	0.424	0.436	0.436

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

5.4. Sub samples of countries

It is possible that our results have been driven by some specific group of countries. Thus, in table 9 we have tested our model over two different ranges of the sample on the basis of income classification. In general, the high income countries are assumed to have better institutional set up and thus more effective policy implementation. Therefore, they can be treated separately from the rest of the world which includes, by IMF classification, the other three categories of countries, namely, upper middle income countries, lower middle income countries, and low income countries. It is possible, thus, that these two sets of countries differ in the realization of the effects of shadow economy. Our results appear to support this conjecture, though, not fully: tax revenue is not affected by shadow sector in high income countries. While other results, vis-à-vis inflation, are unaffected in both sub samples. It implies more uniformity in terms of inflationary outcomes (and thus in the practice of monetary policy) then that of tax revenues. It also partially supports the hypothesis of Dreher and Schneider (2010) that shadow economy has different implications in high income countries.

Table 9. Dependent Variable: Inflation and Tax Revenue, High Income vs. Low Income Estimates

	(1)	(2)	(3)	(4)
	High Inc	Low Inc	High Inc	Low Inc
	CPI	CPI	Tax	Tax
shadow economy	0.182***	0.0917***	0.0103	-0.156***
	(0.0392)	(0.0298)	(0.0378)	(0.0490)
Log GDP per capita	0.0135	0.214	-0.786***	-1.420***
	(0.289)	(0.170)	(0.180)	(0.337)
Openness	-0.0162***	0.0136		
	(0.00356)	(0.0117)		
regulation quality			3.064***	3.752***
			(0.479)	(0.698)
Constant	1.699	-2.532	36.48***	56.65***
	(8.013)	(5.116)	(5.135)	(10.19)
Observations	687	604	422	256
R-squared	0.077	0.013	0.153	0.175

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0

5.5. Considering other quantiles of distribution

Linear regression models predict the conditional mean of the response variable. As our sample comprises all sorts of countries, which differ fundamentally in their inflation outcomes, a conditional mean estimation, at best, provides a very limited view of the conditional distribution of inflation (respectively, tax revenue). One way to relax this restriction is to consider other quantiles of the distribution of our response variables. This possibility is explored in Tables 10 *a* and *b* by employing difference between third and first quartile, rather than conditional mean, to predict inflation (tax revenue) given the same set of regressors.

The results with inter-quartile regression are significant and quantitatively not much different from linear estimates. The inter-quartile regression coefficients reveal that shadow economy's influence on inflation is not due to central tendency of distribution. Rather it is more broadly distributed. Moreover, the positive and significant constant in the final regression (model 3) indicates that the effect of the shadow sector on the inflationary outcome, ceteris paribus, is not constant over conditional distribution of dependent variable[5]. It implies that as we move higher on the percentiles of distribution of inflation, the influence of unofficial economy augments.

Table 10a. Robustness Analysis: Dependent Variable CPI , Inter-Quantile Estimates

VARIABLES	(1)	(2)	(3)
shadow economy	0.185***	0.168***	0.154***
	(0.0183)	(0.0206)	(0.0217)
Log GDP per capita		-0.131	-0.181*
		(0.0945)	(0.109)
Openness			-0.00389*
			(0.00207)
Constant	-0.399	3.352	5.403*
	(0.420)	(2.668)	(3.141)
Observations	1,310	1,291	1,291

*** p<0.01, ** p<0.05, * p<0.1; Bootstrap standard errors in paranthesis

[5] To see it precisely we run regressions for separate quantiles and find that the coefficient on 0.75 quantile is around 5 times as large as on 0.25 quantile.

Table 5 repeats the same analysis for the tax burden. The core results are similar to our previous analysis. The value of constant is positive and significant in each regression indicating an increase in the magnitude of coefficients at higher quantiles of conditional distribution of dependent variable.

Table 10b. Robustness Analysis: Dependent Variable Tax Revenue , Inter-Quantile Estimates

	(1)	(2)	(3)
	model_iq1	model_iq2	model_iq3
	trpgdp	trpgdp	trpgdp
shadow economy	-0.179***	-0.160***	-0.133***
	(0.0296)	(0.0337)	(0.0410)
Log GDP per capita		-0.0923	-0.289
		(0.212)	(0.177)
regulation quality			-0.0589
			(0.719)
Constant	14.03***	15.74***	18.77***
	(1.165)	(5.892)	(5.136)
Observations	756	741	678

*** p<0.01, ** p<0.05, * p<0.1; Bootstrap standard errors in paranthesis

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