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Exploring the relationship between energy consumption and GDP: Evidence from Croatia

Djula Borozan *

J.J. Strossmayer University of Osijek, Faculty of Economics in Osijek, Gajev trg 7, 31000 Osijek, Croatia

HIGHLIGHTS

- There is a unidirectional causality running from energy consumption to real GDP in Croatia.
- There is an impulse response to real GDP caused by energy consumption, being mainly embodied in the first years.
- Energy consumption is an important component determining economic growth.
- Individual energy forms matter when it comes to energy policy formulation.

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ABSTRACT

The main purpose of this paper is to explore the relationship between total energy consumption and real gross domestic product (GDP) covering the period between 1992 and 2010 in Croatia. The methodology employed in this paper is based on the bivariate vector autoregression (VAR) and Granger causality tests. Moreover, the impulse response function and variance decomposition analysis are employed to trace the dynamic response paths of shocks to the system. The empirical analysis shows that, when it is allowed for any deterministic component in the data, total energy consumption and real GDP are not co-integrated in the period observed. Furthermore, there is a unidirectional causality running from total energy consumption to GDP, and an impulse response to GDP caused by energy consumption, being mainly embodied in the first years. The results indicate that total energy consumption is an important component determining economic growth in Croatia and that energy conservation policy should be formulated and implemented wisely. This paper also tests the causality between real GDP and consumption of the five energy variables by using the bivariate VAR. The main implication of these tests is that individual energy forms matter when it comes to energy policy formulation.

1. Introduction

As a production factor, energy plays a vital role in economic growth (Stern, 2011), and the relationship between them is now well established in the literature. However, the theoretical and empirical findings have indicated that the contribution of energy to productivity improvements and economic growth has been greatly underestimated (Sorell, 2010), and that no consensus has emerged regarding the direction of causation in this relationship.

Akinlo (2008) classifies the results from previous studies into three types: (i) unidirectional causality—from energy consumption to growth, or vice versa; (ii) second—bidirectional causality, and (iii) no causality. If there is a relationship between energy consumption and economic growth, the direction of the causal relationship is important and has important implications for policy makers.

If causality exists and runs from energy consumption to real gross domestic product (GDP), an economy will grow if policy makers increase the amount of energy consumption in a country. This also means that a shortage of energy may negatively affect economic growth, and consequently employment and income. In that case, energy can be a limiting factor of economic growth (Narayan and Prasad, 2008; Stern, 2011), and hence, energy policy is extremely important. On the other hand, if causality runs from GDP to energy consumption, any strategy to change the energy will not affect economic growth and employment (Masih and Masih, 1997). If a bidirectional causal relationship exists, energy consumption and economic growth are jointly determined and affected at the same time (Jumbe, 2004). Finally, the absence of a causal relationship implies that energy consumption is not correlated with economic growth. This means that economic growth is insensitive to energy policy (either conservative or expansive).

* Tel.: +385 31 224 400; fax: +385 31 211 604.
E-mail address: borozan@efos.hr

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The paper assumes that there should be a causal relationship running from total energy consumption to real GDP in Croatia. A causal relationship will be tested by using the vector autoregression (VAR) methodology and Granger causality tests. The VAR model, popularized by Sims (1980), has proven to be especially useful for describing the dynamic behaviour of economic time series, i.e. for estimating the long-run causal relationship and forecasting, whereas the Granger's definition of causality (Granger, 1969, 1986, 1988) is the most widely used concept of causality. Additionally, the VAR can be considered as a natural framework for conducting causality tests, or more specifically, Granger causality tests.

Hence, the main aim of this paper is to determine empirically whether there is a causal link between total energy consumption and economic growth in Croatia. Furthermore, the impulse response function and variance decomposition analysis are employed to study the effect of total energy consumption shock on real GDP and vice versa. Certainly, like other post-socialist countries Croatia is an energy intensive growing economy. However, like other non-oil producing countries it meets its energy needs by importing large amounts of energy. Therefore, the role of the energy sector should be considered as significant for accelerating economy in Croatia. Its role has recently become especially important due to ongoing economic crises, scarce domestic energy resources, and instabilities and volatilities existing in the domestic and global energy markets. Under such conditions, the causal relationship between energy consumption and general economic activities is essential to policy makers. To understand this better, the paper also tests the relationships between real GDP and the five energy variables (coal and coke, liquid fuel, natural gas, hydro power and electricity) by using the bivariate VAR.

In Croatia, over the period between 2005 and 2010, GDP had very slow growth at an average annual rate of 0.1%, primary energy production increased at an average annual rate of 2.9%, while total energy consumption stagnated (MELE, 2011). In the future, energy self-supply will continue to decrease. In 2010, it was 55.5%, whereas in 2030 it is expected to reach about 29% (MELE, 2011). This means that Croatia will have to cover the increasing gap between them from imports. Consequently, the question of the relationship between energy consumption and GDP is very important for Croatian policy makers.

