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UNIVERSITY OF AARHUS • DENMARK

INSTITUT FOR ØKONOMI

AFDELING FOR NATIONALØKONOMI - AARHUS UNIVERSITET - BYGNING 350
8000 AARHUS C - ☎ 89 42 11 33 - TELEFAX 86 13 63 34

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Estimating the Shadow Economy in Italy: a Structural Equation Approach[*]

Roberto Dell'Anno[†]

May 2003

Abstract

The aims of this paper are, firstly, to estimate the Italian shadow economy by means of a structural equation approach and, secondly, to verify the generality of the main criticisms about the reliability of the "MIMIC method" (or model approach) for this kind of analysis.

Using the Italian shadow economy, I will show how only some of these are confirmed, others exist as a consequence of the model implementation and sample and some more will exposed to question this methodology. Particular attention is paid to detect the assumptions that should be respected to use appropriately this technique (test of multinormality, independence between measurement and structural errors, unit root detection, etc.). According to the obtained results, is confirmed a sufficient reliability of this approach for the estimate of the size of underground economy.

Keywords: Shadow Economy, Structural Equation Model, Tax Evasion

JEL Classification: O17, C39, H26.

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[†] Department of Economics and Statistics, University of Salerno, Via Ponte Don Melillo, 84084 Fisciano (Sa) – Italy; e-mail: rdellanno@unisa.it

1 Introduction

Many studies and various techniques have been developed, in order to assess the size of unofficial economic activities, but unluckily, for those countries that are common to multiple studies, there is a clear evidence of their divergent outcomes (Fleming et al. , 2000). In this meaning, they are not considerable, to some degree, very reliable methods to estimate the dimension of black economy.

The model approach or MIMIC (**M**ultiple **I**ndicators and **M**ultiple **C**auses) approach is one of these. It considers the dimension of the hidden economy like a "latent variable", therefore it applies the statistical modelling, namely **S**tructural **E**quation **M**odelling (SEM), usually utilized by social research (psychology, sociology, marketing, etc.) to explore this kind of unobservable variables (for example: attitudes, personality, belief, satisfying, etc.).

The aims of this work are, firstly, to produce an estimate of the Italian shadow economy by means of a structural equation approach and, secondly, to verify the generality of the main criticisms about the implementation of this technique for this purpose. Yet, the most common theoretical prepositions about the causality relationships between shadow economy and its determinants, as well as the ambiguous correlation between the unofficial economic activities and the growth rate of GDP are analysed.

About the reliability of model approach, since the first figures pointed out by Frey and Weck-Hannemann (1984), it has improved its statistical accurateness. According to Schneider and Enste (2000), the MIMIC approach shows some progress in the estimation techniques of underground economy. This methodology allows wide flexibility in its framework, therefore it is potentially inclusive of all the indirect methods and thus theoretically, superior to others. Cassar (2001) emphasizes as, in contrast with other indirect methods, it does not need restrictive or implausible assumptions to operate (with exception of the "calibrating value"). Yet, Thomas (1992) states that the only real constraint of this approach is not in its conceptual structure but in the variables chosen. These reasons together with the improvements introduced by Giles (1995, 1999a) about the detection of unit roots, could explain the recent and renovate appeal of the model approach among the scholars.

Unfortunately, Helberger and Knepel (1988) and Schneider (1997) identified several limitations of the MIMIC approach.

The main objections are: (I) there exists instability in the estimated coefficients as the sample size changes[2]; (II) the estimation of the parameters is extremely unstable with respect to alternative model specifications[3]; (III) is complicated to undertake the estimation procedure a pure time-series analysis[4]; (IV) the difficulty in obtaining reliable data on variables other than taxes[5]; (V) the reliability of "causes" and

[2] Helberger C., Knepel H. (1988), pp. 966.
[3] Ibid.
[4] Schneider F. (1997), pp. 47.
[5] Ibid.

"indicators" in explaining the variability of the shadow economy[6]; (VI) the ambiguous meaning of unobservable variable[7].

Using the Italian shadow economy, I will show how only some of these are confirmed, others exist as a consequence of the model implementation and sample and some more will exposed to question this methodology.

The paper is organized as follows. After a preface (paragraph 2), which is necessary to define shadow economy, and a brief survey about the methods to estimate it, in paragraph 3 the SEM is presented. In the 4th section, are discussed the specification of the models and the structural relationships between causes and indicators of shadow economy (which variables should be included in the model? Why assume the relation of causality among the variables? What does literature say about the expected "signs" of coefficients?). In section 5, the models are identified and the structural parameters are tested. Special attention is placed to verify if the assumption of multinormal distribution, required to utilize Maximum Likelihood Estimators (MLE) asymptotically efficient, is respected. In the 6th paragraph, the procedure to obtain the index of the underground economy as a share of official GDP is discussed; moreover, a comparison with other recent estimates is shown. In section 7, summarized are the empirical outcomes of the estimates. The paper ends with some general conclusions about the reliability of the model approach. Five statistical appendixes are supplied.

2 Shadow Economy: Definitions and Methods to Estimate

Before we introduce the structural equation modelling, it is necessary to give a definition of the object of analysis, and summarize the most common techniques developed, in order to measure the size of underground economy. To these aims are devoted the next two paragraphs.

2.1 Definitions of Shadow Economy

The first problem researcher meets with, by approaching this topic, is about the definition and the consequent meanings of shadow economy.

As Tanzi (1999) remarks, exist at least two definitions and thus two measures of the underground economy. The first, is connected to the production (or income) missed in the official statistics; the other, refers to "…*revenue not reported to, and not discovered by, the tax authorities"*. Consequently, *"…the first measure implies that the country is richer than the official statistics show"*[8]*,* the second (namely, tax evasion) indicates that the tax administration draws less revenue than it should.

[6] Schneider F. (1997), and Thomas J. (1992).
[7] Helberger C., Knepel H. (1988), pp. 970
[8] Tanzi V., (1999), pp. 344.

Notwithstanding this difference, the expression tax evasion is often used as synonym of underground, hidden, shadow, black, clandestine, illegal, parallel, irregular, unofficial, subterraneous, informal, economy[9]. One of the broadest definitions of it, includes "*...those economic activities and the income derived from them that circumvent or otherwise elude government regulation, taxation, or observation.*"[10].

Following Fleming et al. (2000), it is possible to distinguish two approaches, in defining hidden economy:

-The Definitional approach, which considers it as simply unrecorded economic activities. Thomas (1999) agrees with this approach, and includes in the underground economy "*...those activities which...are not recorded in the national income accounts*"[11]; for Schneider and Enste (2000) it holds "*all economic activities which contribute to the officially calculated (or observed) gross national product*"[12]; for Smith (1994) this sector is a "*...market-based production of goods and services, whether legal or illegal, which escapes detection in the official estimates of GDP*"[13].

-The Behavioural approach emphasizes the relevance of institutional rules and of the social environment. It interprets the shadow economy as a change in behaviours by economic agents in reaction to institutional constraints. We could include the definitions of Feige (1989) "*...economic activities include conscious efforts to avoid official detection*" [14], and Feige (1990) "*The characteristics of each distinct informal economy are determined by the particular set of institutional rules that its members circumvent*"[15], or Loayza (1996) "*Informal economy is unregulated by the institutions of society, in a legal and social environment in which similar activities are regulated*" [16].

To obtain a more accurate definition of hidden economy is possible to refer at the System of National Accounts (SNA93) and the European System of National Accounts (ESA95)[17].

They define a "non observed economy", it comprises all product activities that can be classified into the following three areas:

(1) Underground production;
(2) Informal production;
(3) Illegal production.

The Underground production represents the area of production activities that are not directly observed due to:

(1.a) Economic reasons (the activities carried out with the deliberate desire to avoid taxes, social contributions in the favour of employees or, also, to avoid observing the law provisions concerning minimum wages, the number of work hours, job safety, etc.)

(1.b) Statistical reasons (production activities that are not registered due to:

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[9] *"...much tax evasion has nothing to do with the shadow economy, for instance one may simply cheat on one's tax declaration by overestimating deductions or by underreporting income or sales*". Tanzi V. (1999), pp. 344.

[10] Feige E.L. (1989), pp. 1.

[11] Thomas J. (1999), pp. 387.

[12] Schneider F., Enste D. (2000), pp. 5.

[13] Smith P. (1994), cited in Schneider F., Enste D. (2000), pp. 5.

[14] Cited in Fleming M.H., Roman J., Farrell G. (2000), pp. 387.

[15] Feige E.L. (1990), pp. 990; cited in Fleming M.H., Roman J., Farrell G. (2000), pp. 390.

[16] Loayza N.V. (1997), pp.1; cited in Fleming M.H., Roman J., Farrell G. (2000), pp. 390.

[17] For more details see: Baldassarini and Pascarella (2003), OECD (2002), Baldassarini and Pisani (2000), Calzaroni (2000).

- The failure to fill out the administrative forms or statistics questionnaires because of the lack of sensitivity to statistics of those asked to fill them out and/or shortcomings in the statistics system;
- The difficulty in grasping the changes of a rapidly evolving productive system, characterised by small productive activities which are often not detectable with the traditional survey techniques.

The Informal production refers to productive institutional units characterised by:

(2.a) a low level of organisation;

(2.b) little or no division between work and capital;

(2.c) work relations based on occasional jobs, kinship, or personal relations. (This context comprises the activity of craftsmen, peddlers without licences, farm workers, home workers, and the unregistered activities of small merchants).

The Illegal activities are all those oriented to the production of goods and services whose sale, distribution or possession is prohibited by law. Falling within this area are also the productive activities carried out by unauthorised operators. Due to the difficulty of estimation, that could be limited the international comparability, the illegal activities are excluded by the national accounts.

Accordance to the SNA93 and ESA95 classification, the use of the terms: non-observed, underground, informal, illegal, economy is not just a question of nomenclature. They clearly measure four different aggregates therefore require four diverse theoretical and empirical methodologies of estimate.

Notwithstanding this remarks, in accordance with the prevalent literature, in this paper I will use underground, informal, illegal, hidden, shadow, black, parallel, unofficial, subterraneous, economy like synonymies.

2.2 Methods of Measuring the Shadow Economy

In the last twenty years publications have increased, concerning methods and estimates of shadow economy (e.g. Feige 1989; Cowell 1990; Thomas, 1992; Pedersen, 1998; Eilat and Zinner, 2000; Schneider and Enste, 2000; Giles and Tedds 2002; etc.). In this section, a brief classification of the different techniques that have been developed to estimate the level of underground economy is presented. Usually, the methods are be placed into three groups[18]:

The **Direct methods** are based on contacts with or observations of persons and/or firms, to gather direct information about not declared income. There are two kinds: (1) the auditing of tax returns and (2) the questionnaire surveys.

The **Indirect methods** try to determine the size of hidden economy, by measuring the "traces" that it leaves in official statistics. They are often called "indicator" approaches and using mainly macroeconomic

[18] It has become impossible to keep track of the hundreds of publications about the estimating of tax evasion, therefore, the citations are limited only about the references concerning the method followed in this paper: the model approach.

data. This strategy include five categories: (1) Discrepancy between national expenditure and income statistics; (2) The discrepancy between the official and actual statistics of labour force; (3) The transaction approach; (4) The currency demand (or cash-deposit ratio) approach; (5) The physical input (e.g. electricity) method.

The **model approach** (or MIMIC method) is based on the statistical theory of latent variables, which considers several causes and several indicators of the hidden economy.

Frey and Weck-Hanneman (1984) have been the first to consider the size of hidden economy as an "unobservable variable". They introduced the MIMIC model of Zellner (1970), Goldberger (1972), Jöreskog and Goldberger (1975) and others in this field. It is a member of the LISREL "**L**inear **I**nterdependent **S**tructural **Rel**ationships" family of models (see Jöreskog and Sörbom, 1993). Following Frey and Weck-Hanneman's example, others economists used this approach for their statistical analysis of the "unofficial" economy: Aigner, Schneider and Ghosh (1988), Helberger and Knepel (1988), Loayza (1996), Pozo (1996), Giles (1995, 1998, 1999a 1999b), Tedds (1998), Eilat and Zinnes (2000)[19], Salisu (2000)[20], Cassar (2001), Prokhorov (2001), Giles and Tedds (2002), Chatterjee, Chaudhuri and Schneider (2003).

3 Structural Equation Modelling: The MIMIC model

SEM are statistical relationships among latent (unobserved) and manifest (observed) variables. It implies a structure of the empirical or databased covariance matrix[21] which, once the parameters have been estimated, can be compared to the resulting model-implied covariance matrix.

If the two matrices are consistent with one another, then the structural equation model can be considered as a likely explanation for the relations among the examined variables.

Compared with the regression and the factor analysis, SEM is a relatively young tool. Just to cite the most comprehensive discussions of its applications: for the sociology: Bielby and Hauser (1977), for the psychology: Bentler (1986), for the economics: Goldberg (1972), Aigner et al. (1984) and for an overview about SEM: Hayduk (1987), Bollen (1989), Hoyle (1995), Maruyama (1997), Byrne (1998).

As Cooley (1978) writes, this approach allows to establishing the plausibility of a theoretical model and to determine the degree to which the explanatory variables have an effect on the unobservable variable.

SEM is an alternative way to test the consistency of a "structural" theory through data; in this sense it is a largely "confirmatory", rather than "exploratory", technique. A researcher should subsequently be more likely to use SEM to determine whether a certain structure is valid, rather than using SEM to "find" a suitable model.

In this work, one special case of SEM is used: the **M**ultiple **I**ndicators and **M**ultiple **C**auses model. This model is introduced by Jöreskog and Goldberg (1975).

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[19] They use a Single Indicators Multiple Causes (SIMIC) model.

[20] He applies a Single Indicators Multiple Causes (SIMIC) model

[21] Hence an alternative name for this field is "analysis of covariance structures".

