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In this paper, we estimate the size and the evolution of the Romanian shadow economy in the period 1998Q1-2008Q4, using a vector error correction model. A special attention it was given to the problem of non-stationarity and cointegration. The results indicate that the shadow economy grows constantly during 1998-1999 until it reaches its maximum at the end of 1999(38.12% in 1999Q2). Then, it decreases slowly and stabilizes around 27% of official GDP.
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JEL classification numbers:C32, E41, O17

I. Introduction

Although the problem of informality is not new, an agreement on a unique accepted definition, as well as a measuring method are still missing. Portes et al. (1989) defines the informal economy as "a process of income-generation characterized by one central feature: it is unregulated by the institutions of society, in a legal and social environment in which similar activities are regulated." Schneider (1998, 2002, 2004, 2005, 2006, 2007) realizes various estimations of the size of shadow economy in Romania using the electricity method and obtains about 26% of official GDP for the period 1990/93, and 28.3% in 1994/95.Applying the currency demand approach and DYMIMIC model, Romania have an ascending trend on the terms of the shadow economy, registering 27.3% of official GDP in 1990/93, 33.4% in 2000/01 and 37.4% in 2002/03.In the last years, it can be observed a decreasing evolution of the shadow economy, who registers 36.2% of official GDP in 2003/04 and 35.4% in 2004/05.

Using discrepancy between actual and desired income and between declared and actual income method, Albu L.(2007, 2008) estimates the lower and upper bound of the shadow economy:(28.6-35.9)% of official GDP in 1990, (23.5-28.7)% in 1995, (22.5-27.3)% in 2004 and (22.5-27.8)% in 2005.

In this paper, we will focus on measuring the size and evolution of informality in Romania, in order to contribute to the understanding of the interaction and effects of the shadow economy. In order to do so, we used a classic currency demand approach, going back in time as much as data constraints allowed us. The paper is structured as follows. In section II, we provide a brief description of the currency demand approach. Section III summarizes the data and methodology and present the results for the vector error correction model (VECM). In section IV we used the VEC estimates to compute the size of shadow economy in Romania.

II.The currency demand approach

Applied to many OECD countries[365], this approach is one of the most commonly used indirect approaches. It was first used by Cagan (1958), who calculated a correlation of

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[365] Schneider (1997, 1998a), Johnson, Kaufmann and Zoido-Lobatón (1998a), Williams and Windebank (1995) and Bovi and Dell'Anno(2007) for OECD countries, Tanzi(1983) for USA, Bovi and Castelucci(2001) for Italy, Giles D.E.

the currency demand and the tax pressure (as one cause of the shadow economy) for the United States over the period 1919 to 1955. Cagan's approach was further developed by Tanzi[366] (1980, 1983), who econometrically estimated a currency demand function for the United States for the period 1929 to 1980 in order to calculate the shadow economy.

Following Cagan's work, a typical currency demand function can be written as:

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

C_0 is the observed cash, Θ the variable that gives incentives to make hidden transactions. 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, Y_0 the registered GDP, α, β, γ, A 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 $\widetilde{C}$. The difference between $\hat{C}$ and $\widetilde{C}$ is the amount of extra currency that measures the amount of illegal money in the economy. Forth more, assuming that the velocity of money is the same in both forma and informal sector, we can obtain an estimate of the size of informal economy multiplying illegal money ($EC = \hat{C} - \widetilde{C}$) by the velocity of money ($v = \dfrac{Y}{C}$).

III. Methodology and Data

The data cover each quarter between 1998 and 2008: the number of observations is 44. The main sources used to collect the data are: Eurostat, National Bank of Romania and National Institute of Statistics, Tempo database. A description of the variables and their sources is summarized in the table 1 of Appendix. As point out by Guissari (1987), one of the first decisions to be taken in a currency demand model is how to deflate the currency series. Spiro (1996) considers the use of monetary aggregate M2 inadequate, since it contains amounts that correspond to long-term wealth accumulation, while currency is used mainly for transaction processes. So, we deflate the series using the national GDP deflator and we construct the following function[367]:

$$C_t = \beta_0 + \beta_1 \cdot Y_t + \beta_2 \cdot Tax_t + \beta_3 \cdot R_t + \beta_4 \cdot Wages_t + \varepsilon_t \quad (2)$$

This specification captures the long-run relationships between the explanatory variables and the currency demand. Regarding the sign of the variables in the model, we expect a positive impact on currency demand for GDP, taxes and wages ($\beta_1, \beta_2, \beta_4 > 0$)[368], and a negative effect from the part of interest rate ($\beta_3 < 0$)[369]. Before proceeding with the estimation, each series is individually examined under the null hypothesis of a unit root against the alternative of stationarity. As shown

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(1999) for New Zeeland, Brambila Macias Jose(2008) for Mexico, Schneider(1986) for Denmark, Schneider and Hametner(2007) for Colombia.

