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Energy consumption and economic growth revisited: Does the size of unrecorded economy matter?

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ABSTRACT

We analyze the long-run relationship between energy consumption and real gross domestic product (GDP) in Turkey taking into account the size of unrecorded economy. Since in developing countries, mainly due to the unrecorded economic activities, the official GDP is not measured correctly, the investigation of the linkage between energy consumption and official GDP may not give reliable results. In this study, empirical results for the case of Turkey over the period 1970–2005 suggest that there is a long-run equilibrium relationship between the officially calculated GDP and energy consumption. Besides, using the error-correction modeling technique, we find out that unidirectional causality runs from official GDP to energy in both short and long runs. However, when we take into account unrecorded economy, we detect neither cointegration nor causality between energy consumption and true GDP. These empirical findings imply that: first, energy conservation policies can be implemented in order to reduce greenhouse gas emissions without any adverse effect on the recorded economic activities; second the production function in the unrecorded economy is not stable. Furthermore, economic policies to combat unrecorded economy may not serve as a complement to energy conservation policies.

1. Introduction and related literature

Since the pioneering work of Kraft and Kraft (1978) the relationship between energy consumption and economic growth is studied by many authors using various methodologies for different time periods. Nevertheless, studies that have tested the causality between these two variables reveal conflicting results on the issue. This is mainly due to the fact that estimation results are very sensitive to the time period considered, the country and the methodology employed. To test for a long-run relationship the cointegration technique developed by Engle and Granger (1987) is used in many studies within the last two decades. If two or more variables are cointegrated then we can conclude that there is a long-run equilibrium relationship between these variables. In this case, using a vector error-correction model (VECM), Johansen (1991) and Johansen and Juselius' (1990) maximum likelihood procedure can be applied to test for the direction of Granger causality (Granger, 1988). In the absence of cointegration, that is, no long-run relationship can be established, no error-correction mechanism binds the non-cointegrated variables and the Granger causality test is applied in a vector autoregression (VAR) context instead of a VECM.

In the literature regarding the causal relationship between energy consumption and economic growth in Turkey, many studies have found inconsistent results. Using a VECM, Soytas and Sari (2003) found a long-run unidirectional causality running from energy consumption to gross domestic product (GDP) per capita. However, using the endogenous break unit root tests proposed by Zivot and Andrews (1992) and Perron (1997), Altinay and Karagol (2004) argued that a spurious causality would exist between the series if the data are mistreated as integrated of order one. Investigating the period of 1950–2000, they showed that both the GDP and energy consumption series in Turkey are trend stationary with a structural break and found no evidence of causality between energy consumption and GDP in Turkey based on the detrended data. On the other hand, using annual data over the period 1970–2003, Lise and Van Montfort (2007) found recently that in Turkey, energy consumption and GDP are cointegrated and the direction of causality is running from GDP to energy consumption. Again for the case of Turkey, in a very recent study, Jobert and Karanfil (2007) using annual time series for the period 1960–2003 argue that in the long run, income and energy consumption are neutral with respect to each other at both the aggregate and industrial levels. Their study reveals also

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a strong evidence of instantaneous causality, which means that contemporaneous values of energy consumption and income are correlated.

In a large number of studies inconsistent results concerning the direction of the relationship have been found for different countries: e.g. for different time periods, in India the direction of causality is from energy to income (Asafu-Adjaye, 2000; Masih and Masih, 1996). However, Paul and Bhattacharya (2004) found bidirectional causality for the same country. On the other hand, empirical studies focusing on some industrialized countries give disparate estimations; e.g. Kraft and Kraft (1978) found a significant causal relationship between income and energy consumption in the case of the United States for the period 1947–1974, supporting the view that income Granger causes energy consumption. However, Stern (2000), using a VAR model, pointed out that the direction of causality runs from energy consumption to income in the United States.

