ECONOMETRIC MODELS OF OIL PRODUCTION IN ROMANIA

Dr. Victor Platon[1]
Dr. Andreea Constantinescu[2]

Abstract
Oil production is a major topic in the Europe 2030 Energy Strategy. The evolution of oil production during 1990-2018 is a fair indicator of the state of the Romanian national economy and of the trends at European level. The steady decrease in the quantities of extracted oil both at EU level and in Romania is representative for the new trends regarding energy resources and atmosphere pollution. It is a scientifically proven fact that oil production is a source of CO_2 emissions, the main pollution factor in the world. The research presented in this article aims to identify an integrative model for oil production in Romania. This model will allow a better management of Romania's energy resources and the possibility of optimizing them in the future. Three time series models have been developed to model oil production. From their analysis, the most significant model was chosen, with the best indicators. The article aimed at achieving the following results: analysis of the structure and volume of oil production at national and EU level; achieving an integrative model of oil production in Romania; conclusions on oil production in Romania.

Keywords
Oil production, statistical modelling, simple regression, polynomial equation

JEL
Q32, Q35, C30

Introduction

The article follows the evolution of oil production in Romania and proposes some models and tools for integrative modeling. The evolution of final oil production, the trends registered in the last 20 years in EU 28 and in Romania are considered (Constantinescu A., 2014). These developments are seen in conjunction with the main trends in EU Member States and global trends. The topic is part of the efforts to optimize the production model of fossil fuel resources in Romania. To analyze how evolved oil production in Romania, statistical data available in the Eurostat database were used. The Statistical Yearbook of Romania offers quantitative data for the period prior to the EU accession but from 2007 only data regarding the energy production are available, lacking the information about quantities of raw materials used to obtain the energy. The lack of continuous data streams was the reason why the analysis are performed only for the period 1990-2016. For this period, annual data strings were identified, without interruptions to the analyzed parameters.

1. Evolution of oil production in Romania

After 1990, the drilling activity for exploration of new oil fields registered a continuous decrease, from 181 000 m in 1991, to about 38 000 m in 1999. The determinations made highlight that the potential of undiscovered reserves represents about 30 % of the volume of reserves discovered so far (Buzatu G., 1998).

If by 1990 in Romania was drilled about 23 000 wells for exploration and exploitation after 1990 drilling activity or geological survey by drilling, experienced a significant decline, mainly due to lack of funds for investment (Axenciuc V., 1992). As a direct result of these decreases, oil production also decreased continuously (Figure 1).

Although it was experiencing a natural decline in oil production, Romania continues to remain the fourth largest oil producing country in the European Union, respectively the fifth country

[1] CS I, Institute of National Economy, victor.platon54@gmail.com
[2] CS III, Institute of National Economy, andreea_constantinescu07@yahoo.com

in Europe (including Norway). Compared to European production, national crude oil production represents about 2% of Europe's production and about 6% of that of the European Union.

At European level, the evolution was slightly different, the last peak of production was recorded in 1999, with a value of 177 789 thousand tons of oil. The trend is decreasing also at European level, at present, the value of the production being below half of the one recorded at the beginning of the analyzed period, respectively 72728 thousand tons in 2016.

