

DEPARTMENT OF ECONOMICS

Working Paper

Using Theory for Measurement:
an analysis of the behaviour of the underground economy

Francesco Busato, Bruno Chiarini
and Vincenzo di Maro

Working Paper No. 2005-19



ISSN 1396-2426

UNIVERSITY OF AARHUS • DENMARK

INSTITUT FOR ØKONOMI

AFDELING FOR NATIONALØKONOMI - AARHUS UNIVERSITET - BYGNING 1322
8000 AARHUS C - ☎ 89 42 11 33 - TELEFAX 86 13 63 34

WORKING PAPER

Using Theory for Measurement:
an analysis of the behaviour of the underground economy

Francesco Busato, Bruno Chiarini and Vincenzo di Maro

Working Paper No. 2005-19

DEPARTMENT OF ECONOMICS

SCHOOL OF ECONOMICS AND MANAGEMENT - UNIVERSITY OF AARHUS - BUILDING 322
8000 AARHUS C - DENMARK ☎ +45 89 42 11 33 - TELEFAX +45 86 13 63 34

USING THEORY FOR MEASUREMENT: AN ANALYSIS OF THE BEHAVIOR OF THE UNDERGROUND ECONOMY*

Francesco Busato^a Bruno Chiarini^b Vincenzo Di Maro^c

This draft: 26-Oct-05

Abstract

This paper generates high frequency data for the underground labor and the underground production using a theoretical general equilibrium model, over the sample 1970:01-1992:04 (32 years; 128 observations). We compare selected time series properties of the generated series with those of the corresponding series estimated with classical methodologies. The generated series for underground labor and underground production present a wider range and are more volatile than all other series estimated with classical methodologies. The analysis, next, suggests that the underground labor is pro-cyclical with respect to the GDP, that is lagging it by approximately one quarter, and that underground labor series generated from the theoretical model are highly persistent. Finally, the estimated correlation between the cyclical component of our generated-from-theory underground labor productivity and the actual series of aggregate GDP is negative (-0.34), while official yearly estimates present a positive (but very low) correlation with the cyclical component of GDP (0.12). This suggests that the underground sector has a positive impact over the productivity at the business cycle frequency, while it dampens productivity fluctuations at a lower frequency.

J.E.L.: E32, E260

Keywords: Real Business Cycle Models, Underground Economy

* We are grateful to John Donaldson, Elisabetta Marzano, Guido M. Rey, for many conversations. Bodil Krog assistance has been valuable as well. We wish also to thank the participants at Seminars and Workshops at University of Rome, la Sapienza, University of Venezia Ca' Foscari for criticisms and suggestions on earlier drafts of this paper. Of course all errors are ours.

^a Department of Economics, School of Economics and Management, University of Aarhus.

^b Corresponding Author. Department of Economics, University of Naples, "Parthenope", Via Medina 40, 80133 Napoli (Italy) Phone: +39.081.5475738; +39-081.5512207; Fax: +39.081.5475750, Email: bruno.chiarini@uniparthenope.it.

^c Department of Economics, University College of London.

1. Introduction

There are several important reasons why economists should be concerned about the relationship between underground activities and the regular economy.⁴ One of the most relevant is probably the fact that unreported activities make a sizeable contribution to national production and to income; it would be difficult, therefore, to understand the business cycles or the GDP growth without some knowledge of the dynamic behavior of this component of the aggregate economy.⁵ This paper focuses its attention on this issue.⁶

To obtain a reasonable understanding of the underground economy we obviously require its measurement. But the underground economy is, by definition, not directly observable; in addition, the estimates produced by the econometric methods, commonly used in the literature, do not pass the basic statistical tests, cover a very limited time-span (usually about a decade), and are characterized by a low frequency (usually the data present an annual frequency).⁷ In particular, three general sets of measurement approaches may be distinguished in the literature.⁸ The “*direct approaches*” are based on surveys among (supposed) suppliers and demanders of informal services and activities, or they rely on auditing of tax returns undertaken by tax collection and social security administrations. The “*indirect approaches*” share the assumption that underground transactions are paid in cash in order to make detection more unlikely. The size of the underground economy is reflected in the amount of cash used in a country, beyond that used for official transactions. Finally, the “*model approaches*” focus on the causes and the effects of underground economy and try to estimate models for labor, money and product markets using “latent variables” techniques. The models seek to identify the unobserved sector relying on several incentives (burden of taxation and

⁴ There is no agreement over what to include in the underground phenomenon. See, for instance, Thomas (1992) or Schneider and Enste, (2000). We refer to this phenomenon as unreported (and therefore untaxed) activities.

⁵ In fact, models that explicitly incorporate an underground sector perform well in replicating the labor market regularities of European economies; the same model, without the explicit introduction of this sector, would perform poorly along the standard business cycle facts.

⁶ Busato and Chiarini (2004) and Busato, Chiarini and Rey (2005) investigate the allocation mechanism and the fiscal policy implications related to the first reason in several recent papers.

⁷ Of course there are many other arguments to investigate on the underground economy. It is clear that the presence of the underground economy distorts many standard economic relations and, therefore, the study of this phenomenon is essential for full understanding of the economic system and for making more effective the policy.

⁸ See, for instance, the surveys of Schneider and Enste, (2000), Frey and Schneider (2000) and OECD (2002; 2004).

of social security contributions, as well as government regulations) and disincentives to be active in the underground economy (e.g. the probability of being detected and the size of punishment, entailed moral costs). The main difficulty, however, with these approaches is that they are generally applicable under very restrictive assumptions; in addition, the estimation techniques tend not to be statistically robust, providing a large range of estimates of the phenomenon that strongly changes with small changes in specification.

The aim of this paper is to generate high frequency series for the underground labor and the underground production using a theoretical general equilibrium model.

Precisely, we follow the idea that unobserved series may be derived by a well-behaved theoretical model first implemented by Ingram, Kocherlakota, and Savin (1997) to the household production sector.⁹ This methodology has the important advantage to produce data for these unobservable components at a high frequency (i.e. quarterly), and over a longer sample (i.e. 32 years); this creates a sufficient numerosity of the observations for undertaking a proper time series econometric analysis with the simulated data. We intend our generated series as complementary to the existing ones, estimated with classical methods.¹⁰

Our benchmark dynamic general equilibrium model presents two sectors, in which there are three agents: firms, households and government; in addition, it assumes that there exists a homogeneous good. The government levies proportional taxes on corporate revenues and income flows, and balances its budget in each period. Firms and households, being subject to distortionary taxation, use the underground sector to evade taxes. The time-series for underground production and underground labor are generated from closed-form equilibrium conditions. The analysis focuses

⁹ The authors construct a dynamic equilibrium model incorporating the economic phenomenon in which they are interested (namely the size and the dynamics of the household production sector), and they use the optimality equilibrium conditions to generate series for that non-directly observable quantity.

¹⁰ In this respect the approach implemented in the paper departs from the classical methodologies mainly because it relies on a theoretical model. A theoretical framework, like the one presented in this paper, becomes important for supporting the “magic numbers” about the size of the underground economy, and its dynamics over the business cycle. In addition, a theoretical model would be of great help for answering several policy questions related to an underground sector and tax evasion. See, for instance, Thomas (1999) and Giles (1999) works. The former author stresses the “heroic assumptions” of the approaches used to estimate the unrecorded sector, whereas Giles provides a milder criticism to the econometric techniques to measure the size of the underground economy.

on the Italian economy, because of the availability of a good dataset for the underground economy, but the methodology can be applied, without loss of any generality, to any other country.

Here is an overview of our results. We generate series for underground labor and underground production for 32 years (128 quarters), over the sample 1970:01 – 1992:04. The generated series for underground labor and underground production present a wider value range, and are more volatile than all other series estimated with classical methodologies. Moreover, the analysis of the generated series suggests that the underground labor is pro-cyclical with respect to the GDP, that is lagging it by approximately one quarter, and that underground labor series generated from the theoretical model are highly persistent.

Finally, we use the generated series of underground labor and of underground production to construct a series of the underground labor productivity to understand its relationship with the aggregate productivity.¹¹ This is an interesting application of the methodology because it contributes to the debate on the sources of aggregate productivity and on the shocks' propagation mechanism. The main result is that the estimated correlation between the cyclical component of our generated-from-theory underground productivity and the actual series of aggregate GDP is negative (-0.34), while official yearly estimates present a positive (but very low) correlation with the cyclical component of GDP (0.12). This suggests that the underground sector has a positive impact on the productivity at the business cycle frequency, while it dampens productivity fluctuations at a lower frequency.

