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EFFECTS ON THE ECONOMIC GROWTH IN BULGARIA DURING THE TRANSITION TO LOW-CARBON ECONOMY IN THE ENERGY SECTOR[5]

The paper analyses the potential macroeconomic effects that the transition to a low-carbon economy would generate on investment activity and employment in the energy sector in Bulgaria. Global and European initiatives and regulations are reviewed. They trace the changes in the structure of the energy sector and may be assessed as an external shock to the country's economic growth. Using the production function approach, the relationship between real GDP, on the one hand, and capital and employees in the energy sector, on the other hand, is modelled and estimated in 1997-2017. The econometric estimate shows that a negative effect on the real GDP growth rate would be expected due to the contraction of the energy sector. Such effects may stem from the reduction of investments because of a decrease in production and profits in the sector, while employment levels have no significant impact on gross value added. This puts much more emphasis on conducting government policies on maintaining the technological level of the sector than on the negative social consequences of increasing unemployment in the energy sector.
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Introduction

At a global and European level, more and more initiatives are being launched to build a new economic model that focuses on sustainable development rather than the traditional goal of accelerating economic growth. The UN Agenda 2030, adopted in 2015, contains 17 Sustainable Development Goals, which include intentions for affordable and clean energy. The 2015 Paris Climate Agreement is accompanied by a Roadmap that envisages coals to be excluded by the energy mix no later than 2030, which requires a carbon tax of at least $50 per ton. In addition, since 2015, the European Commission has been making proposals that have to a great extent already become acquis communautaire and are linked to the European carbon emission market, the construction and management of the Energy Union and the creation of a new model in the electricity market. As part of the Clean Energy Package of 2016, an agreement was reached to reduce greenhouse gas emissions in the EU by 40% until 2030 compared to 1990 with a binding pan-European target of 32% share for energy from renewable sources.

In this regard, there would be some challenges for Bulgaria in the short and long term. As Simon Kuznets's ecological curve (Kuznets, 1955) shows, there is empirical evidence that when an economy is catching up, there is an increase in environmental damages. Such effect is later confirmed by other economists such as Kenneth Arrow (Arrow et al., 1995). The 2018 Report of the Club of Rome states: "More human economy (more people and commodities) means less natural ecosystem. There is an obvious physical conflict between the growth of the economy and the preservation of the environment." (p. 68). Bearing in mind that in 2017, according to Eurostat, Bulgaria ranks third in the EU in the production of harmful emissions of carbon dioxide and the share of coal in the country's electricity mix is 43% by 2017, inevitably the transition to a low-carbon economy would cost the loss of economic growth and jobs in the country. However, accurate estimates are missing at ьnational level. An additional negative effect may be caused on the country's catching-up development and convergence towards the euro area, which may be delayed by environmental considerations.

The purpose of the paper is to evaluate and measure the effect on the economic growth in Bulgaria due to limitation of carbon dioxide emissions in the economic sector D. "Electricity, gas, steam and air conditioning supply" up to NACE. The sizing of the environmental impact allows both to outline the future prospects for the country's economic development stemming from the state of the energy sector and to frame the subsequent macroeconomic policy challenges. The paper begins with an overview of economic research on the relationship between the state of the energy sector and macroeconomic development. The specific global and European energy initiatives that outline the challenges facing the sector are also reviewed. On this basis, we evaluate the economic effects of changes in the energy sector based on the production function approach and the Solow growth model using data for the period 1997-2017. In conclusion, the results are discussed, and the dimensions of the transition to a low-carbon economy in terms of GDP and employment effects in the country are outlined.

Effects of the Energy Sector on the Macroeconomic Development

The macroeconomic changes that the transition to a low-carbon economy would bring about can be considered in several aspects. First, we focus on sector processes that pose macroeconomic effects and then on purely macroeconomic changes related to the impact on economic growth, employment, investments and foreign trade. We attempt to systematize the research studies both in terms of direct effects on economic growth and the macroeconomic dimensions of environmental transformations in the energy sector.

Despite the declared need for creating a new model of sustainable economic development in the scientific literature and the emphasized positives of the transition to a low-carbon economy, the ensuing effects of these processes should be evaluated in regard to the time period and the level of economic development. Ambiguous economic effects can be clearly identified in the short and long term while the level of technological development and welfare of particular countries also matter. According to some authors, such a divergence in the ecological adjustment of the energy sector is due to the different degree of energy intensity of production processes and the use of coal in electricity production (Cooper et al., 1999). Differences are also observed due to the rates and specifics of economic growth. A study in China finds that the limit of 7% annual economic growth turns out to be crucial for neutralizing the negative effects of the transition to a low carbon economy (Li et al., 2018).

The differences between the short and long-term effects on economic growth from the transition to a low-carbon economy raise the more serious question about the specifics of the traditional economic development model (Ivanova, Chipeva, 2019). The traditional economic growth model does not account for the benefits of the circular economy and the negative environmental effects (Fontana, Sawyer, 2016). However, higher economic prosperity means more greenhouse gas emissions and resource consumption (Chancel, Piketty, 2015). This is a direct consequence of the paradox of Jevons (Bauer, Papp, 2009) according to which people tend to consume more resources when they are more efficient, and thus exceeding much of the savings achieved which potentially leads to even greater consumption of resources in a growing economy. Consequently, there is a conflict between the traditional goal of accelerating economic growth and achieving a sustainable economic development, which sets the macroeconomic dimensions of the transition to a low-carbon economy (Göpel, 2016). In these circumstances, economic growth cannot be viewed as an indicator for achieving sustainable development goals which poses challenges the GDP to be viewed as a measure of national wealth and the GDP growth to be related to the increase of employees (Sotirova, 2019).