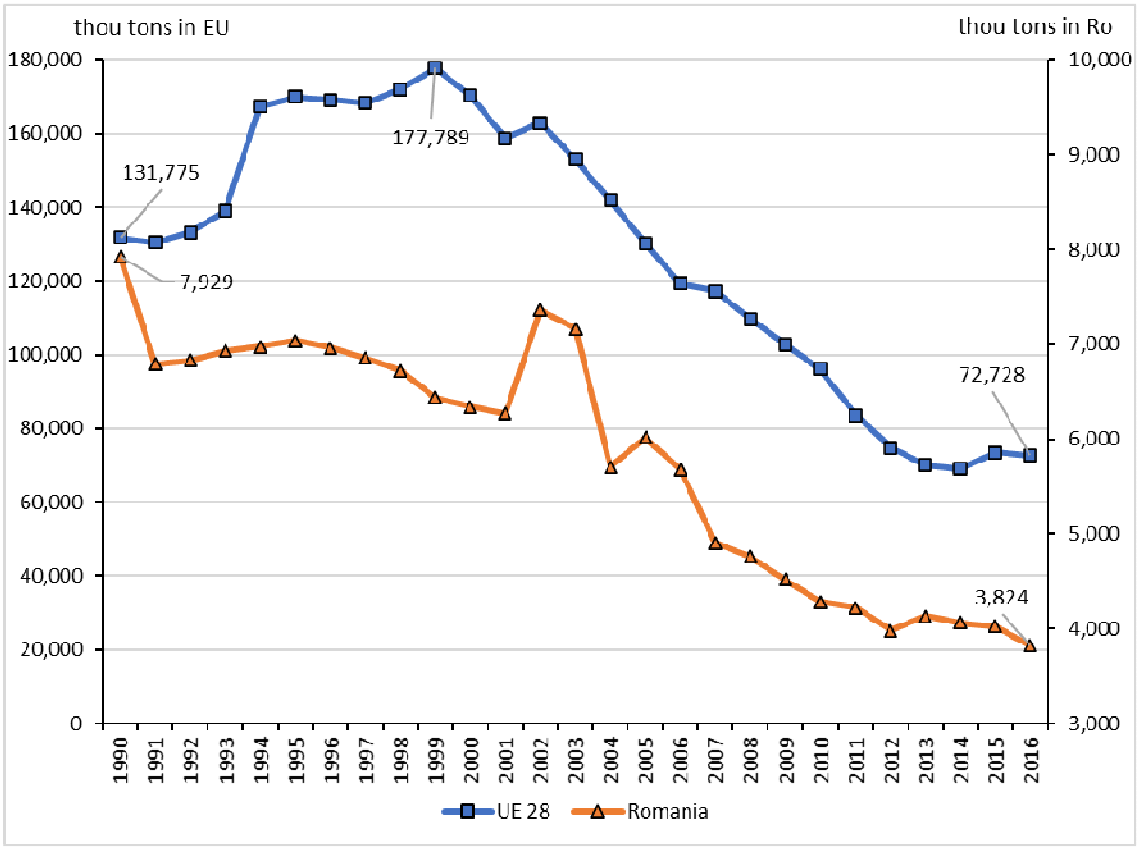


Figure 1 Evolution of oil production in Romania and the EU (1990-2016)
Source: Own processing according to Eurostat data.

As can be seen in Figure 1, oil production followed a decreasing trend for the entire period analyzed, except for a peak production in 2002-2003. However, values like those recorded before 1990, the last one being 7 929 thousand tons (in 1990), were never recorded again (Buliga, Ghe., Fodor, D., Diță, S., 2014). At the level of 2016 (the latest statistical data available), the oil production registered a value of only 3 824 thousand tons, about half of the value recorded in 1990.

2. Evolution of oil production in the EU

For the period analyzed in this article (1990-2016) the oil production in EU had a parabolic evolution: the production increased during 1990-2000, followed by a sharp decrease in the period 2000-2013, as at present, the oil production at European level to be growing slowly (Constantinescu A., Frone S., 2015).

Oil production in the European Union is currently on a downward trend. The highest production was recorded in 1999, with a total of 177 789 thousand tons of crude oil. The main oil producers at European level are: first place Norway, second place Great Britain, followed by Denmark, Romania (fourth place) and Germany.

