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LONG-RUN DEMAND FOR MONEY AND THE SIZE OF SHADOW ECONOMY İN ROMANIA: AN APPLICATION OF ARDL MODEL

Abstract. *The paper aims to estimate the currency demand and the size of Romanian shadow economy (SE) using a revised version of the currency demand approach. This article is an attempt to examine the short and long-run relationship between currency demand, real income, tax burden, interest rate and wage ratio in the case of Romania's economy.*

The bounds testing approach to cointegration and error correction models, developed within an autoregressive distributed lag (ARDL) framework is applied to quarterly data for the period 2000 to 2010 in order to investigate whether a long-run equilibrium relationship exists between currency demand and its determinants. The result of the bounds test indicates that there is a stable long-run relationship between the currency demand and its determinants. In addition, the CUSUM and CUSUMSQ tests confirm the stability of the money demand function.

This research provides fresh evidence on the size of the SE to the recorded GDP in Romania which ranges from 45% to 37.4% over the estimation period.

Keywords**:** *shadow economy, currency demand approach, ARDL model, error correction model, CUSUM test, Romania*.

JEL classification: C51, E26, O17

1. Introduction

Formed in the literature under various names, the shadow economy exists in a more or less extent in all countries, regardless of their level of development, enjoying an enduring existence, although as area of research is a new "young" area, what it also explains the lack of agreement among experts, even in the name and definition of the phenomenon.

The assessment of shadow economy is important, essential for the understanding of current situation and of the long-term consequences, both direct and indirect of economic policy options and in particular tax to be made.

Clandestine by nature is difficult to assess the size of the unofficial economy, people preferring anonymity for fear of severe consequences[1].

The paper aims to estimate the currency demand and the size of the Romanian shadow economy using a revised version of the currency demand approach based on bounds testing approach to cointegration and error correction models, developed within an autoregressive distributed lag (ARDL) framework for quarterly data covering the period 2000-2010. The paper is divided three sections presenting the data, the methodology and the main econometrical results.

2. Methodology and data

The currency demand and the size of Romanian shadow economy was estimated using one of the most commonly used indirect methods proposed by Cagand and Tanzi's that assumes that shadow (or hidden) transactions are undertaken in the form of cash payments, so as to leave no observable traces for the authorities. An increase in the size of the shadow economy will therefore increase the demand for currency. To isolate the resulting „excess" demand for currency, an equation for currency demand is econometrically estimated over time:

$$C_0 = A \cdot (1+\Theta)^{\alpha} \cdot Y_0^{\beta} \cdot \exp(-\gamma i) \qquad (1)$$

where:

C_0 represents the observed cash;

Θ represents the variable[2] that gives incentives to make hidden transactions;

[1] The main empirical results regarding the Romanian shadow economy are obtained by both national and international studies using different estimation methods and are presented in table 1.

Table 1. The size of Romanian shadow economy(% of official GDP)

Authors	Approach	Period	Size of SE (min-max)
Albu(2003, 2008, 2010, 2011)	Discrepancy between actual and desired income	1995-2007	14.6%-22.3%
National Institute of Statistics	Labour input method	1998-2009	14.5%-23.5%
Johnson(1997, 1998)	Physical input method	1990-1995	18.0%-28.3%
Lacko(1999)	Physical input method	1990-1995	20.9%-31.3%
Schneider et al.(1998, 2000, 2002, 2004, 2005, 2006, 2007, 2009)	DYMIMIC model and currency demand approach	1990-2005	26.2%-37.4%
Schneider et al.(2010)	MIMIC model	1999-2006	34.4%-36.7%

Y_0 represents the registered GDP, but also it can be used GDP per capita, consumption per capita;
i represents the interest rate;
α, β, γ, A represents the parameters.

Estimating equation (1), it will be obtained $\hat{C}$ .Setting the incentive variable Θ equal to zero, and leaving the coefficients of the other variables unchanged, we obtain $\tilde{C}$ .The difference between $\hat{C}$ and $\tilde{C}$ is the amount of extra currency. The difference measures the amount of illegal money in the economy. Forth more, assuming that the velocity of money is the same in both official and shadow sector[3], we can obtain an estimate of the size of shadow economy multiplying illegal money ($EC = \hat{C} - \tilde{C}$) by the velocity of money ($v = \frac{Y}{C}$).

The main purpose is to estimate the demand for money function in Romania and specifically to examine whether a long-run equilibrium relationship exists among Romania's broad money aggregate and its determinant using bounds testing approach to cointegration and error correction models.

