Estimating the size of non-observed economy in Croatia using the MIMIC approach

VJEKOSLAV KLARIĆ*
vjekoslav_klaric@yahoo.com

Article**
JEL: 017, E26, C30, C51, H26, P2
UDC: 331.526.8

* The author thanks the two anonymous referees for their insight, helpful comments and suggestions.

** Received: August 9, 2010
Accepted: November 21, 2010

Abstract

This paper gives a quick overview of the approaches that have been used in the research of shadow economy, starting with the definitions of the terms "shadow economy" and "non-observed economy", with the accent on the ISTAT/Eurostat framework. Several methods for estimating the size of the shadow economy and the non-observed economy are then presented. The emphasis is placed on the MIMIC approach, one of the methods used to estimate the size of the non-observed economy. After a glance at the theory behind it, the MIMIC model is then applied to the Croatian economy. Considering the described characteristics of different methods, a previous estimate of the size of the non-observed economy in Croatia is chosen to provide benchmark values for the MIMIC model. Using those, the estimates of the size of non-observed economy in Croatia during the period 1998-2009 are obtained.

Keywords: non-observed economy, shadow economy, Croatia, MIMIC

1 INTRODUCTION

Anyone who has ever tried applying a mathematical model in real life knows that mathematical models work ideally and without problems only on paper. Those who have dealt with models in economics know that modelling economic phenomena tends to be more difficult than modelling any natural occurring ones. No previous experience is required, though, to guess that dealing with the shadow economy presents a particular challenge. Even without knowing its definition, the very term "shadow economy" makes this obvious and it is also intuitively clear that it describes activities that are out of sight, activities that remain hidden. While some are out of sight due to mistakes, most of the activities belonging to the shadow economy are actually designed to be concealed. It is difficult even to describe what cannot be seen, let alone measure it. The task at hand, however, is to try to do both.

The first part of the task, choosing a definition of the shadow economy and/or non-observed economy, is mostly arbitrary, a matter of personal preference, since no single definition of the term is generally accepted. Different definitions have to be given to illustrate that point, but in order to insure consistency in this paper, only one can be chosen. This will be done in the second section of this paper, and section three will give a short overview of the methods used for measuring the Croatian non-observed economy.

The MIMIC approach will be used for the second part of the task. One of the goals of this paper is to present the MIMIC model, its characteristics and the theory behind it. Choosing the right way of implementing the model, as well as collecting the data to be inputted into the model presents an additional challenge. Finally, after running the data through the appropriate software, the model's output has to be carefully processed and interpreted, both mathematically and economically. This should enable the achievement of this paper's main goal, to utilize the MIMIC model to assess the size of the non-observed economy in Croatia, the effects the beginning of the recession had on it and its relationship to other economic variables. While these effects should be predictable, their extent is not. MIMIC in general will be described in section four of the paper, while section five will deal with the application of MIMIC to the Croatian economy. The choice of variables and the benchmarking procedure will be explained in detail in the appendices. The final appendix will examine the procedures used in the research in the light of Breusch's (2005) remarks.

It will be interesting to see if the slightly controversial MIMIC approach is at all applicable to an economy such as the Croatian, and what challenges a researcher faces during such a project. If it proves possible, gaining an estimate of the Croatian non-observed economy should also be interesting all by itself, since there are few estimates available for this period.

2 WHAT ARE SHADOW ECONOMY AND NON-OBSERVED ECONOMY

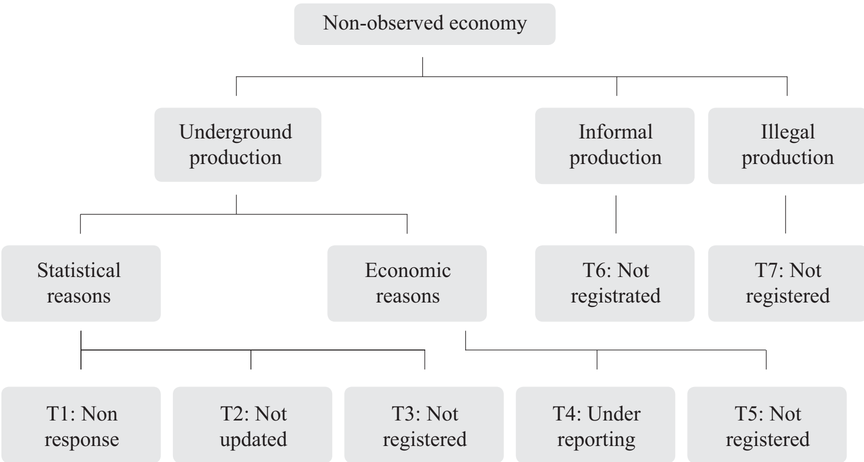
2.1 TRYING TO DEFINE SHADOW ECONOMY

During the course of research on the shadow economy, different scientists have used different definitions of it. Some definitions have been short and concise, while others have been more complex and elaborate. For instance, Schneider and Enste (2000) define the shadow economy as economic activities that contribute to the officially measured GDP, but are unregistered.

Feige (1979) simply defined the shadow economy as economic activities that go unreported or are unmeasured. Yet later, the same author (Feige, 1990) gives a much more complicated definition. He states that all economic activities can be divided into two groups; those that comply with the existing institutional rules, and those that do not. The latter activities belong to the shadow economy and can be further divided into illegal, unreported, unrecorded and informal economy. Activities belonging to the illegal economy defy legal rules, activities belonging to unreported economy produce income not reported to fiscal authorities, the ones belonging to unrecorded economy are not reported to statistical authorities and those belonging to the informal economy circumvent the costs associated with regulations, but they are excluded from benefits given by the regulations.

Another example of a "branched" definition has been given by OECD (2002) in its handbook "Measuring the Non-Observed Economy". The term primarily described is the Non-Observed Economy (NOE) and the analytical framework for the NOE is provided by the Italian National Institute of Statistics (ISTAT). It divides the NOE into underground, informal and illegal production. Underground production is further divided by reasons of occurrence. Finally, there are seven types of NOE according to ISTAT, labelled T1 – T7.

Figure 1
ISTAT framework for NOE[1]



Source: OECD (2002).

The term "shadow economy" does not appear explicitly in this framework. Strictly speaking, the term refers to T4, T5 and T6, that is, the economic part of the NOE. However, it is often used in a broader context, as a synonym for NOE.

A modification of this framework has been given by Eurostat (OECD, 2002), originally created for the European Union candidate countries. It is characterized by the additional type (T8) of NOE activities and a more detailed classification.

T8 covers a series of reasons for the lack of exhaustiveness not previously mentioned. The types of GDP under-coverage belonging to T8 are: production for own final use, tips, wages and salaries in kind, valuation of NOE adjustments, taxes and subsidies of products and reliability of quantity-price methods and product balances.

2.2 EUROSTAT METHOD OF ESTIMATING THE SIZE OF NON-OBSERVED ECONOMY

There is a method of estimating the size of the NOE based on the Eurostat (2002) framework, called the Eurostat method. It is actually a set of methods for estimating the size of each type of NOE according to Eurostat. This method is probably one of the most detailed methods of estimating NOE, if not the most detailed. Most detailed also means most complicated, so this method is rarely used for estimating NOE for more than a couple of years at a time.

[1] Different versions of the branching of the NOE are also available, having in mind the specificity of each of the national economies.

One issue which can possibly arise when using this method is that every estimate brings with it a certain error, and when several estimates are combined, several errors will be combined.

3 SOME OTHER METHODS OF ESTIMATING THE SIZE OF NON-OBSERVED ECONOMY

Just as the definitions of the shadow economy or the non-observed economy vary greatly, so do the methods of estimating its size. Here are just a few examples of such methods previously used on the Croatian economy. Their results are shown in figure 5.

3.1 SYSTEM OF NATIONAL ACCOUNTS METHOD

The System of National Accounts (SNA) method is another method tied to a specific definition, and is in a way a predecessor to the ISTAT/Eurostat approach. The SNA (1993), gives a statisticians' view on the NOE, and divides it into underground production, informal production, illegal production and production for own final use. The SNA method uses discrepancy in national accounts to estimate the size of NOE and rests on the fundamental law of the circular flow in the economy. That law states that expenditure to one entity in the economy is revenue to another entity in the same economy. The NOE is measured as the difference between the officially recorded GDP based on expenditure and production approaches, that is, the difference between total supply and total demand.

