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MAREK BOTEK
University of Chemistry and Technology, Prague, Czech Republic

OLGA KUTNOHORSKÁ
University of Chemistry and Technology, Prague, Czech Republic

DANA STRACHOTOVÁ
University of Chemistry and Technology, Prague, Czech Republic

STANISLAVA GROSOVÁ
University of Chemistry and Technology, Prague, Czech Republic

PRODUCTIVITY DEVELOPMENT OF COMPANIES OF THE CZECH CHEMICAL INDUSTRY

Abstract:

This article studies the performance of selected companies of the Czech chemical industry. Data from financial statements are used for the analysis. The initial data is processed by the Data Envelopment Analysis (DEA) method. Furthermore, the authors use the Malmquist Productivity Index (MPI) to analyze changes in the productivity of companies, and the bootstrap method tested the statistical significance of these indexes. The authors examined the development of selected data over a longer time horizon in order to identify changes, for example, in the period before and after the COVID 19 epidemic. The findings of the study not only show the development of productivity, but also reveal the causes of the development.

Keywords:

Chemical industry, Data envelopment analysis, Malmquist productivity index, Bootstrapping, Financial statements

JEL Classification: C10, D20

1 Introduction

The performance of the chemical industry, one of the most important industries in the Czech Republic, has gradually stabilised after the crisis period of 2019-2020. Thus, the high increase in energy prices at the end of 2021 and, in particular, the war conflict in Ukraine, which reinforced negative expectations of further developments in the availability of cheap energy resources for Europe, continued to negatively affect particularly energy-intensive industries, due to the need to increase the prices of chemical derivatives production and the subsequent gradual decline in demand from downstream industries.

The chemical industry's position still ranks 2nd - 3rd among the manufacturing industries in the Czech Republic with a share of more than 13 percent of total production. The Association of Chemical Industry (2023) in its Yearbook for 2022 states that the total output of the chemical industry in the Czech Republic (CZ NACE 20) reached CZK 360 billion in current prices, gross value added of CZK 59 182 million, and employment of 33 178 persons. These are figures that show that the chemical business is one of the most important manufacturing sectors. The chemical industry is therefore essential to the Czech economy. However, chemical companies face health, safety, and environmental costs that are not as prevalent in other sectors. Rajeev et al. (2019) identified that most companies in this sector provide economic benefits to the manufacturer at the expense of negative environmental and social impacts. Therefore, chemical companies have to incur higher costs for sustainable business.

The chemical industry is highly interconnected and relies on complex global supply chains to ensure a steady flow of raw materials, intermediates, and finished products (Abedsoltan, 2023). Therefore, the further development of the industry will continue to be influenced by the energy crisis in the coming period. Market demand and the overall trade balance are significantly influenced by the availability of raw materials and the ongoing military conflict in Ukraine and Houthi attacks in the Red Sea. In addition, the competitiveness of the European chemical industry is significantly affected not only by access to cheaper goods from third countries, and restrictions on exports to third countries but also by the limited availability and use of support programs to offset the negative effects of the gradual implementation of the European Green Deal legislation.

The main objective of this study is to test the applicability of the Data Envelopment Analysis (DEA) methodology to monitor the performance of manufacturing firms based on publicly available financial indicators. The objective is to determine the relationship between selected parameters characterizing the business and the financial performance of firms. Environmental costs are important for the chemical industry. However, in order to examine environmental management, it is first necessary to look at the overall performance of the companies. For the management of these firms, and especially for their owners, the answer to the question of how environmental costs will affect their performance is certainly important. In the follow-up part of the research, the authors will continue to collect data on the environmental costs of chemical companies in order to identify the impact of these costs on the evolution of their productivity.

Data Envelopment Analysis (DEA) has long been used to measure operational performance (Sueyoshi and Goto, 2011, Zanella et al., 2012). There are several methods of measuring changes in efficiency over time in DEA, one of which is the Malmquist productivity index (Färe et al., 1994). The Malmquist productivity index is also used to calculate productivity growth and its components.