Following the empirical literature in demand for currency, we form the long-run relationship between currency demand, income, interest rates, wages and tax burden in linear logarithmic form, with a view of estimating the size of the SE in Romania as follows:

$$C_t = \alpha_0 + \alpha_1 \cdot Y_t + \alpha_2 \cdot Tax_t + \alpha_3 \cdot R_t + \alpha_4 \cdot WS_t + \varepsilon_t \quad (2)$$

where:
C is the currency in circulation outside the banks (at the end of the period in millions RON) normalized by the GDP deflator;
Y is the real gross domestic product in millions RON, base year (2000=100);
Tax is the total tax revenues normalized by GDP;
R is the 1 year real saving deposit interest rate;
WS is the ratio of wages and salaries in national income;
ε is the regression error term.

The time span covered by the series is from 2000:Q1 to 2010:Q2. Apart from the real interest rates and the real currency outside banks, the data were seasonally

[2] This is the key variable of all currency models and it can be approximated using government consumption normalized by GDP, tax rates (direct and indirect taxes), tax revenues to GDP. An increase in Θ is expected to have a positive impact on currency demand, since agents will have more incentives to go to the shadow sector, demanding more currency for their transactions;
[3] This assumption has been criticized and, as Ahumada et al. (2007) claim, even if the velocity is the same, previous works that find $\beta \neq 1$ (i.e. income elasticity different from 1) are incorrect. Therefore, they propose an alternative way of correcting the estimates.

adjusted by means of tramo seats method. All series were expressed in logarithmic form. A description of the variables and their sources is summarized in appendix A.

It is assumed that a rise in the tax burden variable will lead to an increase in the size of the unrecorded economic activities which requires a higher level of demand for currency. We expect a positive impact on currency demand for GDP, taxes and wages ($\alpha_1, \alpha_2, \alpha_4 > 0$), since an increase in these variables will put pressure on currency demand.[4]On the other hand, interest rate increases are expected to have a negative effect, prompting economic agents to get rid of their currency holdings ($\alpha_3 < 0$).

In order to estimate the amount of currency demand, the bounds test approach was applied, developed within an autoregressive distributed lag (ARDL) framework, that have the econometric advantage that the method could be implemented irrespective of whether the underlying regressors are purely I(0), purely I(1), or a mixture of both.

The ARDL[5] technique is used to investigate the existence of a long-run relationship in the form of the unrestricted error correction model of equation (2) as suggested in Engle-Granger (1987):

$$\Delta C_t = c_0 + \sum_{i=1}^{m} c_{1i}\Delta C_{t-i} + \sum_{i=0}^{m} c_{2i}\Delta Y_{t-i} + \sum_{i=0}^{m} c_{3i}\Delta Tax_{t-i} + \sum_{i=0}^{m} c_{4i}\Delta R_{t-i} + \sum_{i=0}^{m} c_{5i}\Delta WS_{t-i} + \gamma\varepsilon_{t-1} + \mu_t \quad (3)$$

where: Δ represents change , γ is the speed of adjustment parameter and ε_{t-1} is the one period lagged error correction term, which is estimated from the residuals of equation (1), "m" represents number of lags. This approach, also known as autoregressive-distributed lag (ARDL), combines Engle-Granger (1987) two steps into one by replacing ε_{t-1} in equation (3) with its equivalent from equation (2). ε_{t-1} is substituted by linear combination of the lagged variables.
An ARDL representation of equation (2) is formulated as follows:

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[4] Note that the positive impact of taxes on currency demand can be interpreted in Tanzi's spirit as follows: as the level of taxation rises, economic agents will be encouraged to engage tax-evading activities, which are facilitated by the use of currency, due to the intractability of cash; as a consequence, the use of currency rises(Brambilla Macias and Cazzavillan, 2009).

[5] The ARDL approach involves ***two steps*** for estimating long run relationship (Pesaran *et al.*, 2001). The first step is to investigate the existence of long run relationship among all variables in the equation under estimation. The ARDL method estimates $(p+1)^k$ number of regressions in order to obtain optimal lag length for each variable, where *p* is the maximum number of lags to be used and *k* is the number of variables in the equation. The second step is to estimate the long-run relationship and short-run bi-directional causality between running actors. We run second step only if we find a long-run relationship in the first step (Narayan *et al.*, 2005).

$$\Delta C_t = b_0 + \sum_{i=1}^{m} b_{1i}\Delta C_{t-i} + \sum_{i=0}^{m} b_{2i}\Delta Y_{t-i} + \sum_{i=0}^{m} b_{3i}\Delta Tax_{t-i} + \sum_{i=0}^{m} b_{4i}\Delta R_{t-i} + \sum_{i=0}^{m} b_{5i}\Delta WS_{t-i} + b_6 C_{t-1} + b_7 Y_{t-1} + b_8 Tax_{t-1} + b_9 R_{t-1} + b_{10} WS_{t-1} + \mu_t \quad (4)$$

Equation (4) provides the short-run and long-run effects simultaneously after the adjustment is completed. The first part of the equation with b_{2i}, b_{3i}, b_{4i}, and b_{5i}. represents the short-run dynamics of the model whereas the parameters b_7, b_8, b_9, and b_{10} represents the long-run relationship.

