Underground economy estimates for non-OECD countries using currency demand method, 1984-2005

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ABSTRACT

The paper estimates the size of underground economy induced by tax evasion for cross-section of non-OECD countries using currency demand method. Unlike previous studies which usually focus only on the tax rate as the tax evasion factor, the paper presents theory consistent tax evasion estimates by augmenting the enforcements strength of the tax administration as additional determinant of the level of tax evasion. The estimation strategy includes the use of the Arellano-Bond GMM dynamic panel data method that is suitable in dealing with the issue of persistence and endogeneity problems in the estimation of currency demand equation. The study finds substantial underground economy in the non-OECD countries for the period 1984-2005 ranging from 2-69 percent of GDP.

JEL classification: *H21; H26; C33; E41; O17*

Key words*: Tax evasion, underground economy, currency demand, enforcement, non-OECD, Dynamic Panel Data.*

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1. Introduction

There has recently been renewed interest in the measurement and analysis of the underground economy using the currency demand method. Most of these studies, however, have focused on the economies of the OECD countries. Beginning with the seminal work of Tanzi (1980) for the U.S. economy, these studies include Matthews (1982) for the U.K., Klovland (1984) for Norway and Sweden, Bajada (1999) for Australia, Giles (1999) for New Zealand, Schneider (2002) for 21 OECD countries, and Giles and Tedds (2002) for Canada. These studies, which all point to significant amount of tax evasion in these countries, have broadened our understanding on the causes and extent of tax evasion in developed countries.

The underground economy in developing countries is apparently higher due to the inefficiency in the tax system. Using data from tax returns, Alm, Bahl and Murray (1991), for instance, calculate the rate of tax evasion for Jamaica at about 40 percent for the year 1983.[1] Because of such considerable tax evasion, tax revenue mobilization is difficult in many of the countries. As a result, the governments of these countries often resort to financial repression to meet their spending needs; this has led, however, to various distortions such as reduced investment and economic growth (Alm and Buckley (1998); Roubini and Sala-i-Martin (1995)). Thus, studying the underground economy of such countries is of paramount importance.

The use of the currency approach to estimate the underground economy in developing countries has been ignored until recently. To our knowledge, Bagachwa and Naho (1995) for Tanzania, Faal (2003) for Guyana and Koyame (1996) for eight Sub-Saharan African countries are the only studies that estimate underground economy for non-OECD countries using currency demand method. The omission is mainly due to unavailability of adequate data; data constraints are now, however, being relaxed.

In this paper, we estimate the size of the underground economy induced by tax evasion for a panel of non-OECD countries. We make several contributions to the literature of tax evasion and the demand for currency. First, by using panel data estimation methods we are now able to include in our analysis many developing countries for which usually data spanning long period of time (that enable a robust application of time series methods) are not available. Panel data overcomes such hurdle by providing more degrees of freedom in the estimation of the currency equation.

Second, the use of panel data helps to condition the currency ratio on variables that are not available in time series modeling because such variables do not have much intra-country variation overtime (e.g., institutional quality indicators). Time series estimation methods cannot adequately pick the effect of such variables on currency demand; the panel data method, however, can do so by accounting for the cross-sectional variation of the variables.

[1] Given that their study deals only with filed taxes, the rate of tax evasion is likely to be higher for that year than the amount reported by the authors. It has to be pointed out that such studies, though useful, are few.

Other contribution of this study builds on the flaw of recent studies of tax evasion and currency demand: they are misspecified due to omitted variable problem. Previous studies don't include the enforcement strength of the tax authorities in the estimation of the currency equation because they include only the tax rate as the tax evasion factor. It is well documented in the literature of tax evasion that enforcement strength of the tax authorities is a crucial tax evasion factor with the relationship that higher enforcement reduces tax evasion (see e.g., Allingham and Sandmo (1972)). Thus, any analysis of tax evasion without enforcement parameter is incomplete leading to the misspecification bias. To remedy this problem, we use institutional quality indicators as a proxy for the enforcement strength of the tax authorities.

The main contribution of the study lies in its ability to estimate the underground economy for various non-OECD countries in different periods. The absence of adequate cross-sectional estimates of the underground economy has limited the study of the causes and consequences of underground economy. Our study contributes towards relaxing such constraint. With our estimates of underground economy for a panel of countries, it is now possible, for instance, to reexamine previous studies of the relationship between underground economy and other macroeconomic aggregates using panel data instead of simple cross-section relationship.