The shadow economy (η) is linearly determined, subject to a disturbance ζ, by a set of observable exogenous causes $x_1, x_2, \ldots, x_q$:

$$\eta = \gamma_1 x_1 + \gamma_2 x_2 + ... + \gamma_q x_q + \zeta \qquad (1)$$

The latent variable (η) determines, linearly, subject to a disturbances $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_m$, a set of observable endogenous indicators $y_1, y_2, \ldots, y_p$:

$$y_1 = \lambda_1 \eta + \varepsilon_1 \ , \quad y_2 = \lambda_2 \eta + \varepsilon_2 \ , \quad .... \ , \quad y_p = \lambda_p \eta + \varepsilon_p . \qquad (2)$$

The structural disturbance $\boldsymbol{\zeta}$, and measurement errors $\boldsymbol{\varepsilon}$ are all normal distributed, mutually independent and all variables are taken to have expectation zero.

Considering the vectors:

$\mathbf{x'} = (x_1, x_2, \ldots, x_q)$	observable exogenous causes
$\boldsymbol{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_q)$	structural parameters (Structural Model)
$\mathbf{y'} = (y_1, y_2, \ldots, y_p)$	observable endogenous indicators
$\boldsymbol{\lambda} = (\lambda_1, \lambda_2, \ldots, \lambda_p)$	structural parameters (Measurement Model)
$\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_p)$	measurement errors
$\boldsymbol{\upsilon} = (\upsilon_1, \upsilon_2, \ldots, \upsilon_p)$	standard deviations of the $\boldsymbol{\varepsilon}$'s

The (1) and (2) are wrote as:

$$\eta = \gamma' x + \zeta \qquad (3)$$

$$y = \lambda \eta + \varepsilon \qquad (4)$$

by assuming $E(\zeta\varepsilon') = 0'$ and defining $E(\zeta^2) = \sigma^2$ and $E(\varepsilon\varepsilon') = \Theta^2$, where $\underset{(pxp)}{\Theta}$ is diagonal matrix with υ, displayed on its diagonal[22]. The model can be solved for the reduced form as function of observable variables:

$$\mathrm{y} = \lambda(\gamma' \mathrm{x} + \zeta) + \varepsilon = \Pi' x + v \qquad (5)$$

the reduced form coefficient matrix and disturbance vector are respectively:

$$\Pi = \gamma\lambda', \quad \text{and} \quad \mathrm{v} = \lambda\zeta + \varepsilon.$$

Therefore, is obtained the covariance matrix (model-implied):

$$\hat{\Sigma} = \mathrm{E}(\mathrm{vv}') = \sigma^2 \lambda\lambda' + \Theta^2 . \qquad (6)$$

The assumption on independence between structural disturbance $\boldsymbol{\zeta}$, and measurement errors $\boldsymbol{\varepsilon}$ is central to the reliability of estimates. Unluckily, previous studies do not test this hypothesis and, the SEM packages, do not perform test about it. This constraint on disturbances could be considered too restrictive manly using economic dataset and, consequently, espoused to question the validity of this approach.

Fortunately, as Hayduk (1987) explains it"…*is purely a matter of arbitrary convention*"[23] and is possible through a model re-paramtrization to test this assumption (the analysis is shown in appendix E). The tests do not

[22] In the standard MIMIC model the measurement errors are assumed to be independent of each other, but this restriction could be relaxed. (see Stapleton D.C. 1978, pp. 53). In this analysis, greater number of models estimated, the covariance between the real growth rate of GDP (Y_1) and the growth rate of currency (Y_2) is not statistically different from zero. Yet, in the models where this assumption is relaxed the changes in the estimates of

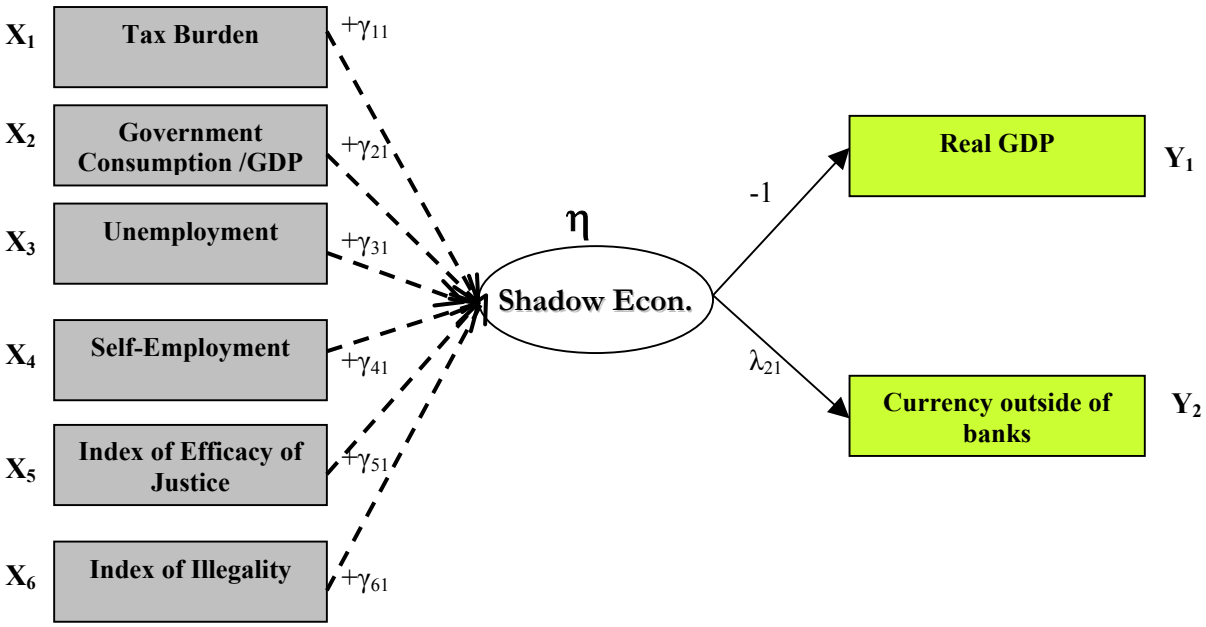
reject the hypothesis of independence between structural and measurement errors, therefore the MIMIC is correctly applied.

4 Specification of Model: the Theoretical Background

The MIMIC approach considers the size of the hidden economy as a "latent" variable, linked, on the one hand, to a number of observable indicators (reflecting changes in the size of the shadow economy) and on the other, to a set of observed causal variables, which are regarded as some of the most important determinants of the unreported economic activity.

The identification procedure starts from the most general specification (MIMIC 6-1-2)[24] and continues leaving out the variables which have not structural parameters statistically significant[25] (Graph 1).

Graph[26] 1: MIMIC 6-1-2



The shadow size is obviously restricted to be examined as a linear combination of a small set of variables, and certainly other and/or more suitable data can be employed, to explain a very complex phenomenon as the underground economy. As Duncan (1975) points out: "*The meaning of the latent variable depends completely on how correctly, precisely and comprehensively the causal and indicator variables correspond to the intended semantic content*

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structural coefficients are slightness, therefore the standard restriction is hold in order to have more degrees of freedom.

[23] Hayduk Leslie A. (1987), pp. 193.

[24] This nomenclature means a structure with six determinants and two indicators of one latent variable.

[25] The SEM permits to consider and estimate the correlations between the X-variables. In my analysis as expected is statistically different from zero the correlation between tax burden and government consumption as well as the index of efficacy of justice and the index of illegality.

of the latent variable"[27], likewise Thomas (1992) indicates in the choice of variables the only real limit of this approach. The next eight paragraphs are devoted to support theoretically the presence of these variables in the econometric framework.

Explanatory variables (Causes):

4.1 Tax Burden

In literature the most popular determinant of tax evasion is tax rates. The common hypothesis is that an increase of tax burden furnishes a strong incentive to work in the unofficial market.

Very extensive studies have provided theoretical foundations to the hypothesis that underground economy increases with tax burden (e.g. for the first Allingham and Sandmo, 1972). As regards the empirical analysis, just a quote among the most recent are: Thomas (1992), Lippert and Walker (1997), Schneider (1994a, 1994b, 1997, 1998), Schneider and Enste (2000), Johnson, Kaufmann and Shleifer (1997), Johnson, Kaufmann and Zoido-Lobaton (1998), Tanzi (1999), Giles (1997, 1999b), Giles and Tedds (2002), etc. Among these, Johnson et al. (1998) consider tax burden one of the three main causes[28] of underground economy; Schneider and Enste (2000) argue that the taxes, together with the State regulatory activities, are the most important determinants behind the growth of hidden economy. Additionally, in all the MIMIC applications this variable is included and, a strong (direct) effect on the shadow economy, is confirmed.

In the econometric framework, the tax burden is measured by means of the total share of direct and indirect taxes and social contribution, as a percentage of gross domestic product.

4.2 Real Government Consumption

According to Aigner et al. (1988), a rise in the size of public sector, and/or the degree of regulation of the economic system, gives a relevant incentive to enter in the informal economy. Johnson, Kaufmann, and Shleifer (1997) and Johnson, Kaufmann, and Zoido-Lobaton (1998) state that the degree of *"…regulatory and burocracy discretion is a key determinant of underground activity*"[29]. Yet, Frey and Weck-Hanneman (1984) and Giles, Tedds (2002) find a significant and positive relationship between a proxy of regulation burden and the hidden economy.

To take this into account, the real government consumption is introduced as a proxy of all State activities.

An eventual positive sign of this coefficient will support the hypothesis that "more State" in the market, and subsequently an increase in regulation, gives an incentive to operate in the unofficial economy.

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[26] In order to eliminate the non-stationarety: X_1, X_2, X_3, X_4, X_5 are taken as first differences, X_6, Y_1, Y_2 are converted in the first differences of logarithm.

[27] Duncan O. D. (1975), pp. 149, cited in Giles D.E.A., Tedds L.M. (2002), pp. 103.

[28] The others two causes are regulation and corruption.

[29] Johnson S., Kaufmann D., Zoido-Lobáton P. (1998), pp. 391.

4.3 Unemployment rate

As Giles and Tedds (2002) state, there are two antagonistic forces which determine the relationship between the unemployment rate and the shadow economy. On one side an increase in unemployment should imply a decrease in the black economy as the underground economy is positively related to the growth rate of GDP and the latter is negatively correlated to unemployment. On the other side some "official" unemployed spend a portion of their time in working in the black economy[30], thus there is a positive correlation.

Tanzi (1999) writes that "…*the relation between the shadow economy and the unemployment rate is ambiguous*"[31]. He remarks that very heterogeneous workers compose the labour force of hidden economy. A part of those is classified as unemployed because they are components of the official labour force, the other part of "hidden" workers is composed by retired people, illegal immigrants, minors or housewives who are not part of the official work force, furthermore, there are people who have at the same time an official and unofficial job[32]. In this sense, the official unemployment rate is weakly correlated with the shadow economy[33]. In the same work, Tanzi states that "...f*or OECD countries there seems to be a broad relation between the panel data of the size of underground economy and the official unemployment rates"*[34].

4.4 Self-Employment

The rate of self-employement as a percentage of the labour force is considered as a determinant of informal economy. According to Bordignon and Zanardi (1997), the significant diffusion of small firms and the large proportion of professionals and self-employed respect to the total workforce[35] are the most important characteristics that distinguish the Italian productive system from the other economies of Western Europe.

As the two authors remark: "*a large proportion of professionals and self-employed implies greater possibilities for transferring expenses from consumption to production (to be deducted from taxes), simplified accounting, and easier path collusion with customers*"[36].

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[30] Giles D.E.A., Tedds L.M. (2002), pp. 127.
[31] Tanzi V. (1999), pp. 341.
[32] Tanzi V. (1999), pp. 343.
[33] To confirm this view, the Italian empirical evidence shows that only the 30% of non-regular workers are components of the official labour force (ISTAT, 2001).
[34] Tanzi V. (1999), pp. 343
[35] "According to OECD estimates for 1993, the ratio of self-employed to the total workforce, net of farm workers, was 26,7% in Italy as compared to 8,4% in Germany, 8,8% in France, and 13,1% in the United Kingdom. Companies with more than 100 employees at the end of 1980s accounted for just a little over 20% of the total workforce as compared to over 80% in the UK and Germany." Bordignon M., Zanardi A. (1997), pp. 172.
[36] Bordignon M., Zanardi A. (1997), pp. 172.

Indexes of "Rule of Law":

The lasts two determinants of illegal economy are linked with sociological characteristics and aspects of system for the repression of crime. Behind these regressors are three assumptions:

1) The efficacy of tax judicial system can be approximate to the efficacy of the criminal judicial system. This statement presupposes that the Italian State manages the fight against crimes (more dangerous for the community) and the tax offences alike.
2) More illegality leads to an increase in the readiness with which individuals enter in the irregular market and dodge the State.

Obviously, the proposed variables are only an attempt in order to take account of these factors in the analysis of the shadow economy that, in author's opinion, play an important role to understand correctly the dynamics of the hidden economy.

Unfortunately the reliability of these proxies[37] can be questioned for several reasons. Firstly, to quantify, with an index, the relationship between State citizen and/or community citizen is a very hard task. Objections can be raised with reference to the first assumption (i.e hypothesis that the capacity of the State to instil respect for fiscal laws is similar to its ability to punish crimes) the two systems are different in terms of procedure, structure, personnel and political interest. Specifically, it is general opinion that Italians politicians have neglected tax evasion at least until the Maastricht agreement (Bovi and Castellucci, 2001)[38]. Regarding the reliability of the number of recorded crimes like an index of illegality, it is pointed out that it can be reduced not only for a greater respect of law but also artificially due to the lack of confidence in the justice system which leads to not report crimes to the police.