3.2 CURRENCY METHODS

Currency methods are common methods for estimating the size of the NOE. They are characterized by simple data collecting and calculations, but also some strong conditions which are required for the methods to function. The primary condition used in most monetary methods, such as Gutmann (1977) and Tanzi (1983), is that the velocity of currency in the NOE is equal to the velocity of currency in the official economy, which is controversial at best.

There are some further issues when trying to apply monetary methods to the economies of the transitional countries. These methods simply are not designed to take into consideration some of the phenomena which might occur in such economies, e.g. hyperinflation, and therefore require modifications before they can be applied to those economies.

The currency method has evolved substantially since its first appearance, though, and methods based on Gutmann's and Tanzi's approach are still being used to assess the sizes of the non-observed economies around the world to this very day.

3.3 ELECTRICITY CONSUMPTION METHOD

Methods like the electricity consumption method are based on the presumption that NOE activities, although undeclared, still have to use resources, like electricity. The size of NOE in that method is estimated by observing the relationship between the electricity consumption and the GDP.

The main source of criticism of any electricity consumption method is the questionable stability of the relationship between the electricity consumption and the GDP. This relationship could most likely be affected by a number of outside factors, such as the weather. Most of the electricity consumption methods, especially the ones using aggregate electricity consumption, also are affected by the process of transition. The others, like the household electricity approach, developed by Lacko (1998), although not as seriously affected by transition, tend to have a limited scope. The household electricity approach is, for instance, limited to non-registered activities consuming household electricity.

4 MIMIC MODEL

4.1 ABOUT MIMIC

When trying to analyze and model a certain variable, probably the first thing that springs to mind is regression analyses. The benefits of knowing how other variables affect the subject of research are quite obvious. This procedure, however, requires a number of values of not only independent, but also dependent variables to be known or estimated. With NOE being unobservable, doing just a regression is not really an option, at least not without finding a way of assessing the size of the NOE prior to the procedure.

The reason why the application of MIMIC to NOE is quite appealing is that this model appears to give us both the estimate of NOE and its relationship to other variables.

The multiple indicator multiple cause (MIMIC) model belongs to the linear independent structural relationship (LISREL) family of models and utilizes structural equation modelling (SEM) to get information about the subject of research. It was first introduced by Jöreskog and Goldbreger (1975) and its contemporary form is perhaps best described by Giles and Tedds (2002).

MIMIC in a way circumvents the issue of the subject at hand being an unobservable variable. First, an equation system just like the one in the regression analyses is introduced:

$$\eta_t = \gamma' x_t + \zeta_t, \qquad (1)$$

with $x_t = [x_{1t}\ x_{2t} \ldots x_{qt}]'$ being a (q x 1) vector of time series variables, each of which is a potential cause of the unobservable time series variable η_t, γ' being a (1 x q) vector of coefficients describing the relationship between x_t and η_t, and ζ_t being an error term.

The model represented by equation (1) is called a structural equation model and it is basically a regression model with an unobservable dependant variable. Even though η_t cannot be measured directly, the idea is that it still has impact on another set of observable variables. Those variables are called indicators, and their relationship to η_t is described by what is called a measurement model:

$$y_t = \lambda \eta_t + \varepsilon_t, \tag{2}$$

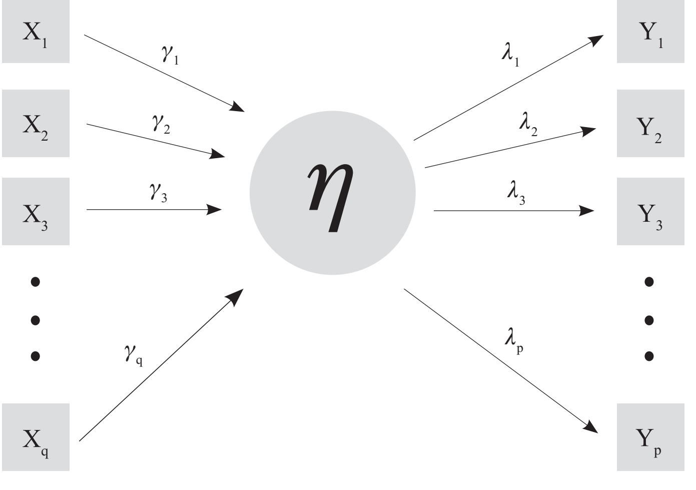
with $y_t = \lfloor y_{1t}\ y_{2t} \ldots y_{pt} \rfloor'$ being a (p x 1) vector of indicators, λ being a (p x 1) vector of coefficient describing the relationship between η_t and y_t, and ε_t being an error term of the I(0) kind.

It is assumed that both error terms have zero means ($E[\zeta_t] = 0$, $E[\varepsilon_t] = 0$), and are uncorrelated with each other. Furthermore, there are some standard abbreviations:

Σ – entire MIMIC model covariance matrix
Φ – covariance matrix of x_t
Ψ – variance of ζ_t
Θ = covariance matrix of ε_t.

The structure of the model can be presented by a path diagram.

FIGURE 2
The structure of a MIMIC q-1-p model



Source: Based on Giles and Tedds (2002).

FINANCIAL THEORY AND PRACTICE
35 (1) 59-90 (2011)

VJEKOSLAV KLARIĆ:
ESTIMATING THE SIZE OF NON-OBSERVED ECONOMY IN CROATIA USING
THE MIMIC APPROACH

So, the two sets of observable variables are connected through the unobservable variable:

$$\begin{aligned}
&\eta_t = \gamma' x_t + \zeta_t \\
&y_t = \lambda \eta_t + \varepsilon_t \quad \Rightarrow \lambda^{-1}(y_t - \varepsilon_t) = \eta_t \\
\hline
&\lambda^{-1}(y_t - \varepsilon_t) = \gamma' x_t + \zeta_t \\
&y_t = \lambda\gamma' x_t + \lambda\zeta_t + \varepsilon_t
\end{aligned}$$

or

$$y_t = \Pi x_t + v_t,$$

where $\Pi = \lambda\gamma'$ and $v_t = \lambda\zeta_t + \varepsilon_t$, although this abbreviated form can be a bit deceiving in its resemblance to a linear regression equation. The problem at hand is once again more complicated. There is an extra condition which has to be considered when estimating the parameters. The parameters have to be estimated in such a manner that if we mark the rows of Π with $r_1,\ldots, r_p$ and the columns with $c_1,\ldots, c_q$:

$$\Pi = \begin{bmatrix} r_1 \\ r_2 \\ \cdot \\ \cdot \\ \cdot \\ r_p \end{bmatrix} \Rightarrow r_i = \lambda_i \lambda_j^{-1} r_j, \forall i, j = 1,\ldots,p$$

$$\Pi = \begin{bmatrix} c_1 & c_2 & . & . & . & c_q \end{bmatrix} \Rightarrow c_k = \gamma_k \gamma_l^{-1} c_l, \forall k, l = 1,\ldots q.$$

The rank of matrix Π has to be 1, since all its rows and columns obviously have to be dependent, due to the fact that Π is a product of a (p x 1) vector and a (1 x q) vector:

$$\Pi = \lambda\gamma' = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \cdot \\ \cdot \\ \cdot \\ \lambda_p \end{bmatrix} \begin{bmatrix} \gamma_1 & \gamma_2 & . & . & . & \gamma_q \end{bmatrix} = \begin{bmatrix} \lambda_1\gamma_1 & \lambda_1\gamma_2 & . & . & . & \lambda_1\gamma_q \\ \lambda_2\gamma_1 & \lambda_2\gamma_2 & . & . & . & \lambda_2\gamma_q \\ . & . & . & & & . \\ . & . & & . & & . \\ . & . & & & . & . \\ \lambda_p\gamma_1 & \lambda_p\gamma_2 & . & . & . & \lambda_p\gamma_q \end{bmatrix}$$

Even if all the values in Π are known, there is still the matter of separating γ from λ.

That part of the problem becomes quite simple though, when acting upon the convention adopted by Giles and Tedds (2002). Since the MIMIC model is unable to determine the scale of all of the parameters, a normalization condition is required, and their convention is to set the first element of λ, to be unity, as $\lambda_1 = 1$. Depending on what the assumed relationship between η_t and y_t is, λ_1 is sometimes set to $\lambda_1 = -1$.

