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APPLICATION OF SYNTHETIC TAXONOMIC MEASURES TO ASSESS THE INVESTMENT ATTRACTIVENESS OF THE SELECTED COMPANIES IN THE CONSTRUCTION MATERIALS INDUSTRY LISTED ON THE WARSAW STOCK EXCHANGE

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Abstract: The study used the synthetic taxonomic measure TMAI and BZW to determine whether the fundamental strength of 17 companies from the construction material industry listed on the Warsaw Stock Exchange affects their investment performance. Companies whose operations are conducted mainly in Poland and whose profit and loss account is prepared in the calculation system were selected for the study. It was checked how the use of different methods of aggregation of the same diagnostic variables (with and without a pattern) affects the classification results. Investment efficiency was measured with the annual, logarithmic rate of return and the created rankings of companies for the years 2016-2021 were compared with it.

Keywords: synthetic taxonomic measure, TMAI, BZW, building materials company, Warsaw Stock Exchange

JEL classification: C1, G11

INTRODUCTION

The development of the economy and markets has meant that the demand for specialized tools to support and facilitate decision-making is constantly growing. In practice, each decision is multidimensional, which results from the interaction of many phenomena. This is especially evident in the field of economics. The effectiveness of action in a complex economic reality is determined by good and

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reliable information and its proper processing, so that decisions made on its basis are effective [Łuniewska, Tarczyński 2006].

Assessment of the investment attractiveness of listed companies is a complex process that includes multidimensional comparative analysis and interdependence research, i.e., methods related to fundamental analysis. It mainly concerns long-term investing. It refers to the study of the foundations on which the share price is based, and one of the factors determining the formation of these prices in the long term is the financial condition of the company [Jajuga and Jajuga 2000].

The methods of linear ordering of objects are one of the groups of Multidimensional Comparative Analysis methods. In the literature, you can find many algorithms for creating synthetic measures that use properly selected diagnostic variables. Z. Hellwig [1968) was the first to propose a synthetic measure of development to compare the level of economic development of selected countries. Since then, the methodology of constructing taxonomic measures for various applications has been developed in Poland by, among others, Cieślak [1974]; Bartosiewicz [1976]; Strahl [1978]; Zeliaś, Malina [1997]; Kukuła [1986, 2000]; Walesiak [2003]; Gatnar, Walesiak [2004] as well as Tarczyński and Łuniewska [2006].

In the works of Tarczyński [1994, 2002] and Łuniewska and Tarczyński [2006], the authors proposed the use of fundamental analysis in the construction of a taxonomic measure of investment attractiveness (TMAI) based on publicly available indicators of the financial condition of the company and the development of the capital market. The concept of an algorithm created by Hellwig [1968] was used to build the meter.

The main aim of the study is to assess the fundamental strength of 17 companies from the construction materials industry listed on the Warsaw Stock Exchange using two taxonomic measures TMAI and BZW and its impact on investment performance. Rankings for the years 2016-2021 were built and it was checked how the use of different methods of aggregation of the same diagnostic variables [with and without a pattern] affects the classification results. As a measure of investment efficiency, annual, logarithmic rates of return were used, with which the obtained results of the classification of the surveyed companies were compared. The work uses: taxonomic measure of investment attractiveness (TMAI), in which the distance from the pattern is calculated for each object, taking into account the different impact of variables on the studied phenomenon, and the relative level of development index (BZW) calculated without a pattern. These measures allow for a comprehensive analysis of enterprises based on the most important financial indicators, presenting it in the form of a ranking.

The very important role of the construction industry results from the implementation of investments present in everyday life of almost everyone and the ability to generate economic growth. Analyses of the construction market and the construction materials industry are carried out on many levels. They are important from the point of view of the needs of the sector's enterprises themselves, who want

to achieve an adequate profit from their operations, but also from the point of view of the needs of households, who are customers and investors. The article is a continuation of the author's research on the possibility of an objective fundamental assessment of companies from the construction industry and the construction materials industry. Hence, it is advisable to select 17 companies for the analysis, including two companies whose shares were delisted from the stock exchange in 2020 (ES-System S.A.) and in 2021 (Ceramika Nowa Gala S.A.). It is assumed that the companies that have been delisted are at the bottom of the fundamental valuation scale. This allows the positions of the remaining companies to be compared.

LITERATURE REVIEW

The fundamental strength of a company is a term used for the first time in the work of Tarczyński [1994] and is a concept closely related to fundamental analysis, which allows to determine the economic and financial condition of a company. In recent years, an increasing role of fundamental factors in the market assessment of companies can be observed.

Benjamin Graham is considered to be the creator of the concept of using fundamental analysis methods in the investment process [Graham, Dodd, 2005; Graham, 2007]. The concept of fundamental strength has evolved in the literature on the subject, often not being referred to as such [Tarczyński et al., 2017].

A whole range of practical applications of fundamental analysis to assess the value of listed companies can be found in many works.