The paper is organized as follows. Section 2 presents the model. Section 3 discusses the traditional methods used by the existing literature to estimate underground activities. Section 4 presents our approach: “using theory for measurement”, in the spirit of Ingram, Kocherlakota, and Savin (1997). Next, Section 5 shows the empirical results, whereas Section 6 performs a sensitivity

¹¹ The dynamic behavior of the factors' productivity has been widely discussed in the literature (i.e. Basu and Kimball (1997), or Nucci and Marchetti (2005)).

analysis for a set of parameters of the model. Section 7 concludes the paper. Data and sources are discussed in the Appendix.

2. Model structure

The economy is populated with a large number of identical households, each of which will live forever and each with identical preferences defined over consumption and labor inputs at every date. Each household allocates labor services in the regular sector and in the informal sector. The economy is also populated by a large number of identical firms, each of which rent capital and labor services from the households.

2.1 Households' preferences

There is a continuum of agents indexed by $\gamma \in [0,1]$ with preferences over consumption and labor services. We restrict the momentary utility function to have the following form:

$$U_t^\gamma = \frac{(c_t^\gamma + \varphi c_{G,t}^\gamma)^{1-q} - 1}{1-q} - B_M \frac{(n_t^\gamma)^{1+\xi}}{1+\xi} - B_U \frac{(n_{U,t}^\gamma)^{1+\psi}}{1+\psi}, \quad (1)$$

where c_t^γ is the private consumption, $c_{G,t}^\gamma$ stands for government purchases of the homogeneous good produced in the economy, n_t^γ is the total labor services supply, and $n_{U,t}^\gamma$ is the underground

labor supply. Notice that $B_U \geq 0; B_M \geq 0$. The last term $B_U \frac{(n_{U,t}^\gamma)^{1+\psi}}{1+\psi}$ is the idiosyncratic cost of

working in the underground economy, and the term $B_M \frac{(n_t^\gamma)^{1+\xi}}{1+\xi}$ stands for the overall disutility of

working.

There are two resource constraints; the chosen working time which must be allocated to the regular and underground sector; and the total use of goods for consumption and investment cannot exceed the disposable income net taxes:

$$\begin{aligned} n_{M,t}^\gamma + n_{U,t}^\gamma &\leq n_t^\gamma \\ c_t^\gamma + i_t^\gamma &= (1 - \tilde{\tau}_t^\gamma) (w_{M,t}^\gamma n_{M,t}^\gamma + r_t^\gamma k_t^\gamma) + w_{U,t}^\gamma n_{U,t}^\gamma \end{aligned} \quad (2)$$

$$k_{t+1}^\gamma - (1 - \Omega)k_t^\gamma = i_t^\gamma,$$

where Ω denotes a quarterly depreciation rate for private capital stock. In addition, the households own an initial stock of capital, $k_{i,0}^\gamma$, which they rent to firms and may augment through investment.

The household's problem is the following:

$$\begin{aligned}
& \max_{\{c_t^\gamma, i_t^\gamma, n_{M,t}^\gamma, n_{U,t}^\gamma, n_t^\gamma\}_{t=0}^\infty} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^\gamma, n_{M,t}^\gamma, n_{U,t}^\gamma, n_t^\gamma; c_{G,t}, \Xi) \\
& s.t. \\
& c_t^\gamma + i_t^\gamma = (1 - \tilde{\tau}_t^\gamma) (w_{M,t} n_{M,t}^\gamma + r_t k_t^\gamma) + w_{U,t} n_{U,t}^\gamma \\
& i_t^\gamma = k_{t+1}^\gamma - (1 - \Omega) k_t^\gamma \\
& n_{M,t}^\gamma + n_{U,t}^\gamma = n_t^\gamma \\
& k_{i,0}^\gamma, c_{G,t} \text{ given}; c_t^\gamma, n_{M,t}^\gamma, n_{U,t}^\gamma, n_t^\gamma > 0 \\
& \tilde{A}_{t+1} = dF(\tilde{A}_{t+1}; \tilde{A}_t),
\end{aligned} \tag{3}$$

where E_0 is the mathematical expectation operator (at $t=0$), Ξ stands for the parameter's set, and $\tilde{A}_t = [\tilde{\tau}_t^\gamma, \tilde{\tau}_t^\pi, \lambda_t]$ is a stochastic disturbances vector that will be discussed below. Consumers take government purchase of final commodities, $c_{G,t}$, as given.

The representative consumer choice leads to the following equations:

$$n_{U,t}^\gamma = \left(\frac{w_{U,t} - (1 - \tilde{\tau}_t^\gamma) w_{M,t}}{(1 - \tilde{\tau}_t^\gamma) w_{M,t}} \right)^{\frac{1}{\psi}} \left(\frac{B_M}{B_U} \right)^{\frac{1}{\psi}} (n_t^\gamma)^{\frac{\xi}{\psi}} \tag{5}$$

$$(c_t^\gamma + \varphi c_{G,t})^q = \left(\frac{w_{U,t} - (1 - \tilde{\tau}_t^\gamma) w_{M,t}}{B_U (n_{U,t}^\gamma)^\psi} \right) \tag{6}$$

Equation (5) shows that the underground labor supply depends on the total labor supply n_t^γ , the ratio between the two inverse elasticities (ξ/ψ), and the difference between the wage rates.

Equation (6) shows that the aggregate consumption is determined by the tax wedge, which, in turn, depends on the income tax $\tilde{\tau}_t^\gamma$. Condition (6) suggests that the larger the tax wedge is, the more resources are allocated to the underground sector. Households may finance increases in consumption by raising their underground income by working in the underground sector.

Optimal investment choice depends on the following Euler equation:

$$\left(c_t^\gamma + \varphi c_{G,t}\right)^{-q} = \beta E_t \left(c_{t+1}^\gamma + \varphi c_{G,t+1}\right)^{-q} \left((1 - \tilde{\tau}_{t+1}^Y) r_{t+1} + 1 - \Omega\right) \quad (7)$$

The economy wide constraint is given by

$$C_t + I_t + G_t = Y_t, \quad (8)$$

where G_t denotes aggregate government spending; aggregate variables are defined as $C_t = \int_0^1 c_t^\gamma d\gamma$;

$$I_t = \int_0^1 i_t^\gamma d\gamma; Y_t = \int_0^1 y_t^i di.$$

2.2 Production technologies

Each firm $i \in [0,1]$ uses employment supplied to the regular labor market and capital to produce the regular output $y_{M,t}^i$, whereas employment supplies to the informal sector are used to produce underground output $y_{U,t}^i$.¹²

$$y_{M,t}^i = \lambda_t (k_t^i)^\alpha (n_{M,t}^i)^{1-\alpha}; \quad y_{U,t}^i = \lambda_t (n_{U,t}^i) \quad (9)$$

The production technologies are scaled by λ_t , an exogenous productivity shock which is able to alter the average level of output.

2.3 A model of tax evasion

Firms may be discovered evading with probability $p \in (0,1)$ and forced to pay the stochastic tax rate τ_t^Π , increased by a surcharge factor $s > 1$. The following scheme summarizes the tax evasion model:

$$REV_t^i \begin{cases} \rightarrow \text{Detected} (\sim p) & REV_{D,t}^i = (1 - \tau_t^\Pi) y_{M,t}^i + (1 - s\tau_t^\Pi) y_{U,t}^i \\ \rightarrow \text{Not Detected} (\sim 1-p) & REV_{ND,t}^i = (1 - \tau_t^\Pi) y_{M,t}^i + y_{U,t}^i \end{cases} \quad (10)$$

In order to compute the expected revenues, we apply linear projection:

$$E_t REV_{D,t}^i = p REV_{D,t}^i + (1-p) REV_{ND,t}^i, \text{ which yields:}^{13}$$

¹² This technology specification is proposed in Busato and Chiarini (2004), and it can be shown that it is derived by a more general set-up where both production functions use capital and labor inputs.

$$E_t REV_{D,t}^i = (1 - \tau_t^\Pi) y_{M,t}^i + (1 - ps \tau_t^\Pi) y_{U,t}^i \quad (11)$$

2.4 Firm behavior

At each date t , firm i maximizes period expected profits¹⁴:

$$\begin{aligned} \max_{\{n_{M,t}^i, n_{U,t}^i, k_t^i\}} \tilde{\Pi}_t^i &= E_t REV_t^i - w_{M,t} n_{M,t}^i - w_{U,t} n_{U,t}^i - r_t k_t^i \\ \text{s.t.} & \\ y_{M,t}^i &= \lambda_t (k_t^i)^\alpha (n_{M,t}^i)^{1-\alpha} : \quad y_{U,t}^i = \lambda_t (n_{U,t}^i) \\ E_t REV_{D,t}^i &= (1 - \tau_t^\Pi) y_{M,t}^i + (1 - ps \tau_t^\Pi) y_{U,t}^i \\ n_{U,t}^i &> 0; n_{M,t}^i > 0; k_t^i > 0 \end{aligned} \quad (12)$$