According with these previous remarks, outcomes of these two variables should be considered cautiously. In order to not question the reliability of the statistical results, tests and estimates of the model all outputs are presented.

4.5 Index of Efficacy of Judicial System

An index based on statistical crimes published by ISTAT (2000) was built in order to consider the efficacy of the judicial system. It is measured by dividing the number of condemned for theft, robbery, extortion and kidnapping, for the number of the same-recorded crimes.

Following Eilat and Zinnes (2000), is assumed that an inefficient judicial system reduces the benefit of being official (access to the legal system) therefore, operating in the illegal economy became relatively more attractive. If the hypothesis that the efficacy of criminal judicial system is accepted as proxy of

[37] Previous versions of models herein estimated utilized alternative indexes proposed in literature (e.g. corruption indexes, index of economic freedom, etc.); unlikely these time series have not sufficiently sample size to allow a correct application with the model approach.

[38] This unconcern for an adequate contrast to irregular economy (verifiable by recurring conditional amnesty for tax evaders, chronic tax proceedings delays, insufficiency of auditing, etc.) can be motivated like a "compensation" for the inefficiency of public services.

efficacy in the fiscal auditing, then is expected a negative relationship between the variable and the hidden economy.

4.6 Index of Illegality

The last potential cause considered is the growth rate of the recorded crimes[39]. This index can have a double meaning: (1) it is a proxy of the illegality in the society. Increase in the recorded crimes lead to decrease in the contributors' fair attitude towards the State therefore a decline of social stigma (or reputational cost); (2) it measures the efficacy of police force to contrast the crime. About the relevance of this kind of variables, Eilat and Zinnes (2000) argue that the receipt of police protection is a fundamental element to evaluate the "cost" to participate in the illegal activities.

Indicators:

4.7 Real Gross Domestic Product (variable of scale)

The discussion about this variable is crucial to the problem of identification, as well as for the theoretical consequences it implies, mainly because it is chosen as *variable of scale* (or *reference variable*).
A priori, it is not possible to determine what is the effect of the "regular" economy on underground economy.
May a downturn in the economic official activities lead to a loss of jobs and thus drive more individuals into the hidden economy or, on the contrary, a contraction in the GDP, may reduce the demand for underground products and thus offset the first effect?
The shadow economy represents a "life jacket" for firms and individuals in financial troubles and for that reason, it increases when the GDP decreases, or rather more growth means more opportunity to evade?
Giving an answer to these scientific puzzles is a very hard task moreover, in the specified SEM, it is required as exogenous choice of the researcher.
The statistical reason is that the reduced forms (3) and (4) remain unchanged when λ is multiplied by a scalar and γ and σ are divided by the same scalar. Consequently, in order to estimate not only the relative size of the parameters but their levels, is necessary to fix a scale for the unobserved variable. A natural normalization would be to assign a unit variance to latent variable but a more convenient alternative is fix one non-zero coefficient to reduced form (4). That is, changing the scale of η would violate the normalization. In this sense, fixing the scale of measurement coefficient matrix fixes the scale of η (Stapleton, 1978).
The value of fix parameter is arbitrary, but using a positive (or negative) unit value is easier to find out the relative magnitude of the other indicator variables[40].

[39] Only the offences that involve in criminal proceedings are considered.
[40] "For instance if the estimate of one of the other elements of λ is 3, then the corresponding indicator variable is 3 times as important as the variable that is the basis for normalization". Giles D., Tedds L. (2002), pp. 109.

To choice the "sign" of coefficient of scale (λ_{11}) is based on theoretical and empirical motivations.

In literature, there is no agreement about the effects of the shadow economy on economic growth. Particularly relevant is a recent survey by Eilat and Zinnes (2000); following their review, in table 1, a broad empirical literature about this theme is summarized and special attention is paid to previous studies in which the model approach is used.

Table 1: Relationship Underground Economy – Growth rate of GDP

	Authors	Country	Notes
POSITIVE Relation	Adam, Ginsburgh (1985)	Belgium	---
	Tedds (1998)	Canada	MIMIC method
	Giles (1999b)	New Zealand	MIMIC method
	Giles, Tedds (2002)	Canada	MIMIC method
	Chatterjee, Chaudhuri, Schneider (2003)	18 Asian Countries	MIMIC method
NEGATIVE Relation	Frey, Weck-Hannemann (1984)	17 OECD countries	MIMIC method
	Helberger, Knepel (1988)	17 OECD countries	MIMIC method
	Loyaza (1996)	14 Latin America countries	MIMIC method. In economies where[41]: "(1) the statutory tax burden is larger than the optimal tax burden and (2) the enforcement of compliance is too weak", thus: The increase of the relative size of the informal economy generates a reduction of official economic growth"[42]. "The negative effect is due to the shadow economy's congestion effects that: (1) reduce the availability of public services to the official economy and (2) result in the existing public services being used less efficiently".
	Kaufmann, Kaliberda (1996)	Transition countries	The shadow economy mitigates the decrease in official GDP, particularly in countries that experienced a large drop. They find that for every 10 percent cumulative decline in official GDP, the share of the irregular economy in the overall increases by almost 4 percent[43].
	Eilat, Zinnes (2000)	24 Transition countries	"A change in GDP is associated with an opposite change in the shadow's size"[44] and "a one-dollar fall in GDP is associated with a 31percent increase in the size of the shadow economy"[45].
	Schneider, Enste (2000)	76 countries	"According to some studies, a growing shadow economy has a negative impact on official GDP growth"[46].

[41] Cited in Schneider F., Enste D., (2000), pp. 27.

[42] In particular, for a one-percentage point increase in the shadow economy (relative to recorded GDP), the growth rate of official real GDP per capita decreases by 1.22 percentage points.

[43] Eilat Y., Zinnes C. (2000), pp. 46.

[44] Eilat Y., Zinnes C. (2000), pp. 47.

[45] Ibid.

As in the MIMIC model, if the "sign" of the coefficient of scale (λ_{11}) is changed, all the structural parameters of the causes became from positive to negative (keeping the same absolute values), it is possible to use a "reductio ad absurdum" to solve this ambiguous relationship in the Italian context.

A value (+1) is assigned to λ_{11} ($Y_1 = \lambda_{11}\eta + \varepsilon_1$) consequently, the coefficients of X_1 and X_2 are negative[47], but this result completely diverges from well-known theories and empirical studies that assign a "positive" link between underground economy and tax burden and/or government consumption. For this reason the hypothesis that supports the sign "minus" for the relation between shadow economy and growth rate of GDP is accepted as more credible.

Therefore, the hypothesis of Frey and Weck-Hannemann (1984), Loayza (1996), Kaufmann and Kaliberda (1996), Eilat and Zinnes (2000) is held in this work.

4.8 Currency in circulation outside of banks

The monetary approach to estimate the size of shadow economic activities is based on the assumption that, the irregular transactions, only are paid in cash instead of cheque or credit card in order to circumvent the auditing controls. Hence, if this assumption is accepted, it is possible to estimate the hidden economy by comparing the actual demand for cash with the demand that could be expected if there were no shadow economy. In particular, the currency-ratio method, estimates changes in the currency compared to a wider monetary aggregate.

In the estimated models is not used this ratio as indicator of shadow economy but easily the growth rate of currency outside of banks. The reasons for this preference are herein summarized:

(1) A greater fluctuation of the interest rate in the considered sample, which strongly changes the "opportunity cost" to keep currency instead of deposits.

(2) The innovations in the bank system, the rise of credit cards, new kinds of debit system, etc. encourage people to put more of their money into deposit instead to keep currency[48].

(3) *"New investment incentives caused further increases in M3. All of these changes affected the ratio of currency either M1 or M3 for reasons unrelated to the size of the hidden economy*"[49].

According with Giles and Tedds' (2002) hypothesis, the growth rate of currency in circulation outside of banks is considered as more reliable then the ratio between currency and some broader measure of monetary aggregate.

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[46] Schneider F., Enste D., (2000), pp. 44.
[47] The shadow economy decreases by increasing tax burden and public consumption.
[48] Giles D.E.A, Tedds L.M. (2002), pp. 125.
[49] Ibid.

5 Model Identification and Multivariate Normality

The structural equation models are "*regression equations with less restrictive assumptions that allow measurement error in the explanatory as well as the dependent variables*"[50]. For the Lisrel nomenclature, the equations system with the relationships among the latent variable (η) and the causes (X_q) is called "structural model"; the links among indicators (Y_p) and underground economy is the "measurement model". An analytical representation of the most general model identified (MIMIC 6-1-2) is below:

Structural Model

$$\eta = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \gamma_{15}X_5 + \gamma_{16}X_6 + \zeta \tag{7}$$

Measurement Model:

$$Y_1 = \lambda_{11}\eta + \varepsilon_1 \tag{8}$$

$$Y_2 = \lambda_{21}\eta + \varepsilon_2 \tag{9}$$

To facilitate the identification of SEM three conditions are available but, unfortunately, none of these is a necessary and sufficient condition (Bollen, 1989). Especially in the case of this work the following restrictions are respected:

The necessary (but not sufficient) condition, so-called *t-rule*, enunciates that the number of nonredundant elements in the covariance matrix of the observed variables must be grater or equal to the number of unknown parameters in the model-implied covariance matrix[51].

A sufficient (but not necessary) condition of identification, is that the number of indicators is two or greater and the number of causes is one or more, provided that to η is assigned a scale (MIMIC rule).

In accordance with these conditions, the MIMIC models are built to estimate the size of shadow economy as percentage of GDP.

A relevant point, often undervalued in the previous analyses of shadow economy with SEM, is the detection of multivariate normality. This assumption is central to preserve the statistical properties of estimators, as well as the "chi-square" tests used to evaluate the fitting of models with the dataset. The next paragraphs and the appendix B are devoted to examine this aspect.

5.1 The Relevance of Multivariate Normality in the Structural Equation Models

When the variables are not (multivariately) normally distributed, then it is possible for maximum likelihood estimators, to produce biased standard errors and an ill-behaved "chi-square" test of overall

[50] Bollen K.A. (1989), pp. v.

[51] Bollen K.A. (1989), pp. 93. More clearly, the number of observed variances and covariances must be equal to or greater than the number of parameters to be estimated (including variance of latent factor, variances of disturbances, covariances among observed variables, etc.).

model fit. To determine whether multivariate nonnormality is present, Mardia's test (1970)[52] is used. It is important to highlight that, the maximum likelihood estimations, are quite robust to several types of violations of multivariate normality. *"…The issue, the is not whether nonnormality exists, but rather the degree of nonnormality is sufficient to disrupt effective data analysis"*[53].

Given an unacceptable level of nonnormality, we have some possible corrections (Bollen, 1989):

1 To transform the variables in order to obtain a better approximate to multinormality.
2 An alternative approach is to employ another estimator that, in spite of the nonnormality, keeps the asymptotic efficiency, for instance the Generalized (or Weighted) least squares estimator[54].
3 Providing adjustments to the usual statistical tests and standard errors, and therefore correcting asymptotically the fitting function (Browne, 1982, 1984).
4 Employing bootstrap resampling procedures to form nonparametric significance tests (Bollen and Stine, 1987).

For the analysis of the Italian shadow economy the first strategy is followed, as the applied transformations solve, in some cases, also the non-stationarity in the time series. The outputs of multinormality tests are shown in appendix B, to detection of the unit root, see the appendix C.

In table 2(a, b), the estimates of 24 different specifications of the Italian informal economy are presented.

[52] This test is performed by PRELIS 2.53. It is a computer software that accompanies LISREL 8.53 and performs normality diagnostics. It provides measures of univariate and multivariate skewness and kurtosis. In addition, a test "chi-square" can be used to check whether there is statistically significant difference from multivariate normality.

[53] Jaccard J., Wan C.K. (1996), pp. 75.

[54] This strategy is not used because GLS: (1) requires a very large sample [see Bollen K.A., 1989], (2) returns inaccurate parameter estimates more often than ML [see Olsson U. H., Troye S. V., Howell, R. D., 1999].