Among others, in the article by Mrzygłód and Nowak [2013], fundamental analysis was used to assess the investment strength of the Warsaw Stock Exchange itself after the demutualization process. The authors presented the conclusions that in the years following the IPO [November 9, 2010] an improvement in the operating results of the WSE could be observed, which had an impact on investors' decisions.

Using the idea of a taxonomic measure of investment attractiveness [TMAI], Juszczyk [2015] in her work assessed the financial condition of companies from the food sector listed on the Warsaw Stock Exchange. The study was conducted from data from 2012. In addition, the author compared the TMAI values with the actual rates of return in the same period and showed a statistically significant, although weak, correlation between the average synthetic measures of investment attractiveness changing over time and the rates of return for the surveyed enterprises.

Empirical studies for companies listed on the Warsaw Stock Exchange using TMAI and BZW measures can be found in Tarczyński and Łuniewska's [2004b, 2006] papers, where the authors constructed investment portfolios, and in the article by Zielińska-Sitkiewicz [2015] article, which analysed the fundamental strength of food sector companies. In addition, the efficiency of Chinese banks was assessed using BZW and TMAI in the paper by Witkowska [2010].

The aim of the authors, Muhammad and Gohar [2018], was to examine the ability of historical accounting data to predict future twists and turns using

fundamental analysis. Data was collected for an eleven-year period from 2007 to 2017 for 115 non-financial companies listed on the Karachi Stock Exchange [KSE] in Pakistan. In the paper, four indicators from different areas were used, i.e. profitability ratios, liquidity ratios, leverage ratios and market-based ratios. For the purpose of the analysis, the authors used the penal data analysis [common effect model, fixed effect model, and random effect model]. The results indicated that the fundamental analysis can predict future stock returns in Pakistani listed companies.

In turn, Bintara, Wahyudi and Molina [2019] assessed the impact of selected financial ratios: Return On Assets (ROA), Current Ratio (CR), Debt to Equity Ratio (D/E), Price to Earnings Ratio (P/E) and Price to Book Value (P/B) per stock price. For the years 2012-2016, the authors examined banking companies that are included in the Kompas 100 index listed on the Indonesian Stock Exchange (IDX). Multiple regression tests were used as the analytical method to test the hypothesis. The results show that ROA and CR are positively related to the share price, but D/E affects the share price negatively. P/E is positively but insignificantly related to the share price and P/B has no effect on it.

In the article by the authors of Witkowska, Kuźnik [2019], a study was conducted on the impact of the company's fundamental strength on its investment performance. The analysis covered 27 non-financial companies listed on the Warsaw Stock Exchange, belonging to the WIG20 and mWIG40 portfolios. The results obtained by the authors for the years 2012-2017 indicated that the proposed synthetic TMAI measure makes it possible to estimate the fundamental strength of listed companies. In addition, a positive, but mostly statistically insignificant, correlation was found between the values of the constructed measure and the rates of return.

In the work of Tan, Wang, Xiong, Liu [2022], the authors attempted to examine the relationship between fundamentals and stock returns on Chinese stock markets. From 27 fundamental variables including: firms' basic information, valuations, profitability, operational efficiency, quality, inventory, sales expenses and growth, they selected 8 for the study: asset growth, return on assets, profit margin, earnings per share, gross profitability, leverage, current assets to net assets and current liabilities to total liabilities. The results of the analysis showed that fundamental factors and price factors are complementary in predicting future returns on stocks in the Chinese market. In turn, in the study of one-factor fundamental strategies, the one based on ROA turned out to be the most effective.

METHODOLOGY AND DATA

Seventeen listed companies from the construction materials industry sector, listed on the main market of the Warsaw Stock Exchange since at least 2010, whose activities are conducted mainly in Poland and whose profit and loss account is prepared in the calculation system, were selected for the study.

From the point of view of the nature of the business conducted by the analysed companies, they can be divided according to the following criteria:

- companies specializing in the production of interior finishing materials: Decora S.A., Ceramika NovaGala S.A., Ferro S.A., ES-System S.A., Lentex S.A., Pozbud S.A., Śnieżka S.A.;
- companies whose production focuses on prefabricated elements and products for the construction industry: Izolacja-Jarocin S.A., Izostal S.A., KBDom S.A., Lena Lighting S.A., Libet S.A., Mercor S.A., MFO S.A., Ropczyce S.A., Selena FM S.A., ULMA Construction S.A.

When analysing the data on sales revenues for all enterprises, it should be noted that from 2016 to 2021 they have been growing steadily, with different growth dynamics. The lowest increase in revenues was recorded in 2019/2018 and amounted to only 2.8%, and the highest in 2021/2020 and accounted for nearly 18%, despite the inclusion of a depleted group of 15 companies in 2021 [see table 1]. In the years of the 2021/2020 pandemic, the revenues of companies producing prefabricated elements and materials for the construction industry increased by 24.6%, and by companies on the interior finishing materials market by 7.6%.

