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DP/74/2009

The Size of the Shadow Economy in Bulgaria: A Measurement Using the Monetary Method

Hildegart Ahumada
Facundo Alvarado
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IN MEMORIAM

Alfredo Canavese

Alfredo Juan Canavese (1945–2009), Member of the Argentine Academy of Economic Sciences, Professor of Economic Law at the *Universidad Torcuato Di Tella* in Buenos Aires and economic adviser in two Argentine governments, more than 40 years worked on econometrics and political economy issues. His papers were published in renowned academic journals.

Alfredo Canavese shared his experience and knowledge with Bulgarian economists: he was a guest lecturer in the Faculty of Economics of St Kliment Ohridski University and an adviser in the area of macroeconomic stabilization and structural reforms. In 1996 the Agency for Economic Analysis and Forecastsing published *The State-owned Enterprises Behaviour and Inflation* paper by Mariella Nenova and Alfredo Canavese in Bulgarian. In 2004 Prof Canavese was an honoured lecturer at the Second Annual Conference of the Balkan Countries' Central Banks organized by the BNB. In 2008 Prof Canavese read his lecture *Inflation Stabilization Efforts in Argentina* at the seminar *The Future through the Culture of the Past: Bulgarian Economic and Social History* of the Centre for Liberal Strategies. This paper was written during Prof Canavese's visit to the BNB as a guest researcher in April 2008.

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Contents

SUMMARY. The monetary method is a widely used approach to measure the size of the shadow economy. It is based on the assumption that cash is used to make transactions that agents want to keep hidden from official records. This paper provides a formal aggregation framework which stylizes the steps followed in the standard empirical application of the method and use this framework to point out some pitfalls that are present in most estimations based on this approach. The paper also suggests solutions for them. As an exercise, a corrected version of the method is applied to estimate the size of the Bulgarian shadow economy.

JEL: H3-K4

This paper was written while Alfredo Canavese was with the Visiting Researchers Program of the Bulgarian National Bank (BNB). Mariella Nenova, Head of the Research Department, made valuable comments with useful insights about the particularities of the Bulgarian economy. We want to acknowledge the willing assistance of the Research Department economists and the working atmosphere and financial help provided by the BNB. As usual, only the authors are responsible for mistakes and omissions.

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Introduction

No hay ejercicio intelectual que no sea finalmente inútil. Una doctrina filosófica es al principio una descripción verosímil del universo; giran los años y es un mero capitulo – cuando no un párrafo o un nombre – de la historia de la filosofía.
Jorge Luís Borges,'Pierre Menard, autor del Quijote'. Ficciones

National accounts do not register a whole set of economic transactions. The size of such transactions and the causes and consequences of their existence are studied under different names: hidden, unrecorded, underground, parallel, black or shadow economy. Undeclared, under-declared, non-measured and under-registered transactions made to avoid the burden of taxes or to circumvent regulations, illegal transactions connected with crime and corruption and legal but non-market activities are included in the concept of shadow economy.

Economists have been interested in this topic during the last twenty-five years although the concepts analyzed are not uniform. A volume of The Economic Journal (1999), a survey by Schneider and Enste (2000) and a recent international seminar held at Marne la Vallée University (France, 2007) gathering academic experts and government officials concerned with this subject, thoroughly document such interest. In recent years the issue also attracted the attention of the press. The reason is straightforward: underestimating the GDP implies, for example, an overestimation of the *public deficit/GDP* and *debt/GDP* ratios; therefore, any fiscal and monetary policy decision would be based on biased official figures. Additionally, country unions (notably the European Union) usually determine budget targets and member contributions with reference to the GDP and, consequently, any discrepancy in the shadow economy rates across nations is at the center of the problem. On top of that, estimated values for the size of the shadow economy in different countries are important: averages vary from 11 per cent of registered GDP for OECD members to 20 per cent for transition economies and 39 per cent for developing countries.

The very nature of the shadow economy makes its measurement a difficult task. Furthermore, different estimation methods target different concepts.[1] So, estimation methods have become an important theoretical and empirical issue. There are four main methods used to measure the size of the shadow economy:

[1] Authors do not seem to be always aware of this observation.

1. Methods based on the estimation of discrepancies between registered aggregate income and aggregated implied microeconomic expenditures identified in "ad hoc" surveys.
2. Methods based on tax and regulatory surveys.
3. Methods based on observed discrepancies between inputs used (usually labor and electricity) and outputs declared by industrial firms.
4. Methods based on estimated discrepancies between money required to finance observed GDP and total currency.

The monetary method is included in the fourth group and is the most widely used in the literature. It has the broadest scope since it covers all money transactions (not only industrial or consumption transactions), it does not need costly surveys restricted to a sample and it allows performing yearly, quarterly or even monthly estimations to trace the evolution of the size of the shadow economy with easily available data.

The main purpose of this paper is to use the formal aggregation framework presented in Ahumada, Alvaredo, and Canavese (2007a) which stylizes the steps usually followed in empirical applications to point out some pitfalls that are present in most estimations based on this approach and to apply it, as a corrected version of the monetary method, for estimating the size of the shadow economy in Bulgaria.

