https://doi.org/10.53656/str2024-3s-8-dyn

DYNAMIC DETERMINATED FACTORS ANALYSIS OF LABOUR PRODUCTIVITY IN THE BULGARIAN ENERGY SUBSECTOR

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Abstract. This article presents a dynamic determined factor analysis of labour productivity in the Bulgarian energy subsector for the period 2013 – 2022. The purpose of this article is to reveal the quantitative influences of the factors operating revenues and number of employed persons on the development of the indicator labour productivity in the Bulgarian energy subsector through the averaged chain substitution method. The quantitative influences of operating revenues and number of employed persons on the deviation of the labour productivity indicator in the energy subsector are outlined. The results of the deterministic factor analysis make it possible to draw reasonable conclusions and to reveal the trends in the development of the factors operating revenues and number of employed persons, as well as the indicator of labour productivity in the Bulgarian energy subsector.

Keywords: energy subsector; labour productivity; dynamic determined factor analysis; averaged chain substitution method

Introduction

The energy subsector is one of the main subsectors of the national economy in the Statistical Classification of Economic Activities for the European Community. According to the Classification of Economic Activities 2008, it includes the following subsectors:

– Production, transmission, and distribution of electrical energy.
– Production and distribution of gaseous fuels along gas distribution networks.
– Heat energy production and distribution.

According to (Sterev & Biolcheva 2022) "The energy sector is subject to increased strategic geo-political and economic interests, both within the country and abroad".

In recent years, the Bulgarian energy subsector has achieved one of the highest labour productivity in the Industry sector, as well as in our national economy. The lack of specialized developments related to the analysis of labour productivity in

the Bulgarian energy industry make it difficult to practically solve the specific and complex problems related to the effective management of human resources, staff motivation and factors affecting labour productivity in enterprises from the energy subsector. It is necessary to clearly outline the trends in the development of the labour productivity indicator in the Bulgarian energy subsector.

Now, we have sufficient statistical information of a macro- and microeconomic nature about the processes and phenomena that occurred in the past, on the basis of which we can build trends and forecasts for the future development of the labour productivity indicator in the Bulgarian energy subsector.

The purpose of this article is to present the results and to reveal the quantitative influences of the factors operating revenues and number of employed persons of the enterprises from the Bulgarian energy subsector on the result indicator of labour productivity through the averaged method of chain substitutions for the period 2013 – 2022.

1. Main economic indicators of the Bulgarian energy subsector for the period 2013 – 2022

According to the information officially published by the National Statistical Institute (NSI), and according to data by the INFOSTAT information system of the NSI (INFOSTAT 2024), given in Table 1, most of Bulgarian energy companies currently achieve good production and economic results.

Table 1. Main economic indicators of the Bulgarian energy subsector

Economic Indicators	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of enterprises, num.	2104	2043	1945	1871	1786	1790	1820	2137	2995	4368
Number of persons employed, num.	32658	32425	31590	31926	31549	31570	31234	31146	32101	32669
Operating revenues, BGN'000.	16920453	16881547	17290843	16565649	17551319	17991110	18812040	17435695	36243764	76851264
Operating expenses, BGN ,000	16534487	17189284	16928784	16080261	17046849	17596312	17780195	16680078	33110674	72451785
Financial result operating activities, BGN ,000	385966	-307737	362059	485388	504470	394798	1031845	755617	3133090	4399479

Value of non-current assets, BGN'000	21515838	21221340	22168115	22397109	22094134	21813023	21566233	16010334	16454606	15578384
Production value, BGN ,000	9042951	7275149	7899400	7648455	7738857	7018349	7288712	7061998	11570685	n.a.
Turnover, BGN ,000	15634003	15809097	16345425	15160539	16099175	16313234	16623535	15572967	32609534	n.a.
Value added at factor cost, BGN ,000	3322549	2540952	3136440	3410150	3537944	3640262	4103941	3884476	3906744	n.a.
Personnel costs, BGN ,000	665247	675997	693932	716248	751141	793116	830985	872569	936243	n.a.

Source: INFOSTAT (INFOSTAT, 2024), compiled by the author.