Accordingly, a joint significance test that implies no cointegration[6] hypothesis, (H_0: $b_6 = b_7 = b_8 = b_9 = b_{10} = 0$)(there is no long-run relationship), against the alternative hypothesis, (H_1: $b_6 \neq b_7 \neq b_8 \neq b_9 \neq b_{10} \neq 0$) should be performed for equation (4).

Once cointegration is confirmed, we move to the second stage and estimate the long-run coefficients of the money demand function and the associated ARDL error correction models.

The standard ECM involves estimating the following equation:

$$\Delta C_t = b_0 + \sum_{i=1}^{m} b_{1i}\Delta C_{t-i} + \sum_{i=0}^{m} b_{2i}\Delta Y_{t-i} + \sum_{i=0}^{m} b_{3i}\Delta Tax_{t-i} + + \sum_{i=0}^{m} b_{4i}\Delta R_{t-i} + \sum_{i=0}^{m} b_{5i}\Delta WS_{t-i} + \lambda ECM_{t-1} + \mu_t \quad (5)$$

A negative and statistically significant estimation of λ not only represents the speed of adjustment parameter but also provides an alternative means of supporting cointegration between the variables; ECM is the residuals that are obtained from the estimated cointegration model of equation(4).

To ascertain the goodness of fit of the ARDL model, diagnostic and stability tests are conducted. The diagnostic test examines the serial correlation, functional form, normality, and heteroscedasticity associated with the model. Parameter stability is important since unstable parameters can result in model misspecification (Narayan and Smith, 2004). The Pesaran and Pesaran (1997) test involves

[6] The F- statistic tests therefore checking for the joint significance of the coefficients on the one period lagged levels of the variables. The computed F-statistics is compared with the critical values tabulated by of Pesaran (2001) or Narayan (2005) for limited samples (40-45 observations).

If the computed F-statistics is greater than the upper bound critical value, and then we reject the null hypothesis of no cointegration (no long-run relationship) and conclude that there exists steady state equilibrium between the variables. If the computed F-statistics is less than the lower bound critical value, then we cannot reject the null of no cointegration. If the computed F-statistics falls within the lower and upper bound critical values, then the result is inconclusive.

estimating the conditional VECM from equation(4) and applying the cumulative sum of the residuals(CUSUM) and the CUSUM of square(CUSUMQ) test to assess the parameter constancy.

3. Empirical results

3.*1. Estimating the currency demand*

Before testing the cointegration relationship, a test of order of integration for each variable using the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests are conducted. The results are displayed in table 2. All of the series in equation (2) appear to contain a unit root in their levels but are stationary in their first differences except the taxation variable which is stationary in its level form.

Table 2. ADF and PP Test results

Variable		Logarithmic Levels ADF	lag	PP	lag	First differences ADF	lag	PP	lag
C	T&C	-1.72	(4)	-2.91	(5)	-1.95	(3)	-9.80*	(26)
	C	-1.42	(4)	-0.88	(18)	-2.01	(3)	-10.30*	(27)
	None	1.59	(4)	3.56	(14)	-1.06	(3)	-6.98*	(4)
Y	T&C	-1.24	(1)	0.16	(2)	-3.50***	(0)	-3.55*	(1)
	C	-1.64	(1)	-1.49	(3)	-3.19**	(0)	-3.19**	(0)
	None	1.72	(1)	2.73	(3)	-2.60*	(0)	-2.60*	(0)
Tax	T&C	-4.36*	(0)	-4.46*	(3)	-10.47*	(0)	-13.94*	(5)
	C	-4.12*	(0)	-4.15*	(3)	-10.61*	(0)	-14.16*	(5)
	None	-0.70	(1)	-0.48	(0)	-10.67*	(0)	-13.15*	(4)
Rr_{12}	T&C	-2.40	(2)	-1.90	(2)	-4.48*	(0)	-4.45*	(1)
	C	-1.41	(1)	-1.68	(1)	-4.53*	(0)	-4.53*	(0)
	None	-2.40	(0)	-2.10	(1)	-4.37*	(0)	-4.37*	(0)
WS	T&C	-1.08	(5)	-1.33	(1)	-5.07*	(0)	-5.07*	(1)
	C	-0.72	(0)	-0.94	(2)	-5.05*	(0)	-5.05*	(0)
	None	0.53	(0)	0.49	(1)	-5.08*	(0)	-5.08*	(0)

Note:
T&C represents the most general model with a drift and trend; C is the model with a drift and without trend; None is the most restricted model without a drift and trend. Numbers in brackets are lag lengths used in ADF test (as determined by SCH set to maximum 12) to remove serial correlation in the residuals. When using PP test, numbers in brackets represent Newey-West Bandwith (as determined by Bartlett-Kernel). Both in ADF and PP tests, unit root tests were performed from the most general to the least specific model by eliminating trend and intercept across the models (Katircioglu, 2009). *, ** and *** denote rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. Tests for unit roots have been carried out in E-VIEWS 6.0.