1.1 Literature Review

The Malmquist Index (MI) was created in 1953 by Swedish entrepreneur Staffan B. Malmquist as a non-parametric indicator of productivity (Farnoudkija, 2024). The output-oriented function for the Malmquist index has the form:

$$d^T(\boldsymbol{x}^t, \boldsymbol{y}^t) \equiv \inf [\Theta : (x^t, \boldsymbol{y}^t/\Theta) \varepsilon S^t] \quad (1)$$

where $\boldsymbol{x}$ denotes a vector of inputs, $\boldsymbol{y}$ denotes a vector of outputs, S is the technology set and superscript T denotes the technology reference period; usually $T=t$ or $T=t+1$. $1/\Theta$ defines the amount by which outputs in year t could have been increased, given the inputs used, if the technology for year T had been fully utilised (Nektarios, Barros, 2010).

The original index has been modified by Färe et al (1992) and is still used as a geometric mean calculating data for years t and $t+1$ and using a decomposition into technical efficiency change and technological change. It is widely used because it is based only on the technical efficiency formulation. Thus, tracking input and output data is sufficient for the calculation (Walheer, 2022).

The disadvantage of the MI is its high sensitivity to the data used or its completeness (Akbarian, 2020). Also, its construction as an indicator of change between two states does not allow direct comparison of continuous changes over a longer period (Wahleer, 2022). Other disadvantages include that in many situations a structural approach would be preferable to a technical formulation of efficiency (Walheer, 2022).

The DEA methodology has been applied to a wide range of research problems. Firsova and Chernyshova (2020) used it for efficiency analysis of regional innovation development, Lenort et al. (2019) for measuring economic and environmental efficiency in the chemical industry, Liu and Wang (2008) for semiconductor packaging and testing companies in Taiwan, and Nektarios and Barros (2010) identified many studies of insurance efficiency.

The Malmquist index is also used separately to measure productivity growth. Simar and Wilson (1999) extended Färe et al. (1992) by providing a statistical interpretation of their Malmquist productivity index and presenting a bootstrap algorithm that can be used to estimate confidence intervals for the indices. Another modification is to decompose the technical efficiency change component into pure efficiency change and scale efficiency change (Nektarios and Barros, 2010).

Development is also carried out in the search for the production possibilities frontier (operational efficiency). Standard mathematical programming models are used for this purpose. In Data Envelopment Analysis (DEA), stochastic nonparametric programming (Frontier analysis (SFA), see Odeck and Schøyen, 2020) is implemented, or even the stochastic nonparametric envelopment of data (StoNED), proposed by Yu and Hiroshi (2024), which combines the DEA and SFA approach.

Most studies, however, stick to using the standard MI according to Färe et al (1994) and the DEA approach. Therefore, this combination will also be used in our paper.

2 Methodology

2.1 Data Acquisition

The selection of companies for the research was based on statistical yearbooks of the Association of Chemical Industry of the Czech Republic, which represents the majority of the Czech chemical industry in terms of turnover, profit generation, and contribution to the state budget of the Czech Republic (The Association of Chemical Industry, 2023).

Companies were included in the research in terms of their turnover. The selected companies represent different areas of activity in the Czech chemical industry. Companies from the distribution of raw materials, inorganic and organic chemistry, consumer chemistry, qualified chemistry, production of technical gases, and others are represented.

The data collection was completed in June 2024, when the financial statements of all monitored firms for the year 2023 were not yet available. Therefore, the analyzed time series was completed in 2022. The productivity of the selected firms was monitored in the period between 2008-2022. The whole period was divided into 2 periods in order to identify the influence of the used input and output parameters of the model on the performance of the firms. Both periods were purposely chosen so that the first period includes the effects of the 2008 global crisis. The first period ends in 2014. The results can provide insights into what causes imperfect competitive conditions in the chemical industry.

It was not possible to work with environmental data at this stage of the research, as the only publicly available information of this kind is available from the Czech Statistical Office only in aggregated form.

2.2 Selection of adequate data

All data sources were obtained from the annual reports of the selected companies in the selected time 2008-2022. It is therefore clear that the authors used Balance sheets and Profit and loss accounts. The annual reports were downloaded from the Justice.cz web portal.