The paper has six sections. In the first section the evolution of the monetary method used to compute the size of the shadow economy is reiewed. We note that early efforts were based on the assumption that there was a period in history in which no hidden transactions were concluded (known as "initial condition"). In the second section a formal aggregation framework which stylizes the steps followed in most empirical applications of the method is built. This aggregation framework shows how the use of econometrics allowed estimations to get rid of the need to know the "initial condition" and makes clear why the equality of circulation velocities for the registered and hidden sectors is a common assumption. It is also used to get the requirements that the income elasticity of the demand for real money balances should meet to produce coherent estimates under that assumption and to present a direct estimation method that avoids assuming equality of circulation velocities for the registered and hidden sectors. In the third section we point out that the use of short-run econometric estimates reintroduces the problem of the 'initial condition' in the calculation of the size of the shadow economy. In section fourth we analyze the introduction of threshold values for the variable that induce agents to hide transactions. In section five a corrected method in which the three mentioned pitfalls are solved, is applied for measuring the size of the Bulgarian shadow economy. Some conclusions and comparisons of results are presented in the last section. The two appendixes present the data and several alternative specifications of the models used in the main text.

1. A Review of the Monetary Approach Evolution

The monetary approach to measuring the size of the shadow economy is based on the assumption that cash is used to make transactions that agents want to keep hidden from official records. Transactions made using cash are difficult to trace because they leave no tracks. Other assets are registered in financial institutions and their uses are recorded in such a way that transactions made with them can be easily inspected. If the amount of currency used to make hidden transactions can be estimated, then this amount could be multiplied by the income -velocity of money to get a measure of the size of the shadow economy.

The monetary approach was first presented by Gutman (1977) and Feige (1979) and it evolved to use econometric tools in estimates made by Tanzi (1982, 1983), which are based on Cagan (1958). Conditions to get coherent estimations have been presented by Ahumada, Alvaredo and Canavese (2007a). Tanzi's approach became the standard technique and was applied to measure the size of the shadow economy in the US, Italy, Norway, Canada, South Africa, Tanzania, Mexico, India, Australia, Austria, Belgium, Denmark, France, Germany, Great Britain, Ireland, the Netherlands, New Zealand, Spain, Sweden, Switzerland, Argentina, *etc.*[2]

Gutman's method (1977) is based on four key assumptions: (a) high taxes and government regulations are the main causes of the existence of a shadow sector, (b) only cash is used to make transactions in the shadow economy, (c) the ratio of currency to demand deposits, C/D, is only influenced by changes in taxes and regulations, and (d) there was some point in time, in the past, when no shadow economy existed. As the ratio C/D of that period should have prevailed except for changes in the level of taxes and regulations, increases in C/D are directly linked to the extra currency used in the shadow economy. The method assumes that the income -velocity of circulation, v, is equal for the registered and the hidden economies; hence the size of the hidden sector is v times the extra currency.

Feige's method (1979) uses the standard version of the quantity theory of money $Mv = PT$, where M is money including demand deposits. The value of transactions is PT. Assuming that the ratio of the value of transactions to nominal income remains constant through time and that it was known for a period

[2] **Tanzi** (1999) gives a skeptical view based on the wide diversity of the obtained results.

in which there were no hidden transactions then, total nominal income can be estimated for any period. The difference between estimated total nominal income and observed nominal income is the size of the shadow economy. Feige assumes that hidden transactions are made using either cash or checks.

It is important to point out that both Gutman's and Feige's estimation methods required assuming that there was a past period in which no hidden transactions were made: this "initial condition" is necessary to get the size of the shadow economy.

The works of Tanzi (1982, 1983) and all the papers following his approach, perform econometric estimates of the monetary aggregates used to finance hidden transactions based on demand functions of the Cagan (1958) type. The introduction of econometric tools recognizes that the income velocity depends not only on variables that induce economic agents to make hidden transactions but also on income and the opportunity cost of holding cash. The estimated equation of the demand for currency is also useful to get the extra cash held by economic agents to finance hidden transactions without postulating that there was some point in time, in the past, when no shadow economy existed. It is again assumed that the income velocity of circulation for registered and hidden transactions is equal, and so the size of the shadow economy is measured multiplying the extra cash by the econometrically obtained value of v.

2. An Aggregation Framework, the Assumption of Equal Circulation Velocities and a Direct Estimation Technique

In most published papers, the dependent variable of the econometrically estimated equation of the demand for currency is observed real cash holdings. This variable is the aggregated value of real cash used to finance registered transactions plus real cash used for hidden transactions. Thus, the estimated demand for currency function should result from the aggregation of demands for real cash used for each type of transactions.

This section is devoted to building a formal aggregation framework to get an aggregate currency demand function of the Cagan[3] type and to show that the size of the shadow economy can be directly estimated without assuming equal circulation velocities for both hidden and registered sectors.

[3] Functions following Cagan's tradition are not the only alternative. **Bhattacharyya** (1990) suggests a different aggregation in which real cash demanded for hidden transactions depends only on the value of these transactions and consequently, the observed real cash demand function is not a Cagan type function. But most published papers use an aggregate Cagan type demand without performing any explicit aggregation assumption.

A currency demand function in Cagan's (1958) tradition can be written as:

$$C_{Ot} = A(1 + \Theta_t)^{\alpha} Y_{Ot}^{\beta} \exp(-\gamma i_t) \quad (1)$$

where C_{Ot} denotes observed real cash balances at time t, Θ_t is the variable which induces agents to make hidden transactions (for example the ratio of taxes or government expenditure to GDP), Y_{Ot} is a scale variable (for example registered real GDP), i_t measures the opportunity cost of holding cash (the interest rate or the rate of inflation); A, α, β and γ are positive parameters. Observed real currency, C_{Ot}, is equal to total real currency, C_{Tt}, which includes real cash used for recorded transactions, C_{Rt}, plus real cash used for hidden transactions, C_{Rt},

$$C_{Ot} = C_{Tt} = C_{Rt} + C_{Ht} \quad (2)$$

Observed real GDP, Y_{Ot}, is the registered real GDP, Y_{Rt}, which does not include real hidden GDP, C_{Ht}, so

$$Y_{Tt} = Y_{Ot} + Y_{Ht} = Y_{Rt} + Y_{Ht} \quad (3)$$

Since observed currency includes C_{Ht} but observed GDP excludes Y_{Ht}, the usual econometric regression of C_{Ot} on CY_{Ot} would result in biased and inconsistent estimates.

