Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

MASTER THESIS

Natural Gas Consumption and Economic Growth in European Union

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Academic Year: **2014/2015**

Declaration of Authorship

The author hereby declares that she compiled this thesis independently, using only the listed resources and literature.

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Signature

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Abstract

The objective of this Master thesis is an evaluation of relationship between natural gas consumption and economic growth in Europe. The sample includes panel time series data over the period from 1997 to 2011 for 26 EU member states (countries of the Euro zone). Based on neoclassical growth model, a multivariate model including gross fixed capital formation and total labor forces of a country as additional explanatory variables was created. Using recent econometric techniques: panel cointegration tests and error correction modeling, it was found that there existed long-run relationship between economic growth, natural gas consumption, labor and capital. In addition, it was investigated that in the short-run there existed bidirectional causality between natural gas consumption and economic growth. It appears that the causality between economic growth and the natural gas consumption is positive. On the other hand, the reverse causality (a relationship between natural gas consumption and economic growth) appears to be negative.

JEL Classifications: N70, O40, Q32, Q43

Keywords: natural gas consumption, economic growth, capital, labor, panel data, multivariate model, Eurozone

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Acronyms

EU	European Union
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital formation
ILO	International Labor Organization
LGC	Log of Natural Gas Consumption
LGDP	Log of Gross Domestic Product
LK	Log of Gross Fixed Capital Formation
LL	Log of Total Labor Force
OECD	Organization of Economic Co-operation and Development
TOE	Toans of Oil Equivalent

Master Thesis Proposal

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Notes: The proposal should be 2-3 pages long. Save it as "yoursurname_proposal.doc" and send it to mejstrik@fsv.cuni.cz, tomas.havranek@ies-prague.org, and zuzana.irsova@ies-prague.org. Subject of the e-mail must be: "JEM001 Proposal (Yoursurname)".

Proposed Topic:

Natural Gas Consumption and Economic Growth in European Union

Motivation:

The relationship between energy consumption and economic growth discussed in recent yearsmore often. Researchers dealing with this problem cannot agree on the role of energy in economic development. It's espessialy important, because it can help us in determination of natural gas prices volatility and making long-term natural gas contracts. On the other hand, it reduces uncertainty about future demand of natural gas and improves managing of demand and supply for more efficient usage in total economy as well as in different sectors of economy.

The sample of EU countries is relevant because of the fact that natural gas is an important source of energy in the Europe. In the time of growing world energy consumption and scarcity of non-renewable reserves, efficient allocation of energy recourses, in our case natural gas, and energy security of its markets, are one of main objectives in policy of many countries of Europe and worldwide.

Academic studies of last years, e.g. Eggoh et al. (2011), To et al. (2012) and Śmiech & Papież (2013), about the relationship between the basic macroeconomic indicator of economic development of a country such as GDP on the one hand and gross fixed capital formation, and labor forces in a country on the other hand, show different results of unidirectional and bidirectional relationship between energy consumption and economic growth. So, in our work we also take into the accont the effects of these variables. Time series period will be given for 15 years. It should help us to include in our analysis larger size of of countries.

So, the aim of this Master thesis will be examination of how energy consumption, in our case natural gas consumption, can affect economic growth in European countries.

Hypotheses:

1. Hypothesis #1: Natural gas consumption has a statistically significant impact on real GDP.
2. Hypothesis #2: Real GDP has a statistically significant impact on natural gas consumption.

Methodology:

This thesis deals with the relationship between natural gas consumption and economic growth in the European Union countries using data for 28 member states, except Cyprus and Malta. The final sample contains 26 European countries. Annual time series data are collected from 1997 to 2011 through EuroStat and WorldBank to estimate the model. Gross domestic product (GDP) per capita will be used as a measure of economic growth on the one hand, natural gas consumption as a proxy for energy consumption,gross fixed capital formation as a proxy for capital and total labor forces will measure labor into multivariate model.

Based on Smiech and Papiez (2013), Adhikari D. & Chen Y. (2013) and To et al. (2013) a three-step procedure will be used. To dermine the order of integration we will use unit root test. Then we apply Pedroni's cointegration test (Pedroni, 1999, Pedroni, 2000) to find the long-run equilibrium relationship. And finally we will finad causal relationship between variables using Error Correction Model (ECM). Additionally, we will run OLSregression and estimate Panel GMM model to solve the problem of endogeneity.

Expected Contribution:

We suppose that should exist positive correlation between natural gas consumption and real GDP, which is running in both directions.The results will be useful for investigation the tendency in correlation between natural gas consumption and economic growth. In future it can help to energy companies, Governments and financial institutions allocate their investments more efficiently in different sectors of economy. Aalso can help to improve the Energy Security policies in the Eropean Union, and possible substitution of natural gas by other source of energy.

Outline:

1. Intoduction: main theoretical backgrounds and intoduction to the problem.
2. Literature review: description of previous studies and important empirical findings.
3. Methodology: hypothese formulation, model specification and used statistical techniques .
4. Results: results of empirical model estimation.
5. Conclusion: main conclusions about results, implications for policy and future research.

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Author **Supervisor**

1. Introduction

This Master thesis 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 (Sickles, 2008). Namely, it is concerned with the main theoretical trends in the interpretation of relationship between energy consumption and economic 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.

To start with, a few words should be said about debates on relationship between energy consumption and economic growth that appeared in recent years. Researchers dealing with this problem cannot agree on the role of energy in economic development. According to Stern (2010) and Nwosa (2013), 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. On the one hand, some economists, the representatives of mainstream growth theory, argue that energy cannot be a factor, affecting economic growth, because energy consumption does not stimulate economic growth or this stimulation is quite insignificant. This theory is represented by neoclassical growth model proposed by Solow (1956), where capital, labor 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 views represented by ecological and energy economists, who argue that energy is a crucial input also like other factors of production such as capital and labor. 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 labor. 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 (Stern, 2004; Stern, 2010). Thus, energy is becoming an important requirement for economic growth and determinant factor to economic development of society (Stern, 2010; Nwosa, 2013). 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. Eggoh et al. (2011), Śmiech & Papież (2013) and Belke et al. (2010). According to them nowadays there exist four points of view on this problem. These four hypotheses are different by the direction of the casual relationship between energy consumption and economic growth. 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 one, “conservation hypothesis”, is represented by unidirectional causality running from economic growth to energy consumption. In other words, an increase or decrease of economic growth leads to the positive or negative change in energy consumption. The next one is a “feedback hypothesis”, which point out to existence of bidirectional causality between energy consumption and economic growth. And the last one is “neutrality hypothesis” describing no existence of causality between energy consumption and economic growth. It means that energy consumption and economic growth don’t affect each other (Eggoh et al., 2011; Śmiech S. & Papież M., 2013; Belke et al., 2010).

The aim of this thesis is an evaluation of the relationship between natural gas consumption and basic macroeconomic indicators. The relationship between economic output and energy consumption has been analyzed in numerous empirical studies. Unfortunately, literature about relationship between economic output and natural gas consumption is quite limited. Nevertheless, many authors in their works are dealing with energy consumption and economic growth, taking individual sources of energy as proxy variables for empirical testing the model.

The nexus between energy consumption and economic growth can be tested in two different ways. One of them takes energy consumption at aggregate level. The other one, so called disaggregate level, compares economic growth and energy consumption given by individual sources of energy (e.g. natural gas, oil, coal and etc.). Also we can find two kinds of correlation between energy consumption and economic growth. First of them is a correlation in time, when energy consumption changes in the same way like economic growth. The second one is correlation in space, which means that more developed countries also have higher level of energy consumption (Amar, 2013).

An investigation that constitutes the main value-added of this Master thesis is 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. While natural gas production in Europe has declining tendency, European dependence on natural gas as well as share of natural gas in electricity production is expected to grow. With growing world energy consumption and scarcity of non-renewable reserves, efficient allocation of energy recourses, in our case natural gas, and energy security of fuels markets, in particular natural gas markets, are taking a significant place in policy of many states of Europe and worldwide.

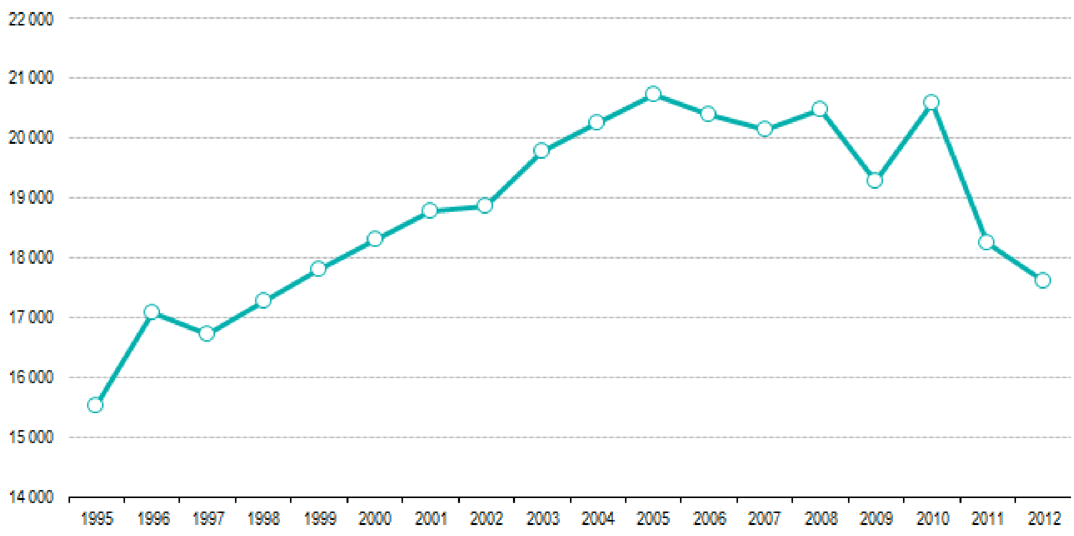
Given the numerous academic studies, reports and papers, e.g. Eggoh et al. (2011), To et al. (2012) and Śmiech & Papież (2013), showing the relationship between the basic macroeconomic indicator of economic development of a country such as GDP on the one hand and gross fixed capital formation, and labor forces in a country on the other hand, the empirical part of this work also takes into the accont the effects of these variables. Time series period includes 15 years, which helps us to include in our analysis as largest size of a sample of countries as possible.

This Master thesis is structured as follows: Chapter 1 provides an Introduction to the issues tackled by this thesis. Chapter 2 represents various theoretical findings and previous empirical studies about role of energy for economic development, mainly, description of natural gas in Europe, including main tendency and benefits of using natural gas in production of energy. Chapter 3 describes empirical methodology, including hypotheses what we suppose to test, model specification with obtained secondary data for its analysis and description of statistical techniques for evaluation and interpretation of result. In Chapter 4 are given results of empirical model estimations with its discussion. Chapter 5 contains main conclusions about results obtained from empirical analysis and policy implications, which can be done on the basis of these results, with possible recommendations for future investigation.

2. Natural gas consumption in Europe: a literature review

Natural gas consumption is a crucial aspect for the energetic sectors in most of the European countries. According to Eurostat (2014), in terms of supply of natural gas in years 2012 and 2013, Norway imported 23.8 % of natural gas, Russian Federation supplied 17.5 %, Qatar and Algeria gave 7.1 % and 6.0 % respectively. If we look at natural gas dependency for 28 European countries, we can see that it was about 65.2 % in year 2013 comparing with 66.0 % in year 2012. It has to be noted, however, that for 16 EU Member States, natural gas dependency is higher than 90 %. Figure 2.1 describes natural gas consumption in European Union countries over the period from 1995 to 2012.

Figure 2.1: Gross inland natural gas consumption in EU-27 2012, in thousand terajoules (Gross Calorific Value).[1]



Provisional data for 2012
(1) Due to confidential data, Bulgaria is not included in the EU-27 aggregate for reference years 2011 and 2012.
Source data: nrg_103m, nrg_124m, nrg_134m

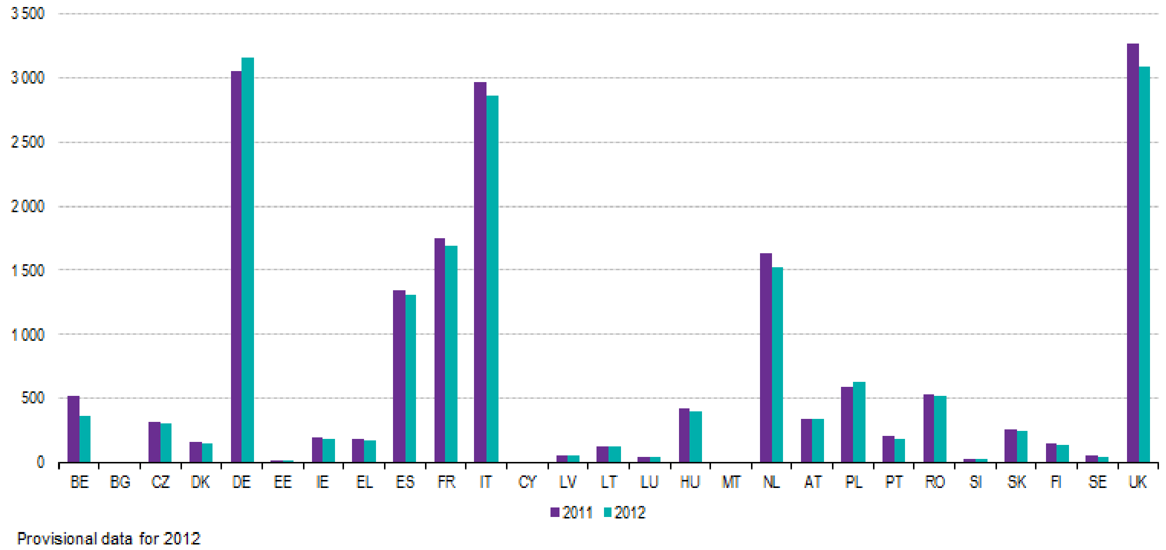
As one can see from Figure 2.1, after the financial crisis in 2008 natural gas consumption in the European Union dropped down during the period from 2008 to 2009. But in next period from 2009 to 2010 a sharp growth to previous level to year 2008 can be

[1]Source: ttp://epp.eurostat.ec.europa.eu/statistics_explained/index.php/File:Gross_inland_consumption_in_EU-27_2012,_in_thousand_terajoules_(Gross_Calorific_Value).png

observed. After that, during the period from 2010 to 2012 it again falls down extremely, even more than during the previous drop.

Figure 2.2 depicts natural gas consumption in European Union countries dividing observations for each country separately for year 2012 compared to previous year 2011.

Figure 2.2: Gross inland natural gas consumption in EU-27 2012, in thousand terajoules (Gross Calorific Value) compared to previous year 2011.[2]



From this histogram shown in Figure 2.2, can see how individual countries differ in their natural gas consumption. For example, countries of Western Europe (Germany, Spain, France, Italy, Netherlands and United Kingdom) have higher natural gas consumption in comparison with other countries of European Union. Belgium, Poland and Romania consume natural gas more or less on the level of 500 thousand terajoules. Other countries consume natural gas on the level below 500 thousand terajoules. Luxembourg, Estonia, Latvia, Lithuania, Sweden and Slovenia consume natural gas in quite low rate. A little bit more natural gas is consumed by Czech Republic, Denmark, Ireland, Greece, Hungary, Austria, Portugal, Slovakia and Finland. Malta and Cyprus do not consume natural gas at all. For Bulgaria there is no data available for the time period in question.

There are some benefits of using natural gas. For example, from environmental point of view, natural gas does not contain solid particles and inorganic materials. The other thing

[2] Source: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/File:Gross_inland_consumption,_2012,_in_thousand_terajoules_(GCV).png

is that natural gas does not increase SO_2 emissions in the atmosphere. In comparison with other fuels natural gas produces less CO_2 emissions, so it is becoming more advantageous to use for safeguard the environment. Comparing natural gas with renewable and nuclear sources of energy, it is should be pointed that natural gas has wider application than renewable and nuclear forms of energy because of its less necessary investment costs. Also, political decision making initiatives play important role for choosing the source of energy (Homer, 1993).

