ESTIMATING THE UNDERGROUND ECONOMY AND TAX EVASION: COINTEGRATION AND CAUSALITY EVIDENCE IN THE CASE OF CYPRUS, 1960-2003

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Abstract

We empirically investigate the size of the underground economy and the amount of tax evasion in the light of Tanzi's currency demand framework for the Cyprus economy. The study covers the period 1960–2003. The paper has two purposes: (1) to find out whether any long run relationship exists for the pairs of measured GDP-underground economy, tax rates, tax evasion and underground economy-tax rates, and (2) to investigate the direction of causality between the pairs. Our findings suggest that (i) one co-integrating vector exists between the variables by using the Johansen co-integration approach; (ii) the measured GDP and tax rates are the causes of underground economy and tax evasion respectively whereas bidirectional causality is found between tax rates and underground economy when the FPE, Wald, Sim's LR and Holmes-Hutton causality techniques are applied; (iii) significant underground economic activity

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and changes in tax rates might stimulate greater loss of tax revenue or more tax evasion with a larger budget deficit and slower economic growth.

Introduction

The size of the underground economy and tax evasion have long been of interest and empirically investigated in a number of recent studies. In the relevant literature, a common question is: 'Is there is any relationship between measured GDP and the underground economy?', in other words, 'Are measured GDP and changes in tax rates causes of both underground economy and tax evasion?' It is really hard to provide precise answers for these questions in the first place. However, it is widely agreed that there exists a relationship between measured GDP and the underground economy (see Giles, 1997 and Giles et al., 2002) or between tax rates and the amount of tax evasion (see Kesselman, 1989 and Trandel and Snow, 1999). Policy makers are also aware that significant underground economic activities and changes in the tax rates are associated with slower economic growth, more tax evasion, greater loss of tax revenue and higher budget deficits.

It is important to note that the causality issue between these variables is still controversial and unresolved due to ambiguous evidence in the literature. Nevertheless, some studies on the underground economy provide strong evidence that the direction of causality runs from measured GDP to the underground economy (Giles, 1997) and from tax rates to measured GDP (Scully, 1996). Some evidence also supports the presence of causality between tax rates and the size of underground economy (Giles and Caragata, 2001).

According to the European Union (EU) Report on Undeclared Work in an Enlarged Union (2004), it is highlighted that very little is known about the Cypriot situation regarding the underground economy. There is only one study by Georgoiu and Syrichas (1994) where the size of underground economy in Cyprus is measured for the period 1960-1990. Cyprus has been a new Member of the EU since May 2004 having an estimated amount of $20300 GDP per capita and 3,2 per cent unemployment rate in 2004 (The World Fact Book, 2004). Despite the low unemployment figure, the existence of relatively small, family size enterprises and the rapid increase of illegal immigrants may create favorable conditions for a thriving underground economy (Cyprus National Action Plan for Employment 2004-2006, p.37).

In this paper, we aim to estimate the size of underground economy and the amount of tax evasion in Cyprus by conducting Tanzi's (1980, 1983) currency demand approach over the period 1960-2003. Then, we estimate time series data to examine the relationship between measured GDP and underground economy and between tax rates and tax evasion by employing cointegration and causality techniques. Applying these econometric techniques to the Cypriot case to determine both long- and short-run causal relationship between the variables is the first of its kind to the best of our knowledge.

The rest of this paper is organized as follows: Section II presents the theoretical modeling in estimating the size of underground economy. Section III describes the data and the methodology respectively. Section IV discusses the findings. Finally, Section V provides some concluding remarks.

Theoretical modeling in estimating the size of underground economy

The *currency demand* approach has been the most influential and widely used or cited method. Cagan (1958) used this method to calculate the correlation between currency demand and tax pressure for the U.S. economy. Gutmann (1977) also utilized a similar approach in finding the ratio between currency and demand deposits in a simpler framework. Cagan's idea was later developed by Tanzi (1980; 1983) to empirically investigate the size of the US underground economy.

Tanzi (1983) proposed a basic regression equation which contains weighted average tax rate, proportion of wages and salaries in national income, interest rate on savings deposits, and per capita income as a function of currency ratio in circulation to broad money. The model assumes that cash or currency is the main factor that determines underground economic activities. The second assumption is that the velocity of money in an official economy equals the velocity of money in an unofficial economy. The third stems from a tax burden or very high tax rate that causes the underground economy in that individuals thus prefer to work in the underground economy to avoid high tax burden. The main idea in the model is that a rise in the underground economy will cause an increase in demand for money. In order to find out the size of the underground economy (i.e. excess money in money demand), the currency demand regression should be run over time (see Thomas, 1999 and Bhattacharyya, 1999 for a detailed criticism of the assumptions of currency demand model). The modeling framework of the *Currency demand approach* employed in this study is as follows:

Using Tanzi (1980; 1983) the currency demand approach is considered in the following equation:

$$RCM2 = \alpha_o\, YT^{\alpha_1}\, WSY^{\alpha_2}\, IR^{\alpha_3}\, INF^{\alpha_4}\, PGNP^{\alpha_5} \text{ or}$$

$$\ln RCM2 = \alpha_0 + \alpha_1 \ln YT + \alpha_2 \ln WSY + \alpha_3 \ln IR + \alpha_4 \ln INF + \alpha_5 \ln PGNP + \varepsilon_t \qquad (1)$$

Where RCM2 is real currency in circulation to money supply (M2) ratio, TY is the average tax calculated as direct taxes on income expressed as a percentage of GNP, WSY is the share of wages and salaries in GNP, IR is one-year nominal interest rate on saving deposits, INF is the growth rate of consumer price index and PGNP is the real per capita GNP. Ln and ε_t denote natural logarithms and error term respectively.