The actual estimate of the parameters in the MIMIC model is obtained using the model's covariance matrix. That matrix describes the relationship between the observable variables in term of their covariances and it is given by:

$$\Sigma = \begin{bmatrix} \Pi\Phi\gamma + \lambda\Psi + \Theta & \Pi\Phi \\ \Phi\Pi' & \Phi \end{bmatrix}.$$

The parameters are estimated in such a way that Σ is as close as possible to the sample's covariance matrix.

4.1 CRITICISM OF THE MIMIC APPROACH

One of the most prominent critics of using MIMIC models for estimating the size of the NOE is Professor Trevor Breusch of the Australian National University. In his paper, Breusch (2005) critically examines the entire MIMIC approach, as well as its application by Giles and Tedds (2002), Bajada and Schneider (2005), and Dell'Anno and Schneider (2003) to illustrate the common errors and anomalies that might occur when using MIMIC to estimate the size of the NOE.

The main concerns Breusch (2005) expressed looking at the MIMIC approach and its applications are:

1) Undocumented data transformations such as differencing, transforming into deviations-from-means, scaling to have unit standard deviation… Estimating coefficients using transformed data and then applying them to the untransformed variables.
2) Sensitivity to the change of units of measurement: different results can be obtained by measuring the variables in different units.
3) Differencing variables to insure stationarity being unnecessary, inefficient, creating problems and/or resulting in a predictor that has no long-run relationship with the endogenous variables it is supposed to predict.
4) The sign of the unit coefficient during normalization is sometimes chosen simply out of convenience or so that the signs of the other coefficients would make sense. Inverting the sign of the unit coefficient inverts the time path of the result, if the latent variable is interpreted as a series of changes.
5) Arbitrary benchmarking: using addition to adjust the level, not the scale of the latent variable, "sliding" it into place.
6) A single causal variable can dominate the latent variable, and contribute almost all of the movement of the estimated time series.

FINANCIAL THEORY AND PRACTICE
35 (1) 59-90 (2011)

7) The time path of the NOE estimate has little to do with the NOE activities but rather with the trends present in the entire economy and the economic variables related to it.
8) The NOE not being a latent or hypothetical quantity like, for instance, intelligence, making MIMIC not as applicable in economy as it is in psychometrics, where it originates from. Unlike the psychometric example where the units of measurement can be resolved by convention, the concept and measurement of income in the non-observed economy are the same as in the observed economy.
9) Versions of observed GDP and currency holdings cannot be a measurement of the same unobserved entity, let alone the NOE.

The procedures used to apply the MIMIC model to Croatian economy in the next chapter are examined having these points in mind in appendix 4.

5. APPLYING MIMIC TO CROATIAN ECONOMY

5.1. CHOOSING CAUSES AND INDICATORS

5.1.1 Causes

The first thing that has to be done so that the MIMIC model can be applied is deciding on the variables and collecting data. It is clear that the subject of this paper is the size of NOE in Croatia, so the list of possible causes and indicators of the NOE has to be made. The following causal variables have been used in this research.

Tax burden is probably the most frequently used explanatory variable when talking about the NOE. Certain methods actually treat taxes as the sole or, at least, the prime reason for venturing into the realms of the non-observed economy.

Taxes affect the cost of living, as well as costs of doing business, and they are incorporated into every price in the official economy. Tax evasion therefore might seem tempting as a way of increasing one's wealth. On the other hand, penalties are put in place for those trying to evade taxes. Those obligated to pay taxes have to weigh the gains of evasion against the risks of being caught. It is therefore reasonable to assume that the greater the tax burden, the greater the willingness to evade it and underground and informal production, for instance unregistered employment, are likelier to occur.

There is another reason why it might be especially interesting to observe the influence taxes have on NOE. While most economic variables can only be influenced through a set of measures, the results of which can be uncertain, the level of taxes can be directly dictated by the government.

The influence of three groups of taxes and contributions (direct and indirect taxes and social security contributions) should be observed separately. The direct taxes are those directly paid to the government by individuals or companies, e.g. taxes on income and profits. In the case of indirect taxes, the one paying the taxes to the government is not the one bearing the ultimate burden, only an intermediary. The most important indirect tax in Croatia is the value added tax.

The unemployment rate is defined as the number of unemployed persons divided by the size of active population (unemployed and employed persons), and shown as a percentage. The influence it might have on NOE is not easily predicted. On one hand, the greater the unemployment, more people will look for work in the NOE. On the other, the official economy and the NOE are not completely unrelated and the rise of the unemployment rate might indicate difficulties in the entire economy, so the output of the NOE might be in decline as well. Also, income losses due to unemployment affect demand in both the official and the non-observed economy. Finally, several activities belonging to NOE are usually done by people employed in the official economy, so the increase of unemployment would mean fewer opportunities to perform those activities.

5.1.2 Indicators

The set of indicators is more or less standard in all the papers dealing with the subject.

Gross Domestic Product (GDP) has a relationship with the NOE which could be either positive or negative, just as in the case of the unemployment rate. The lower the GDP, the likelier it is that the people will look for opportunities in the NOE. Yet, once again the relationship between the official and non-observed economy has to be taken into consideration. Favourable economic conditions, as well as unfavourable ones, affect them alike, having a similar impact on both. Also, for instance, higher income in the official economy may result in higher demand for the output of the non-observed economy.

M1 monetary aggregate in general includes currency held by the public, travellers' checks, checkable (a vista) deposits and, where available, Automatic Transfer Service (ATS) accounts. It is used as an indicator of NOE due to the fact that the transactions in NOE are usually carried out using cash, which requires no paperwork and is difficult to trace. The increase in M1 would therefore be indicative of the increasing NOE.

5.1.3 About the choice of variables

Even though doing research with a larger number of variables would be both interesting and instructive, that simply was not an option. Sample sizes when using MIMIC models recommended in the literature are virtually impossible to obtain for Croatia at this point in time, even when using a MIMIC 4-1-2 model. A larger number of variables would negatively affect the reliability of the results. On the other hand, further reduction would have probably been counterproductive for the research.

The data to which the model has been applied is quarterly, for 1998-2009. Despite the fact that some of the variables are measured monthly, most of them are measured quarterly at best, so it was not possible to increase the size of the sample by further reducing the time interval.

5.2 DATA COLLECTED

After deciding what should be the causes and the indicators, the data has to be collected.

Data on *taxes and contributions collected* used in this paper is data on taxes and contributions collected as consolidated general government revenues. The reason why consolidated general government revenues were chosen, instead of budgetary or consolidated central government revenues, is the assumption that the tax payers perceive taxes the same way, regardless of what level of government's budget they end up in.

Data for the amount of taxes collected was provided by the Croatian Ministry of Finance (http://www.mfin.hr/en/time-series-data). The quarterly data was available from the second half of 2004 on. The rest of the time series was extrapolated using the annual data (http://www.mfin.hr/en/annual-reports-of-ministry-of-finance), which is available for the entire 1998-2009 period, and the trends demonstrated by the available quarterly data.

The amounts of direct taxes, indirect taxes and social security contributions in the calculations in this paper are marked with Dir, Indir and Soc, respectively.

The *unemployment rates* in Croatia vary from source to source, due to differences in methodology. For instance, the rate provided by the Croatian Employment Service (CES) is always a couple of percentages higher than that provided by the Croatian Bureau of Statistics (CBS). Luckily, the trends are basically the same, no matter what the source.

Also, when trying simply to calculate the rate, assessing the size of the active population actually proves more challenging then acquiring the number of unemployed persons, which is regularly made public by the CES.

The unemployment rates in this paper (marked "UR" in the calculations) were obtained from the publications of the Croatian Ministry of Finance. Quarterly unemployment rates are available from the beginning of 2004 on, and the rest of the data in the time series was calculated using the data published in the Ministry's monthly statistical reviews (http://www.mfin.hr/en/monthly-statistical-reviews). It has to be said that the unemployment rates published in monthly reviews seem to be rough estimates. They are often subject to change during the following months and appear to be in a slight discrepancy with the annual unemployment rates, once they are published by the same source. Since those discrepancies are fairly constant, monthly data has been scaled accordingly, and out of those modified monthly rates, the quarterly rates have been calculated.

As far as *gross domestic product* is concerned, data used is the Croatian Bureau of Statistics' estimate of GDP by the expenditure approach, in current prices (http://www.dzs.hr/default_e.htm). The estimates of the annual GDP are provided for the entire period and the estimates of the quarterly GDP are available from the year 2000 on. Quarterly GDP estimates for 1998 and 1999 have been extrapolated.