Most empirical evidence on the relationship between energy consumption and economic growth is based on the western or Asian economy context and there is a gap of evidence from transitional economies or post-socialist countries. The paper adds to the existing body of evidence by exploring a causal relationship between energy consumption and GDP in a small open, non-oil producing and post-socialist country that will become the 28th member state of the European Union (EU) in 2013. Conclusions for Croatia may be relevant not only for the country itself, but also for a number of countries that have to go through a similar development path.

The remainder of this paper is organized as follows: the next section and section three briefly describe energy consumption in Croatia and literature findings, respectively. Section four discusses the data and methodology, as well as the results of the empirical analysis. The last section gives concluding remarks.

2. Energy consumption in Croatia

Total energy consumption, which represents the quantity of energy necessary to meet the energy consumption in Croatia, was at a very low level over the Homeland war (1991–1995), as illustrated in Fig. 1. Although this is not visible in the figure, it was about to decline. The decline was especially rapid during the first two years of the war (1991–1992). For example, in 1992, when total energy consumption was at its minimum (298.77 PJ), it was 30.61% lower than in 1988. This can be explained not only by the Homeland war, but also by deindustrialisation processes and transition depression in the 1990s.

Over the period from 1992 to 2010 total energy consumption had an average annual growth rate of 1.8%. The fastest growth in energy consumption was observed in the period 2000–2005, when the growth rate of consumption was 3.4%. Over the period from 2005 to 2010 it was relatively stagnant. It is interesting to explore the shares and the growth rates of specific individual energy forms in total energy consumption. More specifically, total energy consumption can be disaggregated into coal and coke, liquid fuels, natural gas, electricity, hydropower, renewables (e.g. fuel wood) and heat. The average structure of total energy consumption and the average annual rates with regards to individual energy forms in the period 1992–2010 are reported in Table 1.

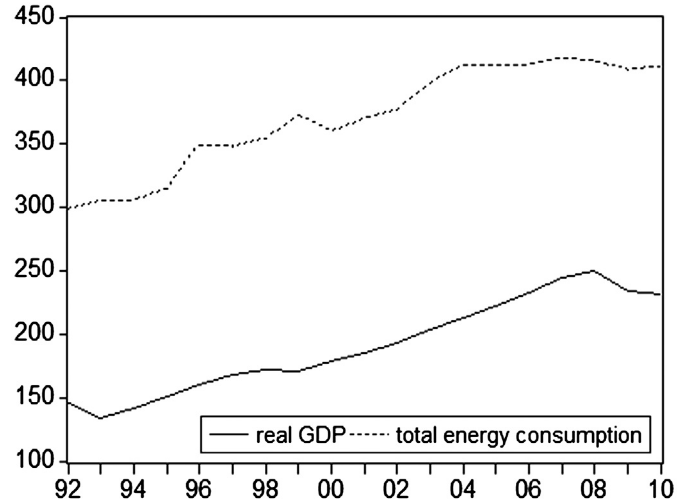

Fig. 1. Total energy consumption and real GDP in the period 1992–2010. *Note*: Total energy consumption is measured in Petajoules (PJ), whereas real GDP is expressed in billions of national currency (HRK); the base year is 2000.
Source of data: Energy Institute “Hrvoje Pozar” (EIHP) for energy consumption and the World Economic Outlook Database for real GDP.

Table 1
Mean share and average annual growth rate of specific energy consumption forms in the period 1992–2010, in %.
Source of data for calculation: Energy Institute “Hrvoje Pozar” (EIHP)

Energy form	Mean share	Average annual rate
Coal and coke	5.10	2.88
Liquid fuel	44.83	1.18
Natural gas	26.74	1.23
Hydropower	15.34	3.47
Electricity	3.86	3.03
Renewables	4.04	1.67
Heat	0.10	37.93
Total	100.00	1.80

Note: the annual average rate is calculated as a geometric mean. Data on coal and coke are related only to imported quantities since they are not commercially produced in Croatia. Liquid fuel data include Croatia's own production of crude oil, net imports of crude oil and oil derivatives, respectively. Natural gas also includes own production and net imports. Electricity refers to net imports of electricity. When counting electricity in total energy consumption, the EIHP uses a conversion factor of 3.6 PJ/TW h. This is consistent with the European convention. However, when counting hydropower, the EIHP uses a conversion factor whose value fluctuates slightly around 9.45 PJ/TW h. Heat consumption in total energy consumption relates to the use of heat energy from heat pumps, whereas renewables relate to fuel wood and other renewables (e.g. wind energy, solar energy, geothermal energy).