Prof. Saša Žiković, Ph.D.[1]
Prof. Nela Vlahinić-Dizdarević, Ph.D.[2]

UDK 330.567.4:665.6>:330.43(4)
Original scientific paper
Izvorni znanstveni rad

OIL CONSUMPTION AND ECONOMIC GROWTH INTERDEPENDENCE IN SMALL EUROPEAN COUNTRIES[3]

ABSTRACT

The paper examines the existence and the direction of causality between the oil consumption and the economic growth in small European countries over the period 1980–2007 for the developed countries and 1993-2007 for the transition countries. Our findings show that small European states can be divided into two groups. The first group is characterized by the causality running from real GDP to oil consumption and is composed of the most developed European countries and a number of transition countries. In the former case, the direction of causality is a consequence of a highly developed post-industrial society with a strong tertiary sector. In the case of transition economies the direction of causality can be related to deindustrialization process and transition depression that resulted in a sharp industrial decline and decreased industrial oil demand. The second group is characterized by the causality running from oil consumption to economic growth, in which case the state should employ additional resources in subsidizing oil prices and securing long term and stable oil sources for its economy. In such countries the reduction of oil consumption because of different reasons (external prices shocks, increased taxes on oil and its derivatives, restrictive ecological laws regarding CO_2 emission) could lead to a fall in economic growth.

Key words: *oil consumption, economic growth, small European countries, Granger causality, Error Correction Model (ECM)*

1. INTRODUCTION

During the last two decades there have been a number of papers dealing with the causality between economic growth and energy, although only a few studies specifically focused on the causal relationship between oil consumption and economic growth. Since the economic relevance of oil and its derivatives is increasing in times of energy crises, especially for small countries, it is worthwhile examining this causality in the case of small economies that are especially vulnerable to exogenous supply shocks which directly change their oil consumption. The exogenous supply shocks, such as an increase in the price of oil or constraints in the oil supply have a strong impact on the open and import-dependent small countries' macroeconomic indicators, especially gross domestic product (GDP) growth rate

[1] Faculty of Economics, University of Rijeka, I. Filipovića 4, 51000 Rijeka, e-mail: szikovic@efri.hr

[2] Faculty of Economics, University of Rijeka, I. Filipovića 4, 51000 Rijeka, e-mail: nela@efri.hr

[3] The presented results are part of research projects (Economic impacts of regulatory reforms in electricity sector, No. 081-0361557-1455 and Strategy of socioeconomic relations of the Croatian society, No. 081-0000000-1264) supported by the Ministry of Science, Education and Sports of the Republic of Croatia.

and macroeconomic stability. Therefore we focus our research on a sample of small European countries, taking into consideration their level of development and economic characteristics, since it can significantly influence their growth and oil consumption patterns.

The purpose of this paper is to investigate the existence and the direction of causality between the economic growth and the oil consumption in small European countries. There are several reasons why such an analysis is worthwhile. First, in the light of escalating tensions with some large oil and gas producers, there has been an ongoing debate, in Europe and worldwide, on how to reduce dependence on foreign (import) energy supply in a reasonable time-frame without reducing economic growth. Therefore it is very important to know the direction of the causality between energy imports and consumption on one hand, and GDP growth on the other. If causality runs from energy to GDP, it would imply that the reduction in energy net imports would considerably harm economic activities. Second, pollution and global worming has become an important issue for economic policy. Since energy production and consumption are one of the main sources of CO_2 emissions, the dilemma whether the reduction of energy production and use would lower economic growth has become a crucial issue for economic and energy policy. Third, in the context of European goal to increase energy efficiency, it is important to know what this target would mean for the GDP growth.

Our hypothesis is that energy-development relationship differs considerably along the different stages of development. Therefore small developed countries will show similar causality pattern, i.e. causal relationship running from GDP growth to oil consumption due to the income effect. The GDP and income growth increases the demand for all goods in an economy and consequently for the energy required to produce them. Over time, at higher level of development, consumers use more energy due to increases in transportation, services appliances, housing etc. On the other hand, in small, less developed countries that have undergone a transition from planned to market economy; one could expect a reverse causal relationship running from oil consumption to GDP growth. This can be explained by the fact that in these economies the share of industrial oil consumption exceeds the share of residential oil consumption and therefore one could assume that the total oil consumption causes economic activity and economic growth.

The paper is organized in the following manner: Section 2 analyses the economic characteristics of small countries discuses the economic consequences of oil shocks on national economies. Section 3 provides empirical findings on the role of energy in economic growth. Section 4 describes the applied econometric methodology and presents the obtained empirical results. Final section summarises the conclusions.

2. ECONOMIC CHARACTERISTICS OF SMALL COUNTRIES

An early introduction to the discussion relating to the economic growth of small economies began in the early 1960s with the publication of Kuznets (1960) seminal work. The issues of small states in theory have than again been ignored till 1989, which was the turning point in the global balance of power and changing European geography. With the fall of the iron curtain and the break-up of Soviet Union the number of small countries has increased dramatically, in Europe and worldwide, and consequently the research focus has been turned towards advantages, disadvantages and dilemmas that are being faced by the small countries.