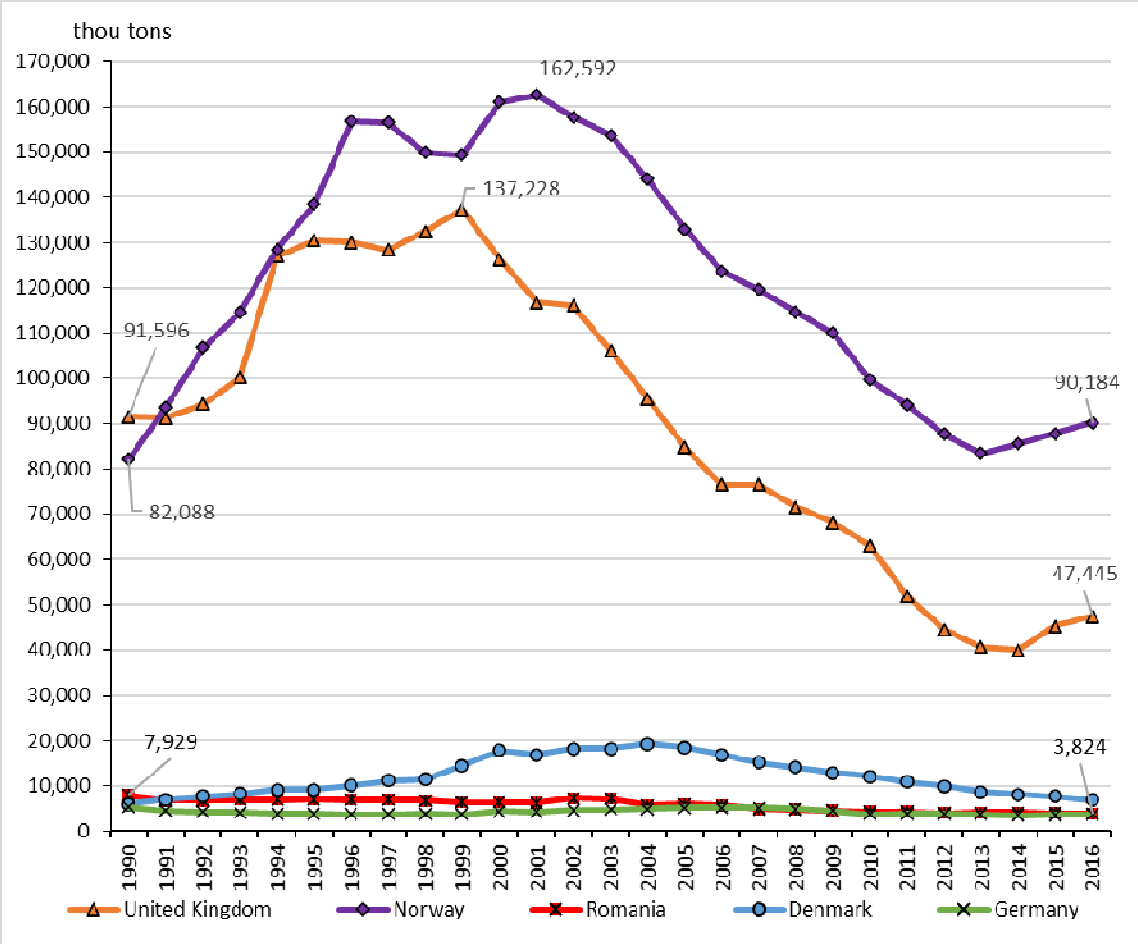


Figure 2 Evolution of oil production in Europe - main producers (1990-2016)
Source: Own processing according to Eurostat data.

United Kingdom was in first place in 1990, with 91 596 thousand tons of oil annually. It had a constant increase of production to a maximum reached in 1999, respectively 137 228 thousand tons, after that it entered a decreasing trend, so in 2016 it was second in EU 28, with 47 445 thousand tons of crude oil.

Norway was in second place in 1990, with a production of 82 088 thousand tons of crude oil annually. After a period of constant growth of production, which culminated in 2001, respectively 162 592 thousand tons. Norway also recorded a decreasing trend, yet it remains the largest producer of crude oil in the EU 28, with an amount of 90 184 thousand tons in 2016.

As we can see in Figure 2, as of 2013 Norway and the United Kingdom have returned to a slow growing trend, while all other European countries continue to have an increasingly low oil production.

In 1990, Romania was in third place in Europe in the production of crude oil, with a value of 7 929 thousand tons, and at present, with a value of 3 824 thousand tons, it is in fourth position, on a par with Germany (Platon V., Constantinescu A., 2006).

3. Integrative modeling of oil production

For the integrative modeling of oil production in Romania, the following methodology (Dejong, D. N., Dave C., 2007) was used:

1. The series considered are time series, expressed in physical units (thousands of tons).
2. For each series, 2-3 regression equations were analyzed, which were then separated by the AIC (Akaike Info Criterion) and RMSE (root mean square error) indicators (Pindyck R., Rubinfeld D. 1997).
3. Coefficients of the equations will be considered statistically significant if the probability of having the null value is less than 5% (Sadoulet, E., De Janvry, 1995).
4. Autocorrelation of errors have been eliminated by introducing the first autoregressive term AR (1).

Analyzing the evolution of the time series (petrol extraction in Romania) we can see a rapid increase, up to a maximum in 1977 (14,65 mil. tons), followed by a decrease of production to 3,71 mil. tons in 2016. Taking into account the oil reserves, this evolution pose the problem of depletion of the oil resource, except for the identification of new petroleum perimeters or major technological changes in the extraction of remaining oil (Yergin, D., 2007).