The empirical applications based on the monetary approach follow four steps. First, a demand for currency is estimated as in (1).[4] Second, under the assumption that the demands for C_R and C_H have the same functional form with equal parameters, Θ is set equal to zero to get an estimate of the amount of cash demanded under no incentives to hide transactions, $\hat{C}_{Rt}$,

$$\hat{C}_{Rt} = \hat{A} Y_{Ot}^{\hat{\beta}} \exp(-\hat{\gamma} i_t) \quad (4)$$

Third, since $\hat{C}_{Rt}$ is known from (4) and C_{Tt} is observed currency, C_{Ot}, then $\hat{C}_{Ht}$ can be obtained by difference,[5]

$$\hat{C}_{Ht} = C_{Tt} - \hat{C}_{Rt} \quad (5)$$

Fourth, to get the size of the shadow economy it is assumed that the circulation velocity for both registered and hidden transactions is the same, so

$$v_{Rt} = \frac{Y_{Rt}}{C_{Rt}} = \frac{Y_{Ht}}{C_{Ht}} \quad (6)$$

[4] To take into account that the time series are integrated, some works consider equation (1) as a long-run relation. Other papers estimate first difference equations, partial adjustment models or hybrids.

[5] **Tanzi** (1982) uses $\hat{C}_T$ instead of C_T in (5).

Then,

$$\hat{Y}_{Ht} = \hat{v}_{Rt}\hat{C}_{Ht} \tag{7}$$

$\hat{Y}_{Ht}$ is the estimation of the size of the shadow economy and it is obtained using $\hat{C}_{Ht}$ from (5) and $\hat{v}_{Rt}$ from (6).

So far we have described the standard steps followed in the literature. The key assumption made explicit in (6) requires β = 1, which is evident if we recall that the income velocity for registered money is

$$v_{Rt} = \frac{Y_{Rt}}{C_{Rt}} = \frac{Y_{Rt}}{AY_{Rt}^{\beta}\exp(-\gamma i_t)} = \frac{Y_{Rt}^{1-\beta}}{A\exp(-\gamma i_t)} \tag{8}$$

while the velocity for the hidden economy is

$$v_{Ht} = \frac{Y_{Ht}}{C_{Ht}} = \frac{Y_{Ht}}{AY_{Ht}^{\beta}\exp(-\gamma i_t)} = \frac{Y_{Ht}^{1-\beta}}{A\exp(-\gamma i_t)} \tag{9}$$

The velocity is the same in both sectors if β = 1.[6] Those studies that find β ≠ *1* but follow the steps described above are therefore incorrect.[7]

Equations (8) and (9) show the precise relationship between v_H and v_R since

$$\frac{v_{Ht}}{v_{Rt}} = \left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{1-\beta} \tag{10}$$

and so, for the usual case in which β < 1 and $Y_H < Y_R$, it is $v_H < v_R$ as empirically expected.

The assumption that the demands for C_R and C_H follow Cagan's type forms with equal parameters allows for an explicit aggregation of (2) as:

$$C_{Tt} = AY_{Rt}^{\beta}\exp(-\gamma i_t) + AY_{Ht}^{\beta}\exp(-\gamma i_t) = AY_{Rt}^{\beta}\exp(-\gamma i_t)\left(1+\left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) \tag{11}$$

This formulation does not need to be restricted to currency. It is also valid for any wider aggregate (e.g. M_1) as long as the interest rate or the inflation rate is the opportunity cost of holding it. However β obtained from (1) only matches β in (11) if the ratio $\frac{Y_{Ht}}{Y_{Rt}}$ is independent of Y_{Rt}.[8] It must be stressed that all papers using this approach implicitly make this assumption.

[6] The velocity is also the same for the improbable case in which $Y_R = Y_H$ for any β.

[7] It should be stressed that currency is the money aggregate whose demand should have income elasticity equal to one. While this value may appear reasonable and theory-based in the case of the demand for the aggregate used to finance all transactions (e.g. the demand for M_1), it may not necessarily be correct for narrower definitions of money. For instance, in Baumol-Tobin's model, the value of transactions elasticity is 1/2.

[8] For this reason it is convenient to measure Θ normalized by registered GDP.

Equation (11) summarizes the aggregation process and we use it to show that there is no need to impose *ad hoc* restrictions on the circulation velocity when the currency demand approach is followed to compute the size of the hidden economy.

Equation (11) can be written as:

$$C_{Tt} = AY_{Rt}^{\beta} \exp(-\gamma i_t)(1+\Theta_t)^{\alpha} \tag{12}$$

which is equal to (1).

Recalling that $Y_O = Y_R$, $C_T = C_O$ and that C_T and Y_R are observed variables, (12) can be econometrically estimated as in (1)[9], and so, from (11) and (12), we can write:

$$C_{Rt} = AY_{Rt}^{\beta} \exp(-\gamma i_t) \left(1+\left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) = AY_{Rt}^{\beta} \exp(-\gamma i_t)(1+\Theta_t)^{\alpha} \tag{13}$$

which implies that:

$$\left(1+\left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) = (1+\Theta_t)^{\alpha} \tag{14}$$

Equation (14) provides an expression for $\hat{Y}_{Ht}$ given Y_{Rt}, Q_t, $\hat{\alpha}$ and $\hat{\beta}$. So there is no need to make the usual ad hoc assumption on the equality of income velocities for both sectors to get an estimation of the size of the shadow economy.[10]

It should be mentioned that when the ratio of two monetary aggregates is econometrically estimated instead of a money demand equation, the same objection discussed above remains unsolved. Once money used to finance non-registered transactions is calculated, the assumption of equal velocities of circulation for registered and hidden currencies is again made in the literature to get the size of the shadow economy. In fact, velocity should be "known" to get transactions. The critical point is that velocity depends on the income elasticity of money demand which is an empirical issue. Indeed, this case is even worse since no estimations of such elasticity are obtained by modeling ratios.[11]

[9] The variable $(1+\Theta)^{\alpha}$ is sensitive to changes in the units in which Θ is measured, as pointed out in **Breusch** (2005a) and (2005b). We keep the notation to maintain Tanzi's original functional form. Nevertheless, changing $(1+\Theta)^{\alpha}$ for ($exp(\alpha\Theta)-1$) could solve this problem.