In the short run and from a sector point of view, the replacement of fossil fuels with biofuels would lead to a significant change in the energy mix. As a result of the partial or total cessation of the operation of the coal-fired power plants, it is expected that unemployment will rise, ceteris paribus, the employment in the energy sector will be restructured, and the price of electricity will increase because of the increased benchmark market prices for the emissions of carbon dioxide. Such processes would have not only economic but also social effects (Hardt, O'Neil, 2017) especially given the high sensitivity to energy poverty in some countries such as Bulgaria. Meanwhile, other authors argue that an increase in market prices for carbon dioxide emissions creates investment incentives and leads to positive redistributive effects for consumers. So they cannot be considered as pure welfare loss (Kober et al., 2016), and more broadly they lead to technological advancements that boost economic growth (Duarte et al., 2018).

On the other hand, the use of fertile land and forests for the production of biofuels would put pressure on the agricultural sector and would further limit the possibilities for domestic production of fruits and vegetables (Beluhova-Uzunova, Shishkova, 2019). In a broad context, this is even emphasized as a prerequisite for forced emigration, especially from developing countries and Africa (Liberti, 2013). The requirements in the construction sector to build the so-called "Green buildings" with high energy efficiency could increase production costs and hence real estate prices in short run. At the same time, stimulating green investments and promoting so-called investments for impact, based on environmental, social or management criteria, could put pressure on the investment plans of financial institutions.

Globally, the transport sector is responsible for about 30% of carbon pollution. The shift to electromobile transport is being considered an inevitable measure for achieving sustainable development. However, with a low level of income, purchasing electric vehicles would remain limited. Moreover, raising the price of electricity while restricting the use of coal would lead to a further increase in the costs of this type of transport. In foreign trade, this would adversely affect transport services which are currently subject to various restrictions, especially in the European Union.

The 2018 Report of The Club of Rome proposes reforming the rules in the World Trade Organization and imposing customs restrictions on trade with goods and services whose production or consumption process cause environmental damages. Taking such measures will also limit foreign trade globally. This is particularly true for investment goods that are used in domestic production and together with rising energy prices will adversely affect local competitiveness in foreign markets. Higher exports are often a source of pollution. It is estimated that around 30% of environmental damage and threats to biodiversity is attributed to international trade (Lenzen et al., 2012). Similarly, the proposals to introduce an internationally harmonized but nationally imposed carbon tax would have a direct effect on the industry and its competitiveness. The contradictory effects of such taxation as a way to limit greenhouse gas emissions are highlighted in a study for Australia. The negative impact on key macroeconomic indicators such as GDP, employment, household consumption, exports and imports of goods and services is combined with not sufficient reduction in air pollution which demonstrates its controversial relevance (Asafu-Adjaye, Mahadevan, 2013).

In the long run, the transition to a low-carbon economy is associated with greater efficiency of resource utilization, including through technological improvements and innovations; employment restructuring and its directing to high-tech sectors. Achieving greater resource efficiency is a prerequisite for a continuous increase in the economic growth rates during the transition to sustainable development which is completely in line with the neoclassical growth model of Robert Solow (Solow, 1956). Thus, it is argued that increasing the share of energy from renewables and increasing the efficiency of energy utilization would lead to increased competitiveness and more workplaces in developed Western European countries such as Finland, France, the Netherlands, Spain and Sweden (Wijkman, Skånberg, 2016).

Other researchers view the increase in resource productivity as an argument for reducing the unemployment and raising public welfare because of the restructuring of employment and directing employees to higher-income groups (von Weizsacker et al., 2009). In the same vein, it is argued that economic growth should not be viewed as "victim" of improved resource efficiency but rather that this increased efficiency is a prerequisite for accelerating it (McDonough, Braungart, 2013). Meanwhile, it should not be overlooked that the usage of technologies in developing countries is directly dependent on the penetration of technology in developed countries which corresponds with some lag. This would further exacerbate the occurrence of long-term effects of low carbon transition, and short-term losses may have leading importance for lower-income countries such as Bulgaria (Rezai, Sigrid, 2016). Such negative consequences justify the question on the use of financial resources to limit and tackle the negative effects on economic development posed by ecological measures, which poses challenges to fiscal and monetary policy (Zhelyazkova, 2017). In particular, the role of macroeconomic policy in the process of adapting the national economies to the new realities in the field of the usage of energy resources has been studied for Poland which is one of the EU countries with the largest share of coal in its energy mix (Böhringer, Rutherford, 2013).

Innovations and Regulations Imposing the Transition to Low-Carbon Economy

The coal power plants are a major source of carbon dioxide emissions, given off into the atmosphere. These specifics place their activity at the centre of actively pursued policies at national and international levels that are related to climate change and the transition to a low-carbon economy.