Table 1. Sales revenues in thousands of PLN

	Sales Revenue					
COMPANY	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**
all	**7679489**	**6509195**	**6171670**	**6003806**	**5594936**	**5046265**
Ceramika Nowa Gala S.A.		87078	145825	150322	156609	170982
Decora S.A.	480585	370809	306290	277570	234745	208537
ES-System S.A.		171297	211056	191731	189699	182131
Ferro	830503	519090	451257	405571	364680	332490
FFiL Śnieżka S.A.	794863	821330	717082	586777	564481	575636
Izolacja-Jarocin S.A.	30523	26326	27681	27631	28764	22091
Izostal S.A.	795889	860051	770331	808128	563996	379878
Korporacja Budowlana Dom S.A.	14420	12610	12543	39467	120110	140218
Lena Lighting S.A.	148426	132728	118387	130289	137134	130483
Lentex S.A.	412233	372354	320840	477469	478677	488029
Libet S.A.	284475	250178	199967	177891	288206	284236
Mercor S.A.	386186	396066	370919	370919	318467	269498
MFO S.A.	990376	422481	437439	414303	366227	256080
Pozbud T&R S.A.	210916	193746	197009	130458	126097	167564
Ropczyce S.A.	361893	297673	329192	363588	277044	244106
Selena Fm S.A.	1728350	1384735	1326486	1227971	1178706	1013819
Ulma Construccion Polska S.A.	209851	190643	229366	223721	201294	180487

Source: self - elaboration based on financial statements of companies

The COVID-19 pandemic did not significantly slow down the construction sector in Poland and in the world, as shown in the annual reports of *The Global Powers of Construction* prepared by Deloitte, and the recorded increase in the revenues of the surveyed companies at that time was primarily influenced by significant increases in the prices of raw materials and materials. In 2021, the highest increase in revenues was generated by MFO S.A. (by 134.4%) and Ferro S.A. (by 59.9%) companies, and slight decreases were recorded by Izostal S.A. (by 7.5%), Śnieżka S.A. (by 3.2%) and Mercor S.A. (by 2.5%).

When examining the net financial result achieved by companies producing construction materials, it can be seen that the net profit for the entire group recorded the lowest level in 2017, and steadily increased in subsequent years. Companies on the interior finishing materials market in 2020 recorded a spectacular three-fold increase in the net profit (see table 2). This could have been a positive side effect of the Covid-19 pandemic, as research shows that in 2020 every fifth Pole decided to renovate their own flat. Compared to other surveyed companies, the following companies stand out positively: MFO S.A., Ferro S.A., Selena S.A., Izostal S.A., Decora S.A. and Śnieżka S.A., which in the years 2016-2021 systematically improved their financial results. In addition, it should be noted that the surveyed group of companies invests a significant part of its sales on foreign markets, achieving high revenues from exports.

Table 2. Net income/net loss in thousands of PLN

	Net Income / Net Loss					
COMPANY	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**
all	**648650**	**468453**	**254772**	**256701**	**104752**	**245847**
Ceramika Nowa Gala S.A.		2872	-103463	-21146	-5334	-8950
Decora S.A.	66686	56623	25282	20021	15037	13035
ES-System S.A.		-7422	7905	5608	7024	3290
Ferro	109569	62080	40000	37709	11064	29087
FFiL Śnieżka S.A.	64340	86194	62647	63389	56692	53930
Izolacja-Jarocin S.A.	1258	1663	688	810	1202	448
Izostal S.A.	19551	15177	13031	14473	9136	7093
Korporacja Budowlana Dom S.A.	-4992	-3031	-2589	-25661	-102418	-6540
Lena Lighting S.A.	9108	12277	6122	7246	10782	-11582
Lentex S.A.	40526	42773	21623	35144	41045	73953
Libet S.A.	-13423	-1637	17778	-30749	-21299	-6072
Mercor S.A.	29521	23363	15261	14817	11024	3795
MFO S.A.	132964	26953	25410	27901	20715	17774
Pozbud T&R S.A.	34435	28712	11829	6717	7621	6416
Ropczyce S.A.	31432	27559	27367	26765	11397	25029
Selena Fm S.A.	102697	74108	39680	26660	6839	32249
Ulma Construccion Polska S.A.	24978	20189	46201	46997	24225	12892

Source: self - elaboration based on financial statements of companies

All studied companies were subjected to a fundamental analysis. A group of nine financial indicators recommended by the literature [Łuniewska, Tarczyński, 2004a, 2006] was used for the construction of the synthetic Measure of Attractiveness of the Investment (TMAI) for companies in the building materials industry. They characterise the most important aspects of the company activity: profitability (*ROE, ROA, ROS*), liquidity (*CR*), efficiency *(ITR, LR, ATR, RTR*) and debt (*DR*).