Data and Methodology

A. Data

The data[1] we have employed for the Cypriot economy are annual figures covering the period 1960 – 2003. The first data set is for the exploitation of the *currency demand approach:* RCM2 is real currency in circulation to money supply (M2) ratio, TY is the average tax calculated as direct taxes on income expressed as a percentage of GNP, WSY is the share of wages and salaries in GNP, IR is one-year nominal interest rate on saving deposits, INF is the growth rate of consumer price index and PGNP is the real per capita GNP. For the use of

[1] Data are taken from *Statistical Abstract*, Department of Statistics and Research, Ministry of Finance, Nicosia, Cyprus, *various years*.

cointegration and causality analyses, the variables in the second data set, namely underground economy (UGE) and tax evasion (TEVA), are estimated by the authors. GDP and tax rate series are extracted from *Cyprus Statistical Abstract*. All variables in the second data set are deflated by a GDP deflator.

B. Methodology

Time series data can be non-stationary (trended) and this kind of data can be regarded as a potentially major problem for applied econometric studies. It is well known that trends may cause spurious regression problems. The presence of a trend can be determined by examining the existence of unit roots in time series data. A number of tests were widely recommended for the existence of unit roots in the time series data in the relevant literature such as the *Augmented Dickey-Fuller (ADF)* (1981), *Phillips and Perron*, (PP) (1988) and *Kwiatkowski et al. (KPSS)* (1992).

The *Augmented Dickey-Fuller (ADF)* and unit root tests are usually employed respectively in the empirical literature to test the stationarity of the variables for the sake of confirmation. The most reliable and general model of the ADF test can be reformulated as follows[2]:

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_j \Delta y_{t-i-1} + \in_t \qquad (2)$$

Where Δ is the first difference operator, y is the series; t = time (trend factor); a = constant term (drift); ε_t = Gaussian white noise and p = the lag order. The number of lags "p"

[2] Ender (1995) points out that the most appropriate model of ADF is to include constant term and trend factor in the unit root process.

in the dependent variable is chosen by the Akaike Information Criteria (AIC) to ensure that the errors are white noise. One problem with the presence of the additional estimated parameters is that it reduces the degrees of freedom and the power of the test.

To confirm the test results obtained from the ADF test, *Kwiatkowski Phillips, Schmidt and Shin's* test (1992) (*KPSS*) is suggested to avoid a possible low power against stationary near unit root processes which occurs in the *ADF* test. The KPSS test complements the ADF test in which the null hypothesis of KPSS test is that a series is stationary. This means that a stationary series is likely to have insignificant KPSS statistics and significant ADF statistics.

The KPSS test is based on an assumption that a series can be investigated in three parts: a time trend, a random walk and a stationary error in the following equation:

$$y_t = \rho t + rw_t + \varepsilon_t \tag{3}$$

Where $rw_t = rw_{t-1} + v_t$ *and* v_t *is i.i.d* $(0, \delta_v^2)$. Basically, the regression above can be run in two ways: first with a constant in the case of level stationary, second both a constant and a trend in the case of trend stationary. We then use the residuals ε_t from the regression and compute the LM statistics in the following equation:

$$LM = T^{-2} \sum_{i=1}^{T} V_t^2 \Big/ V_{\varepsilon_t}^2 \tag{4}$$

Where V_t^2 is the estimate of the variance of ε_t and V_t is defined as follows:

$$V_t = \sum_{i=1}^{t} \varepsilon_i \qquad (5)$$

Kwiatkowski et al. (1992) provide the critical values for the distribution of LM that is non-standard. Due to the assumptions of the behavior of ε_t, V_t^2 can be constructed to be more consistent estimator as in the following equation, similar in Phillips and Perron's (1988):

$$V^2(p) = T^{-1} \sum_{t=1}^{T} \varepsilon_t^2 + 2T^{-1} \sum_{v=1}^{p} w(v,p) \sum_{t=v+1}^{T} \varepsilon_t \varepsilon_{t-k} \qquad (6)$$

Here $w(v,p)$ is an optional weighting function as regards to the choice of a spectral window. Following Newey and West (1987) the Bartlett window can be used as $w(v,p)=1-v/\ (v+1)$. Finally the test statistics of the KPSS test can be considered as follows:

$$t = T^{-2} \sum_{i=1}^{T} V_t^2 \Big/ V^2(p) \qquad (7)$$

It is worth to emphasize that the value of the test statistics depends on the choice of the lag truncation parameter. The sample of autocorrelation function of $\Delta\varepsilon_t$ can be calculated to find out the maximum value of the lag length p.

With respect to the series, there is a potential break in 1974-the war effect. Hence, we utilize the Perron Additive Outliner Model (AOM) for unit roots whether the order of integration is changed by the potential structural break. This test is carried out in two steps. In the first step, we estimate residuals using OLS as follows:

$$X_t = \mu + \delta DU_t + e_t \tag{8}$$

Where $DU_t=1$ *if* $t>T_b$ and *0* otherwise. T_b is the point where the break occurs. In the second step, we run the following modified regression by using OLS. The test of negativity of γ is checked by using appropriate critical values reported in Rybinski's papers (1994; 1995):

$$\Delta e_t = \sum_{i=0}^{K} \phi_i (DUTB)_{t-i} + \gamma e_{t-1} + \sum_{i=1}^{K} \alpha_i \Delta e_{t-i} + \varepsilon_t \tag{9}$$

Where $(DUTB)_t=1$ if $t=T_b+1$ and *0* otherwise, T_b is the break year, *DUTB* is dummy variable for the break year, e_t is residual obtained from equation (8) using OLS and ε_t is an error term.