2.1. Literature review

Over the recent years, there appeared numerous studies and reports that provided evidence about the relationship between energy consumption and economic growth. Some of them are presented only one country, the other ones works with a set of countries or specific group of countries. For example, one can find studies, which deal with OECD and non-OECD countries. Other studies work with a sample of developing countries or countries in specific region, e. g. African or Asian countries. And there are also studies in which countries are not divided into any groups or any region location. Time period of data in the sample is varying. In some studies, the time period includes 15 years, in the others time period can achieve 20, 30, and even 40 years. Statistical techniques are also different. They differ in a way and methods of finding unit roots, testing of panel cointegration and causal relationship between variables. Interpretations of results had been made according to its trend long-run or short-run, according to specific group of countries or region location and according to division into income groups. Table 2.1 that follows offers the summary of of main studies on relationship between energy consumption and economic growth in different countries.

Table 2.1: Summary of main studies on relationship between energy consumption and economic growth in different countries all over the world.

Authors	Period	Country	Methodology	Causality relationship
Chontanawat J., Hunt L. & Pierse R. (2006)	1960-2000 for most of 30 OECD countries. 1971 to 2000 for most of 78 non-OECD countries.	30 OECD and 78 non-OECD countries	Cointegration via the Johansen method. Bivariate VAR. Hsiao's Granger technique.	EC→GDP (OECD and non-OECD countries). GDP→EC (OECD and non-OECD countries). EC~GDP (China, India).
Śmiech S. &Papież M. (2013)	1995-2010	Central and Eastern European countries	Panel cointegration test. Granger causality test.	EC←→GDP (in the short-run). EC~GDP (in the long-run).
To H., Wijeweera A, & Charles M. (2012)	1970-2011	Australia	Bound cointegration approach. Multivariate Granger causality.	EC~GDP (in the short-run). EC~GDP (in the long-run).
Eggoh J. C., Bangaké C. &Rault C. (2011)	1970-2006	21 African countries	Panel cointegration test. Granger causality test.	EC←→GDP (net energy exporters and net energy importers).
Bhusal T. P. (2010)	1975-2009	Nepal	Granger causality test. Error-correction modelling.	EC←→GDP (in the short-run). EC←→GDP (in the long-run).
Belke A.,	1981-2007	25 OECD	Panel cointegration	EC←→GDP (in the

Dreger C., &Haan F. (2010)		countries	test. Granger causality test.	long-run).
Nwosa P. I. (2013)	1980-2010	Nigeria	Johansen multivariate cointegration. Error-correction modelling	EC~GDP (in the long-run). EC→GDP (in the short-run).
Asafu-Adjaye J. (2000)	1973-1995 (India and Indonesia). 1971-1995 (Thailand and Philippines).	Four Asian countries (India, Indonesia, the Philippines and Thailand)	Panel cointegration test. Error-correction modelling techniques.	EC→GDP (India and Indonesia). EC←→GDP (Thailand and Philippines).
Farhani S. & Ben Rejeb J. (2012)	1971-2008	95 countries	Panel cointegration test. Granger causality test.	GDP→EC (in the long-run for low and high income countries). GDP←→EC (in the long-run for the lower-middle and upper-middle income countries).
Olusegun Odularu G. & Okonkwo C. (2009)	1970-2005	Nigeria	Panel cointegration test. Error-correction modelling.	EC→GDP
Adhikari D. & Chen Y. (2013)	1990-2009	80 developing countries	Panel cointegration test. Panel dynamic OLS (DOLS).	EC→GDP (upper-middle income countries and lower-middle income countries). GDP→EC (low-income countries).
Notes: EC→ GDP there is causality which runs from energy consumption to economic growth. GDP → EC there is causality which runs from economic growth to energy consumption. EC ←→GDP there is bidirectional causality between energy consumption and economic growth. EC ~ GDP there is no causal relationship between energy consumption and growth.				

Source: Own compilations

First, I would like to start with description of studies, which were made only for individual country, not for the set or group of countries.

To et al. (2012) tested the casual relationship between energy consumption and economic growth over the period from 1970 to 2011 in Australia using labor, capital, human capital, and energy consumption as explained variables for Australian gross domestic product (GDP). This multivariate model is based on the production function in order to reduce potential omitted-variable biases. For analyzing short-run and long-run elasticities the bound testing cointegration approach was used. This cointegration testing is based on the autoregressive distributed lag (ARDL) model. Results suggest that in the long-run as well as in the short-run there is no any causal relationship between energy consumption and economic growth (To et al., 2012).

The same testing of the long-run and short-run elasticities was provided by Bhusal (2010). He found bidirectional causality between energy consumption and economic growth in the short-run and long-run using specific statistical techniques, like Augmented Dickey–Fuller (ADF) unit root test, Johansen maximum likelihood test of cointegration and Error Correction Modelling (ECM) (Bhusal, 2010).

There are investigations conducted for Nigeria and provided by Nwosa (2013) and Olusegun Odularu & Okonkwo (2009). Investigation of Nwosa (2013) using the data over the period from 1980 to 2010 found that in the long-run there is causal relationship between fuel consumption (petrol, kerosene and diesel) and economic growth. At the same time, in the short-run we can see existence of causal relationship between petrol consumption and economic growth as well as causality between diesel consumption and economic growth, and absence of causality between kerosene consumption and economic growth. The multivariate model was based on production function including capital and labor. As methods of testing were used Augmented Dickey–Fuller (ADF) and Philip-Perron unit root tests, Johansen maximum likelihood test of cointegration and Error Correction Modelling (ECM) (Nwosa, 2013). Olusegun Odularu & Okonkwo (2009) in their study used the data over the period from 1970 to 2005 with subsequent creation of multivariate model based on production function. Augmented Dickey–Fuller (ADF) unit root test, test of cointegration and Error Correction Modelling (ECM) were used as statistical techniques to test the model. The main finding is the existence of a positive relationship between energy consumption and economic growth (Olusegun Odularu & Okonkwo, 2009).

Therefore, as one can see, all four authors used almost the same statistical techniques to investigate the relationship between energy consumption and economic growth. Results are mixed. It’s hard to make some clear conclusion about this relationship. Now we will see how can change situation if we take into account studies including several countries.

Chontanawat et al. (2006) tested relationship between energy consumption and economic growth taking as sample 30 OECD and 78 non-OECD countries over the time period from 1960 to 2000 for most of 30 OECD countries and from 1971 to 2000 for most of 78 non-OECD countries. The authors use unit root test, Johansen maximum likelihood test of cointegration, Error Correction Modelling (ECM) and Hsiao’s Granger technique. Results suggest that two sorts of causality exist in OECD countries sample and non-OECD countries sample. First one runs from energy consumption to economic growth and the second one runs from economic growth to energy consumption. These both directions of causality are more prevalent in the OECD countries than in the non-OECD countries (Chontanawat et al., 2006).

Śmiech & Papież (2013) examined short-run and long-run causality between energy consumption and economic growth. They provided investigation over the time period from 1995 to 2010 for countries of Central and Eastern Europe. To get this result the authors created multivariate model based on production function, where four variables: economic growth, capital, labor and energy consumption, are included. For testing the model different test were used, e.g. testing of unit roots was provided by Levin, Lin and Chu unit root test, Im, Pesaran and Shin unit root test and Maddala and Wu unit root test, for finding cointegration relationship between variables Pedroni's cointegration test was used, and finally, to test long-run causality the authors used the between-group method of fully modified OLS (FMOLS), the short-run relationship was estimated using panel Vector Error Correction Model (VECM) (Śmiech & Papież, 2013).

The same investigation we can find in the work of Eggoh et al. (2011). This study was prepared for set of 21 African countries divided into two groups. Time period includes years from 1970 to 2006 for both net energy importers and net energy exporters. The investigation had been done using Im, Pesaran and Shin unit root test and Cross-Sectionally Augmented IPS (CIPS) unit root test to determine the order of integration of the variables. To find a cointegration relationship Pedroni's cointegration test and Westerlund panel cointegration test. For testing long-run causality the authors use Dynamic OLS (DOLS) estimator and for short-run they use Pooled Mean Group (PMG) estimator. As in previous works, the authors created multivariate model based on production function, where additionally to existing four variables: economic growth, capital, labor and energy consumption included into the model, had been added the price of energy. Empirical results suggest that there exists a long-run equilibrium between energy consumption and economic growth for net energy countries and for net energy importers countries as well as for the whole set of countries. Also it was found for both groups of countries that there is bidirectional causality between energy consumption and economic growth (Eggoh et al., 2011).

Belke et al. (2010) tested the long-run relationship between energy consumption and economic growth taking into account prices of energy. The investigation was prepared for set of 25 OECD countries over the period from 1981 to 2007. For checking main hypotheses the authors applied different statistical techniques. First of all, they used Augmented Dickey -

Fuller (ADF) test, the Phillips and Perron (PP) test and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, additionally Levin, Lin, and Chu (LLC) test and Im, Pesaran, and Shin (IPS) test were applied to ensure robustness. The test of cointegration had been done using Johansen maximum likelihood test. And finally, the authors use Dynamic Ordinary Least Squares (DOLS) estimator to find long-run equilibrium and Error Correction Modelling (ECM) for testing dynamic panel causality in the short-run. The results of provided analysis support the hypothesis about existence of cointegrated relationship between energy consumption, economic growth and energy prices. Additionally, it indicates about price-inelasticity of energy consumption. Also, as the results suggest, there exists bidirectional causality between energy consumption and economic growth in the long-run (Belke et al., 2010).

Asafu-Adjaye (2000) investigated the relationship between energy consumption and economic growth on a sample of four Asian developing countries (India, Indonesia, the Philippines and Thailand) taking into account energy prices. Time period in the study includes years from 1973 to 1995 for India and Indonesia, and from 1971 to 1995 for Thailand and Philippines. According to the results of estimated models obtained using Augmented Dickey - Fuller (ADF) test and Phillips - Perron (PP) test for finding the order of integration, Johansen maximum likelihood test of cointegration and Error Correction Modelling (ECM) the authors conclude that there is unidirectional causal relationship, which runs from energy consumption to economic growth in India and Indonesia, and there is bidirectional causal relationship running from energy consumption to economic growth for Thailand and the Philippines (Asafu-Adjaye, 2000).

If one wants to see how the relationship between energy consumption and economic development for the sample of numerous countries can be interpreted with respect to different income level of countries, we should take note to works of Farhani & Ben Rejeb (2012) and Adhikari & Chen (2013). First study of Farhani & Ben Rejeb (2012) examined relationship between energy consumption and economic growth for the sample of 95 countries over time period from 1971 to 2008. This sample includes countries from different income groups. For checking order of integration they used Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), Maddala and Wu (MW) and Hadri unit root tests. Pedroni's cointegration test and Kao cointegration test are used for testing cointegrated relationship between variables. Engle and Granger causality test with Error Correction Modelling, fully modified OLS (FMOLS) and Dynamic OLS (DOLS) are used for finding long-run and short-run equilibrium of the model.

Results indicate that there is a causal relationship running from economic growth to energy consumption in the long-run. This result is given for low and high income countries. On the other hand, the authors found bidirectional causal causality between energy consumption and economic growth, represented in the long-run for the lower-middle and upper-middle income countries (Farhani & Ben Rejeb, 2012). The second study of Adhikari & Chen (2013) about the relationship between energy consumption and economic growth for 80 developing countries. Countries were divided into three income groups, and time period is given from 1990 to 2009. Main findings suggest that there is causal relationship, which runs from energy consumption to economic growth. This result is given for upper-middle income countries and lower-middle income countries. On the other hand, the causal relationship running from economic growth to energy consumption exists only for low-income countries. This investigation was provided using four different unit root tests: Levin, Lin and Chu (LLC) test, Im, Pesaran and Shin (IPS) test, Maddala and Wu (MW) test and Choi test. Then Pedroni's cointegration test was applied. As in previous work, fully modified OLS (FMOLS) and Dynamic OLS (DOLS) were used for finding long-run and equilibrium of the model (Adhikari & Chen, 2013).

Previous seven studies describing relationship between energy consumption and economic growth mostly show an existence of causality whether running from energy consumption to economic growth or, opposite, running from economic growth to energy consumption, or bidirectional causality. It supports the assumption about causal relationship between energy consumption and economic growth. Taking into account these results, in empirical part of this work we will use some statistical techniques which are going to help investigate the relationship between energy consumption and economic growth in European Union countries with a time series data trend.

3. Empirical model specifications

3.1. The aim of the empirical model

The aim of the empirical model computed in this Master thesis is a statistical verification of the relationship between natural gas consumption expressed by gross inland natural gas consumption and economic growth of a country measured by GDP per capita. Also relationship between natural gas consumption and economic growth will be verified by including gross inland natural gas consumption, as component of production, into multivariate model, based on production function, on the one side with capital measured by gross fixed capital formation and labor expressed by total labor forces in the country.

3.2. Determination of hypotheses, data sources model specifications

On the basis of the review of the research literature the following research hypotheses were formulated:

H1: Natural gas consumption has a statistically significant impact on real GDP.

H2: Real GDP has a statistically significant impact on natural gas consumption.

3.3. Data

The analysis of causal relationship between natural gas consumption and economic growth is based on the secondary annual panel data, which was collected for 28 member states of European Union, except Cyprus and Malta (which are not using natural gas). Thence, the final sample contains 26 countries. This sample will employ annual time series data from 1997 to 2011 sourced from the EuroStat and WorldBank database to estimate the model.

In this study, as economic output, we use gross domestic product (GDP), which is taken as dependent variable in our model. GDP is represented per capita in current US dollars. As explanatory variables we took stock of capital, stock of labor and energy consumption. Stock of capital is represented by Gross fixed capital formation in current US dollars, also given as gross domestic fixed investment. Stock of labor is given by total labor force in a country represented by people older than 15 years, who is economically active according to the definition of International Labor Organization. Natural gas consumption has been chosen as a proxy for energy consumption and it is expressed as the final natural gas consumption in thousands of tons of oil equivalent (TOE).