The selected data were divided into inputs and outputs for the purpose of modeling (see Table 1). Inputs were represented mainly by balance sheet items such as business assets (total assets) and then its subparts, fixed assets, and current assets. Resource shares, i.e. equity and foreign capital, were also included in the examination. Power consumption was the last input item.

Outputs included operating sales, but were limited to revenues from the sale of products, services and goods. In addition, value added, accounting result and earnings before tax (EBT) were used. The data obtained were then subjected to statistical processing.

Table 1: Descriptions of input and output variables in the DEA model

Variables	Description
Inputs	
I1	business assets, the total sum of assets
I2	fixed assets
I3	current assets
I4	equity capital
I5	foreign capital
I6	power consumption, material, energy, and service costs
Outputs	
O1	operating sales, only products, services, and goods
O2	added value
O3	accounting result, operational
O4	earnings-before-tax (EBT)

Sources: own adjustment based on research data

2.3 Descriptive statistic

The research period was from 2008 to 2022. Table 2 provides descriptive statistical characteristics of the population used, giving mean and standard deviation values for each year for all input and output variables. All values are given in units of millions. CZK.

The average input variable I1 from 2008 through 2022 ranged from 2595.42 million CZK to 5126.06 million CZK has an increasing tendency. The average input variable I2 ranged from 1179.604 million CZK to 2659.63 million CZK over the research period. CZK. The other input variable I3 has been increasing relatively steadily throughout the research period, its average ranging from CZK 1082.35 million to 2462.31 million CZK. Input variable I4 takes average values from 1091.12 million CZK to 3052.82 million CZK. The average of input variable I5 is in a relatively narrow range of CZK 1,294.17 million CZK to 2184.27 million CZK. The average values of the last input variable I6 range from 3025.54 million CZK to 6409.87 million. The values tend to stagnate during the period under review, with a significant increase only in the last year of the period.

The average of the output variable O1 ranges from CZK 3,646.20 million to 8026.62 million CZK, with a rapid increase occurring again in the last year of the period. The output variable O2 ranges on average from CZK 360.61 million to 1616.76 million CZK. The average of the output variable O3 is in the range of CZK 1.94 million CZK to 769.56 million. CZK. The last input variable O4 ranges in its average from CZK 7.89 million to 755.49 million CZK. The significant growth occurs again in the last year of the period under review.

Table 2: Average values of the indicators during 2008-2022 (million CZK)

	I1	**I2**	**I3**	**I4**	**I5**	**I6**	**O1**	**O2**	**O3**	**O4**
2008	2750.1	1644.3	1086.2	1373.9	1395.9	3976.1	4795.2	510.0	69.5	44.8
2009	2595.4	1496.8	1082.3	1237.7	1364.2	3025.5	3646.2	360.6	1.9	7.9
2010	2649.7	1412.6	1225.6	1387.0	1294.2	3719.3	4511.0	538.1	191.5	204.8
2011	2759.0	1282.3	1462.7	1335.9	1487.2	4218.1	5243.4	546.8	109.4	129.1
2012	2734.1	1236.0	1475.2	1300.9	1433.2	4127.1	5139.9	502.4	197.9	181.3
2013	2691.2	1179.6	1429.4	1148.9	1467.1	3920.6	4756.0	425.7	99.3	97.1
2014	2758.6	1273.6	1486.1	1091.1	1626.3	4589.5	5476.0	579.4	225.8	227.0
2015	2730.4	1317.9	1383.1	1450.7	1415.8	3757.4	4686.3	706.2	360.5	362.1
2016	3282.5	1643.6	1607.5	1709.9	1526.7	4337.2	4048.8	468.8	320.6	330.7
2017	3729.6	1931.3	1735.5	2222.3	1491.1	4274.7	5119.6	846.6	509.3	484.9
2018	4137.4	2234.0	1831.1	2470.1	1660.4	4600.9	5340.8	740.2	416.2	456.1
2019	4192.1	2318.1	1873.6	2539.0	1539.1	4462.4	5160.3	697.4	234.2	233.7
2020	4082.2	2546.1	1529.1	2455.2	1623.3	3095.2	3829.2	731.6	344.9	344.8
2021	4872.0	2734.0	2121.3	2676.4	2184.3	4668.3	5666.8	1000.1	386.5	412.8
2022	5126.1	2659.6	2462.3	3052.8	2137.9	6409.9	8026.6	1616.8	769.6	755.5