Table 2 (a): Output LISREL - Coefficients and Tests -

Models	Tax Burden	Governm. Consumpt.	Unemploym.	Self Employm.	Efficacy of the Justice	Index of Illegality	Currency	Chi-square (p-value)[1]	RMSEA (p-value)[2]	Multi Normal.[3]	Df[4]
MIMIC 6-1-2	0,58* (2,89)	1,23* (3,79)	0,51 (1,94)	0,50 (1,78)	1,51* (2,75)	4,49 (1,52)	-0,01 (-1,84)	7,81* (0,9865)	0,000* (1,00)	0,000	18
SIMIC 6-1-1	0,51* (2,49)	1,20* (3,63)	0,60* (2,24)	0,57 (1,66)	1,64* (2,93)	4,53 (1,60)	--	0,00* (1,00)	0,000* (1,00)	0,000	12
MIMIC 5-1-2	0,56* (2,74)	1,31* (4,03)	0,53* (1,98)	0,72* (2,15)	1,17* (2,25)	--	-0,01 (-1,83)	7,40* (0,8804)	0,000* (0,94)	0.111*	13
SIMIC 5-1-1	0,49* (2,34)	1,28* (3,87)	0,62* (2,28)	0,69* (2,02)	1,30* (2,46)	--	--	0,00* (1,00)	0,00* (1,00)	0,009	8
MIMIC 5-1-2	0,59* (2,79)	1,35* (4,02)	0,49 (1,79)	0,94* (2,90)	--	1,74 (0,64)	-0,00 (-2,11)	5,78* (0,9539)	0,000* (0,98)	0,000	13
MIMIC 5-1-2	0,63* (3,08)	1,12* (3,45)	0,44 (1,67)	--	1,85* (3,55)	5,45 (1,96)	-0.01 (-1,75)	7,34* (0,8342)	0,000 (0,91)	0,000	12
MIMIC 5-1-2	0,66* (3,25)	1,19* (3,61)	--	0,51 (1,49)	1,48* (2,65)	4,71 (1,66)	0,00 (-2,12)	4,38* (0,9755)	0,000* (0,99)	0,000	12
MIMIC 4-1-2	0,65* (3,26)	1,19* (3,64)	--	0,77* (2,54)	--	1,91 (0,76)	0,58 (1,36)	0,69* (0,9999)	0,000* (1,00)	0,325*	9
MIMIC 4-1-2	--	1,49* (4,54)	0,74* (2,67)	0,77* (2,19)	1,33* (2,43)	--	-0,09 (-0,25)	5,78* (0,8332)	0,000* (0,91)	0,036	10
MIMIC 4-1-2	0,61* (2,92)	1,20* (3,63)	0,45 (1,66)	--	1,51* (2,98)	--	-0,01 (-1,71)	7,42* (0,4921)	0,000* (0,63)	0,183*	8
SIMIC 4-1-1	0,54* (2,53)	1,18* (3,51)	0,54* (1,97)	--	1,53* (3,15)	--	--	0,00* (1,00)	0,00* (1,00)	0,022	4
MIMIC 4-1-2	--	1,61* (4,79)	0,64* (2,29)	1,06* (3,13)	--	1,15 (0,41)	-0,02 (-1,54)	2,79* (0,9721)	0,000* (0,99)	0,014	9
MIMIC 4-1-2	0,64* (3,09)	1,28* (3,85)	--	0,62 (1,85)	1,13* (2,13)	--	-0,01* (-2,12)	4,42* (0,8176)	0,000* (0,89)	0.223*	8
MIMIC 4-1-2	0,72* (3,31)	--	0,56 (1,90)	0,49 (1,32)	1,47* (2,55)	--	-0,26 (-1,20)	8,09* (0,6196)	0,000* (0,75)	0,018	10

For notes, see table 2 (b)

Table 2 (b): Output LISREL - Coefficients and Tests -

Models	Tax Burden	Governm. Consumpt.	Unemploym.	Self Employm.	Efficacy of the Justice	Index of Illegality	Currency	Chi-square (p-value)[1]	RMSEA (p-value)[2]	Multi Normal.[3]	Df[4]
MIMIC 4-1-2 No legality var.	0,57* (2,74)	1,37* (4,11)	0,50 (1,82)	0,96* (2,95)	--	--	0,00 (-2,08)	5,64* (0,6879)	0,000* (0,79)	0.188*	8
MIMIC 4-1-2 No labour var.	0,69* (3,37)	1,11* (3,35)	--	--	1,77* (3,36)	5,49 (1,95)	0,00 (2,02)	3,96* (0,8607)	0,000* (0,92)	0,000	9
MIMIC 4-1-2 No gover. var.	--	--	0,69* (2,26)	0,44 (1,12)	1,94* (3,04)	5,79 (1,79)	-0,26 (-1,20)	2,52* (0,9804)	0,000* (0,99)	0,000	9
MIMIC 3-1-2	0,82* (3,70)	--	0,44 (1,47)	0,78* (2,20)	--	--	0,00 (-1,78)	5,57* (0,3505)	0,038* (0,46)	0,067*	5
MIMIC 3-1-2	0,81* (3,77)	--	0,42 (1,45)	--	1,58 (2,89)	--	-0,01 (-1,47)	7,23* (0,2998)	0,051* (0,42)	0,053*	6
MIMIC 3-1-2	0,85* (3,99)	--	--	0,43 (1,18)	1,31* (2,28)	--	0,00 (-1,78)	4,11* (0,6614)	0,000* (0,76)	0,100*	6
MIMIC 3-1-2	0,65* (2,98)	1,24* (3,57)	0,36 (1,28)	--	--	--	0,00 (2,05)	5,69* (0,2238)	0,073* (0,32)	0,284*	4
MIMIC 3-1-2	0,69* (3,35)	1,06* (3,19)	--	--	--	2,35 (0,91)	0,64 (1,33)	0,53* (0,9704)	0.000* (0,98)	0,649*	4
MIMIC 3-1-2	0,67* (3,22)	1,19* (3,53)	--	--	1,43* (2,79)	--	-0,01* (-1,99)	4,04* (0,5441)	0,000* (0,65)	0.326*	5
MIMIC 3-1-2	0,65* (3,08)	1,34* (3,95)	--	0,86* (2,64)	--	--	0,00* (-2,34)	2.77* (0,7351)	0,000* (0,81)	0.616*	5

Notes:

t-statistic are given in parentheses.

* Means |t-statistic|>1,96.

[1] If the structural equation model is correct and the population parameters are known, then the matrix S (sample covariance matrix) will equal to $\Sigma(\theta)$ (model-implied covariance matrix) therefore the perfect fitting correspond to p-value=0,000. This test has a statistical validity if there are large sample and multinormal distributions. This point is very relevant to evaluate the reliability of previous analyses of underground economy.

[2] p-value for Test of Close Fit (RMSEA < 0,05)

[3] Is reported the output of PRELIS 2.53: Test of Multivariate Normality for Continuous Variables, p-value of skewness and kurtosis (Mardia, 1970). D'agostino (1986, pp. 391) recommends N $\geq$ 100 for this test. In our case the sample is approximately eighty for this, the results should be interpreted cautiously. Only when the multinormality is present (or at least no excessive kurtosis), the MLE can be used.

[4] The degrees of freedom are determined by 0,5(p+q)(p+q+1)-t, where "p" is the number of indicators, "q" the number of causes and "t" is the number of free parameters.

6 The Shadow Economy in Italy

The models selected are four: two models MIMIC 3-1-2, a SIMIC 4-1-1 and the MIMIC 5-1-2.

This choice is based on: the statistical significativity of parameters, the parsimony of specification, the p-value of "chi-square" and the Root Mean Square Error of Approximation (RMSEA) test[55], the normal distribution in the residuals (graph 3), and if the model is multinormally distributed. Fortunately, the choice is made easier by the alikeness and stability of coefficients.

Regarding the selection of the kind of estimators, except for the SIMIC[56], it is possible to apply the best estimator for the Lisrel methodology: the MLE.

The index of shadow economy is estimated by equation (10), the structural coefficients are multiplied for the "filtered" data for stationarity, therefore the latent variable is estimated in the same transformation of independent variables (first difference):

$$\Delta\hat{\eta} = \hat{\gamma}_{11}\Delta X_1 + \hat{\gamma}_{12}\Delta X_2 + \hat{\gamma}_{13}\Delta X_3 + \hat{\gamma}_{14}\Delta X_4 + \hat{\gamma}_{15}\Delta X_5 \qquad (10)$$

Successively, the index is converted in a "level" time series. In order to obtain the actual values of the underground economy in term of official GDP, *a priori* known value is required. To guarantee greater truthfulness of this exogenous information, is chosen a year in which there are several estimates of the hidden economy. The year elected is the 1978 because it is possible to build an average with eight different estimates and almost all the kinds of methodologies[57].

Table 3: The Shadow Economy in Italy (1976-1980)

N°	Methods of Estimate	Average over '76-'80
	Direct Method:	
1)	Tax Auditing	3,9
	Indirect Methods:	
2)	Discrepancy between expenditure and income	4,3
3)	Discrepancy between official and actual employment	18,4
4)	Currency demand (Tanzi's method)[a]	15,9
5)	Cash-deposit ratio	27,2
6)	Transaction Approach	26,4
	Approach Method:	
7)	MIMIC Method	10,5
	AVERAGE 1978	**15,2**

Source:

Extract by Schneider and Enste (2000)[58], tab.12, pp. 43.

[a] This value is the mean between 13,2 (Schneider and Enste, 2000) and 18,6 (Bovi and Castellucci, 2001).

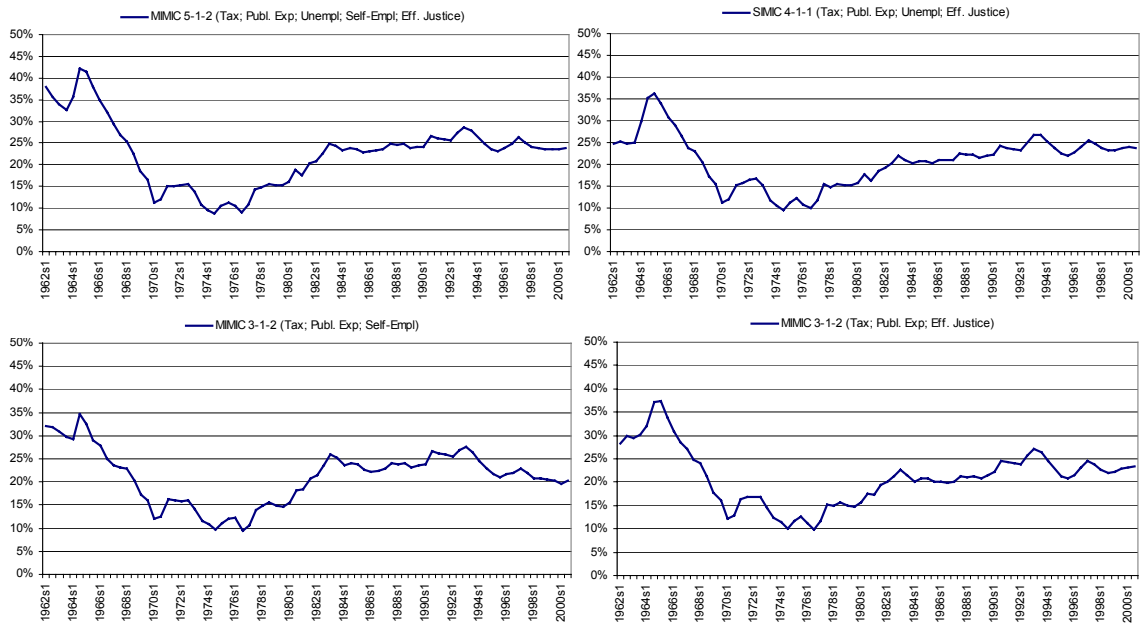
[55] Unfortunately, the LISREL package does not perform other *goodness of fit statistics* if the dataset includes missing values.

[56] It is considered one of the better models, because is not multinormal distributed but has the best p-value for the "chi-square" test and the RMSEA.

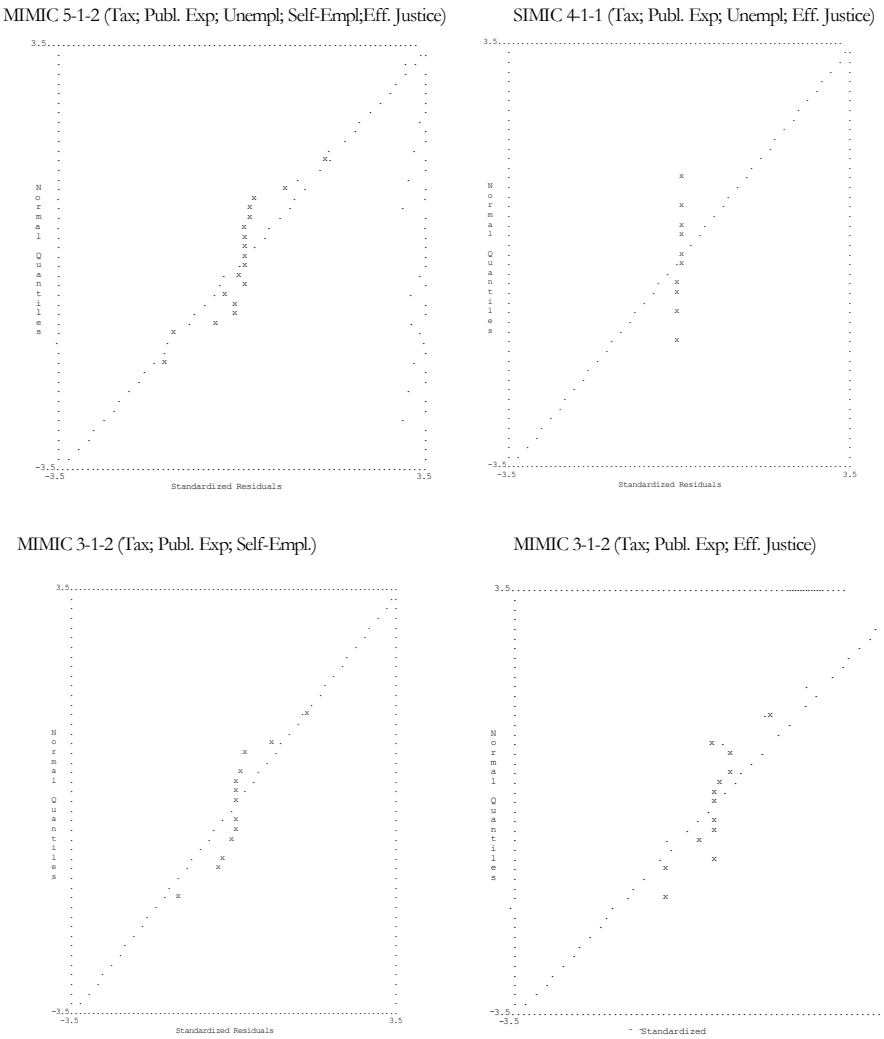
[57] Schneider and Enste (2000) group the estimates for the period '76-'80; here is averaged and assigned this value to year 1978.

[58] The authors using as sources: Thomas (1992), Lippart and Walker (1997), Pozo (1996), Schneider (1994a, 1994b, 1997), Bendelac and Clair (1993), Frey and Weck-Hannemann (1984).