In the first stage of the ARDL procedure, the long-run relationship of equation (2) was established in two steps. First, the order of lags on the first-differenced variables for equation (4) was obtained from unrestricted VAR by means of the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC).

It is therefore important that the lag order p of the underlying VAR is selected appropriately. There is a delicate balance between choosing p sufficiently large to mitigate the residual serial correlation problem and, at the same time, sufficiently small so that the conditional ECM (5) is not unduly over-parameterized, particularly in view of the limited time series data which are available (Pesaran, Shin and Smith, 2001, pp.308).

Due to the fact that data series examined are quarterly, maximum duration of lag should be taken as 4, but because of small sample data (only 42 observations), we have chosen the maximum lag length to be 3 and the number of lags has been determined as 1 according to Schwarz criterion and 2 according to Akaike criterion.

The lag order selected by AIC is $\hat{p}_{AIC}$ =2 and by SBC is $\hat{p}_{SBC}$ =1 irrespective of whether a deterministic trend term is included or not. The results indicate that there is little to choose between the conditional ECM with or without a linear deterministic trend.

Secondly, bounds F-test was applied to equation (4) to establish a long-run relationship between the variables under the three scenarios: with restricted deterministic trends (F_{IV}), with unrestricted deterministic trends (F_V) and without deterministic trends (F_{III}) and with all intercepts unrestricted (table 3).

Table 3. The Bounds Test for Co-integration

	With Deterministic Trends			Without Deterministic Trends		
Variables	F_{IV}	F_V	t_V	F_{III}	t_{III}	Conclusion
$p_{AIC} = 2^*$		7.55c	-5.85c	7.79c	-5.98c	H_0 Rejected
3		3.18a	-3.65b	3.12b	-3.52b	
4		5.50c	-3.11a	11.31c	-3.55b	
5		1.87a	-1.30a	1.51a	-1.14a	
$p_{SBC} = 1^*$		5.41c	-4.85c	5.46c	-5.04c	Rejected
2		7.55c	-5.85c	7.79c	-5.98c	
3		3.18a	-3.65b	3.13a	-3.52b	
4		5.50c	-3.11a	11.31c	-3.55b	

Note: Akaike Information Criterion (AIC) and Schwartz Criteria (SBC) were used to select the number of lags required in the co-integration test. The term p shows lag levels and * denotes the optimum lag selection in each model. F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend. F_V represents the F statistic of the model with unrestricted intercept and trend, and F_{III} represents the F statistic of the model with unrestricted intercept and no trend. t_V and t_{III} are the t ratios for testing $b_6 = 0$ in Equation (13) with and without a deterministic linear trend. [a] indicates that the statistic lies below the lower bound, [b] that it falls within the lower and upper bounds, and [c] that it lies above the upper bound (Katircioglu, 2009).

Table 4. Critical Values for ARDL Modeling Approach

	90% level		95% level		99% level	
k = 4	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
F_V	3.33	4.43	3.95	5.22	5.37	7.09
F_{III}	2.66	3.83	3.20	4.54	4.42	6.25
t_V	-3.13	-4.04	-3.41	-4.36	-3.96	-4.96
t_{III}	-2.57	-3.66	-2.86	-3.99	-3.43	-4.60

Source: Narayan (2005) for F-statistics (n=40 observations) pg. 1988-1990 and Pesaran et. al (2001) for t-ratios pg. 303-304.

Note: (1) k is the number of independent variables in ARDL models (Erbaykal, 2008), F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend (testing $\pi_{CC} = 0$ and $\pi_{Cx.x} = 0$, $c_1 = 0$ in equation (15)). F_V represents the F statistic of the model with unrestricted intercept and trend (testing $\pi_{CC} = 0$ and $\pi_{Cx.x} = 0$ in equation (15)), and F_{III} represents the F statistic of the model with unrestricted intercept and no trend(testing $\pi_{CC} = 0$ and $\pi_{Cx.x} = 0$ with c_1 set equal to zero in equation (15). (2) t_V and t_{III} are the t ratios for testing $b_6 = 0$ in Equation (13) with and without a deterministic linear trend (Katircioglu, 2009).

For $p_{AIC} = 2$ and 4, the F_V lay outside the 0.05 critical value bounds. We therefore rejected the null hypothesis that there is no level currency demand equation, irrespective of whether the regressors are I(0) or I(1). For $p_{AIC} = 3$ and 5, the F_V lay below the lower bound, revealing that there is not a level currency demand equation.

When the bounds F-test is applied to the currency demand equation without a linear trend, for $p_{AIC} = 2$ and 4, the F_{III} lay outside the 0.01 critical value bounds and therefore the hypothesis of no levels currency demand equation is conclusively rejected. For $p_{AIC} = 3$, the results of the test is inconclusive. For $p_{AIC} = 5$, the F_{III} lay below the lower bound, revealing that there is not a level currency demand equation.