[10] **Ahumada et al.** (2007a) suggest a way to correct the estimated size of the shadow economy when the income elasticity of the demand for money is not one and apply the correction to some published results available for different countries.

[11] It should be noted that a significant effect of transactions (as in Tanzi's econometric equation) indicates different elasticities for the aggregates entering the ratio and thus different velocities.

3. Short-run *vs.* Long-run Estimates

The direct method to get the size of the shadow economy suggested in the previous section is based on an aggregate Cagan type money demand with no dynamic structure. During the last twenty years more accurate representations of money demand have been developed to take into account the time series properties of the data involved (cash holdings, income, interest rates, inflation), which are either integrated or highly persistent. From 'partial adjustment' to 'equilibrium correction' these dynamic models admit two types of estimates: one for the short-run and another for the long-run. Thus, long-run estimates (as those performed using equation (1)) were replaced by short-run estimates as a central input to the method. When the short-run models that include the lagged dependent variable are used to get the size of the shadow economy the problem of the 'initial condition' reappears: previous values of the size of the shadow economy (and eventually a period without hidden transactions) must be identified to perform an accurate measurement. It must be stressed that no need of such 'knowledge' appeared to be a remarkable advantage of the econometric approaches, when compared with previous methods.

To analyze this issue, we consider a usually estimated log form of regression that includes the lagged dependent variable,

$$c_{Tt} = b_1 + b_2 c_{T\,t-1} + b_3 y_{rt} + b_4 i_t + b_5 \ln(1+\Theta_t) \qquad (15)$$

where lower case letters stand for logarithms. Equation (15) can be seen as a model of partial adjustment to reach

$$C_{Tt} = A Y_{Rt}^{\beta} \exp(-\gamma\, i_t)(1+\Theta_t)^{\alpha}$$

which is the same as equation (12), or in logs:

$$c_{Tt} = \ln(A) + \beta\, y_{Rt} - \gamma i_t + \alpha \ln(1+\Theta_t) \qquad (16)$$

as the equilibrium value for the desired level of real cash holdings. Equation (15) has the following long-run solution:

$$\begin{aligned} c^{*}_{Tt} &= c_{T\,t-1} \\ c^{*}_{Tt} &= \frac{b_1}{1-b_2} + \frac{b_3}{1-b_2} y_{Rt} + \frac{b_4}{1-b_2} i_t + \frac{b_5}{1-b_2} \ln(1+\Theta_t) \end{aligned} \qquad (17)$$

It can be readily seen from (16) and (17) that:

$$\frac{b_1}{1-b_2} = \ln(A); \quad \frac{b_3}{1-b_2} = \beta; \quad \frac{b_4}{1-b_2} = -\gamma; \quad \frac{b_5}{1-b_2} = \alpha$$

In this case it is straightforward to show that when $\Theta = 0$, C_{Rt} can be directly obtained. However, to get C_{Rt} for the short run from equation (15) is a quite different issue since C_{Rt-1}, or a previous value of it, should be known. To further analyze this issue it is convenient to show the aggregation assumed for C_T in the partial adjustment model. To get equation (15) taking logs[12] it should be

$$C_{Tt} = C_{Tt-1}^{\lambda} \ C_{Tt}^{*(1-\lambda)} = \left(C_{Rt-1} + C_{Ht-1}\right)^{\lambda} \left(C_{Rt}^{*} + C_{Ht}^{*}\right)^{(1-\lambda)} \tag{18}$$

where

$$C_{Tt}^{*} = AY_{Rt}^{\beta} \exp(-\gamma i_t)\left(1 + \left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) = AY_{Rt}^{\beta} \exp(-\gamma i_t)(1 + \Theta_t)^{\alpha} \tag{19}$$

When $\Theta = 0$, only that part of C^*_{Rt} (target or desired) due to registered transactions can be obtained but not C_{Rt} as a whole since C_{Rt-1} should also be known. In most applied work C_{Tt-1} is used instead of C_{Rt-1}, and so C_{Rt} is overestimated as χ estimates are positive. If C_{Rt-1} were substituted by C_{Rt-2} and C_{Rt-2} by its previous value and so on, the required knowledge about registered currency would be moved back to an initial value C_{R0} (the initial condition of the solution of the pertinent first order difference equation for the log of currency demand). But C_{R0} is registered real cash for $t = 0$ which can only be identified if there were no hidden transactions at $t = 0$ so that $C_{R0} = C_{T0}$.

To sum up, the only way to avoid *ad hoc* assumptions about previous values of registered currency is to restrict the measures of the size of the shadow economy to those based on the long-run estimates of the money demand.[13]

4. The Use of Thresholds

In the standard monetary approach, the amount of currency held by economic agents in excess of the amount they need to finance registered transactions is obtained by making zero the value of the variable which induces to hide transactions, Θ, in the econometric estimation of a Cagan type demand for cash function. Some published papers assume that no hidden transactions are induced for small values of Θ^0: economic agents want to avoid an excessive burden of government taxes and regulations, not all taxes and regulations.