Table 3 presents the formulas for calculating the selected indicators recommended in the paper by Tarczyński and Łuniewska [Łuniewska, Tarczyński, 2004a, 2006] and their impact on the general criterion.

Table 3. The selection of variables and their impact on the general criterion

Ratio	Formula	The impact on the general criterion
Return on Equity (*ROE*)	*Net Income / Shareholder Equity*	stimulant
Return on Assets (*ROA*)	*Net Income / Average Total Assets*	stimulant
Return on Sale (ROS)	*Net Income / Sales Revenue*	stimulant
Inventory Turnover Ratio (ITR)	*Net Sales / Average Inventory*	stimulant
Liabilities Ratio (*LR*)	*(Average Liabilities / Net Income)* * 365	stimulant
Asset Turnover Ratio (ATR)	*Net Sales Revenue / Average Total Assets*	stimulant
Receivable Turnover Ratio (*RTR*)	*Sales Revenue/ Average Receivables*	nominant (7 – 10)
Current Ratio (*CR*)	*Current Assets / Current Liabilities*	nominant (1.0 – 1.2)
Debt Ratio (*DR*)	*Total Liabilities / Total Assets*	nominant (57%-67%)

Source: self - elaboration based on papers by Tarczyński and Łuniewska [2006]

In the first stage of the study, all variables were transformed as part of the standardization process - formula (1) for determining the value of the TMAI measure.

$$z_{ij} = \frac{x_{ij} - \overline{x}_j}{S_j}, \tag{1}$$

$\overline{x}_j$ - mean for j-th variable

S_j - standard deviation for j-th variable

Due to the specificity of the variables, Current Ratio (*CR*), Debt Ratio (*DR*) and Receivable Turnover Ratio (*RTR*) were individually transformed from nominants into stimulants according to the formula:

$$x_{ij}^{s} = \frac{\min\left\{x_j^N ; x_{ij}^N\right\}}{\max\left\{x_j^N ; x_{ij}^N\right\}} \tag{2}$$

x_j^N - nominal level of *j-th* variable,

x_{ij}^N - value of *j-th* nominant in *i-th* object.

A detailed description of the criteria for normalization of variables and transformation of indicators into stimulants was presented in the works of Walesiak [2004, 2014] and Zielińska-Sitkiewicz [2017].

In the second stage of the study, according to the procedure described by Tarczyński and Łuniewska [2005, 2017], the Taxonomic Measure of Attractiveness of the Investment was determined for each analysed period 2016 – 2021, where the distance of each object is calculated from the pattern, taking into account the different influence power of the financial ratios on the analysed investment

attractiveness of the companies. The formula for calculating the distance from the pattern is as follows:

$$d_i = \sqrt{\sum_{j=1}^{m} w_j (z_{ij} - z_{0j})^2}, \qquad (i = 1,\ 2,\ldots,n), \tag{3}$$

z_{ij} - standardized value of the attribute *j* for the object *i*,

z_{0j} - maximum value of z_{ij} for the object *i*.

In the study, in order to identify possible differences in the rankings, it was decided to compare the synthetic measure of investment attractiveness - TMAI, calculated with the weights for the financial indicators, with the taxonomic measure BZW, calculated without the weights.

The weights for the financial indicators used were adopted in accordance with the expert method. The group of experts consisted of representatives from the accounting and financial professions. It was found that profitability ratios have the greatest impact on the assessment of the company's situation. This is followed by ratios related to the working capital. Indicators relating to balance sheet items that may result from one-time events, e.g. on December 31, have a relatively low information potential. According to the above findings, the following weights have been selected: profitability ratios *ROE, ROA* and *ROS* - weight of 0.2; liquidity ratio *CR* and debt ratio *DR* - weight of 0.1; efficiency ratios *ITR, LR, ATR, RTR* - weight of 0.05.

The following formula is used to determine the TMAI measure based on the given distance from the pattern:

$$TMAI_i = 1 - \frac{d_i}{d_0}, \qquad (i = 1,\ 2,\ldots,n), \tag{4}$$

$TMAI_i$ – synthetic measure for the object *i*,

d_i – distance between the object *i* and pattern object,

d_0 – norm assuring that $TMAI_i$ reaches values ranging from 0 to 1calculated according to the formula:

$$d_0 = \bar{d} + k \cdot S_d, \tag{5}$$

$\bar{d}$ – average value of d_i

S_d – standard deviation of d_i

and *k* is the constant determined as:

$$k \geq \frac{d_{i\max} - \bar{d}}{S_d}, \tag{6}$$

$d_{i\max}$ – is the maximum value of d_i.

The next stage of the work involved determining the BZW measure for the years 2016-2021. The same criteria were used to normalize the variables and transform the indicators into stimulants as in the TMAI calculation. However, the BZW calculation did not include weights for the financial indicators used. The following equation has been applied:

$$BZW_i = \frac{\sum_{j=1}^{k} z_{ij}}{\sum_{j=1}^{k} \max_{i} \left\{ z_{ij} \right\}}, \quad z_{ij} = x_{ij}^{*} + \left| \min_{i} \left\{ x_{ij}^{*} \right\} \right|, \tag{7}$$

x_{ij}^{*} – standardized value of the variable x_{ij}.