The organization of the rest of the paper is as follows. Section 2 discusses the determinants of the currency ratio which will serve to determine which variables must be included in the estimation of currency equation. Section 3 discusses the estimation methodology and the data used in the study. Section 4 presents the estimation results for the currency equation and the estimates of underground economy for the countries in our sample. Finally, section 5 concludes.

2. Determinants of the Currency Ratio and a Brief Description of the Currency Demand Method

We use Tanzi (1980) currency demand method to estimate the underground economy. The method consists in estimating an equation with currency to M2 ratio as the dependent variable and several explanatory variables measuring tax evasion and non-tax evasion activities. The key assumption in the currency demand approach is that underground economic activities are the direct cause of high taxes and that currency instead of demand deposits is used for undertaking such transaction because currency leaves no trace.

Following Cagan (1958) and subsequent studies, we include the tax rate (T), real per capita income (Y), and interest rate on time deposits as explanatory variables. To these we augment the degree of urbanization (U), the enforcement strength of the tax administration (E), and the inflation rate (π), as discussed in more detail later. The equation, therefore, can be given by:

$$\ln C/M2 = f(T, Y, R, E, \pi, U) \qquad (1)$$

The expected sign on Y, E and R are negative, while on T is positive. The expected signs on U and π are ambiguous.

Cagan (1958) argues that as income increases the currency ratio falls because demand deposits are superior assets than currency. In cross-country context, economic development or financial sophistication, as proxied by per capita income, leads to reduced use of currency and increased use of checks, implying a negative relationship between per capita income and currency to M2 ratio. The interest rate is the opportunity cost of holding currency rather than interest bearing assets such as time and saving deposits. The effect of the interest rate on the currency ratio is, therefore, negative.

Although he doesn't empirically test for it, Cagan (1958) argues that the degree of also urbanization as a potential determinants of the currency ratio. On the one hand, urbanization causes people to trade where they are not known, which reduces the use of checks and increase the use of currency. On the other hand, the use of checks is lower in rural areas than in cities where the people are more sophisticated. Because of these two conflicting effects, the net effect of the degree of urbanization on the currency ratio is ambiguous.

Next we discuss briefly the effects of the tax rate, the enforcement strength of the tax authorities, and the inflation rate. These variables constitute the tax evasion factors. Since currency provides anonymity, individuals who decide to evade tax use more currency and less demand deposits. In particular, the higher the tax rate, the higher the currency ratio. Another crucial tax evasion factor that was overlooked in previous studies of currency demand is the enforcement strength of the tax administration. There is an unambiguous positive relationship between higher tax enforcement capability of the tax administration and the level of the tax evasion (see e.g., Allingham and Sandmo (1972)). Previous studies don't include any measure or proxy of tax enforcement strength when estimating the currency equation. This omission is likely to lead to the misspecification bias in the estimated relationship. Inflation is also another factor that possibly affects tax evasion that previous studies have omitted in the currency demand analysis. When tax systems are not indexed, higher inflation creates tax bracket creep and increases the tax liabilities of taxpayers which results in higher tax evasion. Fishburn (1981) argues that one way inflation can affect the decision to evade taxes is based on the fact that inflation erodes the real value of a given level of nominal disposable income which gives taxpayer the incentive to evade more taxes to restore their purchasing power. Crane and Nourzad (1986) test the effect of inflation on United States aggregate tax evasion for the period 1947-81and they find that tax evasion is positively related to the inflation rate. Inflation, however, can also affect the currency ratio negatively when individuals lessen the erosion of the purchasing power of their currency by substituting it for interest bearing assets such as time deposits.

Once equation (1) is estimated, it can be used to calculate the yearly underground economy as follows. First the predicted value of the currency with all factors included (C*) is computed. From this then is subtracted the predicted value of currency when the tax rate and enforcement strength are assigned zero and 1, respectively (C**).[2] The result

[2] Some time series studies use the minimum tax rate that the country experienced instead of the zero tax rate to find the level of currency demand associated with no-tax evasion situation (the same applies to the other tax evasion factors); however, this is not the appropriate approach especially for the study which includes varied cross-section of countries having widely varying minimum tax rates. This is because a country that has high tax rate for the current year will have its underground economy calculated very low if its minimum tax is also high or close to the given year's tax rate. Similarly, a country with moderate tax rate in a given year will have its underground economy calculated very high if its minimum tax is very low.

is the stock of currency attributed to tax evasion which when multiplied by velocity of money yields the amount of income or transactions supported by this stock of illegal currency.[3] Finally dividing this quantity by the GDP, we find the underground economy as percentage of the official economy.

