Charles University

Faculty of Social Sciences

Institute of Economic Studies

MASTER'S THESIS

Analysis of Energy Economy to drive Ukraine's economic growth

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, July 31, 2017

Signature

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Abstract

This thesis investigates the relationship between energy consumption and economic growth in 15 post-Soviet states with a primary focus on Ukraine over the time period 1991-2013. First, panel unit root tests are applied to the time series for energy use and GDP for each post-Soviet country, then cointegration tests are run to identify the relationship between the variables. The empirical strategy of the panel data analysis is based on a neoclassical growth model specification, which includes the gross capital formation and total labor force of each country as additional explanatory variables for economic growth, along with energy inefficiency, % fossil fuel use, liberalization of the energy sector, and several other variables. The dataset is analyzed using Pooled OLS, Fixed Effects and Random Effects models, with Fixed Effects being identified as the optimal estimator. The results of the analysis show that there is a positive, bidirectional causality relationship between economic growth and energy consumption for Ukraine (the "Feedback Hypothesis"). In addition, the results of the panel data analysis suggest that reducing energy inefficiency, increasing "own production" of energy (including renewable energy), and liberalizing the energy sector of Ukraine could all be valuable strategies for increasing the country's economic growth.

JEL Classification	C12, C23, N70, O40, Q43
Keywords	energy consumption, economic growth, capital, labor, panel data, energy efficiency, post-Soviet states

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Abstrakt

Tato práce vyšetřuje vztah mezi spotřebou energie a ekonomickým růstem patnácti postsovětských republik s primárním zaměřením na Ukrajinu v období let 1991 – 2013. Testy panelových jednotkových kořenů jsou nejprve aplikovaný v časových řadách energetické spotřeby a hrubého domácího produktu (GDP) pro jednotlivé země bývalého Sovětského svazu. Poté jsou použity testy kointegrace pro identifikace vztahů mezi jednotlivými proměnnými. Empirická strategie analýzy panelových dat je založena na specifikaci neoklasického růstového modelu, který obsahuje gross capital formation a celkovou zaměstnanost jednotlivé země jako dodatečné vysvětlující proměnné pro ekonomický růst spolu s energetickou neefektivností v procentech (%), využití fosilních paliv, liberalizaci energetického sektoru a několik dalších proměnných. Datová sada je analyzována pomocí metody nejmenších čtverců (Pooled OLS), metody fixních efektů a metody náhodného modelu efektů, s čímž metoda fixních efektů je identifikována jako optimální estimátor. Výsledek analýzy ukazuje že existuje pozitivní obousměrný příčinný vztah mezi ekonomickým růstem a energetickou spotřebou Ukrajiny („Hypotéza zpětné vazby“). Navíc výsledek analýzy panelových dat naznačuje, že snižování energetické neefektivnosti zvyšuje vlastní produkci energie (včetně obnovitelné energie) a liberalizace energetického sektoru Ukrajiny by mohla být hodnotná strategie pro zvýšení ekonomického růstu země.

Klasifikace	C12, C23, N70, O40, Q43
Klíčová slova	Spotřeba energie, hospodářský růst, kapitál, práce, panelové údaje, energetická účinnost, bývalý Sovětský svaz

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Acronyms

GDP Gross Domestic Product

EU European Union

FE Fixed Effects

RE Random Effect

OECD Organization of Economic Co-operation and Development

OLS Ordinary Least Squares

VAR Vector Autoregressive

US United States

Master's Thesis Proposal

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Proposed Topic:

Analysis of Ukraine‘s energy sector as a potential driver of economic growth

Motivation:

Ukraine has one of the lowest gas prices for households in Europe (IEA, 2012). The retail gas and heating tariffs remain the lowest in Europe, at only eleven to twenty-five percent of the level in other gas-importing countries in the region and significantly below even levels in Russia, a major oil and gas producer (IMF 2014a). The Ukrainian state holding company Naftogaz Ukrainy buys natural gas domestically produced by partially state-owned companies at an extremely low price (Åslund, 2015).

Many have argued that Ukraine's energy sector should be reformed and that the state should allow energy prices to stabilize at the market level by eliminating subsidies, so that energy companies will be given normal price incentives to work more efficiently and people would be interested in saving energy. Such a solution has been implemented in many post-transition countries, with Poland and Estonia being two examples of success. The International Monetary Fund, World Bank, International Energy Agency, and Organization for Economic Cooperation and Development have all published reports in this area and endorsed the steps of energy sector liberalization.

While these steps are internationally recommended, how useful will they be in stimulating Ukraine's overall economic growth? The goal of this thesis is to analyze this central question, using several approaches.

Hypotheses:

The following hypotheses will be tested:

1. Hypothesis 1: The energy sector development of post-Soviet countries has been significant in determining their post-independence economic growth over the past ~25 years.
2. Hypothesis 2: There are specific policy measures related to Ukraine's energy sector that can be identified using panel data approaches that are more likely to be positive contributors to the country's economic growth than others.
3. Hypothesis 3: There is a positive two-way causality relationship between energy consumption and economic growth in Ukraine.

Methodology:

The following data will be used for testing hypotheses: State Statistics Service of Ukraine, Ministry of Energetics and Coal Industry of Ukraine, data from the World Bank, reports and researches of other governmental and international departments.
The main part of the analysis in this thesis will be devoted to studying the relationship between energy sector characteristics (such as the overall level of energy consumption) and economic growth in post-Soviet states with a focus on Ukraine, using panel data methods. I will create a panel dataset of post-Soviet countries and first run a regression examining how important energy sector developments were as determinants of economic growth. Then, I will run more detailed regressions that include specific energy sector characteristics (such as a dummy variable for energy sector liberalization, or a variable representing the percentage of fuel that is imported) to address hypothesis 2 and identify the policy measures most likely to contribute to economic growth.
My third hypothesis suggests that there is a positive two-way causality relationship from energy consumption to economic growth (the "Feedback Hypothesis"), given that further energy consumption could directly contribute to boosting the growth of the country's gross domestic product,while higher economic growth can also boost the energy sector (and energy consumption) through additional investments in this area. I plan to analyse this relationship by following time series analysis processes and test Granger causality using vector error correction model (VECM). These approaches should help determine which growth hypotheses hold in Ukraine, such as the Growth Hypothesis, Conservation Hypothesis, Feedback Hypothesis and Neutrality Hypothesis. The Growth Hypothesis is valid when there is a one-way causality relationship from energy consumption to economic growth. The Conservation Hypothesis is valid when there is one-way causality relationship from economic growth to energy consumption and due to this hypothesis economic growth is the factor which drives energy consumption. The Feedback Hypothesis is valid when there is a two-way or mutual causality relationship between energy consumption and economic growth, when energy-saving policies and energy supply shocks affect economic growth in a negative way and accordingly this negativity is reflected in energy consumption. The Neutrality Hypothesis is valid when there is no causality relationship between energy consumption and economic growth.

Expected Contribution:

Energy sector reform is a potential strategy for Ukraine to jumpstart its economy. The goal of this thesis is to empirically analyze how important the energy sector has been as a driver of economic growth in post-Soviet countries, as well as to identify specific policies that are most promising in terms of potential to help drive positive economic growth.

Outline:

The structure of the thesis will be as follows:

1. **Introduction:** discussion of the relevance of the proposed topic, motivation for choosing specific methodological approach
2. **Literature review:** will consist of a review of relevant literature related to the linkage between economic growth and energy efficiency
3. **Data:** full description of used data

4. **Methodology:** detailed description of the econometric models used for the panel data regressions and to test the main hypotheses of the study
5. **Results:** presentation of the results of my empirical analysis, including which hypotheses were found to hold
6. **Discussion:** a critical discussion of my results
7. **Conclusion:** summary of the main findings and policy implications for Ukraine.

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Author **Supervisor**

1 Introduction

The relationship between energy consumption and economic growth has been widely investigated in the economic literature. Many researchers have sought to determine how strong the dependence is between these two time series, and identify the presence of any causality between them. However, past works have not settled the direction of causality or the existence of this relationship clearly.

Such studies can be divided into two major groups. The first group suggests that energy is a critical input for economic and social development, that at the same time can also be a limiting factor for economic development. The second group shows that there is no dependence between energy consumption and economic growth – a concept referred to as the "neutrality hypothesis." Multiple papers have been written about the nature of the causality between energy consumption and economic growth for several post-Soviet countries, with some of the researchers including Ukraine in their analysis. However, none of these researchers made Ukraine the main focus of their investigation, or analyzed a panel including all the post-Soviet countries. A main hypothesis of this study is that a dependence between these two time series exists in the case of Ukraine.

There are few reasons why this analysis is important. First, given the growing tension with large oil producers such as Russia or countries in the Middle East, many countries are seeking to find strategies to reduce their dependence on energy imports within a reasonable time frame without greatly harming their economic growth. Two other related issues on the agenda are pollution and climate change, whose solutions include the greater use of renewable energy and policies to increase the efficiency of energy consumption. However, at the same time reducing energy consumption can lead to lower economic growth, so the main question is how to gradually increase energy efficiency and reduce the use of fossil fuels without negatively influencing the economy.

Ukraine has the lowest gas price for households in Europe (IEA, 2012). Retail gas and heating fees remain the lowest in Europe, at only 11 to 25 percent of the level in other gas-importing countries in the region and significantly below even levels in Russia, a major oil and gas producer (IMF 2014a). The Ukrainian state holding company Naftogaz Ukrainy buys natural gas domestically produced by partially state-owned companies at an extremely low price (Åslund, 2015).

Economists have argued that Ukraine's energy sector should be reformed and that the state should allow energy prices to stabilize at the market level by eliminating subsidies, so that energy companies will be given normal price incentives to work more efficiently and people would have a greater reason to save energy (Åslund, 2015). Such a solution has been implemented in many post-transition countries, with Poland and Estonia being two examples of success. The International Monetary Fund (IMF), World Bank, International Energy Agency, and Organization for Economic Cooperation and Development have all published reports in this area and endorsed the steps of energy sector liberalization.

While these steps have been recommended internationally by organizations like the World Bank and IMF, how useful will they be in stimulating Ukraine's overall economic growth? The goal of this thesis is to analyze this central question, using several approaches.

The main part of the empirical analysis in this thesis will be devoted to studying the relationship between energy consumption and economic growth in post - Soviet countries - with a focus on Ukraine - using causality tests and panel data methods. These methods allow the determination of which hypothesis of growth holds for each country, with the four possible hypotheses consisting of the Growth Hypothesis, the Conservation Hypothesis, the Feedback Hypothesis and the Neutrality Hypothesis. Below, I explain my three main hypotheses in more detail.

1. Hypothesis 1: The energy sector development of post-Soviet countries has been significant in determining their post-independence economic growth over the past ~25 years.

2. Hypothesis 2: There are specific policy measures related to Ukraine's energy sector that can be identified using panel data approaches that are more likely to be positive contributors to the country's economic growth than others.

3. Hypothesis 3: There is a positive two-way causality relationship between energy consumption and economic growth in Ukraine.

Energy sector reform is a potential strategy Ukraine could employ to jumpstart its economy. The goal of this thesis is to empirically analyze how important the energy sector has been as a driver of economic growth in post - Soviet countries, as well as to identify specific areas that are most correlated with positive economic growth.

The main part of the analysis in this thesis will be devoted to studying the relationship between energy sector characteristics (such as the overall level of energy consumption, energy efficiency and fossil fuels consumption) and economic growth in post-Soviet countries - with a focus on Ukraine - using panel data methods. The analysis of a panel dataset of post - Soviet countries helps to examine how important energy sector developments were as determinants of economic growth. More detailed regressions that include specific energy sector characteristics (such as a dummy variable for energy sector liberalization, or a variable representing the percentage of fuel that is imported) are used to investigate hypothesis 2 and identify the policy measures most likely to contribute to economic growth.

The third hypothesis suggests that there is a positive two-way causality relationship from energy consumption to economic growth in Ukraine (the “Feedback Hypothesis“), given that further energy consumption could directly contribute to boosting the growth of the country’s gross domestic product, while higher economic growth can also boost the energy sector (and energy consumption) through additional investments in this area. This relationship is analyzed using time series analysis processes and tests for Granger causality using a vector autoregressive model (VAR). These approaches should help determine which growth hypotheses hold in Ukraine, such as the Growth Hypothesis, Conservation Hypothesis, Feedback Hypothesis and Neutrality Hypothesis. A paper by Koçak and Şarkgüneşi (2016) discusses these four primary hypotheses in order to test the direction of the relationship between energy consumption and economic growth. The Growth Hypothesis is valid when there is a one-way causality relationship from energy consumption to economic growth. The Conservation Hypothesis is valid when there is one-way causality relationship from economic growth to energy consumption and due to this hypothesis economic growth is the factor which drives energy consumption. The Feedback Hypothesis is valid when there is a two-way or mutual causality relationship between energy consumption and economic growth, when energy-saving policies and energy supply shocks affect economic growth in a negative way and accordingly this negativity is reflected in energy consumption. Besides that, the Feedback Hypothesis can show the interdependent relationship between GDP and energy consumption where each component may act as a complement to each other. In the presence of such a relationship, increase in energy consumption results in increase in GDP and the other way around increase in GDP may result in increase in energy consumption and other way around. The Neutrality Hypothesis is valid when there is no causality relationship between energy consumption and economic growth (Koçak and Şarkgüneşi, 2016).