In retrospect, several international instruments have a direct impact on electricity production. The United Nations Framework Convention on Climate Change (UNFCCC) focuses on increased greenhouse gas emissions and the prevention of negative impacts for the environment, and it was adopted as early as 1992. In the same year, the first United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro, adopting a program for the environment and development in the XXI century. The specific targets for reducing the harmful emissions are set out in the Kyoto Protocol[6] Adopted in 1997 to the UN Convention. Its primary objective is to reduce the harmful carbon dioxide emissions, given off in the atmosphere, by at least 5% globally in comparison to their corresponding levels in 1990. Each country should reduce its share by a certain percentage. In order to achieve these goals, market mechanisms are at the forefront, and any country or company in its territory may sell or buy carbon dioxide allowances (quotas) on domestic or international markets. The Paris Agreement on Climate Change, which came into force on 4 November 2016, sets out the EU's leading role in combating climate change through the active financial support to developing countries. The main objective is to limit the global warming process by up to 1.5°C. Despite the relevance of the

[6]. The Kyoto Protocol enters into force on 16.02.2005. Bulgaria ratified the document in 2002. Bulgaria majorly aims to reduce the emissions (measured as carbon dioxide equivalent) by 8% in 2008-2012 in comparison to 1990.

initiatives undertaken, they are treated by an ambiguous way globally and very often the direct negative economic effects outweigh the serious commitment to conducting long-term sustainable development reforms.

The EU is undergoing a major shift in the energy sector. It is triggered both by the climate change debate and carbon dioxide reduction policies at the global level and by the measures taken at a national level. In the Europe 2020 Strategy adopted in 2010 the European Commission sets out in the EU's economic development model the achievement of "the 20/20/20 targets until 2020": 20% reduction of greenhouse gas emissions, a 20% share of renewable energy resources in gross final energy consumption and a 20% improvement in energy efficiency. Member States with a lower GDP per capita than the EU average should cover lower targets with the gap being covered by the EU Member States with a higher GDP than the EU average. In this respect, changes in the energy sector are also linked to the implementation of the Europe 2020 strategy in terms of production structures, foreign investment in the country, R&D expenditure and others (Rangelova, 2011).

The Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants has a direct effect on the operation of coal plants. This Directive was replaced by the Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) with effect from 7 January 2013 for new installations and from 1 January 2016 for existing installations. Hence, the EU regulatory framework has an impact on coal plants as follows:

- *Meeting EU environmental standards.* A number of thermal power plants in Europe have already rehabilitated their production facilities in order to reduce harmful sulfur dioxide emissions and dust concentrations. Despite the measures taken, new investments are needed to meet the standards on permissible levels of mercury in the atmosphere. These one are the cost of the project for the Rehabilitation of Units 1-4, construction of desulphurisation units of Units 1, 2, 3 and 4, and modernization of units 6 and 8 of "Maritza East 2 TPP" EAD that worth EUR 226 million.

- *Greenhouse gas emission allowance (quotas) trading*. The quotas operate on a "limitation and trade" basis, and they are regulated under the Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community. During the current third phase of the EU Emission Trading System, the total number of allowances decreases by 1.74% each year between 2013 and 2020. The corresponding decrease set for the period between 2021 and 2030 is 2% when carbon dioxide emissions in the EU, in line with the objectives of the Paris Agreement, must be reduced by at least 40%. However, it is too ambitious goal bearing in mind the current situation. The reduced number of allowances and the increased electricity production in the EU in recent years have dramatically increased the cost of carbon dioxide emissions: from 5 euros/tonne (mid-2017) to nearly 28 euros/tonne in 2019, an increase of more than 5 times.

- *The increased share of renewables in electricity production.* Bulgaria has achieved the target set for the share of renewable energy in the gross final energy consumption – 16% by 2020. Already in 2012, renewable energy sources accounted for 16.1% of gross final consumption. Only for the period of March to June 2012 more than 1000 MW photovoltaic power plants were brought into use. In 2013 the share of renewable energy resources was 19% and in the following years it remained above 18%. The rapid deployment of renewable energy sources at national and European level is also supported by the preferential prices at which electricity produced is purchased. The Plan for the Development of the Electricity Transmission Network in Bulgaria for the period 2019-2028, prepared by the "Electricity System Operator" Ltd, draws attention that the bringing into use of renewable energy sources will continue beyond 2020 but at a slower pace and through economic regulated schemes for the purchase of electricity produced. The Clean Energy for All Europeans legislative package adopted in 2016 sets the primary objective of at least 27% of total energy consumption in the EU by 2030 to be generated from renewable sources. The scenarios examined in the Energy Roadmap till 2050 envisage the electricity from renewable energy sources to be at least 55% of gross final energy consumption in 2050. With an achieved high energy efficiency, their share will reach 64%. The scenario with high energy efficiency and the possibility of storing electricity estimates 97% share of renewable energy in gross final consumption.

The Effect of the Global and European Initiatives on the Energy Sector in Bulgaria

With the EU regulatory framework examined, the Member States where coal-fired power plants produce most of the required electricity are the most affected by European legislation in the energy sector. Among them is Bulgaria. The lignite coal power plants have the largest share in the country's production mix in 2017 (43%) with the largest contribution being the "TPP Maritza East 2" Ltd, "ContourGlobal Maritsa East 3" Ltd and "AES – 3C Maritza EAST I" Ltd. In addition to the European directives listed the operation of these power plants has been severely hampered by the recent price regulatory periods, as well as by some specificities related to the organization of the local electricity sector.

In the electricity system of Bulgaria, TPP "Maritza East 2" has a function to regulate power, and it operates daily. This calls into question its functioning through the use of market principles. The main expense of the company is related to the purchase of greenhouse gas emission allowances, and together with the cost of the main fuel, their purchase forms 76% of the cost of the electricity produced by the power plant. "Maritza East 2 TPP" is included in the National Investment Plan, agreed with the European Commission, and according to it, the TPP receives a certain number of free quotas after the implementation of investment projects. These free grants shall be reduced each year. The estimated expected number of grants awarded in 2013-2020 is 15 727 524 tonnes carbon dioxide (about 30% of total emissions) of the quantities emitted by the plant.

