TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY
ISSN 2029-4913 / eISSN 2029-4921

2017 Volume 23(4): 667–686
doi:10.3846/20294913.2017.1323318

THE IMPACT OF BIOFUELS UTILISATION IN TRANSPORT ON THE SUSTAINABLE DEVELOPMENT IN THE EUROPEAN UNION

Mihaela SIMIONESCU[a], Lucian-Liviu ALBU[a],
Monica RAILEANU SZELES[a, b], Yuriy BILAN[c]

[a]*Institute for Economic Forecasting of the Romanian Academy, Bucharest, Romania*
[b]*Transilvania University of Brasov, Bucharest, Romania*
[c]*University of Szczecin, Poland, Microeconomics Department,*
Mickiewicza 64, Szczecin, 71-101 Poland

Received 06 February 2017; accepted 23 April 2017

Abstract. The biofuels sustainability in transport depends on the energetic products demand and the limited resources. According to European legislation, the energy consumption in transport from renewable energy in the European Union should increase by 10% till 2020. Considering the environmental requests related to greenhouse gases reduction and a lower dependency on oil fuels stimulated more the biofuels production, this research empirically assessed the impact of energy consumption in transport based on biodiesel and bioethanol on sustainable development in terms of economic growth and greenhouse emissions. Using dynamic panel and panel vector-auto-regression models for European Union countries during 2010–2015, we proved that only the energy consumption in transport based on biodiesel had a positive impact on economic growth. The greenhouse emissions did not have any impact on economic growth while the energy consumption in transport based on bioethanol negatively affected the economic growth. The Granger causality tests on panel data indicated a bilateral relationship between economic growth and energy consumption in transport based on biodiesel and between economic growth and energy consumption in transport based on bioethanol. Given these empirical results, the energy policies should focus on the higher utilisation of biodiesel in transport in the EU.

Keywords: sustainable development, biodiesel, bioethanol, economic growth, greenhouse emissions.

JEL Classification: C53, Q16, Q43.

Corresponding author Mihaela Simionescu
E-mail: *mihaela_mb1@yahoo.com*

Introduction

The fossil fuels are still the main resources of the energy market. The conventional fuels (natural gas, coal, oil) will continue to be used in the near future. The demand for natural gas and petroleum will increase because of the high economic growth of developing countries like Russia, China, Brasil and India. On the other hand, the fuels potential of exploitation at actual cotes is limited. For example, the resources of petroleum are available for 30 more years in the conditions of actual cotes of exploitation, while the natural gas and coal arrive for 125 years, respectively 220 years, according to US Energy Information Administration. Given this resources rarity, confirmed by the Economics law, the efforts at global level should intensify in order to develop more the renewable resources. The highest investment in renewable resources was made in China, India, Brasil and South Africa.

The biofuels represent one of the alternatives to fossil fuels and have several advantages: the biofuels could be stocked and they reduce the import dependence by their local production. As energy resources, these biofuels might solve current issues related to energy security, the new jobs creation or the reduction of greenhouse emissions for controlling the climatic changes at global level. The global energy market is characterized by a continuous growth in the energy demand and all the long-run scenarios indicate a considerable growth of energy consumption, even if there are high prices on this market. Asia became one of the greatest energy consumer without any negative influence of the economic crisis over 2007–2009. For 2030 Energy Institute anticipated a growth in the world energy demand by 35% compared to the level in 2010. On the other hand, the energy production at global level registered a growing trend that was interrupted only in 2009 by the economic and financial crisis. In this global context of higher needs for energy consumption, the biofules production might be a suitable solution.

The biofuels production is stimulated by the changes in petroleum price and the high taxes for fuels. The largest biofuels providers are the US, Brazil and the European Union. The ascending trend in the biofuels production started in 2004 when it almost doubled compared to 2000. The necessity to reduce the greenhouse emissions and the objective of future energy security were factors that determinate more investment in this sector which accelerate the biofuels production. The main contribution belongs to biofuels producers from the US and European Union that implemented policies to sustain the biofuels consumption and regulations for the fuels commercialization. The use of biofuels was encouraged in some regions by a legislative framework that asks for combination between biofuels and usual fuels.

In 2015, three quarters of the biofuels production at global level referred to ethanol and the rest of it referred to biodiesel. The US and Brazil are the main ethanol producers and consumers (more than 80% of the production and consumption of ethanol). However, the biodiesel production has an ascending trend due to new producers from Asia.

The US production of ethanol is mainly based on corn, while Brazil uses mostly sugarcane in producing the ethanol. In the European Union, the biodiesel is based on oilseeds (rapeseed and sunflower). The EU remains the largest producer of biodiesel in the entire world. Spain is the EU country with the highest production capacity of biodiesel, being followed by Germany and France.

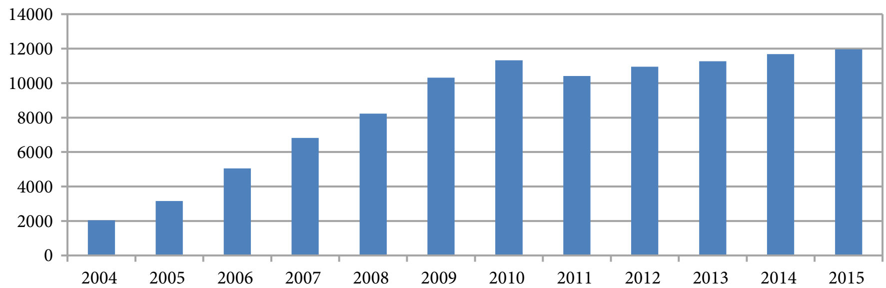

Fig. 1. Biofuel production in the EU (2004–2015) (in 1,000 metric tons of oil equivalent)
Source: author's graph based on Statista database (Economic Freedom Network 2015).

According to Figure 1, the maximum level of biofuels in the EU was registered in 2015.

The biofuels market has many barriers that influence the market development. The biodiesel production cost is greater than the cost of diesel based on petroleum. The biofuels present a high volatility in prices because of volatility in raw materials prices.

Governments make investment in research in order to reduce the production costs. Some of the barriers on fuels market are related to incompatibilities regarding the fuels mix in certain periods of a year (for example, the minimum temperature for using biodiesel is –15 degrees Celsius). Biodiesel needs a competitive price that could be similar with that of the diesel fuel.

There are many risks on biofuels production market. The business risk of the investor might be higher than the real risk. For a new industry, the risk perception is higher than the real risk and only the investor experience might reduce this gap between perception and reality.