The following first order conditions characterize the corporate efficiency conditions:¹⁵

$$\begin{aligned} w_{M,t} &= (1 - \tilde{\tau}_t^\Pi)(1 - \alpha)(k_t^i)^\alpha (n_{M,t}^i)^{-\alpha} \lambda_t \\ w_{U,t} &= (1 - ps \tilde{\tau}_t^\Pi) \lambda_t \\ R_t &= (1 - \tilde{\tau}_t^\Pi) \alpha (k_t^i)^{\alpha-1} (n_{M,t}^i)^{1-\alpha} \lambda_t \end{aligned} \quad (13)$$

2.5 Government

The government is described as a sequence $\{\tau_t\}_{t=0}^\infty$ of tax rates on consumers' income and on firms' profits:

$$\{\tau_t\}_{t=0}^\infty = \{\tilde{\tau}_t^Y, \tilde{\tau}_t^\Pi, \tilde{G}_t\}_{t=0}^\infty \quad (14)$$

Government collects tax revenues $R\tilde{V}_t$:

$$R\tilde{V}_t = E_t [(w_{M,t} n_{M,t}^i + r_t k_t^i) \tilde{\tau}_t^Y + \tilde{\tau}_t^\Pi (y_{U,t} ps + y_{M,t})]$$

¹³ Where the following “no bankruptcy condition” is imposed, $(1 - ps \tau_t^\Pi) \geq 0$.

¹⁴ In Prescott and Mehra's (1980) recursive equilibrium scheme, firms solve a myopic profit maximization problem on a period-by-period basis. See also the papers included in Cooley (1995).

¹⁵ It can be shown that when there is no distortionary taxation, the equilibrium underground labor services equal zero, as long as underground sector average productivity is sufficiently low. This represents the trade-off between employing professional labor services in the regular market (and paying taxes on it), and employing less productive labor in the underground sector (with the advantage of evading the associated taxes). In this case underground labor services are used for evading taxes, even if those services have a relatively lower productivity.

In this model both consumers and firms evade taxes. Consumers evade income taxation producing an income loss associated to the underground produced income flow $w_{U,t}n_{U,t}\tilde{\tau}_t^Y$. Firms always try to evade an amount of taxes equal to $\tilde{\tau}_t^\Pi y_{U,t}$. When discovered, firms pay the additional fine $\tilde{\tau}_t^\Pi y_{U,t}ps$. That happens, as described above, with probability p . In the other case, firms do evade and are not discovered with probability $(1-p)$. The expected corporate tax evasion equals $(1-p)\tilde{\tau}_t^\Pi y_{U,t}$. Total tax evasion is, therefore:

$$E_t TE_t = \left[(1-p)\tilde{\tau}_t^\Pi y_{U,t} + \tilde{\tau}_t^Y w_{U,t}n_{U,t} \right]$$

Government spending is allocated to purchase of final consumption goods, and it equals government revenues:

$$\tilde{G}_t = R\tilde{V}_t = c_{G,t} \quad (15)$$

2.6 Stochastic disturbances

$$A_{t+1} = QA_t + v_t, \quad (16)$$

where $A_t = [\tilde{\tau}_t^Y, \tilde{\tau}_t^\Pi, \lambda_t]$ and v_t is a vector including shocks' innovations; the autocorrelation coefficient matrix Q and the covariance matrix Σ are defined below:

$$Q = \begin{bmatrix} \varphi_\lambda & 0 & 0 \\ 0 & \varphi_Y & 0 \\ 0 & 0 & \varphi_\Pi \end{bmatrix} \quad \Sigma = \begin{bmatrix} \sigma_{v,\lambda} & 0 & 0 \\ 0 & \sigma_{v,Y} & 0 \\ 0 & 0 & \sigma_{v,\Pi} \end{bmatrix}$$

2.7 Competitive equilibrium characterization

A competitive allocation is a policy $\{\pi_t^*\}_{t=0}^\infty$, an allocation $\{x_t^*\}_{t=0}^\infty = \{K_t^*, C_t^*\}_{t=0}^\infty$ and a price system $\{1, w_{M,t}^*, w_{U,t}^*, r_t^*\}_{t=0}^\infty$ such that, given the policy and the price system, the resulting allocation maximizes the representative consumer utility (condition (4)) subject to *i*) the sequence of budget constraints (condition (2)); *ii*) the price system $\{1, w_{M,t}^*, w_{U,t}^*, r_t^*\}_{t=0}^\infty$ (condition (13)); *iii*) the

government budget constraint is satisfied on average (condition (15)); *iv*) and the market clearing conditions hold for each market (condition (8)).

3. Classical methods for estimating size of the underground economy

Underground economy estimates represent important information for a complete understanding of an economic system, of its fluctuations, and of its response to macroeconomic policies, among the many issues.

The perception that the underground economy is sizable led a number of authors to attempts to measure its size, influence and implications for the national income and labor input (see, for instance, Bhattacharyya, 1999). The authors, often, in carrying out quantitative estimates, do not sufficiently clarify the nature of the phenomenon, because of its complexity.¹⁶ These difficulties, along with the necessity of specifying and implementing a vast range of indicators to capture some elements of the unobservable variables, generate a large gap between estimates over the same period. Of course these results are not valueless. Despite their weakness each estimate of underground economy constitutes a piece of information and can be useful to improve knowledge of dimension and features of the phenomenon. However, the robustness of the various findings is important for evaluating the structural and the cyclical properties of the underground sector's behavior, and when the government wishes to set out measures which aim to push firms and workers to switch into the regular sector. Because of the elusive nature of the underground economy, the estimates provided by the econometrics literature may be taken as purely indicative. The reasons for their imprecision and variability should make us cautious when we assess the real significance, in absolute and relative terms, of the size of the irregular sector. In this context, it could be fruitful to utilize a different framework for data construction. In particular, a new approach which exploits firms and households' optimality to generate data for unobservable variables.

¹⁶ This aspect is documented in the Economic Journal Symposium on the Hidden Economy, Vol. 109, No 456, June 1999. See also Dallago (1990), Thomas (1992), and Chiarini and Marzano (2004).

In addition, the main empirical difficulty is that sufficiently long macroeconomic time series data are not available; furthermore, there exist a number of different estimates in each country.

Here comes our contribution. In order to obtain information on the aggregate fluctuations we use the previously presented two-sector model for generating the unobserved data. The use of a general equilibrium model to infer the size and the dynamics of an unobserved underground sector ensures the consistency with the optimal behavior of the representative households and firms.

Figure 1 compares several existing estimates of the Italian underground economy obtained with different empirical approaches. Italian literature provides a few examples of estimates of macro series, mainly based on the Tanzi methods. In particular, we consider Bovi's (1999) estimates, which range from 1970 to 1997, Zizza (2002) estimates, which range from 1984 to 2000, Chiarini and Marzano (2004) estimates, which range from 1976 to 1998, and the official National Institute for Statistics (Istat) estimates for the period 1992 to 2003.

Here we want to stress a major finding. As noted earlier, although many of these estimates are generated by Tanzi's methods, they provide for the same periods quite different results in terms of size and dynamics of the informal sector. In these circumstances, a different approach to the estimation of the unobservable variables which is consistent with optimal behavior on the part of economic representative agents who are able to operate in both, the regular and the underground sectors, could provide a good measure of this phenomenon and, in any case, a useful benchmark.¹⁷

¹⁷ Moreover, because complete samples of values for the underground economy are difficult to find, the data generated by the model may be used explicitly in econometric modelling.

4. “Using theory for measurement”

The model presented in the previous section, via the optimal inter-temporal and intra-sectoral behavior of the agents and a set of institutional parameters, is capable of generating values for the underground production and for the labor force. Although we do not use statistical inference (observed data to draw conclusions about the population from which the data came), the data and the process that generates them may be useful sources of information and comparison among the many estimates of the underground economy.

4.1 The Ingram, Kocherlakota, Savin (1997) methodology

The first application of the methodology implemented in this paper is due to Ingram, Kocherlakota and Savin (1997) (IKS). They study the cyclical behavior of home production under the motivation that without a good knowledge of the home sector it is not possible to fully understand the business cycle. Their seminal approach follows from the fact that data for home-sector activities is not available at high frequencies (at best is available yearly). In brief, they use macroeconomic theory in conjunction with aggregate macroeconomic data to infer the behavior of unobserved home-sector variables.

In particular, IKS consider a representative agent with stable preferences but stochastic production technologies in the home and market sectors. Then, they assume that observed market variables are well measured and consistent with the optimal behavior of this representative agent. Accordingly, they use the representative agent’s first order conditions to generate quarterly series for the home-sector variables. Here we specialize this approach for the measurement of the underground sector.¹⁸

¹⁸ A comparison between the underground economy and the home production model’s characteristics is reported in Appendix A.3.