In the following empirical section, in which we discuss cointegration and causality between Ukraine’s energy consumption and economic growth, the time series data of GDP per capita and energy consumption per capita during 1991 – 2013 period for Ukraine was used. Energy consumption per capita is expressed in terms of kilograms of oil equivalent. The choice of the starting period is constrained by the availability of data for the post-Soviet period, as Ukraine is independent country as of year 1991.

This thesis is organized as follows. Chapter 1 provides an introduction to the topic of the research. Chapter 2 provides a Literature Review with a discussion of hte different articles and findings which are crucial for understanding the topic and past analyses of the causality relationships for different countries. Chapter 3 is divided into two parts, where the first part presents the current state of Ukraine's economy and its energy sector, and the second part presents the current state of the energy sectors of post-Soviet countries. Chapter 4 describes the model specification and empirical approach used in this thesis. In Chapter 5 is included a description of the data used for the analysis. Chapter 6 presents a discussion of the results obtained and possible policy implications, which can be implemented based on the results and possible future investigations. Chapter 7 presents the conclusion of the thesis, as well as possible policy implications and recommendations, which could be implemented in the case of Ukraine.

2 Literature Review

The relationship between energy consumption and economic growth has been widely discussed and debated by economists and has been a focus of multiple empirical investigations in many countries. Energy economists note that energy is an important stimulus for wealth creation (Stern, 2011), because it plays a large role in output production for the economy as a whole and in addition influences the level of economic growth (Beaudreau, 2005). The historical data indicate a strong linkage between energy availability, energy progress, improvements of living standards and social well-being (Nathwani et al., 1992). Ways to estimate the impact of energy consumption on economic growth has attracted the attention of many energy researchers, with most of the available theoretical and empirical sources indicating that the degree that energy and energy consumption has contributed to productivity development and overall economic growth has been underestimated (Sorrell, 2010).

On one hand, energy is vital and a necessary input together with other factors of production. It is required for economic and social development, so it can be a "limiting factor of economic growth" (Ghali & El-Sakka, 2004). On the other hand, since the cost of energy is a very small proportion of gross domestic product, it might not have significant impact on economic growth. For example, if energy is a significant contributor to GDP, then when consumption of energy is reduced, it could lead to a fall in income and employment.

In Table 2.1. can be found a short overview of the selected studies to represent the relationship between energy consumption and economic growth in different countries and the direction running between them, in there it is very well represented that causality relationships does not depend if country is developed or developing and can show different results for any of them.

Table 2.1. Overview of selected studies on the energy consumption - GDP nexus

Study	Method	Countries	Result
Kraft and Kraft (1978)	Bivariate Sims Causality	USA	Growth —> Energy
Yu and Choi (1985)	Granger Test	USA, UK, Poland, Korea, Philippines	Growth – Energy Energy —> Growth
Masih and Masih (1996)	Sims Causality, Granger Causality	Malaysia, Singapore Philippine Pakistan India Indonesia	Growth – Energy Growth – Energy Growth <-> Energy Energy -> Growth Growth -> Energy
Yu and Jin (1992)	Bivariate Granger test	USA	Growth – Energy
Stern (1993)	Granger Causality	USA	Growth – Energy
Glasure and Lee (1998)	Bivariate VECM	S. Korea & Singapore	Growth <-> Energy
Cheng (1999)	Bivariate VECM	India	Growth —> Energy
Asafu-Adjaye	Trivariate VECM	India & Indonesia Thailand & Philippines	Energy —> Growth Growth <-> Energy
Soytas and Sari (2003)	Bivariate VECM	Turkey, S. Korea Argentina Canada, USA & UK	Growth —> Energy Growth <-> Energy Growth <-> Energy
Fatai et al. (2002)	Granger Causality	New Zealand	Growth – Energy
Altinay and Karagol (2004)	Hsiao`s version of Granger Causality	Turkey	Growth – Energy
Oh and Lee (2004)	Trivariate VECM	South Korea	Growth <-> Energy
Navarayan and Smyth (2008)	Multiv. Panel VECM	G7 Countries	Energy —> Growth
Apergis and Payne (2009)	Multiv. Panel VECM	11 countries of the Commonwealth of Independent States	Growth <-> Energy
Ozturk et al. (2010)	Panel Causality	51 countries Low income Lower middle income Upper middle income	Growth -> Energy Growth <-> Energy Growth - Energy
Lee and Lee (2010)	Multiv. Panel VECM	25 OECD Countries	Growth <-> Energy
Bekle et al. (2010)	Granger Causality Test	25 OECD Countries	Growth <-> Energy
Kaplan et al. (2011)	Granger Causality Test	Turkey	Growth <-> Energy
Adom (2011)	Toda Yamamoto Granger Causality Test	Ghana	Growth —> Energy
Souhila & Kourbali (2012)	Granger Causality Test	Algeria	Growth —> Energy
Apergis and Danuletiu (2012)	Panel Cointegration and VECM	Romania	Energy —> Growth

Note: Growth -> Energy means that the causality runs from economic growth to energy consumption. Growth <-> Energy means that bi-directional causality exists between economic growth and energy consumption. Growth - Energy means that no causality exists between economic growth and energy consumption. Energy -> Growth means that the causality runs from energy consumption to economic growth.

Source: author's compilations

Masih and Masih (1997) seek to analyze whether or not there is causality between energy and GDP growth, and which energy policies may be implemented without harmful side effects on growth and employment, in their paper are included following countries: China, India, Indonesia, Malaysia, Philippines and Thailand. However, a greater causal link between the energy sector and the growth of gross domestic product in developing countries could lead to a larger effect in developing countries when compared with more affluent, developed countries. In this case, any decrease in energy consumption should be undertaken by the developed world in the first place, and not stress the development of less developed countries.

After the publication of the work of Kraft and Kraft (1978), a number of articles have researched whether causal relationships exist between levels of energy consumption and economic growth in both developed and developing countries, but still the empirical results are conflicting. For example, Kraft and Kraft (1978) show that there is unidirectional causality running from real gross national product to energy consumption in the United States of America using data spanning the years between 1947 and 1974. From the other side, Akarca and Long (1980) replicate the work and exclude 1973 - 1974 years from the sample and discuss that the causal relationship showed by Kraft and Kraft (1978) is false and sensitive to the sample period, because of the temporary instability of the oil crisis and price shock.

Yu and Hwang (1984) apply two causality tests, those proposed by Sims (1972) and Granger (1969), for an extended annual dataset from 1947 to 1979 for the United States. In conformity with Akarca and Long (1980), they find that there is no causal relationship between gross national product and energy consumption in the United States. However, when the authors replicated their work using quarterly data and show that there is a unidirectional causality running from income to energy consumption from 1973 to 1981.

More recently, the problem of the causality relationship between energy consumption and economic growth has been addressed by Chontanawat *et al.* (2008), Apergis and Payne (2009), Akinlo (2009), Ozturk and Acaravci (2010), Menegaki (2011), among others. They agree that the reason for this interest is an increased concern about the impact of energy consumption on national economies. But the debate is still not settled, and there is no universally accepted answer regarding the impact of energy consumption on economic growth.

A number of scientists argue that there *is* a causal relationship (Narayan and Smyth, 2008; Akinlo, 2009); they agree that a decrease in energy consumption may restrain economic growth. Other scientists, such as Yoo (2006), Chen et al. (2007) and Jinke et al. (2008), suggest a reverse relationship - economic growth causes energy consumption. Bi-directional causality was found by Mahadevan & Adjaye (2007) and Paul & Bhattacharya (2004), who suggest that large increases in energy consumption can affect economic growth and stimulate further energy consumption in the future. The neutrality hypothesis was put forth by Ozturk & Acaravci (2010), who argue that there is no causal relationship.

Chiou-Wei et al. (2008) investigate the causality between energy consumption and output for eight Asian countries and the United States of America using linear and nonlinear causality tests. They found that in the cases of Taiwan, Singapore, Malaysia and Indonesia causality is reversed, when in the inter-relationship between the variables possible nonlinearity is allowed. Nevertheless, in the cases of South Korea, Hong-Kong, Philippines, Thailand and the United States of America both linear and nonlinear causality tests suggest the same direction of causality or non-causality.

Reynolds and Kolodziej (2008) in their work confirm the absence of causality for Ukraine, as for other countries from the Former Soviet Union. No long run equilibrium is found between electricity energy consumption and economic growth in Ukraine in the research of Acaravci and Ozturk (2009) for 15 transition countries. Apergis and Payne (2009) conclude that total energy consumption has an impact on economic growth and vice-versa using a panel of Commonwealth of Independent States, including Ukraine.

Kalyoncu et al. (2013) investigate the relationship between energy consumption and growth rate in Georgia, Azerbaijan and Armenia by using cointegration methods and causality test. They find that this relationship is not co-integrated for Georgia and Azerbaijan, but is co-integrated for Armenia, and there is a one-way causality from gross domestic product per capita to energy consumption per capita in Armenia (Kalyoncu et al., 2013).

Śmiech & Papież (2013) examined short-run and long-run causality between energy consumption and economic growth. Authors provided investigation over the time period of 1995 to 2010 for countries of Central and Eastern Europe. They created a multivariate model utilizing a production function with four included variables: economic growth, capital, labor and energy consumption. Different tests were used for testing the model, e.g. the testing of unit roots was provided by the Levin, Lin and Chu unit root test, the Im, Pesaran and Shin unit root test and the Maddala and Wu unit root test, for identifying cointegration relationships between variables. In addition, 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), and the short-run relationship was estimated using panel Vector Error Correction Model (VECM) (Śmiech & Papież, 2013).

Studies on the causality relationship between energy consumption and economic growth used time series analysis and a log-linear model calculated using the ordinary least squares method. Later Granger causality (Granger 1969), cointegration, and the vector error correction model (VECM) were deployed to analyze the causal relationship between energy consumption and economic growth.

Masih and Masih (1996) established that there was a cointegration relationship between gross domestic product and energy consumption for India, Indonesia and Pakistan, but no cointegration for Singapore, Malaysia and the Philippines. Nevertheless, the VECM approach gave different results, with causality being observed to run from energy to gross domestic product in India and from gross domestic product to energy consumption for Indonesia. Moreover, in the case of Pakistan, there was bi-directional causality. Data from the Philippines, Malaysia and Singapore were tested by the vector autoregression (VAR) approach, and no causality was discovered in any of the three cases (Masih & Masih (1996)).

An oil market report published in 2012 by Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA, 2012) provides clarity in asserting that oil is still the leading form of energy, because of its flexibility and transportability. That is why the impact of oil prices on economic growth has attracted the attention of many economists during the 1970s. Dogrul and Soytas (2010) suggest that increase in oil prices lead to an increase in the production costs of many sectors, which might reduce production and increase unemployment, at the same time also helping to lead to inflation. In addition, increases in oil prices destroy the export competitiveness of an economy, which is crucial if a country's industries are dependent on importing raw materials and intermediate goods (Dogrul & Soytas, 2010).

To *et al.* (2012) tested the casual relationship between energy consumption and economic growth for 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 bounds-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).

Mudarissov and Lee (2014) in their work investigated the causal relationship between energy use and economic growth for the Republic of Kazakhstan in years 1990 – 2008. In the paper, they tasted Granger causality using the VECM, and augmented Dickey - Fuller and Phillips - Perron unit root tests, as well as the cointegration test. The empirical results showed unidirectional causality relationships running in different direction in the long and short terms. Their results do not follow the neoclassical approach where energy consumption does not have any effect on economic growth in long term. Mudarissov and Lee (2014) concluded that energy conservation policies can slow down economic growth. In terms of the short run, the results showed opposite, causality runs from GDP to energy consumption, which says that energy conservation policies are more than needed.

Vlahinić-Dizdarević and Žiković (2010) examined the causal relationships between energy and economic growth in Croatia in time period from 1993 and 2006, they used a model, which included such variables as real GDP and five energy variables, containing energy consumption in industry and households, net energy imports, primary energy production and oil consumption. Once authors tested all relationships and found cointegration between them, they used an Error Correction Model, which helped to distinguish long and short - term relationships between variables. The empirical results clearly showed causality running from real GDP growth to all energy variables. Their research showed results which are more familiar to the ones investigated for developed and post-industrial economies with strong tertiary sector (Vlahinić-Dizdarević & Žiković (2010)).

Adom (2011) wrote the article about the relationships between electricity consumption and economic growth in Ghana. Previous works investigated in this field were mixed up in the literature for Ghana, main priority for author was to find the direction of causality running between energy, electricity and economic growth. Adom (2011) used the Toda and Yomamoto Granger Causality in order to test the causality between electricity and economic growth. The obtained results showed unidirectional causality running from economic growth to electricity, so the conservation policies can be valuable investigation for Ghana (Adom, 2011).

