MODELING WITHIN NATIONAL ECONOMY USING INDUSTRY-ORIENTED INDICATORS: EVIDENCE FROM CZECH REPUBLIC

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The presented paper solved the question of national economy modeling with emphasis on gross domestic product. The modeling was based especially on industry-oriented indicators and applied to Czech Republic. The multiple linear regression analysis was used as the main research method. The main objective of this paper was to specify the relationship between dependent variable (gross domestic product) and a set of independent variables (nine chosen indicators) that subsequently enables the value estimation of the dependent variable and prediction of its future values. This represents also the key result of the investigation.

KEYWORDS

gross domestic product, multiple linear regression analysis, industry-oriented indicators, Czech Republic

1 INTRODUCTION

From the global point of view, all national economies face an increasing world population, industrialization as well as fast urbanization. Higher degree of the technological innovations is necessity in this times. The proposals for implementation of the innovative procedures can be found in the connection with e.g. development of the new supplier's evaluation tool [Feckova Skrabulakova 2018] or improvement of the company's management by specific process model [Drabikova 2018]. Innovations perform crucial part in the questions as, inter alia, automation, mechatronics or energy-efficient industries.

Demonstration of the innovation level can be conducted through the Global Innovation Index [WIPO 2018]. Mentioned index enables an innovation measurement by using various constructed metrics. Findings include countries around the world. The rankings are compiled and therefore the possibility of comparison arises there. According to report of the World Intellectual Property Organization in cooperation with Cornell University and INSEAD as co-publishers, the global leaders were released regarding the innovation scaling in 2018. The order was specified on the basis of classification by income group. Switzerland was declared as leader in the high-income economies group, China in the upper-middle-income economies, Ukraine in the lower-middle-income economies and Tanzania in the low-income economies. Looking at data provided by the Global Innovation Index Database, Czech Republic was moved out from the group of innovation leaders

in 2018 comparing with year 2017. Belgium replaced it and moved back into this group. It should be noted that the Global Innovation Index categorizes the innovation performance of almost 130 economies across the globe each year.

Modeling within national economy with emphasis mainly on industry, that may help to uncover challenges the certain country is confronted with, requires to consider in addition to innovation also the other influencing elements. We tried to accomplish this ambition by selection of the particular indicators subjected to the testing under research tasks. These are specifically stated in the section Methodological approach.

2 METHODOLOGICAL APPROACH

The main objective of this paper is to ascertain the relationship between dependent variable and a set of independent variables that subsequently enables the value estimation of the dependent variable and prediction of its future values. Accompanying task is the examination of the chosen variables significance and their potential sorting in the case of insignificance identification.

In our case, dependent variable is gross domestic product. Independent variables are gross domestic spending on research and development, value added by activity - industry (including energy), value added by activity - manufacturing, industrial production - total, industrial production - manufacturing, employment by activity - industry (including construction), employment by activity - manufacturing, trade in goods - exports and trade in goods - imports.

Gross domestic product is chosen as a representative for reflexing the national economy state. It can be analysed on the basis of a wide range of indicators. Predominantly industry-oriented indicators are selected for research purposes. The selection of all parameters is based on a previous review of empirical research studies. Modeling is realized within Czech Republic economy. The period under review is in the range of years 1998 - 2017. The data are obtained from the OECD database [OECD 2019] (Aggregate National Accounts, Main Science and Technology Indicators, OECD National Accounts Statistics, Main Economic Indicators, Labour Market Statistics).

The utilized methodological approach rises from the stated goal. Regression analysis (see e.g. [Kaytez 2015, Labant 2016, Marill 2004, Worster 2007]) was applied with regard on the character of the research. As [Jeon 2015] declared, it is quite infrequent to dispose with just one independent variable for the prediction intentions. This claim is confirmed in this paper. Multiple independent variables were picked for the examination what led to multiple regression analysis [Nathans 2012] as a tool choice. Such approach offers consideration of all potentially relevant indicators in the same model. The most suitable was linear variant. Modeling is based on the following equation (Equation 1):

$$Y = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_n x_{in} \qquad (1)$$

Where,
Y is dependent variable,
β_0 is regression constant,
$\beta_1 \ldots \beta_n$ are coefficients of x (represent the contribution of each independent variable to dependent variable),
$x_1 \ldots x_n$ are independent variables.