According to the data in Table 1, 4368 companies and organisations in the field of energy subsector and related activities and services were active in the energy industry in 2022. 32668 people were directly employed in the energy industry. The value of non-current assets exceeded BGN 15.6 billion.

Within the analysed period, the implemented financial result of the activity of the energy enterprises in 2022 has been the highest, namely 4.4 billion BGN, formed by 76.8 billion BGN in operating revenues and 72.4 billion BGN in operating expenses.

It is worth noting that the number of enterprises in the energy subsector in 2022 is growing steadily throughout the analysed period.

The other key indicators realised by the energy subsector for the entire analysed period in 2022 reached their highest value. The most significant growth in 2022 is achieved by operating revenues, operating expenses, and operating profit.

2. Research methods and methodology

According to (Bartholomew 1984): "Deterministic modelling of factor systems is an easy and effective means of formalizing the relationship of economic indicators, which will serve as a basis for quantifying the quantitative influence of individual factors in the change of the performance indicator". If we can add according to: (Joreskog & Sorbom 1979) and (Angelova 2018): "Because deterministic factor analysis is aimed at identifying the influence of the change in the factors involved on the change in the value of the outcome measure of interest, excluding errors, and is most suitable for practical application in market conditions".

According to still other authors (Bobinaite et al, 2022) and (Angelova & Kuzmov 2018), "Labour productivity is an economic indicator reflecting the performance of an economic system in terms of the quantity of goods and services produced over a given period of time with the use of given resources, per worker or per hour worked".

The labour productivity indicator of the Bulgarian energy industry is characterized by the two-factor multiple (relative) model, which has the following form:

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$$LP = \frac{R}{N}, \quad (1)$$

were:

R is the operating revenues of the energy subsector, in BGN thousands;

N – is the number of persons employed in the energy subsector.

For the purposes of dynamic deterministic factor analysis, the analysed period is divided into sub-periods.

The changes of the resultative indicator (ΔLP) and of the participating factor variables operating revenues(ΔR) and number of employed persons (ΔN) during the analysed sub-periods can be represented by the following expressions:

$$\Delta LP_t = LP_t - LP_{t-1}; \quad (2)$$

$$\Delta R_t = R_t - R_{t-1}; \quad (3)$$

$$\Delta N_t = N_t - N_{t-1}; \quad (4)$$

where:

t is the index of the t^{th} value of the performance indicator and of the participating factor variables over time, $t = 0, 1, 2, \dots, T$;

t_0 and t_T are the beginning and the end of the whole analysed period respectively;

t_{t-1} and t_t are the beginning and the end of the t^{th} sub-period respectively.

The index of the t^{th} sub-period takes values between *0÷1* and *t-1÷T* ($t - 1 \div t = 0 \div 1, 1 \div 2, 2 \div 3, \dots$).

From here, it is easy to perform a dynamic DFA of the performance indicator for the whole period and for individual sub-periods.

The averaged chain substitution method is a new method for deterministic factor analysis (DFA), which is characterized by absolute accuracy and unequivocalness of the obtained results and has universal applicability, regarding all types of factor models.

For multiple factor models, such as the mathematical model of labour productivity, it is characteristic that the averaged chain substitution method is the only accurate method of all remaining DFA methods. It was developed and published by the author in the period 2020 ÷ 2023. The individual quantitative influences of the change of the factor variables on the change of the resultative indicator, according to: (Mitev 2020, 2021, 2022, 2023), are determined by the following expressions:

$$\Delta LP_{(R)} = \frac{\Delta R}{2}\left(\frac{1}{N_0} + \frac{1}{N_1}\right); \quad (4)$$

$$\Delta LP_{(N)} = \frac{R_1 + R_0}{2}\left(\frac{1}{N_1} - \frac{1}{N_0}\right). \quad (5)$$

The **methods applied** in the development of this study were: the methods of analysis and synthesis, a systematic approach, the method of comparison, and the averaged chain substitution method.

3. Dynamic deterministic factor analysis of the operating revenues of one employed person in the Bulgarian energy subsector for the period 2013 ÷ 2022

3.1. Input Data and empirical findings

The necessary data for performing the dynamic deterministic factor analysis of labour productivity in the Bulgarian energy subsector for the period 2013 ÷ 2022 were taken from the INFOSTAT system of the National Statistical Institute of Bulgaria.