3 The current state of energy sector

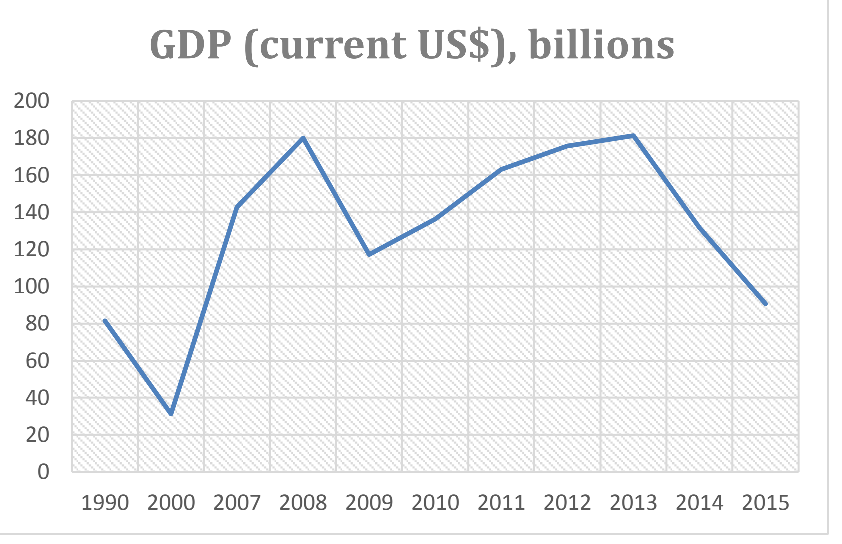
This chapter is divided into two parts. In the first part, the current state of the Ukrainian economy is described and a discussion on the current state of the Ukrainian energy sector is provided. The second part includes a discussion on the energy sectors of the 14 post - Soviet countries, including Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.

3.1 The current state of Ukraine's economy

In just two years, between 2013 and 2015, the GDP of Ukraine has been dramatically reduced by half (Figure 3.1.1). This reduction in output can be explained by the conflict in the eastern part of the country, which has led to the internal displacement of thousands of people, and has made life in general significantly more difficult for many Ukrainians, not only because of the conflict, but also because the country's economy is in a desperate situation. The inflation rate has risen to almost 50 percent, and has become the second highest around the world after Venezuela. In addition, Ukraine's unemployment rate has risen to over 11 per cent in current times.

The industrial Donbass region, located in the eastern part of the country, has also been ruined. Russia was the most important import and export partner of Ukraine, but does not still play this role, leading to a great shift in the country's base economy. Ukraine's national debt in relation to GDP increased by over 50 per cent in the last two years and remains unsustainable. The economy is expected to recover in coming years, but its medium- and long-term stability will depend on the ability of the country to create an environment in which the economy can operate and recover.

Figure 3.1.1. GDP of Ukraine, 1990 - 2015



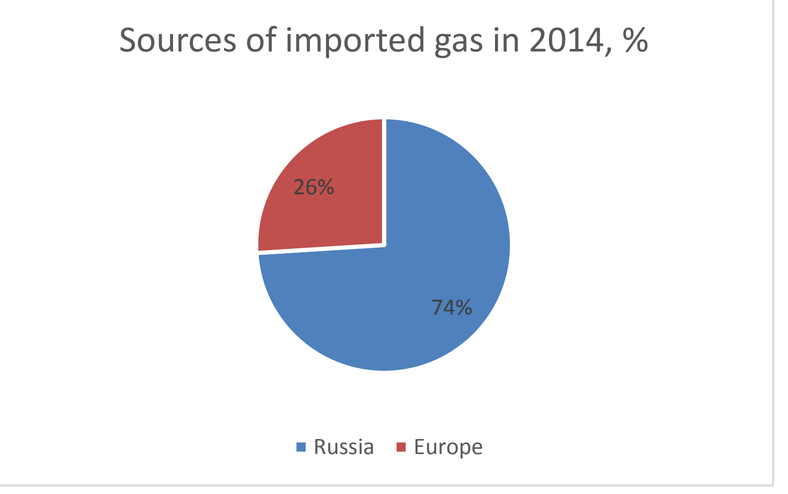
Source: author's computations

The state-owned enterprise Naftogaz Ukrainy is the country's leading energy company, which owns around 97% of Ukraine's oil and gas output. Europe gets about a quarter of its gas from Russia, about four-fifths of that flows through pipelines across Ukraine. However, most of the gas shipped to Ukraine comes from Turkmenistan, a former Soviet republic in central Asia, which sells its fuel cheaper than Russia.

In 2015, imports of gas from the European market more than doubled from 5.0 to 10.3 bcm according to Ukrtransgaz, the Ukrainian gas transmission company (Figure 3.1.2a and Figure 3.1.3b). According to its diversification program launched in 2014, Naftogaz Ukrainy imports gas from more than 10 suppliers now. In 2015, the import from the Russian Federation decreased by more than twice compare to 2014, from 14.5 to 6.1 bcm. Since Euromaidan, Ukraine has become substantially more independent from the Russian Federation in terms of its energy imports.

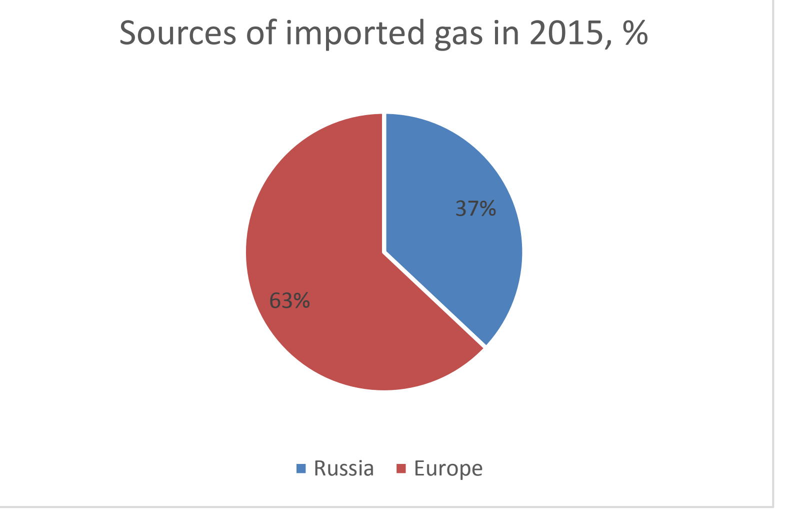
The past two years also brought a significant increase in imports by private traders and gas consumers from the European market. Naftogaz Ukrainy share in imports from Europe decreased to the advantage of the private importers. Last year, private importers imported 1.1 bcm of gas compared to 0.14 bcm in 2014, a 7.5 times increase (Naftogaz, 2015). This change follows the introduction from 1 October 2015 of a new regulatory framework as well as other steps aimed at the creation of an open and competitive gas market in Ukraine. In 2016, Naftogaz Ukrainy did not have any import of natural gas from Russia going to Ukraine.

Figure 3.1.2a. Sources of imported gas in year 2014



Source: Naftogaz Ukrainy

Figure 3.1.2b. Sources of imported gas in year 2015



Source: Naftogaz Ukrainy

Ukraine has successfully implemented reverse gas supplies from Poland, Hungary and Slovakia. In 2013 about 2.2 bcm of gas was produced from the spot markets in the EU. In 2014 and in subsequent years, reverse gas supplies may grow to 10-12 bcm, providing significant diversification and reducing dependence on a monopoly supplier. The pipeline, with a current capacity of 27 mm per day (almost 10 billion. Cubic meters per year), was officially launched for the supply of natural gas to Ukraine from the EU through Slovakia at the beginning of September 2014.

Ukraine covers domestic electricity consumption from its own production. Generating capacities include nuclear, thermal and hydroelectric power plants. Excess electricity of Ukraine goes to Europe, mainly to Hungary, Slovakia, Romania and Moldova. Ukraine has a preferential tariff system, which contributes to the development of renewable energy sources.

The country has large reserves of biomass that can be used for heating and co-generation instead of gas and coal. Number of implemented projects is growing rapidly across the country. Households, utilities and industry have great potential for energy savings (up to 60%) due to reconstruction, rehabilitation and modernization. Rising energy prices stimulate changes in the Ukrainian legislation and consumer behavior towards higher energy efficiency.

Nevertheless, energy efficiency and savings are still not a priority in the strategic documents of the country, despite their crucial value for balancing public and private budgets. Existing state energy development programs conflict with each other in terms of renewable energy and energy efficiency targets, which is dominated by the goal of increasing production capacity in all areas, instead of supporting energy conservation.

Manufacturers are accustomed to receiving government subsidies in accordance with the volume of the energy sources and, hence, are not interested in improving the generation capacity and distribution networks. The non-transparent privatization of energy assets has led to a merger of business and political groups, which have an intention to control and non-transparently allocate financial resources – the profit goes to individuals, while the state is left with debts.

3.2 The current state of Transcaucasia, The Commonwealth of Independent States, Baltic states and Central Asia energy sectors

Transcaucasia, or South Caucasus, includes Georgia, Armenia, and Azerbaijan; Central Asian republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The Commonwealth of Independent States (CIS) includes Russia, Ukraine, and Belarus together with named above Transcaucasia and Central Asia republics, and Moldova. The EU Member States – Estonia, Latvia and Lithuania.

The Transcaucasia (South Caucasus) is often associated with the main route to energy-rich Caspian region between the European Union (EU) and Western actors. The

EU's energy security strategy (European Commission, 2014) considers the South Caucasus as a strategic transit route between Caspian energy resources and European markets.

Armenia does not have substantial local energy resources and imports around 75 per cent of its total energy supply (IEA, 2015). Natural gas comes mainly from Russia through Georgia, and accounts for two thirds of the country's energy supply, with a smaller volume of Iranian gas being used for electricity. Armenia is very dependent on Russian nuclear fuel, which is used for the generation of over one third of the country's electricity at Armenia's only nuclear power plant in Metsamor. Renewable resources make up seven per cent of Armenia's total energy supply. There is a production and even export of the electricity in the country, but its key generation capacities are expected to become outdated in the next few years, so there is a great need for investment.

Azerbaijan has large oil and natural reserves, and is considered a major energy producer among post - Soviet countries. Hydrocarbons are mainly exported to markets in Europe, with a smaller amount going to Russia and other countries in the region. This export explains the sharp economic growth of Azerbaijan in the past ten years; however, the country has faced a slow-down due to the decline in oil production as a result of the drop in oil prices and low growth in its non-oil sector in recent years. The plan of the government is to become an important energy transit country for the European Union, and the country is also interested in involving Iraq and other energy-rich countries in Central Asia.

The Republic of Georgia has an advantage compared with other contries in South Caucasus, in that it has access to Black Sea and land transit links between energy exporter and importer countries, which makes the country a strategic player in gas transit. Georgia has access to the Southern Gas Corridor through the Trans-Anatolian Natural Gas Pipeline, which connects Europe with Azerbaijan through Georgia and Turkey. Natural gas is mainly imported from Azerbaijan, a very small amount comes from Russia, which was the main provider earlier. Georgia owns a large amount of hydropower resources, which are divided between energy suppliers (17 per cent) and electricity generation (80 per cent). However, Georgia depends on regional trade due to the seasonal volatility of hydropower supply, which explains why the country is so interested in developing a greater level of interconnectedness with the countries around its borders.

Kazakhstan is one of the most developed Central Asian countries, it has almost completed its transitional phase and transformed into an industrial country. Kazakhstan has learnt from other transitional and developing economies. The country is open to international trade, its main export goods are oil, petroleum products, coal, iron ore, chemical products, machinery, cereal, wool and meat. The main export partners for Kazakhstan include China, followed by Russia and Germany. The country mainly imports machinery, electric and electronic equipment and food products. Kazakhstan recovered from its recent financial crisis mainly due to the revenue generated through oil export (Saleheen et al., 2012).

Despite of previous countries Kyrgyzstan has problems related to its energy independence. The country's energy sector cannot be expected to become a significant source of economic growth, but this sector has sufficient potential to contribute into economic growth long-term. Economic crisis, market reforms, economic relations and increase in energy consumption have worsened the situation and negatively affected the development of its energy market. Its energy needs cannot be satisfied by energy resources, and as a result Kyrgyzstan is completely dependent on petrol from Russia, gas from Uzbekistan and the rest from Kazakhstan.

According to the report published by Energy Charter Secretariat published in 2014, Tajikistan relies on hydropower for its electricity production for almost 97 per cent of the generated electricity, which comes from existing hydropower plants. This makes the country vulnerable to variations in precipitation and climate change. When Uzbekistan withdrew from the Central Asian integrated power transmission network in 2009, Tajikistan lost its ability to import electricity from there. Nevertheless, interconnections still remain with Kyrgyzstan and Afghanistan. The country has significant electricity shortages in winter due to the high demand for heating in winter, loss of electricity imports and dependence on hydropower system (Energy Charter Secretariat, 2013). Tajikistan still remains the poorest country in the Europe and Central Asia (ECA) region, and economic growth remains largely dependent on the external environment, particularly the country's ability to access energy imports to overcome chronic shortages in winter.