Data on *M1* is provided by the Croatian National Bank (CNB) on monthly bases (http://www.hnb.hr/publikac/epublikac.htm). Three-month averages have been used as quarterly data.

Except for the unemployment rate, every time series mentioned above is monetary, measured in Croatian kuna (HRK). All such variables have been adjusted using the *Consumer Price Index (CPI)*. CPI is provided by CNB on monthly bases (http://www.hnb.hr/statistika/estatistika.htm). Once again, average values have been used to obtain quarterly data.

The data has not been further seasonally adjusted, to keep it as close to the real values and their proportions as possible. Possible deviations from trends in the data could be important when estimating the parameters and any deviations from trends in the results might be significant for the interpretation of the results.

Data coverage and availability in Croatia seem to be improving over time and have become quite good in recent years. However, obtaining data reaching further back in time, especially at intervals shorter than a year, is not the easiest of tasks. The quest for improvement by the appropriate statistical authorities, which is of course necessary, here presents a difficulty, because the changes in methodology pose a problem when trying to maintain data consistency. Although this is something that has to be mentioned when considering the reliability of the final results, every attempt has been made in this study to insure that consistency and to, at least, get a decent estimate of the values required for the application of the model.

5.3 FORMING CAUSAL AND INDICATOR VARIABLES

Now that data has been collected, the next step is to decide on how to form the variables that will go into the model.

When trying to determine the relationship between the variables, what is important are their trends, not the units their values are measured in. For instance, when trying to decide on how best to advertise and sell products, one might want to assess how the market share – measured in percentages, is affected by the price of the product – measured in dollars, the airtime of the commercials – measured in seconds, size of the newspaper ads and the number of flyers distributed.

What is actually determined is how the dependent variable is affected by the change of value of an independent variable. The proper conclusions can be drawn, as long as it is known what units the values of the model's input variables are measured in.

There is, however, a problem when using a MIMIC model. At no point is the relationship between the latent variable and the rest of the variables directly assessed. The initial forms of causal and indicator variables may vary greatly. A cause or an indicator may actually be a combination of a couple of variables, e.g. a ratio. It might be a logarithm of a variable, a difference etc., depending on what the author of the study finds most suited for his/her data. Then, to insure stationarity, some of them can be further differenced once, some more than once and some might not be differenced at all. Therefore, after all the causes and the indicators have taken their final form and are ready to be put into the model, it might not be clear what form the latent variable is in at all.

This is an important issue, uncertainty as to how to interpret the estimated values ($\hat{\eta}_t = \hat{\gamma}' x_t$) renders the estimate virtually useless.

In the case where the latent variable describes the size of the NOE, the interpretation of the model's output can be fundamentally different from study to study. While in most cases the output values are interpreted as percentages of NOE income in proportion to GDP, in some cases they are interpreted as the underground income itself, measured in currency[2].

It seems necessary to make the application of the model as intuitively simple as possible and to try to avoid problems with interpretation of the output. All of the variables in this paper are therefore formed out of collected data in the same manner, as growth rates:

$$\frac{\Delta TS_t}{TS_{t-1}} = \frac{TS_t - TS_{t-1}}{TS_{t-1}} := \left[\frac{TS_1 - TS_0}{TS_0}, \ldots, \frac{TS_i - TS_{i-1}}{TS_{i-1}}, \ldots, \frac{TS_{n-1} - TS_{n-2}}{TS_{n-2}} \right]',$$

where n – sample length (48), $TS_t = Dir_t, Indir_t, Soc_t, UR_t, GDP_t, M1_t$.

Such a choice of variable forms is further explained in appendix 1.

5.4 TESTING THE VARIABLES

After the initial form of the causes and indicators has been chosen, it is customary to test their stationarity, even though the reasoning behind this procedure has been put in doubt by Breusch. Using the augmented Dickey-Fuller (ADF) test (test equation with constant and test equation with constant and trend) and the Phillips-Perron test:

[2] Not necessarily directly as percentages or income, rather some function of percentages or incomes.

Table 1

ADF and Phillips-Perron test results

Variables / Test equat.	$\frac{\Delta Dir_t}{Dir_t}$	$\frac{\Delta Indir_t}{Indir_t}$	$\frac{\Delta Soc_t}{Soc_t}$	$\frac{\Delta UR_t}{UR_t}$	$\frac{\Delta GDP_t}{GDP_t}$	$\frac{\Delta M1_t}{M1_t}$
ADF C	-5.85	-13.40	-6.70	-6.62	-14.89	-6.59
ADF C&T	-5.81	-13.24	-6.62	-6.62	-15.34	-7.28
PP t-ratio	-18.60	-3.37	-6.99	-7.41	-15.45	-2.52

Source: Own calculations.

it can be concluded that all of the variables are stationary. The -2.5214 value obtained by the PP test for the M1 rate is borderline, but the software used to check the presence of the unit root combining both test suggests the null-hypothesis of the unit root should be rejected nevertheless.

Next, the Engle-Granger two-step approach is used in order to check if all of the causes are cointegrated with each of the indicators. Regression equations between the causes and each of the indicators are created:

$$\frac{\Delta GDP_t}{GDP_t} = \alpha_1 \frac{\Delta Dir_t}{Dir_t} + \alpha_2 \frac{\Delta Indir_t}{Indir_t} + \alpha_3 \frac{\Delta Soc_t}{Soc_t} + \alpha_4 \frac{\Delta UR_t}{UR_t} + u_1$$

$$\frac{\Delta M1_t}{M1_t} = \beta_1 \frac{\Delta Dir_t}{Dir_t} + \beta_2 \frac{\Delta Indir_t}{Indir_t} + \beta_3 \frac{\Delta Soc_t}{Soc_t} + \beta_4 \frac{\Delta UR_t}{UR_t} + u_2 ,$$

the regressions' parameters are estimated ($\alpha_1 = -0.1069$, $\alpha_2 = 0.5181$, $\alpha_3 = -0.5184$, $\alpha_4 = -0.4772$, $\beta_1 = -0.0723$, $\beta_2 = 0.1456$, $\beta_3 = 0.9721$, $\beta_4 = -0.1209$) and the residuals u_1 and u_2 are obtained.

Then the ADF test is performed on the residuals, and if the null-hypothesis of the unit root is rejected, the causes are cointegrated with the indicators. The result of the test (ADF1 = -4.8968, ADF2 = -4.0772) is that the causes are cointegrated with the indicators.

This procedure is rarely used, but it helps demonstrate that the choice of variables really makes sense. It is also mandatory in order for some modifications of the MIMIC model to function, for instance EMIMIC, the version of MIMIC designed for long run data introduced by Buehn and Schneider in 2008.

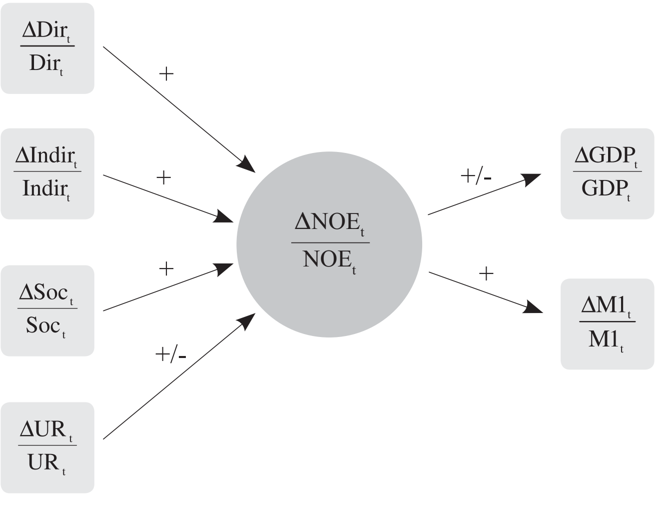
All of the chosen causes and indicators can be retained as input variables, and their form remains unchanged.

Considering the form of the model's input variables, the output of the model has to be interpreted as:

$$\eta_t = \frac{\Delta NOE_t}{NOE_{t-1}} = \frac{NOE_t - NOE_{t-1}}{NOE_t}$$ – growth rate of the NOE income adjusted using CPI.

FIGURE 3

Structure of the model applied to the Croatian economy and the assumed relationship between the variables



Source: Own formations of variables and assumptions.

5.5 ESTIMATING PARAMETERS

Now the data can be inputted into the computer so that the parameters can be estimated. LISREL program, one of more common aids for SEM modelling is used for that purpose.