366 The basic regression equation for the currency demand, proposed by Tanzi (1983), is the following:

ln (C / M2)t = □0 + □1 ln (1 + TW)t + □2 ln (WS / Y)t + □3 ln Rt + □4 ln (Y / N)t + ut

□1 > 0, □2 > 0, □3 < 0, □4 > 0

ln denotes natural logarithms,

C/M2 is the ratio of cash holdings to current and deposit accounts,

TW is a weighted average tax rate (to proxy changes in the size of the shadow economy),

367 This function is a log-linearization of equation (1).

368 The expected positive impact of taxes on currency demand can be interpreted, following Tanzi: if the level of taxation increase, economic agents will be encourage engaging tax-evading activities, using currency, due to the intractability of cash, and than the currency rises.

369 If the interest rate increases, the economic agents get ride to their currency holdings.

in table 2 of Appendix all most all the series turn out to be non-stationary and integrated of order 1.

In Engle-Granger two-step approach (Engle, Granger, 1987) we verify the cointegration of the variables, estimating least square regression with variables in level:

$$C_t = \beta_0 + \beta_1 \cdot Y_t + \beta_2 \cdot Tax_t + \beta_3 \cdot R_t + \beta_4 \cdot Wages_t + \varepsilon_t$$

Using Augmented Dickey-Fuller test, we analyze the assumed cointegration relationship's residuals ε_t. If the causal variables are cointegrated with the dependent variable, we expect the ADF test to reject the null hypothesis of a unit root against the alternative for the error term ε_t. In fact, we can reject the null hypothesis at 10% level and we conclude that the causes are cointegrated with the dependent variable (table 3 of appendix). Because all series turn out to be strongly non-stationary and integrated on the same order, I(1), we also apply the Johansen cointegrating test. Trace tests on one hand indicate three cointegrating equations at the 5% level and one at the 1% level, while the eigenvalue test indicates one cointegrating equation at the 1% level (table 4 of appendix). This allows us to conclude that there exists one cointegration relationship[370].

Given the non-stationarity of our series and the presence of a common stochastic trend, traditional estimation methods are ruled out. So, in order to estimate equation(2) and measure the size of the informal sector, we tackle the problem using a vector correction model(VECM).This type of models present a series of improvements with respect cu standard approaches, allowing us to analyze short and long-run effects.

The VECM estimated can be defined as follows:

$$\Delta Y_t = \delta + \Gamma \cdot \Delta Y_{t-1} + \Pi \cdot Y_{t-1} + \varepsilon_t \quad (3)$$

where Y is a vector formed by the n variables used in our currency demand model(C, Y, TAX, R, and WAGES). Γ, Π are 5×5 matrices made up by system coefficients. If the rank of cointegration r is less than n, then $\Pi = \gamma \beta'$, where γ represents the adjustment coefficients and β the cointegrating vectors; ε corresponds to residuals and δ is a constant term which can be separated in two parts-a trend term and the intercept-in the cointegrating relation.

As expected, the estimated model which corresponds to equation (2), the coefficients for output, tax burden and wages have a positive long-run effect, while interest rate take the pressure off on currency demand. All coefficients are strongly significant and assign relevant weight to GDP with a coefficient of 1.706 and taxes with 3.95.

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370 The existence of only one cointegration vector in our system means that there is a long-run equilibrium relationship between C, Y, R, TAX and WAGES.