3. Estimation Methodology and the Data

Estimation Methodology

We estimate the currency equation using recently developed GMM dynamic panel data method.[4] To explain the tenets of the method, define z_{it} as the logarithm of currency to M2 ratio in country *i* at time *t*. The relationship can then be represented in a dynamic form as in the following equation:

$$z_{it} = \alpha z_{i,t-1} + \beta_i X_{it} + \eta_i + u_{it} \qquad (1)$$

where, $z_{i,t-1}$ is the lagged value of the currency ratio through which dynamics is introduced to the relationship, and X_{it} is a vector of explanatory variables that include tax evasion and nontax evasion factors that potentially determine the currency ratio. η_i is the country specific effect and ε_{it} is the error term which is assumed to be white noise.

First differencing the dynamic equation gets rid of the unobserved individual specific effect and generates the following equation:

$$z_{it} - z_{i,t-1} = \alpha(z_{i,t-1} - z_{i,t-2}) + (X_{it} - X_{i,t-1})'\beta + (u_{it} - u_{i,t-1}). \qquad (2)$$

By construction, the differenced lag of the currency ratio $(z_{i,t-1} - z_{i,t-2})$ in (2) is correlated with the error term, $(u_{it} - u_{i,t-1})$. It is also possible that x also contains potentially endogenous variables such as the tax rate which is jointly determined with tax evasion. Therefore, we need to introduce instruments to fix the effect of the endogeneity problem to get consistent estimates. The dynamic panel data approach instruments the differenced right-hand-side variables with their appropriately lagged levels. Under the assumption of serially uncorrelated errors ($Eu_{it}u_{i,t-1} = 0$), the following moment conditions furnish the appropriate instruments for the differenced lagged dependent variable and the other endogenous regressors:

$$E(z_{it-s}\Delta u_{it}) = 0 \text{ for } t = 3, \ldots, T \text{ and } s \geq 2 \qquad (3)$$

$$E(\mathbf{X}_{it-s}\Delta u_{it}) = 0 \text{ for } t = 3, \ldots, T \text{ and } s \geq 2. \qquad (4)$$

When these two moment conditions hold, we can use the lagged levels of the variables as instruments for the first differenced variables. However, when the lagged

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Such approach has no support in the theoretical literature that promulgates that tax evasion is a function of the economic return from tax evasion which is the current tax burden.

[3] Here it must be assumed that the velocities of money in the underground and official economy are the same and is given by GDP divided by the stock of legal currency.

[4] see Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) for full description of the model. To see how this model compares with other panel data methods, we also present results from traditional panel data methods namely the pooled OLS, the fixed effect, and the random effect methods. The properties of these estimators are well known and, therefore, are not discussed here.

levels i.e., the instruments are weakly correlated with subsequent first differences, correction for small sample must be made. Arellano and Bover (1995) propose an estimator that makes use of additional information in levels. This estimator, referred to as the system GMM estimator, combines the equation in first difference and the equation in the levels. This introduces an additional T-2 moment conditions given by:

$$E[(\eta_i + u_{it})\Delta z_{it-1}] = 0 \quad (5)$$

$$E[(\eta_i + u_{it})\Delta X_{it-1}] = 0\,. \quad (6)$$

In Summary, the GMM system estimator uses the moment conditions (3)-(6) to obtain consistent estimates of the coefficients of the currency equation. We use Sargan (1958) test of over-identifying restrictions to test the validity of the instruments. The null for this test is that the instruments are valid (i.e., orthogonal to the error term). Under the null, the test statistic is distributed $\chi^2_{(L-k)}$, where L is the number of instruments and k is the number of parameters in the model.

Recall that the GMM estimator yields consistent estimates only if the errors in the level equation are white noise; hence, it is important that this condition be satisfied for the estimation to be valid. To test whether the errors in the level equation are white noise, we use the Arellano and Bond (1991) test for the second-order autocorrelation in the difference equation. The null of this test is that there is no second-order autocorrelation in the difference equation.