Graph 2: Estimates - MIMIC (5-1-2); SIMIC (4-1-1); MIMIC (3-1-2)a; MIMIC (3-1-2)b –

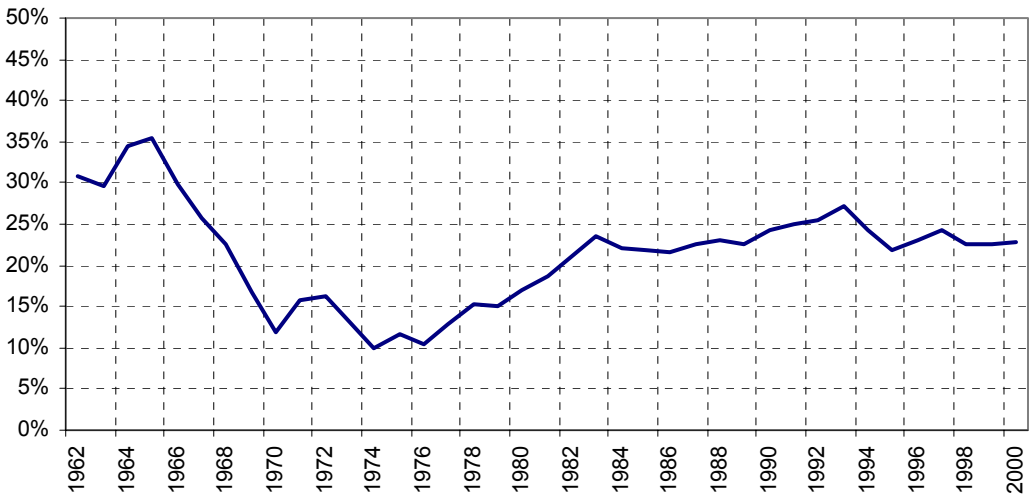


Graph 3: Q-plots residual - MIMIC (5-1-2); SIMIC (4-1-1); MIMIC (3-1-2)a; MIMIC (3-1-2)b -



All the estimates are very alike and the residuals normal distributed, therefore is useful to display an index built as an average of these four models (MIMIC 5-1-2, SIMIC 4-1-1, MIMIC 3-1-2a, MIMIC 3-1-2b).

Graph 4: Shadow Economy as percentage of Real GDP



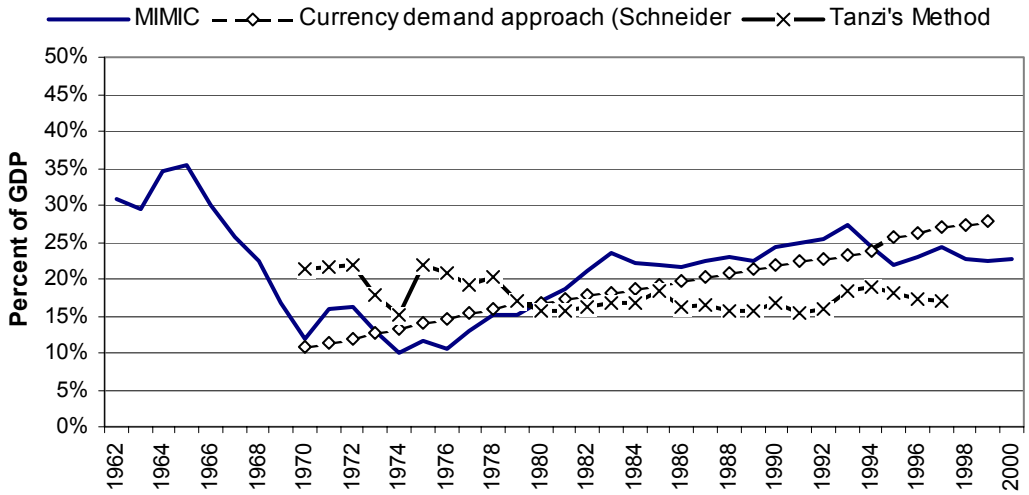
Finally, a comparison with the estimates obtained by two other methods, the currency demand approach (Schneider[59], 2000; Schneider and Enste[60], 2000) and Tanzi's method (Bovi and Castellucci, 2001) is shown. The MIMIC estimates are not far from the previous studies. In particular, in agreement with the currency approach are:

- the increase of shadow economy in the period between 1974 to 1984;
- the size of it, around 25 percent of official GDP, in the last ten years.

With reference to Tanzi's method, although figures calculated here are bigger than Bovi and Castellucci's (about 6 percent after the 1982), there is a convergence with their result of substantial stability in the last fifteen years.

[59] Schneider F. (2000), pp. 86, for the estimates from 1994 to 1998.
[60] Schneider F, Enste D., (2000), pp. 41. For the period 1970-1994 are available only the data of 1970, 1980, 1994, to calculate the time series index is been considered a linear interpolation.

Graph 5: Comparison with other estimates



7 The Results of Model Approach

The econometric conclusions of this work suggests that:

- The dimension of underground economy range from 37 percent, in the 1965, to 10 percent of official GDP in the 1975.
- The trend of shadow economy, after ten year of decrease (1965-1974), increases in the period 1975-1984, to become stable, below the 25 percent, in the last fifteen years.

The results of this estimate find partial support in the latest empirical studies for Italy (see Schneider, 2000; Schneider and Enste, 2000; Bovi and Castellucci, 2001).

The reasons behind the strong reduction of the black economy in the period between 1966 to 1970 (-21,62%) are[61]: a decrease of efficacy of judicial system (-20,67%), of the self-employment rate (-2,23%) and of the government consumption (-1,87%).

Reading the tests of statistical significance of determinants and indicators of irregular economy:

(1) The tax burden (X_1) and the presence of the State in the market, measured by government consumption (X_2) are always statistically significant and positively related to the shadow economy.

(2) The variables concerning the labour market (X_3 and X_4) do not have a great influence on the hidden economy. Their relevance is uncertain: in 16 estimated models where these are included, the coefficients of unemployment and self-employment are not different from zero nine and seven times, respectively. Anyway, a rise in the unemployment rate or self-employment causes an increase in the shadow economy.

As regards the determinants of underground economy connected with efficiency of penal justice and the index of illegality, the empirical outputs are:

[61] In parentheses are reported the averages value of the annual growth rates.

(3) The efficacy of justice measured as ratio of sentences about some crimes (with economic aims) on the number of reports for the same kind of crimes (X_5) is positively related with the shadow economy. This outcome is difficult to understand. A possible explanation of this unexpected sign of coefficient could be that, the ability of the State to punish crimes is unconnected to the efficacy of tax auditing, and hence the statistical significance of the coefficient is a product of spurious correlation with tax evasion[62].

(4) The total amount of recorded crimes (X_6), used as an index of illegality, has not statistical significance in all the estimated models. Therefore, if it is considered a good enough approximation to "respect of Law" in the Italian socio-economic system, the theories based on "social customs" to explain the parallel economy could be not confirmed.

Regarding the indicators, two results in the Italian context are pointed out:

(5) The relationship between underground economy and growth rate of GDP (Y_1) is negative; according to Frey and Weck-Hanneman (1984), on the contrary to the MIMIC estimated in New Zealand (Giles, 1999b) and Canada (Giles and Tedds, 2002).

(6) The tests of statistical significance performed, support the statement that: the growth rate of currency outside of banks (Y_2), in which is based the currency approach (Gutmann's method), is not relevant as indicator of the Italian shadow economy in the analysed period.

The main outcomes of this paper, in accordance with the conclusions founded by Schneider (1997) and Schneider, Enste (2000) are that a rising of taxes and social security contributions, combined with increasing State regulatory activities, *"…are the major driving forces behind the size and growth of the shadow economy"*[63].

8 Conclusions

Following the pioneeristic work of Frey and Weck-Hanneman (1984), the shadow economy in the last forty years is estimated through semi-annual data. Applied are MIMIC and SIMIC models to the Italian economy, in order to (1) test the statistical significance of some of the most relevant determinants of informal activities, (2) the relationship between growth rate of GDP and underground economy.

In the paper, the multinormal distributions[64] of statistical models is tested. This procedure is specifically designed to ensure the correct use of the MLE and therefore to have asymptotically unbiased, consistent

[62] In particular, is estimated a statistically significant covariance between self-employment and index of efficacy of judicial system. Disagree with the hypothesis about the reliable of this index: the variable is sensitive to decrease of sample: if the dataset is reduced of 30 observations the coefficient (γ_{51}) becomes not statistically different from zero. For details, see appendix D.

[63] Schneider F., Enste D., (2000), pp. 44.

[64] Precisely is tested if skewness and kurtosis are jointly approximable to the multinormal distribution (Mardia's test) and the univariate normality (Jarque-Bera's test). For more details, see Bollen K. A. (1989).

and asymptotically efficient estimators (Bollen, 1989). The multinormality is found in half the estimated models[65] and in all the most parsimonious specifications.

Following Giles (1995, 1997, 1999a, 1999b), Tedds (1998), Prokhov (2001), Giles and Tedds (2002) the presence of unit roots is detected and the subsequently corrections are applied. Likewise, to preserve the asymptotical distributions of tests a large time series is employed consisting of approximately eighty observations.

These preliminary tests make inapplicable the criticisms about the intertemporal instability of the parameters (critique I)[66] and the sensibility of coefficients to "…*alternative schemes of weighting the index they* [namely, Frey and Weck-Hanneman (1984)] *use*"[67](critique II).

Regarding the difficulty with the MIMIC approach to undertake a time-series analysis (criticism III), however remains one of the main limitations of this approach. In particular the difficulty (1) to calculate of the confidence intervals associated with estimates of the latent variable; (2) to test the hypothesis of independence between structural and measurement errors; (3) to identify exhaustively the properties of the residuals; (4) to apply the SEM approach to small sample sizes and time series analysis. These remain relevant obstacles in order to assign full reliability to outcomes.

Referring to the low reliability of indicator and explanatory variables (criticism IV and V), and the real meaning of the latent variable (critique VI), they remain difficult objections to overcome as they evolve due to the theoretical assumptions behind the choice of variables and selected data. Nonetheless the theoretical construct defining the "shadow economy" could have other potential definitions, namely socio-economic development, welfare state, etc., while at the same time several and more appropriate variables could be considered to interpret unambiguously the latent variable. In this regard, the small number of variables (especially indicators) used in the presented model, does leave space for major refinements.

According with our estimates, other criticisms could be exposed to question this methodology:

- In our analysis, the amount of variance explained by the models in the shadow economy is very low (ranging from 1 percent (MIMIC 5-1-2; 3-1-2) to 34 percent (SIMIC 4-1-1))[68].
- The frequent possibility the model approach encounters indefinite matrix problems. As Monte Carlo studies demonstrate [see Anderson and Gerbing (1984) and Boomsma (1982, 1985)] when the data provides relatively little information (small sample size, few observed indicator variables, small factor loadings, missing values), non positive definite matrix troubles arise frequently (Bollen and Long, 1993). Unfortunately, these are the usual obstacles met by this kind of application in economics.

[65] The non-multinormality is originated by the excessive kurtosis in the time series of unemployment rate (X_3) and recorded crimes (index of illegality, X_6).

[66] Helberger C., Knepel H., (1988), pp. 969. The appendix D is devoted to examine this critique.

[67] Helberger C., Knepel H., (1988), pp. 966.

[68] This value can be considered like the R^2 value in the regression analysis, but does not assigning to it the meaning of measures of model fit. Kelloway K.E. (1998), pp. 28.

- The strong dependence of outcomes by the (exogenous) choice of the coefficient of scale (λ_{11}). In particular, if the parameter of scale is chosen equal to +1 (instead of –1), the estimated shadow economy became specular to time series displayed in the graph 4 (passing still through the other exogenous value for the year 1978). This means that implicitly the signs of the determinants of hidden economy and consequently the relative estimates, are function of researcher's choice.

Although the highlighted objections and the few implementations of this technique, if we consider the econometric alternatives to measure the shadow economy, the model approach could be considered a relatively robust methodology in this field.

Nonetheless, I form the same conclusion as Giles and Tedds (2002), that the model approach is a work in progress and supplementary improvement is "*not only possible but necessary*"[69].

[69] Giles D.E.A., Tedds L.M., (2002), pp. 103.

References*

Adam Markus, Ginsburgh C. Victor (1985). The Effects of Irregular Markets on Macroeconomic Policy: Some Estimates for Belgium. *European Economic Review, 29/1, pp. 15-33.*

Aigner D.J., Hsiao C., Kapteyn A., Wansbeek T. (1984). Latent variable models in econometrics. In Z. Griliches and M.D. Intriligator, eds.*, Handbook of Econometrics, Vol.2. Amsterdam: North-Holland, pp.1321-1393.*

Aigner Dennis J., Schneider Friedrich, Ghosh Damayanti (1988). Me and my shadow: estimating the size of the U.S. hidden economy from time series data. *Dynamic Econometric modelling. Proceedings of the Third International Symposium in Economic Theory and Econometrics. Edited by Barnett W. Berndt E. White H. Cambridge University Press, pp. 297- 334.*

Allingham M., Sandmo A., (1972). Income Tax Evasion: A Theoretical Analysis, *Journal of Public Economics, 1, pp. 323-338.*

Anderson J.C., Gerbing D.W. (1984). The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. *Psychometrika, 49, 155-173.*

Baldassarini A., Pascarella C. (2003). The Italian approach to estimating the extent of the Non-Observed Economy: methods and results. *Presented at Conference on "The Non-Observed Economy: Measurement and Policy Issues". Rome, 20-21 January 2003.*

Baldassarini A., Pisani S. (2001). Macroeconomic approach to the estimate of the underground economy, *OECD Meeting of National Accounts Experts, Paris, 26-29 September.*

Bendelac Jacques, Clair Pierre-Maurice (1993), Macroeconomic Measure of the Hidden Economy, *International Institute of Public Finance, 49th Congress, Berlin, 1993.*

Bentler P. M. (1986). Structural Equation Modelling and Psycometrika: An historical perspective on growth and achievements. *Psycometrika, 51, pp. 35-51.*

Bhattacharyya Dilip K. (1999). On the Economic rationale of estimating the hidden economy. *The Economic Journal, 109 (June), pp. 348-359.*

Bielby W.T., Hauser M. (1977). Structural equation models. *Annual Review of Sociology, 3, pp. 137-161.*

Bollen K. A. (1989). Structural equations with latent variables. New York: John Wiley & Sons.