Table 1:Normalized Cointegrating Coefficients[371]

Trace statistic		Max Eigenvalue Statistic		C_{t-1}	Y_{t-1}	TAX_{t-1}	R_{t-1}	$WAGES_{t-1}$	Cons	Log likelihood
5% level	1% level	5% level	1% level							
3	3	1	1	1.00	-1.7067* (0.1362)	-3.9510* (0.8587)	0.14318* (0.0336)	-2.2604* (0.2845)	16.5973* (1.2090)	538.7658

IV. The size of informal economy

After estimating the vector error correction model (VECM)[372] and obtaining the coefficients for the long-run relationship of equation (2), we proceed to estimate the size of shadow economy. In order to obtain an estimate of the size of the shadow economy, we compute $\hat{C}$ using all the coefficients in equation (4).Then, we set the tax variable equal to zero and re-estimate the equation, keeping all the other coefficients unchanged to obtain $\widetilde{C}$:

$$\hat{C} = -16.59 + 1.706Y + 3.951TAX - 0.143R + 2.260WAGES \quad (4)$$

The difference between these two variables- $\hat{C}$ and $\widetilde{C}$ -give 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: $\dfrac{Y}{M_1 - EC} = v$ (5)

Equation (5) 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 (5), the dimension of shadow economy using the currency demand approach can be obtained multiplying EC by the velocity of money:

$$EC * v = Y_{informal} \quad (6)$$

Using equation (6), we can infer the size of informal sector in formal GDP terms. From the table of normalized cointegrating coefficients, the coefficient of gross domestic product(Y) in the model is different from 1.Following the Ahumada et al. (2006), we proceed to correct our estimates using their suggested

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371 All variables are in natural logs. All series used are I(1).The complete details and the analysis as well as the matrix of adjustment coefficients can be found in the appendix. The number of lags in the model was determined using the Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC).The model was estimated using two lags and it assume one cointegrating equation. Standard errors are in parentheses. * indicates significance at the 5% level.
372 The long-run relationship between our variables was derived normalizing C.

$$\text{method}^{373}: \frac{Y_{\inf ormal}}{Y_{formal}} = \left(\frac{C_{\inf ormal}}{C_{formal}}\right)^{\frac{1}{\beta}} = \left(\frac{\hat{Y}_{\inf ormal}}{\hat{Y}_{formal}}\right)^{\frac{1}{\beta}} \quad (7)$$

where Y and C are the GDP and currency, while β is the income elasticity. The correction basically deflates the wrong ratio between the official and unofficial output, that we obtained using inappropriately the assumption $\beta = 1$. Equation (7) corrects the estimation when $\beta \neq 1$.

The size of the shadow economy in Romania in the period 1998-2008

— the size of shadow economy
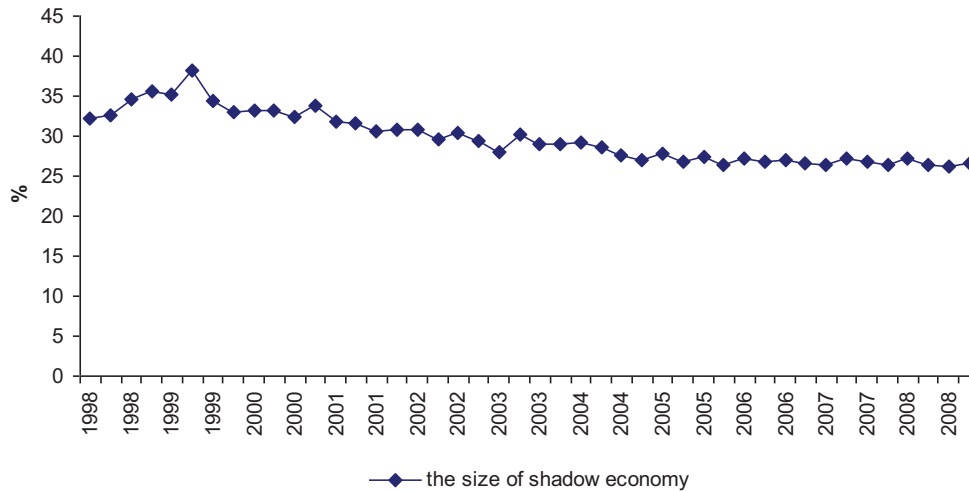
The corrected results normalized by the formal GDP in real terms (2000=100) stabilize around 33-35% in 1998 and 1999, which is in line with the previous studies[374].

Conclusions

In this paper, we used the currency demand approach to obtain a measure of informality in Romania from the first quarter of 1998 until the four quarter of 2008.The informal economy grows constantly during 1998-1999 until it reaches its maximum at the end of 1999(38.12% in 1999Q2).Then, it decreases slowly and stabilizes around 27% of official GDP.

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373 Ahumada et al.(2006) 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 $\beta = 1.706$

374 For Schneider (2007), the size of shadow economy in % of official GDP, measured like average between the DYMIMIC model and currency demand method is 34.4% in 1999/00, 36.1% in 2001/02, 37.4% in 2002/03, 36.2% in 2003/04 and 35.4% in 2004/05.