There are also risks regarding costs financing. Equity holders and creditors might ask for restrictions on corporate activities which decrease the flexibility and rights. For new products, an installation might produce less than expected or it can costs more than expected. Capital injections are necessary to cover the unexpected costs.

The exploitation risks might be, sometimes, inevitable. The administration council might control the operation and interest conflicts between shareholders and administration council might appear. The exploitation risk might also be generated by prices volatility, high costs for entering in the market, the quality of raw material. Government could stimulate the biofuels production by fiscal stimulus. A qualified personal and a corporative structure might bring risks to investors.

The technological barriers like differences between actual infrastructure in distribution networks and new systems need to be solved. Investment in production and distribution infrastructure is required for biofuels market development and more categories are implied: biofuels producers, car manufacturers, engross dealers of liquid fuels, consumers and stations for alimentation with biofuels.

The infrastructure based on pipelines for biofuels should be standardized as to take into consideration the environmental, economic and assurance risks associated to various types of biofuels. The main issues for ethanol are related to corrosion, cracking tendency and elastomers degradation in the mixture of ethanol with gasoline. The scientific research provided some inhibitors to mitigate the corrosion and the steel cracking by the contact with ethanol. In the case of biodiesel, the main issue is related to steel corrosion and its incompatibility with non-ferrous metals.

Many countries promoted the biofuels production for ensuring the fuels in transport sector, for a lower dependence on fossil fuels, for combating the climate changes and for satisfying the growing need of energy. Almost third of the global energy consumption is attributed to transport sector.

The transport is necessary for an efficient economy. The increase in the energy consumption in transport is due to the demand increase in developing countries, mostly BRIC countries (Brazil, Russia, India and China) that registered increasing GDP rates. The economic growth generates the industrial production growth that needs movements of raw materials at the production places, of labour force and the free movement of merchandise till the final consumers.

The petroleum remains the leader in sources of energy used in transport, even if experts claimed about the rarity of this resource. The fossil fuels in transports should be replaced by sustainable liquid fuels in order to ensure the security regarding the energy supply in the entire world and mostly in Europe. Currently, two strategies are used to replace the fuels in transport using as criterion the engine construction. On long-run, the electric engines are more suitable, because they use fuel cells that do not produce emissions. Another concept which might be applied on short-term refers to the use of alternative fuels. The transport sector produces around 25% of the carbon dioxide emissions at global level. For reducing these emissions, the best solution is the use of biofuels.

The energy consumption in transport sector represents around 30% of the total energy consumption, more than 90% of the energy in this sector being based on petroleum fossils. The economic activities and commerce are the main reasons for merchandise transport. Passengers transport is related to factors regarding the necessity to reduce the fuels consumption and the noxious level, urbanization and the way of using the ground. For heavy vehicles, the biofuels are more necessary because the need of reducing the carbon dioxide emissions is more acute.

The new technologies should ensure the total or partial substitution of fossil fuels with biofuels. For road transport, the biofuels are represented by biodiesel, bioethanol and biogas. The bioethanol is frequently used in combination with diesel in road transport.

The most industrialized European countries have the highest weight of biofuels while Malta and Estonia have the lowest weights. An increase in the weight of biofuels used in transportation is expected, from 4.5% (the current value) to 27% in 2050, according to Advanced Motor Fuels.

The biofuels weight in transport sector increased in 2015 compared to 2000 by almost 5 times, while in the European Union the biofuels market grew from 0.3% in 2000 up to 5.1% in 2015. After 2005, the use of biofuels in transport suddenly grew in the EU due to strategies of sustainable development.

The main aim of this paper is to evaluate the impact of biofuels consumption in transport on the sustainable development in the European Union. The sustainable development implies three pillars: the economic development assessed by economic growth, the social development and the environmental protection. In this context, we assess the type of correlation and the causality between economic growth and energy consumption in transport based on biodiesel and bioethanol and between economic growth and greenhouse gas emissions.

The paper continues with a theoretical presentation of the biofuels sustainability in transport. The next section, the literature review, focuses on the description of main research directions regarding the relationship between sustainable development and energy consumption in transport based on biodiesel and bioethanol. After the methodology description, the empirical analysis for EU-28 countries is presented. The last section concludes.

1. The biofuels sustainability in transport

After the first petroleum crisis, the idea of chip oil finished and the optimization solutions were searched. Economic adjustments were made by oil consumers because of the petroleum price increases. The transport costs were reduced because of the improvements regarding the car efficiency, their weight and the performance of electric networks for fuels.

The biofuels sustainability in transport depends on the energetic products demand and the limited resources. According to European legislation, the EU members had to ensure at least 10% of the energy consumption in transport from renewable energy till 2020 (Objectives of the Directive and the inclusion of the ILUC (indirect land-use change) factor 2012/0288). The aviation might need a high amount of biofuels in case some projects will be successfully realized. The biofuels demand will increase with an average growth rate of 5% (Diaz-Chavez 2011).

Most of the alternative fuels need governmental support on the basis of their energy, environmental advantages or energy security. The first generation fuels have some disadvantages related to time needed to produce them, marketability and scalability. Some opinions considered a negative impact of these biofuels on the economy. The cereals prices increased because of the cereals use in making biofuels. Even in the European Union, the price of cereals used in making biofuels increased in the last years. Therefore, the EU legislation limited the cote of biofules in transport to 6%.

Several criteria should be followed in the EU strategy regarding the production and use of biofuels (Ahlgren, Di Lucia 2014). The biofules should reduce the greenhouse gas emissions compared to traditional fuels. The biofuels production should be based on ecological systems of agricultural and forest management in order to create new jobs and preserve the biodiversity and cultural patrimony. The lands should be efficiently used as to not create a conflict between cereals production and biofuels production.

The directive regarding energy from renewable resources (Directive 2009/28/EC) established some compulsory objectives for renewable energy. For example, till 2020 this type of energy should represent 20% of the total EU energy. The biofules used in transport should be sustainable and they should represent at least 10% of the fuels used in transport. The Directive 2009/30/CE regarding fuels quality established the limits in the content of ethanol, ethers and other oxygenic composes.

The EU adopted long term strategies for using renewable resources, for reducing the greenhouse gas emissions in transport and for adopting new technical and non-technical rules for vehicles and fuels used in transport.

The EU Strategy adopted through the renewable energy directive has three objectives: the biofuels promotion in the EU, measures for large scale use of biofuels and cooperation with developing countries for sustainable production of biofuels. The EU proposal is to produce biofuels without affecting the agricultural products prices and without changing the destination of soils for agricultural products.