After the order of integration is determined, co-integration between the variables should be tested to identify any long run relationship. There should be at least one co-integrating vector for a possible co-integration. The Johansen (1988) and Johansen and Juselius (1990) approach allows the estimating of all possible cointegrating vectors between the set of variables and it is the most reliable test to avoid the problems which stem from Engel and Granger's (1987) procedure[3]. This procedure can be expressed in the following VAR model:

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_K X_{t-K} + \mu + e_t \quad (\text{for } t = 1,\ldots T) \tag{10}$$

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[3] See Kremers et al. (1992) and Gonzalo (1994) for comments about disadvantages of Engel and Granger (1987) procedure with respect to Johansen and Juselius (1990) cointegration technique.

Where X_t, X_{t-1}, …, X_{t-K} are vectors of current and lagged values of P variables which are $I(1)$ in the model; $\Pi_1,\ldots,\Pi_K$ are matrices of coefficients with (PXP) dimensions; μ is an intercept vector[4]; and e_t is a vector of random errors. The number of lagged values, in practice, is determined in such a way that error terms are not significantly autocorrelated. By adding X_{t-1}, …, X_{t-K} *and* $\Pi_1 X_{t-2}$, …, $\Pi_{K-1} X_{t-K}$ to both sides and rearranging the terms, the VAR model will be in the following form[5]:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{K-1} \Delta X_{t-K+1} + \Pi X_{t-K} + \mu + e_t \qquad (11)$$

Where $\Gamma_i=-(I-\Pi_i-\ldots-\Pi_i)$; $(i=1, 2, \ldots, K-1)$; $\Pi=-(I-\Pi_1-\ldots-\Pi_1)$ and I is the identity matrix. The rank of the matrix of coefficient, Π gives the number of long-run relationships between the variables of the system. The rank of Π is the number of cointegrating relationship(s) (i.e. r) which is determined by testing whether its Eigen values (λ_i) are statistically different from zero. Johansen (1988) and Johansen and Juselius (1990) propose that using the Eigen values of Π ordered from the largest to the smallest is for computation of the maximal-Eigen value and trace statistics. The maximal-Eigen value statistics (λ_{max}) is computed by the following formula:

$$\lambda_{\max} = -TL_n\left(1-\lambda_{r+1}\right), \quad r = 0,1,2,\ldots, n-2, n-1\ldots \qquad (12)$$

Where T is sample size. In this test, the null hypothesis of r

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[4] • is a vector of $I(0)$ variables which also represents dummy variables. This ensures that errors e_t are white noise.

[5] This form of the equation is also called Vector Error Correction Model (VECM).

cointegrating vectors is tested against the alternative of *r+1* cointegrating vectors. Alternatively, the trace statistic is computed by the following formula:

$$\lambda_{trace} = -T\sum_{i}^{p} Ln(1-\lambda_i), \quad i = r+1, \ldots, n-1 \ldots \qquad (13)$$

Where *p-r* is the smallest Eigen values and the null hypothesis is tested against the general hypothesis (i.e. H_0: r = 0 H_1: r ≥ 1 and so on).

Having conducted both the integration and cointegration tests, we apply the Holmes-Hutton (1988) causality procedures in a bivariate causal model. Since any kind of causality tests are sensitive to the choice of lag length, we prefer to initiate our causality testing procedure by using Akaike's (1974) Minimum Final Prediction Error (FPE) criterion. This criterion alongside Hsiao's (1979) synthesis is used to choose the optimal lag-lengths both in lag-levels and lag-differences (see also Giles et al. 1993). Akaike's minimum FPE can be formulated as follows:

$$FPE(m) = \frac{T+K}{T-K}\frac{SRR(m)}{T} \qquad (14)$$

Where *T* is the sample, and *k* = *m+1* if the variables under study are not cointegrated; *k=m+2* if they are cointegrated (the error correction term should be added to the equation); *SSR(m)* is the sum of the squared residuals. When *m=m** in Equation (14), we change n to find out the value *n=n** so as to minimize *FPE (m*,n)* in which *k=m*+n+2* (in the cointegrated case). If *FPE (m*, n*)* < *FPE (m*)*, this means that *Y* Causes *X*. The values of *m* and *n* are related to Equation (14).