In 2015 the Electricity System Security Fund was established and, according to changes in the Bulgarian Energy Act, it receives 5% of the revenue from electricity produced and sold by all market participants. According to the national legislation, "Maritza East 2 TPP" also pays transmission and access fees totalling EUR 5.24 per MWh. Since 2019 the Energy and Water Regulatory Commission in Bulgaria has also introduced an additional charge for the access to the electricity grid for producers of EUR 1.07 per MWh, excluding VAT, which is due by the electricity producers (except for those, producing solar and wind power). These fees have a direct impact on the financial receipts at "Maritza East 2 TPP" and reduce revenues from the sale of electricity, which necessitated the granting of a loan of EUR 248 million from the Bulgarian Energy Holding Ltd in 2018. However, the granting of the loan may also jeopardize the operation activities of other enterprises in the structure of the vertically integrated organization, as the financial problems of the thermal power plant may be compounded by the increasingly restrictive EU legislative measures. In such an unfavourable scenario the financial deficit must be covered by the redistribution of dividends by the profitable companies, even though EU law prohibits the transfer of funds from one state company to another and to the final consumers of electricity.

The other two power plants in the Eastern region of Maritza river "ContourGlobal Maritsa East 3" and "AES – 3C Maritza EAST I" have no significant financial difficulties at this stage due to compliance with European directives or national legislation. The reason is the signed long-term contracts for the purchase of electricity produced by them at a higher price in order to guarantee the repayment of the investments made. Both plants get the necessary amounts of greenhouse gas emission allowances from international exchanges. Despite these specifics, the costs that "ContourGlobal Maritsa East 3" and "AES – 3C Maritza EAST I" have to make to meet the new requirements for limiting harmful air emissions will adversely affect the financial status of both plants. In the Annual Activity Report and Financial Statement Report of 31.12.2018 "AES – 3C Maritza EAST I" identified as future risk factors for the company's operations the changes in the legislation and the regulatory framework in the field of climate change and the changes in emission limits.

Another debate about the termination of the long-term contracts for power purchase from the two companies also raises a number of questions about their future functioning. All EU legislative initiatives aim at limiting the operation of coal power plants and their future decommissioning. In this context, companies such as "ContourGlobal Maritsa East 3" and "AES – 3C Maritza EAST I" will also have problems when borrowing from banks or finding funds from other private investors.

In addition, district heating companies and so-called factory power plants (companies from the industry, agriculture and health sector), operating on installations for cogeneration production of electrical and heating energy, also pay carbon dioxide emission allowances. According to the data, provided by the Energy and Water Regulatory Commission, thermal power stations on gas and thermal power stations on black and brown coal have a share of about 5% of the total electricity production in Bulgaria. Most of them use natural gas as a main fuel, and they are connected to the network of "Bulgargaz" Ltd and the corresponding gas distribution network. The electricity produced from high-efficiency cogeneration of heating and electricity until 2018 was bought at preferential prices by "National electricity company" Ltd (NEK EAD). Following legislative changes to the Energy Act, the public supplier purchases the generated electricity from the producers with a total installed electrical capacity of less than 1 MW. Producers with a total installed capacity of 1 MW and more than 1 MW participate in the market of balancing energy and the Electricity System Security Fund pays them compensations up to the amount of the quantities. These quantities are determined by a resolution of the Energy and Water Regulatory Commission for setting a preferential price.

The cost of purchasing the primary fuel also influences the estimated market prices of the district heating plants. In 2019 an increase in oil futures prices was observed which had an impact on both natural gas prices and the electricity prices on the European Energy Exchange. In this way, the bilateral relationship between the prices of energy resources in regard to the economic activity is confirmed but also the impact of the state of the economy on their market price (Chevallier, 2011). On the other hand, greenhouse gas emission allowance costs have a greater impact in higher demand months when consumption cannot be covered solely by non-coal-fired plants.

The conducted review of the regulatory framework and its implications on the state of the energy sector in Bulgaria allows us to outline the sector financial dimensions of the transition to lower carbon production in the energy sector whose effects on economic growth we aim to model and measure.

Modelling of the Effects on the Economic Growth in Regard to the Changes in the Energy Sector

In the scientific literature, the most common method for assessing short and long-term effects on economic growth from the transition to a low-carbon economy is employing the Computable General Equilibrium Model. This class of models uses real economic data, and methodologically they are based on a baseline scenario for economic development and econometric analysis, which formalizes and evaluates certain relationships and interdependences between economic variables. Globally, such a model has been used by the World Bank Group to assess the effects of climate change in 2012 on 140 countries, including Bulgaria – the so-called Global Trade Analysis Project (GTAP, 2012; 2016a; 2016b). This model has also been employed by the OECD and the European Commission to explore a wide range of issues related to the green growth, climate change and environmental sustainability. The famous Dynamic Integrated Climate-Economy models by the 2018 Nobel Laureate for Economics, William Nordhaus, as well as by a number of other researchers in the field, such as Berck et al. (1991), Berrittella et al. (2004), Diao et al. (2008) and Fadali et al. (2012) are also built on a similar methodology.

