Measuring Unobserved Economy Through Electricity Demand

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Abstract

Recent research on unobserved economy highlights that the phenomenon is increasing worldwide, thus having important implications for macroeconomic policy. Obtaining information about countries' magnitude of the unobserved economy is crucial for making effective economic policy decisions. Our paper measures the size and development of unobserved economy in Italy using the electricity consumption method. We apply this method to a panel of 103 Italian provinces (NUTS-3 level) for the years 2004-2012. Empirical results show an increasing trend of the size of the unobserved economy, it still has an important weight on the official gross domestic product in Italy.

JEL classification codes: C33; H26; K42 ; Q43.

Keywords: unobserved economy, underground economy, criminal economy, electricity demand approach.

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1. Introduction

Unobserved economy is a widespread phenomenon that poses serious social, economic, cultural and political problems throughout the world. Although it is a topic of considerable interest, many questions relating to its nature and its consequences still remain largely unexplored or unresolved. In particular, the measurement of the unobserved economy is a topic around which economic literature has not found a unanimous consensus. The theoretical and empirical methodologies used so far can be summarized in the following categories:

- Direct methods: they are usually microeconomic and estimate the size of the economy not observed by voluntary responses on surveys or fiscal control methods;
- Indirect methods: they are mostly macroeconomic and use economic and non-economic indicators that contain information on the development of an economy not observed over time;
- The MIMIC approach (multiple indicators, multiple causes) includes statistical models that are used to estimate the unobserved economy as a latent and unobserved variable (Frey and Weck-Hanneman, 1984; Giles, 1999);
- Dynamic stochastic general equilibrium (DSGE) models analyze the unobserved economy and its cyclic behavior in a dynamic stochastic framework (Busato and Chiarini, 2004; Orsi et al., 2014; Argentiero e Bollino; 2015).

In this work, we set ourselves the goal of measuring the size and development of the economy unobserved in Italy by using physical input, electricity consumption. In fact, electricity consumption is able to capture the entire production process, with the related costs, and not just the exchange phase. In particular, we aim at deepening the seminal approach of Kaufmann and Kaliberda (1996), which is an indirect method, through an empirical model of panel data for 103 Italian provinces (NUTS-3 level) for the years 2004-2012. The electricity consumption approach uses electricity consumption as a physical indicator of general economic activity (official +

unobserved, as electricity consumption compared to the elasticity of gross domestic product (hereinafter GDP) is usually close to one. As for the approach of currency demand, electricity consumption is constructed on the basis of the variables linked to the official economy and the determinants of an unobserved economy.

In particular, the amount of electrical energy attributable to the unobserved economy is obtained as the difference between the estimated demand for electricity that takes into account the contribution of all the explanatory variables (both linked to the regular and unobserved economy) and a demand for electricity simulated by zeroing the coefficients relating to the determinants of unobserved electricity (e.g. tax burden).

Thus, unobserved and regular GDPs are derived from a standard production function in which electricity is a factor of production.

We find that the determinants of regular and unobserved electricity demand are both significant and with the expected signals. In particular, by introducing the determinants of an economy not observed in a standard function of electricity demand, the forecast approaches the empirical value: the share of the unobserved economy is about 30%, coherently with Ardizzi et al. (2014) and Argentiero and Bollino (2015), but above the ISTAT estimates.

2. Background

We can find definitions of unobserved economy from various points of view, economical, legitimate, juridical, social and other:

- Unobserved economy comprises production activities that are illegal, underground, informal, or otherwise missed by the statistical system (OECD, 2002);
- All the unregistered economic activities that contribute to the officially calculated (or observed) gross national product (Feige, 1994; Schneider, 2015);
- Any economic activity which increases the total value of national product, but it is not included in national account or shown in gross domestic product (Startienė and Trimonis, 2010).

But why the method based on electricity input (electricity demand approach, EDA) should be better than those already used in literature?