3.3.1. Description of the data

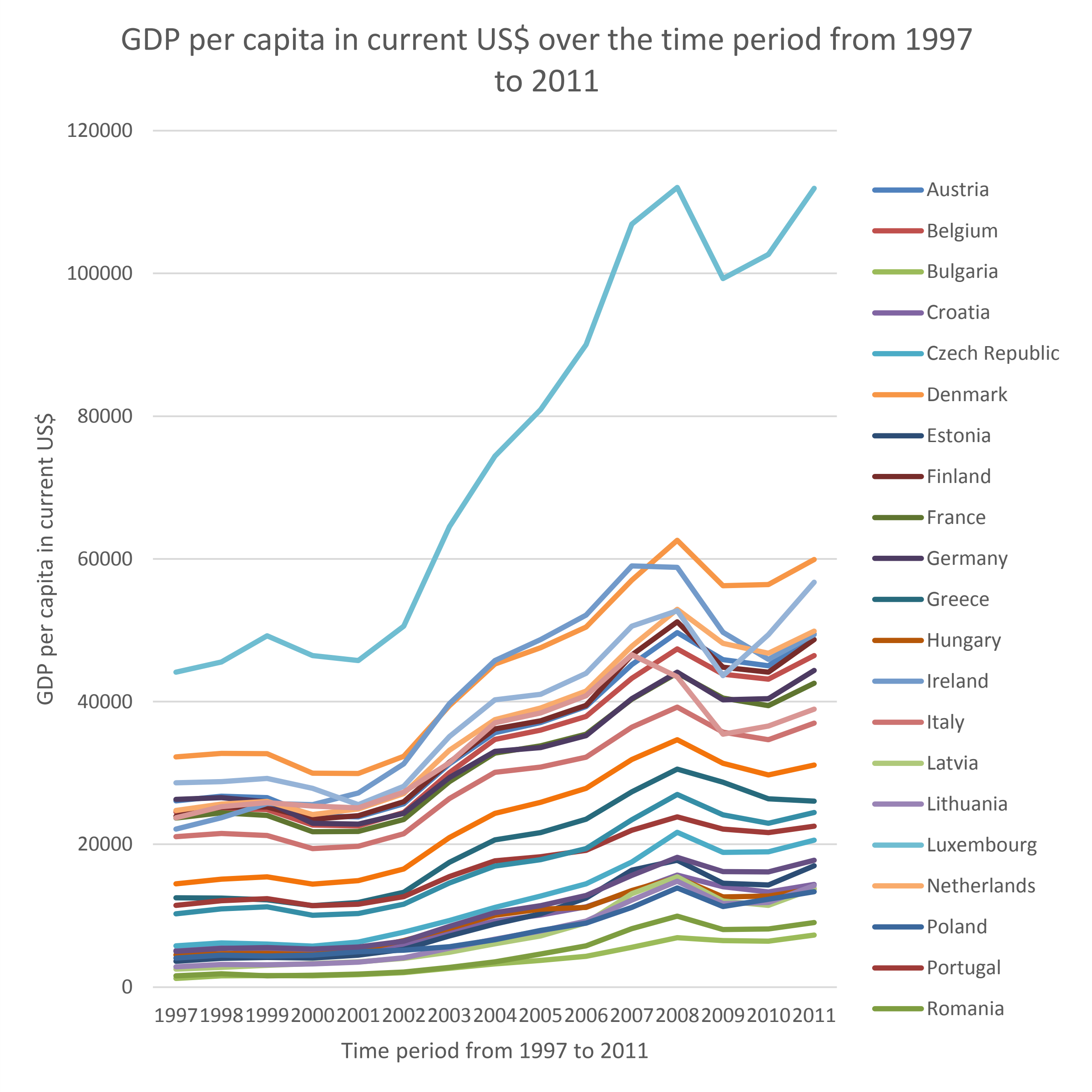
Gross Domestic Product (GDP)

According to the definition given by OECD, *"Gross domestic product is an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production (plus any taxes, and minus any subsidies, on products not* *included in the value of their outputs). The sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, less the value of imports of goods and services, or the sum of primary incomes distributed by resident producer units."* (OECD, 2002).

Definition of GDP contains three different approaches, which are necessary for understanding the concept of GDP. They are: the production approach, the expenditure approach and the income approach. According to Callen (2008), the production approach represents computation of values added through all production process, summarizing them at each level. Next one, the expenditure approach, additionally adds the value of purchase, which final consumer pays for final good or service. And last one, income approach, calculates all incomes from production.

GDP is used for indicating changes in performance of economy, if it's doing good or bad, but there are some disadvantages of using GDP. For example, it doesn't include depreciation of capital used in production process. The other thing is that not all economic activities are computed in GDP, e.g. homework, volunteers' work, black-market activities and etc., which in some countries represent great part of total domestic economic activities (Callen, 2008). Also GDP is not enough to explain well-being of people, because it deals only with monetary values, and it takes into account quantity, but not quality of welfare. Nevertheless, GDP is still remaining the most used macroeconomic indicator of economic development of a country.

Figure 3.1: GDP per capita in current US$ over the time period from 1997 to 2011 for 26-EU countries.



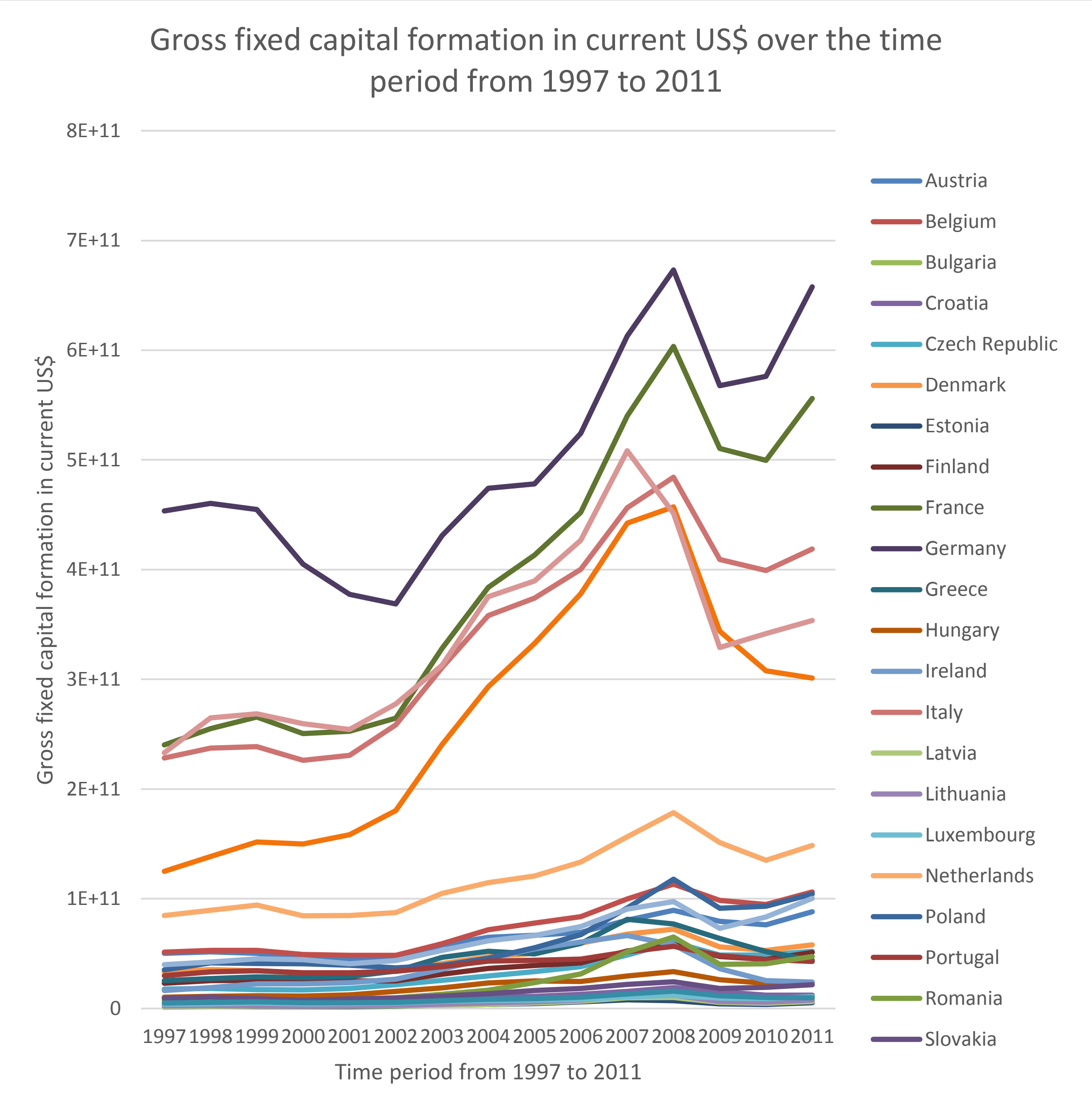
Source: Own results

Gross Fixed Capital Formation (GFCF)

Definition, given by OECD, tells us that *"Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units."* (OECD, 2001).

Gross fixed capital formation, as a part of Gross capital formation, includes all goods and services, which are used for producing other goods or services. It should be pointed, that we can use them repeatedly in the time horizon more than one year (Viet, 2011). For its growth is responsible private sector. And in the long-run it will maintain sustainable economic growth on the both sides, demand-side and supply-side. That's why Gross fixed capital formation is important and one of key factors of production.

Figure 3.2: Gross fixed capital formation in current US$ over the time period from 1997 to 2011 for 26-EU countries.



Source: Own results

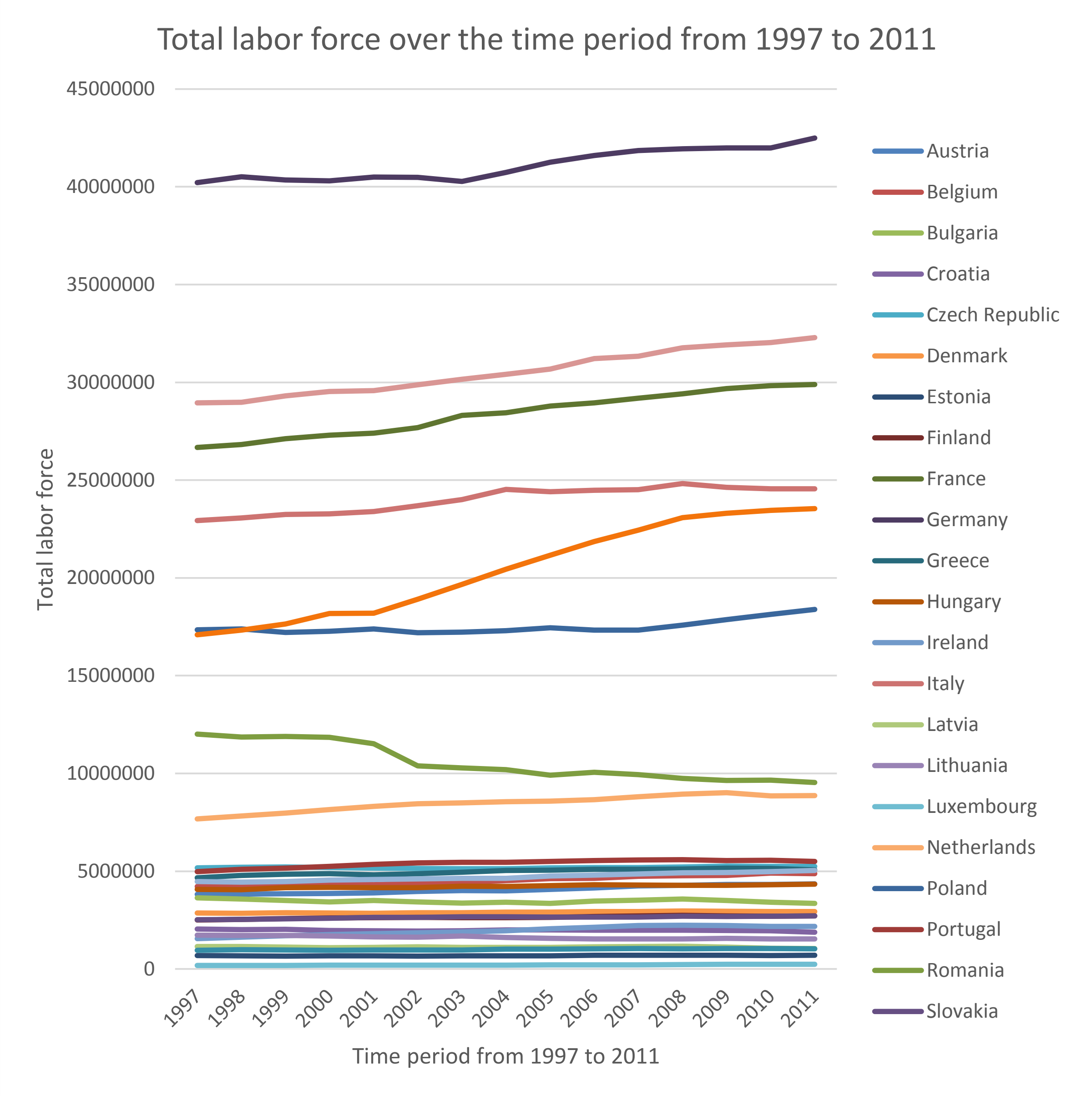
Total labor force

OECD defines total labor force in following way: *"The total labor force, or currently active population, comprises all persons who fulfil the requirements for inclusion among the employed or the unemployed during a specified brief reference period."* (OECD, 2003).

Age of people, who are the subject of this definition, is measured in the range from 16 to 64 years old. We can distinguish two groups of workers, so called primary workers and secondary workers. First group, primary workers, is represented by persons with age from 25 to 54, who are participating in labor force: currently working or temporary unemployed, but actively looking for a job. The other group, secondary workers, is represented by persons, who has labor force age, but regularly not interested in a job (Spencer, 1971).

There are factors, for example: economic, technological, social, educational and others, which play important role in increase of labor force. Thanks to them, higher amount of educated qualified workers can increase the production of domestic economy.

Figure 3.3: Total labor force over the time period from 1997 to 2011 for 26-EU countries.



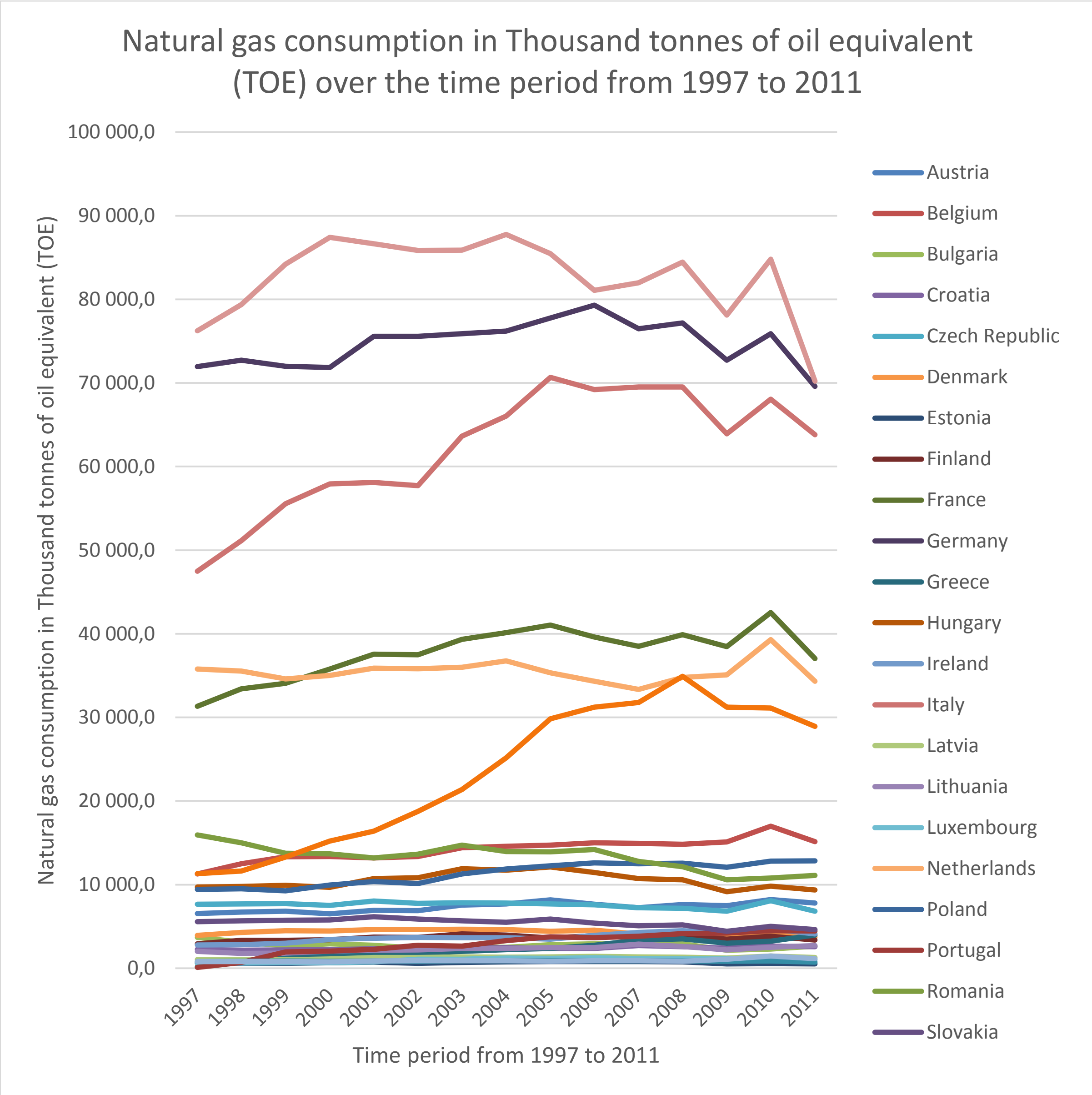
Source: Own results

Natural gas consumption

Natural gas consumption is represented by gross inland consumption of natural gas, which includes consumption in industries, in households, in transportation, in energy production (e.g. electricity) and in other related sectors of economy.