For $p_{SBC} = 1$ (selected by SBC) and 2, the null hypothesis of no cointegration is rejected at 95% level of probability, irrespective of the inclusion of determinstic trend in data.

The results from the application of the bounds t-test to the currency demand equation regarding the imposition of the trend restriction in the conditional ECM are inconclusive. If a linear trend is included, the bounds t-test does reject the null hypothesis of no cointegration for lags 1 and 2. However, when the trend term is excluded, the null hypothesis is rejected only for the first two lags. Therefore, we will estimate the two alternative conditional ECM (with and without deterministic trends) and then we will choose the best model on the basis of diagnostic and stability tests. Overall, test results support the existence of a levels currency demand equation. Therefore, there is a unique cointegration relationship between demand for currency and its determinants.

In the next stage, we select the optimal lag length for ARDL model to determine the long-run coefficients of the model. The ARDL cointegration procedure was implemented to estimate the parameters of equation (4) with the maximum order of lag set to 2 which was selected on the basis of the AIC and SBC, regardless of the trend. The short-run results of equation (14) with and without deterministic trend, based on the AIC and SBC selection criteria are reported in Panel A of table no.5 along with their appropriate ARDL models.

Panel A of table no.5 presents the results of the conditional ECM regression associated with the level equation (the short-run results). The first lagged changes in currency demand are statistically significant, further justifying the choice of $p = 2$.

Examination of error correction model in Panel A shows that taxes and income have the strongest effect on currency demand in the short run and are statistically significant.

The error correction term (EC_{t-1}) has the expected sign (negative) and statistically significant in all of the models indicating another confirmation of the existence of the long-run relationship among the variables in equation (2). Diagnostic tests for serial correlation, autoregressive conditional heteroscedasticity, functional form and normality are conducted and the results are shown in Panel B of table 5. These tests show that short-run models pass through all diagnostic tests in the first stage. The results also indicated that there is no evidence of serial correlation among variables because functional form of model is well specified (Ramsey Reset test results) and there is no evidence for autoregressive conditional heteroscedasticity. The Jarque-Bera results point out the fact the residuals of short-run models are normally distributed.

Table 5. ARDL cointegration results

Panel A: the short-run results Dependent variable: ΔC_t				
Error Correction Representation for the selected ARDL-Model				
	With deterministic trend		Without deterministic trends	
Regressors	AIC ARDL (1,1,1,0,0)	SBC ARDL (1,0,0,0,0)	**AIC ARDL (1,1,1,0,0)**	SBC ARDL (1,0,0,0,0)
ΔC_{t-1}	0.482 (3.55)*	0.413 (2.83)*	**0.408** (3.08)*	0.376 (2.67)*
ΔY_t	-0.114 (-0.13)	1.158 (1.555)	**-0.087** (-0.09)	1.014 (1.36)
ΔY_{t-1}	-1.742 (-2.02)***		**-1.789** (-2.03)***	
ΔTax_t	2.846 (3.20)*	2.151 (2.62)*	**2.851** (3.14)*	2.159 (2.64)*
ΔTax_{t-1}	-3.091 (-2.92)*		**-2.521** (-2.38)*	
ΔR_t	0.015 (0.24)	0.002 (0.004)	**-0.008** (-0.13)	-0.020 (-0.31)
ΔWS_t	0.380 (0.61)	1.060 (1.53)	**0.166** (0.26)	0.963 (1.41)
Constant	0.007 (0.55)	0.017 (1.26)	**0.000** 0.00	0.015 (1.09)
EC_{t-1}	-1.357 (-7.22)*	-1.199 (-6.13)*	**-1.256** (-6.99)*	-1.155 (-6.18)*
$\overline{R}^2$	0.57	0.50	**0.56**	0.50
F-statistic	7.71*	7.56*	**7.26***	7.66*
DW-stat	2.38	2.13	**2.32**	2.14
RSS	0.10	0.13	**0.11**	0.13
Log likelihood	62.69	58.08	**61.90**	58.24
$\hat{\sigma}$	0.057	0.062	**0.058**	0.062
AIC	-2.684	-2.554	**-2.645**	-2.562
SBC	-2.304	-2.258	**-2.265**	-2.266
Panel B: the short-run diagnostic test statistics				
Serial Correlation LM test	3.95 [0.14]	1.73 [0.42]	**3.51** [0.17]	2.11 [0.34]
Normality test	0.016 [0.99]	1.53 [0.46]	**0.03** [0.98]	1.94 [0.38]
ARCH test	2.60 [0.11]	3.50 [0.06]	**0.62** [0.43]	2.37 [0.12]
Ramsey RESET test	1.57 [0.26]	1.39 [0.23]	**1.024** [0.24]	1.26 [0.26]
Panel C: the long-run results Dependent variable: C_t				
Y_t	1.559 (4.77)*	1.776 (6.33)*	**1.875** (11.49)*	1.983 (12.48)*
Tax_t	6.007 (3.13)*	2.162 (2.00)***	**5.442** (2.74)*	1.982 (1.78)***
R_t	-0.123 (-3.29)*	-0.086 (-1.94)***	**-0.141** (-3.87)*	-0.111 (-3.05)*
WS_t	1.349 (3.70)*	1.657 (4.24)*	**1.557** (4.72)*	1.910 (6.95)*
Constant	-13.024 (-3.72)*	-15.256 (4.58)*	**-16.54** (-11.55)*	-17.904 (-12.40)*