Turkmenistan has the worst situation in terms of economic and trade liberalization compared with the other Central Asian countries. For example, Kyrgyzstan and Kazakhstan rapidly reoriented their economies in more market oriented direction, while Turkmenistan preferred to follow a 'national way of development' and did not attempt to modernize its economy, which remains to be as it was during Soviet era. Turkmenistan is also noted to have a large budget surplus stemming from the exploitation of energy sources in the country. This is leading to more needed investments in infrastructures and public services. Sadly, even taking into account economic changes and new policies the country's overall situation is unlikely to improve in the near future. Its economy depends on large, state-owned companies, especially focused in heavy industry and more recently oil and gas industry.

Uzbekistan is one of the most energy- and carbon-intensive countries in the world (IEA, 2010). Energy sector supports Uzbek sustained growth and private sector development, country relies on abundant fossil fuel energy resources. In 2010, export of natural gas accounted for 29% of total export and 10% of Uzbek gross domestic product (GDP). At the same time aging of infrastructure and lack of investment has been leading to decline in oil production, so government is seeking for the solution how to enhance output of its petroleum and natural gas, attract attention of direct foreign investment and increase exports (IEA, 2010).

The Republic of Belarus is heavily dependent on oil and gas imports (mainly from the Russian Federation), as it does not have sufficient primary energy sources. Its imports of fuel and energy are around 85% of total consumption (Energy Charter Secretariat, 2013). Since the begging of 1990s, country has chased a consistent government policy to improve the energy efficiency of Belarusian economy, which include the establishment of a regulatory framework, mechanisms of state support and investments, system of key performance indicators. The country has developed an infrastructure for transporting oil, oil products and electricity. The significant growth of GDP has not resulted in a material change in primary and final energy consumption. Over two decades (1990 – 2000 and 2000 - 2010) the energy intensity of Belarus' GDP decreased 2.7 times, and the gross consumption of fuel and energy resources decreased 1.6 times, with GDP increasing by more than 1.5 times (Energy Charter Secretariat, 2013).

The Russian energy sector is a pillar for constant economic growth of the country. The Russian Federation holds one of the world's largest reserves of gas, oil and coal. Its liquids production has reached historical highs, yet major additional upstream investments and technology upgrades will be needed to sustain these levels in the long term (International Energy Agency, 2014). Its gas production is also at high levels, with Gazprom being the dominant producer, and with other companies now taking significant roles. Russia experienced a decade in the 2000s of almost uninterrupted strong economic growth figures – the Russian economy grew 4.7% on average in the period 2001 - 12, including 6.6% in the period 2001-08. However, the economy slowed down to 1.3% annual growth in 2013 despite continued very high Ural oil price levels close to USD 110 per barrel (USD / bbl). This has underlined the existence of fundamental obstacles to growth requiring structural economic reforms, as the increase in oil prices and production is no longer driving economic growth as in previous years (International Energy Agency, 2014).

Moldova has small reserves of coal, petroleum and natural gas, this led to its dependence on imports from Russia, Ukraine and Romania. In 2013 total import consisted 87% of the total energy supply, main part of this was natural gas (44.7%) and petroleum (34.1%). Key challenges of county's energy sector are insufficient generation capacity located on the right bank of the Nistru river, where electricity generation represents only 30% of total consumption, and advanced level of degradation of power stations, high voltage power lines and distribution frameworks. The energy intensity of country has significantly decreased from 2005, but at the same it remains relatively high compare to the level within EU.

According to the report of International Energy Agency report published in 2013, Estonia is one of the unique countries among European Union (EU) member states, its energy sector is dominated by only one primary source of energy, oil shale. The country is one of the largest producers of oil shale in the world and its domestic energy sector relies heavily on this source, from which the majority of its electricity is produced (IEA, 2013). This Baltic state is largely self-sufficient in energy terms and is able to meet its electricity and heat needs from domestic sources. The usage of oil shale reserves for heat and electricity production provides Estonia with a level of energy autonomy, but oil shale transformation to electricity and heat is by its nature carbon dioxide (CO2) intensive and thus raises questions of long-term sustainability. Over the longer term, the Estonian government is trying to examine measures to reduce the use of oil shale for electricity production and increase production of shale oil, which may bring measurable economic benefits and diversify energy supply (IEA, 2013).

ERRA (2013) has published a work on Baltic Energy Market Profile and claimed that Latvia is a net energy importer country. The state-owned company JSC "Latvenergo" dominates the field of electricity supply in Latvia, controlling more than 90% of installed capacity for the generation and produces about 85 % of the total generation volume in Latvia. Natural gas supply to Latvia is highly dependent on external suppliers – Russian Gazprom and "IteraLatvija" Ltd. Alternative gas supplies would become possible if the Russian gas market will be liberalised, and connections to other EU countries and Norway will be ensured, or the liquefied natural gas storage and/or regasification plant will be built. All of this would require significant investments, and they would not be cost-effective at the current falling annual consumption of natural gas (ERRA, 2013).

Lithuania is a part of the European smallest national gas markets until recent dependent, just like Latvia and Estonia, on imported Russian pipeline gas for all its natural gas requirements. After decades of dependence on a single natural gas supplier exported from Russia, the Lithuanian state reformed its natural gas market in just a few years (Pakalkaité, 2016). The shareholders of the main Lithuanian natural gas company, Lietuvos Dujos, initially responded by persuasion, legal and diplomatic tools, but eventually had to implement the gas transmission ownership unbundling option. The Lithuanian state bought the shares of Lietuvos Dujos. Simultaneously, the Lithuanian state established a liquefied natural gas terminal on the shore of the Baltic Sea, which has been operational since the end of 2014 (Pakalkaité, 2016).

4 Methodology

The main focus of this thesis is to analyze the relationship between energy consumption and economic growth. First of all, a neo-classical production function will be established in order to test the dependence of economic growth with other variables, then multiple panel unit toots rest will be used in order to see whether our variables are stationary or not. Pedroni (1999) cointegration test will help to examine the cointegration between variables if it exsists. The next part of methodological part is devoted to description of vector autoregressive model and Granger causality test. The last part is devoted to Granger causality analysis for remaining 14 post – Soviet countries.

4.1 Model Specification

In this thesis, the relationship between energy consumption and economic growth of post-Soviet countries will be examined using a neo-classic production function where the technology component is replaced with energy consumption variable. In this case, production function of capital, labor and energy use is defined as follows:

$$Y = f(\, K_{it}, L_{it}, E_{it}),$$

where Y stands for economic growth or gross domestic product per capita, K stands for gross capital formation, L is total labor force and E stands for energy consumption. One of the most commonly used ways to study the relationship between economic growth and its determinants is the static panel data models. In this study, the panel-data analysis technique was chosen because it has an advantage of containing the information necessary to deal with both the intertemporal dynamics and the individuality of the entities being investigated.

There are basically three types of panel-data models namely, a pooled Ordinary Least Square (OLS) regression, panel Random Effect model and panel Fixed Effects model.

The formal model of pooled OLS regression is written as follows:

$$Y_{it} = \beta_{1i}K_{it} + \beta_{2i}L_{it} + \beta_{3i}E_{it} + \varepsilon_{it}$$

In the equation i and t show number of countries and time period. β_1, β_2 and β_3 are revenue resilience of capital, labor and energy consumption and ε is the error term. However, when using a pooled OLS regression, unobservable individual effects of countries are not controlled. Bevan and Danbolt (2004) in their work mentioned that heterogeneity of the countries under consideration for analysis can influence measurements of the estimated parameters. Panel-data models with incorporation of individual effects, has a number of benefits, for example, it allows us to account for individual heterogeneity.

4.2 Panel Unit Root Tests

In order to test whether our variables are stationary or not, multiple unit root tests will be used. It includes Levin, Lin, and Chu (2002) and Maddala and Wu (1999) for testing data with none of the effects, individual effects and individual effect with trends will be tasted by the test mentioned above and also by Im, Pesaran and Shin Test (2003) and Hadri (2000).

4.3 Pedroni Panel Cointegration Test

Pedroni (1999) followed the introduction of the residual-based cointegration tests and extended his panel cointegration testing procedure for the models where there are more than one independent variable in the regression equation.

The starting point of the residual-based panel cointegration test statistics of Pedroni (1999) is the computation of the residuals of the hypothesized cointegrating regression:

$$y_{i,t} = \alpha_i + \delta_{i,t} + \beta_{1i}x_{1i.t} + \beta_{2i}x_{2i.t} + \ldots + \beta_{Mi}x_{Mi.t} + \varepsilon_{i,t}, t = 1, \ldots, T; i = 1, \ldots, N,$$

where T is the number of observations, N represents the number of individual members in the panel, and M is the number of independent variables. The slope coefficients $\beta_{1i}, \ldots, \beta_{Mi}$ and member specific intercept α_i are assumed to vary across each cross-section, and $\delta_{i,t}$ allows for time trends.

The null hypothesis suggests that there is no cointegration between variables H_0: $\rho_i = 0$. Akaike information criterion (AIC) is used for lag length selection for statistical analysis.

Pedroni uses seven residual based tests, first block is panel based and includes panel υ, panel ρ, panel *PP* and panel *ADF*.

Panel υ-Statistic: $Z_v = (\sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} e_{it-1}^{2})^{-1}$

Panel ρ-Statistic: $Z_\rho = (\sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} e_{it-1}^{2})^{-1}(\sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} (e_{it-1}\Delta e_{it} - \lambda_t))$

Panel PP-Statistic: $Z_t = (\sigma^2 \sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} e_{it-1}^{2})^{-1/2}(\sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} (e_{it-1}\Delta e_{it} - \lambda_t))$

Panel ADF-Statistic: $Z_t^* = (s^{*2} \sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} e_{it-1}^{*2})^{-1/2}(\sum_{i=1}^{N}\sum_{t=1}^{T} R_{11i}^{-2} (e_{it-1}{}^{*}\Delta e_{it}{}^{*}))$

Group Pedroni (1999) tests are calculated as following three statistics: group ρ, group PP and group ADF. Previous panel statistics are based on the within dimension of the panel, group statistics are based on between dimensions of the panel.

Group ρ-Statistic: $\tilde{Z}_\rho = \sum_{i=1}^{N}(\sum_{t=1}^{T} e_{it-1}^{2})^{-1}\sum_{t=1}^{T}(e_{it-1}\Delta e_{it} - \lambda_t)$

Group PP-Statistic: $\tilde{Z}_t = \sum_{i=1}^{N}(\sigma^2 \sum_{t=1}^{T} e_{it-1}^{2})^{-1/2}\sum_{t=1}^{T}(e_{it-1}\Delta e_{it} - \lambda_t)$

Group ADF-Statistic: $\tilde{Z}^{*}{}_t = \sum_{i=1}^{N}(\sum_{t=1}^{T} s_i^2 e_{it-1}^{*2})^{-1/2}\sum_{t=1}^{T}(e_{it-1}{}^{*}\Delta e_{it}{}^{*} - \lambda_t)$

All of these test are asymptotically normal distributed, on the basis of critical values for these tests null hypothesis of lack of cointegration can be accepted or rejected.

Let us apply Pedroni (1999) cointegration test for the model created in previous section and the equations will take the following shape:

$$\ln(Y)_{i,t} = \alpha_{1i} + \delta_{1i,t} + \beta_{11}\ln(K)_{i.t} + \beta_{12}\ln(L)_{i.t} + \beta_{13}\ln(E)_{i.t} + \varepsilon_{1i,t},$$

$$\ln(K)_{i,t} = \alpha_{2i} + \delta_{2i,t} + \beta_{21}\ln(Y)_{i.t} + \beta_{22}\ln(L)_{i.t} + \beta_{23}\ln(E)_{i.t} + \varepsilon_{2i,t},$$

$$\ln(L)_{i,t} = \alpha_{3i} + \delta_{3i,t} + \beta_{31}\ln(Y)_{i.t} + \beta_{32}\ln(K)_{i.t} + \beta_{33}\ln(E)_{i.t} + \varepsilon_{3i,t},$$

$$\ln(E)_{i,t} = \alpha_{4i} + \delta_{4i,t} + \beta_{41}\ln(Y)_{i.t} + \beta_{42}\ln(K)_{i.t} + \beta_{43}\ln(L)_{i.t} + \varepsilon_{4i,t},$$

where $Y_{i,t}$ is gross domestic product, $K_{i,t}$ represents Gross Capital Formation, $L_{i,t}$ – labor force and $E_{i,t}$ stands for energy consumption.

4.4 Granger Causality and VAR Model

This study examines the relationship between energy consumption and economic growth in post-Soviet countries with a main focus on Ukraine. Kraft and Kraft (1978) use gross national product as an indicator of economic growth, but Soytaş *et al.* (2001) stress that it is more appropriate to use the gross domestic product value since energy consumption is related to the goods and services produced inside of the country.

To get valid results along with the Granger test, the analysis of the stationarity of the original variables and then test cointegration between them. According to Granger (1986), the test is valid if the variables are not cointegrated. The second important element is the analysis of lag length. The studies have shown that the result of Granger causality test is very sensitive to the selection of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag length is more the true lag length, the irrelevant lags in the equation cause the estimates to be inefficient and does not give expected results.

Two or more variables are said to be cointegrated if they share common trends i.e. they have long run equilibrium relationships. The technique of cointegration involves three steps. The first step requires a determination of the order of integration of the variables of interest.