Natural gas holds significant place in heating systems of European countries. In most of the countries it is the primary source for heating homes, schools, offices, hospitals and public institutions. Demand for natural gas is particularly important during winter months when heat costs increase. The role of natural gas in commercial sector increased during last 20 years, and, as it’s forecasted, will have stable growth over next 20 years.

Figure 3.4: Natural gas consumption in Thousand tonnes of oil equivalent (TOE) over the time period from 1997 to 2011 for 26-EU countries.



Source: Own results

3.4. Model specifications

Although, many studies used bivariate and multivariate models to investigate the relationship between energy consumption and economic growth, there is a big advantage of multivariate model, because it helps us to solve the problem of omitted variables (To et al., 2012).

My study is based on neoclassical growth model proposed by Solow with neoclassical aggregate production function:

$$Y = F(K, L, A) \quad (1)$$

where

Y – aggregate real output

K – stock of capital

L – stock of labor

A - technology

According to Olusegun Odularu & Okonkwo (2009) energy is one of the key components of technology. The usage of energy determines technological change, but it should be noticed that it's not only one determinant factor.

After studying empirical works and theoretical concepts related to our Master thesis topic and taking into account that energy can be taken as a part of technology, the model can be formalized in the following way:

$$Y = F(K, L, E) \quad (2)$$

where

Y – Economic output (GDP)

K – Gross fixed capital formation (K)

L – Labor forces (L)

E – Energy consumption, represented by natural consumption (GC).

Therefore, my formal model can also be expressed in the following, somewhat more parametric way:

$$GDP_{PP} = \alpha + \beta_1 K_s + \beta_2 L_s + \beta_3 E_c + \varepsilon \quad (3)$$

where:

K_s - stock of capital represented by gross fixed capital formation in current US dollars, also given as gross domestic fixed investment

L_s– stock of labor given by total labor force in a country represented by people older than 15 years, who is economically active according to the definition of International Labor Organization (ILO).

E_c – energy (natural gas) consumption is a proxy for energy consumption given by final natural gas consumption in thousands of tons of oil equivalent (TOE).

3.5. Methods of evaluation and interpretation of obtained data

In the empirical part of this thesis, the three-step procedure is used. First, one needs to determine the order of integration using unit root test. Next step we apply panel cointegration test, to find cointegrated relationship between variables. It can be applied only if unit root test showed that all variables are non-stationary. And at the last step we will find causal relationship between variables, if any exists. In addition, OLS regressions is run in order to see whether there are any relationships between the variables in question.

*3.5.1. **Panel Unit root test***

To test if our variables are stationary or not, we will use several different unit root tests assuming cross-sectional independence. First three tests are tests with common unit root process: Levin, Lin, and Chu (2002), Breitung (2000) and Hadri (2000). Test with individual unit root process Im, Pesaran and Shin Test (2003) and Fisher-type test (Fisher-ADF and Fisher-PP) proposed by Maddala and Wu (1999) and Choi (2001).

*3.5.2. **Panel Cointegration test***

Testing of cointegrated relationship between variables will be done using two tests. One of them is Pedroni (1999) cointegration test and the second one is Kao (1999) cointegration test.

Pedroni cointegration test

Test of cointegrated relationship developed by Pedroni (1999) includes four within-dimension based tests and three between-dimension based tests.

$$Y_{it} = \alpha_i + \gamma_{it} + \sum_{j=1}^{m} \beta_{ji} X_{jit} + \varepsilon_{it} \quad t = 1, \dots, N \;\; i = 1, \dots, N \tag{3}$$

where i= 1,..., N represent each country in the panel, t = 1,...,T represent the time period.

The null hypothesis suggests that there is no cointegration between variables $H_0: \rho_i = 0$.For statistical analysis we used automatic lag length selection based on the Schwarz Information Criterion (SIC).

Applying Pedroni cointegration test for our model we will get the following equations:

$$LNGDP_{it} = \alpha_{1i} + \gamma_{1it} + \beta_{11} LNK_{it} + \beta_{12} LNL_{it} + \beta_{13} LNGC_{it} + \varepsilon_{1it} \tag{4}$$

$$LNK_{it} = \alpha_{2i} + \gamma_{2it} + \beta_{21} LNGDP_{it} + \beta_{22} LNL_{it} + \beta_{23} LNGC_{it} + \varepsilon_{2it} \tag{5}$$

$$LNL_{it} = \alpha_{3i} + \gamma_{3it} + \beta_{31} LNGDP_{it} + \beta_{32} LNK_{it} + \beta_{33} LNGC_{it} + \varepsilon_{3it} \tag{6}$$

$$LNGC_{it} = \alpha_{4i} + \gamma_{4it} + \beta_{41} LNGDP_{it} + \beta_{42} LNK_{it} + \beta_{43} LNL_{it} + \varepsilon_{4it} \tag{7}$$

Kao cointegration test

Test of cointegrated relationship developed by Kao (1999) is based on Augmented Dickey-Fuller (ADF) statistics.

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \varepsilon_{i,t} \quad t = 1, \dots, N \quad i = 1, \dots, N \tag{8}$$

where i = 1,..., N represent each country in the panel, t = 1,...,T represent the time period.

The null hypothesis suggests that there is no cointegration between variables $H_0: \rho_i = 0$. For statistical analysis we used automatic lag length selection based on the Schwarz Information Criterion (SIC).

Now we will apply Kao test for our specific model:

$$LNGDP_{it} = \alpha_{1i} + \beta_{11}LNK_{it} + \beta_{12}LNL_{it} + \beta_{13}LNGC_{it} + \varepsilon_{1it} \quad (9)$$

$$LNK_{it} = \alpha_{2i} + \beta_{21}LNGDP_{it} + \beta_{22}LNL_{it} + \beta_{23}LNGC_{it} + \varepsilon_{2it} \quad (10)$$

$$LNL_{it} = \alpha_{3i} + \beta_{31}LNGDP_{it} + \beta_{32}LNK_{it} + \beta_{33}LNGC_{it} + \varepsilon_{3it} \quad (11)$$

$$LNGC_{it} = \alpha_{4i} + \beta_{41}LNGDP_{it} + \beta_{42}LNK_{it} + \beta_{43}LNL_{it} + \varepsilon_{4it} \quad (12)$$

3.5.3. **Panel Causality test**

To obtain coefficients of the long-run equilibrium, we will use panel fully modified OLS procedure (FMOLS), which were proposed by Pedroni (2000). The long-run parameters will be estimated using grouped method without constant and specific trend. We are using FMOLS procedure to obtain the residuals for including them into Error Correction Model (ECM).

For finding short-run relationship we will use Error Correction Model (ECM). It will be represented as follows:

$$\Delta LNGDP_{it} = \varphi_{1i} + \sum_{k=1}^{m} \varphi_{11ik} \Delta LNGDP_{it-k} + \sum_{k=1}^{m} \varphi_{12ik} \Delta LNK_{it-k} + \sum_{k=1}^{m} \varphi_{13ik} \Delta LNL_{it-k} + \sum_{k=1}^{m} \varphi_{14ik} \Delta LNGC_{it-k} + \tau_{1i} ECT_{it-1} + \varepsilon_{1it} \quad (13)$$

$$\Delta LNGC_{it} = \varphi_{2i} + \sum_{k=1}^{m} \varphi_{21ik} \Delta LNGDP_{it-k} + \sum_{k=1}^{m} \varphi_{22ik} \Delta LNK_{it-k} + \sum_{k=1}^{m} \varphi_{23ik} \Delta LNL_{it-k} + \sum_{k=1}^{m} \varphi_{24ik} \Delta LNGC_{it-k} + \tau_{2i} ECT_{it-1} + \varepsilon_{2it} \quad (14)$$

$$\Delta LNGDP_{it} = \varphi_{3i} + \sum_{k=1}^{m} \varphi_{31ik} \Delta LNGDP_{it-k} + \sum_{k=1}^{m} \varphi_{32ik} \Delta LNK_{it-k} + \sum_{k=1}^{m} \varphi_{33ik} \Delta LNL_{it-k} + \sum_{k=1}^{m} \varphi_{34ik} \Delta LNGC_{it-k} + \tau_{3i} ECT_{it-1} + \varepsilon_{3it} \quad (15)$$

$$\Delta LNGDP_{it} = \varphi_{4i} + \sum_{k=1}^{m} \varphi_{41ik} \Delta LNGDP_{it-k} + \sum_{k=1}^{m} \varphi_{42ik} \Delta LNK_{it-k} + \sum_{k=1}^{m} \varphi_{43ik} \Delta LNL_{it-k} + \sum_{k=1}^{m} \varphi_{44ik} \Delta LNGC_{it-k} + \tau_{4i} ECT_{it-1} + \varepsilon_{4it} \quad (16)$$

4. Results of empirical model estimations

4.1. Unit root test: results and discussions

The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests with individual effects, with individual effects including individual linear trends, and without individual effects and individual linear trends for variable LGC are presented in Table 4.1.

Table 4.1: The results of Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests on LGC.

	Individual effects							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-6.61	0.0000	26	346	-9.47	0.0000	26	325
Im, Pesaran and Shin W-stat	-2.81	0.0024	26	346	-11.60	0.0000	26	325
ADF - Fisher Chi-square	88.32	0.0012	26	346	222.52	0.0000	26	325
PP - Fisher Chi-square	115.92	0.0000	26	264	298.75	0.0000	26	338
	Individual effects, individual linear trends							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-0.0077	0.49	26	348	-14.86	0.0000	26	335
Breitung t-stat	1.82	0.96	26	322	-0.54	0.29	26	309
Im, Pesaran and Shin W-stat	-0.72	0.23	26	348	-14.70	0.0000	26	335
ADF - Fisher Chi-square	75.62	0.017	26	348	248.78	0.0000	26	335
PP - Fisher Chi-square	105.17	0.0000	26	364	304.10	0.0000	26	338
	None							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	1.68	0.95	26	346	-17.85	0.0000	26	329
ADF - Fisher Chi-square	21.83	0.99	26	346	348.77	0.0000	26	329
PP - Fisher Chi-square	23.21	0.99	26	364	401.71	0.0000	26	338
** All tests assume asymptotic normality, except Fisher tests, for which an asymptotic Chi-square distribution was used to compute probabilities.								

Source: Own results

Statistics of unit root tests at level including individual effects suggests that we can reject null hypothesis about non-stationarity of variable. All of the tests are significant at 5%. On the other hand, statistics including individual effects and individual linear trends tells us that the majority of tests (three of five) can't reject the null hypothesis about non-stationarity. Statistics, which doesn't include individual effects and individual trends, shows that we can't reject the null hypothesis in all three tests at significance of 5%. The majority of tests indicate that we can't reject the null hypothesis about non-stationarity of variable LGC. It means that our variable LGC is non-stationary at 5% level of significance. At first difference, it's supposed that our variable must be stationary. All statistics supports this hypothesis, except Breitung (2000) test including individual effects and individual linear trends.

The results of Hadri (2000) panel unit root test with individual effects and with individual effects including individual linear trends for LGC are presented in Table 4.2.

Table 4.2: The results of Hadri (2000) panel unit root test on LGC.

	Individual effects			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	11.75	0.0000	7.90	0.0000
Heteroscedastic Consistent Z-stat	7.95	0.0000	5.61	0.0000
	Individual effects, individual linear trends			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	10.58	0.0000	12.71	0.0000
Heteroscedastic Consistent Z-stat	10.33	0.0000	16.70	0.0000
** Probabilities are computed assuming asympotic normality.				

Source: Own results

Statistics of unit root tests, suggested by Hadri (2000), at level including individual effects suggests that we can reject null hypothesis about stationarity of variable at 5% level of significance. The same we can conclude about statistics including individual effects and individual linear trends. At first difference, all statistics supports this hypothesis, including individual effects, and including both individual effects and individual linear trends. The test indicates that we can reject the hypothesis about stationarity of variable, so our variable LGC is non-stationary. The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test

(2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests with individual effects, with individual effects including individual linear trends, and without individual effects and individual linear trends for variable LGDP are presented in Table 4.3.

Table 4.3: The results of Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests on LGDP.

	Individual effects							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-0.42	0.33	26	336	-13.51	0.0000	26	317
Im, Pesaran and Shin W-stat	4.33	1.00	26	336	-6.96	0.0000	26	317
ADF - Fisher Chi-square	9.49	1.00	26	336	139.53	0.0000	26	317
PP - Fisher Chi-square	9.33	1.00	26	364	76.56	0.014	26	338
	Individual effects, individual linear trends							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-6.18	0.0000	26	339	-11.29	0.0000	26	318
Breitung t-stat	-4.099	0.0000	26	313	-8.0088	0.0000	26	292
Im, Pesaran and Shin W-stat	-4.49	0.0000	26	339	-2.98	0.0014	26	318
ADF - Fisher Chi-square	103.14	0.0000	26	339	79.82	0.0078	26	318
PP - Fisher Chi-square	17.034	1.00	26	364	33.52	0.97	26	338
	None							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	10.37	1.00	26	333	-7.89	0.0000	26	326
ADF - Fisher Chi-square	1.0044	1.00	26	333	121.61	0.0000	26	326
PP - Fisher Chi-square	0.93	1.00	26	364	137.50	0.0000	26	338
** All tests assume asymptotic normality, except Fisher tests, for which an asymptotic Chi-square distribution was used to compute probabilities.								

Source: Own results

Statistics of unit root tests at level including individual effects suggests that we can’t reject null hypothesis about non-stationarity of variable. All of the tests are insignificant at 5%. On the other hand, statistics including individual effects and individual linear trends tells us that the majority of tests (four of five) can reject the null hypothesis about non-stationarity.

Statistics, which doesn't include individual effects and individual trends, shows that we can't reject the null hypothesis in all three tests at significance of 5%. The majority of tests indicate that we cannott reject the null hypothesis about non-stationarity of variable LGDP. It means that our variable LGDP is non-stationary at 5% level of significance. At first difference, it is supposed that our variable must be stationary. All statistics supports this hypothesis, except PP - Fisher Chi-square test including individual effects and individual linear trends.

The results of Hadri (2000) panel unit root test with individual effects and with individual effects including individual linear trends for variable LGDP are presented in Table 4.4 that follows.

Table 4.4: The results of Hadri (2000) panel unit root test on LGDP.

	Individual effects			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	12.75	0.0000	-0.65	0.74
Heteroscedastic Consistent Z-stat	12.81	0.0000	-0.50	0.69
	Individual effects, individual linear trends			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	4.17	0.0000	7.80	0.0000
Heteroscedastic Consistent Z-stat	4.13	0.0000	8.20	0.0000
** Probabilities are computed assuming asympotic normality.				

Source: Own results

Statistics of unit root tests, suggested by Hadri (2000), at level including individual effects suggests that one can reject null hypothesis about stationarity of variable at 5% level of significance. The same we can conclude about statistics including individual effects and individual linear trends. At first difference, statistics including individual effects does not support this hypothesis, but including both individual effects and individual linear trends we can reject the null hypothesis about stationarity. The test indicates that we can reject the hypothesis about stationarity of variable, so our variable LGDP is non-stationary.

The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests with individual effects, with individual effects including individual linear trends, and without individual effects and individual linear trends for variable LK are presented in Table 4.5.

Table 4.5: The results of Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests on LK.