The determination of the absolute changes in labour productivity as a result of the absolute changes in the factor variable operating revenues and the number of persons employed used the averaged chain substitution method. The quantitative impact of the change in operating revenues on the absolute change in labour productivity is determined by formula 4. Accordingly, the quantitative impact of the change in the number of persons employed on the absolute change in labour productivity is determined by formula 5.

The input data and the results obtained from the dynamic deterministic factor analysis using the averaged chain substitution method of the indicator operating revenues of one employed person in the Bulgarian energy subsector by years and for the entire period 2013 ÷ 2022 are presented in table 2.

Table 2. Input data and analysis results obtained from the dynamic deterministic factor analysis using the averaged chain substitution method of the indicator operating revenues of one employed person in the Bulgarian energy subsector by sub-periods and for the entire period 2013 ÷ 2022.

Input data

Indicators	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Operating revenues (Rt), BGN'000	16,920,453	16,881,547	17,290,843	16,565,649	17,551,319	17,991,110	18,812,040	17,435,695	36,243,764	76,851,264
Number of persons employed (N_t), , num.	32,658	32,425	31,590	31,926	31,549	31,570	31,234	31,146	32,101	32,669
Operating revenues per one employed person (LPt), BGN'000/employed person	**518.111**	**520.634**	**547.352**	**518.876**	**556.319**	**569.880**	**602.294**	**559.805**	**1129.054**	**2352.422**

Source: INFOSTAT (NSI, 2024), compiled by the authors.

Analysis results

Indicators	2013÷2014	2014÷2015	2015÷2016	2016÷2017	2017÷2018	2018÷2019	2019÷2020	2020÷2021	2021÷2022	2013÷2022
Absolute change in operating revenues ($\Delta R=R_t-R_{t-1}$), BGN'000	-38,906	409,296	-725,194	985,670	439,791	820,930	-1,376,345	18,808,069	40,607,500	59,930,811
Relative change in operating revenues ($\%R=\Delta R*100/R_{t-1}$), %	-0.23%	2.42%	-4.19%	5.95%	2.51%	4.56%	-7.32%	107.87%	112.04%	354.19%
Absolute change in the number of employed persons ($\Delta N=N_t-N_{t-1}$), бр.	-233	-835	336	-377	21	-336	-88	955	568	11
Relative change in the number of employed persons ($\%N=\Delta N*100/N_{t-1}$), %	-0.71%	-2.58%	1.06%	-1.18%	0.07%	-1.06%	-0.28%	3.07%	1.77%	0.03%
Absolute change in operating revenues per one employed person ($\Delta LP=LP_t-LP_{t-1}$), BGN'000/employed person	2.523	26.718	-28.475	37.443	13.561	32.414	-42.488	569.249	1223.368	1834.311
Relative change in operating revenues from the activity per one employed person ($\%LP=\Delta LP*100/LPt-1$), %	0.49%	5.13%	-5.20%	7.22%	2.44%	5.69%	-7.05%	101.69%	108.35%	354.04%
Quantitative influence of the change in operating revenues ($\Delta LP_{(R)}$), BGN'000/employed person	-1.196	12.790	-22.836	31.058	13.935	26.143	-44.128	594.885	1253.995	1834.795
Quantitative influence of the change in operating revenues ($\%LP=\Delta LP(R)*100/LP_{t-1}$), %	-0.23%	2.46%	-4.17%	5.99%	2.50%	4.59%	-7.33%	106.27%	111.07%	354.13%
Quantitative influence of the change in the number of employed persons ($\Delta LP_{(N)}$), BGN'000/employed	3.719	13.928	-5.640	6.385	-0.375	6.270	1.639	-25.637	-30.627	-0.483
Relative influence of the change in the number of employed persons ($\%LP=\Delta LP(N)*100/LP_{t-1}$), %	0.72%	2.68%	-1.03%	1.23%	-0.07%	1.10%	0.27%	-4.58%	-2.71%	-0.09%
Complex influence: $\Delta LP = \Delta LP_{(R)} + \Delta LP_{(N)}$, BGN'000/employed person	2.523	26.718	-28.475	37.443	13.561	32.414	-42.488	569.249	1223.368	1834.311
Verification: $\Delta LP=\Delta LP_{(R)} + \Delta LP_{(N)}$	False	False	True	False	False	True	True	True	True	True
Error value, BGN'000/employed person	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Verification: $\%LP=\%LP_{(R)}+\%LP_{(N)}$	False	False	False	False	False	False	False	False	False	False
Relative error value, %	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%	0.000000%

Figure 1 presents the quantitative factor influences of the factors operating revenues and number of employed persons on the quantitative change of labour productivity in the energy subsector.