Data

The data sources for each of the variables are as follows. The Data for the currency, M2, and interest rate are drawn from International Monetary Fund's *International Financial Statistics CD-ROM (2008).* Currency is defined as the notes and coins held outside banks, and M2 consists of money plus quasi money. The interest rate measure used is the bank deposit rate. The data for the tax rate, the rate of inflation, degree of urbanization, and per capita income are drawn from the *World Development Indicators CD-ROM (2007).* The tax rate measure used is the total tax burden given by the total tax revenue as percentage of GDP.[5] The degree of urbanization is measured by the percentage of population living in urban areas. The measure of the average income of the taxpayer is the per capita income in constant 2000 U.S. dollars. Inflation is defined as the percentage change in consumer price index.

The variable enforcement strength of the tax administration is proxied by a measure of institutional quality indicators.[6] The proxy is constructed as the product of

[5] We also use direct and indirect tax rates to see the separate effect of these rates on tax evasion. The results using these rates perform poorly and are not reported here. The result is most probably due to the problems of multicollinearity when direct and indirect tax rates are included in the same regression. The number of observations are also lower when both of these tax rates are used which makes the multicollinearity problem more severe.

[6] Ideally, the enforcement strength is measured by the likelihood of detection of tax evaders and the severity of penalty imposed on them. The probability of detection of violators would be measured by the number of people audited per total number of taxpayers. The penalty rate would be measured by the statutory rate at which the government penalizes the violators. Such data are not readily available for most countries. Even if they were, they are unlikely to be good proxy for the tax enforcement strength because when one thinks about tax law enforcement, the letter of the law is one thing and the zeal or efficiency with

two institutional quality indicators, the scores of *quality of bureaucracy* and the *rule of law*.[7] When taxpayers contemplate underreporting income, they consider the efficiency or strength of the bureaucracy in fighting tax evasion. In a corrupt tax administration, it would be easy to get away with dodging tax (if caught) by bribing the tax collector. Therefore, institutional quality indicators can adequately proxy for the level of efficiency of the tax administration.[8] The *quality of bureaucracy* and *rule of law* scores are drawn from the International Country Risk Guide (ICRG) of the *Political Risk Services (2006)* in which data points are available since 1984. The sample includes non-OECD countries and the study period is 1984-2005. The countries included in the sample are reported in Table 1. See the Appendix for all tables.

4. Estimation Result of the Currency Equation and Underground Economy

Estimation of the Currency Equation

Table 2 reports both the descriptive statistics and the correlation matrix for the variables used in the estimation. The upper part of the table reports the descriptive statistics for the main variables. The descriptive statistics demonstrates that there is a wide cross-country variation in the currency ratio for non-OECD countries ranging from 1 to 86 percent. The lower part of the table reports the correlation matrix for the variables. The correlation results show that there is not much multicollinearity between the explanatory variables. With regard to each explanatory variable's relationship to the currency ratio, the results show that each variable, except the tax rate, is related to the currency ratio as expected. The tax rate is inversely related to the currency ratio which is contrary to the expectation that higher tax rate results in higher tax evasion and hence higher currency holdings relative to broad money.

A simple correlation coefficient between two variables indicates a linear relationship between the variables without controlling for the effect of other potential explanatory variables. To gauge the separate effect of each explanatory variable after controlling for the effects of other variables, we further investigate the relationship using regression analysis.

In using the regression approrach, we find evidence that the there is persistence in the dependent variable and the explanatory variables are endogenous. When such econometric problems are present, the traditional panel data estimators (Pooled OLS,

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which such law is implemented is another. In countries where the tax administration is inefficient, higher rate of audit doesn't translate into higher detection and punishment as people caught might easily get away with it because of corruption in the tax administration. Similarly, higher statutory penalty rate decreed by law doesn't imply higher actual penalty due to weak enforcement capabilities.

[7] The data on "rule of law" ranges from 0 to 6, low to high rule of law; the original data for quality of bureaucracy ranges from 0 to 4, low to high quality of bureaucracy, respectively. We convert quality of bureaucracy to 0 to 6 ranges by multiplying the original data by 1.5 to conform to the 0-6 scale of the rule of law score. Then, *Enforcement* = (*quality of bureaucracy * rule of law/36).* This maps the enforcement strength variable to 0-1 scale.