3.1. The simple and polynomial regression model of second degree (Eq 1a and 1b)

The results of two models are included in Table 1: a first model resulting from the application of a simple regression line (Eq1a) and a second polynomial model (Eq 1b). Both models have statistically significant coefficients, considering a probability of 5%. Also R^2 has similar values (0.85 in the case of linear regression and 0.88 in the case of parabolic regression). Both models, from the figures of the distribution of the residuals and from the value of the Durbin-Watson statistic (which is low, closed to 1), showed a significant correlation of the errors, which raises question marks on the two models.

As a result, we will move to the following two models.

Table 1: Comparison between Model 1a and Model 1b

Model 1a: Simple linear equation

Eq1a: PRODUCTION_OIL_THOU_T = C(1) + C(2)*TIME

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	422418.6	23014.09	18.35478	0.0000
TIMP	-207.9045	11.57611	-17.95979	0.0000

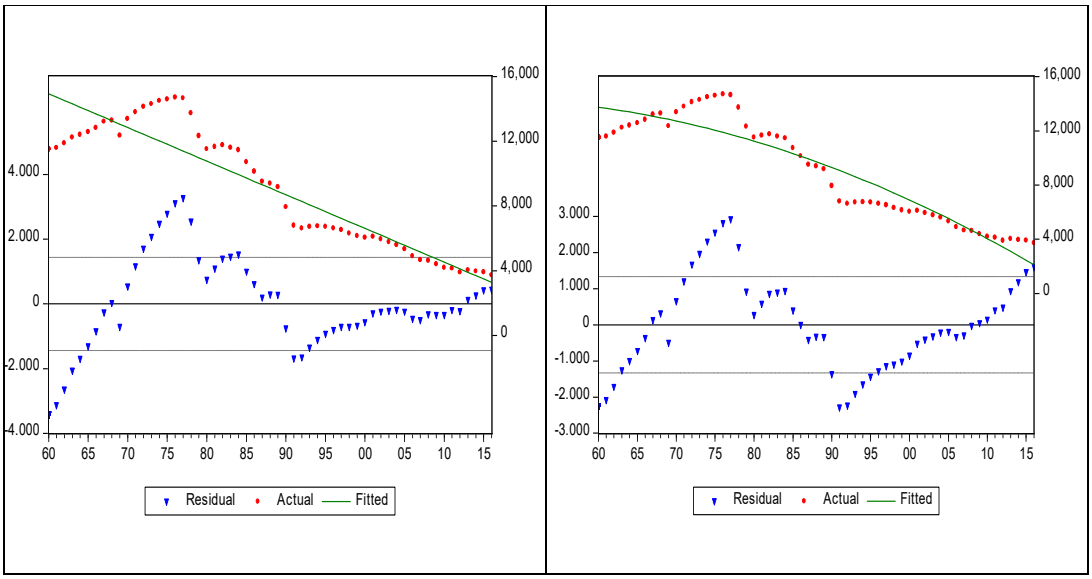
R-squared	0.854325	Mean dependent var	9104.544
Adjusted R-squared	0.851677	S.D. dependent var	3733.472
S.E. of regression	1437.863	Akaike info criterion	17.41416
Sum squared resid	1.14E+08	Schwarz criterion	17.48585
Log likelihood	-494.3036	Hannan-Quinn criter.	17.44202
F-statistic	322.5540	Durbin-Watson stat	0.092313
Prob(F-statistic)	0.000000		

Model 1b: Polynomial equation of second degree

Eq1b: PRODUCTION_OIL_THOU_T = C(1) + C(2)*TIME + C(3)*TIME^2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8603373.	2888777.	-2.978206	0.0043
TIMP	8872.991	2906.354	3.052963	0.0035
TIMP^2	-2.283927	0.730969	-3.124519	0.0029

R-squared	0.876630	Mean dependent var	9104.544
Adjusted R-squared	0.872060	S.D. dependent var	3733.472
S.E. of regression	1335.413	Akaike info criterion	17.28306
Sum squared resid	96299724	Schwarz criterion	17.39059
Log likelihood	-489.5674	Hannan-Quinn criter.	17.32485
F-statistic	191.8530	Durbin-Watson stat	0.104074
Prob(F-statistic)	0.000000		



Source: Own processing according to Eurostat data.