Sources: own adjustment based on research data

Table 3: Standard deviations of the indicators during 2008-2022 (million CZK)

	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
2008	5482.5	3265.6	2220.0	2329.3	3371.4	14499.4	15646.1	738.6	322.1	394.8
2009	5535.4	3072.4	2476.3	2001.0	3724.8	11079.8	11530.6	487.3	400.9	477.8
2010	5572.1	2877.1	2721.2	2131.7	3684.2	13573.0	14373.6	769.7	386.8	459.9
2011	5757.9	2526.4	3267.5	1885.2	4387.1	15325.8	16629.2	764.8	906.3	958.9
2012	5767.0	2473.5	3256.4	1982.7	4214.4	14318.7	15703.8	628.9	432.0	480.2
2013	5704.0	2164.4	3222.5	1599.5	4527.3	13388.1	14354.0	528.7	417.7	464.4
2014	5932.1	2502.1	3509.1	1711.8	4564.6	16649.6	18043.3	861.7	494.0	518.4
2015	5972.3	2457.4	3590.7	2517.5	3754.3	13364.1	15569.2	1515.9	1031.7	1062.9
2016	8791.6	4214.4	4622.7	3843.4	5165.0	13276.2	12441.4	542.2	984.6	1059.0
2017	10770.7	5656.7	5161.2	6377.0	4499.4	15430.5	17486.9	2107.4	1739.8	1563.8
2018	12707.1	7038.9	5726.2	7696.3	5110.2	17322.9	18796.2	1560.7	1463.3	1642.0
2019	13264.4	7874.4	5443.4	7733.4	4702.3	17096.8	18439.4	1422.2	392.1	439.8
2020	12281.4	8459.2	3876.7	6849.3	5548.5	10149.9	11574.9	1494.7	1026.9	1121.6
2021	15089.8	9218.2	5915.1	7363.7	7879.0	16637.8	19080.0	2489.9	769.0	782.4
2022	15940.4	9208.4	6803.4	8744.6	7270.9	23976.8	3025.2	6311.5	2801.6	2762.7

Sources: own adjustment based on research data

Table 3 shows the variability of input and output variables through Standard Deviation.

Table 4 shows the correlation coefficients characterizing the correlation between the input and output variables used for DEA. The results show that all correlations are significant and all variables are positively correlated with each other. This suggests that an increase in the value of the input variable should not lead to a decrease in the value of the output variable. According to Charnes et. al (1985) and Talluri et al (1997), this indicates the appropriateness of using the selected input and output variables to measure the efficiency of firms.

Table 4: Correlation coefficient for inputs and outputs

	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
I1	1									
I2	.959**	1								
I3	.911**	.757**	1							
I4	.980**	.961**	.857**	1						
I5	.857**	.763**	.874**	.747**	1					
I6	.621*	.421	.829**	.546*	.718**	1				
O1	.587*	.402	.780**	.516*	.714**	.943**	1			
O2	.836**	.733**	.870**	.811**	.824**	.790**	.842**	1		
O3	.782**	.660**	.840**	.788**	.689**	.713**	.681**	.899**	1	
O4	.797**	.674**	.853**	.801**	.709**	.709**	.670**	.891**	.996**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Sources: own adjustment based on research data

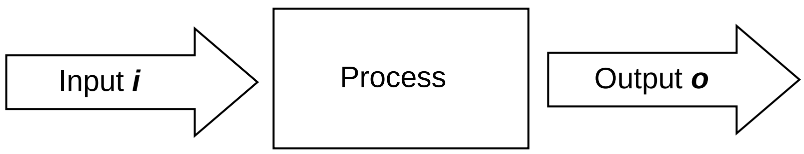
2.4 Malmquist index

The Malmquist Index can be calculated in several ways. In this study, we estimate an output-oriented Malmquist Productivity Index, based on DEA. Output-oriented efficiency measurements are appropriate if we assume that chemical companies act in a competitive market. In output-oriented models, such as the one adopted in this paper. DEA allows for the estimation of total productivity change in the form of a Malmquist Index.