We then apply the Holmes-Hutton (HH) (1988, 1990a, 1990b) test to determine the direction of causality between the variables rather than use the Granger causality testing procedure. The Granger model is premised on the maintained hypothesis of correct functional form (i.e. linear), homoscedasticity and normality of the error term. Holmes and Hutton (HH) argue that violation of these conditions can influence causality conclusions. They suggest an alternative procedure for causality testing based on rank ordering of each variable. The rank order is obtained from the first difference of each series, and each lagged variable is ranked separately. A null hypothesis of no causality is rejected if an F-statistic based on the estimated coefficients of the lagged causal variable is statistically significant. The Holmes-Hutton (1988) procedure generates a multiple-rank F-test and can be expressed in the following model:

$$R(DLX)_t = \alpha + \sum_{i=1}^{m} \beta_i R(DLX_{t-i}) + \sum_{j=1}^{n} \gamma_i R(DLY_{t-j}) + \varepsilon_t$$
$$(Y \rightarrow X) \qquad (15)$$

$$R(DLY)_t = c + \sum_{i=1}^{q} d_i R(DLY_{t-i}) + \sum_{j=1}^{r} e_i R(DLX_{t-j}) + w_t$$
$$(X \rightarrow Y) \qquad (16)$$

Where DL is logarithm differences of the variables and R is the rank procedure. ε_t and w_t are serially uncorrelated random disturbances with zero mean respectively. In each case, H-H test is associated with test on the significance of the *γ's* and the *e's* conditional on the optimal lag lengths, *m, n, q,* and *r*. Here, we test to see if *Y* HH causes *X* by using a multiple rank F-test and utilizing the following hypothesis:

(i.e. $H_0 = e_1 = e_2 = e_3 = \ldots = e_n$ is rejected against the alternative $H_1 = not\ H_0$).

Empirical Results

Estimating the Size of Underground Economy and Tax Evasion

We estimate the size of Cypriot underground economy and tax evasion by using Tanzi's currency demand model (equation 1) for the period between 1960 and 2003. The OLS regression results that are shown in Table 1 are remarkably good. The variables used in the model are statistically significant and have the expected signs. The adjusted R^2 is very high and this indicates that the model is capable of explaining most of the explanatory power in the dependent variable over the period. The Durbin Watson statistics and all diagnostic tests results are also at satisfactory levels. It is worth emphasizing that tax variable (YT) and per capita income (PGNP) are at 10% significance of level compared with the other variables.

The tax variable shows that an increase in tax rate in terms of tax evasion effect results in more use of currency whereas an increase in PGNP means that economic development reduces currency ratio. Furthermore, WSY confirms that a larger share of wages and salaries in national income indicates more use of currency. The interest rate (IR) and the rate of inflation (INF) are both highly significant and depict that an increase in the two variables results in a fall in the currency ratio. The additional variable-DUM74 is also highly significant and justifies the war effect and its recovery period assigning the value 0 for the period 1960-1973 and 1 for the period 1974-

2003[6].

With the aid of Table 1, we can proceed to the estimation of the underground economy and tax evasion in Cyprus. Table 2 provides the logarithm of the estimated currency ratio for the years between 1960 and 2003. Given M2 we can compute the estimated currency holdings as ecc. To determine these values, let *Y=ln(C/M2)*, then *Y=lnC-lnM2* or equally *ecc=exp(Y+lnM2)*. Columns 1 and 2 in Table 2 depict the actual and estimated currency holdings. To estimate ecct values (Column 3), we can set the tax variable in equation 1 equal to zero by applying the same procedure. Column 4 in the same table indicates that the difference between ecc and ecct is a measure of the excess amount of money-imon (illegal money). Column 5 calculates legal money that is defined as the difference between M1 and illegal money (imon). Column 6 calculates the income velocity of legal money as equal to GNP divided by legal money. A key assumption here is that the velocity of money in the underground economy is the same as in the registered economy so that the estimated size of the underground economy (UGE) can be calculated as the product of the velocity of money and illegal money. These values are shown in Column 7 whereas column 10 demonstrates the same values as a proportion of GDP (i.e. UGE/GDP). Column 8 shows the estimates for tax evasion (TEVA)[7] which is calculated by multiplying the estimated size of underground economy by estimated ratio of the total tax gap[8] to illegal money plus underground economy. Column 9 shows the same values as a proportion of GDP (i.e. TEVA/GDP).

[6] See Georgiou and Syrichas (1994) for more details about the use of dummy variable for the Cypriot economy.
[7] See Feige (1989, p44) and Faal (2003, p20) for a similar formula.
[8] See Giles (1999, p375) for the total tax gap formula.

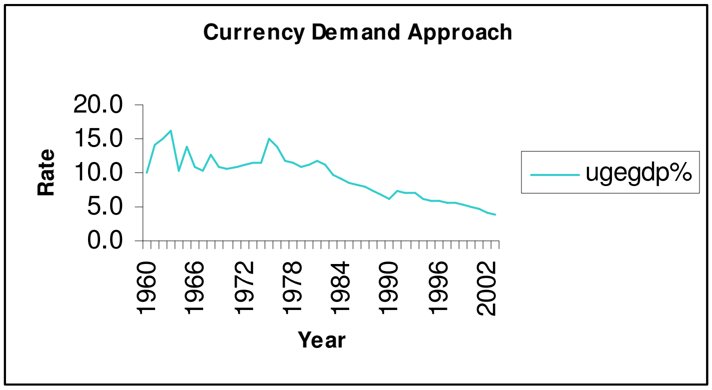

Figure 1

Estimates[9] indicate that the ratio of underground economy in Cyprus varies between 3.9% and 16.1% of GDP. Columns 7 and 10 in Table 2 depict that the size of estimated underground economy is the lowest in 1960 with Cyp £9.08 million as 9.9% of GDP whereas the highest is in 2000 with Cyp £280.4 million as 5.1 percent of GDP. Figure 1 also illustrates a trend representing the ratio of underground economy to GDP. The average ratio for the period 1960-2003 is 9.41 percent of GDP[10]. Earlier work on Cyprus by Georgiou and Syrichas (1994) estimated the underground economy for the period 1960-1990 to be on average 8.8%.