It is more than likely that the energy demand will increase and the greenhouse gas emissions will increase. For environment protection, the industry should pass from the oil consumption to biofuels that provide less greenhouse gas emissions. Some measures like the use of woods as fuel by deforestation were not sustainable, generating the global warming. A global policy having as objective the efficiency in all sectors might reduce the greenhouse gas emissions and might slow the climatic changes. The EU established that the quantity of greenhouse gas emissions should not exceed 130 grams of CO2 per kilometre since 2015. In Italy, France, Spain, Ireland and Finland there are more than 15 regulations regarding the reduction of greenhouse gas emissions and fuels consumption while in Slovenia and Lithuania only 5 regulations were adopted till now.

The average yield of fuels in the EU in case of automobile is higher than in the US (Graham, Glaister 2002). Therefore, in the EU the costs for reducing the greenhouse gas emissions are higher. The weight of technologies with low greenhouse gas emissions should increase from the actual value of 45% till 60% in 2020. The EU objective of reducing the greenhouse gas emissions by 80–95% till 2050 compared to 1990 will be achieved by the measures established in the White Paper on Transport and the Green Paper on Transport in the EU.

According to White Paper on Transport from 2011, the technological innovation should follow several directions: the ecological use of energy, the vehicles efficiency, a better utilization of network transport in the EU by using alternative fuels to reduce the petroleum consumption. The investment in research and development for getting innovative technologies will improve the air quality, will reduce pollution and will ensure a healthier population. The EU strategy regarding the non-polluted and efficient vehicles called COM 186 promotes the ecological and efficient vehicles and the use of vehicles with low carbon emissions like those with hydrogen and electric vehicles.

A common strategy was adopted by the EU for energy security and environment protection. The energy security is defined as the continuous physical availability of the energy products on the market at an accessible price for any consumer (Demirbas 2009). For the energy security in transport, issues like global population growth, higher urbanization degree, higher mobility and world economic growth are important challenges that impose the energetic infrastructure adaptation. Since 2000, the energy intensity in transport with respect to GDP increased in the EU. Even if the energy intensity grew, the energy demand could double till 2050. Considering the lack of global accords regarding the energy policies, the government should establish regulations for ensuring a sustainable energy system.

The EU proposed to use the biofuels advantages to support the economic activity and the creation of new jobs as to achieve the objectives of cohesion and rural development policies. In this context, the animal sub-products and the waste are used as energy sources. The raw materials should be produced in a sustainable way in order to avoid water pollution, soil degradation and to protect species and habitats as well as the biodiversity. Some researches are based on the biofules using residuals that suppose microorganisms ingesting organic material. The Europe 2020 Strategy – A resource-efficient Europe – proposed an efficient economy with low greenhouse gas emissions and transport decarburization.

2. Literature Review

Since the 1970s, the biofuels become a good solution to overcome the issue of oil dependency. Since 1980, the weak quality of environment and the global warming stimulated the concerns for sustainable development and environmental protection. In this context, the high level of carbon dioxide emissions encouraged the replacement of fossil fuels with renewable sources. The environmental requests related to greenhouse gases reduction and a lower dependency on oil fuels stimulated more the biofuels production (Feehan, Petersen 2004). Even if fossil fuels can renew themselves, experts take into account their extinction in the near future and the necessity of biofuels energy becomes more acute. The EU took many initiatives to increase the small share of transport fuels. Consequently, this biofules expansion raised many questions regarding their impact on economic and social development and the effects on environment.

The advantages of biofuels in transport are multiple (security of energy supply, low-carbon emission, more energy resources, alternative market for agricultural products, better biodiversity). Some advantages and disadvantages of biofuels are presented in Table 1.

Table 1. The main benefits and disadvantages of biofuels

Benefits	Disadvantages
Potential contribution to sustainable development	High production costs
Renewability	High prices
Fuel diversity	Fertilizers utilization
More rural manufacturing jobs	Monoculture
Agriculture development	Less food security
More investment in equipment and plant	High water use
More income taxes	Industrial pollution
Less dependency on petroleum from import	Deforestation
Biodegradability	Special management for transportation and storage
Carbon sequestration	nitrogen oxide emissions
International competitiveness	additional land use
Greenhouse gas reductions	Less engine durability
Less air pollution	
Higher combustion efficiency	
Energy security	
Improved land and water use	

Source: authors' synthesis.

As nonrenewal energy resources contribute to the environmental pollution, governments and households are paying more attention to environmental protection and renewable energy consumption. One of the renewable energies is represented by biomass energy whose consumption can reduce the CO_2 emissions.

Most of the studies evaluated the social and environmental effects of biofuels production and consumption (Diaz-Chavez, Woods 2008; Lynd *et al.* 2011), but less researchers analyzed the effects of biofuels consumption on the entire economy (Demirbas 2009; Mukhopadhyay, Thomassin 2011). Few studies analyzed the economic and social implications of energy production based on biomass in relation with labour conditions, health, forced labour, rights for using the land, forced labour (Diaz-Chavez 2011).

Regarding the economic effects of biofuels energy consumption, the impact of biofuels energy on economic growth was considered in few studies. Two main conclusions were drawn: on one hand, the biofuels energy consumption energy had a positive effect on GDP growth and this type of energy should be promoted, while on the other hand, efforts should be made for keeping the prices in agriculture at a low level. The effects of biofuel energy on economic growth, agricultural production and price, pollution were analyzed in the major energy consuming states over 2000–2010 using the panel data approach. The biofuel energy had a positive effect on economic growth and pollution level, but it brought higher agriculture prices and higher production in this sector (Al-Mulali 2015). Aslan showed that in the US the biomass energy consumption had a direct influence on economic growth over 1961–2011 (Aslan 2016).

Many studies in literature focused on the causality relations between economic growth and energy consumption. For example, there was a causal relationship in the US from energy consumption to gross national income over 1947–1974 (Kraft J., Kraft A. 1978). On the other hand, there is not a unique opinion regarding the causality sense from energy consumption to economic growth (Bhattacharya *et al.* 2016). Narayan and Smyth (2008) and Akinlo (2009) considered that causality is from energy consumption to economic growth (Narayan, Smyth 2008; Akinlo 2009).

The causality between energy consumption and real GDP per capita was analyzed for 15 former Soviet Union countries over 1992–2009 using various models based on panel data. The results indicated a causal relationship only from energy consumption to the real GDP per capita only on long term (Dedeoglu, Piskin 2014).