In the first stage of analysis to determine the stationarity of time series of GDP and energy consumption, we apply the augmented Dickey – Fuller (ADF) unit root test (Dickey & Fuller, 1979), which is calculated from

$$\Delta X_t = \mathrm{a} + \mathrm{b}X_{t-1} + \sum_{i=1}^{\gamma} \mathrm{c}\Delta X_{t-1} + \varepsilon_t, \qquad (1)$$

where a, b, and c are parameters to be estimated, ε_t is the residual. The null hypothesis of the test is if $H_0: \rho = 1$, y_t is nonstationary, and if $H_1: \rho > 1$, y_t is stationary.

Granger causality test estimates following VAR model:

$$y_t = a_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$

$$x_t = a_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \sigma_j y_{t-j} + e_{1t}$$

with the assumption of correlation and production of white noise.

For testing Granger-causality between x and y we need to specify two bivariate models, one for x and second one for y. If these two variables are nonstationary, they become stationary after first differencing, the standard form of Granger-causality test would be specified as follows:

$$\Delta y_t = \alpha_{11} + \sum_{i=1}^{L_{11}} \beta_{11i}\, \Delta y_{t-i} + u_{11t},$$

$$\Delta y_t = \alpha_{12} + \sum_{i=1}^{L_{11}} \beta_{11i}\, \Delta y_{t-i} + \sum_{j=1}^{L_{12}} \beta_{12j}\, \Delta x_{t-j} + u_{12t},$$

$$\Delta x_t = \alpha_{21} + \sum_{i=1}^{L_{21}} \beta_{21i}\, \Delta x_{t-i} + u_{21t},$$

$$\Delta x_t = \alpha_{22} + \sum_{i=1}^{L_{21}} \beta_{11i}\, xy_{t-1} + u_{11t}$$

where x_t and y_t represent natural logarithms of energy consumption (kg of oil equivalent per capita) and GDP per capita (current US$), respectively, Δ is the difference operator, L is number of lags, α and β are parameters to be estimated, and u_t is the error term.

The first two equations are used to detect whether the coefficients of the past lags of x can be zero as whole. By the same logic, last two equations represent whether the coefficients of the past lags of y can be zero as whole. To describe it differently, if the estimated coefficient on lagged values of x in second equation is significant, it indicates that it explains some of the variance of y that is not explained by the lagged values of y itself. This implies that x is causally prior to y and said to Granger-cause y. Thus, F-statistics is calculated to test whether the coefficients of lagged values can be zero.

Similar reasoning is possible for examining whether y Granger-cause x. If two variables are also non-stationary after first differencing but they become stationary after second differencing, all equations should be estimated with second differenced data to test for Granger-causality between two variables. This is because stationary series should be used in order to apply all equations to test for Granger-causality between energy consumption and economic growth.

Hypotheses for Granger causality rest are:

$H_o: \sum_{i=1}^{n} \beta_i = 0,\ x_t$ does not influence y_t

$H_1: \sum_{i=1}^{n} \beta_i \neq 0,\ x_t$ influences y_t.

5 Description of the data

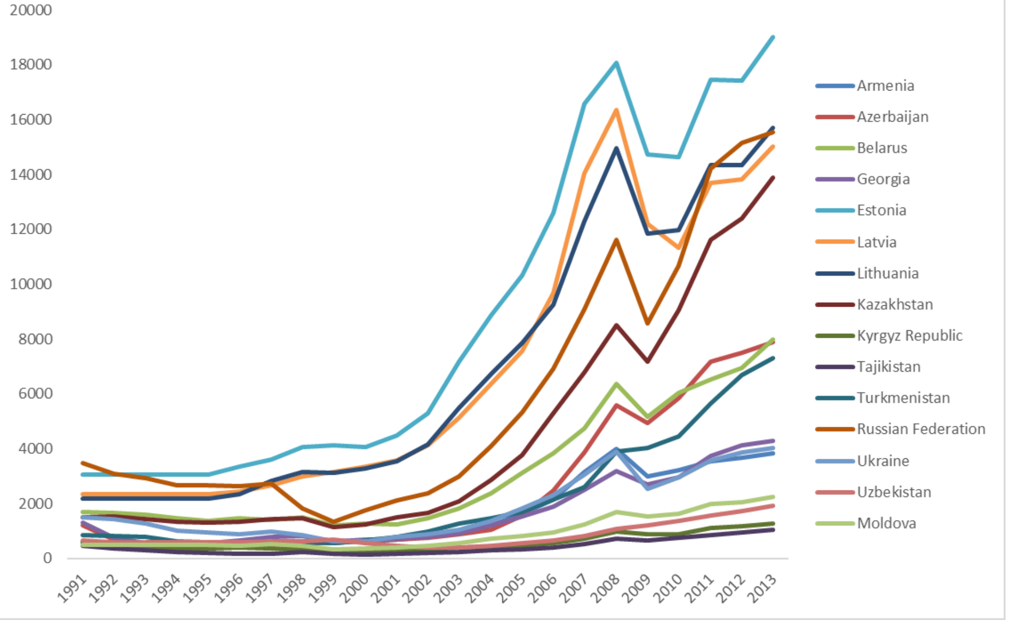
In this section, we will review data used in the thesis. In the section 5.1 is reviewed dataset used in the first part of following analysis. In the section 5.2 is reviewed data with country-specific focus which is used for the analysis of causality relationship in Ukraine.

5.1 Data for the panel of post - Soviet countries

World Bank defines Gross domestic product per capita as it is GDP itself divided by midyear population. GDP is calculated as a sum of gross value added by all country producers contributing to the economy plus any product taxes and minus any subsidies, which are not included in the value of the products (World Bank, 2002).

Gross Domestic Product (GDP) per capita taken for the range of 1991 – 2013 for 15 post - Soviet countries. From the Figure 5.1.1 we can see that up to 2007 countries had relatively stable economic growth, but during and after the crisis of 2008 there was a gap up until 2010. Looking at the economic growth of post-crisis years we can see that up until 2013 Ukraine is in the top three countries for GDP per capita in current US$.

Figure 5.1.1. GDP per capita (in current $US) per years 1991 - 2013

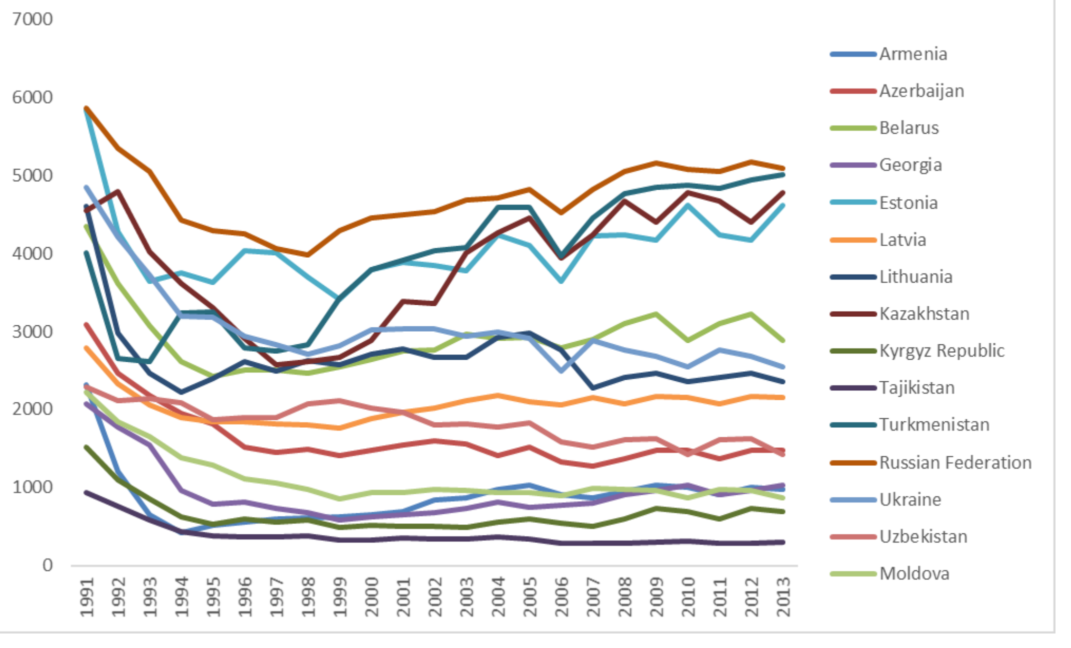


Source: author’s computations

World Bank states that Energy Use in kilogram of oil equivalent per capita is a use of primary energy before its transformation to other end-use fuels. This use is equal to indigenous production plus imports and stock changes, minus exports and fuels used for ships and aircrafts supplies to international transport (World Bank, 2002).

Figure 5.1.2 represent changes in energy consumption within countries between 1991 and 2013. We can observe decrease in energy use started in mid 90s, is is grually goes down

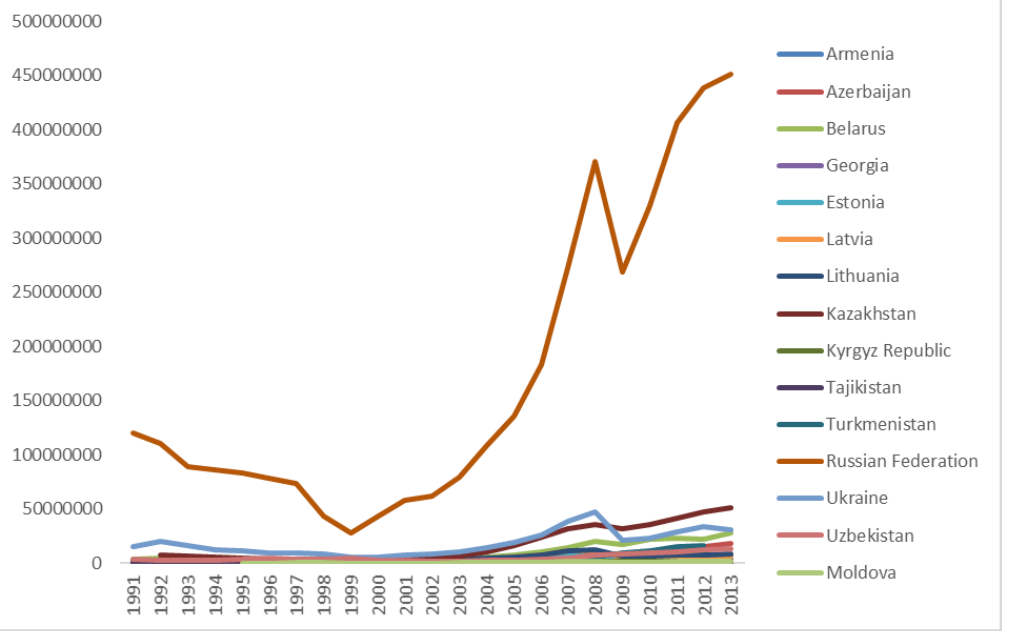
Figure 5.1.2. Energy Use (kg of oil equivalent) per years 1991 - 2013



Source: author's computations

From the Figure 5.1.3 below we can observe than up to end of the 1990s, when the Financial Crises of 1998 happened, the economy was at a stable level, but in the recovery period we can see that some countries like Moldova, Ukraine and Russian Federation had stable growth up until crises of 2008. In the post crisis period, all countries have recovered in term of Gross Capital Formation. At the same time can observe big jump in Gross Capital Formation of Azerbaijan compare to the other countries. For the other countries, it keeps going upwoards, but not as fast as in the case of Azerbaija.

Figure 5.1.3. Gross Capital Formation (current $US) per years 1991 - 2013

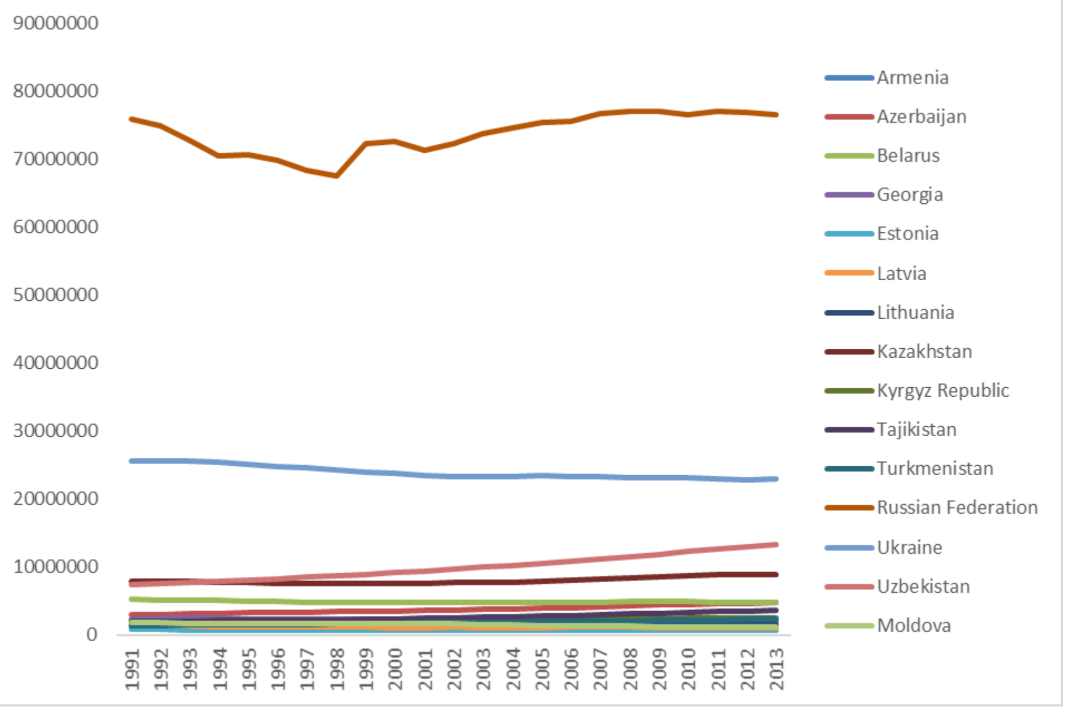


Source: author's computations

World Bank defines Labor force as a sum of people of age 15 and older who contribute to the production of goods and services during defined period, which includes currently employed people as well as people who are seeking job and first - time job - seekers. However, some countries exclude members of the army forces together with students and unpaid workers. The count of labor force can vary due to seasonal workers (World Bank, 2002).