The software program DEAP version 2.1 (The University of Queensland, 2024) was used to calculate the Malmquist index. Individual combinations of outputs and inputs for selected groups of firms were entered into the software in turn. The processing followed a general model (see Fig. 1). The output module allows the following Malmquist index indicators to be obtained for each of the firms analysed each year:

1. technical efficiency change (relative to a CRS technology),
2. technological change,
3. pure technical efficiency change (relative to a VRS technology),
4. scale efficiency change,
5. total factor productivity (TFP).

Figure 1: A general model for calculating the Malmguist index



Sources: own processing

The output from the SW contains additional summary tables from which the evolution of the Malmquist index over a certain time can be identified for all firms studied and for individual firms over the entire time. The tables, which are presented in the following section, show the Malmquist index evolution (efficiency) over time for all firms in total.

3 Results and discussion

Within the DEAP version 2.1 solutions, the calculations were performed sequentially for different combinations of input and output factors according to the model (see Fig. 1). To illustrate the results in this paper, a model was selected where the input value was total assets and the output value represented operating sales. Table 5 shows the values of total factor productivity (TFP) in each period and for all companies included in the analysis (the number of firms was 39). The last entry in the table characterises the average value in a given year.

Table 5: Resulting values of the efficiency scores for the used step companies (part 1)

Nr. of companies	2009	2010	2011	2012	2013
1	0.849	1.074	1.206	0.898	0.727
2	1.063	0.620	1.483	0.934	0.916
3	1.339	0.849	1.015	0.821	1.154
4	1.630	0.596	1.108	1.296	1.318
5	0.610	1.584	0.980	1.114	1.010
6	0.914	1.068	1.290	0.988	0.909
7	2.921	1.252	0.871	0.782	1.044
8	0.768	1.205	1.108	1.013	1.019
9	0.877	0.766	1.012	1.127	1.064
10	0.889	1.395	1.044	1.011	1.056
11	1.099	0.879	0.630	0.939	1.383
12	0.888	0.958	1.150	1.004	0.811
13	0.713	6.027	1.639	4.381	1.116
14	0.842	0.916	1.005	1.336	0.840
15	0.899	1.064	0.986	1.410	1.124
16	1.087	1.029	0.923	1.006	0.844
17	0.865	1.087	1.064	1.088	0.988
18	0.956	0.944	0.909	1.049	0.693
19	0.972	0.946	1.201	0.966	0.798
20	0.652	1.901	1.015	0.955	1.003
21	0.891	0.988	1.096	1.007	0.965
22	0.984	0.942	0.981	1.322	0.791
23	0.756	1.370	0.891	1.050	1.096
24	1.138	1.025	1.004	0.854	0.976
25	0.941	1.077	1.014	1.031	0.992
26	0.689	1.568	1.029	1.023	0.954
27	0.336	0.341	5.876	0.881	0.959
28	0.720	1.245	1.134	0.943	0.907
29	0.668	1.190	1.441	1.214	0.473
30	1.212	1.088	1.015	1.002	0.828
31	0.933	1.107	1.041	1.063	1.005
32	1.008	1.244	1.132	1.016	1.127
33	0.773	1.297	1.578	1.036	0.942
34	0.803	1.454	1.217	0.871	1.013
35	1.126	1.049	1.240	1.156	0.976
36	0.912	1.376	0.965	1.017	1.729
37	0.886	1.237	1.098	1.169	0.973
38	1.011	0.988	2.304	1.038	0.948
39	1.073	1.292	0.898	1.156	1.033
mean	0.915	1.112	1.145	1.072	0.968

Sources: own adjustment based on research data

Table 5: Resulting values of the efficiency scores for the used step companies (part 2)