In a case in which no normalization condition is imposed, the coefficients are estimated as follows[3].

TABLE 2

Parameters obtained without normalization

Variables	$\frac{\Delta Dir_t}{Dir_t}$	$\frac{\Delta Indir_t}{Indir_t}$	$\frac{\Delta Soc_t}{Soc_t}$	$\frac{\Delta UR_t}{UR_t}$	$\frac{\Delta GDP_t}{GDP_t}$	$\frac{\Delta M1_t}{M1_t}$
Parameters	-0.02	0.07	-0.06	-0.07	7.13	4.10
T-values	-3.81	8.26	-2.11	-4.91	-	4.92

Source: Own calculations.

[3] The growth rates were inputted in the software in form of percentages.

After applying the convention introduced by Giles and Tedds (2002) by setting the parameter in front of the M1 rate indicator to +1, the following estimates are obtained.

Table 3

Parameters obtained when normalizing the parameter in front of M1 rate

Variables	$\frac{\Delta Dir_t}{Dir_t}$	$\frac{\Delta Indir_t}{Indir_t}$	$\frac{\Delta Soc_t}{Soc_t}$	$\frac{\Delta UR_t}{UR_t}$	$\frac{\Delta GDP_t}{GDP_t}$	$\frac{\Delta M1_t}{M1_t}$
Parameters	-0.07	0.29	-0.25	-0.28	1.74	1.00
T-values	-3.16	4.66	-1.98	-3.70	4.92	-

Source: Own calculations.

A positive sign of the parameter in front of the M1 rate variable is expected, unlike the one in front of the GDP rate, where both signs are possible. Therefore, M1 has been chosen for normalization.

Some symptoms consistent with the small sample size are exhibited in the application of the model. The goodness of fit is not great with a high root mean squared error of approximation (RMSEA) measured at 0.259, while chi-square value is 12.24, all of which is to be expected. Seemingly the biggest issue is a slightly negative error variance. This can also be attributed to a small sample size. Van Driel (1978) suggests that in such cases the confidence interval based on the standard error of the error variance should be formed. If that interval includes zero, it is concluded that the variance is positive but near zero and that the negative estimate is due to chance. A similar procedure is suggested by Chen et al. (2001).

The error variance is estimated at -0.27 with a standard error of 4.58 in the normalized model (and -0.0053 with a standard error of 0.09 in the one that was not normalized). Van Driel's conclusions can therefore be applied.

The signs of a couple of parameters, namely those for direct taxes and social security contributions, are somewhat unexpected, and need to be addressed further. Those signs are in fact neither inexplicable nor undocumented in other studies.

For instance, as far as social security contributions are concerned, more contributions collected would ultimately mean more contributions received, which should in theory mean lesser need to turn to non-observed economy. There is, however, always the question of how many recipients of the contributions there are. Incidentally, the ratio of contributors to beneficiaries is currently a big issue in Croatia.

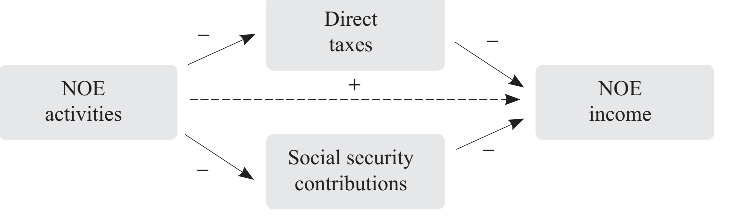
Direct taxes and social security contributions are very similar variables, often treated as a single variable, due to the similar payment procedures and dynamics.

One possible explanation for their relationship to NOE is that the amount of direct taxes and social security contributions collected is actually indicative of the observed, registered activities belonging to official economy, as opposed to the non-observed ones. It could especially be indicative of the workers registered and working in the official economy as opposed to those working in NOE.

An increase of, for instance, non-registered labour definitely leads to a decrease in the amount of income taxes collected. Also, if the rest of the economic variables, including the unemployment rate are held fixed, and the tax rates have not been changed, the decrease in the amount of direct taxes and social security contributions collected can easily be attributed to the increase in the non-observed activities. This can be shown by the following diagram.

Figure 4

The relationship between the amount of direct taxes and social security contributions collected and the NOE income[4]



Source: Own work.

Although this might explain the observed relationships, it definitely is not their only cause. Cichocki (2008) deals with the shadow economy in Poland, as well as its relationships to the state budget and the tax system. His work included building a vector autoregressive model and drawing impulse reaction functions. He discovered that the shadow economy grows when the effective tax rate for indirect taxes increases. The response of the shadow economy to an impulse of the effective tax rate for direct taxes, however, leads to a decrease in the size of the shadow economy. He therefore concluded that there is a positive relation between the shadow economy and indirect tax burden and a negative relation between the shadow economy and direct tax burden.

The theory depicted by figure 4 does not explain Cichocki's (2008) results, since he uses tax rates as measures of tax burden. This would mean that the roots of the

[4] The depicted relationship is the result of the relationship between NOE activities and the amount of direct taxes and social security contributions collected and the relationship between NOE activities and the NOE income.

relationship run deeper than first expected and probably should be subject of separate research, but nevertheless this relationship does exist.

5.6 BENCHMARKING

It has been mentioned before that part of the appeal of the MIMIC model is that it appears to give us both the estimate of NOE and its relationship to other variables. MIMIC ultimately comes up short in that respect. While it can assess the relationships of the unobservable variable to other variables, as well as its trends, its true levels and its real scale remain unknown. In order to obtain them, the observation of the unobserved variable is still required. In other words, MIMIC needs another method of estimating, so it can use its findings as a benchmark.

The ways benchmarking is performed vary from study to study but it all essentially comes down to two methods. The benchmark value is reached by the corresponding element in the time series outputted by MIMIC either by multiplication (1) of addition (2). The same procedure is then used on the rest of the time series:

$$\frac{Val_{tbm}}{\tilde{\eta}_{tbm}} = c \qquad (1)$$

$$\tilde{\eta}^{(bm)} = c * \tilde{\eta}$$

or

$$Val_{tbm} - \tilde{\eta}_{tbm} = a \qquad (2)$$

$$\tilde{\eta}_i^{(bm)} = \tilde{\eta}_i + a,$$

where Val_{tbm} – benchmark value at time index *tbm*, $\tilde{\eta}$ – estimates obtained by MIMIC, $\tilde{\eta}_i^{(bm)}$ – benchmarked estimates.

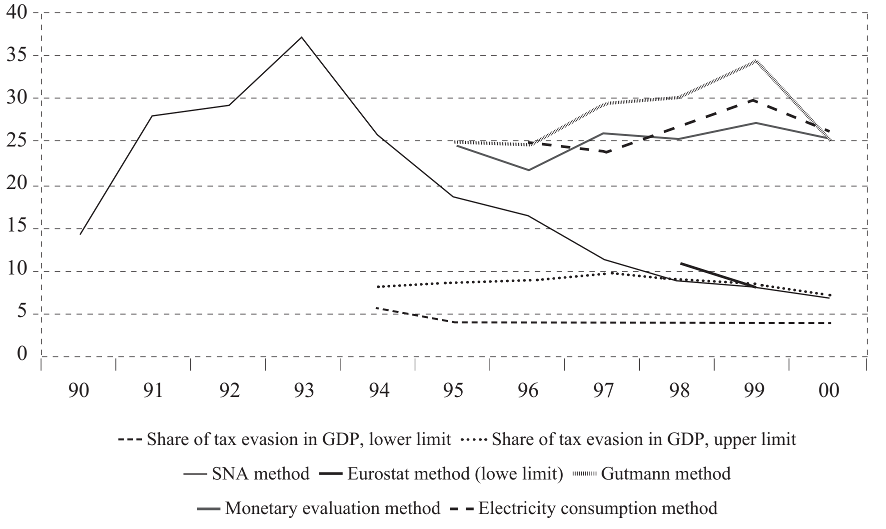
Although it sometimes seems like a convenient choice, it has to be noted that the results of benchmarking by addition are not entirely independent from the choice of indicator variable to be normalized.

Values used as a benchmark in this paper are obtained by Lovrinčević, Mikulić and Nikšić-Paulić (2002), using the Eurostat method. It is interesting to note that the levels of NOE evaluated using several methods coincide in the 1998-2000 period and that period seems to be an obvious choice for providing a benchmark value. The work of Lovrinčević, Mikulić and Nikšić-Paulić covers 1998 and 1999 giving an estimate of 8.9% and 8.1%, respectively.