3.2. The model of interrupted regression and interrupted regression with self-regressive term (Eq 1c and Eq 1d)

The second set of models are built as a discontinued regression. The discontinuity took place at the level of 1977 when the decline in oil production begins (Table 2). The 1d model includes an autoregressive component. The analysis of the statistical indicators shows the following:

- Model 1c has all statistically significant coefficients (C1 and C2), while model 1d has only two statistically significant coefficients out of four.
- R^2 has the value 0.96 in the case of the 1c model and the value 0.98 in the case of the 1d model.
- The autocorrelation of the errors is significantly lower in the case of the 1d model (the Durbin-Watson statistic has the value 1.53 against 0.38 in the 1c model).

Table 2: Comparison between Model 1c and Model 1d

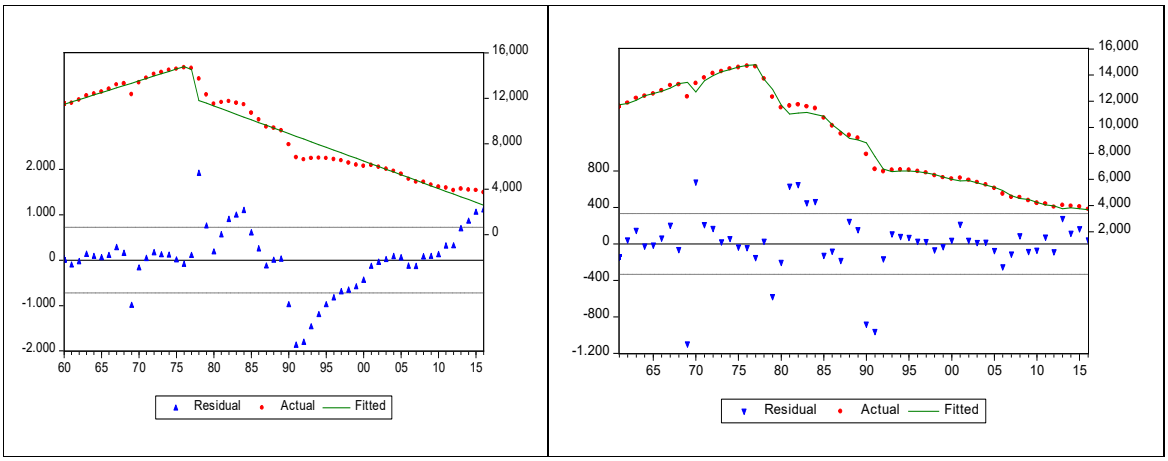
Model 1c: Interrupted Regression	**Model 1d: Interrupted regression and self-regressive term**
Eq 1c: PRODUCTION_OIL_THOU_T = C(1) + C(2)*TIME + C(3)*LEVEL3 + C(4)*TREND3	**Eq 1d: PRODUCTION_OIL_THOU_T = C(1) + C(2)*TIME + C(3)*LEVEL3 + C(4)*TREND3 + C(5)*PRODUCTION_OIL_THOU_T(-1)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-393676.9	65504.94	-6.009881	0.0000
TIMP	206.7127	33.27741	6.211804	0.0000
LEVEL3	-2491.451	388.4021	-6.414619	0.0000
TREND3	-448.9605	34.86778	-12.87608	0.0000

R-squared	0.964778	Mean dependent var	9104.544
Adjusted R-squared	0.962785	S.D. dependent var	3733.472
S.E. of regression	720.2333	Akaike info criterion	16.06462
Sum squared resid	27493005	Schwarz criterion	16.20799
Log likelihood	-453.8416	Hannan-Quinn criter.	16.12034
F-statistic	483.9203	Durbin-Watson stat	0.381896
Prob(F-statistic)	0.000000		

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-58845.89	40811.94	-1.441879	0.1554
TIMP	31.14227	20.96042	1.485766	0.1435
LEVEL3	-1033.511	209.6520	-4.929652	0.0000
TREND3	-61.37768	32.70340	-1.876798	0.0663
PRODUCTIE_TITEI_MII_T(-1)	0.825988	0.058844	14.03701	0.0000

R-squared	0.992704	Mean dependent var	9061.768
Adjusted R-squared	0.992131	S.D. dependent var	3753.139
S.E. of regression	332.9264	Akaike info criterion	14.53877
Sum squared resid	5652839.	Schwarz criterion	14.71960
Log likelihood	-402.0854	Hannan-Quinn criter.	14.60887
F-statistic	1734.663	Durbin-Watson stat	1.539073
Prob(F-statistic)	0.000000		



Source: Own processing according to Eurostat data.

Conclusions

The research presented in this material follows the evolution of the Romanian oil production, possible models and tools for its integrative modeling, the trends registered during the last 20 years in the EU (EU 28) and in Romania. These developments are seen in conjunction with the main trends in EU Member States and global trends.