The equation matching with our research issue and adjusted in accordance with specified factors is given below (Equation 2):

$$GDP = \beta_0 + \beta_1 GDS + \beta_2 VAAI + \beta_2 VAAM + \beta_4 IPT + \beta_5 IPM + \beta_6 EAI + \beta_7 EAM + \beta_8 TGE + \beta_9 TGI$$

(2)

Where,

GDP is gross domestic product - total (million US dollars),

GDS is gross domestic spending on research and development - total (million US dollars),

VAAI is value added by activity - industry, including energy (% of value added),

VAAM is value added by activity - manufacturing (% of value added),

IPT is industrial production - total (2015=100),

IPM is industrial production - manufacturing (2015=100),

EAI is employment by activity - industry, including construction (thousand persons),

EAM is employment by activity - manufacturing (thousand persons),

TGE is trade in goods - exports (million US dollars),

TGI is trade in goods - imports (million US dollars).

3 RESULTS AND DISCUSSION

The following section of the paper introduces the research findings. Descriptive analysis was executed before regression analysis. The essential results are singled out in Tab. 1 (Source: author's calculations). The first indicator is the dependent variable. This is followed by independent variables in the order identical as specified in Equation 2.

Table 1. Descriptive analysis report

	GDP	GDS	VAAI	VAAM	IPT	IPM	EAI	EAM	TGE	TGI
MEAN	262698.9	3835.93	31.055	25.3	82.81	78.555	1908.81	1325.43	88017.8	86456.2
MEDIAN	278650.5	3681.5	31.045	25.375	86.25	81.3	1892.3	1308.95	103394	101433.5
STANDARD DEV.	75674.1715	1374.1248	0.7924	1.1380	15.7054	18.1455	53.1795	59.1290	49275.5859	43946.7516
KURTOSIS	-1.0760	-1.3921	0.0795	-0.3858	-1.0627	-1.0438	-0.2813	-0.1093	-1.6195	-1.6126
SKEWNESS	0.1119	0.3598	-0.4552	-0.3792	-0.1922	-0.0403	0.8693	0.6813	-0.3632	-0.3932
MINIMUM	153452	2138	29.26	22.86	57.4	51.2	1844.4	1235.9	18043	22505
MAXIMUM	402796	6082	32.39	26.84	110.1	111.3	2027.3	1454.8	146442	135846

Table 2. Values pertaining to regression statistics

REGRESSION STATISTICS

MULTIPLE R	0.997588945
R SQUARE	0.995183704
ADJUSTED R SQUARE	0.990849038
STANDARD ERROR	7239.04132

Another relevant statistics are highlighted in Tab. 2 (Source: author's calculations). Next, the multiple linear regression model was applied in order to determine the relationship between dependent variable and a set of independent variables. The utilization of such a model has led to the acquisition of coefficients for every variable. They disclose the contribution of independent variable predictions. Obtained coefficients can be observed in Tab. 3 (Source: author's calculations). It should be added that employment of the chosen research tool consists of two modeling steps. Stated Tab. 3 is related to the first one.

Table 3. Results for the first step of the modeling by multiple linear regression analysis

	COEFFICIENTS	STANDARD ERROR	T STAT	P-VALUE	LOWER 95%	UPPER 95%
INTERCEPT	348229.1695	126424.9135	2.754435	0.020323	66536.91	629921.4
GDS	9.967158595	7.55271253	1.319679	0.216355	-6.86133	26.79565
VAAI	-7250.009125	9287.027579	-0.78066	0.453086	-27942.8	13442.78
VAAM	-2543.178247	8014.36636	-0.31733	0.757521	-20400.3	15313.94
IPT	-8622.251326	3899.537616	-2.2111	0.051465	-17311	66.45994
IPM	12459.98295	3624.735954	3.437487	0.006358	4383.568	20536.4
EAI	212.6345184	115.8054232	1.836136	0.096205	-45.396	470.6651
EAM	-348.3616121	144.6628007	-2.40809	0.036803	-670.69	-26.0328
TGE	0.684084282	1.30025708	0.526115	0.610277	-2.21307	3.581238
TGI	-1.196201482	1.325967436	-0.90213	0.388198	-4.15064	1.758238

Based on results over the analysis' first step we excluded two indicators, specifically value added by activity - manufacturing and trade in goods - exports, looking at p-values (Tab. 3). The decision to exclude given variables is matching with the procedures used in the empirical studies discussing the similar topic as well as the rules applicable to p-value grounded decision making.