The direction of Granger Causality between energy consumption and economic growth was the subject of many studies that proposed 4 possible hypotheses: "conservation hypothesis", "feedback hypothesis", "neutrality hypothesis" and "growth hypothesis" (Narayan, Smyth 2008). The neutrality hypothesis reflects the lack of any causality between output (GDP) and biofuels energy consumption, while the conservation assumption states the uni-directional causality from GDP to energy consumption. For this second hypothesis, the policies based on energy conservation designed to reduce the biofuels energy consumption have no effect on economic growth. If there is no causal relationship between variables, the sustainable development could not be achieved by biofuels utilization in energy sector. In the context of growth hypothesis, biofuels energy consumption is accepted as a cause for output. Therefore, under this hypothesis, the energy consumption has an essential role in achieving economic growth and the reduction of biofuels energy consumption might produce a decrease in the economic growth. This negative shock to energy consumption might have many negative consequences: higher energy price, decrease in the GDP and higher energy conservation policies. The feedback hypothesis confirms the bidirectional causality between output and biofuels energy consumption.

The literature that focused on the causal relationship between biomass energy and economic growth is sparse, if we make the comparison with other studies on different types of energy. In the last few years, this causal relationship was analyzed by Bildirici for America (Bildirici 2012, 2013). For developing countries like Brazil, Argentina, Bolivia, Colombia, Chile, Jamaica and Guatemala, Bildirici obtained the following results: unidirectional causality from GDP to biomass energy consumption in Colombia, unidirectional causality from biomass energy consumption to GDP in Brazil, Bolivia and Chile, bidirectional causality in Guatemala (Bildirici 2012). Bildirici discovered a co-integration relationship over 1980–2009 between biomasss energy consumption and economic growth for Cuba, Argentina, Costa Rica, Bolivia, El Salvador, Nicaragua, Jamaica, Panama, Peru and Paraguay (Bildirici 2013). The results indicated a causal relationship from biomass energy consumption to GDP in the case of Cuba, Argentina, Costa Rica, Nicaragua, Jamaica, Panama and Peru. A bidirectional relationship was observed for El Salvador.

Aslan showed that in the US there is a unidirectional causality going from biomass energy consumption to economic growth over 1961–2011 (Aslan 2016). For 6 Central American countries, Apergis and Payne obtained a bilateral relation between renewable energy consumption and GDP in both the short-term and the long-term over 1980–2006. They indicated bidirectional causality (Apergis, Payne 2011).

For some transition countries (Romania, Bulgaria, Poland, Latvia, Lithuania, Estonia, Belarus, Georgia, Albania and Moldova), the causality and co-integration relationship between the biomass energy consumption and economic growth were studied using Pedroni co-integration analysis and panel ARDL models during 1990–2011 (Bildirici 2014). The two variables are co-integrated and biomass energy consumption had a positive effect on the economic growth.

Recent studies focused on the relationship between renewable energy and GDP (Mun 2016). For China, Fang obtained a direct correlation between GDP and renewable energy (Fang 2011), while Wang *et al.* employed multivariate co-integration and ARDL models to show a long-run and short-run positive effect of energy consumption on the China economic growth (Wang *et al.* 2015). For Brasil, Sebri and Ben-Salha also indentified a positive relationship between economic growth and renewable energy consumption using Granger causality test and ARDL approach (Sebri, Ben-Salha 2014). For Brasil, Al-Mulali *et al.* employed a vector error correction model (VECM) and the Autoregressive Distributed Lag (ARDL) approach over 1980–2012 and showed that biofuel energy consumption contributed to Brasilian economic growth on short and long-run together with urbanization, capital and globalization (Al-Mulali *et al.* 2016).

In Germany, the increase in the renewable energy consumption generated economic growth. On the basis of less fossil fuels import and more renewable energy export, in Germany the GDP is expected to increase by 3.1% till 2030 (Blazejczak *et al.* 2014). The policies on the EU level follow a moderate economic growth and an increase in the employment due to renewable energy development (Ragwitz *et al.* 2009).

Bhattacharya *et al.* investigated the consequences of renewable energy consumption on the economic growth taking into consideration major states that use renewable energy (Bhattacharya *et al.* 2016). 38 of these countries were selected to explain the economic growth over 1991–2012 using panel data models. The estimations suggested a long-run impact of renewable energy consumption on the economic growth of the selected countries due to government policies. The positive contribution of biofuels to economic growth was showed by Hausmann and Sturzenegger for Latin America and Africa due to investment in natural resource-extractive industries (Hausmann, Sturzenegger 2007).

Another subject of the debates regarding biofuel production and consumption is related to the environmental implications. The main advantage of biofuels is related to GHG emissions reduction because of the biomass that captures carbon that is in the air. On the other hand, biofules needs energy for growth, its processing and transportation. These processes suppose positive net emissions. For ethanol Pimentel computed a negative energy balance when the source is the corn (Pimentel 2003). Graboski and McClelland considered that biofuels are a significant net energy contributor (Graboski, McClelland 2002). Moreover, by clearing the new land for getting biofuel production, large emissions of GHGs are released, because of the organic matter burning and decomposition (Fargione *et al.* 2008). In literature, these land-conversion emissions are known as "carbon debt".

For United States, Menyah and Wolde-Rufael found a causality relationship from nuclear energy consumption to CO_2 emissions, but no causal relationship between renewable energy and CO_2 emissions over 1960–2007 (Menyah, Wolde-Rufael 2010).

For achieving a sustainable transport sector, recent studies has considered the relationships between economic growth/GDP, energy consumption in transport sector, CO_2 emissions and transport infrastructure. Liddle employed panel data models to show the causality from transport energy consumption to GDP (Liddle 2009). For Malaysia, Ang indicated a causal relationship from GDP to transport energy consumption in the long-run (Ang 2008). On the other hand, for Malaysia there was a weak causality from CO_2 emissions to GDP. In the case of Thailand, Malaysia and Philippines, Hossain showed that there is no long-run causality between CO_2 emissions, energy consumption and income, but there is a short-term causality from income to CO_2 emissions (Hossain 2011). For OECD countries, Saboori *et al.* indicated a bilateral relation between CO_2 emissions and GDP over 1960–2008 (Saboori *et al.* 2014). For these countries, Pradhan showed a causal relation from economic growth to energy consumption over 1970–2007 (Pradhan 2010).

3. Research methodology

As we stated, the main objectives of this paper focus on the type of correlation and causality between economic growth and biodiesel and bioethanol energy consumption in transport. For achieving these objectives a suitable methodology is applied. The research is conducted on panel data referring to the EU-28 countries during a small time period (2010–2015), because of the data availability which is a limit of this research. A dynamic panel data model and a panel vector-autoregression were estimated to measure the impact of biofuels energy consumption in transport on economic growth. The causality relationships were checked using a Granger test on panel data (Panel VAR-Granger causality Wald test).

