



# Energy efficiency and natural gas consumption in the context of economic development in the European Union



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## ABSTRACT

Our paper evaluates the relationship between energy efficiency (which is the key issue of European climate policy), consumption of the natural gas, and economic development in the European Union.

We employ the panel time series data from 1997 to 2011 that covers 26 EU Member States (represented by the countries of the Eurozone). We build and test a multivariate model originating from the neoclassical growth model and amended to include gross fixed capital and total labour as our explanatory variables. We use the panel cointegration tests and error correction modelling for determining whether there exists a long-term causality between economic growth and natural gas consumption in the EU. Moreover, we aim to derive the existence of the two-way causality between natural gas consumption and economic growth in the EU Member States. Our results show that the relationship between economic development and the consumption of the natural gas is positive, while the relationship between the consumption of the natural gas and economic development in the EU appears to be negative. Our findings might be relevant for formulating the policy framework targeting and increasing energy intensity and efficiency.

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## 1. Introduction

Our paper focuses on several fundamental questions in energy economics, a broad area of economic theory that is dealing with the supply and use of energy in human society [1]. Namely, it is concerned with the main theoretical trends in the interpretation of relationship between energy consumption and economic

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growth, the kind of this relationship (unidirectional or bidirectional) between these two aspects, as well as on determining the importance of natural gas important for economic growth and society in general.

In recent years, debates on relationship between energy efficiency, energy consumption and economic growth is gaining on intensity [24]. Researchers dealing with this problem cannot agree on the role of energy efficiency and energy consumption in economic growth and development. According to [2–5] there are two basic interpretations of the role of energy in economic growth. These two theoretical backgrounds are based on mainstream growth theory and ecological economics approach [5]. On the one hand, some economists (especially the representatives of mainstream growth theory) argue that energy cannot be a factor that affects economic growth, because energy consumption does not stimulate economic growth or this stimulation tend to be quite insignificant. This theory is represented by neoclassical growth model proposed by [6], where capital, labour and land are taken as primary factors in production process. Here, energy plays the role of intermediate input and can be substitutable by capital. The other point of view is expressed by the ecological and energy economists, who view the energy as an economic factor of production alongside with labour and capital. The ecological point of view is based on the argument that energy in the long-run is non-reproducible input, in comparison with others reproducible capital and labour. According to a biophysical model of energy can be presented as primary factor in economic growth because of the limited possibility to substitute by capital or technology [2,8]. Thus, energy is becoming an important requirement for economic growth and determinant factor to economic development of society [2,4]. Taking into account these two approaches, one should think about the role of energy in economic growth.

In the economic research literature dealing with a task of relationship between energy consumption and economic growth we can find different hypotheses describing this relationship. Description of them can be found in some previous studies devoted to this problem, e.g. [9–13]. According to them, nowadays there exist four points of view on this problem. These four hypotheses some what differ in their explanation of the links between the consumption of energy and economic development. The first one tells us about key role of energy consumption for economic growth. An increase or decrease of energy consumption leads to the positive or negative change in economic growth. This is so called “growth hypothesis”. Another “conservation hypothesis” is represented by the unidirectional causality that looks for the link between economic development and the consumption of energy. In another words, a change in economic development might lead to the change in the consumption of energy. The next one is a “feedback hypothesis” which assumes the bidirectional causality between economic growth and the consumption of energy. Finally, the last one is the so-called “neutrality hypothesis” that denies any existence of causality between economic development and energy consumption. Thence, consumption of energy and economic development should not in principle correlate with each other (see e.g. [9,10,14], or [10]).

In this paper, we attempt to assess the relationship between energy efficiency, consumption of the natural gas and various macroeconomic indicators [39]. While the relationship between economic output and energy consumption was tackled in many studies, economic and energy literature does not preoccupy with the links between economic output and natural gas consumption. Nevertheless, many authors look for the ties between economic development and energy consumption by imputing various energy resources as proxy variables into their empirical models.

We think that the relationship between energy consumption and economic development can be tested using two different

approaches. The first one uses energy consumption at its aggregate level. The second one (a so-called “disaggregate level”) compares economic development and energy consumption expressed by the usage of various energy sources (e.g. natural gas, coal, oil, renewables, etc.). Additionally, there are two kinds of correlation between economic development and energy consumption. While the first one is a correlation in time (energy consumption changes at the same rate as the economic growth), the second one is a correlation in space (meaning that more wealthier and developed countries also consume more energy) (see [15]).

The main value-added of this paper is the empirical analysis that employs the sample of 26 European Union Member States. The sample of EU countries is relevant due to the fact that natural gas is an important source of energy in the EU. Although one can observe the decline in the production of the natural gas in the EU, its dependence on natural gas as well as the rising share of natural gas in the generation of the electric energy is likely to increase. As the energy consumption is gradually increasing and the non-renewable resources become more scarce, the efficient allocation of these resources (represented in our study by the natural gas), as well as the energy security (in relation to the markets for fuel) is becoming a crucial aspect of the energy-related policies of all the EU Member States and worldwide.

Since many academic studies (see [8,15], or [9]) elaborate on the relationship between the macroeconomic development indicators (e.g. GDP) on the one hand, and gross fixed capital formation, and labour forces in a country, on the other hand, our paper also considers the effects of these variables and takes them into account while building our empirical models.

## 2. Natural gas and energy consumption in the EU

Natural gas represents a crucial and non-refundable resource for the energetic sectors of the majority of the EU Member States. According to the Eurostat (2014), between 2012 and 2013 Norway imported 23.8 % of its natural gas. Russian Federation imported 17.5 %, while Qatar and Algeria imported 7.1 % and 6.0 % respectively. If one looks at the natural gas dependency for 28 European countries, she or he would be able to see that it was about 65.2 % in 2013 comparing with 66.0 % in 2012. Nevertheless, it has to be noted that for the 16 EU Member States out of present 28, natural gas dependency is higher than 90 %. After the financial crisis in 2008, natural gas consumption in the European Union dropped down between 2008 and 2009. However, in the next period (2009–2010), an abrupt return to the level of 2008 can be noted. Then, between 2010 and 2012, natural gas consumption declined again noting a sharper recession.

Various EU countries differ in their consumption of the natural gas. For example, Western Europe countries such as France, Germany, Italy, Spain, Netherlands and United Kingdom consume more natural gas in comparison with the other EU Member States. In Belgium, Poland, and Romania the consumption of natural gas oscillates around 500 thousand terajoules, while in Luxembourg, Estonia, Latvia, Lithuania, Sweden, and Slovenia its consumption is far below that rate. On the other hand, Czech Republic, Denmark, Ireland, Greece, Hungary, Austria, Portugal, Slovakia, and Finland tend to consume natural gas above 500 thousand terajoules, while Malta and Cyprus do not use the natural gas (see e.g. [11,16]).

Using natural gas yields many benefits. For example, from environmental point of view natural gas is rather harmless since it does not contain solid particles and inorganic materials. Moreover, natural gas does not increase SO<sub>2</sub> emissions to the atmosphere. In comparison with other biofuels and renewables, natural gas also produces less CO<sub>2</sub> emissions [see e.g. [21–23]]. Comparing natural gas with the renewables and the nuclear power, the gas seems to

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