In the last stage, annual logarithmic rates of return were calculated, according to the formula:

$$R_{it} = \ln\left(\frac{y_{it}}{y_{it_0}} \right), \qquad (i = 1,\ 2, \ldots, n \quad t = 2016, ..., 2021), \tag{8}$$

y_{it}, y_{it_0} – share price quotations of i-the company on the last and first day of Warsaw Stock Exchange trading in t-the year.

RESULTS

Analysing both the TMAI and BZW rankings, it can be seen that in all analysed years, companies specializing in the production of interior finishing materials open the presented classifications, while companies producing prefabricated elements and materials for the construction industry tend to close them. The best companies include: Śnieżka S.A., Decora S.A., Ferro S.A and MFO S.A., and the weakest are represented by KBDom S.A., Libet S.A. and delisted Ceramika Nowa Gala S.A. (March 8, 2021) and ES-System S.A. (April 14, 2020).

In the 2016 – 2020 rankings, both delisted companies are in the final positions. Therefore, it was considered that this does not detract from the value of the overall analyses. The fact that the companies were delisted also provides a certain result in the fundamental strength analysis, and for the comparison of the company rankings in 2020 and 2021, the delisted companies can be assumed to occupy the final positions.

Śnieżka S.A. (manufacturer of paints and varnishes) is one of the leaders among all the analysed enterprises. The company owes its success to high profitability ratios: equity – over 20% and sales – over 11%. The return on the company's assets was above 13%, with the level of 2% to 6% required from the lenders' point of view. Among all companies in the sector, Śnieżka S.A. made the best use of its assets, did not involve excessive foreign capital in financing its operations, and achieved optimal, almost textbook values in the turnover of

receivables. However, the average values of annual rates of return place the company in the ninth position.

Table 4. Results of the TMAI measure of the studied companies for years 2016-2021

COMPANY	2021		2020		2019		2018		2017		2016		Average
Ceramika Nowa Gala S.A.	*	*	0.306	↑ 14	0.000	↓ 17	0.075	↓ 16	0.588	↑ 13	0.081	↓ 16	0.210
Decora S.A.	0.580	↓ 2	0.611	↑ 1	0.644	↑ 4	0.483	↑ 5	0.652	↓ 8	0.461	↑ 5	0.572
ES-System S.A.	*	*	*	*	0.608	↑ 10	0.319	↑ 14	0.562	15	0.222	↓ 14	0.428
Ferro	0.557	3	0.536	↑ 3	0.639	↓ 5	0.536	2	0.698	↑ 2	0.536	↑ 3	0.584
FFiL Śnieżka S.A.	0.473	↓ 4	0.552	↓ 2	0.672	1	0.557	1	0.701	↑ 1	0.618	↓ 2	0.595
Izolacja-Jarocin S.A.	0.344	↓ 13	0.385	↑ 10	0.594	↓ 13	0.413	↓ 9	0.654	↑ 7	0.326	11	0.453
Izostal S.A.	0.352	↑ 12	0.323	↓ 13	0.627	↑ 7	0.411	↓ 10	0.684	↑ 5	0.366	↑ 9	0.461
Korporacja Budowlana Dom S.A.	0.157	↑ 15	0.173	↓ 16	0.509	↓ 16	0.085	↑ 15	0.294	↓ 17	0.154	↓ 15	0.125
Lena Lighting S.A.	0.363	↓ 11	0.417	↑ 8	0.530	↓ 15	0.320	↑ 13	0.560	↑ 16	0.000	↓ 17	0.365
Lentex S.A.	0.383	↑ 8	0.416	↑ 9	0.567	↓ 14	0.411	↓ 11	0.619	↓ 10	0.526	↓ 4	0.487
Libet S.A.	0.165	↑ 14	0.212	↓ 15	0.619	↑ 9	0.000	↓ 17	0.579	14	0.233	↓ 13	0.301
Mercor S.A.	0.469	↑ 5	0.449	6	0.635	↑ 6	0.460	↓ 7	0.670	↑ 6	0.357	↓ 10	0.507
MFO S.A.	0.647	↑ 1	0.448	↓ 7	0.654	↑ 2	0.523	↑ 3	0.691	↓ 4	0.630	↑ 1	0.599
Pozbud T&R S.A.	0.421	↓ 7	0.450	↑ 5	0.606	↑ 11	0.391	↓ 12	0.634	↓ 9	0.382	↓ 8	0.481
Ropczyce S.A.	0.371	↑ 9	0.356	↑ 11	0.598	↓ 12	0.471	↑ 6	0.608	↓ 11	0.391	↓ 7	0.466
Selena Fm S.A.	0.469	↓ 6	0.465	↓ 4	0.651	↑ 3	0.431	↓ 8	0.692	↑ 3	0.419	↓ 6	0.521
Ulma Construccion Polska S.A.	0.369	↑ 10	0.340	↓ 12	0.622	↓ 8	0.501	↑ 4	0.588	↑ 12	0.279	↑ 12	0.450