[8] There are, however, some limitations on the institutional quality indicators data available- they are institutional quality measures at large and not specific to tax administration. However, if we think institutional quality as a reflection of the government's inefficiency, then inefficiency in one function of the government is reflected in other functions. Likewise, an improvement of efficiency in one of the functions of government generally spills over to the other functions. Thus, our use of these aggregate institutional indicators as a measure of enforcement strength in tax administration does not bias our results.

Fixed Effect and Random Effects models) don't yield consistent estimates. The GMM dynamic panel data method, however, can simultaneously deal with the problem of persistence and endogeneity. We, therefore, restrict our estimation to this estimator as discussed below.[9]

Table 3 reports the results of estimating the currency demand equation using the GMM dynamic panel data model. Different specifications are reported in the table. The first specification, for instance, shows estimation results when enforcement strength is not included, reminiscent of previous studies.

Before we discuss the individual coefficient estimates of this specification, it is vital to check whether the conditions for using the dynamic panel data model are met. The use of GMM dynamic panel data model requires that the error term of the equation in levels be white noise. This is tested by checking the absence of second order autocorrelation in the differenced equation. Therefore, the first specification test pertains to testing the presence or absence of second order autocorrelation. Specifically, we test the null that there is no second order autocorrelation in the differenced equation. The result of our test reports an autocorrelation test statistic with p-value greater than .05 implying that the null is not rejected at 5 percent. We, therefore, conclude that there is no evidence for second order autocorrelation.

The other test is the validity of the instruments used. The endogenous variables considered are the lagged value of the dependent variable and the tax rate. We use the Sargan test of over-identifying restrictions to test the validity of the instruments. The table reports the p-value of the Sargan test of joint validity of instruments. The p-value shows that the null cannot be rejected at 5 percent significance level which leads us to conclude that the use of the lagged values of the explanatory variables as instruments is valid.

Turning to the individual estimates, the lagged value of the currency ratio is highly significant in each specification which implies that the dependent variable is persistent. In the first specification where we don't control for enforcement strength, the tax rate is not significant. Once we control for enforcement parameters, however, it becomes significant and is positive. It can be argued that the effect of the tax rate on the currency ratio can be properly gauged only after we control for the enforcement strength. The higher tax burden, the higher the tax evasion and higher currency holdings relative to M2, other things being equal. The estimate on enforcement strength variable is negative and significant as expected. Given these results on the tax rate and the enforcement variable, it can be said that countries with high tax rates and weak enforcement capabilities experience rampant tax evasion; if high tax rate rates can be backed by strong enforcement capabilities, however, tax evasion would be small.

In the third equation, we report the results of robustness checks on the coefficient estimates of the variables of interest i.e., the tax rate and enforcement strength variables. The robustness check is undertaken by including the percentage of underage population as additional conditioning variable. Ladenson and Makinen (1992) argues that because the underage are not allowed to own demand deposits by law in most countries but do substantial transactions in cash, currency holding will be higher the higher the relative size of the underage population, ceteris paribus. The results of including this covariate in

[9] As expected, estimations results from the traditional panel data methods perform poorly and are not reported here to save space. They are available from the authors upon request

our estimation demonstrate that it is not significant. More importantly, it doesn't reduce the robustness of the significance of the tax rate and enforcement variables. Given these results, our preferred specification is one represented by the second equation because of its parsimony. The discussion of the coefficient estimates for the other variables of the model are based on this preferred equation.

The coefficient on income per capita is also negative and significant as expected. A negative estimate for per capita income implies that as a country develops the use of currency relative to M2 declines due to increased financial sophistication. The coefficient estimate on interest rate is significant and negative. The result vindicates that as the opportunity cost of holding currency rises, the cost of holding currency increases reducing the currency to M2 ratio. Higher inflation rate increases an individual's nominal income, and since most tax systems are not indexed, higher inflation leads to tax bracket creep; and as the taxpayers move to higher tax brackets their tax liabilities increases which leads them to evade more resulting in higher currency ratio. The result shows that the estimate of the inflation rate is positive but it is not significant. Finally, the coefficient estimate on urbanization is positive but not significant.

Estimation of Underground Economy

Having estimated the currency equation, it is possible now to calculate the yearly estimate of the underground economy induced by tax evasion for the countries in the sample. Our preferred specification is the one given by second equation in Table 3 since the coefficient estimates on the tax evasion factors have the expected sign and is more parsimonious than the third equation.