However, the implementation of such a method for Bulgaria has encountered a number of difficulties related to the relatively short time-series of statistical data, administratively imposed restrictions on the provision of information about the energy sector in the country as well as its diverging development in recent years. Following the purpose of the paper to highlight the macroeconomic impact of the transition to a low-carbon economy, we use the Solow growth model approach and the Cobb-Douglas production function. In this way, by including labour, capital and total factor productivity, we can cover the macroeconomic variables on which the transition to sustainable development is dependent on.

We use the two-factor production function of Cobb-Douglas to describe production in the energy sector as follows:

$$lnY_e = lnA_e + \alpha lnK_e + \beta lnL_e \quad (1)$$

where:

Y_e stands for the gross value added in the energy sector;

A_e is the total factor productivity of the sector;

K_e is the quantity of physical capital used in the energy sector;

L_e is the number of employed persons in the sector;

α and β are respectively the elasticity of production in regard to capital and employees.

The total factor productivity is an implicit economic variable, and it includes a wide range of determinants of economic development such as social infrastructure, scientific and technological progress, and human capital. As we aim to examine the direct macroeconomic effects of the state of the energy sector, we are abstracting from its direct changes.

The value of capital in the energy sector is modelled by the so-called perpetual inventory method (Ganev, 2005):

$$K_{e_t} = K_{e_{t-1}}(1 - \delta) + I_{e_t} \quad (2)$$

where:

$K_{e_{t-1}}$ is the value of energy sector capital in the previous year;

δ is the depreciation rate;

I_{e_t} is the gross fixed capital formation in the energy sector.

When determining the level of energy sector capital from the previous period $(K_{e_{t-1}})$, we use the ratio between the current level of capital in the sector from the previous year $(K_{e_{t-1}})$ and production in the sector two years ago $(Y_{e_{t-2}})$ which, given the steady-state level of capital in the energy sector over the long term, is assumed to be constant. In the scientific literature, this ratio is known as an incremental capital-output ratio, as defined in Minasyan (2008), and it is expressed as:

$$\sigma = \frac{K_{e_t}}{Y_{e_{t-1}}} \quad (3)$$

where σ is the share of the current level of capital in the gross value added of the energy sector from the previous year and it is a positive value $(\sigma > 0)$.

Therefore, the value of the capital in the energy sector in the current year (K_{e_t}) is determined as a constant share (σ) of the gross value added two years ago $(Y_{e_{t-2}})$ given a constant depreciation rate (δ) and the newly formed capital (I_{e_t}):

$$K_{e_t} = \sigma Y_{e_{t-2}}(1 - \delta) + I_{e_t} \quad (4)$$

We find the coefficient σ using the OECD methodology (OECD, 2014), which is based on the calculation of the share of the gross capital formation of the sector from the gross value added and its real growth rate:

$$\sigma_t = \left[\left(\frac{I_{e_{t-1}}}{VAD_{e_{t-1}}}\right) * \left(\frac{Y_{e_t}}{Y_{e_{t-1}}} - 1\right)\right] * 100 \quad (5)$$

where:

$VAD_{e_{t-1}}$ is the gross value added of the sector from the previous year.

Employment in the sector is based on statistical data.

Econometric Estimation and Results

Following the modelling of the production function of the energy sector in the country, we estimate econometrically the effect on the real GDP from the level of capital and employment in the energy sector. Thus, we also want to measure the expected effects on real GDP growth rates.

The regression equation we estimate is in the following form:

$$logY_t = \alpha + \beta_1 logK_{e,t} + \beta_2 logL_{e,t} + u_t \quad (6)$$

where:

Y_t is the value of the real GDP at constant prices as of 2010, calculated by the production method;

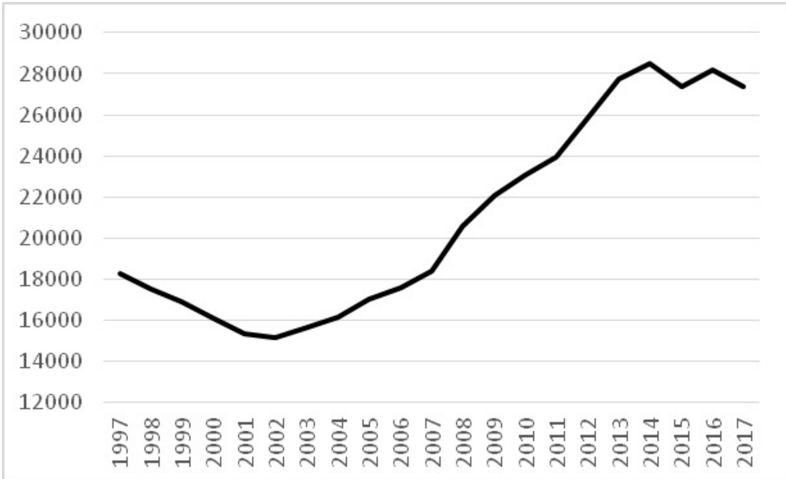
u_t reflects the value of residuals.

The econometric estimation of equation (6) is based on calculations of the value of capital in the energy sector based on equation (4) as well as statistics on the number of persons employed in economic sector D."Electricity, gas, steam and air conditioning supply" up to NACE. The statistical data in 1997-2017 are from Eurostat.