There is a threshold for the value of Θ such that no hidden transactions are done for $\Theta < \Theta^0$; hidden transactions are done only when $\Theta > \Theta^0$. It is a plausible idea. There are sizes of taxes and regulation that are tolerated (or

[12] If partial adjustments were assumed for each component (C_R and C_H) in equation (17), this equation would not allow us to estimate the share $\frac{Y_R}{Y_H}$, as it cannot be isolated from $\frac{Y_R C_{Rt-1}}{Y_H C_{Ht-1}}$ unless $C_{Rt-1} = C_{Ht-1}$.

[13] An alternative presentation of this issue appears in **Ahumada et al** (2007b).

even welcomed). For such cases equation (1) should become either

$$C_{Ot} = A\left(1+\Theta_t - \Theta^0\right)^{\alpha I(\Theta_t > \Theta^0)} Y_{Ot}^{\beta} \exp(-\gamma i_t) \tag{20}$$

or

$$C_{Ot} = A(1+\Theta_t)^{\alpha I(\Theta_t > \Theta^0)} Y_{Ot}^{\beta} \exp(-\gamma i_t) \tag{21}$$

and so equation (14) should be written either as

$$\left(1+\left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) = \left(1+\Theta_t - \Theta^0\right)^{\alpha} I(\Theta_t > \Theta^0) \tag{22}$$

or as

$$\left(1+\left(\frac{Y_{Ht}}{Y_{Rt}}\right)^{\beta}\right) = \left(1+\Theta_t\right)^{\alpha} I(\Theta_t > \Theta^0) \tag{23}$$

Equations (20) and (21) represent two different ways of thinking about the existence of a threshold. In equation (20) only the burden of taxes and regulations in excess of the value of the threshold induces agents to hide transactions while in equation (21) the whole burden of taxes and regulations induce agents to hide transactions whenever that burden exceeds the threshold.

The difficult point in performing estimations is to find out the empirical value of the threshold. In all published papers the value of Θ^0 is either chosen arbitrarily or fixed equal to the minimum value of Θ_t in the data series used. Both ways of selecting the value of the threshold make an exogenous parameter. We suggest that Θ^0 should be selected as an endogenous variable.

The following algorithm is adopted to find out the value of the threshold endogenously. Define

$$\psi = (\ln A, \beta, \gamma, \alpha)$$

$$Z(\Theta^0) = \ln(1+\Theta-\Theta^0) I(\Theta > \Theta^0)$$ [14]

$$X(\Theta^0) = \left[1, \ln Y_O, i, Z(\Theta^0)\right]$$

where variables without subscript indicate vectors containing all the observations for that variable – that is, X is a Tx5 matrix. Consider a discretization of the interval (min Θ, max Θ) : pick dN and ε small enough and build the grid

G = [min Θ + ε, min Θ + ε +dN, min Θ + ε +2dN, ..., max Θ - ε]

[14] This is the case for the model specified in (20). We could alternatively consider $Z(\Theta^0) = \ln(1+\Theta) I(\Theta > \Theta^0)$ for the model specified in (21).

For each $\Theta^0 \in G$, estimate

$$\hat{\psi}(\Theta^0) = \left(X(\Theta^0)' X(\Theta^0) \right)^{-1} X(\Theta^0)' \ln C_0$$

and compute

$$RSS(\Theta^0) = \left(\ln C_0 - X(\Theta^0) \hat{\psi}(\Theta^0) \right)' \left(\ln C_0 - X(\Theta^0) \hat{\psi}(\Theta^0) \right)$$

Then,

$$\hat{\Theta}^0 \in \arg\min RSS(\Theta^0)$$

$$\hat{\psi} = \hat{\psi}(\hat{\Theta}^0)$$

Notice that using this algorithm allows us to transform a non-linear problem into two standard OLS procedures.

5. Application to Bulgaria

In this section the corrected monetary technique suggested to solve the methodological pitfalls of the standard monetary approach is applied to measure the size of the shadow economy for Bulgaria. The application illustrates the use of the corrected method.

Several versions of equations (20) and (21) were econometrically estimated in its logarithmic form. Estimations were performed using quarterly data for a period beginning in the first quarter of 1998 and ending in the fourth quarter of 2007. Quarterly observations start after the introduction of a currency board arrangement in Bulgaria in July 1997 and include a period of 'financial deepening'.[15] The best econometric results were obtained for the following two functions:[16]

$$\ln C_{0t} = \ln A + \beta \ln Y_{0t} + \gamma i_t + \alpha \ln(1 + \Theta_t - \Theta^0) I(\Theta_t > \Theta^0) + \delta \frac{D_t}{Y_{ot}} + \varepsilon_t \qquad (24)$$

and

$$\ln C_{0t} = \ln A + \beta \ln Y_{0t} + \gamma i_t + \alpha \ln(1 + \Theta_t) I(\Theta_t > \Theta^0) + \delta \frac{D_t}{Y_{ot}} + \varepsilon_t \qquad (25)$$

where C_0 is quarterly average real cash balances hold by economic agents (cash outside banks), Y_0 is quarterly real registered (observed) GDP, i is the quarterly average annual nominal interest rate on time deposits in euro, Θ is total government expenditures as a share of registered GDP and D/Y_0 is the quarterly average of total nominal overnight deposits as a share of registered GDP. This last variable is included to approximate the 'financial deepening' process experienced by the Bulgarian economy after the introduction of the

[15] A description of the data that were used is included in Appendix 1.

[16] Other versions based also in (20) and (21) are included in Appendix 2.

currency board. In this period all monetary aggregates grew as an answer to the introduction of a more developed payments system.