Madžarević-Šujster and Mikulić (2001) give an estimate of 9.1% and 8.4% respectively for those two years using the SNA method. Similar results are obtained by Madžarević-Šujster (2001), measuring tax evasion (upper limit). Both the SNA method and the tax evasion method show that the level drops to just below 7% in 2000.

FIGURE 5

Estimates of the NOE in Croatia using various methods, 1990-2000



Source: Ott (2002).

The estimates obtained using the Gutmann method, monetary evaluation method and electricity consumption method are a bit more dispersed, but still also grouped fairly close together during that period, just on a higher level. However, the suitability of monetary methods for Croatian economy is questionable at best. On the other hand, the Eurostat method is one of the most extensive methods of estimating NOE and therefore a choice for providing a benchmark value for this study.

The estimated values in this case are interpreted as growth rates, and on a quarterly level, which, combined with benchmark values on an annual level makes for a complicated benchmarking procedure.

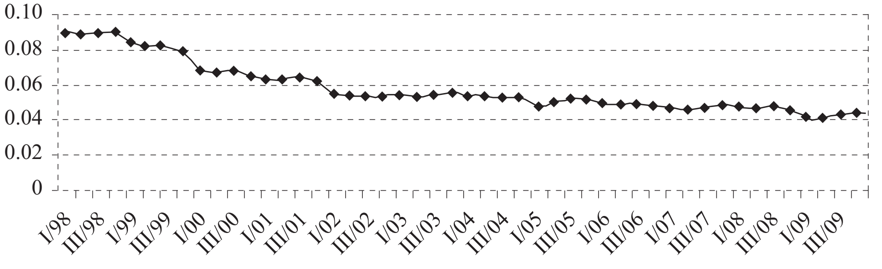
Benchmarking by multiplication probably is the optimal method[5] and will be used in this paper. The result of this procedure is the same, no matter which variable has been normalized and the adjustment does not affect the ratios between the estimates. More than one benchmark value will have to be used in this case, since two unknown values have to be determined. One is a coefficient that should be used to modify the rates, and the other is income during one of the periods, so that the rest can be extrapolated. Benchmarking procedure is given in detail in appendix 3.

The results of the benchmarking procedure are shown in figures 6-8.

[5] See appendix 2.

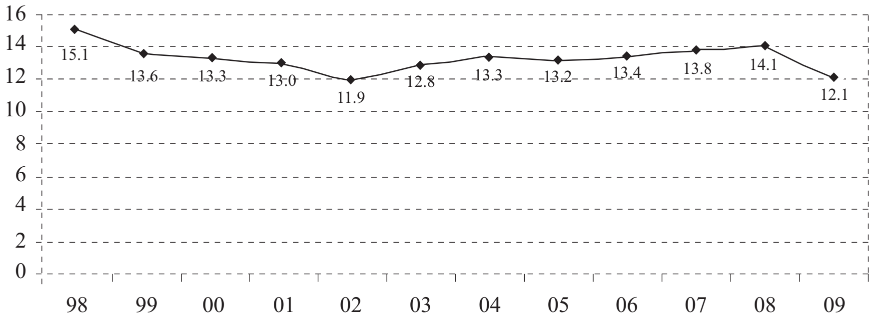
The benchmark values used to obtain those results were the lower limit estimates for the years 1998 and 1999; and therefore, as an extension of such an estimate, the obtained values should be viewed as lower limit estimates as well.

FIGURE 6
Estimate of the quarterly NOE income relative to the official GDP, 1998-2009



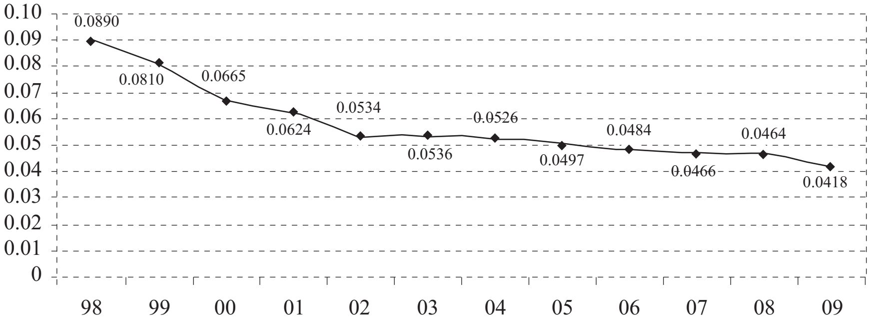
Source: Own calculations.

FIGURE 7
Estimate of the annual NOE income, 1998-2009



Source: Own calculations.

FIGURE 8
Estimate of the annual NOE income relative to the official GDP, 1998-2009



Source: Own calculations.

5.7 ABOUT THE RESULTS

The obtained estimates are a direct result of the benchmarking procedure and values, rather than independent estimates. The first two annual values are, of course, the exact values obtained by Lovrinčević, Mikulić and Nikšić-Paulić (2002). The third annual value (for the year 2000) is similar to the one obtained using the SNA and the upper limit tax evasion methods. Since the 1998-2009 period is "under the magnifying glass", it might seem that the ratio of NOE income to the official GDP dropped fairly rapidly until 2002, followed by a period of only slight changes until 2008. The changes are in fact not that dramatic in any period, when looking at the bigger picture, and the overall results are pretty stable.

Another relatively big drop surprisingly happened in 2009, compared to 2008. While both NOE income and the official GDP decreased, the decrease in the NOE income seemed to be more severe. There can be several explanations for such a result. One is simply that the MIMIC approach is not best suited to measure the size of NOE, and that it reflects the trends of other economic indicators, rather than estimate the actual size of NOE[6]. Another reason might be purely statistical in nature, as the data for the year 2009 is still fresh and may still be subject to revisions.

Provided the results are viewed as correct, there are some economic explanations. First of all, it is quite possible that the economic crisis and the measures to counteract it left the entire economy shaken up and it will take some time for all the subjects to adapt to the new situation. Some of the variables used to model the NOE probably lag in showing the full effects of global economic phenomena such as the crisis. The NOE itself in reality probably lags even further, needing time to respond to the major changes in the values of its causes. It is also plausible, given the wide array of the NOE activities, that once the crisis hit and people needed to make cutbacks, some of the activities belonging to NOE were the first to be cut. There are activities that are both non-economic (for instance, prostitution, "recreational" use of illegal drugs (T7), or even tips (T8)), and economic in nature. As far as economic activities are concerned, it is probably easier to lay off a non-registered than a registered worker, who has certain rights and is to an extent protected by law and possibly by the union. These are all short term measures, however. In the long run, during extended periods of crisis, the NOE activities would undoubtedly flourish, and their ratio to the official GDP should rise. Looking at the quarterly ratio of NOE income to GDP in 2009 (shown in figure 6), exactly that seems to be the case. Growth during three consecutive quarters seems to be the longest period of growth in the obtained estimate.

It also has to be mentioned that the MIMIC approach allows for a surprisingly large number of implementation strategies and procedures, especially when it comes to forming the input variables and benchmarking. Or, to be more precise, a

[6] See section 4.2 and appendix 4.

large number of implementation strategies has thus far been used by various researchers using the MIMIC approach. The "looseness" of the implementation algorithm might be viewed as a curse or a blessing, since economics as a science is not nearly as strict as mathematics. It, however, undoubtedly casts a shadow on the integrity of the resulting estimate. Therefore, it would therefore probably be a good idea to work on the standardization of the procedure to avoid this issue in the future.

6 CONCLUSION

Since the first research into the non-observed economy and attempts to measure it, the researchers have tackled the subject from different angles, using different approaches, and still no optimal approach on which all would agree has been found. This paper focused on the MIMIC approach. Has MIMIC proved itself to be better or worse than other methods? That depends on what is expected of it. It probably works best when applied on older, well developed and established economies, able to provide longer, more stable data series. That is true for most methods, though.

One thing MIMIC can do without any outside help is estimate relationships between the latent variable and its causes and indicators. While most of the relationships outputted by the model have been expected, an interesting negative relationship between the direct taxes and NOE and social security contributions and NOE has been estimated. This relationship seems to be present in the economies of the transitional countries.

MIMIC should however be viewed as complementary to other methods of estimating the NOE, rather than a method itself. For instance, elaborate methods that produce detailed estimates of the NOE usually cover very short periods of time, often just a year or two. MIMIC can be used successfully to complement those methods and to extend their findings over a longer period of time.