Source: own calculation [* delisting of shares from the stock exchange]

Ferro S.A. (manufacturer of sanitary, installation and heating fittings) focuses on the development of sales through strong expansion and diversification of sales markets and product offer, while continuing to increase operational flexibility and effectively manage supply risk in order to constantly maximize profits and shareholder value. The implementation of this strategy was confirmed by high return on sales – over 13% and growing year by year: return on equity to 30% and return on assets to 18% in 2021. Reasonable use of external capital, proper turnover of receivables and inventories as well as optimal values of the liquidity ratio ensured the company a high position in the TMAI and BZW rankings and a good market rating in the classification of rates of return.

Decora S.A. (manufacturer of floors and floor accessories) in the years 2016-2021 achieved a growing return on sales oscillating from 7% to 17% and a growing return on assets from about 10% to 22%. The increase in the company's turnover to a large extent translated into an increase in profit from sales. In addition, the company was characterized by a low debt ratio, optimal current liquidity values and increasing return on assets, which translated into high positions in the rankings and the highest position in the classification of average rates of return.

MFO S.A. (manufacturer of steel profiles) is a company producing prefabricated elements and products for the construction industry, which occupies

the highest positions in all created rankings. It is present in fifty export markets. In the years 2016-2021, it strongly strengthened the return on sales ratios from 6% to 17%, return on equity from 14% to 31% and return on assets from 9% to 18%. Maintaining optimal liquidity, a relatively low debt ratio and a proper rotation of inventories and receivables allowed for a strong assessment of the company's fundamental strength.

Table 5. Results of the BZW measure of the studied companies for years 2016-2021

COMPANY	2021		2020		2019		2018		2017		2016		Average
Ceramika Nowa Gala S.A.	*	*	0.388	↑ 13	0.213	↓ 17	0.346	↓ 16	0.562	↑ 12	0.280	↑ 15	0.358
Decora S.A.	0.606	↓ 2	0.668	↑ 1	0.679	↑ 4	0.595	↑ 5	0.636	↓ 7	0.512	↑ 6	0.616
ES-System S.A.	*	*	*	*	0.592	↑ 11	0.390	↑ 13	0.485	↑ 16	0.267	↓ 16	0.410
Ferro	0.590	3	0.581	↑ 3	0.668	↓ 5	0.616	3	0.702	3	0.596	3	0.625
FFiL Śnieżka S.A.	0.539	↓ 5	0.605	↓ 2	0.731	1	0.674	1	0.726	1	0.712	1	0.664
Izolacja-Jarocin S.A.	0.412	↓ 11	0.452	↑ 9	0.602	↓ 10	0.532	↓ 9	0.636	↑ 6	0.419	↓ 12	0.509
Izostal S.A.	0.440	↓ 9	0.504	↓ 7	0.665	↓ 6	0.597	↓ 4	0.707	↑ 2	0.532	↑ 5	0.574
Korporacja Budowlana Dom S.A.	0.197	↑ 15	0.214	↓ 16	0.476	↓ 16	0.362	↑ 15	0.309	↓ 17	0.458	↓ 10	0.336
Lena Lighting S.A.	0.395	↓ 13	0.428	↑ 11	0.480	↓ 15	0.373	↑ 14	0.501	↑ 15	0.192	↓ 17	0.395
Lentex S.A.	0.424	10	0.436	↑ 10	0.505	↓ 14	0.482	11	0.582	↓ 11	0.544	↑ 4	0.496
Libet S.A.	0.337	14	0.375	↓ 14	0.618	↑ 9	0.323	↓ 17	0.606	↓ 10	0.459	↓ 9	0.453
Mercor S.A.	0.509	6	0.524	↑ 6	0.628	8	0.554	8	0.628	↑ 8	0.446	↓ 11	0.548
MFO S.A.	0.694	↑ 1	0.545	↓ 5	0.701	2	0.645	↑ 2	0.699	↓ 4	0.686	2	0.662
Pozbud T&R S.A.	0.472	↑ 7	0.504	↑ 8	0.588	12	0.462	↓ 12	0.627	↓ 9	0.503	↓ 7	0.526
Ropczyce S.A.	0.399	↑ 12	0.360	↓ 15	0.557	↓ 13	0.514	↑ 10	0.544	14	0.375	↓ 13	0.458
Selena Fm S.A.	0.545	4	0.557	↓ 4	0.680	↑ 3	0.562	↓ 7	0.680	↑ 5	0.485	↓ 8	0.585
Ulma Construccion Polska S.A.	0.464	↑ 8	0.420	↓ 12	0.638	↓ 7	0.586	↑ 6	0.554	↑ 13	0.341	↑ 14	0.501