Cointegration and Causality Estimations

[9] The relative size of tax evasion (TEVA/GDP) in Cyprus is disclosed in Column 9 in Table 2. As it can be seen, the relative size varies between 0.24% and 0.41%.

[10] This confirms the statement by the Minister of Finance who admitted the existence of underground economy and quoted its size around 10 percent of GDP (Georgiou and Syrichas 1994).

The unit root test results are reported in Table 3. The ADF test shows that all the variables are integrated of order one, that is I(1). This indicates that the first differences of LGDP, LUGE, LTEVA and LTX are stationary. Table 4 reports the KPSS test statistics where the null hypothesis of stationary is constructed against the alternative of a unit root. The results from the KPSS test further confirm that all data series are integrated of order one (i.e. I(1)). The two steps are necessary for the sake of a co-integration procedure prior to the causality tests.

As regards to the variables, in particular the GDP for the period 1960-2003, we observe a decline after 1973-the war effect in 1974. This situation may be capturing a structural break and makes both the ADF and KPSS test results unreliable. We therefore employ Perron's Additive Outlier model (equation 9) to show that there are no spurious roots resulting from any structural break or changing means (see Perron, 1990; Perron and Vogelsang, 1992). The results presented in Table 5 suggest that there is no spurious unit root created by an exogenous break. In other words, the ADF and KPSS results recommend that the variables used for both cointegrating and causality purpose are integrated of order one even when the break is allowed.

After establishing the stationarity of the data, we use the Johansen (1988); Johansen and Juselius (1990) approaches which are very sensitive to the choice of lag length to explore any possible long run relationship among the variables under consideration (see also Chang 2002). We employ both Akaike and Schwartz Criteria to select the number of lags in the co-integration tests where the two criteria suggest a VAR model with 1 lag. The VAR model is used with unrestricted intercept and no trend by considering the dummy variable as I(0) (Pesaran and

Pesaran, 1997).

The results reported in Table 6 suggest that one co-integrating vector exists among the pairs of the variables namely, LGDP-LUGE, LUGE-LTX and LTEVA-LTX. These three bivariate systems confirm the presence of a long run equilibrium relationship for the pairs of the official economy-the underground economy, the underground economy–tax rate and tax evasion-tax rate. Our findings are consistent with the evidence existing in the literature. Christopoulos (2003) found a long run relationship between the underground economy in Greece and the two effective tax rates. Giles (1997), on the other hand, indicated the existence of a long run equilibrating relationship between measured and underground economies in the case of New Zealand (see also Hill and Kabir, 2000). It is also widely agreed that there is a relationship between tax and the amount of tax evasion (see Kesselman, 1989; Trandel and Snow, 1999).

Since a cointegration relationship is found among the variables under inspection, a vector autoregressive (VAR) model should be constructed to determine the direction of the causality. Granger (1988) mentions that there should at least be one direction of causality among the variables if they are co-integrated. The causality VAR model is expressed as in Equations (15) and (16) as the variables are co-integrated (See also Engle and Granger, 1987).

In the relevant empirical literature, a common question is: "Does the official or measured economy cause the underground economy or is an increase in tax rate causing both underground economy and tax evasion?" To answer these questions, the causality testing procedures should be employed. Table 7 reports the optimal lag lengths for both log-level (i.e. long-run) and log-difference (i.e. short-run). In the same table, the values of FPE (m^*, n^*) and FPE (m^*) are reported where these values suggest that there is unidirectional causality from measured GDP to UGE in both long and short-run periods. This result is consistent with those found in Giles (1997) and Giles et al. (2002) for the New Zealand and the Canadian studies respectively. They find a strong evidence of causality from measured GDP to the UGE. There is also bidirectional causality between both pairs of the underground economy (UGE)-tax evasion (TEVA) and tax rate (TX)-tax evasion. This is supported by Giles and Tedds (2002) who address a clear positive relationship between tax rate and underground economy (see also Giles and Caragta, 2001).

Given the results of the FPE test, the Holmes-Hutton causality procedure as well as the Wald and Sim's LR[11] tests are conducted in a bivariate model to confirm the earlier findings obtained from the FPE test. The Wald test statistics refer to the usual asymptotic x^2 distribution and are based on a test of zero restriction on the independent variables in Equations 15 and 16. The results in Table 8 show that the causality is bidirectional between UGE and TX in both short and long-run periods. Also there is a flow of causality from TX to TEVA for both periods; however the causal relationship between GDP and UGE is slightly mixed. In the short run, the unidirectional causality is found from GDP to UGE and a feedback between GDP and UGE in the long run period.

In general subtle, the FPE results indicate that there

[11] A simple logarithmic transformation can be used to convert the Wald statistics into Sim's LR test statistics in order to obtain the results for the Sim's LR test. This transformation is also asymptotically x^2 (see Giles et al., 1993 p. 202; Sims, 1980 p. 17).

is bidirectional causality between TX and UGE at both log-level (i.e. long-run) and log-difference (i.e. short-run) and this situation is supported by the Wald test, Sims' LR test and HH causality test. For the causal relationship of the pair of GDP-UGE, we cannot reject the hypothesis that the measured or official economy does not cause the underground economy. Hence, it is obvious that causality runs from GDP to UGE in almost all cases except at the log-level on the basis of the Wald, Sim's LR and HH causality test. There is also causality evidence running from tax rate (TX) to tax evasion (TEVA) at almost all cases.