4.2 Derivation of the dynamic equilibrium conditions

According to the model presented in Section 3, the representative agent makes optimal choices on how much to consume, to invest, and how many hours to allocate in each sector, at every point in time, taking into account both the regular and the underground sectors. This section derives the equilibrium condition characterizing the optimal labor allocation to the underground sector. The optimality condition, next, can be used to generate data for the underground sector.

Combine, first, the optimality condition (5) and the corporate efficiency condition

$w_{U,t} = (1 - ps\tilde{\tau}_t^\Pi)\lambda_t$ to obtain:

$$\frac{n_{U,t}^\gamma}{n_t^\gamma} = \left(\frac{(1 - ps\tilde{\tau}_t^\Pi)}{(1 - \tilde{\tau}_t^\gamma)w_{M,t}} - 1 \right)^{\frac{1}{\psi}} \left(\frac{B_M}{B_U} \right)^{\frac{1}{\psi}} (n_t^\gamma)^{\frac{\xi-1}{\psi}} \quad (17)$$

At every point time firms' optimality conditions imply that the wage in the regular sector can be expressed as $w_{M,t} = (1 - \tilde{\tau}_t^\Pi)(1 - \alpha)(k_t^i)^{\alpha} (n_{M,t}^i)^{-\alpha} \lambda_t$. This equation can be rewritten imposing also the normalization restriction $\lambda_t = 1$, as follows:¹⁹

$$w_{M,t} = (1 - \tilde{\tau}_t^\Pi)(1 - \alpha) \frac{y_{M,t}^i}{w_{M,t}} \quad (18)$$

This allows us to express the labor-input ratio as follows:

$$\frac{n_{U,t}^\gamma}{n_t^\gamma} = \left(\frac{(1 - ps\tilde{\tau}_t^\Pi)}{(1 - \tilde{\tau}_t^\gamma)(1 - \tilde{\tau}_t^\Pi)(1 - \alpha) \frac{y_{M,t}}{w_{M,t}}} - 1 \right)^{\frac{1}{\psi}} \left(\frac{B_M}{B_U} \right)^{\frac{1}{\psi}} (n_t^\gamma)^{\frac{\xi-1}{\psi}}. \quad (19)$$

Now, equation (19) expresses the share of underground employment (out of total employment) as a function of total employment n_t^γ , productivity in the regular sector $\frac{y_{M,t}}{w_{M,t}}$, preference and taxation

parameters. An implication of (19) is that whenever the total employment and the productivity are

¹⁹ Notice that in our model the scale productivity parameter λ_t enters both the production function of the regular and underground sectors in the same fashion.

at their equilibrium values, the share of underground employment will be at its equilibrium value as well. On the other hand, if one variable is out of its equilibrium value then the others will adjust to keep the equality in (19).

Equation (19), moreover, is an equilibrium relationship, and it does not necessarily hold if one (or both) of the series in the right-hand side exhibit a trend. Accordingly, we apply the Hodrick-Prescott filter to the series for the regular sector productivity and for the total employment and use de-trended series in the generation of the unobserved share of underground employment series.²⁰ The de-trended series will fluctuate around zero with departures from equilibrium expressed in the specific series' units (for example for the total employment the disequilibrium will be expressed in number of labor units in excess, or below, of the equilibrium value). To make the series consistent with a common metric of disequilibrium we implement a two-step transformation: first, we assume that the mean of each series is a proxy of its equilibrium value. Then, we transform the series in order to have as equilibrium value. In brief, the result of this strategy is that the series for total employment and the productivity in the regular sector take value 1 when they are at their equilibrium value (the mean) and values expressed as percentage of the mean when out of the equilibrium.

To summarize, our procedure for measuring the underground sector consists of two main parts. First, we use prediction from theory; in particular, we use the representative consumer's optimality conditions and the corporate efficiency conditions to derive an equation that expresses the underground unobserved sector variable (in our case the underground employment quota) as a function of only observed variables. The second step is to use the observed data to generate the underground, not directly observable, variables. This step involves also to rescale the observed

²⁰ See the Appendix for details on the data set.

series in order to make them consistent with the fact that equation (19) is an equilibrium condition.²¹

5. Results

We generate series for the share of employment in the underground sector (see Figure 2) using condition (19) and the parameterization of the model reported in Table 1 (see below). Preference and technology parameters are consistent with the standard literature: logarithmic utility ($q=1$); $\beta=0.984$, $\alpha=0.33$ and $\Omega=0.025$. Labor supply parameters follow the analysis of Blundell and MaCurdy (1999), whereas the disutility parameters are calibrated to match volatilities of aggregate labor and investment. For the probability of being detected (p) and the penalty factor (s) we refer to Busato and Chiarini (2004) who calibrate these parameters using the information on the number of inspected firms.²²

The estimated average value for effective income tax rate equals $\tau^Y=0.3426$, over the sample 1970-2000; the estimated average corporate tax rate, next, equals $\tau^\Pi=0.4155$ (Data source: OECD (2003) database and authors' calculations).

[Here FIGURE 2]

Table 1: Parameterization of the model

τ^Y	τ^Π	α	Ω	p	s	ψ	B_M	B_U	q	ξ
0.3436	0.4155	0.33	0.025	0.03	1.3	0.06	1.2	1.4	1	1

²¹ This methodology is robust to changes of the context in which one applies it. Here we apply the procedure to generate a particular kind of unobserved variable, the employment in the underground sector. However, the same methodology could be applied to generate any kind of unobserved series as long as there is a model that delivers usable predictions.

²² We may wonder if the settled parameterization provides business cycle statistics able to replicate current data. The numerical results of simulating this economy are shown in Appendix A.2.

Figure 3 presents the generated series for the share of underground GDP. This series is constructed using the underground sector production technology function as in (10) for the parameterization presented in the previous table²³.

[insert FIGURE 3]

Table 2, next, reports selected descriptive statistics for our two generated series and for the selected other series that estimate Italian underground economy, discussed in Section 3 (see Figure 1).

Notice that our generated series are quarterly while, all the other series are yearly and span different time periods (see details in Table 2). This makes the comparison not easy, but it does not rule out the possibility of highlighting some general patterns. First, our generated series are more volatile than all the other series and they span a range consistently larger than the other estimates (precisely, the largest values reach 25.6% and 23.4% for underground employment and GDP share, respectively, while the highest other series' range is Bovi's with 6.39%).

The normalized standard deviation of the generated underground production series is remarkably large compared with the estimated series. Second, there is evidence of a higher persistence of our generated series, since the first autocorrelation is consistently higher than the other series, even though the Istat's "min" series shows a quite large autocorrelation (0.798). Third, all the series appear to be pro-cyclical: they are positively correlated with the Hodrik-Prescott (1997) filtered GDP.

²³ The series of the underground GDP shares the same characteristics of the series of the underground employment as a result of the particular production technology in the underground sector assumed by our model. Accordingly, all the following analyses are conducted on the underground employment series.

Table 2 – Comparisons with existing estimates of underground sector

Statistics	$\left(\frac{n_{U,t}^y}{n_t^y}\right)^*$	$\left(\frac{y_{U,t}^y}{y_t^y}\right)^*$	Chiarini Marzano (2004) – series # 1	Chiarini Marzano (2004) – series # 2	Istat GDP max	Istat GDP min	Istat ULA	Bovi (1999)	Zizza (2002)
Numb. Of Obs	128	128	23	23	9	9	23	28	16
Mean	22.1	21.6	22.5	7.7	16.8	15	6.0	14	16.5
Min	13.1	12.8	19.5	6.9	15.8	12.9	5.1	11.7	14.8
Max	38.7	36.2	25.6	8.6	17.7	15.9	6.5	18.1	18.7
Range	25.6	23.4	6.1	1.7	1.9	3	1.4	6.39	3.89
σ_{series}	0.227	0.187	0.080	0.062	0.030	0.070	0.063	0.136	0.065
$\frac{\sigma_{series}}{\sigma_{GDP}}$	19.730	16.253	6.954	5.388	2.619	6.091	5.475	11.847	5.675
$\rho(series, GDP)$	0.548	0.467	0.634	0.645	0.15	0.392	0.84	0.459	0.726
$\rho(t, t-1)$	0.904	0.842	0.910	0.910	0.089	0.798	0.861	0.545	0.568

Notes. Frequency and period: $\left(\frac{n_{U,t}^y}{n_t^y}\right)^*$, $\left(\frac{y_{U,t}^y}{y_t^y}\right)^*$ quarterly, 1970:1-2001:4; Chiarini, Marzano (2004) series # 1, yearly, 1976-1998; Chiarini, Marzano (2004) series # 2, yearly, 1976-1998; Istat max, Istat min, yearly, 1992–1998; Istat ULA, yearly, 1980-2002; Bovi, yearly, 1970–1997; Zizza, yearly, 1984 – 1992.