It is obvious that the small size of a country has both some advantages and disadvantages. With the beginning of new a millennium it seemed that there was significant evidence that small countries were in a better position than they had been in modern history. Therefore some economists concluded that small countries were benefiting more than they were losing in global market conditions and that liberalised and globalised environment represented a new honeymoon for small states (Daniels and Svetličič, 2001). With the right policies, institutional setting and flexibility the small countries could expect to overcome their "natural" disadvantages. Today, majority of the countries are, de facto, becoming small, especially European ones, in terms of their diminishing influence on the world economy, but still there are some well-established criteria to defining the size of an economy. There are various criteria, such as: the population size, the level of GNP or GDP, geographical area and ability to affect world prices. The mostly widely accepted and probably the best single criteria is the population size since it implies the size of the domestic demand, the size of human resources and aggregate supply. We use the usual benchmark of 10 million inhabitants in defining small countries. We are aware that small countries do not represent a homogenous group and that their growth and oil consumption patterns are different, depending to a large extent on their level of development. We define the developed countries as high-income OECD countries while other European countries are treated as transitional. The interdependence between energy, other inputs and economic activity change significantly as an economy moves through different stages of development. For example, oil consumption in the developed small countries is mostly used in final consumption (transport, heating and cooling) rather than in the production processes. In such cases the external shocks have less effects on economic growth, while, at the same time, economic growth has a more significant impact on the level of oil consumption. It can be assumed that less developed small countries with relatively higher share of industry in their GDP will show a causality pattern that runs from oil consumption to economic activity because of the high industrial oil-intensity in comparison to their service sector.

The main economic features of small countries, relevant for our research, are related to their high trade dependence and limited energy (oil) resources. In contrast to the large countries, small economies generally export a higher proportion of their output and import a higher proportion of their consumption. Of course, the development process significantly affects the extent of trade openness. According to Damijan (2001), the relationship between the level of development and trade openness is not linear but log-linear, which means that the ratio of exports to GDP grows much faster at the beginning of the development process than at the later stages of development. Additionally, the size of a country determines the trade openness, especially in the advanced countries since the production structure in the transition countries may not be concentrated enough to allow for significant exports. Since the sample of small European countries is not homogenous, the differences in the level of development among European countries could be the factor that drives the differences in the trade openness. The more open an economy is through trade, the more vulnerable it becomes to economic and political conditions outside its control.

In the context of our research, an important economic characteristic of small countries is their limited and less diversified natural and energy resource endowment. Indeed, most of the small countries are net energy importers especially of oil and its derivatives. The importance of oil in the total final energy consumption in small European countries is presented in Table 1.

Table 1 The final consumption of oil in small European countries in 2006

Country	Final Consumption of Oil (Mtoe)	Total Final Consumption of Energy (Mtoe)	Share of Final Consumption of Oil in TFC of Energy (%)
Lower-middle-income economies*			
Albania	1,31	1,80	72,77
Moldova	0,62	2,14	28,97
Upper-middle-income economies*			
Bulgaria	4,24	10,76	39,41
Bosnia and Herzegovina	1,14	2,77	41,16
Latvia	1,51	4,23	35,70
Lithuania	1,84	5,51	33,39
Macedonia	0,71	1,72	41,28
High-income non-OECD economies*			
Croatia	3,49	7,10	49,15
Cyprus	1,16	1,61	72,05
Estonia	0,99	2,99	33,11
Malta	0,20	0,36	55,56
Slovenia	2,60	5,24	49,62
High-income OECD economies*			
Austria	13,12	27,97	46,91
Belgium	21,60	43,55	49,60
Czech Republic	9,55	28,35	33,69
Denmark	7,59	15,93	47,65
Finland	8,86	27,14	32,65
Ireland	8,79	13,40	65,60
Norway	8,89	20,78	42,78
Slovakia	3,05	11,43	26,68
Sweden	13,03	34,99	37,24
Switzerland	12,57	22,24	56,52

*Note: According to the World Bank's classification, countries are divided according to 2008 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $975 or less; lower middle income, $976 - $3,855; upper middle income, $3,856 - $11,905; and high income, $11,906 or more.

Source: IEA Statistics, Energy balances of non-OECD countries, Edition 2009 and Energy balances of OECD countries, Edition 2008

Though the share of oil in total energy consumption has decreased over the years, the data shows that oil is still the most important energy resource in small European countries, regardless of their level of development. The share of the oil consumption in the total consumption of energy ranges from 27% in case of Slovakia to 83% in Albania. In contrast to most of its other uses, consumption of oil by the transport sector has continued to grow strongly over the recent decades, reflecting the high income elasticity of demand for private transport[4] (OECD, 2004). The differences between the developed and the transition countries with regards to elasticities is reflected in the fact that the latter typically have lower price elasticities and often higher income elasticities, particularly if they are fast growing

[4] Estimates of the long-run income elasticity of demand for transport fuels is generally estimated to be greater than one, while the long-run price elasticity is estimated to be between -0.6 and -0.8.

economies. As far as import dependence is concerned, all small European countries are net importers of oil (with the exception of Norway) and strongly depend on developments in the global oil markets.