	Individual effects							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-1.91	0.028	26	353	-10.80	0.0000	26	323
Im, Pesaran and Shin W-stat	2.55	0.99	26	353	-5.94	0.0000	26	323
ADF - Fisher Chi-square	21.15	1.00	26	353	121.099	0.0000	26	323
PP - Fisher Chi-square	19.56	1.00	26	364	91.60	0.0006	26	338
	Individual effects, individual linear trends							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-3.76	0.0001	26	338	-9.35	0.0000	26	322
Breitung t-stat	-2.24	0.012	26	312	-4.39	0.0000	26	296
Im, Pesaran and Shin W-stat	-2.36	0.009	26	338	-2.66	0.0038	26	322
ADF - Fisher Chi-square	73.49	0.026	26	338	75.13	0.019	26	322
PP - Fisher Chi-square	13.62	1.00	26	364	45.56	0.72	26	338
	None							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	7.11	1.00	26	351	-11.17	0.0000	26	335
ADF - Fisher Chi-square	3.14	1.00	26	351	183.41	0.0000	26	335
PP - Fisher Chi-square	3.20	1.00	26	364	175.35	0.0000	26	338
** All tests assume asymptotic normality, except Fisher tests, for which an asymptotic Chi-square distribution was used to compute probabilities.								

Source: Own results

Statistics of unit root tests at level including individual effects suggests that we can't reject null hypothesis about non-stationarity of variable in three of four tests at the significance level of 5%. On the other hand, statistics including individual effects and individual linear trends tells us that the majority of tests (four of five) reject the null hypothesis about non-stationarity. Statistics, which doesn't include individual effects and individual trends, shows that we can't reject the null hypothesis in all three tests at significance level of 5%. The majority of tests indicate that we can't reject the null hypothesis about non-stationarity of variable LK. It means that our variable LK is non-stationary at 5% level of significance. At first difference, it's supposed that our variable must be stationary. All statistics supports this hypothesis, except PP - Fisher Chi-square test including individual effects and individual linear trends.

The results of Hadri (2000) panel unit root test with individual effects and with individual effects including individual linear trends for variable LK are presented in Table 4.6.

Table 4.6: The results of Hadri (2000) panel unit root test on LK.

	Individual effects			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	11.44	0.0000	0.96	0.16
Heteroscedastic Consistent Z-stat	11.51	0.0000	1.13	0.12
	Individual effects, individual linear trends			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	5.96	0.0000	7.80	0.0000
Heteroscedastic Consistent Z-stat	5.39	0.0000	10.18	0.0000
** Probabilities are computed assuming asympotic normality.				

Source: Own results

Statistics of unit root tests, suggested by Hadri (2000), at level including individual effects suggests that we can reject null hypothesis about stationarity of variable at 5% level of significance. The same we can conclude about statistics including individual effects and individual linear trends. At first difference, statistics including individual effects doesn't support this hypothesis, but including both individual effects and individual linear trends we can reject the null hypothesis about stationarity. The test indicates that we can reject the hypothesis about stationarity of variable, so our variable LK is non-stationary.

The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests with individual effects, with individual effects including individual linear trends, and without individual effects and individual linear trends for variable LL are presented in Table 4.7.

Table 4.7: The results of Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) and Fisher-type (Fisher-ADF and Fisher-PP) panel unit root tests on LL.

	Individual effects							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-3.39	0.0003	26	362	-11.61	0.0000	26	335
Im, Pesaran and Shin W-stat	1.72	0.95	26	362	-8.56	0.0000	26	335
ADF - Fisher Chi-square	47.45	0.65	26	362	165.86	0.0000	26	335
PP - Fisher Chi-square	46.17	0.70	26	364	168.47	0.0000	26	338
	Individual effects, individual linear trends							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	-0.63	0.26	26	356	-12.75	0.0000	26	334
Breitung t-stat	2.91	0.99	26	330	-6.75	0.0000	26	308
Im, Pesaran and Shin W-stat	1.12	0.86	26	356	-6.23	0.0000	26	334
ADF - Fisher Chi-square	42.20	0.83	26	356	125.31	0.0000	26	334
PP - Fisher Chi-square	31.36	0.98	26	364	161.57	0.0000	26	338
	None							
	At level				At first difference			
Method	Statistic	Prob.**	Cross-sections	Obs.	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu t*	10.28	1.00	26	360	-9.31	0.0000	26	334
ADF - Fisher Chi-square	24.63	0.99	26	360	192.007	0.0000	26	334
PP - Fisher Chi-square	29.26	0.99	26	364	194.16	0.0000	26	338
** All tests assume asymptotic normality, except Fisher tests, for which an asymptotic Chi-square distribution was used to compute probabilities.								

Source: Own results

Statistics of unit root tests at level including individual effects suggests that we can’t reject null hypothesis about non-stationarity of variable in three of four tests at 5% level of significance. On the other hand, statistics including individual effects and individual linear trends tells us that according to all tests we can't reject the null hypothesis about non-stationarity. Statistics, which doesn't include individual effects and individual trends, shows that we can't reject the null hypothesis in all three tests at significance of 5%. The majority of tests indicate that we can't reject the null hypothesis about non-stationarity of variable LL. It means that our variable LL is non-stationary at 5% level of significance. At first difference, all statistics supports this hypothesis, including individual effects, and including both individual effects and individual linear trends. The test indicates that we can reject the hypothesis about stationarity of variable, so our variable LL is non-stationary.

The results of Hadri (2000) panel unit root test with individual effects and with individual effects including individual linear trends for variable LL are presented in Table 4.8.

Table 4.8: The results of Hadri (2000) panel unit root test on LL.

	Individual effects			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	13.99	0.0000	3.28	0.0005
Heteroscedastic Consistent Z-stat	12.077	0.0000	3.91	0.0000
	Individual effects, individual linear trends			
	At level		At first difference	
	Total (balanced) observations: 390		Total (balanced) observations: 364	
Method	Statistic	Prob.**	Statistic	Prob.**
Hadri Z-stat	7.34	0.0000	9.21	0.0000
Heteroscedastic Consistent Z-stat	7.63	0.0000	14.82	0.0000
** Probabilities are computed assuming asympotic normality.				

Source: Own results

Statistics of unit root tests, suggested by Hadri (2000), at level including individual effects suggests that we can reject null hypothesis about stationarity of variable at 5% level of significance. The same we can conclude about statistics including individual effects and individual linear trends. At first difference, all statistics supports this hypothesis, including individual effects, and including both individual effects and individual linear trends. The test indicates that we can reject the hypothesis about stationarity of variable, so our variable LL is non-stationary.

4.2. Panel Cointegration test: results and discussions

The results of Pedroni residual cointegration test using four within-dimension based tests and three within-dimension tests between four variables (LGDP, LGC, LK and LL) without deterministic trend, without deterministic intercept or trend, and with deterministic intercept and trend are presented in Table 4.9. LGDP is taken as dependent variable.

Table 4.9: The results of Pedroni residual cointegration test between LGDP, LGC, LK and LL. LGDP is taken as dependent variable.

	No deterministic trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.024	0.49	0.75	0.22
Panel rho-Statistic	2.88	0.99	2.32	0.98
Panel PP-Statistic	1.84	0.96	0.65	0.74
Panel ADF-Statistic	-0.96	0.16	-4.15	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.43	1.00		
Group PP-Statistic	0.58	0.72		
Group ADF-Statistic	-6.63	0.0000		
	Deterministic intercept and trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	9.64	0.0000	2.39	0.0083
Panel rho-Statistic	3.95	1.00	3.58	0.99
Panel PP-Statistic	-1.64	0.049	-1.98	0.023
Panel ADF-Statistic	-4.96	0.0000	-4.93	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	5.66	1.00		
Group PP-Statistic	-2.73	0.0031		
Group ADF-Statistic	-5.36	0.0000		
	No deterministic intercept or trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.60	0.72	-1.93	0.97
Panel rho-Statistic	2.017	0.97	1.88	0.97
Panel PP-Statistic	1.60	0.94	0.78	0.78
Panel ADF-Statistic	-0.24	0.40	-1.93	0.026
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.27	1.00		
Group PP-Statistic	2.33	0.99		
Group ADF-Statistic	-3.85	0.0001		

Source: Own results

Statistics based on common and individual coefficients without deterministic trend suggests thattwo of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Taking into account deterministic intercept and trend, eight of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Two of eleven tests can reject the null hypothesis about non-cointegrated relationship between variables without deterministic intercept or trend.

The results of Kao residual cointegration test between four variables (LGC, LGDP, LK and LL) are presented in Table 4.10. LGDP is taken as dependent variable.

Table 4.10: The results of Kao residual cointegration test between LGDP, LGC, LK and LL. LGDP is taken as dependent variable.

Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	-6.55	0.0000
Residual variance	0.0032	
HAC variance	0.0049	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.29	0.034	-8.57	0.0000
D(RESID(-1))	0.52	0.050	10.43	0.0000

R-squared	0.24	Mean dependent var	0.014
Adjusted R-squared	0.24	S.D. dependent var	0.067
S.E. of regression	0.058	Akaike info criterion	-2.81
Sum squared resid	1.16	Schwarz criterion	-2.79
Log likelihood	478.16	Hannan-Quinn criter.	-2.80
Durbin-Watson stat	1.83		

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between LGDP, LGC, LK and LL on significance level of 5 %.

4.3. Results of Panel OLS and Panel GMM estimations

At first, we will use variables without log specification to test our model. Then, we will compare our findings with results from the model, which uses variables with log specification. Estimating Panel GMM model for solving the problem of endogeneity, we need to know probability of J-statistic for checking of over-identification of the model, to find out how suitable instrument we have.

Table 4.11: The results of Panel Ordinary Least Squares (OLS) estimation without log specification between GDP, capital, labor and natural gas consumption according to the model, where GDP is taken as dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	24710.22	1078.548	22.91063	0.0000
K	1.51E-07	1.48E-08	10.19163	0.0000
L	-0.002035	0.000224	-9.067790	0.0000
GC	0.180322	0.084262	2.140030	0.0330

R-squared	0.257313	Mean dependent var	24052.85
Adjusted R-squared	0.251541	S.D. dependent var	18543.51
S.E. of regression	16042.64	Akaike info criterion	22.21409
Sum squared resid	9.93E+10	Schwarz criterion	22.25477
Log likelihood	-4327.748	Hannan-Quinn criter.	22.23022
F-statistic	44.57821	Durbin-Watson stat	0.188725
Prob(F-statistic)	0.000000		

Source: Own results

The results for Panel Ordinary Least Squares (OLS) linear regression without log specification, where GDP is dependent variable, suggest that labor has negative and statistically significant impact on economic growth, 1% increase of labor decreases GDP by 0.002%. Both, natural gas consumption and gross fixed capital formation, have positive and statistically significant impact on economic growth, 1% increase of natural gas consumption increases GDP by 0.18%, and 1% increase of gross fixed capital formation leads to increase of GDP by 0.0000015%. All results are presented at 5% level of significance (see Table 4.11).

Table 4.12: The results of Panel Generalized Method of Moments (GMM) estimation without log specification between GDP, capital, labor and natural gas consumption according to the model, where GDP is taken as dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	1.213148	0.042741	28.38394	0.0000
GDP(-2)	-0.293657	0.030933	-9.493393	0.0000
K	8.55E-09	3.11E-09	2.746157	0.0064
L	0.000249	0.000810	0.307445	0.7587
GC	-0.122637	0.185729	-0.660301	0.5096
GC(-1)	-0.011465	0.099716	-0.114978	0.9085
@LEV(@ISPERIOD("2000"))	-956.0638	202.5404	-4.720360	0.0000
@LEV(@ISPERIOD("2001"))	1555.453	194.7883	7.985355	0.0000
@LEV(@ISPERIOD("2002"))	932.5486	114.3593	8.154551	0.0000
@LEV(@ISPERIOD("2003"))	2042.773	178.4249	11.44892	0.0000
@LEV(@ISPERIOD("2004"))	-1177.073	198.2471	-5.937402	0.0000
@LEV(@ISPERIOD("2005"))	-1416.380	287.3772	-4.928646	0.0000
@LEV(@ISPERIOD("2006"))	1082.530	269.3350	4.019268	0.0001
@LEV(@ISPERIOD("2007"))	2321.676	259.9063	8.932743	0.0000
@LEV(@ISPERIOD("2008"))	-2204.939	425.2790	-5.184688	0.0000
@LEV(@ISPERIOD("2009"))	-5770.993	447.8696	-12.88543	0.0000
@LEV(@ISPERIOD("2010"))	5370.523	412.2220	13.02823	0.0000
@LEV(@ISPERIOD("2011"))	1449.449	404.8462	3.580247	0.0004

Effects Specification

Cross-section fixed (first differences)
Period fixed (dummy variables)

Mean dependent var	1453.752	S.D. dependent var	3079.174
S.E. of regression	2195.784	Sum squared resid	1.42E+09
J-statistic	20.89127	Instrument rank	27
Prob(J-statistic)	0.013142		

Source: Own results

The results of Panel Generalized Method of Moments (GMM) estimation without log specification, where GDP is dependent variable, indicate that only gross fixed capital formation has positive and statistically significant impact on economic growth at 5% level of significance, 1% increase of gross fixed capital formation increases GDP by 0.0000000055%. Labor has positive, but statistically insignificant impact on economic growth. At the same time natural gas consumption and instrumental variable of natural gas consumption at first difference level have positive, but also insignificant impact on economic growth. These three variables are insignificant at both 5% level and 1% level of significance. But, as we can see from the model, probability of J-statistic is quite small 0,013, at 5% level of significance. It means that we can reject the null hypothesis about validity of instrument and apply alternative one that model is invalid (see Table 4.12).

Next two tables represent results of Panel OLS and Panel GMM models with log specification (Table 4.13 and Table 4.14).

Table 4.13: The results of Panel Ordinary Least Squares (OLS) estimation with log specification between GDP, capital, labor and natural gas consumption according to the model, where GDP is taken as dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.164973	0.186983	-0.882288	0.3782
LK	1.030693	0.011378	90.58812	0.0000
LL	-0.979284	0.016351	-59.89085	0.0000
LGC	-0.011974	0.013018	-0.919833	0.3582

R-squared	0.958907	Mean dependent var	9.744691
Adjusted R-squared	0.958587	S.D. dependent var	0.918390
S.E. of regression	0.186893	Akaike info criterion	-0.506354
Sum squared resid	13.48263	Schwarz criterion	-0.465676
Log likelihood	102.7391	Hannan-Quinn criter.	-0.490229
F-statistic	3002.421	Durbin-Watson stat	0.402522
Prob(F-statistic)	0.000000		

Source: Own results

The results for Panel Ordinary Least Squares (OLS) linear regression with log specification, where GDP is dependent variable, indicate that gross fixed capital formation has positive and statistically significant impact on economic growth, 1% increase of gross fixed capital formation increases GDP by 1.03% (Table 4.13). Labor has negative and statistically significant impact on economic growth, 1% increase of labor decreases GDP by 0.97%. These two variables are significant at 5% level of significance. On the other hand, natural gas consumption doesn't have any impact on economic growth neither 5% level, nor 1% level of significance.