The demeaning transformation met in panel data generates the issue of unobserved heterogeneity. The dynamic panel models are based on first differencing for deleting the unobserved heterogeneity. The partial adjustment mechanism is made by considering the lagged variable or more lagged variables in the model. The demeaning procedure brings a regressor that is not independently distributed by the error. In case of correlation between the explanatory variables and the lagged dependent variable, we have biased coefficients. On the other hand, a Fixed-Effect Model presents the Nickell bias.

This bias is present even for independent and identically distributed errors. A solution might be the calculation of first differences of the initial model. In case of a single explanatory variable and a lagged dependent variable Y, we consider the model:

$$y_{it} = \beta_0 + \rho \cdot y_{i,t-1} + \beta_1 \cdot X_{it} + u_i + \varepsilon_{it},$$

where: X_{it} – exogenous variables; y_{it} – dependent variable; u_i – unobserved individual effect; ε_{it} – error term.

The model in first difference supposes the elimination of the constant and of the individual effect:

$$\Delta y_{it} = \rho \cdot \Delta y_{i,t-1} + \beta_1 \cdot \Delta X_{it} + \Delta\varepsilon_{it}.$$

In this model, we still have errors correlation with the lagged dependent variable.

We can construct instruments for the lagged dependent variable starting with the 2nd and the 3rd lag. In case of i.i.d. error, the lags are correlated with the lagged dependent variable, but not with the composite error.

Let us consider the following equations:

$$y_{it} = \beta_0 \cdot X_{it} + \beta_1 \cdot W_{it} + v_{it};$$
$$v_{it} = u_i + \varepsilon_{it},$$

where: X_{it} – exogenous variables; W_{it} – predetermined and endogenous variables correlated with u_i.

The first-differencing equation deletes the unobserved individual effect, but we still have the omitted variable bias.

In case of Arrelano-Bond (AB) and System GMM (Generalized Method of Moments) estimator, we have several assumptions:

– Many cross-sections and few time periods;

– A functional and linear relationship between variables;

– One left-hand dynamic characteristic;

– Not strictly exogenous right-hand regressors;

– Fixed individual effects implying unobserved heterogeneity;

– Serial correlation and homoskedasticity within cross-sections.

The AB estimator uses generalized method of moments. The model is based on a system of equations with different instruments for each equation. The limit of AB estimator is solved by Arrelano-Bond-Blundell-Bond (ABBB) estimator. The lagged levels are weak instruments for the first difference variables. The new estimator (ABBB estimator) contains lagged differences and lagged levels. The first estimator is known as difference GMM, while the expanded one is called System GMM and it considers supplementary restrictions related to the initial conditions for generating the dependent variable.

A panel VAR model will also be proposed for capturing the potential effects of previous values of the variables on actual values variables. The panel vector-autoregressive model is:

$$y_{it} = u_i + A_i(j) \cdot Y_{i(t-1)} + e_{it'};$$

$Y_{it} = (y_{1t'}, y_{2t'}, \ldots, y_{nt'})$ includes the data for all cross-sections, $i = 1, 2, \ldots, n$,

where: y_{it} – variables vector for each cross-section; u_i – specific- constant for cross-section; $A_i(L)$ – lag polynomial that includes VAR coefficients; $e_{it'}$ – errors (null mean, cross-section- specific dispersion σ_i^2), K – number of variables.

In case of a model without restrictions, $n \times k \times n$ coefficients are presented in the matrix A_n.

The coefficients that appear in $A_i(L)$ vary randomly across cross-sections under the assumption of mean group estimator. The standard element a_{ijm}^p in $A_i(L)$ is: $a_{ijm}^p = a_{jm}^p + \mu_{ijm}^p$. In this casem p is the lag order of the VAR model, $p = 1,2,\ldots, P$ while i is the cross-section index, j, m= 1, 2, …, K.

The VAR model in the reduced-form is written as:

$$y_{it} = u + A_i(L) \cdot y_{it} + e_{it'}.$$

In this study, a panel VAR model will be built for three variables (real GDP rate, biodiesel and bioethanol energy consumption in transport). Therefore, k will be 3. There are 28 cross-sections corresponding to the 28 EU countries. The time period covers the years from 2010 to 2015 (6 years, t = 2010,…, 2015).

4. Biofuels energy consumption in transport and sustainable development

In this study, the data refer to the following variables:

- Real GDP rate (%);
- Biodiesel energy consumption in transport (thousand tons of oil equivalent);
- Bioethanol energy consumption in transport (thousand tons of oil equivalent);
- Greenhouse emissions by energy consumption (index 2000=100).

The data are registered for all the countries of the EU-28 during 2010–2015. We also included Croatia, even if this state entered the EU in 2013. The source of data is represented by Eurostat.

We have already considered that our objectives are the evaluation of the impact of biofuels energy consumption in transport on the sustainable development (economic growth and greenhouse emissions) and the type of causality between biofuels energy consumption in transport and economic growth, respectively biofuels energy consumption in transport and greenhouse emissions.

In terms of impact assessment of biofuels energy consumption in transport on the economic growth, we estimated a dynamic panel data model and a panel VAR model. The data are stationary in level at 5% level of significance.

In the case of the system dynamic panel data model, the real GDP rate in the current period positively depends on the real GDP rate in the previous period. The real GDP rate tends to increase from a year to another. The biodiesel energy consumption in transport had a slow, but positive effect on the economic growth. If the real GDP rate increased in the previous period by one percentage point, the current real GDP rate increased, in average, by 0.7804 percentage points. An increase in the biodiesel energy consumption in transport by one thousand tons of oil equivalent determined, in average, an increase by 0.0054 percentage points in the real GDP rate. The bioethanol energy consumption had a negative impact on the real GDP rate. An increase in the biodiesel energy consumption in transport by one thousand tons of oil equivalent determined, in average, a decrease by almost 0.013 percentage points in the real GDP rate in the EU-28 during 2010–2015. In the EU, the wheat is the principal crop used in bioethanol production and it accounts for 0.7% of the EU land for agriculture. In this context, the European Commission considered that the bioethanol from food crops should be reduced, because of the land use effects and food price. eBIO considered in 2009 that European bioethanol is a source of economic growth by the jobs created in the rural environment. However, the empirical results showed the contrary. The bioethanol energy consumption is still not efficient as to stimulate the economic growth. Therefore, the EU policies should focus on the bioethanol production that does not negatively affect the food price.

Table 2. System dynamic panel data estimation for explaining economic growth in the EU-28 countries during 2010–2015 using the biodiesel and bioethanol energy consumption in transport

Variable	Coefficient	z statistic	P > |z|
Real GDP rate in the previous period	0.7804	6.44	0.000
Biodiesel energy consumption	0.0054	3.64	0.000
Bioethanol energy consumption	–0.01287	–2.22	0.027
Constant	–0.1939	–0.56	0.576

Source: own computations.