A further interesting result arises plotting together the generated underground employment ratio with the Hodrik-Prescott (1997) filtered GDP (see Figure 4). Under the plausible assumption of a procyclical regular employment, it is interesting to observe that also the underground labor shows a pro-cyclical pattern. In addition to the employment series being pro-cyclical, a casual inspection of Figure 4 suggests that underground employment seems to follow the filtered GDP with some lag. This conclusion is confirmed by the values of the correlation between the filtered underground employment variable and the lagged filtered GDP [$\rho(series, GDP_{t-i}) = 0.548 (i=0)$, $0.6698(i=1)$, $0.6995 (i=2)$, $0.6485 (i=3)$, $0.5182 (i=4)$]. The correlation with the 1-period lagged filtered GDP is higher than the contemporaneous correlation.

[insert: FIGURE 4]

5.1 Productivity in the underground sector

We plot the series of the underground productivity generated by our model and the filtered GDP against time in Figure 5.

[insert: FIGURE 5]

[insert: FIGURE 6]

Since Istat provides a yearly estimate of GDP and employment in the underground sector starting from 1992, an estimate of the productivity in the underground sector can be deduced from these official estimates. Figure 6, next, plots together the generated underground productivity series with the Istat's version; both series are Hodrick-Prescott filtered to extract the business cycle component. The figure suggests that our model predicts an underground productivity cycle more volatile than the Istat one (precisely, the model's standard deviation is 0.0042, whereas Istat's statistics is 0.0019).

It is also worth noticing that the correlation between the cyclical component of the underground productivity and the GDP cycle is quite different, since Istat's series shows a positive correlation with the cyclical component of GDP [0.12] while our model's series exhibits a negative and stronger correlation [-0.34]. This feature may be important in the current discussion on the productivity gap and future research could be addressed to this issue. This suggests that the underground sector has a positive impact on the productivity at relatively high frequencies (i.e. along the business cycle), while it dampens productivity fluctuations at a lower frequency (i.e. along the growth theory channel).

6. Sensitivity analysis

6.1 Sensitivity to policy parameters

We explore here the sensitivity of our generated series to changes in the values of the model's parameters. In particular we study the effect of a change of the following policy parameters with respect to the baseline parameterization reported in Table 1: the taxation parameters (τ^Y and τ^Π),

income and corporate tax rate, respectively), the probability of being discovered (p), and the surcharge factor on tax rate if discovered (s). The theory behind our model obviously predicts the sign of these changes. Accordingly, we can think of the analysis we perform here as a test of the “theory used for measurement”²⁴ predictions.

We analyze how the generated series changes in terms of max and min value, range and volatility, and we especially focus on the sign of these changes more than of their magnitude. The results for the series of underground employment are reported in Table 2 .

Table 3: Sensitivity of the generated underground employment series to policy shift.

Baseline parameterization			0,050	0.13	0.39	0.26
New parameter value	Baseline value	New Value	Std Dev	Max	Min	Range
p	0.03	0.1	0.047	0.12	0.37	0.25
		0.01	0.051	0.13	0.39	0.26
s	1.3	2	0.049	0.13	0.38	0.25
		0.5	0.051	0.13	0.39	0.26
τ^Y	0.3436	0.4	0.056	0.15	0.44	0.29
		0.2	0.038	0.1	0.29	0.19
τ^Π	0.4155	0.5	0.061	0.16	0.47	0.31
		0.25	0.035	0.09	0.28	0.19

One major result of this exercise is that all the changes are economically meaningful. In general, an increase in the taxation parameters and a decrease in the evasion model’s parameters (probability of being discovered and surcharge factor) lead to a higher percentage of underground employment and, therefore, to an increase in the underground economy. The mechanism operates in the opposite way if we change the direction of the shifts. For facilitating the reading of Table 2 we can imagine that when income tax rate (τ^Y) moves from the baseline parameterization value (0.3436) to the new higher value (0.4 in the experiment), both the *min* and the *max* of the generated underground employment series increase (the baseline values are, in fact, respectively: *min*=0.13 *max*=0.39;

²⁴ With this term we refer to the methodology behind our generated series, discussed in Section 4. In brief, here we are using at the same time theory and data: we generated our series with the optimality conditions from the model and with the observed data for the regular sector. The sensitivity analysis gains some robustness in this environment, for example it can offer more insights with respect to an analysis conducted with simulated data.

whereas after the policy shift these values are: $min=0.15$ $max=0.44$). Accordingly, the series shifts upward and then the generated underground employment quota predicted is higher.

Notice also that taxation and “enforcement” parameters show some differences in their impact on the underground series. The main pattern is that the generated series is more sensitive to shifts in the taxation parameters. An increase in both the income and corporate tax rates shifts the series up, widens the range the series, and finally makes the volatility increase. On the other hand, a decrease of the enforcement parameters (s and p) does not have almost any effect on the series (anyway there is a slight effect on the volatility), while an increase of p and s brings about a reduction, though slight, in the underground sector and a lower volatility.

The sensitivity analysis is a successful feature of the model approach. With this approach each result is fully informative, and we may consider the unsuccessful effects to improve the model and the estimation of non-observed variables. The fragility of existing specification about, say, the unique productivity shock, the different technologies may be easily assessed and emended.

7. Concluding remarks

An important size of the GDP in all industrialized countries is not reported. Prominent efforts to measure underground production and labor are, at their best, arbitrary. To limit arbitrariness in measuring the underground sector we suggest a further method based on theoretical models that could be useful for defining benchmarks to compare empirical estimates. We see this methodology being complementary to the standard estimation techniques.

The equilibrium expression for labor and underground production is derived from the dynamic general equilibrium model. This produces two welcome consequences. First, our measurement of the underground economy considers both the inter-temporal and intra-temporal dimension of the phenomenon. Second, it is structurally and dynamically consistent with the behavior of the

realizations of the other aggregate macro variables (consumption, investment and capital stock, prices and factor productivity).

The generated series for underground labor and underground production present a wider value range, and are more volatile than all other series estimated with classical methodologies. Moreover, the analysis suggests that the underground labor is pro-cyclical with respect to the GDP, that it is lagging it by approximately one quarter, and that underground labor series generated from the theoretical model are highly persistent. The correlation between the cyclical component of the underground productivity and the GDP one deserves some attention, as well. Official yearly estimates present a positive (but very low) correlation with the cyclical component of GDP [0.12], while our generated quarterly series exhibit a negative and stronger correlation [-0.34].