High oil dependency becomes a significant economic constraint in times of expensive and volatile energy, especially oil, since an increase in the oil prices may reduce the oil consumption, the size of which depends on the price elasticity of oil demand. The exogenous supply shocks are much stronger for the open and import dependent small countries and may significantly affect their level of output, GDP growth rate, trade balance and external debt. According to the macroeconomic theory, in the short run, an increase in oil prices leads to an increase in the domestic price level and a decrease in output due to higher costs. This situation decreases the aggregate demand and may lead firms to change or even cancel their investment plans, especially because increased oil prices can result in higher interest rates. The reduced demand and lower investments cause the fall in tax revenues and an increase in budget deficit due to the rigidities in government spending. The oil-price increase also leads to the pressure on nominal wages and together with lower demand tends to cause higher unemployment. The impact on output and employment is determined by the relative supply responses of labour and capital. To the extent that labour market institutions inhibit the adjustment of real wages to the shocks - i.e. higher oil prices imply higher input prices which reduce the profitability - the deterioration in the terms of trade following an oil shock can affect the equilibrium employment by creating a wedge between the value-added and consumer prices. In general, the short-term economic impact of an oil shock on output and employment would be smaller, the higher the proportion of the price rise that can be passed on to consumers and/or the more flexible are wages, in case that the price rise cannot be passed on (OECD, 2004).

On the country level it leads to the transfer of income from importing to exporting countries due to the shift in terms of trade. The extend of the direct impact depends on the importance of oil in national income, the import dependence of an economy and the ability of end-users to reduce their consumption and switch away from oil. It also depends on to the rise in gas prices as a response to an oil-price increase, the oil as well as gas-intensity of the economy and the impact of higher prices on other forms of energy that compete with oil (and gas) or are generated from oil (and gas), like electricity. Besides changing the balance of trade between countries the oil shocks can also influence their exchange rates. Usually net oil-importing countries experience the deterioration in their balance of payments, which creates pressure on their exchange rates. It makes their imports more expensive and exports less valuable which causes a decrease in real national income. Although the macroeconomic effects of oil shocks have changed over time, producing steadily smaller effects on prices and wages, as well as on output and employment, they still have significant negative effects on the whole economy and economic growth. McKillop (2004) argues that higher oil prices reduce economic growth, generate stock market panics and produce inflation, which eventually leads to monetary and financial instability. High oil prices can also lead to higher interest rates and even a plunge into recession. Jin (2008) argues that a sharp increase in the international oil prices and violent fluctuation of the exchange rates are generally regarded as factors that discourage economic growth. Edelstein and Kilian (2007) document a decrease in the effects of oil shocks on a number of aggregate variables using a vector autoregression (VAR) approach. According to Blanchard and Gali (2007), the weak response of inflation to oil price shocks in recent years can be explained by stronger anti-inflation policy, while the evidence of a smaller decline in employment and GDP suggests that an enhanced anti-inflation credibility may also have played a role. In the medium and long run context, the negative impact of an oil price rise on the domestic demand and income will diminish over time as consumers and producers modify their behaviour. However, recent research (OECD, 2004) seems to indicate that there is an asymmetric effect, insofar as the oil demand does not revert to its initial level as oil prices fall. This means that the income losses experienced by energy importers may eventually be partly reversed. Where fluctuations in the oil prices create uncertainty, there may be a reduction in trend investment activity, but it is less clear that the effects on profitability or capacity utilisation are asymmetric.

3. EMPIRICAL FINDINGS ON THE ROLE OF ENERGY IN ECONOMIC GROWTH

Although strong interdependence and causality between economic growth and energy consumption is a stylized economic fact, the direction of causality between economic growth and energy consumption is not clearly defined. In the last two decades, a number of academic papers explored the relationship between economic growth and energy, mostly energy consumption, as it is stated in the remainder of this section. On one hand, it is argued that energy is a vital and necessary input along with other factors of production (such as labour and capital). Consequently, energy is a necessary requirement for economic and social development so that energy is potentially a “limiting factor to economic growth” (Ghali and El-Sakka, 2004, 225). On the other hand, it is argued that since the cost of energy is a very small proportion of GDP, it is unlikely to have a significant impact; hence there is a “neutral impact of energy on growth”. The overall findings vary significantly with some studies concluding that causality runs from economic growth to energy consumption, other conclude the complete opposite, while a number of studies find bidirectional causality. One of the first relevant studies was the one from Kraft and Kraft (1978) that examined energy consumption and GNP of the USA over the period from 1947 to 1974. They found that the causality runs from GNP to energy consumption. This pioneering study intensified the interest in the research of the relationship between economic growth and energy consumption. Akarca and Long (1980) changed the time period used in Kraft and Kraft and found no statistically significant causal relationship. Erol and Yu (1987) found a significant causal relationship between energy consumption and income in the case of Japan for the period 1950-1982, supporting the view that Granger causality runs from energy consumption to income. Inconsistent results for the causality direction might be due to the methodological differences and the choice of different time periods. Mozumder and Marathe (2007) find unidirectional causality running from GNP to energy consumption in Bangladesh. Shiu and Lam (2004) report unidirectional causality running from energy consumption to GNP in China, while Jumbe (2004) found bidirectional causality between energy consumption and GNP in Malawi. On the other hand, the neutrality hypothesis is found by Yu and Hwang (1984), Yu and Choi (1985), Yu and Jin (1992) and Cheng (1995). For Taiwan, Yang (2000) investigated the causal relationship between real gross domestic product (GDP) and several disaggregate categories of energy consumption, including coal, oil, natural gas, and electricity, and found that there is unidirectional causality running from economic growth to oil consumption in Taiwan without any feedback effect. Similarly, in the case of South Korea, Yoo (2006) finds unidirectional short term causality from economic growth to coal consumption, and long term bidirectional causality.