In view of the foregoing adjustments, Equation 3 can be compiled:

$$GDP = \beta_0 + \beta_1 GDS + \beta_2 VAAI + \beta_3 IPT + \beta_4 IPM + \beta_5 EAI + \beta_6 EAM + \beta_7 TGI$$

(3)

Regression analysis was implemented again. This second step of modeling comprises thus seven independent variables. Corresponding statistics can be found in Tab. 4 (Source: author's calculations).

Table 4. Values of regression statistics corresponding with second modeling step

REGRESSION STATISTICS

MULTIPLE R	0.9974726
R SQUARE	0.994951588
ADJUSTED R SQUARE	0.992006681
STANDARD ERROR	6765.676964

Important coefficients are brought out in Tab. 5 (Source: author's calculations).

Table 5. Results for the second step of the modeling by multiple linear regression analysis

	COEFFICIENTS	STANDARD ERROR	T STAT	P-VALUE	LOWER 95%	UPPER 95%
INTERCEPT	346222.4886	117159.1	2.955149029	0.012029	90954.82099	601490.2
GDS	11.20401059	6.854455	1.634559024	0.128084	-3.730562989	26.13858
VAAI	-9360.026035	2959.376	-3.162837527	0.008178	-15807.95282	-2912.1
IPT	-9068.503841	3068.096	-2.955743379	0.012015	-15753.31033	-2383.7
IPM	12925.90875	2711.783	4.766572414	0.000459	7017.44175	18834.38
EAI	244.1088269	82.66265	2.953072769	0.012075	64.00237998	424.2153
EAM	-396.4083838	108.9534	-3.638330609	0.003398	-633.7973859	-159.019
TGI	-0.471956263	0.272869	-1.729607562	0.109313	-1.066486713	0.122574

Following the principles valid for conclusions that can be made on the p-value fundamentals, listed independent variables were considered and the subsequent equation was assembled (Equation 4) with the addition of appropriate coefficients values attributable for these sorted variables as well as intercept's value based on regression analysis:

$$GDP = 346222.4886 + 11.2040 GDS - 9360.0260 VAAI - 9068.5038 IPT + 12925.9088 IPM + 244.1088 EAI - 396.4084 EAM - 0.4720 TGI$$

(4)

Stated equation represents the final desired relationship. Estimated values serve for assessment of influences caused by independent variables on the dependent one.

4 CONCLUSION

The presented paper dealt with national economy investigation, specifically national economy of the Czech Republic. The gross domestic product was studied more closely. This indicator was suggested as a dependent variable in the modeling. Based on the previous theoretical and empirical studies exploration, nine independent variables were chosen. These were mainly focused on industry segment. Selected independent variables were gross domestic spending on research and development, value added by activity - industry (including energy), value added by activity - manufacturing, industrial production - total, industrial production - manufacturing, employment by activity - industry (including construction), employment by activity - manufacturing, trade in goods - exports and trade in goods - imports.

The crucial point of the research was to find out the relationship between dependent variable and a set of independent variables that makes possible the value estimation of the dependent variable and prediction of its future values. The covering task was to identify insignificant variables from suggested set of independent variables if there were any.

The multiple linear regression analysis was applied as a tool of the examination. The surveyed period constituted years 1998 - 2017 and data were obtained from the OECD database.

In pursuance of the analysis conducting, two indicators were excluded from the data set, namely value added by activity - manufacturing and trade in goods - exports. The rest of them were included in the equation which contained coefficients acquired on the regression analysis basis in its final form. Obtaining this equation fulfilled defined contribution objectives.

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