Another approach is based on the estimation of a panel VAR model to explain the relationship between economic growth, biodiesel and bioethanol energy consumption in transport in the EU-28 countries during 2010–2015. The models that explain the real GDP rate and the biodiesel energy consumption in the current period were valid.

The results are slowly different compared to the previous model. If the real GDP rate increased in the previous period by one percentage point, the current real GDP rate increased, in average, by 0.6642 percentage points. An increase in the biodiesel energy consumption in transport in the previous period by one thousand tons of oil equivalent determined, in average, an increase by 0.0098 percentage points in the current real GDP rate. The bioethanol energy consumption had a negative impact on the real GDP rate. An increase in the biodiesel energy consumption in transport corresponding to the previous year by one thousand tons of oil equivalent determined, in average, a decrease by almost 0.0305 percentage points in the current real GDP rate in the EU-28 during 2010–2015.

The real GDP in the previous year had a negative impact on the current biodiesel energy consumption in transport. If the previous real GDP rate increased by one percentage point, the current biodiesel energy consumption in transport decreased by 20.7054 thousand tons of oil equivalent. On the other hand, if the bioethanol energy consumption in the previous period increased by one thousand ton of oil equivalent, the current biodiesel energy consumption in transport increased, in average, by 0.1183 thousands ton of oil equivalent. Therefore, we can state that the biodiesel utilization in transport in the previous period attracts also the use of bioethanol, but to a less extent.

Table 3. Panel VAR model estimation for explaining economic growth, biodiesel and bioethanol energy consumption in transport in the EU-28 countries during 2010–2015

Variable	Coefficient	z statistic	P > |z|
Dependent variable: Real GDP rate in the current period			
Real GDP rate in the previous period	0.6642	8.33	0.000
Biodiesel energy consumption in the previous period	0.0098	4.08	0.000
Bioethanol energy consumption in the previous period	–0.0305	–3.33	0.001
Dependent variable: Biodiesel energy consumption in the current period			
Real GDP rate in the previous period	–20.7054	–6.75	0.000
Biodiesel energy consumption in the previous period	0.1183	2.12	0.034
Bioethanol energy consumption in the previous period	0.7320	3.53	0.000
Dependent variable: Bioethanol energy consumption in the current period			
Real GDP rate in the previous period	–3.9247	–3.71	0.000
Biodiesel energy consumption in the previous period	–0.0055	–0.95	0.343
Bioethanol energy consumption in the previous period	0.1905	5.21	0.000

Source: own computations

The proposed panel data model fulfills the stability condition. The eigen values are less than 1.

Table 4. Eigen value stability condition

Eigenvalue		Modulus
Real	Imaginary	
0.4557288	0.3168349	0.5550433
0.4557288	0.3168349	0.5550433
0.0617029	0	0.0617029

Source: own computations

The econometric estimations suggested that none of the model put into evidence a significant impact of greenhouse emissions on the economic growth.

The second objective was related to the type of causalities between the variables. The data were stationary and the causality was analyzed in the Granger approach.

Table 5. Panel VAR-Granger causality Wald test for economic growth, biodiesel and bioethanol energy consumption in transport in the EU-28 countries during 2010–2015

Effect	Cause	Chi-squared	Prob. > chi-squared
real GDP rate	biodiesel energy consumption in transport	16.628	0.000
	bioethanol energy consumption in transport	11.115	0.001
	biodiesel and bioethanol energy consumption in transport	16.933	0.000
biodiesel energy consumption in transport	real GDP rate	45.550	0.000
	bioethanol energy consumption in transport	12.432	0.000
	real GDP rate and bioethanol energy consumption in transport	48.370	0.000
bioethanol energy consumption in transport	real GDP rate	13.797	0.000
	biodiesel energy consumption in transport	0.899	0.343
	real GDP rate and biodiesel energy consumption in transport	14.199	0.001

Source: own computations

The results of panel Granger causality test on stationary data indicated the following conclusions:

- biodiesel and bioethanol energy consumption in transport do Granger cause the economic growth;
- real GDP rate and bioethanol energy consumption in transport do Granger cause the biodiesel energy consumption in transport;
- real GDP rate do Granger cause the biodiesel energy consumption in transport.

In other words, we can state that there is a bidirectional relationship between economic growth and biodiesel energy consumption in transport and between economic growth and bioethanol energy consumption in transport in the EU-28 during 2010–2015.

None of the panel data models which explain the relationship between greenhouse emissions by energy consumption and economic growth were valid. We also tested the causality relationship between all variables.

Table 6. Panel VAR-Granger causality Wald test for greenhouse emissions by energy consumption, economic growth, biodiesel and bioethanol energy consumption in transport in the EU-28 countries during 2010–2015

Effect	Cause	Chi-squared	Prob. > chi-squared
Real GDP rate	Emissions	3.295	0.069
Emissions	Real GDP rate	1.301	0.254
Biodiesel energy consumption in transport	Emissions	0.110	0.740
Emissions	Biodiesel energy consumption in transport	2.072	0.150
Bioethanol energy consumption in transport	Emissions	0.080	0.777
Emissions	Bioethanol energy consumption in transport	2.514	0.113

Source: own computations.

The results indicated that there is not any causal relationship between economic growth and emissions, biodiesel energy consumption in transport and emissions, respectively bioethanol energy consumption in transport and emissions.

Conclusions

The global demand for biofuels initially increased because of the high petroleum price and for the need of energy security. Some support measures were taken in countries with high potential in biofuels production and the effects were positive: a lower dependence on fossil fuels, higher incomes from agriculture exploitations, lower environment losses compared to fossil fuels.

This empirical study assessed the impact of energy consumption in transport based on some biofuels (bioethanol and biodiesel) on aspects regarding sustainable development: the economic growth and the greenhouse emissions. The biodiesel energy consumption in the current and previous period had a positive impact on the economic growth in the EU-28. The bioethanol energy consumption in the current and previous period had a negative impact on the economic growth in the EU-28. Even if the European Commission considered the bioethanol use in transport as a potential source of economic growth, the empirical analysis contradicted this expectation. One possible explanation might be related to the high agricultural product prices because of the use of some crops in the bioethanol production. Therefore, the economic policies of the European Commission should focus to an efficient production of this biofuel.