The methodology adopted in the present study can be classified in the context of indirect methods, as described in the introduction. In particular, among these techniques the most well-known in the literature is the one based on the excess of cash demand (currency demand approach, CDA). This method was introduced by Cagan (1958) and developed by Tanzi (1983), Shneider and Enste (2000). The main assumption is that underground transactions take place in money, due to the lack of traceability; the growth of more liquid money aggregate (M1) would indicate an increase in the underground economy. Therefore, in order to capture the excess of cash to be attributed to the underground economy, an equation of cash demand is estimated, using some causes of the underground economy as explanatory variables and as control variables the interest rate, income, technology of the payments. The amount of cash attributable to the underground economy is obtained as the difference between the estimated cash demand taking into account the contribution of all the explanatory variables and the simulated one, making the cause variable, for example the

tax burden, (without which there would not be underground economy) a value of zero or equal to its historical minimum in the period considered. Finally, calculating the money circulation speed for a "basic" year, and assuming that this is the same in the regular and in the irregular economy, we obtain the underground GDP, based on the quantitative theory of the money, using the excess of cash.

However the CDA is not free from criticism:

a) not all submerged transactions take place in cash, see the barter;
b) there is the risk of a mixture of the underground and criminal economy;
c) it is not said that all the causes of the underground economy are included in the estimation equation;
d) some currencies have an excess demand compared to transactions because they are international reserve currencies (dollar);
e) the estimate of a circulation speed in a base year appears arbitrary;
f) the equality between the speed of circulation of money for the underground and regular economies is a strong assumption.

Although some of these criticism (mixture of underground and criminal economy, problems related to the speed of circulation) have been addressed and overcome in recent works (Ardizzi et al. 2014), some remain standing (not all undeground transactions take place in money, the demand for some currencies is independent of underground transactions). Furthermore, the consumption of electricity is able to capture the entirety of the production process, not being limited only to the exchange phase (as for the CDA).

In tables 1 and 2 we show for each contribution of the literature, respectively for the underground economy (table 1) and criminal economy (table 2), the estimation methodology adopted as well as the results found and the reference sample:

Table 1: Existing estimates for underground economy in Italy

CONTRIBUTION	METHODOLOGY	SIZE
Enste and Schneider (2000)	CDA	25.8% (1989-2000)
Zizza (2002)	CDA	16.5% (1984-2000)
ISTAT	Direct methods (labor input)	15.9-17.5% (1992-2008); 12-13% (2009-2013)
Schneider (2015)	MIMIC	27% (1999-2007)
Ardizzi et al. (2013; 2014)	CDA (revised)	16.5% (2005-2008)
Orsi et al. (2014)	DSGE models	23% (1982-2006)
Argentiero and Bollino (2015)	DSGE models	20% (1974-2011)

Table 2: Existing estimates for criminal economy in Italy

CONTRIBUTION	METHODOLOGY	SIZE
Argentiero et al. (2008) Money laundering	DSGE model	12% (1981-2001)
Ardizzi et al. (2014) Money laudenring	CDA (revised)	7% (2005-2008)
Ardizzi et al. (2014)	CDA (revised)	10.9% (2005-2008)
Argentiero and Bollino (2015)	DSGE model	11% (1974-2011)
ISTAT (2014)	Direct (survey)	1% (2011-2013)

3. The empirical strategy

The aggregate production function is assumed to be Cobb-Douglas:

$$\boldsymbol{Y_{it} = A_{it}(K_{it})^{\alpha}(L_{it})^{\beta}(E_{it})^{\gamma}} \qquad \textbf{(1)}$$

where $\boldsymbol{Y_{it}}$ represents GDP, $\boldsymbol{A_{it}}$ is the total factor productivity, $\boldsymbol{K_{it}}$ is the capital stock, $\boldsymbol{L_{it}}$ is the labor input and $\boldsymbol{E_{it}}$ is the electricity demand. The subscripts *it* indicate the *i*-province at time *t*, whereas the exponents α, β and γ are the shares of GDP for each productive factor.

Under the hypothesis of perfectly competitive market[2], the following profit function is maximized with respect to the electricity input:

$$\boldsymbol{Profit_{it} = A_{it}(K_{it})^{\alpha}(L_{it})^{\beta}(E_{it})^{\gamma} - r_{it}K_{it} - w_{it}L_{it} - P_{it}E_{it}} \quad \textbf{(2)}$$

where $\boldsymbol{r_{it}, w_{it}, P_{it}}$ indicate the capital rentals, wages and electricity price, respectively.