Some recent studies have also employed the dynamic panel data approach to investigate the energy–income nexus in both developed and developing countries. For example, using the panel data for 40 countries (22 developed and 18 developing countries), Lee and Chang (2007) showed that there exist a unidirectional causal relationship running from GDP to energy consumption in the developing countries and a bidirectional causality (or feedback) in the developed countries. However, Huang et al. (forthcoming) extended the data to cover 82 countries, which are divided into four categories based on the income levels defined by the World Bank, and they reported that economic growth leads energy consumption positively in the middle income group and negatively in the high income group. They also find no evidence of causality from energy consumption to economic growth in any of the four income groups. Moreover, their VAR model includes other control variables such as pollution level and the share of value added in industry to GDP, since the Granger causality test in a bivariate framework may be subject to the omitted variables bias (Lutkepohl, 1982). Multivariate systems are also used in some recent country-specific case studies. For example Hondroyiannis et al. (2002), employing a trivariate model to analyze the dynamic relationship between energy consumption, income and price level, found that in the long run, energy consumption and economic growth are interrelated in Greece. Again in a trivariate system but using pollutant emissions instead of prices, Ang (2007, 2008) draws the conclusion that economic growth exerts a causal influence on energy use both in France and Malaysia, respectively. In the same framework, Soytas and Sari (forthcoming) using the data on the Turkish economy over the years 1960–2000, pointed out that income and emissions are neutral with respect to each other and that emissions Granger cause energy consumption. In the light of these results, they concluded, as did Jobert and Karanfil (2007) before them, that an energy-saving program can be followed without harming economic growth and that investments on energy technologies should be undertaken in order to switch to less carbon-intensive energy use in Turkey.[1]

We have to also point out that the past studies mentioned above have not examined whether there exist unrecorded (or unreported) economic activities that contribute to the energy use. In a country if the unrecorded economy has an important weight in the overall economic activities then a significant part of the energy use does not seem to create any value added in the officially calculated GDP. That is certainly the case for most of the developing countries. Thus, the investigation of the linkage between energy consumption and official GDP may not give reliable results in such countries.

Smith (1994) gives the definition of underground or shadow economy as "market-based production of goods and services, whether legal or illegal that escapes detection in the official estimates of GDP".[2] There is a large literature on estimating the size of unrecorded economy. Surveys based on household data (direct or micro approach) as well as macroeconomic indicators such as GDP, employment or aggregate currency demand (indirect or macro approach) are commonly used in the relevant literature.

Although the size of unrecorded economy varies in different periods and across different countries, developing countries have fairly the largest unrecorded economies with 44% in African countries and 39% in Latin American countries. Regarding transition and developed countries, unrecorded economy is estimated to account for 20% in Middle and Eastern European countries and for 12% in OECD countries (Gerxhani, 2004). Concerning the Turkish unrecorded economy, the results have been mixed depending not only on the methodology but also on the period considered. Table 1 summarizes the results of the main studies on the size of unrecorded economy in Turkey.

As it can be seen from Table 1, there are several methods used in the estimation of the size of unrecorded economy. According to the transaction approach (Feige, 1979), the difference between nominal GNP and total transactions gives the size of unrecorded economy. On the other hand, the intuition behind the currency demand approach (Cagan, 1958) is that an increase in the tax burden may increase the size of informal economy as well as the currency demand since the unrecorded economic activities are paid in cash. Tanzi's (1983) econometric approach is used to detect the variations in the size of unrecorded economy after a tax rise. In the multiple indicator multiple causes (MIMIC) model (Frey and Weck, 1983a, b) various macroeconomic variables are introduced to estimate the size of unrecorded economy. All of these methods have advantages and weaknesses, which are well documented in the literature (Frey and Pommerehne, 1984; Feige, 1990; Thomas, 1999). Overall empirical results indicate that in Turkey unrecorded economic activities represent a large part of the economy varying between 0% and 45% of annual output. It is then obvious that total energy supply in Turkey is not entirely used in the recorded economic activities; thus the linkage between official GDP and energy consumption in Turkey is very critical.

The purpose of this paper is to empirically re-examine the causal relationship between energy consumption, officially calculated GDP and *true* GDP, that is, the sum of unrecorded economy and official GDP in Turkey. To the best of our knowledge, no study has proposed such an analysis for any country. The results of this paper will improve our understanding of the relationship between energy consumption and recorded and/or unrecorded economic activities. Therefore they have important policy implications for Turkey.

The remainder of the paper is organized as follows. In Section 2, we briefly describe the methodology employed and the data used in the empirical analysis. In Section 3, we present the empirical results and the final section contains the conclusions and the policy implications.

2. Data description and econometric methodology

In a very recent study, Karanfil and Ozkaya (2007) developed a new methodology to estimate the size of unrecorded economy.

[1] Additional empirical results from causality tests for other developing and industrialized countries can be found in Lee (2005, 2006) and Chontanawat et al. (2008).

[2] See Feige (1990) for a detailed classification of underground economic activities.