Table 4.14: The results of Panel Generalized Method of Moments (GMM) estimation with log specification between GDP, capital, labor and natural gas consumption according to the model, where GDP is taken as dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	0.432581	0.146868	2.945370	0.0035
LGDP(-2)	0.000146	0.131379	0.001114	0.9991
LK	0.390615	0.183040	2.134040	0.0337
LL	-0.783451	0.403748	-1.940448	0.0533
LGC	0.073224	0.071678	1.021570	0.3078
LGC(-1)	0.091855	0.051509	1.783285	0.0756
@LEV(@ISPERIOD("2000"))	-0.046505	0.021759	-2.137277	0.0334
@LEV(@ISPERIOD("2001"))	0.040902	0.013421	3.047657	0.0025
@LEV(@ISPERIOD("2002"))	0.062579	0.019955	3.136010	0.0019
@LEV(@ISPERIOD("2003"))	0.084055	0.030429	2.762360	0.0061
@LEV(@ISPERIOD("2004"))	-0.003885	0.022028	-0.176352	0.8601

@LEV(@ISPERIOD("2005"))	-0.039900	0.028245	-1.412647	0.1588
@LEV(@ISPERIOD("2006"))	0.015017	0.011728	1.280397	0.2014
@LEV(@ISPERIOD("2007"))	0.067751	0.027203	2.490555	0.0133
@LEV(@ISPERIOD("2008"))	0.000244	0.018844	0.012940	0.9897
@LEV(@ISPERIOD("2009"))	-0.063069	0.077291	-0.815987	0.4152
@LEV(@ISPERIOD("2010"))	0.072349	0.028584	2.531075	0.0119
@LEV(@ISPERIOD("2011"))	0.056827	0.034737	1.635895	0.1029

Effects Specification

Cross-section fixed (first differences)
Period fixed (dummy variables)

Mean dependent var	0.075410	S.D. dependent var	0.109959
S.E. of regression	0.036657	Sum squared resid	0.395054
J-statistic	9.053888	Instrument rank	26
Prob(J-statistic)	0.337770		

Source: Own results

The results of Panel Generalized Method of Moments (GMM) estimation with log specification, where GDP is dependent variable, show that only gross fixed capital formation has positive and statistically significant impact on economic growth at 5% significance level, 1% increase of gross fixed capital formation increases GDP by 0.39%. Labor has negative, but statistically insignificant impact on economic growth at 5% level of significance, it's significant just at 1% level. The same we can say about instrumental variable of natural gas consumption at first difference level, which is significant only at 1% level of significance, but has positive impact on economic growth. Natural gas consumption doesn't have any statistically significant impact on economic growth neither at 5% level, nor at 1% level of significance. Results of the model show that probability of J-statistic is equal to 0.33, which means that we can't reject the null hypothesis about validity of instrument, at 5% level of significance.

4.4. Conclusions and discussions of results

We found cointegrated relationship between LGDP, LGC, LK and LL. The majority of tests show that these variables are coitegrated between each other, where LGDP is taken as dependent variable.

The results of Pedroni residual cointegration test using four within-dimension based tests and three within-dimension tests between four variables (LGC, LGDP, LK and LL) without deterministic trend, without deterministic intercept or trend, and with deterministic intercept and trend are presented in Table 4.15. LGC is taken as dependent variable.

Table 4.15: The results of Pedroni's residual cointegration test between LGC, LGDP, LK and LL. LGC is taken as dependent variable.

	No deterministic trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.82	0.034	-0.95	0.83
Panel rho-Statistic	0.41	0.66	0.063	0.52
Panel PP-Statistic	-5.26	0.0000	-5.86	0.0000
Panel ADF-Statistic	-5.042	0.0000	-4.10	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	2.17	0.98		
Group PP-Statistic	-8.60	0.0000		
Group ADF-Statistic	-4.88	0.0000		
	Deterministic intercept and trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.78	0.21	-3.40	0.99
Panel rho-Statistic	1.38	0.91	1.38	0.91
Panel PP-Statistic	-7.090	0.0000	-9.29	0.0000
Panel ADF-Statistic	-10.37	0.0000	-8.82	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	3.19	0.99		
Group PP-Statistic	-11.69	0.0000		
Group ADF-Statistic	-9.41	0.0000		
	No deterministic intercept or trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.54	0.93	-1.23	0.89
Panel rho-Statistic	-0.87	0.18	0.0049	0.50
Panel PP-Statistic	-9.62	0.0000	-3.78	0.0001
Panel ADF-Statistic	-0.88	0.18	-5.079	0.0000

	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	1.847	0.96		
Group PP-Statistic	-4.65	0.0000		
Group ADF-Statistic	-4.63	0.0000		

Source: Own results

Statistics based on common and individual coefficientswithout deterministic trend suggests thatseven of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Taking into account deterministic intercept and trend, six of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Five of eleven tests can reject the null hypothesis about non-cointegrated relationship between variables without deterministic intercept or trend.

The results of Kao residual cointegration test between four variables (LGC, LGDP, LK and LL) are presented in Table 4.16. LGC is taken as dependent variable.

Table 4.16: The results of Kao residual cointegration test between LGC, LGDP, LK and LL. LGC is taken as dependent variable.

Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	-18.35	0.0000
Residual variance	0.027	
HAC variance	0.036	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.50	0.022	-22.54	0.0000

R-squared	0.58	Mean dependent var	0.0099
Adjusted R-squared	0.58	S.D. dependent var	0.16
S.E. of regression	0.10	Akaike info criterion	-1.62
Sum squared resid	4.16	Schwarz criterion	-1.61
Log likelihood	297.15	Hannan-Quinn criter.	-1.62
Durbin-Watson stat	0.87		

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between LGC, LGDP, LK and LL on significance level of 5 %.

Therefore, one can conclude that we found cointegrated relationship between LGC, LGDP, LK and LL. The majority of tests show that these variables are coitegrated between each other, where LGC is taken as dependent variable.

The results of Pedroni residual cointegration test using four within-dimension based tests and three within-dimension tests between four variables (LL, LGDP, LK and LGC) without deterministic trend, without deterministic intercept or trend, and with deterministic intercept and trend are presented in Table 4.17. LL is taken as dependent variable.

Table 4.17: The results of Pedroni residual cointegration test between LL, LGDP, LK and LGC. LL is taken as dependent variable.

	No deterministic trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.27	0.39	0.34	0.36
Panel rho-Statistic	2.76	0.99	1.92	0.97
Panel PP-Statistic	0.53	0.70	-1.94	0.025
Panel ADF-Statistic	-0.42	0.33	-3.49	0.0002
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.26	1.00		
Group PP-Statistic	-2.91	0.0018		
Group ADF-Statistic	-5.068	0.0000		
	Deterministic intercept and trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	6.70	0.0000	2.16	0.015
Panel rho-Statistic	4.042	1.00	3.48	0.99
Panel PP-Statistic	-3.27	0.0005	-5.65	0.0000
Panel ADF-Statistic	-4.54	0.0000	-6.69	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.92	1.00		
Group PP-Statistic	-11.19	0.0000		
Group ADF-Statistic	-8.59	0.0000		
	No deterministic intercept or trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-4.21	1.00	-4.33	1.00
Panel rho-Statistic	1.40	0.92	1.34	0.91
Panel PP-Statistic	0.29	0.61	0.71	0.76
Panel ADF-Statistic	-1.80	0.035	-1.36	0.086
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	3.53	0.99		
Group PP-Statistic	0.75	0.77		

Group ADF-Statistic	-3.12	0.0009		

Source: Own results

Statistics based on common and individual coefficients without deterministic trend suggests that four of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. If we take into account deterministic intercept and trend, eight of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. And three of eleven tests reject the null hypothesis about non-cointegrated relationship between variables without deterministic intercept or trend.

The results of Kao residual cointegration test between four variables (LL, LGDP, LK and LGC) are presented in Table 4.18. LL is taken as dependent variable.

Table 4.18: The results of Kao residual cointegration test between LL, LGDP, LK and LGC. LL is taken as dependent variable.

Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	1.90	0.028
Residual variance	0.00027	
HAC variance	0.00043	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.096	0.036	-2.68	0.0079
D(RESID(-1))	0.24	0.061	3.94	0.0001
D(RESID(-2))	0.15	0.066	2.32	0.021
D(RESID(-3))	0.20	0.065	3.19	0.0016
D(RESID(-4))	-0.011	0.064	-0.18	0.85
D(RESID(-5))	0.17	0.054	3.14	0.0019

R-squared	0.18	Mean dependent var	0.0025
Adjusted R-squared	0.16	S.D. dependent var	0.016
S.E. of regression	0.014	Akaike info criterion	-5.57
Sum squared resid	0.049	Schwarz criterion	-5.48
Log likelihood	657.69	Hannan-Quinn criter.	-5.53
Durbin-Watson stat	1.94		

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between LL, LGDP, LK and LGC on significance level of 5 %.

Therefore, one can conclude that we found cointegrated relationship between LL, LGDP, LK and LGC. The majority tests show that these variables are coitegrated between each other, where LL is taken as dependent variable.

The results of Pedroni residual cointegration test using four within-dimension based tests and three within-dimension tests between four variables (LK, LGDP, LL and LGC) without deterministic trend, without deterministic intercept or trend, and with deterministic intercept and trend are presented in Table 4.19. LK is taken as dependent variable.

Table 4.19: The results of Pedroni residual cointegration test between LK, LGDP, LL and LGC. LK is taken as dependent variable.

	No deterministic trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.55	0.28	-0.31	0.62
Panel rho-Statistic	3.20	0.99	2.0088	0.97
Panel PP-Statistic	2.97	0.99	-0.92	0.17
Panel ADF-Statistic	-1.64	0.050	-5.19	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.72	1.00		
Group PP-Statistic	-0.23	0.40		
Group ADF-Statistic	-5.56	0.0000		
	Deterministic intercept and trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	2.61	0.0045	-1.99	0.97
Panel rho-Statistic	3.57	0.99	3.42	0.99
Panel PP-Statistic	-1.45	0.073	-3.82	0.0001
Panel ADF-Statistic	-6.044	0.0000	-8.45	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	5.55	1.00		
Group PP-Statistic	-3.92	0.0000		
Group ADF-Statistic	-6.039	0.0000		
	No deterministic intercept or trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.35	0.087	-1.76	0.96
Panel rho-Statistic	1.93	0.97	1.70	0.95

Panel PP-Statistic	1.87	0.96	-0.076	0.46
Panel ADF-Statistic	-0.46	0.32	-6.61	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.11	1.00		
Group PP-Statistic	1.38	0.91		
Group ADF-Statistic	-7.011	0.0000		

Source: Own results

Statistics based on common and individual coefficients without deterministic trend suggests thatthree of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Taking into account deterministic intercept and trend, seven of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Two of eleven tests can reject the null hypothesis about non-cointegrated relationship between variables without deterministic intercept or trend.

The results of Kao residual cointegration test between four variables (LK, LGDP, LL and LGC) are presented in Table 4.20. LK is taken as dependent variable.

Table 4.20: The results of Kao residual cointegration test between LK, LGDP, LL and LGC. LK is taken as dependent variable.

Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	-7.78	0.0000
Residual variance	0.0059	
HAC variance	0.0081	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.33	0.035	-9.64	0.0000
D(RESID(-1))	0.51	0.049	10.51	0.0000

R-squared	0.29	Mean dependent var	-0.010
Adjusted R-squared	0.28	S.D. dependent var	0.079
S.E. of regression	0.067	Akaike info criterion	-2.55
Sum squared resid	1.51	Schwarz criterion	-2.53
Log likelihood	433.77	Hannan-Quinn criter.	-2.54
Durbin-Watson stat	1.82		

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between LK, LGDP, LL and LGC on significance level of 5 %.

Therefore, one can conclude that we found cointegrated relationship between LK, LGDP, LL and LGC. The majority of tests show that these variables are cointegrated between each other, where LK is taken as dependent variable.

4.5. Panel causality test

The following Table 4.21 represents results of Error Correction Model (ECM) based on the two steps Engle and Granger procedure between four variables (GDP, capital, labor and natural gas consumption). Each of the relationship is based on the equations represented above.

Table 4.21: The results of causal relationship between GDP, capital, labor and natural gas consumption

Dependent variable	Sources of causality				
	Short-run				Long-run
	ΔLNGDP	ΔLNK	ΔLNL	ΔLNGC	ECT
(13) ΔLNGDP	-	-0.467732	0.432817	-0.020960	-0.553551
		(0.0000)	(0.0000)	(0.0093)	(0.0000)
(14) ΔLNK	1.385251	-	1.520729	0.020982	1.640241
	(0.0000)		(0.0000)	(0.0008)	(0.0000)
(15) ΔLNL	0.000731	0.006865	-	-0.009445	-0.027114
	(0.9206)	(0.3772)		(0.0013)	(0.0020)
(16) ΔLNGC	0.135580	0.075212	0.340463	-	0.988354
	(0.0000)	(0.0000)	(0.0000)		(0.0000)

Source: Own results

The results for the model where GDP is dependent variable indicate that in the short-run only labor has positive and statistically significant impact on economic growth, 1% increase of labor increases GDP by 0.43%. Both natural gas consumption and capital have negative and statistically significant impact on economic growth, 1% increase of natural gas consumption decreases GDP by 0.02%, and 1% increase of capital decreases GDP by 0.46%. In the long-run we can see unidirectional causal relationship running from capital, labor and natural gas consumption to GDP. Natural gas consumption responds to deviations from long-run equilibrium at 1% level of significance.

The results of the next model where capital is represented as dependent variable suggest that in the short-run all independent variables, GDP, labor and natural gas consumption have positive and statistically significant impact on gross fixed capital formation, 1% increase of GDP increases gross fixed capital formation by 1.38%, 1% increase of total labor forces increases and natural gas consumption increases gross fixed capital formation by 1.52%, and 0.02% respectively. In the long-run we can see unidirectional causal relationship running from capital, labor and natural gas consumption to GDP.

The model where labor is taken as dependent variable shows that both, GDP and capital, does not have statistically significant impact on total labor forces, even if coefficients of the relationship are positive. On the other hand, natural gas consumption has negative and statistically significant impact on total labor forces, 1% increase of natural gas consumption decrease total labor forces by 0.009%. Also, there is unidirectional causality, which runs from GDP, capital and natural gas consumption to total labor forces at 1% of significance.

If we look at the model with natural gas consumption as dependent variable, we will see that GDP, labor and capital have positive and statistically significant impact on natural gas consumption in the short-run. 1% increase of GDP increases natural gas consumption by 0.13%, 1% increase of capital leads to increase of natural gas consumption by 0.075%, and 1% increase of labor increases natural gas consumption by 0.34% respectively. In the long-run there is unidirectional causal relationship, which runs from GDP, capital and labor to natural gas consumption. GDP responds to deviations from long-run equilibrium at significance level of 1% of the error correction term.

5. Overall conclusions and policy implications

This Master thesis investigated the relationship between natural gas consumption and economic growth for 26 countries of European Union using panel time series data over the period from 1997 to 2011. For this purpose we created multivariate model, based on the neoclassical growth model proposed by Solow (1956). Testing the model had been done using different econometric techniques, like Panel Unit Root tests, Panel Cointegration test, Generalized Method of Moments (GMM) and Error Correction Modelling (ECM). Using multivariate model, it was found that there exists long-run relationship between economic growth, natural gas consumption, labor and capital. Results of GMM model show that natural gas consumption has positive, but statistically insignificant impact on economic growth. In the short-run there is bidirectional causality between natural gas consumption and economic growth. The causality running from economic growth to natural gas consumption is positive, in other words, increase of GDP by 1% leads to increase of natural gas consumption by 0.13%. Surprisingly, the causality, which runs from natural gas consumption to economic growth, is negative. Increase of natural gas consumption by 1% leads to decrease of GDP by 0.02%.

As one can see, growing economic output in European Union countries requires more natural gas for maintaining the sustainable economic growth. Additional natural gas consumption with growing production needs more investments for building infrastructure of processing natural gas terminals and delivery pipelines for transmission natural gas to consumers. On the other hand, one clearly sees that the increase of natural gas consumption leads to the decrease of economic growth. The same results were provided by Ucan et al. (2014) for 15 European developed countries. He found that non-renewable energy consumption leads to decrease of economic growth. The other thing is that consumption of renewable energy increases economic growth. The results of estimated model are dependent on the kind of energy, which is included into the model, and resources of its energy.