The following types of Granger causality were identified based on panel data for the EU countries during 2010–2015:

- There is a bidirectional causality relationship between economic growth and biodiesel energy consumption in transport;
- There is a bidirectional causality relationship between economic growth and bioethanol energy consumption in transport;
- There is a unidirectional causality relationship from bioethanol energy consumption in transport to biodiesel energy consumption in transport.

All in all, we might state that the EU should focus more on the biodiesel utilisation in transport rather than bioetahnol, because of the positive impact on the economic growth. The positive effects of biofuels utilisation in transport on the greenhouse emissions are still not relevant, but an intensive use of energy based on biofuels for ensuring the transport might improve the environmental issues. However, this research is limited by the consideration of only two biofuels and by the impact evaluation of two pillars of sustainable development: economic development and environmental protection. In a future research, we will focus on other biofuels and we will assess the impact of energy consumption in transport based on these biofuels on the life quality. Moreover, a comparative analysis of the impact of energy consumption in transport based on traditional fuels, respectively biofules on the sustainable development is necessary.

References

Ahlgren, S.; Di Lucia, L. 2014. Indirect land use changes of biofuel production – a review of modelling efforts and policy developments in the European Union, *Biotechnology for Biofuels* 7(1):7–35. https://doi.org/10.1186/1754-6834-7-35

Akinlo, A. E. 2009. Electricity consumption and economic growth in Nigeria: evidence from cointegration and co-feature analysis, *Journal of Policy Modeling* 31(5): 681–693. https://doi.org/10.1016/j.jpolmod.2009.03.004

Al-Mulali, U. 2015. The impact of biofuel energy consumption on GDP growth, CO2 emission, agricultural crop prices, and agricultural production, *International Journal of Green Energy* 12(11): 1100–1106. https://doi.org/10.1080/15435075.2014.892878

Al-Mulali, U.; Solarin, S. A.; Ozturk, I. 2016. Biofuel energy consumption-economic growth relationship: an empirical investigation of Brazil, *Biofuels, Bioproducts and Biorefining* 10(6): 753–775. https://doi.org/10.1002/bbb.1675

Ang, J. B. 2008. Economic development, pollutant emissions and energy consumption in Malaysia, *Journal of Policy Modeling* 30(2): 271–278. https://doi.org/10.1016/j.jpolmod.2007.04.010

Apergis, N.; Payne, J. E. 2011. The renewable energy consumption – growth nexus in Central America, *Applied Energy* 88(1): 343–347. https://doi.org/10.1016/j.apenergy.2010.07.013

Aslan, A. 2016. The causal relationship between biomass energy use and economic growth in the United States, *Renewable and Sustainable Energy Reviews* 57: 362–366. https://doi.org/10.1016/j.rser.2015.12.109

Bhattacharya, M.; Paramati, S. R.; Ozturk, I.; Bhattacharya, S. 2016. The effect of renewable energy consumption on economic growth: Evidence from top 38 countries, *Applied Energy* 162: 733–741. https://doi.org/10.1016/j.apenergy.2015.10.104

Bildirici, M. E. 2012. The relationship between economic growth and biomass energy consumption, *Journal of Renewable and Sustainable Energy* 4(2): 23–113. https://doi.org/10.1063/1.3699617

Bildirici, M. E. 2013. Economic growth and biomass energy, *Biomass and Bioenergy* 50: 19–24. https://doi.org/10.1016/j.biombioe.2012.09.055

Bildirici, M. E. 2014. Relationship between biomass energy and economic growth in transition countries: panel ARDL approach, *GCB Bioenergy* 66: 717–726. https://doi.org/10.1111/gcbb.12092

Blazejczak, J.; Braun, F. G.; Edler, D.; Schill, W. P. 2014. Economic effects of renewable energy expansion: a model-based analysis for Germany, *Renewable and Sustainable Energy Reviews* 40: 1070–1080. https://doi.org/10.1016/j.rser.2014.07.134

Dedeoglu, D.; Piskin, A. 2014. A dynamic panel study of energy consumption – economic growth nexus: evidence from the former Soviet Union countries, *OPEC Energy Review* 381: 75–106. https://doi.org/10.1111/opec.12017

Demirbas, A. 2009. Political, economic and environmental impacts of biofuels: a review, *Applied Energy* 86: 108–117. https://doi.org/10.1016/j.apenergy.2009.04.036

Diaz-Chavez, R. A. 2011. Assessing biofuels: aiming for sustainable development or complying with the market?, *Energy Policy* 3910: 5763–5769. https://doi.org/10.1016/j.enpol.2011.03.054

Diaz-Chavez, R. A.; Woods, J. 2008. Sustainability assessment of biofuels in practice, in *5th biofuels International Conference*, 17 June 2008, New Delhi, India.

Directive 2012/0288 (COD) of the European Parliament and of the Council of 17 October 2012 on the promotion of the use of energy from renewable sources.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC

European Commission. 2011. *A resource-efficient Europe-Flagship initiative under the Europe 2020 Strategy* [online], [cited 05.10.2016]. Belgium: Communication (COM (2011) 21). Available from Internet: https://www.eea.europa.eu/policy-documents/a-resource-efficient-europe-flagship.

European Comission. 2011. *White Paper on Transport: Roadmap to a Single European Transport Area: Towards a Competitive and Resource-efficient Transport System* [online], [cited 03.03.2016]. Belgium: Publications Office of the European Union. Available from Internet: https://ec.europa.eu/transport/themes/strategies/2011_white_paper_en

Economic Freedom Network. 2015. *The Fraser Institute database* [online], [cited 07.03.2015]. Canada: The Fraser Institute. Available from Internet: http://www.freetheworld.com/datasets_efw.html

Fang, Y. 2011. Economic welfare impacts from renewable energy consumption: the China experience, *Renewable and Sustainable Energy Reviews* 15(9): 5120–5128. https://doi.org/10.1016/j.rser.2011.07.044

Fargione, J.; Hill, J.; Tilman, D.; Polasky, S.; Hawthorne, P. 2008. Land clearing and the biofuel carbon debt, *Science* 319(5867): 1235–1238. https://doi.org/10.1126/science.1152747

Feehan, J.; Petersen, J. E. 2004. A framework for evaluating the environmental impact of biofuel use, *Biomass and Agriculture: Sustainability, Markets and Policies* 1: 151–167. https://doi.org/10.1016/b978-0-12-408129-1.00003-6

Graboski, M. S.; McClelland, J. M. 2002. A rebuttal to ethanol fuels: energy, economics and environmental impacts, *International Sugar Journal* 104(1240): 162–163.

Graham, D. J.; Glaister, S. 2002. The demand for automobile fuel: a survey of elasticities, *Journal of Transport Economics and Policy* 36(1): 1-25.