Looking at the Figure 5.1.4 we see stability in labor force figure, which is represented by total number of woking population in countries and it was not changing much over the time period.

Figure 5.1.4. Labor Force, total per years 1991 - 2013



Source: author's computations

Descriptive statistics is presented in Table 5.1.1.

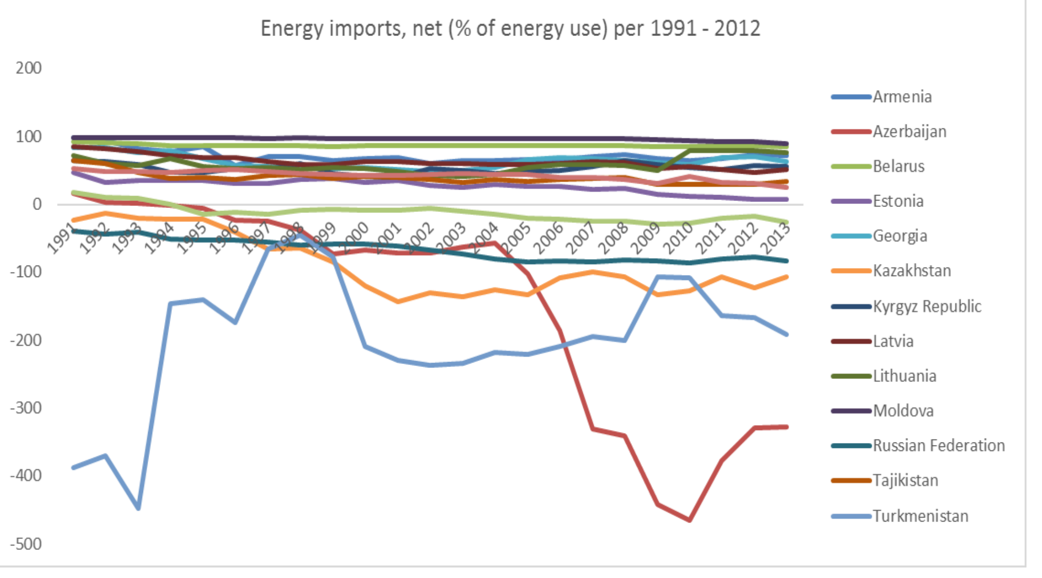
Table 5.1.1. Descriptive statistics of post – Soviet countries

Variable	Obs.	Mean	Standard Deviation	Minimum	Maximum
GDP	345	1512.49	4022.57	139.11	19029.78
Gross Capital Formation	345	2697182.81	60931489.22	20759.02	494000000
Labor Force	345	2271306	18211627.78	659988	77073504
Energy Consumption	345	2146.18	1388.17	281.43	5861.3

Source: author's computations

My second hypothesis includes data about net energy imports, which are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (OECD/IEA 2014).

Figure 5.1.5. Net energy imports per country per years 1991 - 2013



Source: author's computations

From this figure, we can see that the main net exporters of energy are Azerbaijan, Kazakhstan, Turkmenistan, Russian Federation and Uzbekistan. Armenia, Belarus, Georgia, Moldova, Kyrgyzstan, Ukraine and Tajikistan are net energy importers among post - Soviet countries.

5.2 Ukrainian Data

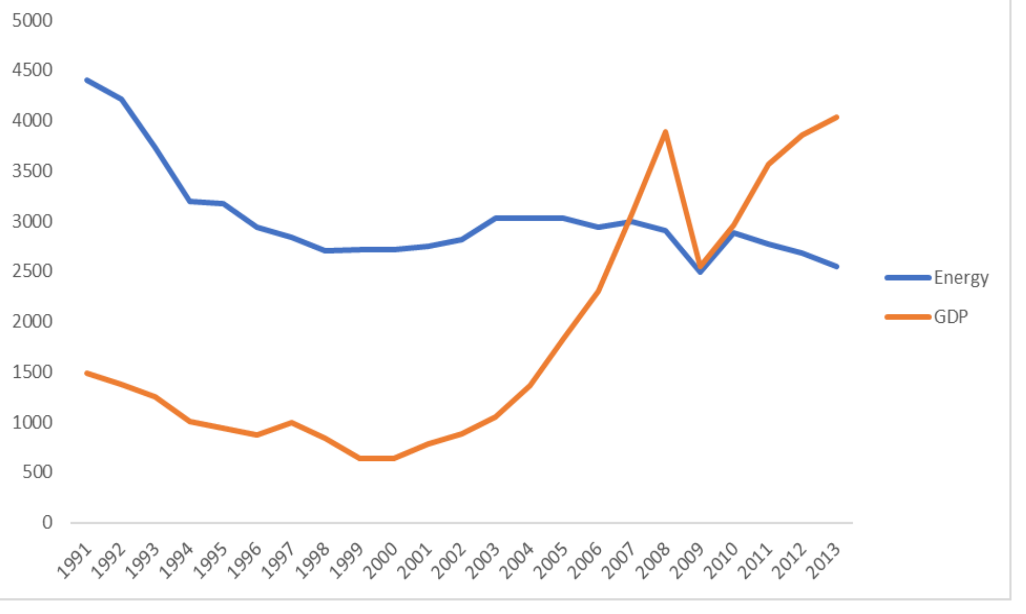
For the third hypothesis "There is a positive two-way causality relationship between energy consumption and economic growth in Ukraine", we use the time series data of GDP per capita and energy consumption per capita during 1991 – 2013 (Table 5.2.1). Data is obtained from World Development Indicators (2010) within World Bank. Energy consumption is expressed by energy use in terms of kg oil equivalent and GDP is expressed in current US$. The choice of starting period is from the year of Ukrainian independence from USSR. The trends of GDP and energy consumption is shown in Figure 5.2.1. From the figure, we can observe relatively stable growth of GDP, while energy use is slowly getting down, which is good for energy efficiency of country.

Table 5.2.1 Summary Statistics

Variable	Obs	Mean	Standard Deviation	Minimum	Maximum
GDP	23	2898.83	380.37	2487.04	4209.62
Energy	23	1312.35	1196.36	635.71	4029.72

Source: author's computations

Figure 5.2.1 GDP and energy use in Ukraine (billion $US)



Source: author's computations

6 Results

In this chapter, the results of the empirical analysis are presented. In the first section, multiple unit root tests for variables used in the modified production function are run. The second section presents results of the panel cointegration analysis and the panel results of two models, including Pooled OLS, Fixed Effects and Random Effects Model. Section 6.3 represents the results of unit root and cointegration tests for the case of Ukraine, and the other post-Soviet countries.

6.1 Unit Root Tests

Results of the Levin, Lin, and Chu (2002), Im, Pesaran and Shin (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests of energy consumption are presented in Table 6.1.1.

Table 6.1.1. Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests on log(E).

	No Effects							
	log(Energy Use)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.4408	0.6594	15	344	-18.747	0.0000	15	343
Im, Pesaran and Shin W-stat	-	-	-	-	-	-	-	-
Maddala and Wu chi-test	0.8336	0.6592	15	344	358.197	0.0000	15	343
Hadri z-test	-	-	-	-	-	-	-	-
	Individual Effects							
	log(Energy Use)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.1554	0.8764	15	344	-21.098	0.0000	15	343

Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Im, Pesaran and Shin W-stat	-2.1995	0.0278	15	344	-20.093	0.0000	15	343
Maddala and Wu chi-test	14.735	0.0006	15	344	358.19	0.0000	15	343
Hadri z-test	4.0425	0.0000	15	344	-0.9576	0.3383	15	343
	Individual Effects with trend							
	log(Energy Use)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.0335	0.9733	15	344	-27.089	0.0000	15	343
Im, Pesaran and Shin W-stat	-1.6429	0.1004	15	344	-21.46	0.0000	15	343
Maddala and Wu chi-test	14.946	0.0006	15	344	358.2	0.0000	15	343
Hadri z-test	9.7462	0.0000	15	344	-1.0237	0.306	15	343

Source: author's computations

The test statistics of the unit root tests show us that in half of the test we cannot reject the null hypothesis regarding nonstationarity. Levin, Lin and Chu (2001) and Maddala and Wu (1999) show that when there are no effects, we can reject the null hypothesis only in first differences regarding the stationarity of the variable of interest. The majority of tests for Individual Effects and Individual Effects with trend indicate that in both logged and first difference levels we can reject the null hypothesis at a 5% significance level and conclude that the variable for energy consumption is stationary.

The Hadri (2000) z-statistics of the unit root test suggests that we can reject the null hypothesis regarding the nonstationarity of the variable at a 5% significance level. In the first difference case, the statistics do not support this hypothesis, so we do not reject the null hypothesis. The test indicates that we can reject the hypothesis about stationarity of variable, so our logged energy consumption variable is stationary.

Results of the Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests of log GDP are presented in Table 6.1.2.

Table 6.1.2. Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests on log(GDP).

	No Effects							
	log(GDP)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.4442	0.5659	15	344	-17.421	0.0000	15	343
Im, Pesaran and Shin W-stat	-	-	-	-	-	-	-	-
Maddala and Wu Chi-test	0.8441	0.6567	15	344	310.05	0.0000	15	343
Hadri Z-test	-	-	-	-	-	-	-	-
	Individual Effects							
	log(GDP)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-1.8404	0.0657	15	344	-20.69	0.0000	15	343
Im, Pesaran and Shin W-stat	-2.7323	0.0062	15	344	-18.54	0.0000	15	343
Maddala and Wu Chi-test	18.288	0.0001	15	344	310.11	0.0000	15	343
Hadri Z-test	9.8275	0.0000	15	344	-0.9575	0.3383	15	343
	Individual Effects with trend							
	log(GDP)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-2.3524	0.0186	15	344	-26.606	0.0000	15	343
Im, Pesaran and Shin W-stat	-2.2976	0.0215	15	344	-19.75	0.0000	15	343
Maddala and Wu Chi-test	18.933	0.0000	15	344	310.24	0.0000	15	343
Hadri Z-test	15.032	0.0000	15	344	-1.1137	0.2654	15	343

Source: author's computations

Majority of statistics in the case of testing GDP are significant at 5% level for both al log level and first difference for Individual Effects and Individual Effects with trend, which means that we can reject null hypothesis and our logged GDP variable is stationary. At the same time, we can observe that where there are no effects, with the target variable significant only in first differences.

In this test of Hadri (2000) we can observe that in Individual Effects logged GDP is significant at both level and first difference, but in Individual Effects with trend, it is not significant at first difference.

Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests of gross capital formation is presented in Table 6.1.3.

Table 6.1.3. Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests on log(C).

	No Effects							
	log(Gross Capital Formation)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.1282	0.898	15	344	-19.791	0.0000	15	343
Im, Pesaran and Shin W-stat	-	-	-	-	-	-	-	-
Maddala and Wu Chi-test	0.2153	0.8979	15	344	398.58	0.0000	15	343
Hadri Z-test	-	-	-	-	-	-	-	-
	Individual Effects							
	log(Gross Capital Formation)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-1.7226	0.0849	15	344	-22.144	0.0000	15	343
Im, Pesaran and Shin W-stat	-3.0891	0.0020	15	344	-21.324	0.0000	15	343
Maddala and Wu Chi-test	20.889	0.0000	15	344	399	0.0000	15	343
Hadri Z-test	10.78	0.000	15	344	-1.0162	0.3095	15	343
	Individual Effects with trend							
	log(Gross Capital Formation)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.

Levin, Lin & Chu t-test	-2.1435	0.032	15	344	-28.408	0.000 0	15	343
Im, Pesaran and Shin W-stat	-2.7423	0.0061	15	344	-22.833	0.000 0	15	343
Maddala and Wu Chi-test	21.918	0.0000	15	344	399.21	0.000 0	15	343
Hadri Z-test	5.7171	0.0000	15	344	-1.2329	0.217 6	15	343

Source: author's computations

Looking at the results of test, we can see that similarly to tests on GDP, Levin, Lin, and Chu (2002) and Maddala and Wu (1999) logged gross capital formation is not significant at its level, but significant at first differences level with no effects present. Looking at the results of tests for Individual Effects and Individual Effects with trend, we can conclude that variable is significant at 5% level for both when it is at level and when it is at first difference, so we can reject null hypothesis about nonstationarity and say that the variable is stationary.

Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests of Labor Force is presented in Table 6.1.4.

Table 6.1.4. Results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests on log(L).

	No Effects							
	log(Labor Force)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	0.0727	0.942	15	344	-18.474	0.0000	15	343
Im, Pesaran and Shin W-stat	-	-	-	-	-	-	-	-
Maddala and Wu Chi-test	0.1195	0.942	15	344	347.9	0.0000	15	343
Hadri Z-test	-	-	-	-	-	-	-	-
	Individual Effects							
	log(Labor Force)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.1705	0.8646	15	344	-20.93	0.0000	15	343
Im, Pesaran and Shin W-stat	-1.539	0.1238	15	344	-19.777	0.0000	15	343
Maddala and Wu Chi-test	10.874	0.0043	15	344	348.08	0.0000	15	343
Hadri Z-test	41.121	0.0000	15	344	-0.9343	0.3491	15	343
	Individual Effects with trend							
	log(Labor Force)							
	At level				At first difference			
Method	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
Levin, Lin & Chu t-test	-0.2164	0.8287	15	344	-27.867	0.0000	15	343
Im, Pesaran and Shin W-stat	-1.3068	0.1913	15	344	-21.111	0.0000	15	343
Maddala and Wu Chi-test	13.088	0.0014	15	344	348.12	0.0000	15	343
Hadri Z-test	19.929	0.0000	15	344	-1.0107	0.3122	15	343

Source: own computations

Statistics of the unit root tests show us that according to most of the tests, we can conclude that we can reject the null hypothesis about nonstationarity at the first difference level. Levin, Lin and Chu (2001) and Im, Pesaran and Shin Test (2003) in

Individual Effects and Individual Effects with trend show that when variable is in log we cannot reject null hypothesis about stationarity of variable at 5% level, also when there are No Effects for when variable is at level.

Hadri (2000) z-statistics of unit root test suggests that we can reject null hypothesis about stationarity of variable at 5% level of significance. At first difference, statistics does not support this hypothesis, so we do not reject null hypothesis. But in Individual Effects at first difference variable is not significant. Given the results of all tests, we can reject null hypothesis and say that Labor force variable is stationary.

6.2 Panel Cointegration Analysis

In order to show whether our integrated series are cointegrated or not, we can use Pedroni (1999) cointegration test. Under H_0 ('no cointegration') the autoregressive coefficients, γ_i = 1 for all i, versus H_1: γ_i < 1 for all i. The standardized values of the test statistics are asymptotically normal (0,1) under H_0.

Table 6.2.1. Pedroni (1999) Panel Cointegration Test

	Weighted Statistics
Panel v-Statistics	4.033 (0.0005)
Panel rho-Statistics	-3.54 (0.035)
Panel PP-Statistics	-4.19 (0.729)
Panel ADF-Statistics	-11.76 (0.0004)
	Statistics
Group rho-Statistics	-5.62 (0.031)
Group PP-Statistics	-6.822 (0.71)
Group ADF-Statistics	-7.202 (0.681)

Values in parenthesis are probabilities.

Source: author's computations

The null hypothesis of the Pedroni (1999) test is the absence of cointegration. The test is based on seven statistics, four of which are panel based: panel υ, panel ρ, panel PP and panel ADF. They are obtained after polling the within dimension of the panel. Other three statistics are group based: group ρ, group PP and group ADF. They are obtained after polling the between dimension of the panel.

Looking at the table with results, we can say that the null hypothesis cannot be rejected for Panel PP-statistic, Group PP-statistic and Group ADF-statistic. For the rest of statistics, null hypothesis is rejected, so cointegration is present. Majority of tests say that cointegration is present, but at the same time, we cannot say that there is a strong evidence of cointegration.

Table 6.2.2. Panel results of Pooled OLS, Fixed Effects and Random Effects of the first model

Panel data Models: Dependent variable GDP per capita						
Independent variables	Model 1 Pooled OLS		Model 2 Fixed Effects		Model 3 Random Effects	
Capital	3.96E-08	***	3.61E-08	***	3.65E-08	***
	-4.49E-09		4.87E-09		4.01E-09	
Labor	-1.28E-04	***	-8.74E-05		-1.12E-04	***
	1.56E-05		1.96E-04		2.88E-05	
Energy	1.4051	***	1.0446	**	1.2114	***
	0.1457		3.29E-01		0.2569	
Constant	506.99				8.57E+02	
	3.4048E+02				7.05E+02	
Model summary						
R2	0.37		0.24		0.26	
Wald chi2	197.78	***				
F-test	65.927	***				
Hausman test					18.801	***
F-test (Fixed Effects)			10.097	***		
Countries included	15		15		15	
Total panel observations	345		345		345	

*, **, ***Indicate rejection of null hypothesis at the 10%, 5% and 1% level.
Values in parenthesis are standard errors.
Source: author's computations

Given the results of the stationary tests for our variables, we can pool the three models in order to identify which variables influence the growth of GDP the most. The results of Table 6.2.2 show us that in Pooled OLS and Random Effects model all variable has impact on GDP, in Fixed Effects model we can see that Labor Force is not significant. In order to choose model for precise results, we pull different tests, from the table we can see that between Pooled OLS and Fixed Effects, the F-test gives us the result of choosing FE model over Pooled OLS. Running the Hausman test gives us the result of choosing FE model over RE model.

The results of the Fixed Effects model show us that Labor Force is not significant and with a growth in GDP, Labor Force should decrease. At the same time, Gross Capital Formation and Energy Use are significant and give positive changes in the model. One explanation of a negative sign of Labor Force can be the peculiarities of the GDP per capita computation. It can be observed from the data on GDP growth and population growth that GDP growth is much higher than the population growth for the vast majority of countries in the sample during the observation period (1991 - 2013). This can lead to a higher values of GDP per capita variable and, at the same time, to lower values of Labor Force variable. Thus, we can assume that there is a lurking variable, population growth, affecting both dependent and independent variable and leading to a significantly negative coefficient on Labor Force variable.

An increase in one kilogram of oil equivalent per capita leads to increase in GDP per capita by $1.01 US dollars. Regarding Gross Capital Formation increase in one billion of US dollars leads to increase in GDP per capita by $3.61 US dollars.

The second hypothesis assumes that we include liberalization as one of the dummy variables in our model. Energy market liberalization is widely discussed in among countries as, according to European Commission, it will bring a reduction in electricity prices, improving efficiency and securing supply, etc. Increase of efficiency through the pressure of competition is one the key goal of liberalization. Greater efficiency should lead to lower costs and hence prices, this would improve industrial competitiveness which is very important. In case of Germany, liberalization has led to huge price reductions and competition played one of the key roles in that. It can also lead to long-term structural changes that make energy consumption more efficient. The second dummy variable includes data on countries which are the part of European Union, which are Estonia, Latvia and Lithuania from 2004 onwards.

This model also includes net energy import in % of energy consumption, energy consumption of fossil fuels in % of total energy consumption and energy use in kg of oil equivalent per $1000 GDP (constant 2011 PPP).

Now we can review the pooled Ordinary Least Squares, Fixed Effects and Random Effects models with dummy variables included above in Table 6.2.3.

Table 6.2.3. Panel results of Pooled OLS, Fixed Effects and Random Effects of the second model

Panel data Models: Dependent variable GDP per capita						
Independent variables	Model 1 Pooled OLS		Model 2 Fixed Effects		Model 3 Random Effects	
Capital	2.89E-08	***	3.27E-08	***	2.94E-08	***
	(2.13E-09)		(2.41E-09)		(2.09E-09)	
Labor	-6.67E-05	***	-3.86E-04	***	-7.12E-05	***
	(7.39E-06)		(1.04E-04)		(8.89E-06)	
Energy	9.91E-01	***	1.5554	***	1.0458	***
	(8.06E-02)		(1.80E-01)		(0.1016)	
Import	-2.03E+00	*	-7.32E+00	***	-3.19E+00	**
	(9.14E-01)		(1.63E+00)		(1.11E+00)	
Fossil Fuels	1.01E+01	*	1.55E+01		9.77E+00	
	(5.08E+00)		(1.55E+01)		(6.68E+00)	
Energy per $1000	-6.52E+00	***	-8.86E+00	***	-7.19E+00	***
	(5.63E-01)		(8.84E-01)		(6.54E-01)	
Liberalization	1.81E+03	***	2.12E+03	***	1.97E+03	***
	(4.82E+02)		(4.85E+02)		(4.86E+02)	
EU Country	8.30E+03	***	7.82E+03	***	8.13E+03	***
	(3.34E+02)		(3.54E+02)		(3.44E+02)	
Constant	1.55E+03	***			1.71E+03	***
	(1.01E-05)				(4.50E+02)	
Model summary						
R2	0.868		0.819		0.841	
Wald chi2	19.913	***				
F-test	14.186	***				
Hausman test					72.926	***
F-test (Fixed Effects)			5.7278	***		
Countries included	15		15		15	
Total panel observations	345		345		345	

*, **, ***Indicate rejection of null hypothesis at the 10%, 5% and 1% level.
Values in parenthesis are standard errors.
Source: author's computations

Given the results of Table 6.2.2 we can conclude that in the Pooled OLS model, all of the variables are significant and have an impact on GDP per capita. Random

Effects and Fixed Effects models show that Fossil Fuels variable is not significant and does not have a direct impact at the GDP per capita. In order to choose model for precise results, we pull different tests, from the table we can observe that between Pooled OLS and Fixed Effects, F-test gives us the result of choosing FE model over Pooled OLS. Running the Hausman test gives us the result of choosing FE model over RE model.

GDP per capita turns out to be higher for countries with high degree of liberalization. The effect of liberalization is estimated as an increase in GDP per capita by $2,120 US dollars. Increase in 1% percent of energy imports leads to a decrease in GDP per capita by 73.2 US dollars.

An increase in energy consumption of one kilogram of oil equivalent per capita leads to increase in GDP per capita by $1.55 US dollars. Regarding Gross Capital Formation, an increase of one billion of US dollars leads to an increase in GDP per capita by $3.27 US dollars. Besides that, we can observe that Labor Force variable becomes significant in this model, which means that an increase in Labor Force by one million leads to a decrease in GDP per capita by $0.39 US dollars.

Regarding the dummy variable EU country, the results suggest a significant relationship between GDP per capita and EU membership, indicating that becoming a member of the EU led to higher economic growth. However, this is a complicated process, and may be sensitive to time shocks unrelated to EU membership, so this finding is not necessarily settled.

The variable which is energy consumption in kg of oil equivalent per $1000 GDP (constant 2011 PPP) shows us a negative relationship with GDP per capita. An increase in one kilogram of oil equivalent per $1000 GDP (constant 2011 PPP) leads to a decrease in GDP per capita by $8.86 US dollars. This indicates that energy inefficiency leads to a drag on economic growth.

Energy consumption of fossil fuels in % of total energy consumption turned out to be insignificant in Fixed Effects model. This indicates that switching to a greater use of renewable energy sources would not necessarily lead to a decrease in economic growth.

6.3 Unit root and cointegration tests: the case of Ukraine

Table 6.3.1 reports the results of the Augmented Dickey-Fuller test on the integration properties of GDP per capita and Energy Use per capita. The results indicate that Energy Use is stationary in its level and 1st difference, while GDP is nonstationary in its level and stationary in its 1st difference.

Besides that, we test whether a long-run cointegration relationship is present. We consider, given the sample size, a maximum lag length to be equal to two and test the model downwards. The optimal lag length is found to be two based on the Akaike information criteria (AIC).

Table 6.3.1. Unit Root Test Results

Varibles	Model	Test statistics	Lag/bandwidth
Energy			
Level	ADF	-1.1329 (0.3616)	3
	PP	-4.3531*** (0.0109)	2
1st difference	ADF	-3.2488*** (0.0004)	3
	PP	-4.7842*** (0.01)	2
GDP			
Level	ADF	1.2166 (0.4793)	3
	PP	-1.9483 (0.5921)	2
1st difference	ADF	-2.2579** (0.0471)	3
	PP	-3.2936* (0.0925)	2

Notes: Parenthesis value indicates the p-value. Null hypothesis: has a unit root.
*, **, ***Indicate rejection of null hypothesis at the 10%, 5% and 1% level.
Lag is automatic based on AIC.
Source: own computations

A Johansen cointegration test is performed for the VARs at the different levels, with a lag length of two remaining the same for the further analyses. Table 6.3.2 shows the result of Johansen test, which indicates the presence of cointegration between Energy Use and GDP. The test statistic is at a level of 20.38, which exceeds the 5% critical value of 19.96 and indicates that the null hypothesis of $r_0 = 0$ is rejected at the 5% significance level. For the Trace test, the null hypothesis of no cointegration is rejected at 5% significance level. Also, when $H_0 = r_0 \leq 1$, test statistics is equal to 8.30, which is less than 5% critical value of 9.24. Therefore, the null hypothesis at the 5%

significance level is accepted. We can say that there is a long-run relationship between GDP and energy use in Ukraine.