References

- [1] Basu S and M. Kimball, Cyclical Productivity with Unobserved Input Variation , National Bureau of Economic Research, Inc, NBER Working Papers: 5915, 1997.
- [2] Bhattacharyya D. K., 1999, On the Economic Rational of Estimating the Hidden Economy, Economic Journal, 109, 348-359.
- [3] -Benhabib J., R. Rogerson and R. Wright, 1991, Homework in Macroeconomics: Household Production and Aggregate Fluctuations, Journal of Political Economy 99, 1166-1187.
- [4] -Blundell R. and T.E. MaCurdy, 1999, Labor supply: a review of alternative approaches, Handbook of Labor Economics, 3A, Elsevier Science, Amsterdam.
- [5] -Boadway R, N. Marceau and S. Mongrain, 2002, Joint Tax Evasion, Canadian Journal of Economics, 35, 417-435.
- [6] -Bovi M., 1999, Un miglioramento del metodo di Tanzi per la stima dell'economia sommersa in Italia, ISTAT, Quaderni di Ricerca 2, 5-51.
- [7] -Busato F. and B. Chiarini, 2004, Market and underground activities in a two sector dynamic equilibrium model, Economic Theory, 23, 831-861.
- [8] -Busato F., B. Chiarini and G.M. Rey, 2005, Equilibrium implications of fiscal policy with tax evasion, Working Paper, Aarhus University.
- [9] -Castellucci L. and M. Bovi, 1999, What Do We Know about the Size of the Underground Economy in Italy beyond the "Common Wisdom"? Some Empirically Tested Propositions, Far Eastern Meeting of the Econometric Society, Singapore.
- [10] -Chiarini B. and E. Marzano, 2004, Dimensione e dinamica dell'economia sommersa: un approfondimento del *currency demand approach*, in Politica Economica, XX, 303-334.
- [11] -Cooley T., 1995, (ed.) Frontier of Real Business Cycle Research, Princeton University Press.
- [12] -Dallago B., 1990, The Irregular Economy, Dartmouth Publishing Company, Worcester.
- [13] Economic Journal Symposium on the Hidden Economy, Vol. 109, No 456, June 1999.
- [14] -Feige E.L., 1989, The Underground Economies. Tax Evasion and Information Distortion, Cambridge University Press; Cambridge.
- [15] -Frey B. and F. Schneider, 2000, Informal and underground economy, in O. Ashenfelter (ed.), International Encyclopedia of Social and Behavioral Science, Bd. 12 Economics, Elsevier Science Publishing. Amsterdam.
- [16] -Gallie D. and S. Paugam, (eds.), 2000, Welfare regimes and the experience of unemployment in Europe, Oxford University Press.
- [17] -Giles D, 1999, Measuring the Hidden Economy: Implications for Econometric Modelling, Economic Journal, 109, F370-80.
- [18] -Greenwood J. and Z. Hercowitz, 1991, The Allocation of Capital and Time over the Business Cycle, Journal of Political Economy, 99, 1188-1214.
- [19] -Greenwood J, R. Rogerson and R. Wright, 1995, Household production in real business cycle theory, in Cooley T. (ed.), Frontiers of Business Cycle Research, Princeton University Press, Princeton NJ.
- [20] -Hansen G.D., 1985, Indivisible labor and the business cycle, Journal of Monetary Economics, 16, 309-27.
- [21] -King R.G. and S.T. Rebelo, 1999, Resuscitating real business cycles, in Taylor J.B. and Woodford M. (eds.), Handbook of Macroeconomics Vol. 1 Elsevier Science, Amsterdam.
- [22] -Ingram B.F., N.R. Kocherlakota and N.E. Savin, 1994, Explaining Business Cycles. A Multiple-Shock Approach, Journal of Monetary Economics, 34, 415-428.
- [23] -Ingram B.F., N.R. Kocherlakota and N.E. Savin, 1997, Using theory for measurement: An analysis of the cyclical behavior of home production, Journal of Monetary Economics, 40, 435-456.
- [24] Marchetti D. J and F. Nucci, Price Stickiness and the Contractionary Effect of Technology Shocks, European Economic Review, vol. 49, no. 5, July 2005, 1137-63.
- [25] -OECD 2002, Measuring the Non-Observed Economy. A Handbook, Paris.

- [26] -OECD, 2004, Informal employment and promoting the transition to a salaried economy, in Employment Outlook, Paris.
- [27] -Prescott E. C. and R. Mehra, 1980, Recursive competitive equilibrium: the case of homogenous household, *Econometrica*, 1365-79.
- [28] -Schlitzer G., 1994, Business cycles in Italy: a statistical investigation, *European Journal of Political Economy*, 11, 683-98.
- [29] -Schneider F., 2000, The Increase of the size of the shadow economy of 18 OECD countries: Some preliminary explanations, <http://www.economics.unilinz.ac.at/members/schneider/publik.html>
- [30] -Schneider F. and D. Enste, 2000, Shadow Economies: Size, Causes, and Consequences, *Journal of Economic Literature* XXXVIII, 77-114.
- [31] -Slemrod J. and S. Ytzhaky, 2002, Tax Avoidance, Evasion, and Administration, in A. J. Auerbach and M. Feldstein, eds, *Handbook of Public Economics*, 3, North Holland.
- [32] -Tanzi V., 1999, Uses and Abuses of Estimates of the Underground Economy, *Economic Journal*, 109, 338-47
- [33] -Tanzi V., 1983, The Underground Economy in the United States: Annual Estimates, 1930-80, *International Monetary Fund Staff Papers*, 2, 283-305.
- [34] -Tanzi V., 1980, Inflationary Expectations, Economic Activity, Taxes, and Interest Rates, *The American Economic Review*, 70, 1, 12-21.
- [35] -Thomas J.J., 1992, *Informal Economic Activity in LSE Handbooks in Economics*, Harvester Wheatsheaf, London.
- [36] -Thomas J.J., 1999, Quantifying the black economy: 'measurement without theory' yet again?, *Economic Journal* 109, 381-89.
- [37] -Zizza R., 2002, Metodologie di stima dell'economia sommersa: un'applicazione al caso italiano, mimeo, Banca d'Italia.

Appendix

A.1 The data.

Bovi (1999) estimation is achieved using the currency demand approach. Specifically, the author utilizes an extension of Tanzi's monetary method (1980; 1983). This approach assumes that irregular transactions are undertaken in the form of cash payments. An increase in irregular economy implies an increase in the demand for liquidity. To estimate the excess of currency demand, the equation regressors for currency are chosen so as to include not only standard causes of the money demand (interest rates, habits payments and so on) but also the major factors that may generate the irregular economy phenomenon. Among these, tax and social security burdens are the most important causes. Zizza's estimates (2002) used in this work are generated from an application of Tanzi's monetary approach. Moreover, the equation regressors, used by Zizza to allow for a better controlling of the illegal economy, while identifying more precisely the size of the irregular sector. These methods calculate the excess of money setting to zero (or at their minimum level) the "underground factors" which should generate the underground behavior of firms and households.

Chiarini and Marzano's series (2004), as well, are generated using a modified version of the Tanzi's approach, in which the characteristics of non stationarity of the basic series are exploited through cointegration techniques to generate time series of the Italian size of the underground economy (1975-2001). The authors use a different index for the tax burden, also controlling for several dimensions of labor market (unemployment, mismatch in different segments of the market, social benefits for people who are only temporarily out of work).

The National Statistic Institute (Istat) has started very recently a survey on the size of the underground production. However, at moment, there are no quarterly estimates but only annual data for a limited number of years (1992 to 2000). These estimations are based on a complex procedure, accepted at international level by Eurostat and OECD, consisting of three steps: first, a comparison between labor demand (firms) and labor supply (households) statistics to assess the size of unregistered work; second, a correction of the under-reporting of income by the enterprises; finally, a check of consistency of the economic aggregates through the balancing of the resources for each industry.

A.2 Business cycle facts and model prediction.

Table 1.A below presents the relative volatilities with respect to aggregate output; Table 2.A, next, includes the actual and simulated contemporaneous correlations with aggregate GDP. The baseline model predict absolute output volatility equal to 1.54 (0.05), which is close to the actual one which is 1.44.

Table 1.A: VOLATILITIES		
	<i>Actual Data</i>	<i>Simulated Data</i>
C	0.62	0.47
W	0.83	1.06
W _M	-	0.83
W _U	-	1.81
N	0.54	0.54
N _M (*)	0.28	0.85
N _U (*)	0.46	0.92
Y	1.00	1.00
Y _M (*)	1.18	.16
Y _U (*)	2.21	1.23
I	5.25	9.15

Notes. The table includes the relative standard deviations with respect to aggregate GDP standard deviations; (*) annual data. All statistics are computed based on 1000 simulations of 176 period lengths. Source: Actual Data, Schlitzer (1994); statistics for N_M, and N_U are based on authors' calculation.

Table 2.A: CORRELATIONS		
	<i>Actual Data</i>	<i>Simulated Data</i>
C	0.85	0.91
N	0.52	0.60
I	0.78	0.90
W	0.69	0.55

Notes: Actual and simulated contemporaneous correlations with aggregate GDP. All statistics are computed based on 1000 simulations of 176 period lengths. Source: Actual Data, Schlitzer (1994).

The models' performance in predicting labor market dynamics (relative volatilities and contemporaneous correlations) deserves a special mentioning. Standard benchmark models (e.g. Hansen, 1985) have difficulty in replicating those figures, while our model is quite successful. This is indeed a welcome result, since it suggests that the introduction of an underground sector improves the ability of this class of models along labor market dimensions.

A.3 Comparison between underground economy and home production

It is interesting to compare the theoretical structure of our model with household (home) production models.²⁵ We focus on three selected issues: the commodities' number and their substitutability, the financing of capital investment and the insurance opportunities offered by home production and underground activities. First, consider the number of consumption goods and their substitutability. In the home production class of models there exist two goods, denoted as regular and underground commodities, each of which is produced with a sector specific technology. In addition, the preference specification allows for different degrees of substitutability between regular and underground goods. In contrast, in the model with an underground sector there exists only one homogenous good, which, however, is produced using two different technologies: one associated with the regular sector, and the other with the underground sector. In this environment it is natural to focus on the case of perfect substitutability between regularly-produced final output and underground-produced output.

The second difference concerns the financing of investments. In home production models, only regularly-produced goods can be consumed and invested, either into regular capital or into underground capital. There are no uses for home production output other than consumption - it cannot be sold or transformed into capital, for example, the way that regularly-produced output can. In the underground economy model, however, there exists only one capital stock (invested in the regular sector), but regularly-produced and underground-produced output can be transformed into regular capital without any adjustment cost. The underground sector offers an additional channel for financing capital stock accumulation, and an additional dimension along which firms can employ the available labor supply. Summarizing, while the home production model is a legitimate two sector model, our model could be more appropriately defined as a two technology model, since the same good is produced using two different technologies.