Hausmann, R.; Sturzenegger, F. 2007. The missing dark matter in the wealth of nations and its implications for global imbalances, *Economic Policy* 22(51): 469–518. https://doi.org/10.1111/j.1468-0327.2007.00182.x

Hossain, M. S. 2011. Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries, *Energy Policy* 39(11): 6991–6999. https://doi.org/10.1016/j.enpol.2011.07.042

Kraft, J.; Kraft, A. 1978. Relationship between energy and GNP, *Journal of Energy Development* 32: 401–403.

Liddle, B. 2009. Long-run relationship among transport demand, income, and gasoline price for the US, *Transportation Research Part D: Transport and Environment* 142: 73–82. https://doi.org/10.1016/j.trd.2008.10.006

Lynd, L. R.; Aziz, R. A.; de Brito Cruz, C. H.; Chimphango, A. F. A.; Cortez, L. A. B.; Faaij, A.; *et al.* 2011. A global conversation about energy from biomass: the continental conventions of the global sustainable bioenergy project, *Interface Focus* 1(2): 271–279.

https://doi.org/10.1098/rsfs.2010.0047

Menyah, K.; Wolde-Rufael, Y. 2010. Energy consumption, pollutant emissions and economic growth in South Africa, *Energy Economics* 326: 1374–1382. https://doi.org/10.1016/j.eneco.2010.08.002

Mukhopadhyay, K.; Thomassin, P. J. 2011. Macroeconomic effects of the ethanol biofuel sector in Canada, *Biomass and Bioenergy* 357: 2822–2838. https://doi.org/10.1016/j.biombioe.2011.03.021

Mun, B. K. 2016. *Relationship between renewable energy, economic growth and carbon dioxide CO2 in Malaysia* [online], [cited 31 January 2017]. Universiti Tunku Abdul Rahman. Available from Internet: http://www.eprints.utar.edu.my

Narayan, P. K.; Smyth, R. 2008. Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks, *Energy Economics* 305: 2331–2341. https://doi.org/10.1016/j.eneco.2007.10.006

Pimentel, D. 2003. Ethanol fuels: energy balance, economics, and environmental impacts are negative, *Natural Resources Research* 122: 127–134. https://doi.org/10.1007/bf02229143

Pradhan, R. P. 2010. Modeling the nexus between energy consumption and economic growth in India, *IUP Journal of Infrastructure* 81(2): 51–64. https://doi.org/10.1504/ijmdm.2010.035216

Ragwitz, M.; Schade, W.; Breitschopf, B.; Walz, R.; Helfrich, N.; Rathmann, M., Nathani, C. 2009. *The impact of renewable energy policy on economic growth and employment in the European Union* [online], [cited 31 January 2017]. European Commission, DG Energy and Transport. Available from Internet: http://www.apgreenjobs.ilo.org/resources/the-impact-of-renewable-energy-policy-on-economic-growth-and-employment-in-the-european-union

Sebri, M.; Ben-Salha, O. 2014. On the causal dynamics between economic growth, renewable energy consumption, CO2 emissions and trade openness: fresh evidence from BRICS countries, *Renewable and Sustainable Energy Reviews* 39: 14–23. https://doi.org/10.1016/j.rser.2014.07.033

Saboori, B.; Sapri, M.; bin Baba, M. 2014. Economic growth, energy consumption and CO 2 emissions in OECD Organization for Economic Co-operation and Development's transport sector: a fully modified bi-directional relationship approach, *Energy* 66: 150–161. https://doi.org/10.1016/j.energy.2013.12.048

Wang, S.; Fang, C.; Wang, Y.; Huang, Y.; Ma, H. 2015. Quantifying the relationship between urban development intensity and carbon dioxide emissions using a panel data analysis, *Ecological Indicators* 49: 121–131. https://doi.org/10.1016/j.ecolind.2014.10.004

Mihaela SIMIONESCU. Doctor, PhD Supervisor in Economics, Senior Researcher. Institute for Economic Forecasting of the Romanian Academy. Director at the Centre for Migration Studies in Prague Business School. First degree in Economic Statistics and Forecasting, Bucharest University of Economics (2008). Master of Science (2010). Doctor (2013). Habilitated Doctor in Economics (2016). Member of the Economic Society of Albania Romanian Society of Econometrics, Romanian Regional Science Association and International Regional Science Association, General Association of Economists from Romania, International Association of Scientific Innovation and Research (IASIR), Internet Society, Interoperability Solutions for European Public Administrations, EcoMod Network. She has published more than 200 publications. Research interests: macroeconomic modelling and forecasting, forecasts uncertainty, foreign direct investment.

Lucian-Liviu ALBU. Doctor, Senior Researcher. Institute for Economic Forecasting of the Romanian Academy. Director at Institute for Economic Forecasting of the Romanian Academy. First degree in Economics, Bucharest University of Economics (1977). Doctor (1991). Academician (2013). Member of: National Fiscal Council, Bucharest; Network of British Academy Beneficiaries of Research Stages; Scientific Council of NIER, Romanian Academy; International Association of National Accountability, INSEE, Paris; Romanian Society of Economics, Bucharest; Adam Smith Institute, London; Quantitative Macroeconomics and Real Business Cycle theory; Coordinating Council of Statistical Activity, National Institute of Statistics, Bucharest; Global Development Network, New York, Prague, Vienna; Commission of Socio-Economic Cybernetics, Romanian Academy; Centre for Research on Emerging Economies, Staffordshire University, Stoke on Trent; Romanian Association for the Club of Rome; EcoMod Network, Free University of Brussels; Network on Employment and Gender Equality Issues, EC, Brussels, etc. He has published more than 400 publications. Research interests: modern economic theory and non-linear macroeconomics, models on informal economy and tax evasion, economic efficiency and development, econometric modelling and forecast.

Monica RAILEANU-SZELES. Doctor, Full Professor. Faculty of Economic Sciences from Transilvania University of Brasov. Senior Researcher at Institute for Economic Forecasting. First degree in Economics, Faculty of Economic Sciences of Transilvania University of Brasov (1997). Doctor (2004), Bucharest University of Economics. Habilitated Doctor in Economics (2015). She published many articles in prestigious journals. Research interests: economic convergence in the European Union, social exclusion, multidimensional poverty.

Yuriy BILAN. Doctor, Associate Professor. University of Szczecin, Department of Microeconomics. First degree in Economics, Ternopil Academy of National Economy (2000). Doctor (2006), Habilitated Doctor in Economics (2016). He has published more than 100 papers (more than 90 papers in Scopus and Web of Science journals). Research interests: migration in post-transition economies, sustainable development, labour market issues.