The data show that the level of capital in the energy sector in Bulgaria decreased before 2000 due to the contraction of investments under unfavourable economic environment. The gradual opening of the energy sector, the entry of foreign investors and its liberalization lead to almost a double increase in physical capital in 2003-2014. There has been a severe decline in the investment activity in the country as a consequence of the global financial and economic crisis. Thus, we observe a decline in the physical capital, which again demonstrates a strong bilateral relationship between macroeconomic and sector state. However, labour productivity in the energy sector remains on average 3 times higher than labour productivity in the country as a whole due to the high capital intensity of the sector.

Figure 1

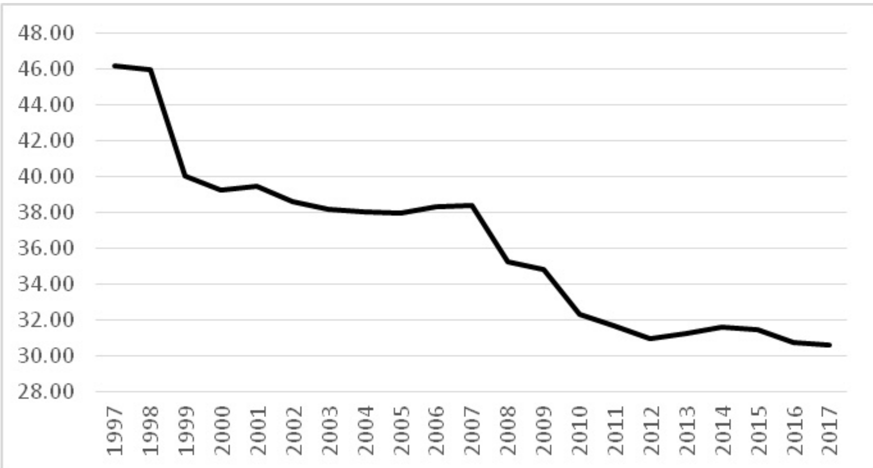
Capital in the energy sector in Bulgaria in 1997-2017 (million BGN)



Source: Author's calculations.

Figure 2

Employees in the energy sector in Bulgaria in 1997-2017 (thousands of people)



Source: Eurostat.

Employees in the sector D. "Electricity, gas, steam and air conditioning supply" up to NACE are experiencing continuously declining which, with the increase of physical capital and persistently high labour productivity in the sector, leads to a relative retention of the sector's gross added value. The average real annual growth of the gross value added of the sector in 2000-2017 is 0.6% with an average decrease of the employed persons in the sector by 1.5% during the same period and a capital increase of 2.8%. This data shows that the sector is becoming more capital intensive with a reduction of employees which allows a relative increase in gross value added averaging 4% as a share of GDP. At a preliminary stage, this also indicates that a reduction in the number of employees in the sector during the transition to a low-carbon economy would not have a significant impact on its gross value added. However, a much more critical factor for sector development are the investments in physical capital.

The results of the estimation of equation (6) using the Ordinary Least Squares (OLS) method are presented in Table 1.

Table 1

Results of the OLS estimation of equation (6)

Dependent variable – $logY_t$, Time period: 1997-2017					
Independent variables	Coefficient	Std. Error*	*t*-Statistic	Prob.	VIF
Constant	10.144	1.552	6.538	0.000	
$logK_{e,t}$	0.392	0.130	3.023	0.007	1.85
$logL_{e,t}$	-0.866	0.094	-9.168	0.000	1.85
Adjusted R^2	0.81				
F-statistic	43.57				
Durbin-Watson statistic	0.52				
BPG *p*-value	0.34				
Number of observations	21				

** Newey–West HAC standard errors*

The variables included in the equation are statistically significant at a significance level $\alpha=0.01$. The results of the Breusch-Pagan-Godfrey (BPG) test show a lack of heteroscedasticity. The variance inflation factor (VIF) is below two for all variables, which means that the degree of multicollinearity is low. The Durbin-Watson test provides information about the presence of autocorrelation. To deal with this problem, the standard errors are calculated using the Newey-West autocorrelation and heteroskedasticity correction method. Econometric residuals are normally distributed with the Jarque-Bera test statistics being 0.02 with p-value 0.98.

The estimated regression coefficients show that a 1% increase in the capital of the energy sector would lead to a 0.39% increase in the real GDP in Bulgaria and a 1% increase in employed persons in the energy sector would lead to a 0.87% decline in the real GDP. The positive sign on the capital variable is expected to have in mind that the sector is capital intensive, but the negative sign of the variable that measures the employed persons in the energy sector raises serious questions. As we have already mentioned, it is statistically visible there is a shrinkage of employees in the sector, which does not have a serious deterrent effect on gross value added (Figure 3) and it is accompanied by a relative retention of the investments in physical capital (Figure 1).

Figure 3

Gross value added (million BGN – left scale) and employees in the energy sector in Bulgarian in 1997-2017 (thousands of people – right scale)

Source: Eurostat.

A purely technical explanation may also be the inclusion of only the energy sector employees in the regression equation (6) while isolating the effect of all other employees on the actual production in Bulgaria. That is, if one employed in a non-energy sector is more productive than one employed in the energy sector, the negative sign before L_e describes the fact that the entrance of new employees in the energy sector would lead to a lower national output than if the same employees had started working in another sector of the national economy. This effect can also be viewed as a loss of national output because the increase in the number of employees in the energy sector must be accompanied by a decrease in the number of employees in other sectors, assuming that the labour force is approximately constant.