Hence, The optimal energy demand in a perfectly competitive scenario is

$$\boldsymbol{E_{it} = \left[\frac{1}{\gamma} * p_{it} * \frac{1}{(A_{it}(K_{it})^{\alpha}(L_{it})^{\beta}}\right]^{1/(\gamma-1)}} \qquad \textbf{(3)}$$

The equation (3) can be estimated through a log-log fixed effects panel model:

$$\boldsymbol{ln(E_{it}) = C + a\, ln(K_{it}) + b\, ln(L_{it}) + c\, ln(A_{it}) + d\, ln(p_{it}) + e\, ln(X_{it}) + dummy_{crisis} + v_i + \varepsilon_{it}} \qquad \textbf{(4)}$$

where $\boldsymbol{C}$ is the constant, $\boldsymbol{X_{it}}$ is a matrix containing the determinants of electricity demand linked to underground and criminal economy, $\boldsymbol{dummy_{crisis}}$ is a dummy variable equal to 1 for each year with a negative GDP growth rate and to 0 elsewhere, $\boldsymbol{v_i}$ are the provincial fixed effects ed $\boldsymbol{\varepsilon_{it}}$ are the residuals.

The data are referred to 103 Italian provinces (NUTS-3 level) for nine years, from 2004 to 2012. Electricity consumption is measured for the Italian productive sectors in Gigawatt (source, Terna), labor input is given by the number of employees (source, ISTAT), the physical capital is measured

[2] The price index is equal to 1.

by the stock of capital (source, ISTAT), while for the total productivity we consider both waste recycling, which is also a proxy of the energy saving attitude (source, ISTAT), and a schooling metrics, i.e. the number of 25-34 men who attended middle school as their highest educational level for 100 men in the same age group. The determinants of underground economy are the provincial tax burden (source, Italian Ministry of Economics and Finance) and the number of verifications with acceptance (source, Italian Revenue Agency), whereas the determinants of criminal economy considered are the number of reports for thefts and robberies (source, Italian Ministry of Interior).

The estimate unobserved GDP, given by the sum of underground and criminal GDP, is obtained by calculating the value of the production function (1) replacing the energy input with the results of the estimates of equation (4) and assuming for capital and labor the rates of irregularities estimated by ISTAT.

4. Preliminary results and conclusive remarks

In figure 1, we show the electricity consumption resulting from the empirical data compared with the predicted electricity consumption both in the presence and in the absence of irregular variables.

Figure 1: Empirical electricity consumption vs predicted electricity consumption

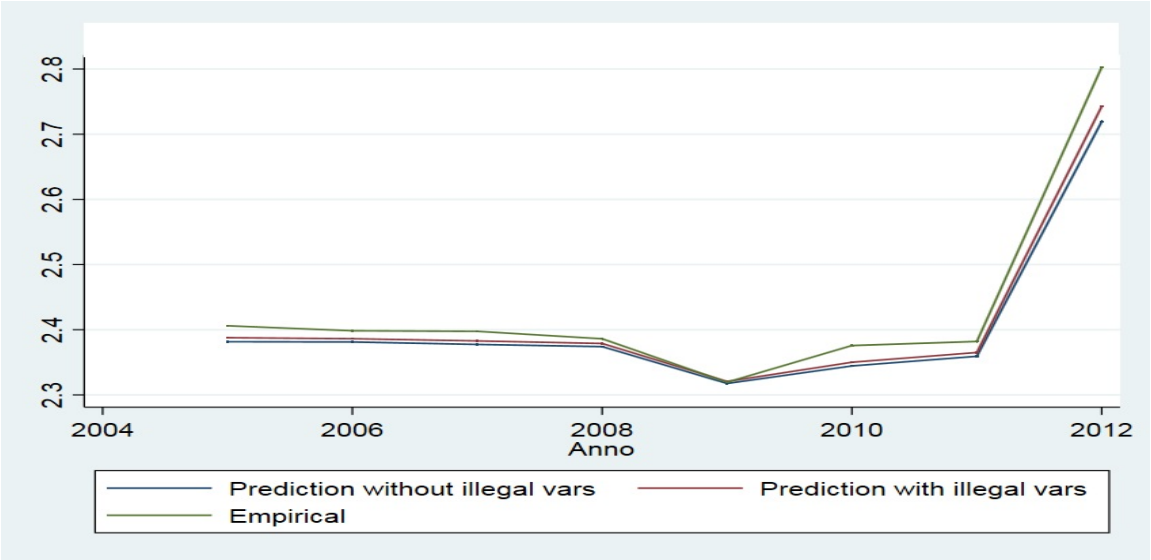

Table 3, instead, shows the preliminary results of the empirical estimations for equation (4).