Most of the studies focus developing countries, which is understandable because these countries are economies with the highest energy intensity aiming to increase the energy efficiency. Still, the empirical evidence is mixed for industrialized countries as well. Erol and Yu (1987) found a significant causal relationship between energy consumption and income in the case of Japan for the period 1950-1982, supporting the view that Granger causality runs from energy consumption to income. Inconsistent results for the causality direction might be due to the methodological differences and the choice of different time periods. Chontanawat, Hunt and Pierse (2008) tested the causality between GDP and energy on large sample of OECD and non-OECD countries. They find that causality from energy to GDP is found to be more prevalent in the developed OECD countries compared to the developing non-OECD countries, implying that a policy to reduce energy consumption aimed at reducing emissions is likely to have greater impact on the GDP of the developed rather than the developing world.

Although the direction or the intensity is not clear, based on the published research one may conclude that there is strong evidence to support the thesis of bidirectional or unidirectional causality between economic growth and energy consumption. The direction of causality has significant policy implications because knowing the direction of causality has direct implications on forming government policies regarding the energy conservation and subsidies system. Under the assumption that there exists unidirectional causality going from economic growth to energy consumption, it means that energy conservation policies will have little or no adverse effects on economic growth of a country. The policymakers may then use these findings in decreasing the tax burden and attracting the investments or in increased government spending. On the other hand, if unidirectional causality runs from energy consumption to economic growth, state should employ additional resources in subsidizing energy prices and securing long term and stable energy sources for its economy. In such a situation, reducing energy consumption, for example through bringing domestic energy prices in line with market prices, could lead to a fall in income and employment.

4. METHODOLOGY AND RESULTS

The data used in this paper is the real GDP annual series in US$, obtained from the UN database (2008) and oil consumption in thousands of barrels per day obtained from the Energy Information Administration (2008). The time period used in the analysis differs among the developed and the transition countries due to data availability. For the developed countries we used the period from 1980 to 2007, while for the transition countries the period from 1993 to 2007 was used. A serious problem of the analysis is the length of the analysed time period due to the short period of independence for a number of countries. Analysis would be far more robust if the quarterly data were available but the lack of the quarterly data on oil consumption prevents this approach. Given the vast amount of estimation undertaken, only a summary of the results is given here and is presented in table 3.

The first attempt at testing for the direction of causality was proposed by Granger (1969). Granger's test is a convenient and a very general approach to detecting the presence of a causal relationship between two variables. A time series *X* is said to Granger-cause another time series *Y* if the predication error of current *Y* declines by using past values of *X* in addition to past values of *Y*. The application of the standard Granger's causality test requires that the series of variables be stationary. Therefore, two variables have to be first transformed to covariance stationary processes. This is usually done by taking their first differences. The Phillips-Perron test or Augmented Dickey-Fuller test is used in examining the unit roots and stationary property of the two variables. To test for the Granger's causality between oil consumption and GDP, two bivariate models are specified, one for oil consumption and another for GDP. If the two variables are stationary, the standard form of the Granger's causality test used in this paper can be specified accordingly as follows:

$$\Delta GDP_t = \alpha_{11} + \sum_{i=1}^{n} \beta_{11i} \Delta GDP_{t-i} + \nu_{11t} \quad (1)$$

$$\Delta GDP_t = \alpha_{12} + \sum_{i=1}^{n} \beta_{11i} \Delta GDP_{t-i} + \sum_{j=1}^{m} \beta_{12j} \Delta OIL_{t-j} + \nu_{12t} \quad (2)$$

$$\Delta OIL_t = \alpha_{21} + \sum_{i=1}^{m} \beta_{21i} \Delta OIL_{t-i} + \nu_{21t} \quad (3)$$

$$\Delta OIL_t = \alpha_{22} + \sum_{j=1}^{m} \beta_{21j} \Delta OIL_{t-j} + \sum_{i=1}^{n} \beta_{22i} \Delta GDP_{t-i} + \nu_{22t} \quad (4)$$

We used the Phillips–Perron (1988) method to test for the existence of unit roots and identify the order of integration for each variable. Unit root tests are performed allowing for an intercept and a time trend. The Newey and West (1987) method was applied to choose the optimal lag lengths. We test for the possibility of structural breaks in the analysed variables by using the Chow test but find no evidence of their existence (due to the limited space the statistics are not reported here but are available from authors upon request)[5] Unit root test for the level and the first differenced real GDP and oil consumption in small European countries in the period 1980-2007 (developed countries) and 1993-2007 (transition countries) is presented in table 2.

Table 2 Unit root test for small European countries

Countries	Level Phillips-Perron values		First difference Phillips-Perron values	
	GDP	OIL	GDP	OIL
Austria	1.2225	-0,1064	-4.2357*	-4.3154*
Belgium	1,3364	-0,6135	-3.6425*	-4.0830*
Denmark	1,5786	-3.9802*	-4.1992*	-5.6173*
Finland	0,7667	-4.4298*	-2,4741	-4.9244*
Ireland	3,3152	0,5188	-3.3903*	-3.6604*
Norway	0,0789	-1,3535	-3.5772*	-5.9941*
Sweden	-0,7491	-4.9733*	-3,0257	-3.5829*
Switzerland	0,3420	-4.8712*	-3.3759*	-7.2949*
Albania	0,1203	-1,9258	-4.0799*	-2,5520
B&H	0,1998	-0,3433	-4.4597*	-3.7109*
Bulgaria	-1,4073	-1,3476	-3.5033*	-2,8082
Croatia	4,9174	-2,6525	-2,4106	-7.2684*
Cyprus	3,4744	0,0053	-3.0332*	-7.6193*
Czech R	2,0644	-0,7731	-1,4440	-2,6436
Estonia	3,5317	-1,3827	-3.0310*	-2.8131*
Latvia	13,7307	-1,5285	-0,7283	-3.9749*
Lithuania	3,1588	-1,5000	-3.4593*	-2,6005
Macedonia	1,2556	-3.9049*	-2,5888	-6.6053*
Malta	-0,1168	-0,6328	-2.6502*	-7.1333*
Moldova	0,5098	-5.8099*	-1,2699	-6.3775*
Slovakia	2,0346	-3,0753	-0,2198	-4.6836*
Slovenia	-0,1639	-1,7867	-2,9573	-1,9656