In order to test this hypothesis, the equation (6) was estimated again, adding another control variable, the difference between total employed persons in the country and the employees in the energy sector ($L_t - L_{e,t}$). The corresponding argument can also be made about the addition of the physical capital in the rest of the country among the control variables. However, due to the strong correlation - the correlation coefficient between total capital and capital in the energy sector is 0.94, the econometric results would be degraded. Therefore, we limit ourselves to estimating only the following equation:

$$logY_t = \alpha + \beta_1 logK_{e,t} + \beta_2 logL_{e,t} + \beta_3 log(L_t - L_{e,t}) + u_t \quad (7)$$

The results from the Ordinary Least Square estimation of equation (7) are presented in Table 2.

Table 2

Results of the OLS estimation of equation (7)

Dependent variable – $logY_t$, Time period: 1997-2017					
Independent variables	Coefficient	Std. Error*	*t*-Statistic	Prob.	VIF
Constant	-1.05	2.386	-0.440	0.665	
$logK_{e,t}$	0.171	0.076	2.225	0.038	2.61
$logL_{e,t}$	-1.057	0.098	-10.727	0.000	2.68
$Log(L_t-L_{e,t})$	1.728	0.294	5.885	0.000	1.07
Adjusted R^2	0.95				
F-statistic	122.80				
Durbin-Watson statistic	1.31				
BPG *p*-value	0.71				
Number of observations	21				

* *Newey–West HAC standard errors.*

All variables remain statistically significant, except the intercept of the estimated equation (7). The model's parameters have been improved with the Durbin-Watson test showing that the autocorrelation is lower and it was most likely caused by a missing variable – in this case, employees that are employed in other sectors of the economy. However, the standard errors are still calculated using the Newey-West autocorrelation and heteroscedasticity correction method. The econometric residuals are again normally distributed, with the Jarque-Bera test statistics 4.38 and p-value 0.11.

The estimated regression coefficients of equation (7) show that a 1% increase in the capital of the energy sector would lead to a 0.17% increase in the real GDP. At the same time, equation (7) does not reject the hypothesis for the negative sign of the variable that describes the employees in the energy sector. Economic logic indicates that when one employed person leaves the energy sector the probability of being unemployed is low and he/she becomes employed in other sectors of the economy due to his/her high professional qualification. In technical terms, starting from equation (7), it is possible that the effect described is due to the positive sign of the difference between the total employed in the economy and the employed in the energy sector $(L - L_e)$ combined with the negative sign of the employed persons only in the energy sector (L_e). Therefore, the expected macroeconomic impact of the shrinking investments in the energy sector will be much higher than that of employment where mainly regional effects can be observed given the regional specifics of energy production and the demographic characteristics of the Northwest and Southeast region of Bulgaria (Rangelova&Bilyanski, 2018).

Conclusion

The results of the econometric estimation of the modelled dependencies between real GDP and capital and employment in the energy sector show that a fall in the level of physical capital in the sector by 1% can be expected to reduce real GDP in Bulgaria by between 0.17 and 0.39%. Due to the specifics of the sector, its high capital intensity, high labour productivity and a low number of highly qualified workers, no direct effects of employment contraction on economic growth can be expected. Despite the limitations of the econometric evaluation method and the specifics of the statistical data used, they make it clear that, as a matter of priority, government policy should put an emphasis on the technological adaptation of the energy sector and the retention of its investments. Seeking alternatives to provide energy sources that are not directly dependent on high carbon production can be a way of putting off potential negative effects on economic activity in Bulgaria. This emphasizes the importance of the provision of financing for investments in energy projects and the attraction of foreign investors, which should be put as a priority of the government in the field of energy policy. Last but not least, it must be emphasized that our research interest is driven by drawing the direct effects of the restructuring process of the energy sector at a macroeconomic level and we do not exclude that many other factors could also have an effect. Taking them into consideration, it will be possible a more detailed assessment to be made and more clearly the costs of the transition towards a sustainable development of Bulgarian energy sector in the context of decarbonisation and the circular economy to be highlighted.

References

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C., Jansson, B., Levin, S., Mäler, K., Perrings, C., Pimentel, D. (1995). Economic Growth, Carrying Capacity, and the Environment. – Science, Vol. 268, pp. 520-521.

Asafu-Adjaye, J., Mahadevan, R. (2013). Implications of CO2 Reduction Policies for a High Carbon Emitting Economy. – Energy Economics, Vol. 38, pp. 32-41.

Bauer, D., Papp, K. (2009). Book Review Perspectives: The Jevons Paradox and the Myth of Resource Efficiency Improvements. – Sustainability: Science, Practice, and Policy, 5(1).

Beluhova-Uzunova, R., Shishkova, M. (2019). Concepts and Key Sectors of the Bioeconomy. – Trakia Journal of Sciences, Vol. 17, Suppl. 1, pp. 227-233.

Berck, P., Robinson, S., Goldman, G. (1991). The Use of Computable General Equilibrium Models to Assess Water Policies. – In: Dinar, A., Zilberman, D. (eds.) The Economics and Management of Water and Drainage in Agriculture, New York: Springer, pp. 489-509.

Berrittella, M., Bigano, A., Roson, R., Tol, R. (2004). A General Equilibrium Analysis of Climate Change Impacts on Tourism, No FNU-49, Working Papers, Research Unit Sustainability and Global Change, Hamburg University.

Böhringer, C., Rutherford, T. (2013). Transition towards a Low Carbon Economy: A Computable General Equilibrium Analysis for Poland. – Energy Policy, Vol. 55, pp. 16-26.

Chancel, L., Piketty, T. (2015). Carbon and Inequality: from Kyoto to Paris. Paris School of Economics, Paris.