Nr. of companies	2015	2016	2017	2018	2019	2020	2021	2022
1	1.037	0.816	0.976	0.821	0.964	0.938	1.029	1.363
2	0.895	0.866	0.866	0.927	0.979	0.970	0.981	0.975
3	1.120	0.713	1.323	0.827	1.053	0.898	0.714	1.066
4	1.017	0.907	1.113	0.906	1.052	0.995	1.089	1.018
5	0.870	0.885	1.103	0.916	0.895	0.813	1.038	1.227
6	1.010	1.035	0.978	0.949	0.927	0.910	0.958	1.057
7	1.273	1.130	1.253	0.094	0.562	1.487	0.802	1.534
8	0.880	0.753	1.221	1.033	0.975	0.819	0.966	1.162
9	0.915	0.823	1.242	1.482	0.915	1.078	0.952	1.179
10	0.821	0.865	0.943	1.089	0.977	0.728	1.213	1.214
11	1.387	1.084	1.164	1.008	0.870	1.260	0.756	1.131
12	1.032	1.052	1.032	0.981	1.099	0.936	1.016	0.865
13	1.114	1.040	1.091	0.407	2.556	1.040	1.090	1.517
14	0.730	0.758	1.446	0.977	1.282	0.836	0.871	1.479
15	1.083	0.994	1.130	0.823	0.729	1.476	0.894	1.292
16	1.116	0.994	0.934	0.869	1.055	0.965	0.962	0.968
17	0.996	0.916	0.881	0.824	0.909	0.938	1.183	1.044
18	1.170	1.118	0.880	1.044	0.097	0.854	0.929	0.847
19	1.030	3.106	1.079	0.947	1.064	0.947	1.172	0.981
20	0.965	0.903	0.911	0.909	1.017	0.875	1.188	1.088
21	0.991	1.013	1.017	1.012	1.023	0.892	1.043	1.188
22	0.797	0.744	0.844	1.004	1.050	0.943	1.487	1.503
23	1.069	0.923	0.785	1.025	1.081	1.061	1.174	0.975
24	1.030	0.789	1.008	0.986	1.127	0.085	1.044	1.175
25	0.894	0.998	1.024	0.500	0.984	0.665	1.469	1.180
26	0.978	0.927	0.935	1.159	0.917	0.932	0.515	1.653
27	0.891	1.014	0.957	1.105	1.018	0.670	1.276	1.142
28	0.853	0.537	1.143	0.908	0.940	0.679	1.336	1.500
29	0.957	0.661	1.318	0.512	0.998	1.226	1.195	0.944
30	0.816	0.991	0.941	1.060	1.026	0.940	0.930	1.030
31	1.023	0.943	1.019	1.004	1.148	1.011	1.254	1.104
32	0.901	0.956	0.956	0.919	0.899	1.036	1.199	0.001
33	0.914	0.703	0.982	1.318	0.779	0.771	0.948	1.140
34	1.107	0.802	1.080	1.254	1.030	1.071	1.078	1.086
35	1.037	0.943	0.913	0.983	0.898	0.991	1.054	1.064
36	1.211	0.570	1.666	0.917	1.069	1.011	0.624	2.017
37	0.848	0.746	1.274	0.964	0.939	0.743	1.387	1.255
38	1.040	1.115	0.918	0.911	0.976	0.788	0.957	1.241
39	1.080	1.029	1.045	0.943	1.057	0.930	0.961	0.672
mean	0.989	0,912	1.111	0.877	0.987	0.879	1.022	0.961