In addition, an underground sector offers profit smoothing opportunities for firms and insurance opportunities for consumers. More precisely, firms can smooth their profits by a proper allocation of labor demand between the two sectors, on a period by period basis. In addition, consumers can smooth not only consumption, by substituting consumption and investments over time, but also income, by allocating their labor supply across sectors, on a period by period basis. This mechanism is absent in models with home production.

²⁵ Home production has been part of the standard labor paradigm, but only recently has it been introduced into macro models. See Benhabib, Rogerson and Wright (1991) and Greenwood, Rogerson and Wright (1995) for a survey.

Figures

Figure 1: Series of Italian underground economy (percentage GDP)

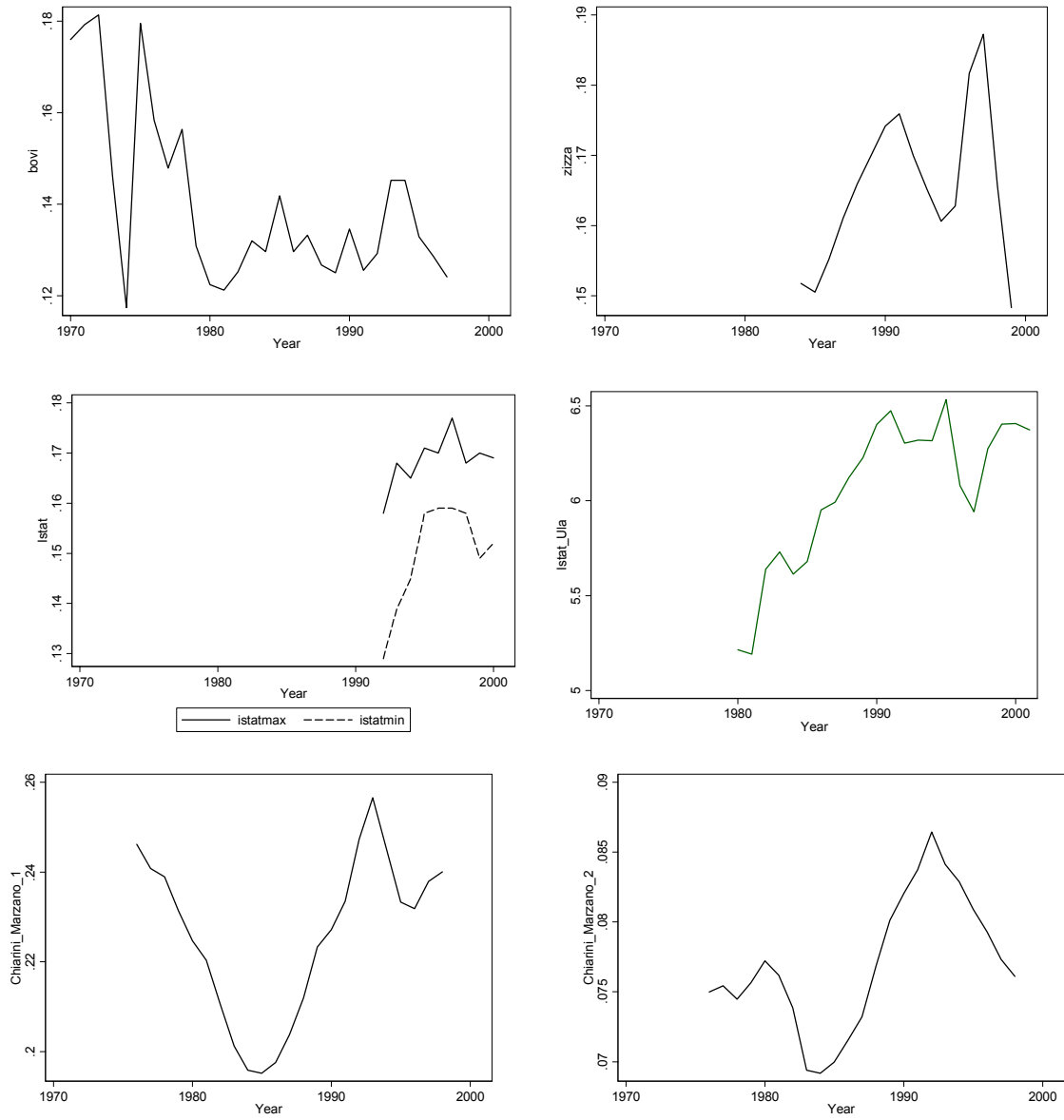


Figure 2 Share of employment in the underground sector

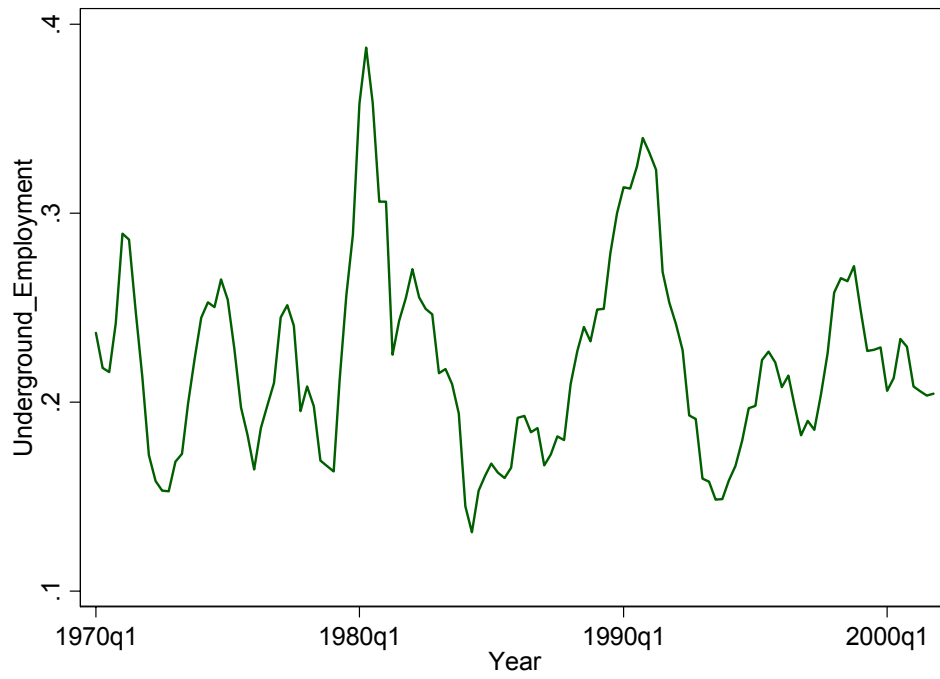


Figure 3 Share of underground GDP

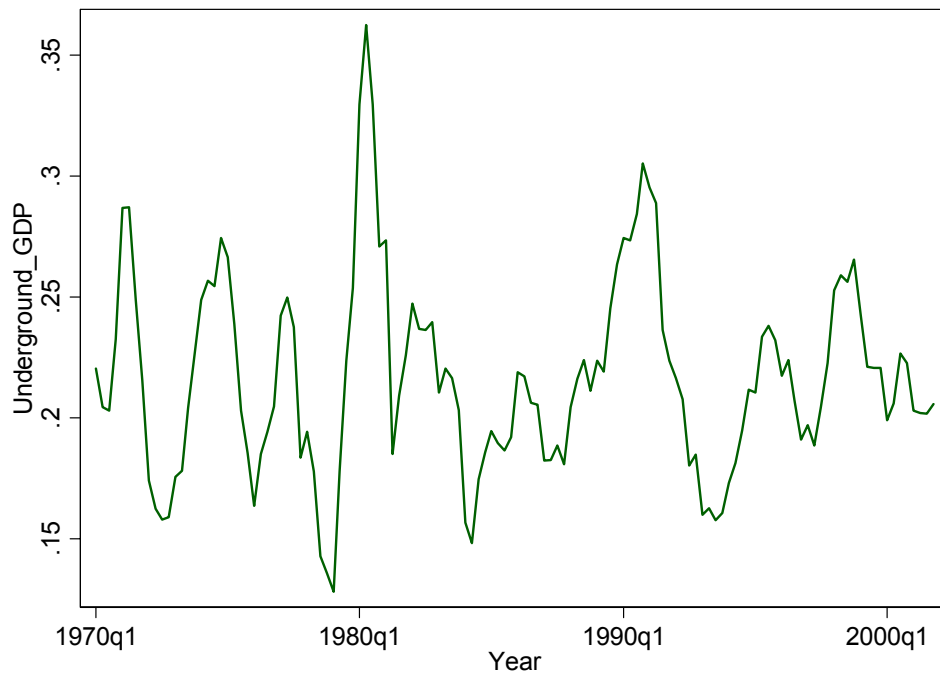
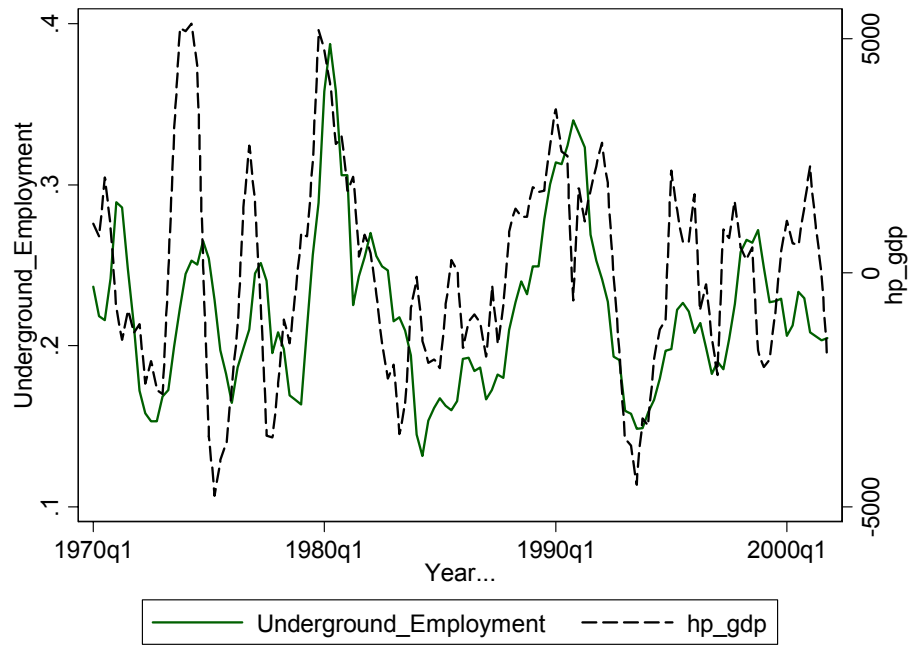
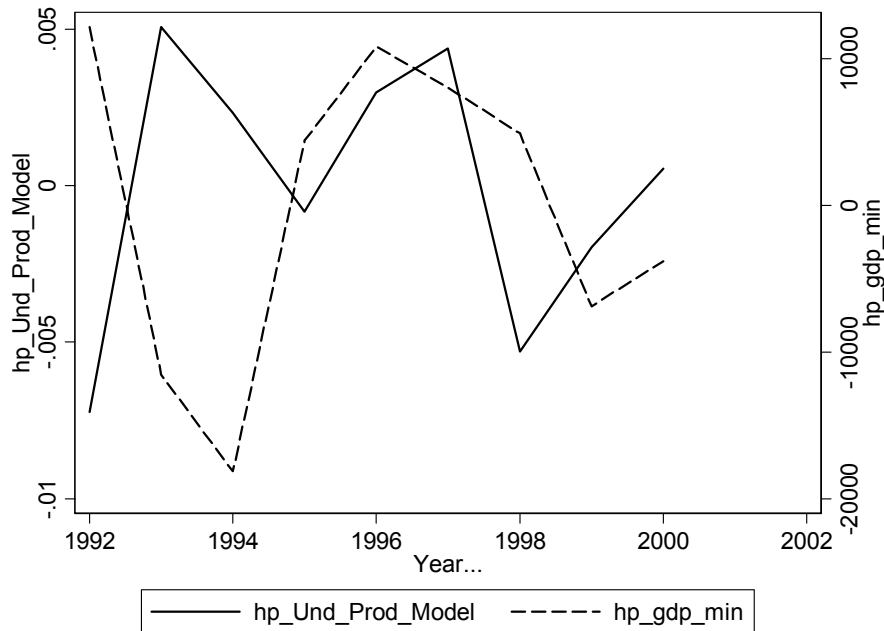


Figure 4: Underground employment share and filtered GDP



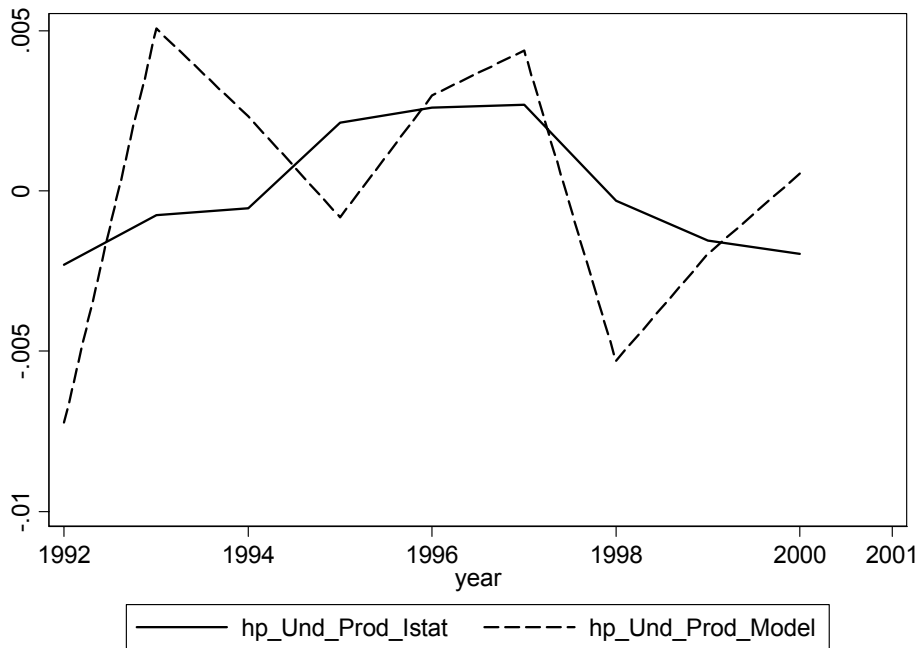
Notes: Solid Line: Hodrick-Prescott filtered underground employment (generated by the model);
Dashed Line: Hodrick-Prescott filtered GDP; Sources: Model generated data and Istat.

Figure 5: Productivity in the underground sector and GDP (both HP filtered)



Notes: Solid Line: Hodrick-Prescott filtered underground productivity (generated by the model); Dashed Line: Hodrick-Prescott filtered GDP; Sources: Model generated data and Istat.

Figure 6: Productivity in the underground sector (HP filtered)