Table 6.3.2. Johansen Cointegration test

Number of cointegration	Test Statistics	Trace test		
		10%	5%	1%
None	20.38	17.85	19.96	24.60
At most 1	8.30	7.52	9.24	12.97

*, **, ***Indicate rejection of null hypothesis at the 10%, 5% and 1% level.
Source: author's computations

The cointegration results presented above imply that the existence of causality in the long run and in possibly both directions. In order to clarify these points, we apply VAR-based causality tests. According to the results given in the Table 6.3.3, given the long-term causality at the 10% level, we can reject the null hypothesis of "GDP does not Granger - cause Energy Consumption." We also find bidirectional causality running from GDP to Energy Consumption and from Energy Consumption to GDP.

Table 6.3.3. Granger causality test result of VAR model

Null hypothesis	T - statistics	Prob > t
GDP does not Granger Energy Consumption	2.768	0.080
Energy Consumption does not Granger cause GDP	3.157	0.057

Source: author's computations

The results imply a long-run relationship between energy consumption and economic growth, which is consistent with the "feedback hypothesis" theory ("Feedback" GDP ↔ Energy Consumption, (Bidirectional)). Therefore, an increase in energy consumption can lead to an increase in economic growth and the other way around. But at the same time, a decrease in energy consumption can lead to a decrease in economic growth, while a decrease in economic growth may also lead to decrease in energy consumption.

6.4 Granger causality test results for post-Soviet countries

Following the analysis from the previous section with the VAR and Granger models, here we run the same structure of the VAR model in order to investigate the Granger causality relationship between energy consumption and economic growth for the remaining 14 post - Soviet countries. Results of these Granger causality tests are presented in Table 6.4.1.

Table 6.4.1. Granger causality test results

Armenia		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.489	0.796
GDP does not Granger-cause Energy	0.291	0.921
Azerbaijan		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	3.082	0.051
GDP does not Granger-cause Energy	2.589	0.082
Belarus		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	32.425	0.0002
GDP does not Granger-cause Energy	1.368	0.357
Estonia		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.389	0.862
GDP does not Granger-cause Energy	0.164	0.978
Georgia		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	4.416	0.016
GDP does not Granger-cause Energy	0.156	0.974
Kazakhstan		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	1.625	0.227
GDP does not Granger-cause Energy	5.941	0.005
Kyrgyz Republic		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.634	0.678
GDP does not Granger-cause Energy	1.297	0.328
Latvia		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	6.729	0.017

GDP does not Granger-cause Energy	0.751	0.632
Lithuania		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.884	0.557
GDP does not Granger-cause Energy	1.117	0.448
Moldova		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.683	0.672
GDP does not Granger-cause Energy	0.6	0.725
Russian Federation		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	0.429	0.836
GDP does not Granger-cause Energy	1.119	0.448
Tajikistan		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	2.016	0.207
GDP does not Granger-cause Energy	0.868	0.566
Turkmenistan		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	4.103	0.055
GDP does not Granger-cause Energy	4.426	0.046
Uzbekistan		
Null hypothesis	T-statistics	Prob > t
Energy does not Granger-cause GDP	11.545	0.004
GDP does not Granger-cause Energy	7.067	0.015

Source: author's computations

In Table 6.4.2 are presented the results on the type of hypothesis found to hodl for each country, which countries received after estimation of models. Here we can see that majority of countries such as Armenia, Estonia, Kyrgyz Republic, Lithuania, Moldova, Russian Federation and Tajikistan were found to have the "Neutral Hypothesis," which means that there is no causality relationship between energy consumption and economic growth. In the case of Belarus, Georgia and Latvia, they follow the "Growth Hypothesis," meaning that there is a one-way causality relationship from energy to economic growth.

Kazakhstan received "Conservation Hypothesis," in which there is a one-way causality relationship from economic growth to energy, which proves the results obtained by Mudarissov and Lee (2014).

Kalyoncu *et al.* (2013) in his work estimates causality relationships for Georgia, Azerbaijan and Armenia by using cointegration methods and causality tests. They found that this relationship is not co-integrated for Georgia and Azerbaijan, but is co-integrated for Armenia, and there is a one-way causality from gross domestic product per capita to energy consumption per capita in Armenia. From our results we can see that in the case of Georgia the "Growth Hypothesis" holds, and in the case of Azerbaijan the "Feedback Hypothesis" holds at a 10% level of significance. In the case of Armenia there is no cointegration, which shows quite different results from the paper of Kalyoncu *et al.* (2013). It can be explained because of the different data used: in this paper, the time period was set from 1995 to 2009. It can be concluded that the time frame also plays an important role in determining the results.

Looking at Azerbaijan, Turkmenistan and Uzbekistan, we can see that they exhibit the "Feedback Hypothesis," which is quite logical given that the economies of these three countries are very dependent on energy resources and energy plays a significant role in the performance of the overall economy. This hypothesis states that these countries have a bidirectional causality relationship between energy consumption and economic growth.

Table 6.4.2. Type of the Granger causality hypothesis

Country	Hypothesis type	Country	Hypothesis type
Armenia	"Neutrality Hypothesis"	Latvia	"Growth Hypothesis"
Azerbaijan	"Feedback Hypothesis"	Lithuania	"Neutrality Hypothesis"
Belarus	"Growth Hypothesis"	Moldova	"Neutrality Hypothesis"
Estonia	"Neutrality Hypothesis"	Russian Federation	"Neutrality Hypothesis"
Georgia	"Growth Hypothesis"	Tajikistan	"Neutrality Hypothesis"
Kazakhstan	"Conservation Hypothesis"	Turkmenistan	"Feedback Hypothesis"
Kyrgyz Republic	"Neutrality Hypothesis"	Uzbekistan	"Feedback Hypothesis"

Source: author's computations

7 Conclusion

This research investigated the question of how energy can influence economic growth. The first part of the analysis is devoted to an analysis of the influence of capital, labor and energy consumption on GDP growth in the case of 15 Post – Soviet countries (Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan) during the time period of 1991 to 2013, and investigated whether energy consumption had a direct positive impact on economic growth for these countries. Capital and energy consumption were shown to have a significant and direct influence on GDP growth per capita, while labor force was not found to be significant for this model.

The second part of empirical analysis utilized a new model, including more variables, most of which were related to the energy sector. These variables included dummy variables for EU membership and whether or not the country had undergone liberalization of its energy sector, energy inefficiency, percentage fossil fuel use, and percentage of energy imported. The results show us that GDP per capita turns out to be higher for countries with high degree of liberalization, which reveals that countries with liberalized energy sectors tend to have higher GDP per capita, indicating that non-liberalized countries could boost their economic growth by liberalizing their energy sector. The energy import variable gave the opposite results, with an increase in imports leading to lower GDP per capita. Looking at this result, we can conclude that - in the case of Ukraine - decreasing energy imports and increasing the use of the country's own domestic energy resources can have a positive impact on the economic growth of the country. EU membership estimation also brought us interesting results, showing a positive impact on economic growth.

In the last part of the empirical analysis, the relationship between energy consumption and economic growth was investigated for the case of Ukraine. Vector autoregressive (VAR) and Granger causality methods were used and a bidirectional causality relationship between energy consumption and economic growth was found to hold. The finding that energy consumption can lead to economic growth provides the knowledge that the use of more energy can be helpful, in order to boost economic growth. In addition, it means that Ukraine has an energy-dependent economy. From that it also applies that increases in energy consumption can positively affect economic growth. As we have bidirectional relationships it also means that increases in economic growth can help to an increase in energy consumption.

At the same time, given the fact that Ukraine has an energy-dependent economy, the country is very sensitive to energy shocks, which have affected the economy quite often and severely in recent years. First of all, Ukraine should look towards energy conservation strategies, given the fact that over-consumption can have a negative impact on the environment. Second, in the Ukrainian energy sector the major consumer is the industrial sector, which is a large part of its economy. Given the knowledge that the majority of plants were built during Soviet times, most of them still use old and costly energy-inefficient technologies - thus, there is a great potential to save energy by implementing energy efficiency policies for the energy sector of Ukraine. The country's energy technology infrastructure needs to be upgraded, and more energy-saving equipment should be employed. Another of the reasons for its energy inefficiency is also that the population does not have full knowledge about energy saving culture because of the low electricity prices. That is why there is a great need to raise the awareness of the population for energy conservation. The third is renewable energy, which could play an important role in the future, given the knowledge that Ukraine has substantial renewable energy resources freely available from nature. But at this time rational use of already available energy, the introduction of energy-saving technologies and the deployment of renewable energy sources should be the key priorities for Ukraine's energy policy.

Below is summarized the main policy recommendations suggested by this analysis:

- A focus on policies to incentivize energy efficiency and conservation – and to upgrade Ukraine's aging and inefficient energy infrastructure
- The economic liberalization of Ukraine's energy sector
- Investments to stimulate Ukraine's domestic energy production, including both renewable energy and fossil fuel resources

In conclusion, the empirical analysis conducted for this thesis found that the energy sector is a significant factor for economic growth, and that reforming and revitalizing Ukraine's energy sector could provide a boost to the country's economic growth. This work suggests that Ukrainian policymakers should implement the economic liberalization of the country's energy sector, put into place policies to promote energy conservation and efficiency, and increase the domestic production of energy through a focus on both renewable energy sources such as wind and solar as well as domestic fossil fuel sources.

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Appendix

VAR model results per country

Table A.1 Armenia VAR Model

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
 0.27893054 -0.01048645  0.04629630 -0.07572596 34.34392220


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

    energy.l1        gdp.l1     energy.l2        gdp.l2         cons
t
  0.004283198   0.070719161   0.222765578  -0.206156924 201.48585292
7
```

Table A.2 Azerbaijan VAR Model

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
 0.04975023  0.04021920  0.38440736 -0.05874183  4.48974589


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
 -2.9028188   0.5146078   2.6276373  -0.2236017 339.9381454
```

Table A.3 Belarus VAR Model

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
 0.46828717 -0.08614161  0.10094718 -0.04349289 37.56254738


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
 -0.66613111  -0.13014059   1.67173892  -0.03331143 438.38060037
```

Table A.4 Estonia VAR Model

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
-0.07481543 -0.06366105 -0.03127421  0.01101414 84.11497211


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
  1.0925431   0.2184874  -0.3294689  -0.2432014 796.9477889
```

Table A.5 Georgia VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
 0.387566211 -0.005683200  0.233794890 -0.004217844 10.584453911


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
   2.6824566    0.2155955    0.9754350   -0.4222162 1113.6374288
```

Table A.6 Kazakhstan VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.39896309  -0.12959847   0.45658070  -0.08329262 156.30693650


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.51965533   0.01081108   0.60925079  -0.04044210 644.27019685
```

Table A.7 Kyrgyz Republic VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.39896309  -0.12959847   0.45658070  -0.08329262 156.30693650


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.51965533   0.01081108   0.60925079  -0.04044210 644.27019685
```

Table A.8 Latvia VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
 0.032010142 -0.016577457  0.351207496  0.002895363 25.871935612


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
  9.7462223   0.2736554  -2.7436950  -0.3994507 688.1729681
```

Table A.9 Lithuania VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const 
 0.18339388  0.04931905  0.02003155 -0.09603560 29.63947395 


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const 
  0.50551173   0.01652545   0.50963175  -0.40229975 980.13343779 
```

Table A.10 Moldova VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const 
 0.12846353 -0.11971569  0.57534396 -0.05156048 15.84980669 


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const 
  0.40761281  -0.04947008   0.36610276  -0.14141140 143.87843012 
```

Table A.11 Russian Federation VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const 
 0.29302879 -0.05655485  0.52931729 -0.04918129 85.82013560 


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const 
  1.2347431  -0.1133987   1.9248756  -0.3424984 971.1075810 
```

Table A.12 Tajikistan VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const 
 0.63078667 -0.10387998  0.03993162 -0.07341602  7.35277588 


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

 energy.l1     gdp.l1  energy.l2     gdp.l2      const 
 0.8967685  0.1317900 -0.3000537  0.2200308 38.5185280 
```

Table A.13 Tukrmenistan VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.03476252  -0.20524724  -0.40244466   0.32726554 113.05220868


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

 energy.l1     gdp.l1  energy.l2     gdp.l2      const
 0.6253978  0.3232719 -0.1112462  0.4368054 64.7339489
```

Table A.14 Ukraine VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
 0.184951004 -0.323379015  0.305169061  0.002580729 43.543281833


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
  0.72526460  -0.24471284   0.33922143  -0.08912965 268.06752264
```

Table A.15 Uzbekistan VAR Model results

```
VAR Estimation Results:
=======================

Estimated coefficients for equation energy:
===========================================
Call:
energy = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

   energy.l1       gdp.l1    energy.l2       gdp.l2        const
 -0.06119129  -0.19179886  -0.24193719  -0.04395630 -33.14614189


Estimated coefficients for equation gdp:
========================================
Call:
gdp = energy.l1 + gdp.l1 + energy.l2 + gdp.l2 + const

  energy.l1      gdp.l1   energy.l2      gdp.l2       const
-0.07551153  0.59791609 -0.24065507  0.22498486 11.24850379
```