Notes: $\overline{R}^2$ is the adjusted squared multiple correlation coefficient, $\hat{\sigma}$ is the standard error of regression, RSS stands for residual sum of squares, AIC and SBC are the Akaike's and Schwarz's Bayesian Information Criteria. *, ** and *** indicate 1%, 5 % and 10 % significance levels, respectively. RSS stands for residual sum of squares. The absolute value of t-ratios is in parentheses. Godfrey Serial Correlation test, ARCH test for heteroscedasticity are distributed as F-statistics and Jarque-Bera test for normality is distributed as Chi-squared variate with degrees of freedom in parentheses. The diagnostic test probability is in bracket parenthesis [].

The long-run results of equation (4) are displayed in Panel C of Table no 5. The estimated coefficients obtained from all the long-run models are very similar, have the expected signs and all regressors are highly significant. The long-run elasticities were statistically significant and display elastic and positive coefficients for income, taxes and wage ratio. We have registered inelastic and negative coefficient only for the case of interest rate.

The long-run coefficients reported in Panel C are used to generate the error correction terms (ECT). The adjusted R^2 are 0.57, 0.50, and 0.56 for the all models respectively, suggesting that such error correction models fit the data reasonably well. In addition, the computed F-statistics clearly reject the null hypothesis that all regressors have zero coefficients for all cases. Importantly, the error correction coefficients carry the expected negative sign and are highly significant in all cases. This helps reinforce the finding of cointegration as provided by the F-test.

Table no.5 enables us to select the most appropriate model for the currency demand equation. According to the reported diagnostic tests results, the AIC-based error correction model of equation(2) without deterministic trend seems to be relatively better fit than others error correction models. Therefore, the results from this model will be used to estimate the size of the shadow economy.

The empirical estimates of the level relationship for the ARDL model (1,1,1,0,0) can be given by:

$$C_t = -16{,}54 + 1.875 \cdot Y_t + 5.442 \cdot Tax_t - 0.141 \cdot R_t + 1.557 \cdot WS_t + \hat{\upsilon}_t \qquad (6)$$

$$\qquad (1.43) \quad (0.163) \qquad (1.98) \qquad (0.036) \qquad (0.33)$$

where:

$\hat{\upsilon}_t$ is the error correction term(EC_{t-1}) and the standard errors are given in parentheses.

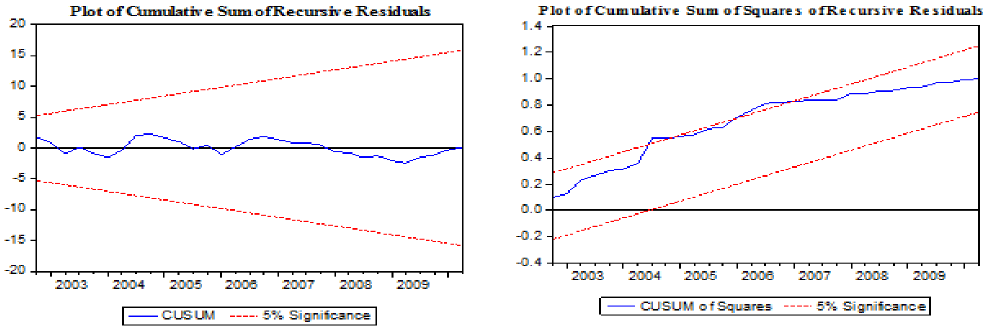
The long-run results of the ARDL model (1,1,1,0,0) without deterministic trend presented in panel C of table 5 indicate that real income, tax burden and wage ratio are positively correlated while interest rate is negatively correlated to real currency holdings. The most significant factor in determining the impact on currency demand in Romania is the tax rate(Tax) with the coefficient of 5.442 showing that in the long run, 1% increase in tax rate as % of official GDP leads to on average 5.4% increase in the currency demand. The next significant factor in determining the positive impact on currency demand is the real GDP (Y) and the coefficient is 1.875 and statistically significant. It shows that in the long run, 1% increase in real income leads to 1.875% increase in currency demand in Romania. Similarly, the impact of real GDP on currency is positive and statistically significant.

Furthermore, wage ratio is also positively related to real currency. Coefficients of interest rate indicate that they have negative significant impact on currency demand has the strongest positive effect on currency demand in the short run and statistically significant.