Oil production followed a decreasing trend for the entire period analyzed, except for a peak production in 2002-2003, both nationally and in the EU (Platon V., Frone S, Constantinescu A., Jurist S., 2010). At the level of 2016 (the latest statistical data available) oil production registered a value of only 3824 thousand tons, about half of the value recorded in 1990.

In the next table there are all four modes compared, taking into account most important indicators. We may notice that the first two models have poor indicators (Durbin-Watson, R^2, RMSE) so we may discard them. Models described by interrupted regression have better indicators (Whitney, J.D., 1994). Of these two models, we decided to select the model described by Eq1c due to the fact that all three coefficients are statistical significant, R^2 is high enough (0.96) and RMSE is low (694.5). We could accept some autocorrelation of errors. We discard model described by Eq1d, because two coefficients are not statistically significant. This model has the highest value for R^2 and lowest value for RMSE (489.67).

Table 3: Comparison between all models

Equation	Significant coefficients (5% prob.)	Durbin Watson statistic	R^2	RMSE
Eq. 1a	All coefficients are significant (2 coeff.)	0,092	0,85	1412,412
Eq. 1b	All coefficients are significant (3 coeff.)	0,104	0,87	1299,796
Eq. 1c	All coefficients are significant (3 coeff.)	0,38	0,96	694,5023
Eq. 1d	Two out of four coeff. Are significant	1,53	0,99	489,6748

Source: Own processing data.

Eq 1c: PRODUCTION_OIL_THOU_T = C(1) + C(2)*TIME + C(3)*LEVEL3 + C(4)*TREND3

As a conclusion, modeling of oil production was done using different regression equations. The most significant model for the evolution of oil production is the 1c model, represented by the above equation.

References

1. Axenciuc, V., (1992), Evoluția economică a României, Cercetări statistico-istorice 1859-1947, Vol.I Industria, transporturile şi construcțiile, Editura Academiei Române, Bucureşti.

2. Buliga, Ghe., Fodor, D., Diță, S.,(2014) Enciclopedia economiei resurselor minerale din România, Editura AGIR şi Editura Asociației Societatea Inginerilor de Petrol şi Gaze.

3. Buzatu, G., (1998), O altă istorie a petrolului românesc, Editura Enciclopedică.

4. Constantinescu A., (2014), Hypostases of resilience for sustainable development, The Second World Congress on Resilience, from Person to Society, E-book, Timisoara.

5. Constantinescu A., Frone S., (2015), Ecosystem approach outcomes of a regional metabolism, Calitatea: Acces la Success; Bucharest Vol. 16, Iss. S1, (Mar 2015), https://search.proquest.com/docview/1667180590/fulltextPDF/58913F33D7B04726PQ/1?accountid=87708.

6. Dejong, D. N., Dave C. (2007), Structural Macroeconometrics. Princeton University Press.

7. Platon V., Frone S, Constantinescu A., Jurist S., (2010), Current Perspectives and Challenges of Biofuel Production and Consumption, Romanian Journal of Economics, vol. 31, Issue 2 (40), Pag.107-128.

8. Platon V., Constantinescu A., (2006), The Sustainable Development in the EU and Romania: Comparative Analysis, Romanian Journal of Economics, vol. 23, Issue 2 (32), Pag.91-99.

9. Pindyck R., Rubinfeld D. (1997), Econometric Models and Economic Forecasts; Cambridge University Press.

10. Sadoulet, E., De Janvry (1995), Quantitative Development Analysis, John Hopkins University Press.

11. Yergin, D., (2007), Premiul - despre petrol, bani si putere, Editura Adevarul, ISBN: 978-973-1848-06-8.

12. Whitney, J.D., (1994), A Course in macroeconomic modelling and forecasting, Harvester Wheatsheaf.

*** Anuarul statistic al României, 1991-2018, Institutul National de Statistica.

*** EUROSTAT, Statistics Explained, https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports/ro#Produc.C8.9Bia_de_energie_primar.C4.83_a_sc.C4.83zut_.C3.AEntre_anii_2006_.C8.99i_2016

***http://old.unibuc.ro/prof/ene_m/docs/2016/oct/29_10_25_5115_Geografia_resurselor_naturale.pdf

***https://web.archive.org/web/20051103023042/http://unstats.un.org/unsd/sna1993/tocLev8.asp?L1=6&L2=8