As was pointed above, we can find an effort of European countries with developed economic systems to reduce greenhouse gas emissions. In that case, Governments and policy makers should focus on renewable sources of energy, like, e.g. solar energy, wind power and hydropower. Also, as points Nwosa (2013), environmental costs should be taken into account when Government provides some energy consumption policies. It is particularly important if energy consumption has impact on economic growth. But if this influence is absent, then implementation of these energy conservation policies will not have negative effect on economic development of a state. All these facts suggest that natural gas will remain an important source of energy for European countries in next years.

The role of natural gas on European market also can be viewed in terms of dependence of the majority of the European Union countries on supplies of natural gas from Russian Federation. Market power of Russian Federation on European natural gas market can harm European energy security. Possible solution is diversification of natural gas suppliers. Besides supply from Russian Federation, European countries should increase presence of other potential players on its market, e.g. possible supply from Caspian region countries. It should not be forgotten about political aspect of Russian Federation's influence. The gas dispute between Russian Federation and Ukraine in years 2006 and 2009 clearly shows possible risks. Also in future we can expect a creation of new cartels between suppliers of natural gas. As a result, possible changes in European energy security will need more time. Effectiveness of their application will be seen in the long-term perspective.

As policy implications for further investigations about this topic, I would recommend to analyze how the results can change taking into account comparison between different sectors economy. For example, it would be interesting to compare relationship between economic growth and natural gas consumption in industrial and household sectors with its possible further dividing in some subsectors. Also, it is possible to try to find time series sample for more years and use not annual, but quarterly data to get stronger causal relationship. With growing usage of renewable resources in European countries, it will be good to include into the model impact of renewable resources of energy.

Knowing of natural gas consumption can help us in determination of natural gas prices volatility or if we are dealing with long-term natural gas contracts. Also it reduces uncertainty about future demand of natural gas. For Governments, energy companies and financial institutions it represents opportunity for best realization of investment projects. The better managing of demand and supply and more efficient usage of natural gas in total economy as well as in different sectors of economy will be profitable for sustainable economic development of European countries.

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Appendix compilation

Appendix A

Observation	Country	Year	GDP	K	L	GC
1	Austria	1997	26082,45851	50365504566	3823344	6 539,3
2	Austria	1998	26743,79194	51659739884	3823826	6 713,5
3	Austria	1999	26563,20954	50305528447	3848325	6 830,7
4	Austria	2000	23974,18307	46502825686	3854452	6 518,7
5	Austria	2001	23833,83424	45139940045	3885271	6 908,6
6	Austria	2002	25679,0944	45721238472	3960542	6 897,3
7	Austria	2003	31268,6307	57917031603	4009337	7 563,6
8	Austria	2004	35662,21182	64941874802	3989535	7 700,7
9	Austria	2005	37067,32383	66827934885	4069449	8 159,2
10	Austria	2006	39299,62251	69267013671	4151191	7 660,9
11	Austria	2007	45181,49851	80439848762	4244400	7 224,6
12	Austria	2008	49679,13172	89565986543	4284068	7 634,5
13	Austria	2009	45872,19805	79418147327	4325557	7 470,4
14	Austria	2010	45016,70385	76152434168	4327016	8 214,4
15	Austria	2011	49485,48219	88258446270	4357198	7 785,7
16	Belgium	1997	24532,02692	51328371673	4215032	11 264,7
17	Belgium	1998	25051,33996	52851744832	4254080	12 474,3
18	Belgium	1999	24886,86566	52961858087	4361766	13 334,9
19	Belgium	2000	22697,0123	49262023217	4411565	13 368,6
20	Belgium	2001	22600,91615	48537807606	4313180	13 179,8
21	Belgium	2002	24465,3335	48341803124	4397376	13 377,9
22	Belgium	2003	30039,09224	58899548533	4429444	14 402,0
23	Belgium	2004	34706,6939	71829543126	4514100	14 570,0
24	Belgium	2005	36011,4694	77954782868	4622255	14 727,8
25	Belgium	2006	37918,78113	83686592394	4640538	15 002,6
26	Belgium	2007	43255,42488	99749875964	4732749	14 928,5
27	Belgium	2008	47374,46816	1,13211E+11	4774549	14 838,2
28	Belgium	2009	43834,08095	98486704137	4788755	15 111,8
29	Belgium	2010	43150,78431	94701646321	4898557	16 998,8
30	Belgium	2011	46463,60378	1,06199E+11	4870949	15 124,1
31	Bulgaria	1997	1209,502744	1140697557	3644216	3 699,7
32	Bulgaria	1998	1581,824574	1707685360	3576613	3 129,1
33	Bulgaria	1999	1611,129004	1988441544	3505909	2 686,2
34	Bulgaria	2000	1579,34824	2036691350	3431024	2 931,4
35	Bulgaria	2001	1729,191157	2534255498	3508509	2 738,1
36	Bulgaria	2002	2030,788523	2917832451	3426987	2 402,3
37	Bulgaria	2003	2641,787723	3928337854	3364376	2 499,6
38	Bulgaria	2004	3249,287396	5148172814	3414437	2 492,7
39	Bulgaria	2005	3733,263161	7440027317	3354628	2 804,1
40	Bulgaria	2006	4313,430636	9169159879	3478286	2 900,6

41	Bulgaria	2007	5581,414132	12080277797	3511993	3 010,4
42	Bulgaria	2008	6916,84628	17412769426	3580609	2 914,2
43	Bulgaria	2009	6524,156879	14021676264	3505857	2 160,7
44	Bulgaria	2010	6453,375276	10882172059	3416896	2 300,4
45	Bulgaria	2011	7286,389592	11535844294	3347104	2 630,3
46	Croatia	1997	5140,349129	4928227948	2049496	2 246,8
47	Croatia	1998	5577,96059	5110731323	2012611	2 159,8
48	Croatia	1999	5067,558475	4709726190	2031081	2 189,8
49	Croatia	2000	4861,67751	4077673768	1965249	2 209,4
50	Croatia	2001	5191,901985	4494384381	1955322	2 315,1
51	Croatia	2002	5974,075765	5677874676	1939022	2 370,3
52	Croatia	2003	7689,956996	8549012746	1948361	2 356,1
53	Croatia	2004	9237,116223	10153955718	1994052	2 458,1
54	Croatia	2005	10090,36669	11078074534	1992660	2 369,8
55	Croatia	2006	11228,62138	12981391853	1977081	2 350,7
56	Croatia	2007	13372,27013	15563498141	1986115	2 701,1
57	Croatia	2008	15694,07747	19035719422	1984670	2 576,8
58	Croatia	2009	14044,14626	15209794426	1973936	2 403,3
59	Croatia	2010	13326,59867	12228047760	1949574	2 632,4
60	Croatia	2011	14371,95378	12060297676	1874244	2 570,2
61	Czech Republic	1997	5770,887652	17811111432	5175174	7 668,9
62	Czech Republic	1998	6203,713058	18197173791	5196678	7 685,3
63	Czech Republic	1999	6044,981144	17174859160	5216521	7 726,6
64	Czech Republic	2000	5734,45959	16901167235	5183636	7 500,2
65	Czech Republic	2001	6301,045025	18274137432	5153550	8 032,2
66	Czech Republic	2002	7691,070679	21595344942	5148742	7 762,0
67	Czech Republic	2003	9347,905577	25547130348	5133561	7 842,2
68	Czech Republic	2004	11177,3604	29544762109	5127955	7 787,9
69	Czech Republic	2005	12737,60581	33584338879	5168891	7 703,4
70	Czech Republic	2006	14491,20633	38067483690	5179779	7 593,5
71	Czech Republic	2007	17524,19035	48764376406	5186846	7 238,7
72	Czech Republic	2008	21707,79076	60403124085	5211792	7 173,5
73	Czech Republic	2009	18880,54167	48580024131	5253968	6 804,3
74	Czech Republic	2010	18950,33508	48724307201	5239905	8 069,5
75	Czech Republic	2011	20584,92655	52137564692	5242209	6 809,2
76	Denmark	1997	32248,95949	33399803165	2858332	3 932,1
77	Denmark	1998	32738,68328	35498149475	2847138	4 272,0
78	Denmark	1999	32685,31895	34423755053	2879103	4 490,9
79	Denmark	2000	29980,15547	32301468496	2864614	4 449,0
80	Denmark	2001	29946,38183	31723939059	2852289	4 631,0
81	Denmark	2002	32344,31979	34054872256	2879651	4 627,3
82	Denmark	2003	39443,26817	40960881643	2872393	4 660,7
83	Denmark	2004	45282,068	47227368779	2905970	4 633,8
84	Denmark	2005	47546,59459	50296069142	2902347	4 399,4
85	Denmark	2006	50462,24772	59420913340	2933043	4 536,6

86	Denmark	2007	57021,16445	67729291394	2933487	4 061,6
87	Denmark	2008	62596,47831	72331803960	2966072	4 073,2
88	Denmark	2009	56226,61511	56118911121	2952487	3 895,5
89	Denmark	2010	56410,83284	52951640937	2930964	4 422,0
90	Denmark	2011	59911,90466	57912033077	2930445	3 708,5
91	Estonia	1997	3608,605498	1420770072	688310	624,2
92	Estonia	1998	4038,706974	1701749189	677254	592,4
93	Estonia	1999	4132,464646	1404028259	663454	575,9
94	Estonia	2000	4062,819268	1458333453	669260	662,0
95	Estonia	2001	4495,411267	1649110107	671144	710,4
96	Estonia	2002	5310,030328	2173611691	658188	595,7
97	Estonia	2003	7182,493739	3107398270	677121	680,0
98	Estonia	2004	8830,058689	3714092118	679359	774,5
99	Estonia	2005	10264,11113	4460020588	674866	799,7
100	Estonia	2006	12472,80527	6043356034	695265	808,1
101	Estonia	2007	16404,86471	7815469816	694702	803,4
102	Estonia	2008	17786,05012	7207077588	700186	770,5
103	Estonia	2009	14542,07485	4111939111	696636	525,1
104	Estonia	2010	14295,03062	3610214694	691625	562,5
105	Estonia	2011	16982,30031	5317500113	698460	503,3
106	Finland	1997	23928,21124	23055778261	2510831	2 906,7
107	Finland	1998	25179,59983	25330440587	2531790	3 335,6
108	Finland	1999	25229,59582	25524184956	2581636	3 338,0
109	Finland	2000	23529,53846	24397457159	2613986	3 422,2
110	Finland	2001	24025,11823	25140939597	2629537	3 706,9
111	Finland	2002	25993,83997	25231507623	2636570	3 683,8
112	Finland	2003	31508,87523	31108352144	2626165	4 084,4
113	Finland	2004	36162,65601	36553612337	2621521	3 950,5
114	Finland	2005	37318,79732	39255335025	2644599	3 598,0
115	Finland	2006	39487,06231	41578600185	2682611	3 875,9
116	Finland	2007	46538,20312	52471985082	2709259	3 722,4
117	Finland	2008	51186,50681	58093553704	2736987	3 853,0
118	Finland	2009	44837,68846	47239443884	2710910	3 484,1
119	Finland	2010	44134,04836	44630455327	2700262	3 837,5
120	Finland	2011	48694,53514	51006786725	2714985	3 360,0
121	France	1997	23705,83186	2,40271E+11	26665873	31 338,7
122	France	1998	24405,87657	2,54988E+11	26822301	33 413,1
123	France	1999	24075,01701	2,65644E+11	27116182	34 068,1
124	France	2000	21774,93717	2,50556E+11	27303844	35 766,4
125	France	2001	21812,19434	2,52736E+11	27396002	37 548,1
126	France	2002	23494,42211	2,64529E+11	27681679	37 484,3
127	France	2003	28794,0856	3,28055E+11	28313015	39 318,0
128	France	2004	32784,83363	3,83914E+11	28444366	40 148,3
129	France	2005	33818,97269	4,1327E+11	28782307	41 025,4
130	France	2006	35457,05773	4,52086E+11	28946653	39 622,1

131	France	2007	40341,94274	5,40106E+11	29188501	38 487,5
132	France	2008	43991,71814	6,03331E+11	29412154	39 885,2
133	France	2009	40487,89707	5,10507E+11	29677817	38 461,8
134	France	2010	39448,09885	4,99513E+11	29836224	42 539,8
135	France	2011	42578,17709	5,55988E+11	29892102	37 041,9
136	Germany	1997	26296,53061	4,53609E+11	40216096	71 948,3
137	Germany	1998	26547,77535	4,60253E+11	40508874	72 728,7
138	Germany	1999	25956,63741	4,54912E+11	40355557	71 995,8
139	Germany	2000	22945,70885	4,04966E+11	40309081	71 853,2
140	Germany	2001	22840,27405	3,77396E+11	40493240	75 591,0
141	Germany	2002	24325,66645	3,68718E+11	40476780	75 570,7
142	Germany	2003	29367,40894	4,31095E+11	40276006	75 875,3
143	Germany	2004	33040,05141	4,74058E+11	40743681	76 185,6
144	Germany	2005	33542,78138	4,781E+11	41261506	77 782,1
145	Germany	2006	35237,61063	5,24148E+11	41605652	79 296,2
146	Germany	2007	40403,01773	6,12999E+11	41860106	76 495,2
147	Germany	2008	44132,06048	6,73132E+11	41939193	77 162,4
148	Germany	2009	40270,14217	5,67693E+11	41983039	72 731,5
149	Germany	2010	40407,96125	5,76191E+11	41990452	75 904,9
150	Germany	2011	44354,68494	6,5777E+11	42490517	69 596,0
151	Greece	1997	12495,06452	25361981095	4660152	171,0
152	Greece	1998	12485,06168	27205832729	4784916	725,4
153	Greece	1999	12238,59337	28717455759	4840264	1 218,0
154	Greece	2000	11396,23257	27933595160	4870258	1 704,5
155	Greece	2001	11855,78949	29172127330	4814884	1 683,0
156	Greece	2002	13296,92353	34115138946	4877848	1 801,1
157	Greece	2003	17502,68646	46670738046	4949986	2 026,2
158	Greece	2004	20618,3075	52140546104	5030949	2 228,8
159	Greece	2005	21642,25847	49768796940	5052616	2 353,5
160	Greece	2006	23518,49931	59186398827	5099003	2 747,2
161	Greece	2007	27361,09709	81254628473	5104774	3 364,1
162	Greece	2008	30536,44871	77060088442	5112965	3 506,1
163	Greece	2009	28695,23153	63808724892	5157853	2 971,0
164	Greece	2010	26379,5302	51897976958	5148705	3 234,5
165	Greece	2011	26061,44027	43917605089	5075020	3 972,2
166	Hungary	1997	4521,963999	10236460894	4067690	9 708,8
167	Hungary	1998	4670,654839	11090468824	4060470	9 776,3
168	Hungary	1999	4713,540459	11525705350	4152706	9 905,1
169	Hungary	2000	4542,72072	11300859088	4178897	9 656,7
170	Hungary	2001	5175,025628	12441977399	4156582	10 710,6
171	Hungary	2002	6535,293936	15509735131	4158101	10 810,6
172	Hungary	2003	8246,995826	18751275040	4227853	11 886,0
173	Hungary	2004	10084,52184	23151020777	4223385	11 712,2
174	Hungary	2005	10936,94861	25128936655	4270023	12 093,9
175	Hungary	2006	11173,56951	24468990922	4309123	11 456,8