Using the above procedure we calculated the yearly underground economy as percentage of GDP for all the countries in the sample for the period 1984-2005.[10] Here, however, we report only the summary statistics of underground economy for entire period of study and for the sub periods given in 5 year interval. These summaries are reported in Table 4. In the first row is given the summary statistics of the underground economy for the entire period of study, 1984-2005. The results show substantial underground economy and a wide variation of its magnitude across countries during the period under investigation. The mean underground economy for the group is about 18 percent of GDP and the standard deviation is 12 percent. The lowest figure of underground economy as a percent of the official economy in the sample is of Kuwait at about 2 percent of GDP, and the highest one is of Ethiopia at about 70 percent of GDP. Comparing the sub-periods, it can be said that the underground economy declined over time for the countries as a whole. This is to be expects as countries increase their tax effort they are able to increase their tax revenue by increasing the efficiency in their tax administration.

Table 5 reports the list of countries and the corresponding mean underground economy for recent period, 2000-2005. The highest underground economy as percentage of GDP for the period is of Democratic Republic of Congo at 61 percent replacing Ethiopia in recent period. The lowest underground economy for the recent period is again of Kuwait at about 2.4 percent of GDP.

[10] The yearly estimates are available from the authors up on request.

We also compare our estimates to an important study done by Schneider (2004). He estimates underground economies for 145 countries for the year 1999-2003 using the Multiple Indicators Multiple Causes (MIMIC) method. The bottom part of Table 4 reports the summary statistics of his estimates. We also report our estimates for the same period along his estimates for the countries included in both studies. The mean of underground economy of his estimates is about 39 percent of GDP compared to ours of about 17 percent (when our sample is restricted to those that are included in his sample). The standard deviation of Schneider's estimates is about 13 percent compared to ours at about 15 percent.

The comparison of the estimates is also presented in Figures 1. The figure shows a scatter plot and an upward slopping linear fit of the underground economy estimates of Schneider (2004) and the author. The fitted line demonstrates a positive correlation between the two estimates, although the R^2 of the fitted line is only 0.12. The low R^2 and a glance at the scatter plot shows that the estimates of the two studies diverge for many countries. Figure 2 reports a plot of the two set of estimates after removing some outliers. The R^2 after removing outliers is 0.13, which demonstrates that the low correlation between the two estimates of underground economy is not derived by outliers.

The divergence in the estimates emanates partly from the difference in the method of estimating of the underground economy. Schneider (2004) uses the MIMIC method to estimate the underground economy. The main tenet of the MIMIC method is that the indices of underground economy rather than the actual underground economy is calculated using its various causes; the indices are then multiplied by a scaling factor to convert the indices into actual underground economy figures. The scaling factor is usually derived from other studies or methods of estimation. Thus, the actual size of underground economy in the MIMIC method is dependent on the choice of this external information. The arbitrary nature of the scaling factor in the MIMIC method is not the only reason for the divergence of the two estimates, though. The most important reason for the divergence has to do with the fact that each study apart from the tax rate uses different additional causes of underground economy. While Schneider (2004) uses a measure of the degree of government regulation as another cause of underground economy in addition to the tax rate, we use a measure of enforcement strength of tax administration as another cause of tax evasion to come up with underground economy estimate that is consistent with the theory of tax evasion. Since Schneider's does not control for enforcement strength, his estimates are such that countries with higher tax rates will have bigger underground economy. In countries with higher enforcement capabilities, however, higher tax rate do not in fact result in higher tax evasion. As most tax rates are calculated as the ratio of tax revenue to GDP, higher tax rates might be the result of higher tax effort of the tax administration.

5. **Conclusion**

The study estimates the underground economy for non-OECD countries using the currency demand method. In estimating the currency demand equation, unlike past studies, we augment a measure of tax enforcement strength of the tax authorities in

addition to the tax rate as the tax evasion factor to have an estimation that is consistent with the theory of tax evasion.

Using the GMM dynamic panel data model for the period 1984-2005, we find that the currency to M2 ratio tends to be higher the higher the economic return from underreporting, as given by the tax rate, and the weaker the enforcement strength of the tax authorities, after controlling for other determinants of currency demand. The control variables are per capita income, the interest rate, inflation, and the degree of urbanization.