The next significant factor in determining the impact on currency is the lag difference of income. The negative sign of this coefficient supports the idea that, income decreases will lead to currency increases, but this impact could only be observed in short-run period. In time of crisis, when uncertainty increases, it is normal to increase the demand for money, because individuals are slowing down their transactions and the money velocity decreases. The short-run effect of other macroeconomic variables on Romanian currency demand is weak and statistically insignificant at even 10% significance level.

The coefficient of ECM term has correct sign (negative) and highly significant. It confirms a long run relationship between the variables in equation (2). The coefficient of the ECM term suggests that adjustment process indicates a high rate of converge to equilibrium, which implies that about 135% of the previous quarter's disequilibrium in stock prices from its equilibrium path will be corrected in the current quarter. The significance of the error correction term (ECT) shows causality in at least one direction.

Next, we examine the stability of short-run and long-run coefficients. We have performed the CUSUM and CUSUMQ stability tests for the AIC-based error correction model. The tests applied to the residuals of the ECM model (equation 5). It can be seen from the figures that the plot of CUSUM stay within the critical 5% bound and the cumulative sum of squares (CUSUMQ) is generally within the 5% significance lines, suggesting that the residual variance is somewhat stable. Thus, the results indicate the absence of any instability of ARDL error correction model coefficients.



Note: The straight lines represent critical bounds at 5% significance level.

Figure 1. Plots of CUSUM and CUSUMSQ Statistics for Coefficient Stability

3.2. Obtaining the size of Romanian shadow economy

In order to obtain an estimate of the size of the shadow economy, we compute $\tilde{C}$ using all the coefficients in equation (7).Then, we set the tax variable[7] equal to zero and re-estimate the equation, keeping all the other coefficients unchanged to obtain $\hat{C}$:

[7] The only reason tax rates would affect the use of cash is that cash is used as a means of evading taxes in the underground economy (Spiro, 1996).

$$\hat{C}_t = -16{,}54 + 1.875 \cdot Y_t + 5.442 \cdot Tax_t - 0.141 \cdot R_t + 1.557 \cdot WS_t + \hat{\upsilon}_t \quad (7)$$
$$(1.43) \quad (0.163) \quad (1.98) \quad (0.036) \quad (0.33)$$

The difference between these two variables-$\hat{C}$ and $\tilde{C}$-gives the amount of extra currency (EC) in the economy. Following Tanzi (1983), we assume equal velocity in both the formal and informal and estimate it as follows:

$$\frac{Y}{M_1 - EC} = v \quad (8)$$

Equation (8) yields the velocity of money in the Romanian economy. Y is the gross domestic product, M_1 corresponds to total currency and deposits in circulation and extra currency (EC) for extra currency or illegal currency. The difference between M_1 and EC can be interpreted as the amount of legal money used in economy.

Once we estimate the velocity from equation (8), the dimension of shadow economy using the currency demand approach can be obtained multiplying EC by the velocity of money:

$$EC * v = Y_{shadow} \quad (9)$$

The main idea behind the model is that a rise in the underground economy will cause an increase in demand for money. Following the Ahumada et al. (2007), we proceed to correct our estimates using their suggested method[8]:

$$\frac{Y_{shadow}}{Y_{official}} = \left(\frac{C_{shadow}}{C_{official}}\right)^{\frac{1}{\beta}} = \left(\frac{\hat{Y}_{shadow}}{\hat{Y}_{official}}\right)^{\frac{1}{\beta}} \quad (10)$$

where: Y is the GDP, C is the currency, while β is the income elasticity. The correction basically deflates the wrong ratio $\left(\frac{\hat{Y}_{shadow}}{\hat{Y}_{official}}\right)$ that we obtained using inappropriately the assumption $\beta = 1$. Equation (10) corrects the estimation when $\beta = 1$.

The corrected results normalized by the formal GDP in real terms (2000=100) follows a decreasing trend during the analyzed period, reaching approximately

[8] Ahumada et al.(2007) show that it is wrong to assume the same velocity of money when the hypothesis $\beta = 1$ is rejected by the econometric estimation of the currency demand model. This is our case, since our model gives us a coefficient $\beta = 1.83$.

45% at the end of 2000 and achieving the value of 37.4% in the last quarters of the period. The estimates are in line with the last empirical studies[9].

It is important to note that because of its undetectable nature and character, it is nearly impossible to measure precisely the size of economic activities taking place in the informal economy of any country in the world, whether developed or less developed. Given this, any theoretical or empirical inference derived from these results should always be regarded as an approximation. In the face of these difficulties, the results drawn from these estimates should be interpreted with due reserve, given the limitations of the methods.