* Signification at the 10% level. The critical value of the Phillips-Perron statistic at the 10% level is approximately 3.13
Source: Authors' calculation

[5] We would like to thank an anonymous reviewer for suggesting it

Table 2 shows that we can reject stationarity in the level of GDP for all countries, which is not the case for the level of oil consumption. Since the level of oil consumption is a stationary process for some countries, we can assume that in such a case there is no cointegration between oil consumption and GDP.

Recent developments of the cointegration concept indicate that a vector autoregressive (VAR) model specified in differences is valid only if the analysed variables are not cointegrated. If they are cointegrated, an error correction model (ECM) should be estimated rather than a VAR as in a standard Granger causality test (Granger, 1988). Hendry and Juselius (2000) emphasize the importance of an error correct model specification. Following Granger (1988), we use an ECM instead of a VAR model, since a VAR model is misspecified in the presence of cointegration. A VAR model may suggest a short run relationship between the variables because the long run information is removed by the first differencing, while an ECM can avoid such shortcomings. In addition, the ECM can distinguish between a long run and a short run relationship between the variables and can identify sources of causation that cannot be detected by the usual Granger causality test.

The ECM model used in this paper can be written as:

$$\Delta GDP_t = \alpha_{12} + \sum_{i=1}^{n} \beta_{11i} \Delta GDP_{t-i} + \sum_{j=1}^{m} \beta_{12j} \Delta OIL_{t-j} + \theta ECM_{t-1} + u_t \qquad (5)$$

$$\Delta OIL_t = \alpha_{22} + \sum_{j=1}^{m} \beta_{21j} \Delta OIL_{t-j} + \sum_{i=1}^{n} \beta_{22i} \Delta GDP_{t-i} + \lambda ECM_{t-1} + \varepsilon_t \qquad (6)$$

Regardless of the formulation used, similar studies have shown that the result of causality is very sensitive to the lag length adopted in the models. Hsiao (1981) introduced a way to help determine the optimum lags to be used, by combining the Granger definition of causality and Akaike's FPE criterion. The Hsiao procedure involves two steps. For the first step Eq. (2 and 4) or Eq. (5 and 6) are estimated with various lag lengths for ΔGDP but with the ΔOIL and ECM terms omitted. The final prediction error (FPE) is computed for each lag length of ΔGDP with the optimal lag (n*) being the one with the minimum FPE, denoted as FPE(I). For the second step Eq. (2 and 4) or Eq. (5 and 6) is estimated, with the lag length on the ΔGDP terms pre-determined by step one, but different lag lengths for the ΔOIL terms. Again a form of the FPE is calculated with the optimal lag length (m*) being that with the minimum FPE, denoted as FPE(II). Finally FPE(II) is compared with FPE(I): if FPE(II) < FPE(I) then OIL (Granger) causes GDP; whereas if FPE(II) > FPE(I) then OIL does not (Granger) cause GDP. These tests determine whether OIL causes GDP. These findings can than be confirmed by using a number of statistical tests. For the standard Granger model, Eq. (2 and 4), causality can be confirmed by doing a joint *F*-test for the coefficients of the lagged ΔOIL variables. For the error correction model, Eq. (5 and 6), where causality comes from two sources, the ECM term and the lagged ΔOIL variables, causality can be confirmed by undertaking a joint *F*-test of the ECM coefficient and the lagged ΔOIL coefficients. The Hsiao (1981) procedure enables a systematic approach which minimizes arbitrary decisions on an individual level.

By using standard Wald test we evaluate Granger weak causality by testing H_0: $\beta_{12j} = 0$ for all j in Eq. (5) or H_0: $\beta_{22i} = 0$ for all i in Eq. (6). Asafu-Adjaye (2000) interpreted the weak Granger causality as short run causality in the sense that the dependent variable responds only to short-term shocks from the stochastic environment. The ECM terms in Eqs. (5 and 6) provide for another possible source of causation. The coefficients on the ECMs represent how fast the deviations from the long run equilibrium are eliminated following the changes in each variable. If, for example, θ is zero, then GDP does not respond to a deviation from the long run equilibrium in the previous period. This can be tested by using a simple *t*-test. If there is no causality in either direction, the "neutrality hypothesis" holds.

The maximum likelihood approach to cointegration developed by Johansen (1988, 1991) makes it possible to test for the cointegration rank, that is, the number of cointegrating vectors. It also allows the estimation of these vectors and to test linear restrictions on the vectors using standard asymptotic inference. In addition, the small sample biases and normalization problems inherent in the OLS approach do not arise in the Johansen method. When testing for cointegration using the Johansen procedure, we employed the specification that allows for a linear trend in the data with an intercept but no trend in the co-integrating vector. The suitability of this choice was tested using Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). To determine the number of the cointegrating vectors, we make use of both the Trace test and the Maximum Eigenvalue test using the critical values of MacKinon–Haug–Michelis (1999).