From the estimated currency demand equation, then, we estimate the underground economy of the countries in the sample. Our calculations show that in many of these countries the size of the underground economy as percent of GDP is substantial and it shows wide variation across the countries.

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APPENDIX

Table 1: Countries

Algeria	Liberia
Argentina	Madagascar
Bahamas, The	Malawi
Bahrain	Malaysia
Bangladesh	Mali
Bolivia	Malta
Botswana	Mexico
Brazil	Mongolia
Burkina Faso	Morocco
Cameroon	Namibia
Chile	Nicaragua
Colombia	Nigeria
Congo, Dem. Rep.	Oman
Congo, Rep.	Papua New Guinea
Costa Rica	Paraguay
Cote d'Ivoire	Peru
Cyprus	Philippines
Dominican Republic	Senegal
Ecuador	Sierra Leone
Egypt, Arab Rep.	Singapore
El Salvador	South Africa
Ethiopia	Sri Lanka
Gabon	Syrian Arab Rep.
Gambia, The	Thailand
Ghana	Togo
Guatemala	Trinidad and Tobago
Guinea-Bissau	Tunisia
Indonesia	Turkey
Iran, Islamic Rep.	Uganda
Israel	Uruguay
Jamaica	Venezuela, RB
Jordan	Yemen, Rep.
Kenya	Zambia
Kuwait	Zimbabwe
Lebanon	

Table 2. Summary Statistics and Correlation Matrix

	C/M2	tax rate	enforce	per capita income	interest rate	inflation	urban
Observations	2587	1530	1846	2538	2690	2419	2690
Mean	0.22	0.17	0.16	2860	0.27	13.47	0.48
Standard Deviation	0.16	0.08	0.17	4051	2.58	25.77	0.24
Minimum	0.01	0.018	0	57	0	-100.00	0.05
Maximum	0.86	0.57	1	29945	93.94	268.15	1.00

	log(C/M2)	tax rate	enforce	per capita income	interest-rate	inflation	urban
log(C/M2)	1						
tax rate	-0.162	1					
enforce	-0.395	0.239	1				
per capita income	-0.410	0.021	0.655	1			
interest rate	-0.046	0.117	-0.104	-0.042	1		
inflation	0.011	0.069	-0.158	-0.100	0.847	1	
urban	-0.251	-0.009	0.376	0.714	0.120	-0.003	1

Table 3. GMM Dynamic Panel Data Estimation Results- Dependent Variable- log(C/M2)

Variables	(1)	(2)	(3)
$\log(C/M2)_{-1}$	0.862***	0.826***	0.818***
	(0.021)	(0.037)	(0.039)
tax rate	0.233	0.447*	0.329*
	(0.177)	(0.263)	(0.198)
inefficiency		0.623***	0.502***
		(0.237)	(0.173)
log(income)	-0.104***	-0.092*	-0.076
	(0.023)	(0.047)	(0.048)
interest rate	-0.164***	-0.135*	-0.185**
	(0.046)	(0.078)	(0.085)
inflation rate	0.001***	0.001	.0012*
	(0.000)	(0.001)	(.0007)
urban	0.480***	0.295	0.472
	(0.115)	(0.243)	(0.460)
dependent population			0.138
			(0.249)
Constant	0.209*	0.071	-0.233
	(0.114)	(0.275)	(0.466)
Serial correlation test statistics (p-value)			
Sargan test statistics (p-value)			
Observations	1073	1042	1042
Countries	84	84	84

Standard errors in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Summary Statistics of the Estimate of the Underground Economy (% of GDP)

Period	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
		Current Estimates			
1984-2005	1277	17.5	12.0	2.1	70.0
1984-1988	272	24.1	15.8	4.7	66.2
1989-1993	285	19.3	13.6	2.7	70.0
1994-1998	259	15.0	9.0	2.1	62.6
1999-2003	415	15.1	8.6	2.1	62.6
2004-2005	97	15.1	7.7	2.1	49.5
		Comparison with Schneider (2004) Estimates[*]			
Author's Estimates	62	14.7	6.6	2.1	34.9
Schneider's estimates	62	34.8	10.4	13.4	53.5

[*]To be comparable, our estimates are restricted to the period 2000-2003, and the countries selected are those which are included in both studies.