Notes: Solid Line: Hodrick-Prescott filtered underground productivity (Istat estimate); Dashed Line: Hodrick-Prescott filtered underground productivity (generated by the model); Sources: Model generated data and Istat.

Working Paper

- 2005-7: Ott Toomet: Does an increase in unemployment income lead to longer unemployment spells? Evidence using Danish unemployment assistance data.
- 2005-8: Marianne Simonsen: Availability and Price of High Quality Day Care and Female Employment.
- 2005-9: Francesco Busato, Bruno Chiarini and Enrico Marchetti: Fiscal Policy under Indeterminacy and Tax Evasion.
- 2005-10: Francesco Busato, Bruno Chiarini, Pasquale de Angelis and Elisabetta Marzano: Capital Subsidies and the Underground Economy.
- 2005-11: Francesco Busato, Alessandro Girardi and Amedeo Argentiero: Do sector-specific shocks explain aggregate fluctuations.
- 2005-12: Hristos Doucouliagos and Martin Paldam: Aid Effectiveness on Accumulation. A Meta Study.
- 2005-13: Hristos Doucouliagos and Martin Paldam: Aid Effectiveness on Growth. A Meta Study.
- 2005-14: Hristos Doucouliagos and Martin Paldam: Conditional Aid Effectiveness. A Meta Study.
- 2005-15: Hristos Doucouliagos and Martin Paldam: The Aid Effectiveness Literature. The Sad Result of 40 Years of Research.
- 2005-16: Tryggvi Thor Herbertsson and Martin Paldam: Does Development Aid Help Poor Countries Catch Up? An Analysis of the Basic Relations.
- 2005-17: René Kirkegaard and Per Baltzer Overgaard: Pre-Auction Offers in Asymmetric - First-Price and Second-Price Auctions.
- 2005-18: Niels Haldrup and Morten Ørregaard Nielsen: Directional Congestion and Regime Switching in a Long Memory Model for Electricity Prices.
- 2005-19: Francesco Busato, Bruno Chiarini and Vincenzo di Maro: Using Theory for Measurement: an Analysis of the Behaviour of the Underground Economy.