Bollen K.A., Long, J. S. (1993). Testing structural equation models. Beverly Hills, CA: Sage.

Bollen K.A., Stine R. (1987). Bootstrapping structural equation models: variability of indirect effects and goodness of fit measures. Unpublished manuscript.

Boomsma A. (1982). The robustness of LISREL against small sample sizes in factor analysis models. In K. J. Jöreskog and H. Wold (Eds.), *Systems under indirect observation: Causality, structure, prediction (Part 1).*Amsterdam: North-Holland.

Boomsma, A. (1985). Nonconvergence, improper solutioms, and starting values in LISREL maximum likelihood estimation. *Psychometrika, 50, 229-242.*

Bordignon Massimo, Zanardi Alberto (1997). Tax Evasion in Italy. *Giornale degli Economisti e Annali di Economia Volume 56, N. 3-4, pp. 169-210.*

Bovi Maurizio (2002). The nature of the underground economy. Some evidence from OECD countries. *Documenti di Lavoro, Institute for Studies and Economic Analyses (ISAE), June.*

Bovi Maurizio, Castellucci Laura (2001). Cosa sappiamo dell'economia sommersa in Italia al di là dei luoghi comuni? Alcune proposizioni empiricamente fondate. *Economia Pubblica. Anno XXXI – n.6, pp. 77-119.*

Browen M. W. (1982). Covariance structures. In D. M. Hawkins, ed., *Topics in Multivariate Analysis. Cambridge University Press, pp. 72-141.*

Browne M. W. (1984). Asymptotic distribution free methods in analysis of covariance structures. *British Journal of Mathematical and Statistical Psychology, 37:62-83.*

Byrne Barbara M. (1998). Structural equation modeling with LISREL, PRELIS, and SIMPLIS Mahwah, N.J.: Lawrence Erlbaum Associates. Multivariate applications book series

Calzaroni M. (2000) The exhaustiveness of production estimates: new concepts and methodologies, *ICES II (Second International Conference on the establishment surveys), Buffalo, 17-21 June.*

Cassar Alan. (2001). An index of the underground economy in Malta. *Bank of Valletta Review, No. 23, Spring, pp. 44-62.*

Chatterjee S., Chaudhuri K., Schneider F., (2003). The Size and Development of the Indian Shadow Economy and a Comparison with other 18 asian countries: An Empirical Investigation. *Presented at European Public Choice Society, Annual meeting 2003 in Aarhus (DK) (mimeo).*

Cooley W. W. (1978). Explanatory observational studies. *Educational Researcher, pp. 9-15.*

Cowell F. A. (1990). Cheating the government: The economics of Evasion *MIT Press, Cambridge, MA.*

D'Agostino R. B. (1986). Tests for the normal distribution. In R.B. D'agostino and M.A. Stephens, eds. *Goodness-of-Fit Techniques. New York: Marcel Dekker, pp. 367-419.*

Duncan Otis D. (1975). Introduction to structural Equation Models. New York: Academic Press.

Eilat Y., Zinnes C. (2000). The Evolution of the Shadow Economy in Transition Countries: Consequences for Economic Growth and Donor Assistance. *CAER II Discussion Paper No. 83. Harvard Institute for International Development.*

Feige Edgard L. (1989). The Underground economies, Tax evasion and information distortion. Cambridge University Press. Cambridge.

Feige Edgard L. (1990). Defininig and Estimating Underground and Informal Economies: The New Institutional Economic Approach, World Development, 18, no. 7, pp. 989 - 1002

Fleming M.H., Roman J., Farrel G. (2000). The Shadow Economy. *Journal of International Affairs, Spring 2000, 53, no. 2.*

Frey Bruno, Weck Hannelore (1983). Estimating the Shadow Economy: a "Naïve" Approach. *Oxford Economic Papers, 35, pp. 23-44.*

Frey Bruno, Weck-Hanneman Hannelore (1984). The Hidden Economy as an "Unobservable" variable. *European Economic Review, Vol. 26, No. 1, pp. 33-53.*

Giles David E.A. (1995). Measuring the size of the hidden economy and the tax gap in New Zealand: an econometric analysis. *Working Paper No. 5a, Working Paper on Monitoring the Health of the Tax System, Inland Revenue Department,Wellington.*

Giles David E.A. (1997). The hidden Economy and the tax gap in New Zealand: a latent variable analysis. *Discussion Paper 97-8, Department of Economics, University of Victoria, Canada.*

Giles David E.A. (1998). The Underground Economy: Minimizing the Size of Government. *Working Paper, Department of Economics, University of Victoria, Canada.*

Giles David E.A. (1999a). Measuring the hidden Economy: Implications for Econometric Modeling". *The Economic Journal, Vol. 109, No 46, pp.370-380.*

Giles David E.A. (1999b). Modeling the hidden Economy in the Tax-gap in New Zeland. *Working Paper, Department of Economics, University of Victoria, Canada.*

Giles David E.A., Tedds Lindsay M. (2002). Taxes and the Canadian Underground Economy. *Canadian Tax paper n.106. Canadian Tax Foundation.* Toronto.

Golob Thomas F. (2001). Structural Equation Modeling for Travel Behavior Research. *Transportation Research Part B: Methodological, November.*

Goldberger A. S. (1972). Structural Equation Methods in the Social Sciences. *Econometrica, Vol.40, pp. 979-1001.*

Gutmann P. M. (1977). Subterranean Economy. *Financial Analysis Journal, November, 34, pp. 26-27.*

Hayduk L. A. (1987). Structural equation modelling with LISREL. Essential and advances. The Johns Hopkins University Press. London.

Helberger C., Knepel H. (1988). How big is the Shadow Economy? A Re-Analysis of the Unobserved-Variable Approach of B.S. Frey and H. Weck-Hannemann. *European Economic Review, 32 pp.965-976.*

Hoyle R. H. (ed.) (1995). Structural Equation Modeling: Concepts, Issues, and Applications. Thousand Oaks, CA: Sage.

ISTAT (2001). Le stime Istat sull'economia sommersa, Dossier 2. Audizione del presidente dell'Istituto nazionale di statistica (23 luglio 2001), Roma. *Documenti on-line.*

ISTAT (2000). Annuario statistiche giudiziarie penali. Roma

Jaccard James, Wan Choi K. (1996). Lisrel approach to interaction effects in multiple regression. *Series: Quantitative Applications in the Social Science. Sage University paper. SAGE publications.*

Johnson S., Kaufmann D., Shleifer A. (1997). The Unofficial Economy in Transition. *Brooking Papers of Economic Activity, 0:2, pp. 159-221.*

Johnson S., Kaufmann D., Zoido-Lobatón P. (1998). Regulatory Discretion and the Unofficial Economy. *American Economic Review, 88:2, pp. 387-92.*

Jöreskog K., Goldberger A. S. (1975). Estimation of a model with multiple indicators and multiple causes of a single latent variable, *Journal of the American Statistical Association*, 70, pp. 631-639.

Jöreskog K., Sörbom D. (1993). LISREL 8, User's Reference Guide. Chicago: Scientific Software International.

Kaufmann Daniel, Kaliberda Aleksander (1996). Integrating the Unofficial Economy into the Dynamics of Post-Socialist Economies: A Framework of Analysis and Evidence, in *Economic Transition in the Newly Independent States, B. Kaminski editor, Armonk, New York: M.E. Sharpe Press.*

Kelloway E. K. (1998). Using LISREL for Structural Equation Modeling. A Researcher's Guide Sage Publications.

Lipert Owen, Walker Michael (eds.) (1997). The Underground Economy: Global Evidences of its Size and Impact. Vancouver, B.C., The Frazer Institute.

Loayza Norman V**.** (1996). The Economics of the Informal Sector: A Simple Model and Some Empirical Evidence from Latin America. *Carnegie-Rochester Conference Series on Public Policy 45, pp. 129-162.*

Mardia K. V. (1970). Measures of multivariate skewness and kurtosis with applications. *Biometrika, 57, pp. 519-530.*

Maruyama Geoffrey M. (1997). Basic of Structural Equation Modeling, SAGE Publications.

OECD (2002). Handbook for measurement of the non observed economy, Paris.

Olsson U. H., Troye S. V., Howell, R. D. (1999). Theoretic fit and empirical fit: The performance of maximum likelihood versus generalized least squares estimation in structural equation models. *Multivariate Behavioral Research, 34(1), pp. 31-59.*

Pedersen Soren (1998). The Shadow Economy in Western Europe, Measurement and Results for selected Countries. The Rockwool Foundation Research Unit. Copenhagen.

Pozo Susan (ed.) (1996). Exploring the Underground Economy. Studies of Illegal and Unreported Activity. *Michigan, W.E. Upjohn, Institute for Employment Research.*

Prokhorov Artem (2001). The Russian Underground Economy as a "Hidden" Variable. Presented at Midwest Slavic Conference, Cleveland, Ohio, March 29-31.

Schneider F. (1994a). Measuring the Size and Development of the Shadow Economy. Can the Causes be Found and the Obstacles be Overcome?. In Brandstaetter, Hermann, and Guth, Werner (eds.), Essays on Economic Psychology, Berlin, Heidelberg, Springer Publishing Company, pp. 193-212.

Schneider F. (1994b). Can the Shadow Economy be reduced Through Major Tax Reforms? An Empirical Investigation for Austria. *Supplement to Public Finance / Finances Publiques, 49, pp. 137-152.*

Schneider F. (1997). The shadow economies of Western Europe. *Economic Affairs, 17:3 pp.42-48, September.*

Schneider F. (1998). Further empirical results of the size of the shadow economy of 17 OECD-countries over time, Paper presented at the 54. Congress of the IIPF Cordowa, Argentina and discussion paper, Department of Economics, University of Linz, Linz, Austria.

Schneider, F., Eneste D. (2000). Shadow Economies Around the world: Size, Causes, and Consequences, *IMF Working Paper n.26*.

Smith Philip (1994) Assessing the Size of the Underground Economy: the Canadian Statistical Perspectives. *Canadian Economic Observer, Catalogue No. 11-010, 3.16-33, 18 March.*

Tanzi Vito (1999). Uses and Abuses of Estimates of the Underground Economy." *The Economic Journal, 109 (June), pp. 338-347.*

Tedds Lindsay (1998). Measuring the size of the hidden Economy in Canada. *MA extended essay, University of Victoria, Department of Economics.*

Thomas Jim (1992). *Informal economic activity.* LSE, Handbooks in Economics, London, Harvester Wheatsheaf.

Thomas Jim (1999). Quantifying the black economy: 'measurement without theory' yet again? *The Economic journal, 109 (June), pp. 381-389.*

Stapleton David C. (1978). Analyzing political participation data with a MIMIC Model. *Sociological Methodology Vol. 15. pp. 52-74.*

Zellner A. (1970). Estimation of regression relationships containing unobservable variables, *International Economic Review,* 11, *pp.* 441-454.

* For the sources of dataset, see the appendix A.

Appendix A – Sources of Data –
Appendix B – Analysis of Multinormality –
Appendix C – Analysis of Non-Stationarity –
Appendix D – Intertemporal Stability of the coefficients –
Appendix E – Testing the correlation between structural and measurement errors –

Appendix A - Sources of data -

Var.	CAUSES	Sources	Unit root	Transf. Used[1]	Skewn. & Kurt.[2]	Jarque-Bera p-value[3]	Kurtosis p-value[2]	Annotations
X_1	Tax Burden / GDP	OECD – Economic Outlook.	I(1)	$\Delta(X_1)$	0,881	0,789	0,728	(Revenue Direct Taxes+ Revenue Indirect Taxes+Social Security Contributions received by Government)/GDP
X_2	Real Government Consumption	OECD - Economic Outlook.	I(1)	$\Delta(X_2)$	0,190	0,172	0,481	Government Consumption, Value (Appropriation Account)/deflator of Government consumption
X_3	Rate of Unemployment	OECD - Economic Outlook.	I(1)	$\Delta(X_3)$	0,001	0,000	0,000	-
X_4	Self Employment / Labour Force	OECD - Economic Outlook.	I(1)	$\Delta(X_4)$	0,224	0,287	0,124	-
X_5	Condemneds for crimes with economic aims / number of the same recorded crimes	ISTAT - Annuario statistiche giudiziarie penali - anno 2000 Tav.8.1 , Tav.8.2	I(1)	$\Delta(X_5)$	0,151	0,074	0,064	Is modified the frequency from annual to half-annual by interpolating two years. To calculate the II semester 2000 is supposed 2001 equal to 2000. There are missing data in the years 1974 and 1975. They are substituted by the averages over the period '70-'78.
X_6	Number of recorded crimes for 100.000 residents	ISTAT - Annuario statistiche giudiziarie penali - anno 2000 Tav 8.1	I(1)	$\Delta LN(X_6)$	0,004	0,000	0,001	Is modified the frequency from annual to half-annual by interpolating two years. To calculate the II semester 2000 is supposed 2001 equal to 2000.
	INDICATORS							
Y_1	Real Gross Domestic Product	OECD - Economic Outlook.	I(1)	$\Delta LN(Y_1)$	0,242	0,549	0,117	GDP /deflator of GDP
Y_2	Currency outside of banks	B.I.P. (Bank of Italy's publicly available statistical data base) TDA00100-S787365M TAME0210-S445908M	I(1)	$\Delta LN(Y_2)$	0,276	0,384	0,166	Is modified the frequency from monthly to half-annual. In the 1998, there is a change in the method to estimate in one among the components of series (*cassa contante)*. Therefore to make homogeneous the series is subtracted a constant (€ 677 mil) for the lasts six semesters.