In the empirical literature the Wald test computed from an unrestricted vector autoregressive (VAR) model also appears frequently. Toda and Phillips (1993) show that the asymptotic distribution of the test in the unrestricted case involves nuisance parameters and nonstandard distributions. An alternative procedure to the estimation of an unrestricted VAR consists of transforming an estimated error correction model (ECM) to its levels VAR form and then applying the Wald type test for linear restrictions to the resulting VAR model. Lütkepohl and Reimers (1992) present the distribution of the Wald statistic for the bivariate case based on Johansen and Juselius' (1990) maximum likelihood estimator of ECMs. The limiting distribution of the statistic for the p-variates model is discussed in Toda and Phillips (1993). Toda and Yamamoto (1995) propose an interesting yet simple procedure requiring the estimation of an "augmented" VAR, even when there is cointegration, which guarantees the asymptotic distribution of the Wald statistic. An analysis and Monte Carlo results for cointegrated data is presented in Dolado and Lütkepohl (1996).

Toda and Yamamoto (1995) prove that the Wald test for restrictions on the parameters of a VAR(k) has an asymptotic χ^2 distribution when a VAR(k + d_{max}) is estimated, where d_{max} is the maximal order of integration suspected to occur in the process. Dolado and Lütkepohl (1996) using a different approach, prove the same result and analyze the power properties of this test. The Wald statistic is computed using only the first k coefficient matrices. This procedure does not require knowledge of either the cointegration properties of the system or the order of integration of the variables. Thus, if there is uncertainty as to whether the variables are I(1) or I(0), the adding of an extra lag insures that the test is being performed on the safe side. The computation of this Wald test is simple (Zapata, Rambaldi, 1997):
(1) Estimate a VAR(k+d_{max}) process by multivariate least squares, where k is the known or pre-determined optimum lag of the system. Denote by $\Phi(L)^{k}_{k+d\max}$, the least squares estimator of the simple VAR parameters with only the coefficients of the first k lags considered;
(2) Let $\hat{\Sigma}^{k}_{k+d\max}$ be a consistent estimator of the variance-covariance of $\Phi(L)^{k}_{k+d\max}$. Then $\lambda_W = T\left(R\hat{\Phi}^{k}_{k+d\max}\right)'\left(R\hat{\Sigma}^{k}_{k+d\max}R'\right)^{-1}\left(R\hat{\Phi}^{k}_{k+d\max}\right)$ has an asymptotic $\chi^2_{(N)}$ distribution, with N being equal to the rows of the restriction matrix R.

Zapata, Rambaldi (1997) present results of a Monte Carlo experiment which studies the performance of two Wald tests, a Wald statistic computed from an estimated "augmented" VAR (MWALD) and a Wald statistic computed from an estimated ECM, and a classical LR tests for Granger non-causality in cointegrated systems. Estimation and testing for two of the tests follows the ML approach of Johansen and Juselius (1990). The third test is computed from the multivariate least squares estimates of a VAR (Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996)). The MWALD test is based on an estimator that does not incorporate the information about the degree of integration and/or cointegration of the variables in the system. An advantage of the MWALD test is that it has a limiting chi-squared distribution even if there is no cointegration or the stability and rank conditions are not satisfied[7]. On the other hand, as the estimator (VAR) is less efficient than the maximum likelihood estimator for cointegrated systems, MWALD would be expected to have a lower power of the test than the WALD and the LR tests in all cases studied in this experiment. The results show this to be the case for small samples all three tests have a high power of the test in moderate to large samples regardless of model structure. In small samples (50 or less observations), the MWALD test suffers the most loss in power, with the LR performing best in terms of power. Furthermore in small samples, when bidirectional causality is expected, the LR seems to be the only test with enough power to detect a false null hypothesis in the bivariate models. Based on these results and our small sample we proceed with using the LR approach.

After obtaining cointegration relations among GDP and oil we estimated the error correction models for the real GDP and oil to derive their short-run elasticities. The ECM has the obtained cointegration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Results of Johansen cointegration test and causality between GDP and oil consumption are presented in table 3.

Table 3 GDP and oil consumption causality in small European countries

Countries	Cointegration	Causality		
		oil → gdp	gdp → oil	bidirectional
Developed				
Austria	√	√		
Belgium	√		√	
Denmark			√	
Finland				
Ireland	√		√	
Norway	√		√	
Sweden			√	
Switzerland				
Developing				
Albania				
B&H	√	√		
Bulgaria		√		
Croatia	√		√	
Cyprus				
Czech R	√	√		
Estonia				
Latvia	√		√	
Lithuania	√		√	
Macedonia				
Malta	√	√		
Moldova			√	
Slovakia	√	√		
Slovenia	√		√	

Source: Authors' calculation

The direction of causality has significant policy implications for all countries, but especially the small ones, since they do not have sufficient energy resources to meet their demand and have limited economic resources in general. The direction of causality should have direct implications on government policies regarding the energy conservation and subsidies system. As we found that 12 out of 22 tested small European countries exhibit cointegration between GDP and oil consumption, there must be either unidirectional or bidirectional Granger causality, since at least one of the error correction terms (ECMs) is significantly nonzero by the definition of cointegration. As expected, we found that in all of the analysed small European countries causality is unidirectional.