Source: own calculation (* delisting of shares from the stock exchange)

Decisive for Selena FM S.A.'s (distributor of construction chemicals) high position in the enterprise rankings was the proper management of the company's assets, as indicated by the receivables, liabilities and inventories turnover ratios. The increase in the value of the asset turnover ratio in 2016-2021 indicated the desired increase in sales per asset unit. Also noteworthy is the growing return on sales in the analysed period, which means that each zloty of the company's revenue resulted in a higher and higher profit**.**

KBDom S.A. is the only company among the surveyed ones that in all surveyed years incurred losses and occupies the last place in the rankings. Until 2012, the company focused a significant part of its business on housing construction, where it suffered extremely high losses. In 2013, the company changed its business profile towards the production of concrete prefabricated elements, which resulted in a temporary improvement in the company's financial results. Analysing the financial statements of this company for the years 2016-2021, it can be concluded that the company had very big problems with paying off its liabilities, which could have been

a consequence of excessive crediting to its own customers and freezing of funds in inventories. This is confirmed by the lowest inventory turnover ratio in the group of surveyed companies and the highest payables turnover ratio, with their untimely repayment. Problems with liquidity and the lack of timely publication of financial statements were the reason for suspending the company's share quotations in 2018, 2019 and 2021. The quotations were permanently suspended on December 1, 2021, and on May 25, 2022, the company was declared bankrupt.

Libet S.A. (manufacturer of paving stones and other concrete elements of the environment arrangement), with low profitability on sales, incurred losses in five years of the analysis (see table 2), which resulted in negative results of indicators based on the financial result and an unfavourable position in the rankings. A high level of debt ratio may suggest that the company has had difficulty repaying its debt. The other surveyed indicators also assume values close to the negative ones. The company explained its problems with the dynamic changes taking place in the macroeconomic environment at the turn of 2018-2019, but the company is constantly trying to rebuild its market and liquidity position. The increase in sales revenues was positively influenced by the company's acquisition of new customers in stable distribution channels and temporary changes in consumer behaviour resulting from the COVID-19 pandemic, especially the increased interest in the company's products during the spring lockdown.

Ceramika Nowa Gala S.A. (former manufacturer of wall and floor tiles, acquired by Cerrad) and ES-System S.A. (manufacturer of lighting fittings, part of the Norwegian Glamox Group since December 2019) recorded low positions in the rankings in the audited years, which were the results of deteriorating profitability ratios, high levels of receivables [freezing of cash] and extended repayment periods. Both companies also felt the negative effects of the situation in Ukraine and Russia, where they exported part of their products.

The convergence of rankings and investment performance of companies was measured with the Spearman's rank correlation coefficient and the significance of the correlation was examined. The values of Spearman's rank correlation coefficients and the results of the verification of hypotheses are presented in Table 7. Based on the obtained results, it can be concluded that the convergence of the rankings constructed on the values of both TMAI and BZW measures is high and statistically significant for all the years studied. Conversely, the correlation between the fundamental strength of the company, as measured using the TMAI, and its investment performance is positive and statistically significant for 2016, 2018 and 2021. Only the BZW measure is negatively correlated with stock market return rank in 2020. For the other years, the correlations BZW with rates of return show the same direction of dependence but are mostly not statistically significant, except for the results for 2018 and 2021.

Table 6. Results of the logarithmic annual rate of return [%] for the years 2016–2021

COMPANY	2021	2020	2019	2018	2017	2016	Average
Ceramika Nowa Gala S.A.	*	26,44	38,57	-129,75	45,59	-2,53	-4,34
Decora S.A.	7,96	48,91	22,12	38,74	7,11	23,53	24,73
ES-System S.A.	*	*	45,86	-21,36	3,52	-9,17	4,71
Ferro	28,67	50,42	13,83	-17,15	33,00	19,56	21,39
FFiL Śnieżka S.A.	-15,94	8,80	5,64	-0,64	21,98	6,57	4,40
Izolacja-Jarocin S.A.	23,80	36,62	-10,92	-15,00	33,55	20,48	14,76
Izostal S.A.	-6,02	-1,50	-7,05	-62,29	-7,03	22,18	-10,28
Korporacja Budowlana Dom S.A.	-48,84	20,31	-35,34	-171,05	-28,09	1,75	-43,54
Lena Lighting S.A.	12,14	10,97	25,13	-58,31	18,10	-6,72	0,22
Lentex S.A.	-16,91	41,60	2,42	-7,80	-26,92	18,72	1,85
Libet S.A.	-25,49	143,12	-77,32	-47,52	36,29	-34,83	-0,96
Mercor S.A.	33,71	16,28	14,44	-31,58	4,01	20,31	9,53
MFO S.A.	63,39	7,19	7,04	-42,65	24,17	78,44	22,93
Pozbud T&R S.A.	53,53	31,14	-26,28	-55,42	19,57	-50,05	-4,59
Ropczyce S.A.	32,87	9,45	-43,70	28,97	24,60	-10,52	6,94
Selena Fm S.A.	26,03	9,59	58,91	-73,37	-11,44	34,48	7,36
Ulma Construccion Polska S.A.	30,60	-13,28	-20,88	-6,11	2,86	-12,42	-3,20

Source: own calculation [* delisting of shares from the stock exchange]

Statistically significant are the correlations between both phenomena, observed for the entire analysis period, both for TMAI and rates of return, as well as BZW and rates of return.