Sources: own adjustment based on research data

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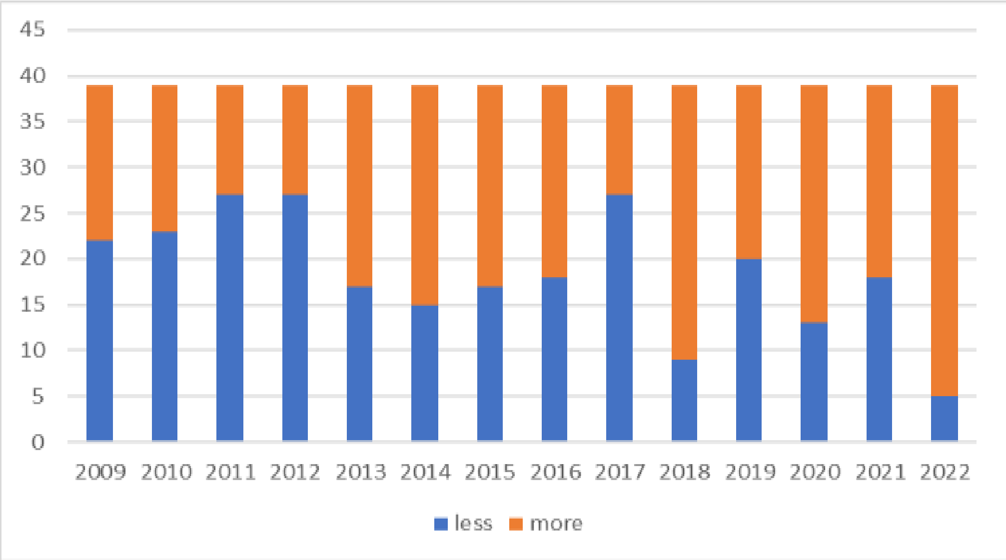
For a clearer display, Figure 2 was created. For each step, it shows the number of firms that have higher or lower performance than the average for the year. The performances were determined based on efficiency scores (Table 5).

Figure 2: Performance of firms in the Czech chemical industry



Sources: own adjustment based on research data

Figure 2 indicates that no prevailing trend can be observed, so it is not possible to transparently assess the performance of the Czech chemical industry as a whole based on the data used due to the diversity of individual companies.

Total factor productivity (TFP) was calculated for each two consecutive years. TFP values allow for a year-on-year comparison of the average efficiency value achieved within the set of all evaluated firms (Table 6).

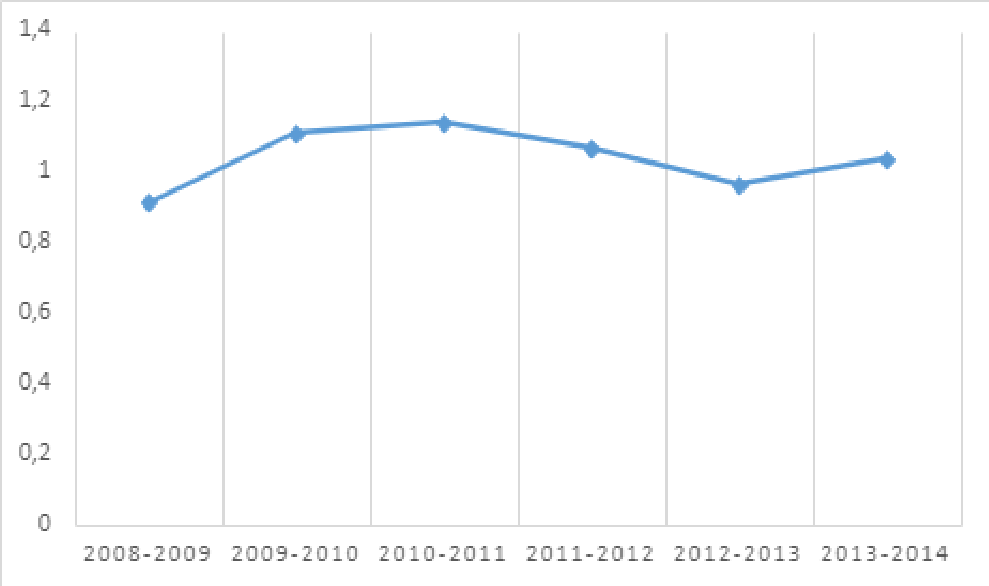
Table 6: The resulting values of the productivity index of all companies of the company

	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
TFP	0.915	1.112	1.145	1.072	0.968	1.039	1.034	1.106	0.883	0.986	0.888	1.021	1.020
mean				1.039						0.988			