MIMIC has been used in such a fashion in this paper, using a previous lower limit estimate of the NOE in Croatia for 1998 and 1999 obtained by Eurostat method as a benchmark, and extending that estimate to 2000-2009. After a serious decrease in the first couple of years of the period covered in this study, the ratio of NOE income to the official GDP maintained almost the same level since 2002. The model would also indicate that the NOE income plummeted with the arrival of the global crisis, even more so than the official GDP, causing another more noticeable relative decrease. However, this will likely cease to be the case during the following period, if the quarterly ratio is any indication.

Appendix 1

Explanation of the choice of growth rates as the model's input variables

The choice of growth rates of samples' values as input variables could be considered slightly controversial, especially when it comes to taxes. It would seem that the plain amount of taxes collected is not really the tax burden, and that per capita values would perhaps be better suited for the task, either used instead of the growth rates, or using their growth rates:

$$(1)\ \frac{\Delta \mathrm{Tax}_t}{\mathrm{Tax}_{t-1}} \mapsto \frac{\mathrm{Tax}_t}{\mathrm{Pop}_t} \qquad \text{or} \qquad (2)\ \frac{\Delta \mathrm{Tax}_t}{\mathrm{Tax}_{t-1}} \mapsto \frac{\Delta\left(\frac{\mathrm{Tax}_t}{\mathrm{Pop}_t}\right)}{\frac{\mathrm{Tax}_{t-1}}{\mathrm{Pop}_{t-1}}}.$$

It could be argued that the amounts of taxes collected are open to external influences, such as sudden changes in the population. However, such changes would be felt all through the model, and would affect all of the variables alike. Also, the size of the population is another variable that can only be roughly estimated, not strictly determined, at least in the periods between the censuses. When those estimates are taken into consideration, it would seem that the size of ever slightly decreasing population of the post-war Croatia does not fluctuate nearly enough to seriously affect the calculated growth rates, and for (2) to be relevant[7]. Also, if some of the variables are created from the average individual's point of view, and some are on a nation-wide scale, it might not be clear how the model's output should be interpreted, especially in (1).

The most common form of the tax related variables in this sort of research is the amount of taxes collected in relation to GDP:

$$(3)\ \frac{\Delta \mathrm{Tax}_t}{\mathrm{Tax}_{t-1}} \mapsto \frac{\mathrm{Tax}_t}{\mathrm{GDP}_t}.$$

Similar reasoning as before can be used here. If some of the variables, like taxes, are used in relation to GDP, while others, like the unemployment rate, simply cannot be used in that fashion, doubts about the nature of the output of the model once again arise.

The relationship of the chosen indicator variables with the latent variable also comes into play here. As mentioned before, the relationship between the GDP and the size of NOE is described as both positive and negative. The negative relationship is due to the fact that the decrease in GDP will push people towards NOE. That would mean that the decrease in GDP would be indicative of both the increa-

[7] If the scope of the research was extended or if the research included the war and immediate post-war periods, the size of the population would be a factor which should definitely be taken into consideration.

se of the NOE income and the increase in NOE relative to the GDP. The positive relationship is explained by relationships between the official and the non-observed economy. By that interpretation, the increase in GDP is an indication of favourable conditions in the entire economy, and therefore the increase in the NOE income, but there is no reason why the NOE income relative to GDP should increase.

As for the relationship between the M1 aggregate and the size of the NOE, it was described as positive, as most of the transactions in the NOE are carried out using cash. In this case, the increase of the transactions in NOE is once again more indicative of the increase of the NOE income than the increase of the NOE income relative to GDP.

Therefore, if those two indicators are used, it makes sense to interpret the size of NOE, of which they are indicative, as the size of NOE income, instead of the size of NOE relative to GDP.

Since the expected output is not relative to GDP, none of the causes are chosen to be relative to GDP.

Appendix 2

Comparison of the benchmarking methods

The difference between the two benchmarking methods can be illustrated using data at hand, those on the Croatian economy used in this paper. The assumption is that the growth rate during the first period should be, for instance, 5%.

Table A1

Comparison of the estimated parameters when normalizing different indicators

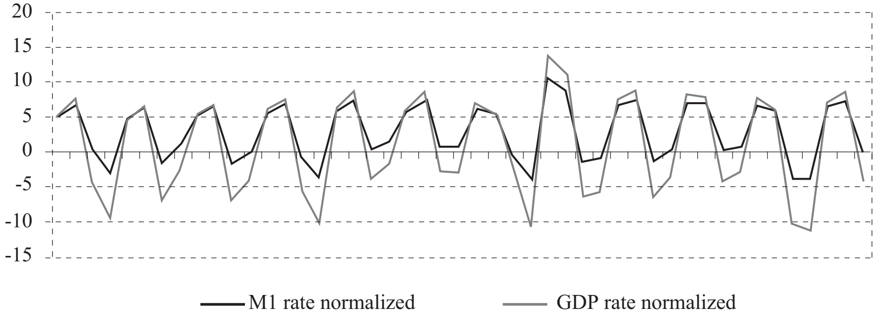
Variables	$\frac{\Delta Dir_t}{Dir_t}$	$\frac{\Delta Indir_t}{Indir_t}$	$\frac{\Delta Soc_t}{Soc_t}$	$\frac{\Delta UR_t}{UR_t}$	$\frac{\Delta GDP_t}{GDP_t}$	$\frac{\Delta M1_t}{M1_t}$
GDP rate normalized	-0.11	0.50	-0.44	-0.49	1.00	0.58
M1 rate normalized	-0.07	0.29	-0.25	-0.28	1.74	1.00

Source: Own calculations.

Here is the comparison of the model's outputs when normalizing different indicators, benchmarked by addition:

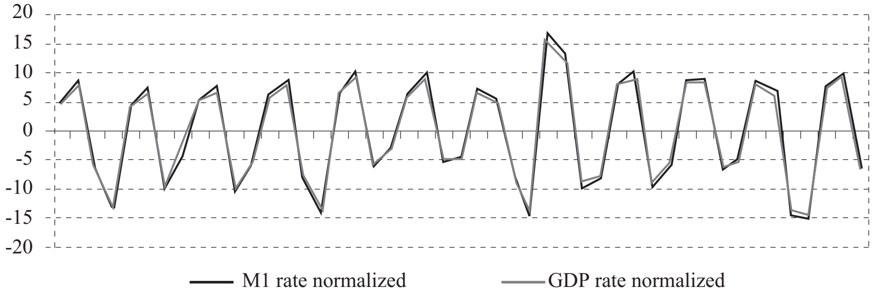
Figure A1

Benchmarking by addition



Source: Own calculations.

FIGURE A2
Benchmarking by multiplication



Source: Own calculations.

This is expected, since, as mentioned before, the MIMIC model is unable to determine the absolute scale of all of the parameters. Therefore, the output of the model is in fact $\tilde{\eta} = \frac{\hat{\eta}}{c}$, where $\hat{\eta}$ represents the real scale (of the estimate) of the latent variable η and c is unknown. This is why any kind of benchmarking is even possible.

FINANCIAL THEORY AND PRACTICE
35 (1) 59-90 (2011)

VJEKOSLAV KLARIĆ:
ESTIMATING THE SIZE OF NON-OBSERVED ECONOMY IN CROATIA USING THE MIMIC APPROACH

Appendix 3

Benchmarking – calculation

The quarterly NOE income is marked with NOE, annual NOE income derived from the benchmark values is marked with B* and the MIMIC output is marked with $\tilde{\eta}$. c is the unknown coefficient.

$$NOE_1 + NOE_2 + NOE_3 + NOE_4 = B_1^*$$
$$NOE_5 + NOE_6 + NOE_7 + NOE_8 = B_2^*$$
$$c\tilde{\eta}_1 = \frac{NOE_2}{NOE_1} - 1,\ c\tilde{\eta}_2 = \frac{NOE_3}{NOE_2} - 1\ ,\ldots,\ c\tilde{\eta}_7 = \frac{NOE_8}{NOE_7} - 1$$

$$\Rightarrow (c\tilde{\eta}_1 + 1)NOE_1 = NOE_2,\ (c\tilde{\eta}_2 + 1)NOE_2 = NOE_3,\ldots,$$
$$(c\tilde{\eta}_7 + 1)NOE_7 = NOE_8$$

$$\Rightarrow (c\tilde{\eta}_1 + 1)NOE_1 = NOE_2,\ (c\tilde{\eta}_2 + 1)(c\tilde{\eta}_1 + 1)NOE_1 = NOE_3,\ldots,$$
$$(c\tilde{\eta}_7 + 1)\ldots(c\tilde{\eta}_2 + 1)(c\tilde{\eta}_1 + 1)NOE_1 = NOE_8$$

$$p_i(c) := \prod_{j=1}^{i}(c\tilde{\eta}_j + 1)$$
$$NOE_1 * P(c) = B_1^*, \qquad P(c) := 1 + p_1(c) + p_2(c) + p_3(c)$$
$$NOE_1 * Q(c) = B_2^*, \qquad Q(c) := p_4(c) + p_5(c) + p_6(c) + p_7(c)$$

$$\frac{B_1^*}{P(c)} = \frac{B_2^*}{Q(c)}$$
$$\frac{B_1^*}{B_2^*} = \frac{P(c)}{Q(c)}$$
$$\frac{B_1^*}{B_2^*} * Q(c) - P(c) = 0.$$

The polynomial above had three real roots, only one of which could be used on as a coefficient for adjusting the growth rates. If there had been more roots that fit the profile, an additional benchmark value would probably be required.