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Table 1: The description and sources of data

Variables 375	Description	Sources	Unit root analysis
C	Natural logarithm of currency in circulation normalized by GDP deflator. 1998Q1-2008Q4 in national currency(mil.RON)	Eurostat-Quaterly National Accounts and Monetary Statistics	I(1)
M_1	Natural logarithm of M_1.1998Q1-2008Q4 in national currency	National Bank of Romania, Monthly Bulletins 2000-2009	I(1)
Y	Natural logarithm of real GDP(2000=100).1998Q1-2008Q4 in national currency(mil.RON)	Eurostat-Quaterly National Accounts	I(1)
TAX	Natural logarithm of 1+total of tax revenues over GDP.1998Q1-2008Q4	Eurostat- Quaterly National Accounts	I(1)
R	Natural logarithm of the 1 year nominal saving deposit interest rate.1998Q1-2008Q4 in %	Eurostat-Interest rates	I(1)
WAGES	Natural logarithm of the ratio of wages in GDP.1998Q1-2008Q4 in %	National Bank of Romania, Monthly Bulletins 2000-2009 National Institute of Statistics, TEMPO database	I(1)

Table 2: Analysis of stationarity[376]

Test	Variables	C	Y	TAX	R	WAGES
ADF-Level	None	0.9983	0.8404	0.7367	0.3518	0.7458
	C	0.9999	0.9647	0.2233	0.6381	0.5311
	T&C	0.0031*	0.0000*	0.9909	0.9379	0.9123
ADF-First difference	None	0.0561*	0.0000*	0.0000*	0.0005*	0.0162*
	C	0.0124*	0.0001*	0.0000*	0.0083*	0.1943
	T&C	0.0038*	0.0004*	0.0000*	0.0270*	0.0000*
ADF-Second difference	None	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	C	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	T&C	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*

Above it is presented the ADF test- one-sided p-values. * means stationary for the level of significance of 5%.The lag length was chosen using Schwarz Information Criterion. Null hypothesis: variable has a unit root.

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375 All variables are in natural logs and seasonally adjusted using the tramo seats method.
376 Following Giles (1995), the problem of non-stationarity is important also the cointegration of time series. To discover the order of integration of the time series used we apply Augmented Dickey-Fuller (ADF) Test. In the following table the p-value of ADF test is reported, and therefore a value greater than 0.05 indicates non-stationary time series. The econometric software Eviews 6.0 was used to perform this analysis.

Table 3.Analysis of Cointegration between Causes and Indicators

Indicators	Causes				t-statistic for Residual	Jarque-Bera Probability
	TAX	Y	R	WAGES		
C	(0.000)	(0.000)	(0.000)	(0.060)	-3.8005	0.99

Note: The critical values of the ADF test's t-statistic are taken from Engle and Yoo(1987).For a sample with 50 observations and for a number of four variables, they are: 4.61(1% level), 3.98 (5% level)   and 3.67(10% level). The order of autoregressive correction has been chosen using the AIC as suggested by Engle and Yoo (1987, pg.16).Thus, the null hypothesis of a unit root is rejected at the 10% level for residual

ε_t .The p-values of the parameter estimators are given in parenthesis.

Table 4. Johansen Cointegrating Test

Null Hypothesis		5% Critical Value	1% Critical Value
Trace statistic test	λ_{trace} *value*		
None**	119.4171	76.07	84.45
At most 1**	70.72629	53.12	60.16
At most 2**	43.74119	34.91	41.07
At most 3	18.05864	19.96	24.60
At most 4	5.194495	9.24	12.97
Max-Eigenvalue Statistic Test	λ_{max} *value*		
None**	48.69083	34.40	39.79
At most 1	26.98510	28.14	33.24
At most 2*	25.68255	22.00	26.81
At most 3	12.86415	15.67	20.20
At most 4	5.194495	9.24	12.97

*(**) denotes rejection of the hypothesis at the 5 %(1%) level.
Trace test indicates 3 cointegrating equation(s) at both 5% and 1% levels.
Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels.
Given the small size of our series we used a maximum of two lags running the tests.
No deterministic trend.

Estimated Matrix of Adjustment Coefficients				
ΔC	ΔY	ΔTAX	ΔR	$\Delta WAGES$
0.103	0.144	0.052	-0.206	0.131
(0.109)	(0.060)	(0.035)	(0.526)	(0.023)

Standard errors in parentheses