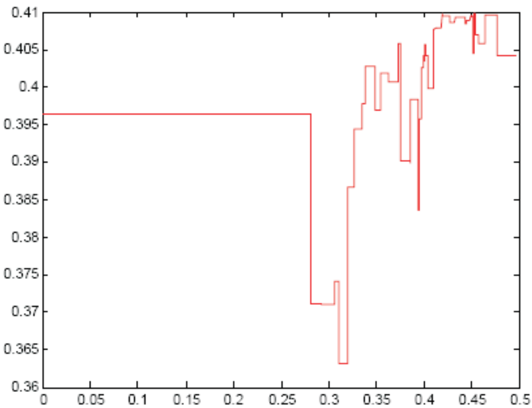
Results for the econometric estimation of equation (24) for an arbitrarily chosen threshold $\Theta^0 = 0$ (the standard application of the method) are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	-0. 42817	0.9445335	-0.45
β	0.99422	0.1508683	6.59
γ	-8.46718	4.737177	-1.79
α	0.55375	0.387145	1.43
δ	0.64348	0.0621462	10.35

and the solution of (22) yields the size of the shadow economy (hidden GDP) as a share of total (registered plus hidden) GDP for each quarter as:

1998		1999		2000		2001		2002	
I	0.16	I	0.18	I	0.18	I	0.19	I	0.17
II	0.19	II	0.18	II	0.16	II	0.18	II	0.17
III	0.13	III	0.17	III	0.17	III	0.15	III	0.14
IV	0.18	IV	0.17	IV	0.19	IV	0.17	IV	0.19
2003		**2004**		**2005**		**2006**		**2007**	
I	0.18	I	0.17	I	0.17	I	0.17	I	0.17
II	0.16	II	0.16	II	0.17	II	0.16	II	0.15
III	0.15	III	0.14	III	0.15	III	0.14	III	0.14
IV	0.19	IV	0.19	IV	0.17	IV	0.18	IV	0.20

The econometric estimation of equation (25) was done for an endogenous threshold Θ^0=0.3104. The residual sum of squares depending on different discrete values of Θ^0 is shown in the following graph:



Residual Sum of Squares depending on Θ^0

Results for the econometric estimation are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	-0. 61887	0.8909873	-0.69
β	1.036205	0.1502917	6.89
γ	-7.83730	4.313162	-1.82
α	0.39420	0.1482395	2.66
δ	0.63872	0.0568126	11.24

and the value of the threshold is significatively different from 0 with *F*=2.8538 and *Pr* > *F* 0.1003. The solution of (23) yields the size of the shadow economy (hidden GDP) as a share of total (registered plus hidden) GDP for each quarter as:

1998		1999		2000		2001		2002	
I	0.13	I	0.14	I	0.14	I	0.14	I	0.13
II	0.15	II	0.14	II	0.13	II	0.14	II	0.13
III	0.00	III	0.13	III	0.13	III	0.12	III	0.11
IV	0.14	IV	0.13	IV	0.15	IV	0.13	IV	0.14
2003		**2004**		**2005**		**2006**		**2007**	
I	0.14	I	0.14	I	0.13	I	0.13	I	0.13
II	0.13	II	0.12	II	0.13	II	0.12	II	0.12
III	0.12	III	0.11	III	0.11	III	0.00	III	0.00
IV	0.15	IV	0.14	IV	0.14	IV	0.14	IV	0.15

Equations (24) and (25) were also estimated considering that the opportunity cost of holding cash is the rate of interest on deposits in levs. So, in these estimations *i* is the quarterly average annual nominal interest rate on time deposits in levs.

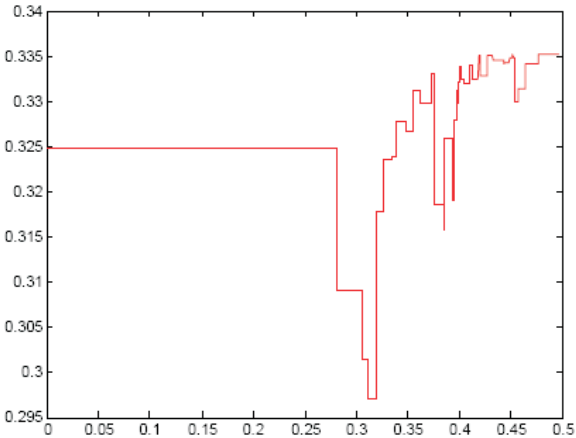
Results for the econometric estimation of equation (24) for an arbitrarily chosen threshold Θ^0=0 (the standard application of the method) are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	-0. 49325	0.9877559	-0.5
β	1.12824	0.1558927	7.24
γ	-23.8972	4.900601	-4.88
α	0.47962	0.3207098	1.5
δ	0.73255	0.0519624	14.10

and the solution of (22) yields the size of the shadow economy (hidden GDP) as a share of total (registered plus hidden) GDP for each quarter as:

1998		1999		2000		2001		2002	
I	0.17	I	0.19	I	0.19	I	0.19	I	0.18
II	0.19	II	0.19	II	0.17	II	0.19	II	0.17
III	0.14	III	0.17	III	0.18	III	0.16	III	0.15
IV	0.19	IV	0.18	IV	0.19	IV	0.17	IV	0.19
2003		**2004**		**2005**		**2006**		**2007**	
I	0.18	I	0.18	I	0.18	I	0.18	I	0.18
II	0.17	II	0.17	II	0.18	II	0.16	II	0.16
III	0.16	III	0.15	III	0.16	III	0.15	III	0.15
IV	0.20	IV	0.19	IV	0.18	IV	0.18	IV	0.20