To sum up, the results in Tables 7 and 8 recommend that the direction of causality is running from GDP and TX to UGE and TEVA respectively whereas bidirectional causality is determined between TX and UGE. This general conclusion is supported by all causality techniques applied in the study. On the basis of the available empirical evidence, it is plausible to conclude that our findings are consistent with the evidence found in Giles (1997) (i.e. GDP-UGE relationship), in Giles and Tedds (2002) (i.e. UGE-TX), in Giles and Caragata (2001) (i.e. TX-TEVA), and Giles et al. (2001) for the relationship between tax rate (TX) and tax evasion (TEVA). These relationships might need further investigation to ensure whether tax evasion is stimulated either by underground economic activity or changes in tax rates (see also Giles, 1999; Giles and Caragata, 2001).

Conclusion

We used time series data analysis to estimate both underground economy and tax evasion in Cyprus by conducting Tanzi's currency demand model over the period

1960-2003. Our estimates show that the relative size of Cypriot underground economy (i.e. UGE/GDP) varies between 3.9% and 16.1% whereas the relative size of Cypriot tax evasion (i.e. TEVA/GDP) varies between 0.21% and 0.41%.

The ADF, KPSS and Perron tests were employed to examine the time series properties and structural break before establishing a long-run relationship between the variables under inspection. The integration tests results indicate that the variables were non-stationary in levels but stationary in differences, even when the break is taken into consideration.

Having confirmed the presence of a long run relationship by using the Johansen approach, we investigated the causal relationship between the variables by applying the FPE, the Wald, the Sim's LR and the HH causality techniques correspondingly. Our findings suggest that the measured GDP and tax rates are the causes of the underground economy and tax evasion in Cyprus respectively. This means that the direction of causality runs from the measured GDP and tax rates to the underground economy and tax evasion. The results also indicate that there is bidirectional causality between tax rates and underground economy in both long-run and short-run periods. Our findings are consistent with the available empirical evidence in the literature (see Giles, 1997; Giles and Caragata, 2001; Scully, 1996; and Trandel and Snow, 1999).

Finally, on the basis of available empirical evidence in the literature and our findings, it is plausible to conclude that significant underground economic activities and changes in the tax rates in many countries might stimulate greater loss of tax revenue with larger budget deficits and slower economic growth.

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APPENDIX:

Table 1 Regression Results for Equation 1

Dependent Variable: LCM2	
Explanatory Variables	Currency Demand Model
C	-6.19 (-5.94)
LYT	0.13 (1.89)*
LWSY	0.64 (2.03)
LIR	-0.53 (-4.07)
LINF	-0.06 (-2.54)
LPGNP	-0.63 (-1.67)*
DUM74	-0.28 (-4.57)
R^2	0.98
$\overline{R}^2$	0.97
DW	1.70
X^2_{SC}	1.23 (Prob=0.267)
X^2_{FF}	1.17 (Prob=0.279)
X^2_{NORM}	2.22 (Prob=0.328)
X^2_{HET}	3.60 (Prob=0.058)

Notes: t-statistics are in parentheses and all diagnostic pass at 5% level of significance for the model. It is worth emphasising that one star (*) indicates 10% level of significance and the rests pass 5% and 1% level of significance. L denotes natural logarithms.

Table 2: Estimating size of Cypriots underground economy by Currency Demand Approach