Sources: own adjustment based on research data

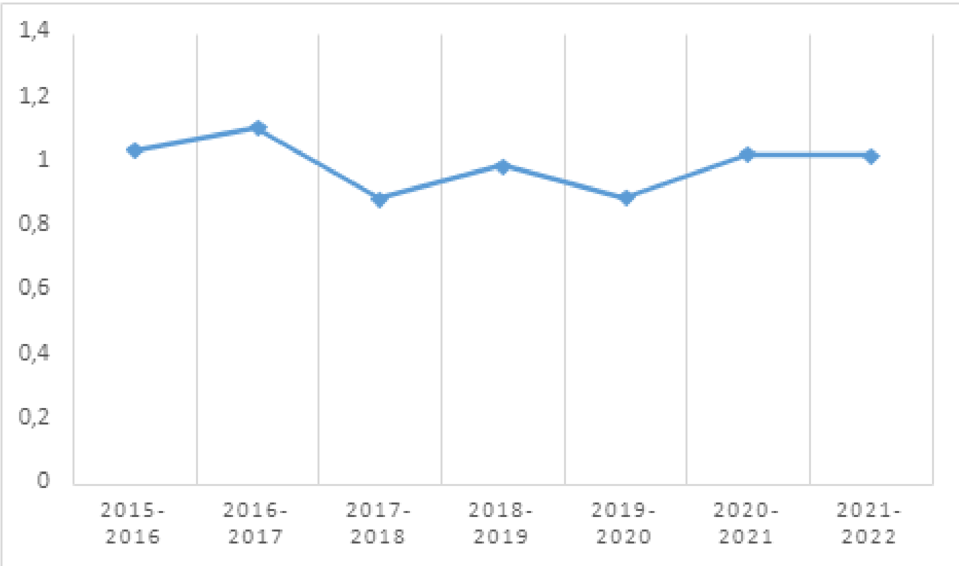
Table 6 shows that in the first selected period (2008-2014) this value increased slightly, which is also evident from the average value. This is logical, as firms have gradually recovered from the global crisis after 2008, while in the second period (2015-2022) the opposite trend is evident. This is caused first by the COVID-19 pandemic and then by the rise in energy prices and, for the chemical industry, the rise in prices of other important raw materials. Again, this can be evidenced by the average TFP value over the period. Both trends are also demonstrated in Figures 3 and 4.

Figure 3: Development of efficiency values of all companies in the years 2008 - 2014



Sources: own adjustment based on research data

Figure 4: Development of efficiency values of all companies in the years 2015 - 2022



Sources: own adjustment based on research data

4 Conclusion

The paper confirms that the DEA method can illustrate the impact of individual appropriately selected model parameters on the performance of firms using a productivity index.

The DEA models in this research did not include all inputs and outputs, although correlations were shown in the Descriptive Statistics section. Two-parameter models were always tested in the computations. The most appropriate input parameter was business assets (i.e. total assets) and the most appropriate output was either operating sales or value added. For example, EBT values proved to be unsuitable for the DEA method.

The paper focused on the development of productivity indices for selected firms in the Czech chemical industry in two consecutive periods. This made it possible to portray the overall situation and reveal possible trends. It turned out that the Czech chemical industry is very heterogeneous, that companies have a broader portfolio of products and activities and therefore do not react in the same way to external influences. It will be interesting to try to group the selected enterprises according to the dominant area of production focus and compare the development of these groups.

From the results obtained, it would also be possible to analyse in more detail the differences in efficiency across the enterprises surveyed. However, the results would not yield significantly different conclusions than those that experienced financial analysts can draw from the actual annual reports from which the data was drawn. For the authors, it was essential to test the DEA methodology so that the next phase of the research could proceed to incorporate data that would better track differences in firm performance. Only then will it make sense to use models with more input and output parameters. It will be important to use other data sources (other than the balance sheet and profit and loss statement) for deeper investigation. A particular challenge is the environmental costs that significantly affect business in the chemical industry. For the management of these companies, and especially for their owners, it is certainly important to answer the question of how these costs will affect their performance. However, the existing Environmental Report 1-01, required by the Ministry of the Environment, is not delivered responsibly enough to the relevant authorities. The challenge for the authors is therefore to obtain this data in a structured form for individual enterprises.

Finally, it is necessary to mention the limitations that the DEA methodology entails. These include the issue of the selection of relevant enterprises to be studied, the choice of appropriate inputs and outputs, and the choice of an appropriate time.

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