The econometric estimation of equation (25) was done for an endogenous threshold Θ^0=0.3104. The residual sum of squares depending on different discrete values of Θ^0 is shown in the following graph:



Residual Sum of Squares depending on Θ^0

Results for the econometric estimation are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	-0. 67821	0.9221515	-0.74
β	1.16197	0.1452246	8.0
γ	-22.70688	4.950818	-4.59
α	0.35682	.1169637	3.05
δ	0.72398	0.0520827	13.9

and the value of the threshold is significatively different from 0 with *F*=2.9107 and *Pr* > *F* 0.0971. The solution of (23) yields the size of the shadow economy (hidden GDP) as a share of total (registered plus hidden) GDP for each quarter as:

1998		1999		2000		2001		2002	
I	0.14	I	0.15	I	0.16	I	0.16	I	0.15
II	0.16	II	0.16	II	0.14	II	0.16	II	0.14
III	0.00	III	0.14	III	0.15	III	0.13	III	0.12
IV	0.16	IV	0.15	IV	0.16	IV	0.14	IV	0.16
2003		**2004**		**2005**		**2006**		**2007**	
I	0.15	I	0.15	I	0.15	I	0.15	I	0.15
II	0.14	II	0.14	II	0.15	II	0.14	II	0.13
III	0.13	III	0.13	III	0.13	III	0.00	III	0.00
IV	0.16	IV	0.16	IV	0.15	IV	0.15	IV	0.17

6. Conclusions and Comparisons

The monetary method to measure the size of the shadow economy is based on econometric estimates of the demand for money. These estimates are used to get the currency held by economic agents in excess of the amount they need to finance registered transactions. The standard monetary approach uses the excess of currency multiplied by the velocity of circulation (assumed to be equal in the registered and the shadow economies) to measure hidden GDP but there are some pitfalls that appear in most publications on the applications of the method.

The first pitfall appears when it is assumed that circulation velocities are equal for registered and hidden sectors. This assumption is accurate only when the income elasticity of the demand for money is one. An explicit recognition that circulation velocities depend on the value of the income elasticity of the demand for money allows a direct econometric estimation of the size of the shadow economy.

The second pitfall appears when short-run representations of the money demand that include the lagged dependent variable are used to estimate the size of the shadow economy. In this case, a past value of the demand for cash used for hidden transactions should be known and this implies assuming that there is a point in time in which no shadow economy existed. So, the only way to avoid *ad hoc* assumptions about previous values of registered currency is to restrict the measures of the shadow economy size to those based on the long run estimates of the money demand.

The third pitfall appears in papers assuming that only values of the burden of taxes and government regulations exceeding a minimum threshold induce economic agents to hide transactions. The value of the threshold is usually chosen arbitrarily as an exogenous parameter. The idea of the existence of such threshold is a plausible one but its value should be selected endogenously.

The corrected method was applied for measuring the size of the shadow economy for Bulgaria. Quarterly estimates were obtained for a period beginning in the first quarter of 1998 and ending in the fourth quarter of 2007. Observations start after the introduction of a currency board arrangement in Bulgaria in July 1997.

Results show that the size of the Bulgarian shadow economy is between 12.2 per cent and 17.5 per cent of its registered or observed GDP as an average for the whole review period depending on the model specification and the definition of variables.[17] These results are lower than previous published estimations. Schneider and Enste (2002) report the average size of the Bulgarian shadow economy as 24.0 per cent of GDP for the period 1989–1990, 26.3 per cent for the period 1990–1993 and 32.7 per cent for the period 1994–1995.[18] The method applied to get these estimations is based on observed discrepancies between the quantity of electricity used as an input and the level of the outputs declared by industrial firms. Nenovsky and Hristov (2000) applied the standard monetary approach for measuring the size of the shadow economy in Bulgaria using quarterly data for the period 1997–1999 and concluded that its average value[19] was 26.78 per cent of registered GDP. They also noted that "...the method applied by us for measuring the shadow economy encompasses only that part which is serviced with levs, i.e. our method does not provide an estimate of the shadow economy that is serviced with foreign currencies..." Based on this logic, the obtained estimates are considerable lower than the actual ones. In other words, our estimates can be regarded as a *shadow economy minimum*.[20] This caveat also applies to the results presented in this paper.

The average size of its shadow economy (between 12.2 per cent and 17.5 per cent of the registered or observed GDP) puts Bulgaria in a set of European countries including Spain (between 16.1 per cent and 17.3 per cent), Sweden (between 15.8 per cent and 17.0 per cent) and Norway (between

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[17] Several models were tried. Average shares of the shadow economy in registered GDP were 12.2 per cent for a model including a threshold for the variable inducing agents to perform hidden transactions and in which the opportunity cost of holding cash was measured as an interest rate in euro, 13.6 per cent for a model including a threshold for the variable inducing agents to perform hidden transactions and in which the opportunity cost of holding cash was measured as an interest rate in levs, 16.8 per cent for a model with no threshold for the variable inducing agents to perform hidden transactions and in which the opportunity cost of holding cash was measured as an interest rate in euro and 17.5 per cent for a model with no threshold for the variable inducing agents to perform hidden transactions and in which the opportunity cost of holding cash was measured as an interest rate in levs.

[18] **Schneider and Enste** (2002), Table 4.2, p. 34.

[19] **Nenovsky and Hristov** (2000), p. 28.

[20] **Nenovsky and Hristov** (2000), p. 28.