Table 5. Estimates of Underground Economy (2000-05)

Countries	Underground Economy	Countries	Underground Economy
Albania	21.3	Lithuania	11.3
Algeria	27.9	Madagascar	40.2
Argentina	8.1	Malaysia	10.5
Armenia	20.8	Malta	12.1
Bahamas, The	8.9	Mexico	9.5
Bahrain	3.8	Moldova	9.1
Bangladesh	16.4	Mongolia	13.9
Belarus	15.9	Morocco	12.3
Bolivia	13.9	Namibia	14.4
Bulgaria	13.2	Nicaragua	14.5
Burkina Faso	16.3	Oman	4.9
Cameroon	19.9	Papua New Guinea	21.0
Chile	8.7	Paraguay	20.9
China	6.2	Peru	13.1
Colombia	21.8	Philippines	9.8
Congo, Dem. Rep.	61.2	Poland	10.7
Congo, Rep.	28.9	Romania	18.2
Costa Rica	10.0	Russian Federation	19.1
Cote d'Ivoire	32.9	Senegal	22.5
Croatia	12.6	Sierra Leone	27.9
Cyprus	11.5	Singapore	6.6
Czech Republic	8.0	Slovak Republic	12.6
Dominican Republic	23.2	Slovenia	10.9
Egypt, Arab Rep.	10.7	South Africa	23.8
El Salvador	13.3	Sri Lanka	13.9
Estonia	12.8	Syrian Arab Republic	11.5
Ethiopia	8.8	Thailand	12.3
Ghana	20.9	Togo	30.4
Guatemala	16.9	Trinidad and Tobago	13.5
Hungary	11.5	Tunisia	11.8
Indonesia	15.0	Turkey	15.6
Iran, Islamic Rep.	6.2	Uganda	9.2
Israel	14.7	Ukraine	14.2
Jamaica	17.5	Uruguay	16.9
Jordan	13.3	Venezuela, RB	22.5
Kenya	20.0	Vietnam	10.5
Kuwait	2.4	Yemen, Rep.	26.9
Latvia	8.2	Zambia	16.5
Lebanon	10.6		

Figure 1. Plot of Schneider's and Author's Estimates of Underground Economy, 2000-2003

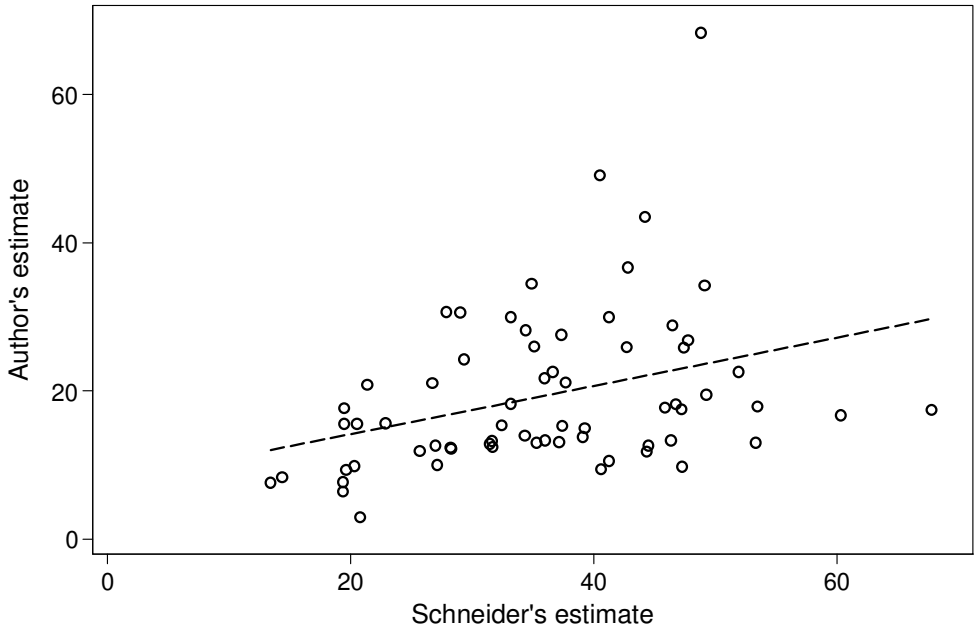

Figure 2. Plot of Schneider (2004) and Author's Estimates of Underground Economy Some Outliers Removed, 2000-2003