From the obtained results we can conclude that all of the diagnostic test statistics are satisfactory. Considered by the significance of the *t* statistics, the coefficients are well determined. The disequilibrium error term is statistically significant in all equations which confirms the existence of long-run relationship between the variables in the error correction models. In addition, all the equations are statistically significant and the overall statistical goodness of fit is acceptable. It can be concluded that the regression coefficients are significantly different from zero. In assessing the robustness of the estimated ECM we conducted several residual tests; Portmanteau autocorrelation tests, ECM residual normality and pairwise Granger causality/Block exogeneity Wald tests. For example, the ECM residual Portmanteau autocorrelation test shows that there is no residual autocorrelation in the bivariate GDP-oil models even up to the 5th lag. The residual normality test is computed using the Jaque–Berra statistic with Cholesky (Urzua) orthogonalization and shows that residuals for all EC models can be viewed as being multivariate normally distributed. Pairwise Granger causality/Block exogeneity Wald test tests whether an endogenous variable can be treated as exogenous.

There are some similarities but also some significant differences between our findings and findings by Chontanawat, Hunt and Pierse (2008), which analyse energy consumption and GDP in the period 1960-2000. We find the same direction of causality from energy (oil) to GDP in case of Czech Republic, Slovakia and Austria while opposing results for Bulgaria, Denmark, Norway and Malta.

Based on the obtained results we can divide the small European countries into two groups. The first group consists of countries where the causality is running from real GDP to oil consumption: Belgium, Denmark, Ireland, Norway, Sweden, Croatia, Latvia, Lithuania, Moldova and Slovenia. The group seems heterogeneous, but is actually composed of two homogenous groups of countries. The reasons for causality from GDP to oil consumption in the most developed countries (Scandinavian economies, Ireland and Belgium) and in the transition countries (Croatia, Latvia, Lithuania and Moldova) are completely different. In the former case, the direction of causality is a consequence of a highly developed post-industrial society with a strong tertiary sector. These countries have reached an improvement in energy efficiency, which has the same effect as lower oil prices, and leads to faster economic growth. This growth effect caused by more efficient technologies leads to increased energy used, which is known as “macroeconomic feedback” (Howarth, 1997) or rebound effect. In the case of transition economies the direction of causality can be related to deindustrialization process and transition depression that resulted in a sharp industrial decline and decreased industrial oil demand. The causality in the transitional countries between real GDP and oil consumption is more related to personal transportation, cooling and heating needs rather then the industry. Under the assumption that there exists unidirectional Granger causality going from economic growth to oil consumption, it could mean that the policies aimed at decreasing oil dependency should not have a significant effect on economic growth of a country. The state may then use potential proceeds from higher duties and taxes on oil to decreasing the overall tax burden on earnings and attracting investments or stimulating the economy by increased government spending.

The second group of countries where the causality is running from oil consumption to real GDP is composed of the following countries: Austria, Czech Republic, Slovakia, Malta, Bulgaria and Bosnia and Herzegovina. Although these countries are also heterogeneous, all of them use oil mostly for industrial purposes and this direction of causality is logical. In these states, where unidirectional Granger causality runs from oil consumption to economic growth, state should employ additional resources in subsidizing oil prices and securing long term and stable oil sources for its economy. In such a situation, reducing oil consumption, because of: external prices shocks, increased taxes on oil and its derivatives, problems in procurement or transportation of oil, as well as restrictive ecological laws regarding CO_2 emission, could lead to a fall in economic growth.

Our results are different from most of the studies analysing developing-transitional countries, which found that causality runs from energy variables to economic growth. On the other hand, opposite causality is common in developed, post-industrial economies with strong tertiary sector. The interdependence between energy, other inputs and economic activity changes significantly as an economy moves through different stages of development. Energy consumption in developed countries is mostly used in final consumption (transport, heating and cooling) rather than in production processes. In such cases the external shocks have less effects on economic growth, while, at the same time, economic growth has a more significant impact on the level of energy consumption, production and imports. Although Croatia, Latvia and Lithuania are transition countries, they show similar economic structure to developed countries with dominant service sector that makes up to 60% of their GDP. Privatisation process in these countries has resulted with brown-field investments in service sector, especially telecommunications and financial sector (Demekas et.al., 2005), because of the high profits in these oligopolistic markets. On the other hand, the industrial production dropped sharply due to the closure and restructuring of heavy industry which was the biggest energy consumer and thus the energy consumption in industry decreased considerably. Uncompetitive position of the industry in transition countries has been additionally enforced by extensive trade liberalisation which led to further decline in industrial production and industrial energy consumption. An important problem that negatively impacts the competitiveness of industry in transition countries is related to higher energy prices for industry in comparison to prices for households. During the 90s in most transition countries industrial tariffs used to be higher than residential tariffs, which is in sharp contrast with the situation in Western Europe where industrial tariffs have been on average two-third of the price charged to households, reflecting the relative costs of supplying these two customer categories (Broadman et.al. 2004). Regarding electricity, prices for industry in EU-27 in 2009 are even 23.8% lower than prices for households, while in EU-27 gas industry the relationship between industry and households prices is even more favourable for industry and is 26.15% lower than for residential costumers (Eurostat, 2010). Despite regular increases in household tariffs in transition countries, cross-subsidisation still exists from industry to households and the latest increases in the oil and gas prices for the industry have further deteriorated their competitiveness. National energy policy should tackle these problems, but it should also include support measures to neutralize the negative economic impact of cost-reflective energy prices on socially vulnerable households.[6]

5. CONCLUSION

We examine the causal relationship between oil consumption and economic growth for small European countries over the period 1980–2007 for developed countries and 1993-2007 for transition countries. We used a bivariate model of real GDP and oil consumption. Since the presence of cointegration was found in over 50% of the analysed countries we used an ECM instead of a VAR model, since the VAR model is misspecified in the presence of cointegration. Apart from that, VAR models may only suggest a short run relationship between the variables because long run information is removed in the first differencing, while an ECM avoids this shortcoming.