176	Hungary	2007	13534,7055	29648290228	4296178	10 704,8
177	Hungary	2008	15364,67955	33466239300	4272342	10 560,8
178	Hungary	2009	12634,55114	26169607512	4272865	9 151,9
179	Hungary	2010	12750,29865	23114028085	4310481	9 815,5
180	Hungary	2011	13784,18353	23454278680	4334180	9 353,9
181	Ireland	1997	22119,81936	16413103823	1550590	2 771,7
182	Ireland	1998	23749,71654	19142626814	1625637	2 802,7
183	Ireland	1999	25723,11972	22423577577	1697536	2 997,2
184	Ireland	2000	25578,73098	22516197878	1756229	3 435,9
185	Ireland	2001	27201,23376	23562203164	1799023	3 583,8
186	Ireland	2002	31286,34589	26625555674	1849663	3 678,7
187	Ireland	2003	39717,134	35720117226	1892574	3 652,6
188	Ireland	2004	45766,41689	45667530715	1947675	3 644,9
189	Ireland	2005	48697,57924	54286257802	2054805	3 469,6
190	Ireland	2006	52118,81563	60627499562	2136958	3 936,2
191	Ireland	2007	59008,35506	66369631909	2216260	4 279,2
192	Ireland	2008	58810,91793	58032491056	2238537	4 477,2
193	Ireland	2009	49707,65437	36206592477	2216357	4 247,8
194	Ireland	2010	45916,68284	25474266542	2184327	4 682,6
195	Ireland	2011	49387,27333	24034436527	2171006	4 115,8
196	Italy	1997	21069,54779	2,28286E+11	22926979	47 485,8
197	Italy	1998	21519,06412	2,37405E+11	23062563	51 126,2
198	Italy	1999	21227,31087	2,38654E+11	23238682	55 568,7
199	Italy	2000	19388,27875	2,26201E+11	23271088	57 940,3
200	Italy	2001	19723,04417	2,30588E+11	23400241	58 099,2
201	Italy	2002	21472,10448	2,58396E+11	23695262	57 706,1
202	Italy	2003	26425,03746	3,10675E+11	24010344	63 621,0
203	Italy	2004	30086,0131	3,58135E+11	24523108	66 019,0
204	Italy	2005	30814,05751	3,74031E+11	24402502	70 651,2
205	Italy	2006	32212,84691	4,00258E+11	24481437	69 191,8
206	Italy	2007	36400,47004	4,56495E+11	24508958	69 530,9
207	Italy	2008	39222,17723	4,84344E+11	24826334	69 519,4
208	Italy	2009	35724,4084	4,09367E+11	24636561	63 901,9
209	Italy	2010	34673,49552	3,99221E+11	24560253	68 056,7
210	Italy	2011	36988,16405	4,18656E+11	24551313	63 814,1
211	Latvia	1997	2521,006909	1056433191	1154277	1 054,4
212	Latvia	1998	2745,603948	1660639537	1147890	1 033,0
213	Latvia	1999	3048,976931	1674735588	1122135	989,8
214	Latvia	2000	3308,512355	1898598516	1091093	1 092,4
215	Latvia	2001	3556,88621	2066355904	1097522	1 269,7
216	Latvia	2002	4032,072092	2217110542	1130449	1 291,5
217	Latvia	2003	4889,279991	2729953191	1111083	1 347,3
218	Latvia	2004	6080,789964	3779480335	1110534	1 332,4
219	Latvia	2005	7165,377699	4911840798	1102913	1 357,9
220	Latvia	2006	8986,401376	6502676660	1127749	1 406,6

221	Latvia	2007	13073,381	9683003114	1144217	1 359,6
222	Latvia	2008	15463,66028	9876162646	1158000	1 333,1
223	Latvia	2009	12082,06368	5551378560	1115189	1 227,2
224	Latvia	2010	11446,50818	4688849090	1062383	1 461,9
225	Latvia	2011	13827,36026	6324840891	1037659	1 288,4
226	Lithuania	1997	2833,094228	2262250000	1729852	2 002,0
227	Lithuania	1998	3170,75246	2680775000	1708071	1 753,6
228	Lithuania	1999	3113,119772	2403550000	1713310	1 812,6
229	Lithuania	2000	3267,347443	2141325000	1683892	2 063,7
230	Lithuania	2001	3503,27358	2446150000	1645950	2 146,1
231	Lithuania	2002	4113,759373	2869561078	1629478	2 170,1
232	Lithuania	2003	5448,769918	3923486556	1691814	2 354,1
233	Lithuania	2004	6709,739811	5025393857	1608351	2 347,7
234	Lithuania	2005	7851,042105	5910505299	1565896	2 476,5
235	Lithuania	2006	9249,909296	7573951308	1536277	2 454,1
236	Lithuania	2007	12170,35217	11064658674	1538593	2 891,6
237	Lithuania	2008	14832,68815	12024886035	1541510	2 595,6
238	Lithuania	2009	11713,9	6307137681	1560384	2 181,3
239	Lithuania	2010	11852,1696	5831460691	1543795	2 491,7
240	Lithuania	2011	14227,68554	7517230261	1539108	2 718,0
241	Luxembourg	1997	44139,78763	4015336040	174176	626,2
242	Luxembourg	1998	45565,1579	4213714159	176826	632,7
243	Luxembourg	1999	49213,96709	4970061794	181873	656,0
244	Luxembourg	2000	46453,24578	4208218168	188849	671,3
245	Luxembourg	2001	45743,43018	4567695749	188947	746,3
246	Luxembourg	2002	50582,82854	5076792772	194612	1 066,8
247	Luxembourg	2003	64531,98944	6445259594	194570	1 079,9
248	Luxembourg	2004	74388,70863	7297684901	200951	1 195,9
249	Luxembourg	2005	80925,21999	7686414963	207436	1 176,3
250	Luxembourg	2006	90015,54662	8150379115	213563	1 230,4
251	Luxembourg	2007	106919,6046	10665069888	216282	1 148,5
252	Luxembourg	2008	112028,5749	11737947617	221180	1 093,2
253	Luxembourg	2009	99281,71869	9498733172	234862	1 112,5
254	Luxembourg	2010	102678,7979	9036415623	237978	1 196,6
255	Luxembourg	2011	111913,1844	10756993796	242808	1 032,9
256	Netherlands	1997	24760,9017	84840749944	7672013	35 765,9
257	Netherlands	1998	25634,61786	89381248611	7819362	35 544,4
258	Netherlands	1999	26021,63765	94164713403	7972655	34 597,6
259	Netherlands	2000	24179,73141	84440759167	8157730	35 009,0
260	Netherlands	2001	24968,81742	84718568233	8309210	35 886,3
261	Netherlands	2002	27110,60685	87391304348	8453375	35 805,0
262	Netherlands	2003	33177,35726	1,04795E+11	8494336	36 001,1
263	Netherlands	2004	37458,43287	1,14763E+11	8555180	36 755,4
264	Netherlands	2005	39122,29108	1,20649E+11	8584798	35 334,2
265	Netherlands	2006	41458,94138	1,33443E+11	8653731	34 309,9

266	Netherlands	2007	47770,8339	1,56493E+11	8813191	33 351,9
267	Netherlands	2008	52951,05599	1,78488E+11	8938018	34 777,2
268	Netherlands	2009	48173,8825	1,51108E+11	9020726	35 087,6
269	Netherlands	2010	46773,35381	1,34939E+11	8854921	39 308,6
270	Netherlands	2011	49886,28451	1,48558E+11	8872112	34 315,2
271	Poland	1997	4066,11171	35214634875	17349192	9 417,4
272	Poland	1998	4471,959897	41627150832	17393291	9 514,3
273	Poland	1999	4340,418356	40951221418	17212025	9 263,2
274	Poland	2000	4476,797076	40666395157	17276925	9 959,7
275	Poland	2001	4978,573826	39394464936	17386454	10 376,6
276	Poland	2002	5183,822606	37125217217	17202621	10 113,2
277	Poland	2003	5674,737044	39535828525	17221938	11 260,7
278	Poland	2004	6620,070424	45701053138	17293719	11 880,6
279	Poland	2005	7963,021208	55379727274	17450631	12 234,5
280	Poland	2006	8958,012422	67141982272	17334574	12 581,5
281	Poland	2007	11157,27319	91708172191	17332847	12 494,6
282	Poland	2008	13886,47243	1,17842E+11	17586185	12 565,9
283	Poland	2009	11294,86775	91230697734	17868450	12 062,4
284	Poland	2010	12303,66187	93297615494	18141020	12 804,7
285	Poland	2011	13384,78217	1,04189E+11	18390262	12 836,4
286	Portugal	1997	11441,45511	29802744425	4982864	86,7
287	Portugal	1998	12092,18518	33232858415	5095875	697,2
288	Portugal	1999	12372,86659	34456424462	5150634	1 945,5
289	Portugal	2000	11399,48335	32465819053	5253013	2 033,8
290	Portugal	2001	11612,01473	32454765101	5353699	2 255,1
291	Portugal	2002	12695,81565	33858554489	5426638	2 729,3
292	Portugal	2003	15482,81028	38201580135	5453429	2 636,3
293	Portugal	2004	17684,06738	43085557480	5454126	3 303,4
294	Portugal	2005	18265,43187	44039322489	5504806	3 750,7
295	Portugal	2006	19177,42991	45023537246	5546703	3 639,6
296	Portugal	2007	21980,70034	51501873364	5580983	3 808,4
297	Portugal	2008	23860,69114	56592838967	5586043	4 138,5
298	Portugal	2009	22153,08436	48106854817	5543982	4 217,2
299	Portugal	2010	21653,00142	44805014471	5553291	4 488,5
300	Portugal	2011	22532,50772	42786925995	5498578	4 463,7
301	Romania	1997	1564,50842	7469426756	12006610	15 938,5
302	Romania	1998	1871,18898	7652471943	11860713	14 984,7
303	Romania	1999	1583,849846	6302201420	11890810	13 731,0
304	Romania	2000	1662,217535	7022615527	11849842	13 679,9
305	Romania	2001	1833,81266	8317529776	11516563	13 179,8
306	Romania	2002	2116,312063	9791583410	10379968	13 628,7
307	Romania	2003	2756,332583	12800153413	10287814	14 729,3
308	Romania	2004	3533,266078	16499988433	10200552	13 937,3
309	Romania	2005	4651,692261	23519134255	9908872	13 923,2
310	Romania	2006	5789,244137	31424892755	10066468	14 198,7

311	Romania	2007	8170,143463	51530934072	9937318	12 762,0
312	Romania	2008	9949,354828	65219785419	9743043	12 159,5
313	Romania	2009	8068,95673	40153771736	9643566	10 580,4
314	Romania	2010	8139,146673	40725573492	9653136	10 788,4
315	Romania	2011	9063,676031	47417767123	9535590	11 105,1
316	Slovakia	1997	5022,770206	9158280276	2516752	5 579,6
317	Slovakia	1998	5431,44324	10463343774	2535421	5 669,5
318	Slovakia	1999	5550,004292	8833981462	2570716	5 738,2
319	Slovakia	2000	5330,401622	7409364290	2596021	5 776,4
320	Slovakia	2001	5636,63909	8644587919	2633336	6 168,4
321	Slovakia	2002	6442,044438	9480259740	2635141	5 867,3
322	Slovakia	2003	8530,472005	11343703160	2666189	5 668,7
323	Slovakia	2004	10437,50991	13454129625	2675194	5 498,4
324	Slovakia	2005	11414,60536	16278395722	2660857	5 883,6
325	Slovakia	2006	12842,24858	18302378623	2653215	5 377,9
326	Slovakia	2007	15649,20474	22031839584	2653184	5 089,3
327	Slovakia	2008	18201,27352	24279941409	2693300	5 166,3
328	Slovakia	2009	16196,28137	18095069464	2686946	4 424,3
329	Slovakia	2010	16151,0909	19358294040	2699760	5 006,4
330	Slovakia	2011	17760,41438	21545732555	2706402	4 637,1
331	Slovenia	1997	10282,32149	4866538453	960003	794,9
332	Slovenia	1998	10974,48893	5411285295	979777	819,3
333	Slovenia	1999	11250,21582	5924270645	965827	853,7
334	Slovenia	2000	10045,36008	5240038392	960314	825,6
335	Slovenia	2001	10290,31605	5128537690	969987	849,9
336	Slovenia	2002	11599,90192	5394686776	974055	819,8
337	Slovenia	2003	14607,2005	7034043406	963442	906,7
338	Slovenia	2004	16944,18953	8457295959	1010178	898,7
339	Slovenia	2005	17854,63533	9070937133	1016321	928,8
340	Slovenia	2006	19405,93327	10330092566	1023041	899,2
341	Slovenia	2007	23462,22869	13144774921	1038356	914,2
342	Slovenia	2008	26989,65269	15716634249	1034978	878,7
343	Slovenia	2009	24125,66711	11485872503	1044099	831,5
344	Slovenia	2010	22942,39832	10133301698	1044577	862,8
345	Slovenia	2011	24478,31997	9648179038	1024814	737,6
346	Spain	1997	14463,12096	1,24991E+11	17088143	11 308,2
347	Spain	1998	15121,72118	1,38471E+11	17323773	11 609,0
348	Spain	1999	15468,04987	1,51781E+11	17644827	13 289,3
349	Spain	2000	14413,78887	1,49996E+11	18185883	15 219,1
350	Spain	2001	14939,06077	1,5836E+11	18200531	16 399,9
351	Spain	2002	16564,56844	1,80421E+11	18913233	18 751,2
352	Spain	2003	20950,20305	2,40429E+11	19665033	21 353,0
353	Spain	2004	24337,5105	2,93098E+11	20448256	25 171,7
354	Spain	2005	25904,17315	3,32592E+11	21163057	29 844,0
355	Spain	2006	27847,45678	3,77929E+11	21852616	31 233,3

356	Spain	2007	31871,09026	4,42375E+11	22435926	31 783,6
357	Spain	2008	34674,17419	4,57093E+11	23087190	34 909,7
358	Spain	2009	31368,49508	3,4368E+11	23303701	31 225,0
359	Spain	2010	29732,43795	3,07904E+11	23457625	31 129,3
360	Spain	2011	31117,89747	3,01235E+11	23543802	28 936,0
361	Sweden	1997	28620,40835	39947085096	4465364	798,7
362	Sweden	1998	28779,11562	42378268909	4437685	791,6
363	Sweden	1999	29218,47171	45242060418	4470663	793,3
364	Sweden	2000	27869,3776	44426120364	4552000	775,8
365	Sweden	2001	25557,61254	40777608891	4581381	875,3
366	Sweden	2002	28118,9848	43551057296	4607053	890,8
367	Sweden	2003	35131,20776	53014852281	4628407	888,3
368	Sweden	2004	40261,12201	61677477823	4636799	884,4
369	Sweden	2005	41040,67418	66331746380	4750423	842,6
370	Sweden	2006	43948,62473	74693330023	4806372	881,9
371	Sweden	2007	50558,39553	90543693601	4864134	910,5
372	Sweden	2008	52730,78206	97374805593	4914929	826,5
373	Sweden	2009	43639,55307	72986960867	4926876	1 089,5
374	Sweden	2010	49376,82237	83480954914	4972087	1 465,9
375	Sweden	2011	56724,36224	1,00218E+11	5038026	1 158,6
376	United Kingdom	1997	23734,42186	2,33191E+11	28954197	76 220,0
377	United Kingdom	1998	25266,39474	2,64889E+11	28980059	79 378,5
378	United Kingdom	1999	25870,98904	2,68487E+11	29316002	84 197,1
379	United Kingdom	2000	25361,93964	2,59496E+11	29529666	87 399,3
380	United Kingdom	2001	25121,03789	2,54219E+11	29572617	86 649,7
381	United Kingdom	2002	27301,46037	2,77467E+11	29878032	85 855,3
382	United Kingdom	2003	31437,00581	3,12828E+11	30153077	85 881,8
383	United Kingdom	2004	37021,14576	3,75376E+11	30406139	87 751,5
384	United Kingdom	2005	38432,31116	3,89767E+11	30683756	85 472,8
385	United Kingdom	2006	40807,56096	4,26618E+11	31212466	81 062,4
386	United Kingdom	2007	46591,12819	5,08208E+11	31342736	81 963,9
387	United Kingdom	2008	43486,91323	4,51405E+11	31767975	84 467,3
388	United Kingdom	2009	35454,94893	3,2901E+11	31922923	78 120,1
389	United Kingdom	2010	36572,50006	3,41717E+11	32029852	84 813,5
390	United Kingdom	2011	38927,06931	3,53641E+11	32287857	70 202,0