14.8 per cent and 16.7 per cent) which are below Italy (between 22.8 per cent and 24.0 per cent) and Belgium (between 19.3 per cent and 20.8 per cent) and above the Netherlands (between 11.9 per cent and 12.7 per cent), Germany (between 11.8 per cent and 12.5 per cent), France (between 9.0 per cent and 13.8 per cent), Denmark (between 10.8 per cent and 15.0 per cent), Ireland (between 11.0 per cent and 14.2 per cent), Great Britain (between 9.6 per cent and 11.2 per cent), Switzerland (between 6.7 per cent and 6.9 per cent) and Austria (between 5.1 per cent and 6.1 per cent).[21]

[21] Data for European countries (except Bulgaria) are taken from **Schneider and Enste** (2002), Table 4.3, p. 35. It has been obtained using the standard monetary method for1989–1990 and 1990–1993.

APPENDICES

Appendix 1

1. Definition of variables

C_0 is real cash balances (the real value of bills and coins) hold by economic agents. It is nominal currency outside banks deflated by the CPI. A real cash balance is a stock variable and it has been calculated as the average of the real stock at the beginning of the quarter (end of previous quarter) and the real stock at the end of the quarter to centre the value of the variable in the middle of the quarter.

Y_0 is the scale variable. It is real GDP. It has been calculated as quarterly nominal GDP (from national accounts) deflated by the CPI.

i is the opportunity cost of holding cash. Two alternative rates were tried: the quarterly average annual nominal interest rate on time deposits in euro and the quarterly average annual nominal interest rate on time deposits in levs,

Θ is the burden of government (taxes and regulations) on the economy. It is the share of nominal government expenditures in GDP. It has been calculated as the ratio between Nominal Government Expenditures from the Consolidated Government Budget and Nominal GDP from the National Accounts.

D/Y_0 is the quarterly average of total nominal overnight deposits as a share of registered GDP. D/Y_0 has been calculated as the monthly average of total nominal overnight deposits for each quarter.

2. Data

Data used in estimations appear in sheets 1 (raw) and 2 (elaborated) of the file BGdataQ.xls.

Appendix 2

This appendix presents some alternative estimations performed with equations (24) and (25).

When the process of financial deepening is ignored (i.e. making D_t/ Y_{0t}=0) and the threshold is arbitrarily chosen as zero (Θ^0=0), equation (24) becomes a classic Tanzi cash demand function. The results of the econometric estimation of this equation version (24) are the following:

Coefficient	Value	Newey-West S.E.	t
ln A	-3.96286	1.20955	-3.28
β	1.40135	0.1995103	7.02
γ	13.00696	10.07739	1.29
α	0.91266	0.7099509	1.29

In this estimation the opportunity cost of holding cash is the quarterly average annual nominal interest rate on time deposits in levs

This estimation presents a high β and a positive γ and inspection of the behavior of residuals shows positive autocorrelation.

When the process of financial deepening is ignored (i.e. making D_t / Y_{0t}=0) and the threshold is endogenously chosen as $\Theta^0 = 0.28$, the results obtained for the econometric estimation of equation (25) are the following:

Coefficient	Value	Newey-West S.E.	t
ln A	-4.07965	0.9475351	-4.31
β	1.42039	0.1759333	8.07
γ	12.11763	9.823528	1.23
α	1.05278	0.2523002	4.17

and the value of the threshold is significatively different from 0 with F=2.6881 and $Pr > F$ 0.1101.

In this estimation the opportunity cost of holding cash is the quarterly average annual nominal interest rate on time deposits in levs.

This estimation presents a high β and a positive γ and inspection of the behavior of residuals shows positive autocorrelation.

To avoid the high values of β shown in the two previous essays, an estimation of equation (25) with $D_t / Y_{0t} = 0$ and $\beta = 1$ was performed. The endogenous value of the threshold was $\Theta^0 = 0.28$ and the results of the econometric estimation of this version of equation (25) are:

Coefficient	Value	Newey-West S.E.	t
ln A	–2.09386	0.3453554	-6.06
β	1.0	–	–
γ	24.66982	9.136332	2.70
α	0.8453185	0.3173508	2.66

and the value of the threshold is significatively different from 0 with F=2.0968 and $Pr > F$ 0.1565.

In this estimation the opportunity cost of holding cash is the quarterly average annual nominal interest rate on time deposits in levs.

This estimation presents a positive γ and inspection of the behavior of residuals shows positive autocorrelation.

Two estimations were done introducing the annual nominal interest rate on time deposits in euro.

When the process of financial deepening is ignored (i.e. making D_t / Y_{0t}=0) and the threshold is arbitrarily chosen as zero (Θ^0=0), equation (24) becomes a classic Tanzi cash demand function. The results of the econometric estimation of this equation version (24) are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	--4.62074	1.036541	-4.46
β	1.59209	0.16112	9.82
γ	-1.7202	8.337473	-0.21
α	1.12187	0.6567903	1.71

This estimation has the expected sign for γ but it still presents a high value for β and inspection of the behavior of residuals shows positive autocorrelation.

When the process of financial deepening is ignored (*i.e.* making D_t / Y_{0t}=0) and the threshold is endogenously chosen as Θ^0=0.28, the results obtained for the econometric estimation of equation (25) are the following:

Coefficient	Value	Newey-West S.E.	*t*
ln *A*	-4.63530	0.8455477	-5.48
β	1.59794	0.1471279	10.86
γ	-2.50514	8.104781	-0.31
α	1.14647	0.2189041	5.24

and the value of the threshold is significatively different from 0 with F=2.8025 and $Pr > F$ 0.1030.

This estimation has the expected sign for γ but it still presents a high value for β and inspection of the behavior of residuals shows positive autocorrelation.

The positive autocorrelation of the residuals suggests that a variable is missing in the estimated equations.

The estimations presented in the main text include a variable taking account of the process of financial deepening that took place in Bulgaria during the period under analysis.

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