Table 3: EDA estimates for Italy

DEPENDENT VARIABLE: log (electricity consumptions)				
log (capital stock)	(0.67)***	(0.71)***	(0.82)***	(0.85)***
log (employers)	(0.14)***	(0.12)***	(0.08)***	(0.10)***
log (electricity_price)	(-0.55)***	(-0.67)***	(-0.50)***	(-0.48)***
log (diff_waste)	(-0.10)***		(-0.05)***	
log (schooling)		(0.29)***		(0.15)***
dummy_crisis	(-0.34)***	(-0.38)***	(-0.21)***	(-0.22)***
log (tax_burden)			(0.06)***	(0.10)***
log (verifications)			(-0.02)***	(-0.01)***
log (thefts_robberies)			(0.09)*	(0.08)*
constant	(1.89)***	(1.99)***	(1.54)***	(1.50)***
R^2overall	0.10	0.08	0.03	0.02
R^2between	0.10	0.09	0.09	0.09
R^2within	0.89	0.81	0.93	0.78
observations	927	927	927	927

All the regressors show the expected sign with 1% of significance levels except for the determinants of crime, whose statistical significance does not exceed 10%.

We are able to assert that by introducing the determinants of the unobserved economy in a standard energy demand function, the prediction gets closer to the empirical value (figure 1).

Furthermore, the share of unobserved economy is around 30%, consistently with Ardizzi et al. (2014) and Argentiero and Bollino (2015), but higher than ISTAT estimates.

5. References

- Ardizzi, G., Petraglia, C., Piacenza, M., Schneider, F., & Turati, G. (2014). Money laundering as a crime in the financial sector: A new approach to quantitative assessment, with an application to Italy. *Journal of Money, Credit and Banking*, *46*(8), 1555-1590.

- Ardizzi, G., Petraglia, C., Piacenza, M., & Turati, G. (2014). Measuring the Underground Economy with the Currency Demand Approach: A Reinterpretation of the Methodology, With an Application to Italy. *Review of Income and Wealth*, *60*(4), 747-772.

- Argentiero, A., Bagella, M., & Busato, F. (2008). Money laundering in a two-sector model: using theory for measurement. *European Journal of Law and Economics*, *26*(3), 341-359.

- Argentiero, A., & Bollino, C. A. (2015). Uncovering unobserved economy: A general equilibrium characterization. *Metroeconomica*, *66*(2), 306-338.

- Busato, F., & Chiarini, B. (2004). Market and underground activities in a two-sector dynamic equilibrium model. *Economic Theory*, *23*(4), 831-861.

- Cagan, P. (1958). The demand for currency relative to the total money supply. *Journal of political economy*, *66*(4), 303-328.

- Feige, E. L. (1994). The underground economy and the currency enigma. *Public Finance= Finances publiques*, *49*(Supplement), 119-136.

- Frey, B. S., & Weck-Hanneman, H. (1984). The hidden economy as an 'unobserved'variable. *European Economic Review*, *26*(1-2), 33-53.

- Giles, D. E. (1999). The rise and fall of the New Zealand underground economy: are the responses symmetric? *Applied Economics Letters*, *6*(3), 185-189.

- Kaliberda, A., & Kaufmann, D. (1996). *Integrating the unofficial economy into the dynamics of post-socialist economies: A framework of analysis and evidence*. The World Bank.
- OECD (2002). Measuring the Non-Observed Economy - A Handbook.
- Orsi, R., Raggi, D., & Turino, F. (2014). Size, trend, and policy implications of the underground economy. *Review of Economic Dynamics*, *17*(3), 417-436.
- Schneider, F. (2015). Size and development of the shadow economy of 31 European and 5 other OECD countries from 2003 to 2014: Different developments?. *Journal of Self-Governance and Management Economics*, *3*(4), 7-29.
- Schneider, F., & Enste, D. H. (2000). Shadow economies: size, causes, and consequences. *Journal of economic literature*, *38*(1), 77-114.
- Tanzi, V. (1983). The underground economy in the United States: annual estimates, 1930-80. *Staff Papers*, *30*(2), 283-305.