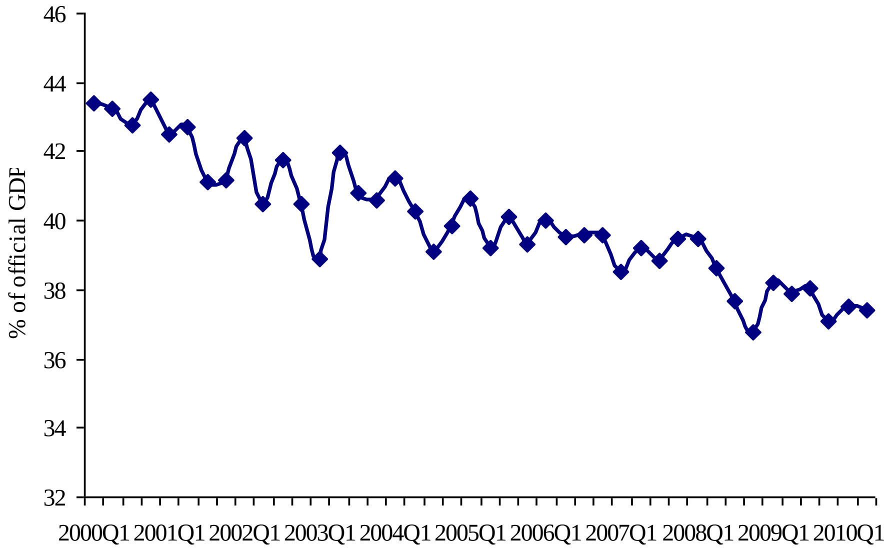


Figure 2. The size of Romanian shadow economy as % of official GDP

Conclusions

We attempted to estimate an aggregate currency demand function and the size of Romanian shadow economy (SE) using a revised version of the currency demand approach and to examine the short and long-run relationship between currency demand, real income, tax burden, interest rate and wage ratio in the case of Romania's economy.

The bounds testing approach to cointegration and error correction models, developed within an autoregressive distributed lag (ARDL) framework is applied

[9] For Schneider et al. (2010), the size of shadow economy in % of official GDP, using the DYMIMIC model is 34.4% in 2000, 35.4% in 2002, 35.9% in 2004, 36.2% in 2005 and 36.7% in 2006.

to quarterly data for the period 2000 to 2010 in order to investigate whether a long-run equilibrium relationship exists between currency demand and its determinants. The result of the bounds test indicates that there is a stable long-run relationship between the currency demand and its determinants. In addition, CUSUM and CUSUMSQ tests confirm the stability of the money demand function.

According to the empirical results, the size of Romanian shadow economy as % of official GDP was estimated to range from 45% to 37.4% over the analyzed period.

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APPENDIX A

Table 1. The description and sources of data

Variables	Description	Sources
C	Natural logarithm of real currency holdings measured as nominal currency in circulation normalized by GDP deflator (2000=100). 2000Q1-2010Q2 in national currency (mil.RON). The values of currency, all notes and coin outside the banking system are those at the end of the quarter.	The series of nominal currency is available in National Bank of Romania Monthly Bulletins 2000-2010. The series of GDP deflator (2000=100) is available in Eurostat, Quarterly National Accounts database.
M_1	Natural logarithm of monetary aggregate M_1. 2000Q1-2010Q2 in national currency (mil. RON).	The definition of monetary aggregate according to the methodology of European Central Bank beginning with 2007 produces some led to changes in monetary aggregate M_1 who includes from 2007 in addition to the structure employed until December 2006, the demand deposits of household savings expressed in RON and sight foreign currency deposits of residents previously included in quasi-money, being considered as having the same degree of liquidity as the demand deposits of economic agents. The series has been recalculated for the period 2000-2006 using data from National Bank of Romania, Monthly Bulletins 2000-2010.
Y	Natural logarithm of real GDP (2000=100).2000Q1-2010Q3 in national currency (mil.RON).	The series is available in Eurostat, Quarterly National Accounts database.
TAX	Natural logarithm of 1+ total of tax revenues (taxes on production and imports, current taxes on income, wealth, social contributions) over GDP. 2000Q1-2010Q2 in %.	The series is available in Eurostat, Quarterly Government Finance Statistics database.
Rr_{12}	Natural logarithm of 12-month Real Romanian inter-bank offered rate (ROBOR). 2000Q1-2010Q2 in %.	The series is calculated using nominal interest rate and average inflation rate from Eurostat, Quarterly Interest

		Rates database, National Bank of Romania respectively National Statistics Institute TEMPO database. The series of inflation rate(π) is calculated as a geometric mean of the chain-based monthly indices of consumer prices, from which the comparison base equaling 100 is subtracted. The source of the data was the National Statistics Institute TEMPO database.
WAGES	Natural logarithm of the ratio of gross wages and salaries in GDP. 2000Q1-2010Q2 in %.	The series is computed based on official data from National Bank of Romania, Monthly Bulletins 2000-2010, National Institute of Statistics, TEMPO database.