Year	cc (1)	ecc (2)	ecct (3)	imon (4)	lmon (5)	vel (6)	uge (7)	teva (8)	tevagdp% (9)	ugegdp % (10)
1960	7.890	7.763	6.453	1.310	13.580	6.937	9.089	0.375	0.409	9.922
1961	8.770	8.615	6.577	2.038	14.992	6.917	14.099	0.287	0.286	14.043
1962	9.030	8.708	6.309	2.399	16.551	7.039	16.886	0.223	0.198	14.970
1963	9.480	9.900	7.164	2.736	17.644	6.903	18.885	0.247	0.210	16.045
1964	10.910	10.121	8.101	2.020	20.210	5.557	11.223	0.331	0.307	10.401
1965	11.730	12.206	9.304	2.902	21.558	6.536	18.966	0.380	0.280	13.966
1966	12.210	12.397	9.923	2.475	23.465	6.431	15.915	0.470	0.318	10.760
1967	13.630	12.586	9.945	2.641	26.499	6.540	17.273	0.462	0.273	10.220
1968	15.490	15.415	11.850	3.564	29.126	6.444	22.970	0.487	0.265	12.524
1969	17.190	16.622	12.960	3.662	34.348	6.332	23.192	0.556	0.263	10.997
1970	18.420	18.653	14.733	3.921	38.659	6.053	23.731	0.630	0.278	10.473
1971	21.760	19.699	15.243	4.456	42.274	6.377	28.415	0.640	0.245	10.866
1972	26.270	24.604	19.027	5.577	51.873	5.899	32.897	0.728	0.245	11.073
1973	29.740	28.476	22.403	6.072	54.768	6.226	37.809	0.977	0.296	11.461
1974	35.750	30.530	23.921	6.609	59.111	5.354	35.387	0.868	0.285	11.618
1975	35.230	34.211	26.440	7.771	54.139	5.009	38.927	0.856	0.333	15.147
1976	40.830	38.603	29.282	9.321	69.989	4.969	46.322	0.859	0.257	13.873
1977	44.670	38.664	29.966	8.698	76.772	5.756	50.066	1.140	0.269	11.833
1978	52.740	46.239	36.350	9.889	90.291	5.834	57.695	1.476	0.291	11.389
1979	63.990	59.819	47.735	12.084	114.796	5.679	68.622	1.971	0.313	10.896
1980	75.950	76.628	61.938	14.689	137.581	5.720	84.028	2.689	0.354	11.050
1981	89.510	98.775	79.665	19.110	168.260	5.367	102.557	3.179	0.363	11.707
1982	101.640	114.194	92.807	21.387	195.593	5.396	115.402	3.811	0.372	11.260
1983	115.860	126.945	105.156	21.790	226.330	5.119	111.534	4.237	0.373	9.812
1984	122.220	126.794	105.452	21.342	238.508	5.709	121.839	4.863	0.364	9.110
1985	127.880	136.696	114.598	22.098	263.512	5.723	126.462	5.393	0.364	8.532
1986	130.670	127.523	106.489	21.034	262.346	6.178	129.947	5.400	0.338	8.123
1987	142.580	142.309	119.112	23.198	293.052	6.160	142.897	6.053	0.340	8.023
1988	157.640	154.141	129.534	24.607	335.373	6.010	147.895	6.444	0.323	7.423
1989	169.070	155.690	131.965	23.726	361.124	6.345	150.531	7.126	0.316	6.672
1990	183.530	172.147	146.850	25.297	413.423	6.282	158.930	7.947	0.312	6.232
1991	195.530	192.443	160.918	31.525	429.715	6.330	199.539	8.462	0.317	7.476
1992	215.050	203.540	170.592	32.948	471.062	6.671	219.799	9.536	0.308	7.102
1993	229.420	226.312	190.542	35.770	512.620	6.480	231.806	10.470	0.322	7.130
1994	246.570	226.128	193.652	32.476	542.244	6.809	221.122	11.627	0.323	6.143
1995	257.140	223.472	191.148	32.323	581.397	6.967	225.187	11.901	0.305	5.772
1996	265.830	250.759	215.375	35.384	617.856	6.774	239.702	12.662	0.304	5.763

1997	276.310	271.370	234.546	36.824	667.316	6.611	243.423	13.541	0.310	5.566
1998	290.090	270.283	231.698	38.585	691.365	6.827	263.430	13.688	0.291	5.608
1999	313.830	370.672	318.060	52.612	987.028	5.114	269.076	13.499	0.268	5.349
2000	333.610	384.954	332.365	52.589	1037.361	5.331	280.367	14.907	0.270	5.087
2001	356.530	364.998	317.902	47.096	1028.124	5.730	269.879	15.583	0.265	4.590
2002	379.450	355.297	314.517	40.780	1019.710	6.132	250.056	16.905	0.274	4.058
2003	402.370	356.196	316.153	40.042	1005.718	6.576	263.326	17.884	0.267	3.932

Table 3: ADF Test for Unit Root

Test Statistics (Levels)	LGDP	LUGE	LTX	LTEVA
τ_T (ADF)	**-3.21 (1)**	**-2.58 (1)**	**-3.20 (1)**	**-2.66 (0)**
τ_μ (ADF)	**-0.93 (0)**	**-2.45 (1)**	**-0.49 (1)**	**-0.42 (0)**
Test Statistics (First Difference)	LGDP	LUGE	LTX	LTEVA
τ_T (ADF)	**-5.46 (0)**	**-7.95 (0)**	**-6.75 (0)**	**-5.28 (0)**
τ_μ (ADF)	**-5.52 (0)**	**-8.09 (0)**	**-6.91 (0)**	**-5.34 (0)**

Notes:
1. τ_T represents the most general model with a drift and trend; τ_μ is the model with a drift and without trend. 2. Numbers in brackets are lag lengths used in ADF test (as determined by AIC) to remove serial correlation in the residuals. 3. Critical values are τ_μ= -2.93 and τ_T= -3.52 at the 5% significance level respectively. 4. Tests for unit roots have been carried out by Microfit 4.0. (Pesaran and Pesaran, 1997).

Table 4: KPSS Test for Unit Root

Test Statistics (Levels)	LGDP	LUGE	LTX	LTEVA
η_u (KPSS)	**1.54* (2)**	**1.41* (2)**	**1.37* (2)**	**1.51* (2)**
η_t (KPSS)	**0.16* (0)**	**0.31* (2)**	**0.15* (1)**	**0.18* (1)**
Test Statistics (First Difference)	LGDP	LUGE	LTX	LTEVA
η_u (KPSS)	**0.07 (2)**	**0.35 (2)**	**0.17 (2)**	**0.09 (1)**
η_t (KPSS)	**0.04 (2)**	**0.05 (2)**	**0.06 (2)**	**0.08 (1)**

Notes: 1. η_u and η_t represent constant and trend in the model with the critical values 0.463 and 0.146 at 5% significance level respectively. 2. Numbers in brackets are lag lengths indicating the lag truncation for Bartlett Kernel suggested by Newey-West (1987). 3. *denote significance at the 5%. Critical values are taken from Kwiatkowski et al. (1992). 4. Tests for unit roots have been carried out by Stata 8.0.