Chevallier, J. (2011). A model of Carbon Price Interactions with Macroeconomic and Energy Dynamics. – Energy Economics, Vol. 33, N 6, pp. 1295-1312.

Cooper, A., Livermore, S., Rossi, V., Wilson, A., Walker, J. (1999). The Economic Implications of Reducing Carbon Emissions: A Cross-Country Quantitative Investigation using the Oxford Global Macroeconomic and Energy Model. – *The Energy Journal*, Vol. 20, Special Issue: The Costs of the Kyoto Protocol: A Multi-Model Evaluation, pp. 335-365.

Diao, X., Dinar, A., Roe, T., Tsur, Y. (2008). A General Equilibrium Analysis of Conjunctive Ground and Surface Water Use with an Application to Morocco. – Agricultural Economics, Vol. 38 (2), pp. 117-135.

Duarte, R., Sánchez-Chóliz, J., Sarasa, C. (2018). Consumer-side Actions in a Low-carbon Economy: A Dynamic CGE Analysis for Spain. – Energy Policy, Vol. 118, pp. 199-210.

Fadali, E., Rollins, K., Stoddard, S. (2012). Determining Water Values with Computable General Equilibrium Models. The Importance of Water to the U.S. Economy: Technical Workshop, National Academy of Public Administration, Washington, DC.

Fontana, G., Sawyer, M. (2016). Towards post-Keynesian Ecological Macroeconomics. – Ecological Economics, Vol. 121, pp. 186-195.

Ganev, K. (2005). Measuring the Total Factor Productivity: growth accounting for Bulgaria. – BNB Discussion Papers 48/2005 (in Bulgarian).

Göpel, M. (2016). The Great Mindshift (How a New Economic Paradigm and Sustainability Transformations go Hand in Hand), Springer, Berlin.

Hardt, L., O'Neil, D. (2017). Ecological Macroeconomic Models: Assessing Current Developments. – Ecological Economics, Vol. 134, pp. 198-211.

Ivanova, V., Chipeva, S. (2019). Transition to a Circular Economy Model in the European Union – State and Outlook. – International E-Journal of Advances in Social Sciences, Vol. V, N 14.

Kober, T., Summerton, P., Pollitt, H. et al. (2016). Macroeconomic Impacts of Climate Change Mitigation in Latin America: A cross-model Comparison. – Energy Economics, Vol. 56, pp. 625-636.

Kuznets, S. (1955). Economic Growth and Income Inequality. – American Economic Review, Vol. 49, pp. 1-28.

Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L., Geschke, A. (2012). International Trade Drives Biodiversity Threats in Developing Nations. – Nature 486, pp. 109-112.

Li, Y., Wei, Y., Shan, S., Tao, Y. (2018). Pathways to a low-carbon economy: Estimations on macroeconomic costs and potential of carbon emission abatement in Beijing. – Journal of Cleaner Production, Vol. 199, pp. 603-615.

Liberti, S. (2013). Land Grabbing: Journeys in the New Colonialism. Verso, London, ISBN: 978-1781681176.

McDonough, W., Braungart, M. (2013). The Upcycle. Beyond Sustainability, Designing for Abundance. North Point Press, New York.

Minasyan, G. (2008). Financial programming. Klasika i stil, Sofia (in Bulgarian).

Nordhaus, W. (2014). Scientific and Economic Background on DICE-2013R Model.

OECD. (2014). The Economic Outlook for Southeast Asia, China and India 2014: Beyond the Middle-Income Trap.

Rangelova, R., Bilyanski, V. (2018). Demographic Development of Bulgaria in a Regional Plan as a basis for Economic Development. – Economic Studies, Vol. 27 (6), pp. 141-154.

Rangelova, R. (2011). "Europe 2020" Strategy and Bulgaria's Economic Growth. – Economic Thought, N 3, p. 3-29 (both in English and Bulgarian language).

Rezai, A., Stagl, S. (2016). Ecological Macroeconomics: Introduction and Review. – Ecological Economics, Vol. 121, ISSN 0921-8009, pp. 181-185.

Solow, R. (1956). A Contribution to the Theory of Economic Growth. – The Quarterly Journal of Economics, Vol. 70, N 1, p. 65-94.
Sotirova, M. (2019). The Future of Employment – between Equilibrium Labour Price and Equilibrium Working Hours in Actual and/or Potential production. – UNWE Scientific Papers (forthcoming), (in Bulgarian).
von Weizsäcker, E., Wijkman, A. (2018). Come on! Capitalism, Short-termism, Population and the Destruction of the Planet, Club of Rome.
von Weizsäcker, E., Hargroves, K., Smith, M., Desha, C., Stasinopoulos, P. (2009). Factor 5: Transforming the Global Economy through 80% Increase in Resource Productivity. London: Earthscan.
Wijkman, A, Skånberg, K. (2016). The Circular Economy and Benefits for Society: Jobs and Climate Clear Winners in an Economy based on Renewable Energy and Resource Efficiency: a Study pertaining to the Czech Republic and Poland, Winterthur, Club of Rome.
World Bank. (2012). Greening India's Growth.
World Bank. (2016a). Georgia Country Environmental Analysis.
World Bank. (2016b). An Evaluation of Climate Change on Water Resources in the Sava River Basin.
Zhelyazkova, V. (2017). Introduction to the Circular Economy (financing, accounting, reporting), ISBN 978-954-8590-51-8 (in Bulgarian).