Notes: (p-value are calculated on transformed data).

[1] "Δ" means first difference, "LN" means natural logarithm.

[2] P-value are computed by PRELIS 2.53.

[3] P-value of Jarque-Bera test is calculated by Eviews 4.1.

Appendix B -Analysis of Multinormality -

(Output PRELIS, Time series description)

The following tables present the tests of Normality (Univariate and Multivariate) of the most general model estimated: the MIMIC 6-1-2. For the other tests about the multivariate normality distribution, the results are reported in tables 2(a) and 2(b).

The sample size is 81, the "*effective sample size*" 77 (Listwise deletion).

Univariate Summary Statistics for Continuous Variables

Variable	Mean	St. Dev.	T-Value	Skewness	Kurtosis
Tax Burden	0.217	0.667	2.858	0.096	-0.251
Gov.Consump.	0.058	0.421	1.203	0.459	0.285
Unempl.Rate	0.093	0.494	1.645	-0.075	4.193
Self-Employ.	-0.096	0.390	-2.170	-0.210	0.910
Real Growth GDP	1.514	1.426	9.312	0.164	0.936
Currency outs.	5.091	2.794	15.987	0.216	-0.607
Eff.Justice	-0.015	0.244	-0.547	0.154	1.217
Illegality	0.013	0.050	2.214	0.051	3.454

Test of Univariate Normality for Continuous Variables

	Skewness		Kurtosis		Skewness and Kurtosis	
Variable	Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value
Tax Burden	0.363	0.716	-0.347	0.728	0.253	0.881
Gov.Consump.	1.682	0.093	0.705	0.481	3.326	0.190
Unempl.Rate	-0.285	0.776	3.620	0.000	13.183	0.001
Self-Employ.	-0.789	0.430	1.538	0.124	2.989	0.224
Real Growth GDP	0.619	0.536	1.567	0.117	2.837	0.242
Currency outs.	0.813	0.416	-1.384	0.166	2.578	0.276
Eff.Justice	0.583	0.560	1.855	0.064	3.782	0.151
Illegality	0.192	0.848	3.314	0.001	11.022	0.004

Test of Multivariate Normality for Continuous Variables

Skewness		Kurtosis		Skewness and Kurtosis	
Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value
4.031	0.000	2.825	0.005	24.228	0.000

Appendix C

- Analysis of Non-Stationarity -

Causes (X-variables)

In this appendix, the tests to detect the order of integration in the time series are shown. Pioneer to tackle the problem of non-stationarity in the MIMIC models has been Giles (1995).

To find out the unit roots, the Augmented Dickey-Fuller (ADF) Test and the Philliphs-Perron (PP) Test are used. Both are performed with constant, trend & constant and neither. To choose a number of lags[70] sufficient to remove serial correlation in the residuals, are applied the Akaike information criterion (A), the Schwarz information criterion (S), 4 and 5 lags.

All time series are integrated of first order; in particular: index of illegality (X6), real GDP (Y1) and currency outside of banks (Y2) are transformed in log-difference, to improve their distribution to normal.

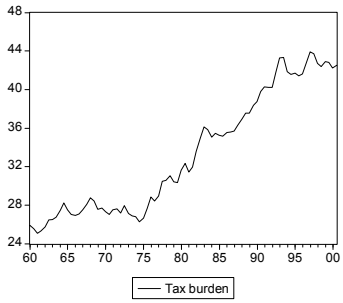
In the following tables the p-value of over mentioned tests are reported. For both the null hypothesis is the presence of unit root, therefore a value larger than 0,05 means non-stationary time series.

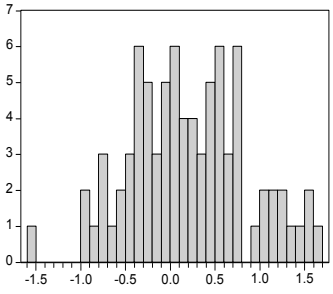
The plot graphs relate to raw data, the histograms and the descriptive statistics to the transformed times series. The econometric software Eviews 4.1 is used in order to carry out this analysis.

1. Tax Burden (OECD)

Unit Root test

Variable	Constant		Trend & Constant		None	
Tax Burden	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**A,S** 2 (0,9430) 4 (0,9416) 5 (0,9485)	0,9514	**A,S** 2 (0,7337) 4 (0,6897) 5 (0,5913)	0,5306	**A,S** 2 (0,9991) 4 (0,9966) 5 (0,9926)	0,9987
First Difference	**A,S** 1(0,000) 4 (0,0033) 5 (0,0036)	0,000	**A,S** 1 (0,000) 4 (0,0169) 5 (0,0179)	0,000	**S** 1 (0,000) **A** 2 (0,000) 4 (0,0024) 5 (0,0043)	0,000





Series: TAX_BURDEN_DIFF
Sample 1960:2 2000:2
Observations 81

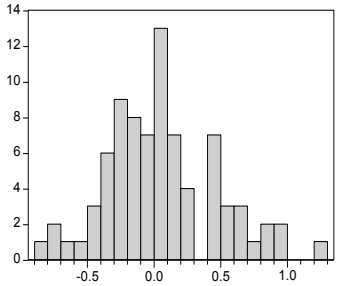
Mean	0.205384
Median	0.151687
Maximum	1.640170
Minimum	-1.501237
Std. Dev.	0.658281
Skewness	0.127326
Kurtosis	2.725012
Jarque-Bera	0.474073
Probability	0.788962

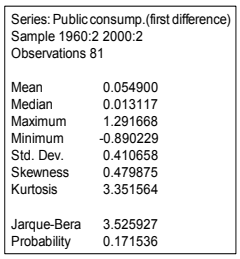
[70] In tables, the lag is indicated outside the brackets

2. Government Consumption (OECD)

Unit Root Test

Variable	Constant		Trend & Constant		None	
Gov. Consump.	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**A,S** 1 (0,2381) 4 (0,2310) 5 (0,3740)	0,3308	**A,S** 1(0,2685) 4(0,4256) 5(0,5788)	0,5632	**S** 1 (0,8572) **A** 3 (0,9032) 4 (0,8861) 5 (0,8732)	0,8843
First Difference	**A,S** 0 (0,000) 4 (0,0021) 5 (0,0163)	0,000	**S** 0 (0,000) 4 (0,0089) 5 (0,0621) **A** 10(0,0970)	0,000	**A,S** 0 (0,000) 4 (0,0001) 5 (0,0014)	0,000

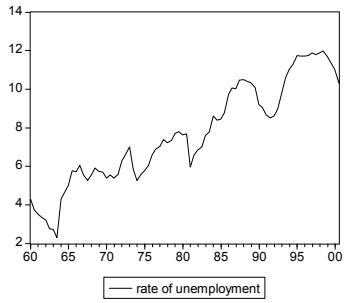


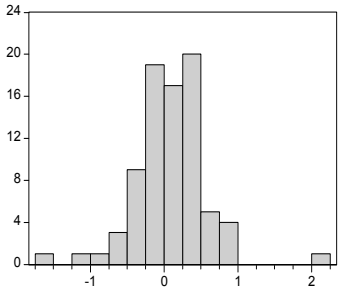


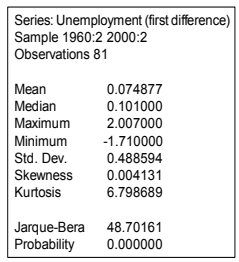
3. Unemployment Rate (OECD)

Unit Root Test

Variable	Constant		Trend & Constant		None	
Unemployment	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**S** 0 (0,7458) **A** 1 (0,5930) 4 (0,5330) 5 (0,4030)	0,6966	**S** 1 (0,1046) 4 (0,0208) 5 (0,0074) **A** 10 (0,0791)	0,0783	**S** 0 (0,9110) **A** 1 (0,8704) 4 (0,8905) 5 (0,9038)	0,8689
First Difference	**S** 0 (0,000) 4 (0,0016) 5 (0,0009) **A** 10 (0,0005)	0,000	**S** 0 (0,000) 4 (0,0089) 5 (0,0052) **A** 10 (0,0035)	0,000	**S** 1 (0,000) 4 (0,0003) 5 (0,0002) **A** 10 (0,000)	0,000



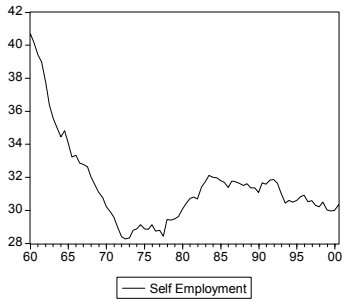


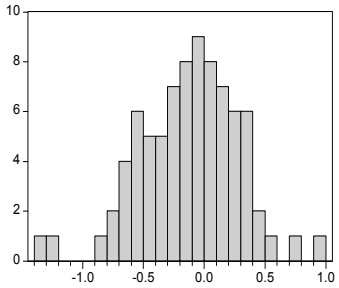


4. Self Employment on Labour Force (OECD)

Unit Root Test

Variable	Constant		Trend & Constant		None	
Self Employment	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**A,S** 2 (0,0028) 5 (0,1621) 4 (0,0220)	0,0001	**S** 0 (0,0033) 5 (0,4250) 4 (0,1071) **A** 2 (0,0375)	0,0133	**A,S** 2 (0,2265) 5 (0,4925) 4 (0,3962)	0,0393
First Difference	**A,S** 1 (0,0085) 5 (0,0286) 4 (0,0126)	0,000	**A,S** 1 (0,0102) 5 (0,1798) 4 (0,0685)	0,000	**A,S** 1 (0,0007) 5 (0,0011) 4 (0,0005)	0,000





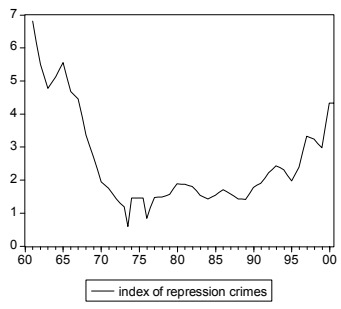
Series:Self Employment (first difference)
Sample 1960:2 2000:2
Observations 81

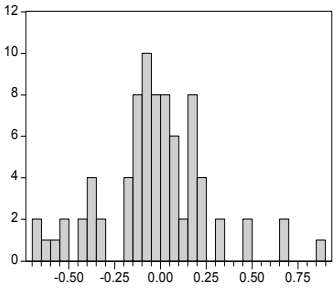
Mean	-0.127755
Median	-0.088646
Maximum	0.995241
Minimum	-1.366158
Std. Dev.	0.410315
Skewness	-0.274610
Kurtosis	3.661137
Jarque-Bera	2.493267
Probability	0.287471

5. Index of Efficacy of judicial System

Unit Root Test

Variable	Constant		Trend & Constant		None	
Index Effic. Justice	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**S** 1 (0,2145) 4 (0,4922) **A** 5 (0,4641)	0,515	**S** 0 (0,7897) 4 (0,9708) **A** 5 (0,9400)	0,7814	**S** 1 (0,1582) 4 (0,3269) **A** 5 (0,4121)	0,0406
First Difference	**S** 0 (0,000) **A** 4 (0,0877) 5 (0,2151)	0,000	**A,S** 0 (0,000) 4 (0,0196) 5 (0,0436)	0,000	**S** 0 (0,000) **A** 4 (0,007) 5 (0,0245)	0,000





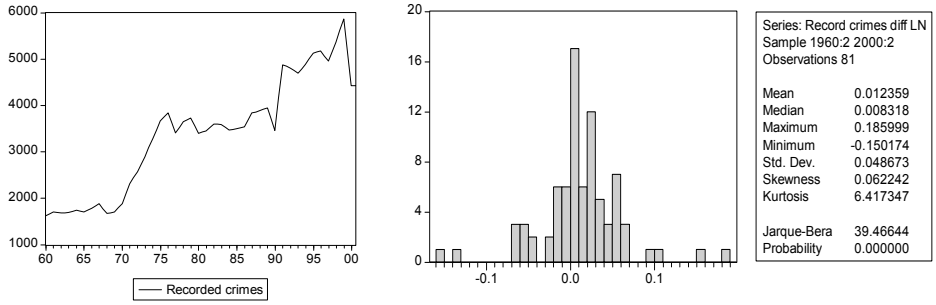
Series: repression crimes (first difference)
Sample 1961:2 2000:2
Observations 79

Mean	-0.031298
Median	-0.030633
Maximum	0.859900
Minimum	-0.651903
Std. Dev.	0.284704
Skewness	0.228879
Kurtosis	4.171865
Jarque-Bera	5.210080
Probability	0.073900

6. Index of Illegality

Unit Root Test

Variable	Constant		Trend & Constant		None	
Index of Illegality	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**A,S** 7 (0,5201) 5 (0,6720) 4 (0,8054)	0,6615	**A,S** 7 (0,2061) 5 (0,4881) 4 (0,7754)	0,4943	**A,S** 7 (0,7747) 5(0,8953) 4(0,9839)	0,9067
First Difference	**A,S** 6 (0,2704) 4 (0,0270) 5 (0,0134)	0,0000	**A,S** 6 (0,6144) 4 (0,1188) 5 (0,0675)	0,0002	**A,S** 6 (0,0661) 4 (0,0056) 5 (0,0037)	0,0000
LogN	**S** 2 (0,6584) 4 (0,5848) 5 (0,4988) **A** 7 (0,4259)	0,5408	4 (0,8991) **S** 5 (0,7177) **A** 7 (0,4782)	0,8929	**S** 2 (0,9901) 4 (0,9858) 5 (0,9444) **A** 7 (0,9020)	0,9827
First Difference LogN	**S** 1(0,000) 4 (0,0498) 5 (0,475) **A** 6 (0,2474)	0,0001	**S** 1 (0,000) 4 (0,1376) 5 (0,1281) **A** 6 (0,4682)	0,0004	**S** 4 (0,0105) 5 (0,0115) **A** 6 (0,0607)	0,0000