Our findings show that small European states can be divided into two groups. The first group consists of countries where the causality is running from real GDP to oil consumption: Belgium, Denmark, Ireland, Norway, Sweden, Croatia, Latvia, Lithuania, Moldova and Slovenia. The group seems heterogeneous, but is actually composed of two homogenous groups of countries. The reasons for causality from GDP to oil consumption in the most developed countries (Scandinavian economies, Ireland and Belgium) and in the transition

[6] These measures may combine social support for households that suffer from energy poverty with support for increased energy efficiency.

countries (Croatia, Latvia, Lithuania and Moldova) are completely different. In the former case, the direction of causality is a consequence of a highly developed post-industrial society with a strong tertiary sector. In the case of transition economies the direction of causality can be related to deindustrialization process and transition depression that resulted in a sharp industrial decline and decreased industrial oil demand. The causality in the transitional countries between real GDP and oil consumption is more related to personal transportation, cooling and heating needs rather then the industry. Under the assumption that there exists unidirectional Granger causality going from economic growth to oil consumption, it could mean that the policies aimed at decreasing oil dependency should not have a significant effect on economic growth of a country. The state may then use potential proceeds from higher duties and taxes on oil to decreasing the overall tax burden on earnings and attracting investments or stimulating the economy by increased government spending.

The second group of countries where the causality is running from oil consumption to real GDP is composed of the following countries: Austria, Czech Republic, Slovakia, Malta, Bulgaria and Bosnia and Herzegovina. Although these countries are also heterogeneous, all of them use oil mostly for industrial purposes and this direction of causality is logical. In these states, where unidirectional Granger causality runs from oil consumption to economic growth, state should employ additional resources in subsidizing oil prices and securing long term and stable oil sources for its economy. In such a situation, reducing oil consumption, because of: external prices shocks, increased taxes on oil and its derivatives, problems in procurement or transportation of oil, as well as restrictive ecological laws regarding CO_2 emission, could lead to a fall in economic growth.

A significant limitation of this study is the short time period for the transition countries and questionable quality of data in the early 1990s. In the future it may be interesting to investigate causality over a longer time span and with higher frequency data, for example, quarterly data, since temporal aggregation of higher frequency data to annual data may weaken causal relationships between the variables. Despite these limitations this is, as far as we known, the first systematic analysis of causality between oil consumption and economic growth performed on a larger group of countries. The results we obtained have important consequences for small countries in light of the ongoing desire to reduce oil dependency and CO_2 emissions.

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MEĐUZAVISNOST POTROŠNJE NAFTE I EKONOMSKOG RASTA U MALIM EUROPSKIM ZEMLJAMA[7]

SAŽETAK

Rad istražuje postojanje i smjer kauzalne povezanosti između potrošnje nafte i ekonomskog rasta u malim europskim zemljama u periodu 1980.-2007. za razvijene zemlje i 1993.-2007. za tranzicijske zemlje. Naši rezultati pokazuju da se male europske zemlje mogu podijeliti u dvije grupe. Prvu grupu karakterizira smjer kauzalnosti od realnog BDP-a prema potrošnji nafte, a čine ju najrazvijenije europske zemlje te jedan dio tranzicijskih zemalja. U prvom slučaju, smjer kauzalnosti posljedica je visokorazvijenih post-industrijskih društava sa snažnim uslužnim sektorom. U slučaju tranzicijskih zemalja, ovakav smjer kauzalnosti može se povezati s procesom deindustrijalizacije i tranzicijskom depresijom koji su rezultirali snažnim padom industrijske proizvodnje i smanjenom industrijskom potražnjom za naftom.

Drugu grupu zemalja karakterizira kauzalnost u smjeru od potrošnje nafte prema ekonomskom rastu, a u takvom slučaju država treba angažirati dodatne resurse za subvencioniranje cijene nafte i osiguranje dugoročnih i stabilnih izvora nafte za ekonomiju. U ovim zemljama smanjenje potrošnje nafte zbog različitih razloga (eksternih cjenovnih šokova, porasta poreza na naftu i naftne derivate, restriktivnih ekoloških zakona zbog CO_2 emisija) mogu voditi padu ekonomskog rasta.

Ključne riječi: *potrošnja nafte, ekonomski rast, male europske zemlje, Granger kauzalnost, Error Correction Model (ECM)*

[7] Prikazani rezultati proizašli su iz znanstvenih projekata (Ekonomski učinci regulatornih reformi elektroenergetskog sektora, br. 081-0361557-1455 i Strategija ekonomsko-socijalnih odnosa hrvatskog društva, br. 081-0000000-1264), provođenih uz potporu Ministarstva znanosti, obrazovanja i športa Republike Hrvatske.