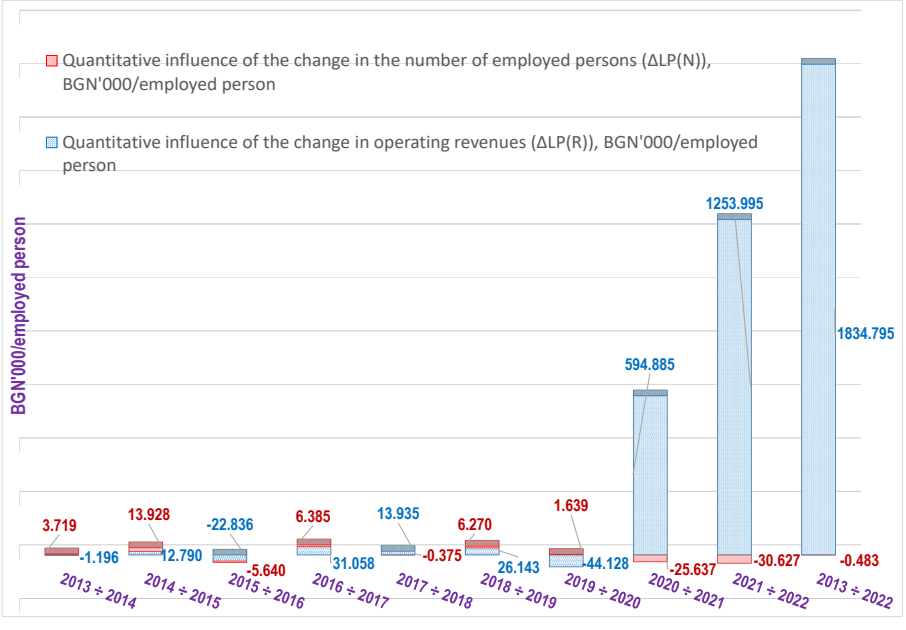

Figure 1. Quantitative influences of the factors operating revenues and number of employed persons on the change of the indicator operating revenues of one employed person in the Bulgarian energy subsector by subperiods calculated by the averaged chain substitution method

3.2.. Discussion of Results

For the entire analysed period 2013 – 2022, the operating revenues of one employed person in the Bulgarian energy subsector increased by BGN 1834.311 thousand or by 354.04%. The increase in operating revenues by BGN 59,930,811 thousand or by 354.19% improves labour productivity by BGN 1,834,795 thousand/employed or by 354.13%. The increase in the number of employed persons by 11 employed persons or by 0.03% slightly impairs labour productivity by BGN 0.483 thousand/employed person or by 0.09%.

A check that the absolute change in the performance indicator is equal to the sum of the two-factor influences shows some minor errors far behind the decimal point. This confirms the high accuracy of the averaged chain substitution method.

Conclusions and summary

As can be seen from Table 2 and Figure 1, the main factor for increasing labour productivity in the energy subsector for the entire analysed period is the significant increase in operating revenues. The weak increase in the number of

persons employed during the period 2013 – 2022 insignificantly worsens labour productivity.

Hence, the increase in the operating revenues during the analysed period in the Bulgarian energy subsector plays a key role in increasing labour productivity. The increase in the number of employed persons by 11 during the analysed period, it had a negligible negative impact on the increase in labour productivity.

The results of the dynamic deterministic factor analysis show that the Bulgarian energy subsector managed to significantly increase the level of labour productivity during the analysed period. The high growth of operating revenues is the main factor for the improvement of labour productivity in the Bulgarian energy industry.

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