Appendix 4

Procedures used in this research and Breusch's criticism

What can be said about the procedures done in this paper in light of Breusch's objections mentioned in section 4.2?

Breusch assumes that the reason for undocumented transformations of data lies in the incorrect use of the software used for the calculations. LISREL, mentioned by Breusch, at least its newer versions, allow the user to choose what format the data is in and what actions should be taken with it. The user only has to be careful what options he/she chooses. The data in this paper has not been through any significant transformations besides taking the form of growth rates.

The units of measurement are not really a factor in this paper: No matter what unit the original data is in, it is in essence cancelled out during the transformation of variables into growth rates, leaving all of the input variables measured in percentages. The only possible issue concerning the units of measurement is the matter of interpreting the outputted growth rates, but this possible problem is mostly economic in nature and has little to do with the model itself.

Differencing in this paper was not the result of attempts to obtain stationarity. It is a by-product of the before-mentioned transformation. The variables are stationary without additional differencing but the co-integration between the causes and the indicators is still present. While the format of the input variables might not be ideal statistically speaking, it does obviously have several desirable characteristics, which is why it has been chosen.

The normalization in this paper has been carried out in a manner that gives it a sound economic background. Different sign of the unit coefficient would invert the resulting time path, but there could not be any explanation for such an action, so it is not really an option.

Benchmarking really is a serious issue and as it is shown in appendix 2, it should be done by multiplication. The choice of benchmark values is another matter and is more or less an arbitrary procedure. This is why, as mentioned before, MIMIC should be, more than anything, used as an extension of other methods. The biggest benchmarking issue in this paper is the requirement for two benchmarking values, which largely dictates the resulting time path. However, the result for the year 2000, compared to the results obtained by the SNA method and the tax evasion method would indicate that the MIMIC method was in this case a valid extension of the Eurostat method, which was a source of the benchmark values.

None of the causal variables seem to be dominant in this case.

Objections mentioned in (7), (8) and (9) speak of the approach in general, not its applications. And while they are valid and need to be taken into consideration, if taken as absolutes, there is not much a potential user of the MIMIC approach can do about those, other than not to use this approach at all. That actually is what Breusch suggests. It might, however, be viewed as questionable if, for instance, using variables that are not very much alike is a bad thing, or if it in fact decreases the possibility that the result is exclusively a reflection of the trend of a single indicator, rather than the size of the NOE. It is also questionable if the similarities between the non-observed and the official economy are caused by the issues with the approach, or if they reflect a natural order of things.

There has actually been an entire paper published (Dell'Anno and Schneider, 2006), focusing exclusively on answering Breusch's claims. Since there is no perfect method, each method is bound to have its proponents and its critics, and different people are also bound to have different opinions on each method. The MIMIC approach has sparked a lively discussion, if not an argument, among the researchers and it will most likely continue to do so in the foreseeable future.

LITERATURE

Bajada, C. and Schneider F., 2005. "The Shadow Economies of the Asia-Pacific". Pacific Economic Review, 10 (3), 379-401.

Breusch, T., 2005. *Estimating the Underground Economy using MIMIC Models* [online]. Available from: [http://129.3.20.41/eps/em/papers/0507/0507003.pdf].

Buehn, A. and Schneider, F., 2008. "MIMIC Models, Cointegration and Error Correction: An Application to the French Shadow Economy". *CESIFO Working Paper,* No. 2200.

CBS. Croatian Bureau of Statistics – Released Data.

Chen, F. [et al.], 2001. "Improper Solutions in Structural Equation Models: Causes, Consequences, and Strategies". *Sociological Methods and Research,* 29 (4), 468-508.

Cichocki, S., 2008. "Shadow Economy and its Relations with Tax System and State Budget in Poland 1995-2007". *Working Papers,* No. 5/2008.

CNB. *Statistical Survey.* Zagreb: Croatian National Bank.

Dell'Anno, R. and Schneider, F., 2003. "The Shadow Economy of Italy and other OECD Countries: What do we know?". *Journal of Public Finance and Public Choice,* XXI (2-3), 97-120

Dell'Anno, R. and Schneider, F., 2006. "Estimating the Underground Economy Using MIMIC models: A Response to T. Breusch's Critique" [online]. *Working Paper No. 0607*, 2006. Available from: [http://www.econ.jku.at/papers/2006/wp0607.pdf].

Feige, E., 1979. "How Big is the Irregular Economy". *Challenge* (November-December).

Feige, E., 1990. "Defining and Estimating Underground and Informal Economies, the New Institutional Economics Approach". *World Development,* 18 (7), 989-1002.

Giles, M. and Tedds, D., 2002. *Taxes and the Canadian Underground Economy.* Toronto: Canadian Tax Association.

Gutmann, P., 1977. "The Subterranean Economy". *Financial Analyst Journal,* 33 (November-December).

Jöreskog, K. and Goldberger, A., 1975. "Estimation of a Model with Multiple Indicators and Multiple Causes of a Single Latent Variable". *Journal of the American Statistical Association,* 70 (351), 631-639.

Lacko, M., 1998. "The Hidden Economies of Visegrad Countries in International Comparison: A Household Electricity Approach" in: *Hungary: Towards a Market Economy.* Cambridge: Cambridge University Press, 128-158.

Lovrinčević, Ž., Mikulić, D. and Nikšić-Paulić, B., 2001. "Pristup službene statistike procjeni neslužbenog gospodarstva". *Financijska teorija i praksa,* 26 (1), 83-116.

Madžarević-Šujster, S. and Mikulić, D., 2001. "Procjena neslužbenog gospodarstva sustavom nacionalnih računa". *Financijska teorija i praksa,* 26 (1), 31-56.

Madžarević-Šujster, S., 2001. "Procjena porezne evazije u Hrvatskoj". *Financijska teorija i praksa,* 26 (1), 117-144.

Mikulić, D., 2000. "Assessment of the Unofficial Economy in the Republic of Croatia in 1998 Using the System of National Accounts". *Croatian Economic Survey,* 2000-2002, 93-117.

Ministry of Finance. *Monthly Statistical Reviews and Annual Reports* – various numbers. Zagreb: Ministry of Finance.

OECD, 2002. *Measuring the Non-observed Economy – A Handbook*. Paris: OECD.

Ott, K., 2002. "The Underground Economy in Croatia" [online]. *Occasional Paper,* No. 12. Available from: [http://www.ijf.hr/OPS/12.pdf].

Schneider, F. and Enste, D., 2000. "Shadow Economies: Size, Causes and Consequences". *Journal of Economic Literature*, 33 (March), 77-114.

Stapel, S., 2000. "Enlargement and Exhaustiveness: The Eurostat Pilot Project with the EU Candidate Countries". *Joint Workshop on Measurement of the Non-Observed Economy.* Available from: [http://www.unescap.org/stat/meet/wnoe/waisq_background2.pdf].

Tanzi, V., 1983. "The Underground Economy in the United States: Annual Estimates 1930-1980". *International Monetary Fund, Staff Papers.*

UN, 1993. *System of National Accounts*. Geneve: United Nations.

Van Driel, O. P., 1978. "On various causes of improper solutions in maximum likelihood factor analysis". *Psychometrika,* 43 (2), 225-243.