Table 5: The Perron Unit Root Test for Structural Break

Variable	Break Year	Test Statistics	Critical Value
		Level	(5%), λ=0.34
LGDP	1974	-1.66	-3.49
LUGE	1974	-3.36	-3.49
LTX	1974	-1.55	-3.49
LTEVA	1974	-2.24	-3.49

Note: We use the critical value reported by Rybinski (1994; 1995) instead of the original critical value reported by Perron. The corresponding break fraction for 44 numbers of observations is calculated easily with $\lambda = (T_b/T)$ (See Perron and Vogelsang, 1992). For 1974, the relevant break year fraction is $\lambda = 15/44 = 0.34$. In most cases, an augmentation of one appeared to be sufficient to secure lack of autocorrelation of the error terms.

Table 6: Co-integration Tests based on the Johansen (1988) and Johansen and Juselius (1990) Approach

Cointegration Regressions	H_0	H_1	λ_{max}	C.V. at 5%	λ_{Trace}	C.V. at 5%
LGDP-LUGE	r = 0	r = 1	20.07*	14.88	20.19*	17.86
	r <= 1	r = 2	0.13	8.07	0.13	8.07
LUGE-LTX	r = 0	r = 1	27.09*	14.88	28.17*	17.86
	r <= 1	r = 2	1.08	8.07	1.08	8.07
LTEVA-LTX	r = 0	r = 1	19.41*	14.88	22.43*	17.86
	r <= 1	r = 2	3.02	8.07	3.02	8.07

Notes: 1. r indicates the number of cointegrating relationships, λ_{max} is the maximum eigen value statistics and λ_{trace} is the trace statistics. 2. VAR 1 based on both Akaike Information Criterion (AIC) and Schwartz Criteria (SC) is used to select the number of lags required in the co-integration test and unrestricted intercepts and no trends in the VAR model are not rejected in all cases. 3. DUM74 is considered as exogenous I(0) variable. 4. * denotes significance at 5% level and the critical values are obtained from Osterwald-Lenum (1992).

Table: 7 Selection of Lag Lengths Using The Final Prediction Error (FPE)

Dependent Variable	Independent Variable	m^*	n^*	FPE (m^*)	FPE (m^*, n^*)
LOG-LEVELS					
LGDP	**LUGE**	1	1	5.91×10^{-3}	5.92×10^{-3}
LUGE	**LGDP**	3	1	1.54×10^{-2}	1.37×10^{-2}
LUGE	**LTX**	4	1	1.85×10^{-2}	1.69×10^{-2}
LTX	**LUGE**	1	1	5.07×10^{-2}	3.19×10^{-2}
LTEVA	**LTX**	1	1	5.05×10^{-2}	4.75×10^{-2}
LTX	**LTEVA**	1	1	13.5×10^{-3}	9.36×10^{-3}
LOG-DIFFERENCES					
DLGDP	**DLUGE**	1	3	5.92×10^{-3}	6.17×10^{-3}
DLUGE	**DLGDP**	4	1	1.47×10^{-2}	1.42×10^{-2}
DLUGE	**DLTX**	1	2	1.94×10^{-2}	1.78×10^{-2}
DLTX	**DLUGE**	2	1	3.48×10^{-2}	2.53×10^{-2}
DLTEVA	**DLTX**	4	1	6.97×10^{-3}	6.93×10^{-3}
DLTX	**DLTEVA**	2	2	3.45×10^{-2}	3.48×10^{-2}

Notes: 1. If FPE (m^*, n^*) < FPE (m^*), Y causes X. 2. m^* denotes maximum lag on dependent variable. 3. n^* denotes minimum lag on independent variable.

Table 8: The Wald, Sim's LR and the HH Causality Tests.

Dependent Variable	Independent Variable	Degrees of freedom[a]	Wald Test	Sim's LR Test	m*	n*	HH Multiple-rank F-test	Causal Inference
LOG-LEVELS								
LGDP	**LUGE**	2	11.26*	13.06*	1	1	6.92* (2,39)[b]	UGE → GDP
LUGE	**LGDP**	1	9.50*	10.88*	3	1	11.59* (1,36)[b]	GDP → UGE
LUGE	**LTX**	1	5.14*	5.51*	4	1	5.46* (1,37)[b]	TX → UGE
LTX	**LUGE**	1	17.11*	21.81*	1	1	26.43* (1,40)[b]	UGE → TX
LTEVA	**LTX**	1	4.60*	4.86*	1	1	4.79* (1,40)[b]	TX → TEVA
LTX	**LTEVA**	1	0.12	0.13	1	1	0.10 (1,40)[b]	NC
LOG-DIFFERENCES								
DLGDP	**DLUGE**	1	0.077	0.078	1	3	0.071 (1,38)[b]	NC
DLUGE	**DLGDP**	1	3.03**	3.15**	4	1	3.04** (1,36)[b]	GDP → UGE
DLUGE	**DLTX**	1	3.09**	3.22**	1	2	3.03** (1,38)[b]	TX → UGE
DLTX	**DLUGE**	1	3.11**	3.25**	2	1	3.12** (1,39)[b]	UGE → TX
DLTEVA	**DLTX**	1	3.25**	3.38**	4	1	3.19** (1,32)[b]	TX → TEVA
DLTX	**DLTEVA**	1	1.18	1.20	2	2	1.14 (1,39)[b]	NC

Notes: 1. * indicates significance at the conventional levels (5% and 1%) and ** indicates significance at the 10% level respectively. 2. [a] χ^2 degrees of freedom for both the Wald and the Sims's LR tests. 3. [b] degrees of freedom for HH multiple-rank F-test. 4. NC; no causality.