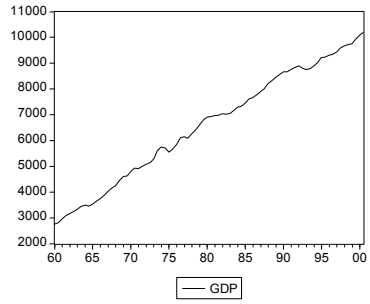


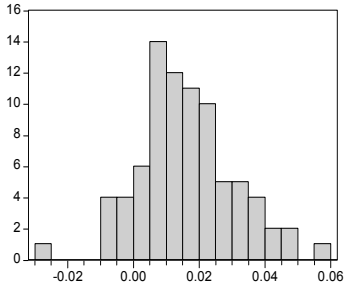
Indicators (Y-variables)

7. Real Gross Domestic Product (OECD)

Unit Root Test

Variable	Constant		Trend & Constant		None	
Real Gross Dom. Prod.	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	**A,S** 2 (0,8193) 4 (0,7950) 5 (0,7883)	0,7959	**S** 1 (0,1695) **A** 2 (0,5335) 4 (0,6509) 5 (0,5527)	0,4965	**S** 1 (1,000) **A** 2 (1,000) 4 (0,9993) 5 (0,9956)	1,000
First Difference	A,S 1 (0,000) 4 (0,0025) 5 (0,0115)	0,000	**A,S** 1 (0,000) 4 (0,0116) 5 (0,0443)	0,000	**S** 0 (0,0004) 4 (0,2037) **A** 5 (0,2794)	0,0006
LogN	**A,S** 2 (0,0016) 4 (0,0071) 5 (0,0176)	0,000	**A,S** 2 (0,7194) 4 (0,7862) 5 (0,7687)	0,5026	**A,S** 1 (1,000) 4 (0,9986) 5 (0,9930)	1,000
First Difference LogN	**A,S** 0 (0,000) 4 (0,0482) 5 (0,917)	0,000	**A,S** 1 (0,000) 4 (0,0071) 5 (0,0232)	0,000	**S** 0 (0,0005) 4 (0,0836) **A** 5 (0,0939)	0,0007





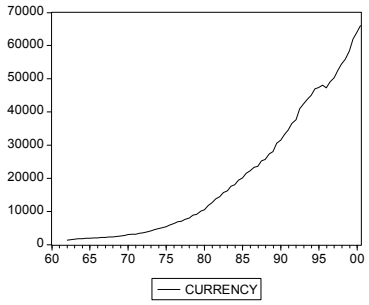
Series: GDP (first log difference)
Sample 1960:2 2000:2
Observations 81

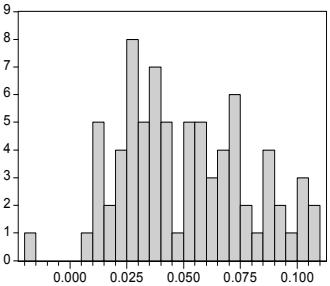
Mean	0.016126
Median	0.014966
Maximum	0.058110
Minimum	-0.028418
Std. Dev.	0.014733
Skewness	0.148352
Kurtosis	3.517000
Jarque-Bera	1.199214
Probability	0.549027

8. Currency outside of banks (B.I.P. Bank of Italy)

Unit Root Test

Variable	Constant		Trend & Constant		None	
Currency outside banks	**ADF**	**P.P.**	**ADF**	**P.P.**	**ADF**	**P.P.**
Level	4 (0,9999) 5 (1,000) **S** 7(1,000) **A** 10 (0,9981)	1,000	4 (0,9959) 5 (0,9969) **A,S** 7 (0,9959)	0,9997	4 (0,9939) 5 (0,9976) **S** 7 (0,9999) **A** 10 (0,8704)	1,000
First Difference	4 (0,7895) 5 (0,8483) **S** 9 (0,9137) **A** 11 (0,9015)	0,0008	4 (0,510) 5 (0,0809) **A,S**11(0,0011)	0,0000	4 (0,7761) 5 (0,8342) **S** 9 (0,9507) **A** 11 (0,9244)	0,0017
LogN	**A,S** 4 (0,6922) 5 (0,5423)	0,0742	**A,S** 4 (0,9024) 5 (0,9562)	0,9992	**A,S** 4 (0,9424) 5 (0,9491)	1,000
First Difference LogN	**A,S** 3 (0,3472) 4 (0,2882) 5 (0,4775)	0,0000	**A,S** 3 (0,5241) 4 (0,3723) 5 (0,5177)	0,0000	**A,S** 3 (0,3470) 4 (0,4126) 5 (0,4976)	0,0000





Series: Currency (first log difference)
Sample 1962:2 2000:2
Observations 77

Mean	0.050911
Median	0.049457
Maximum	0.108976
Minimum	-0.016703
Std. Dev.	0.027944
Skewness	0.211816
Kurtosis	2.354316
Jarque-Bera	1.913359
Probability	0.384166

Appendix D

- Intertemporal Stability of the coefficients -

One of the strongest criticisms relating to the first estimate of shadow economy with the model approach was about the intertemporal stability of coefficients. Reporting the original words: "…*if the model claims to represent legitimate causal relations and not merely an ad hoc-approximation of the data, the coefficients should be stable over time.*"[71]

Helberger and Knepel's (1988) criticism to Frey and Weck-Hannemann's (1984) work showed that the results of MIMIC changed dramatically to modify of sample size.

As revealed by table 4, in the Italian case this critique is not confirmed for reduction of sample less then 37 percent (30 obs.), moreover there are no "fluctuations" about the relative importance among the variables pointed out by Helberger and Knepel (1988)[72]. Following, are re-detected the parameters for some MIMIC decreasing progressively the size of sample.

Table 4: Intertemporal stability of the estimates

Models	Tax Burden	Governm. Consump.	Unempl.	Self Employ.	Efficacy Justice	Index Illegal.	Currency	Chi-square (p-value)
MIMIC 6-1-2 Complete range	**0,58*** **(2,89)**	**1,23*** **(3,79)**	**0,51** **(1,94)**	**0,50** **(1,78)**	**1,51*** **(2,75)**	**4,49** **(1,52)**	**-0,01** **(-1,84)**	**7,81*** **(0,9865)**
MIMIC 6-1-2 (range '65:2-'00:2)	0,55* (2,70)	1,15* (3,49)	0,58 (1,88)	0,36 (0,90)	1,49* (2,44)	4,48 (1,53)	0,37 (0,95)	2,97* (0,9999)
MIMIC 6-1-2 (range '65:2-'95:2)	0,63* (2,86)	1,15* (3,37)	0,60 (1,87)	0,42 (0,97)	1,82* (2,48)	3,42 (1,12)	0,56 (1,40)	2,58* (0,9999)
MIMIC 6-1-2 (range '65:2-'90:2)	0,62* (2,29)	1,57* (4,04)	0,43 (1,21)	0,49 (0,99)	1,20 (1,46)	3,12 (0,87)	0,26 (0,70)	3,40* (0,9999)
MIMIC 4-1-2 Complete range	**0,61*** **(2,92)**	**1,20*** **(3,63)**	**0,45** **(1,66)**	--	**1,51*** **(2,98)**	--	**-0,01** **(-1,71)**	**7,42*** **(0,4921)**
MIMIC 4-1-2 (range '65:2-'00:2)	0,55* (2,64)	1,23* (3,67)	0,49 (1,60)	--	1,21* (2,13)	--	0,32 (0,79)	1,93* (0,9831)
MIMIC 4-1-2 (range '65:2-'95:2)	0,64* (2,85)	1,20* (3,53)	0,50 (1,58)	--	1,91* (2,64)	--	0,51 (1,27)	1,48* (0,9931)
MIMIC 4-1-2 (range '65:2-'90:2)	0,66* (2,52)	1,66* (4,39)	0,34 (0,96)	--	1,31 (1,65)	--	0,16 (0,43)	2,00* (0,9810)
MIMIC 3-1-2 Complete range	**0,67*** **(3,22)**	**1,19*** **(3,53)**	--	--	**1,43*** **(2,79)**	--	**-0,01*** **(-1,99)**	**4,04*** **(0,5441)**
MIMIC 3-1-2 (range '65:2-'95:2)	0,68* (3,02)	1,17* (3,39)	--	--	1,66* (2,34)	--	0,62 (1,44)	0,46* (0,9935)
MIMIC 3-1-2 (range '65:2-'90:2)	0,69* (2,62)	1,68* (4,42)	--	--	1,15 (1,47)	--	0,17 (0,44)	1,99* (0,8504)
MIMIC 3-1-2 Complete range	**0,65*** **(3,08)**	**1,34*** **(3,95)**	--	**0,86*** **(2,64)**	--	--	**0,00** **(-2,34)**	**2,77*** **(0,7351)**
MIMIC 3-1-2 (range '65:2-'95:2)	0,66* (2,88)	1,18* (3,34)	--	0,55 (1,35)	--	--	0,75 (1,57)	1,71* (0,7883)
MIMIC 3-1-2 (range '65:2-'90:2)	0,61* (2,24)	1,77* (4,60)	--	0,59 (1,27)	--	--	0,19 (0,51)	3,11* (0,5401)

Notes:

t-statistic are given in parentheses.

* Means |t-statistic|>1,96.

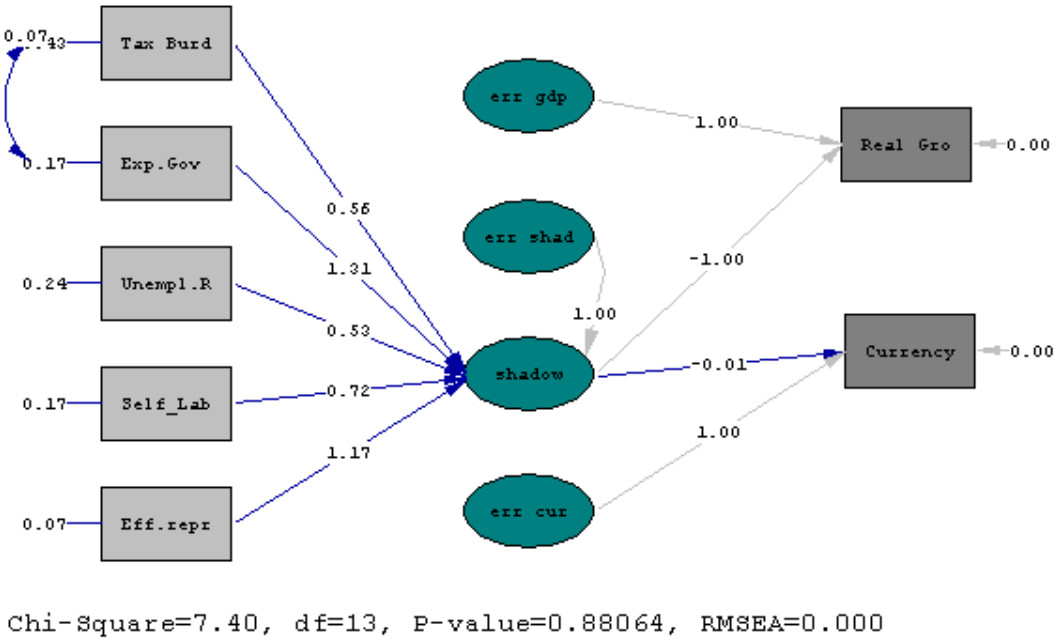
[71] Helberger C., Knepel H. (1988), pp. 969.

[72] The coefficient "insensitivity" to the model specification is obtained also by Giles, 1999b.

Appendix E - Testing the correlation between structural and measurement errors[73] -

As Hayduk (1987) demonstrates, it is possible by re-parameterisation, to obtain from the original model an equivalent revised model. Incorporating this replaced are measurement and structural errors in latent variables (graph 6), so that both can be represented in the same parameter matrix. The modification indices (MI)[74] may be able to give insight into the correlation between structural and measurement errors.

Graph 6: The MIMIC (5-1-2) re-parametrized in MIMIC (5-4-2)



Chi-Square=7.40, df=13, P-value=0.88064, RMSEA=0.000

Since the MI is approximately equal to the difference in chi-squares between two models in which one parameter is fixed or constrained in one model and free in the other, all other parameters being estimated in both models, it is possible to test the hypothesis of correlation between structural and measurement errors. In table 5, reported are the outcomes of the four models considered to obtain the time series index of the Italian shadow economy.

Table 5: Modification Indices among structural and measurement errors

	Measurem. error (Y_1)	Measurem. Error (Y_2)
Structural error (η)(MIMIC 5-4-2)	0,74	-- --
Structural error (η) (MIMIC 4-3-1)	1,18	-- --
Structural error (η) (MIMIC 3-4-2)a	-2,03	-- --
Structural error (η) (MIMIC 3-4-2)b	-2,22	-- --

Define $\chi^2_{df_1}$ the original value of chi-square and $\tilde{\chi}^2_{df_2}$ the value associated with the revisited model, from table 5: $\chi^2_{df_1} - \chi^2_{df_2} \leq 1{,}18$, with 1 degree of freedom. This difference is distributed again as a chi-square, thus it is not statistically different from zero (p-value 0,277). Hence relaxing the constraint between structural and measurement errors, models do not improve the global goodness of fitting therefore, the assumption of $E(\zeta\varepsilon') = 0'$ is empirically confirmed, and the MIMIC models can be correctly used.

[73] I wish to thank Edward E. Rigdon for helpful comments.

[74] The modification index measures how much chi-square is expected to decrease if this particular parameter is set free and the model is re-estimated. Jöreskog K., Sörbom D. (1993).

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