Table 7. Relations between TMAI and BZW and **rates** of **return**

	2021	2020	2019	2018	2017	2016	Average
	Spearman's rank correlation coefficient						
TMAI and BZW	0,9286	0,8853	0,9779	0,9240	0,9375	0,8186	0,9289
t-statistics	9,6896	7,3731	18,1326	9,3599	10,5484	6,6083	9,7162
p-value	7,55E-08	2,32E-06	1,30E-11	1,18E-07	2,46E-08	8,32E-06	7,29E-08
	Spearman's rank correlation coefficient						
TMAI and rofr	0,5143	0,0662	0,2181	0,6324	0,1005	0,5074	0,6863
t-statistics	2,3225	0,2569	0,8657	3,1614	0,3912	2,2802	3,6543
p-value	0,0347	0,8008	0,4003	0,0065	0,7012	0,0376	0,0023
	Spearman's rank correlation coefficient						
BZW and rofr	0,7143	-0,1809	0,1225	0,4951	0,2451	0,2451	0,5784
t-statistics	3,9528	-0,7123	0,4782	2,2070	0,9791	0,9791	2,7463
p-value	0,0013	0,2436	0,6394	0,0433	0,3430	0,3480	0,0150

Source: own calculation

The correctness of the classification of companies producing building materials in the rankings obtained as a result of the application of the TMAI method, verified by an expert analysis of financial statements, is relatively slightly higher than as a result of using the BZW measure. The team of experts assessed the financial

ratios of profitability, liquidity, efficiency and debt, as well as the cash flow statement, and consisted of accountants from listed companies not included in the analysis. The weights used for the financial ratios in the TMAI construction were also reviewed and confirmed. Furthermore, it can be concluded that the TMAI rankings tend to show a slightly stronger correlation with the order of the companies according to their stock market returns than the BZW rankings, which also confirms the effectiveness of this approach.

CONCLUSION

The paper presents the results of rankings built for seventeen companies from the construction materials industry, based on selected nine most important financial indicators describing the condition of enterprises. Taxonomic measures TMAI and BZW, which measure the fundamental strength of companies, were used as a research method. The obtained classifications were compared with the investment results of the surveyed companies, measured by the logarithmic annual rate of return.

The obtained results indicate that in all cases [except one - with BZW measure] the correlation between taxonomic measures and logarithmic rates of return is positive. However, statistically significant relationships between the values of TMAI and BZW and the rates of return on shares of the analysed companies are observed only for the entire study period 2016-2021 and for 2018 and 2021 for current relations.

The statement that the fundamental strength of companies affects their investment performance seems to be confirmed, although the study also shows that there are other factors affecting the rates of return of the shares of the analysed companies. Moreover, for data from individual years, the correlation between the two phenomena is usually not very strong. In addition, a slightly better convergence of the investment efficiency, as measured by the rate of return on shares, with the assessment of the fundamental strength of the companies studied, calculated with the TMAI algorithm, than with the BZW has been demonstrated.

The obtained results are consistent with the research in the works of Juszczyk [2015] and Witkowska, Kuźnik [2019], although it should be taken into account that in the analysis carried out, a different group of enterprises was used for the construction of taxonomic measures, a different time horizon was considered and a slightly different set of variables.

It should be emphasized that synthetic taxonomic measures make it possible to measure the company's fundamental strength and to build rankings of companies with a similar asset structure within the analysed group, from the point of view of assessing the level of financial condition and investment attractiveness of the surveyed companies. The results of the research presented in this article confirm the validity of the use of multidimensional comparative analysis methods in the analysis of the capital markets.

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PREDISPOSITIONS TO THE DEVELOPMENT OF ELECTROMOBILITY IN SELECTED CITIES IN POLAND

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Abstract: Without a doubt, the issue of electromobility is as important as it is complex. All the more so because, on the one hand, there are limitations and obstacles to its development on many levels, and on the other hand, especially in the current political and economic situation in the national and international arena, this solution has a huge potential to alleviate the effects of the crisis. The complexity of the issue of electromobility entails the need to look for new, supporting solutions and research, such as the multidimensional comparative analysis method carried out in this work, which, based on the results of expert research, allowed to determine indicators that influence the development of electromobility strategies in cities.

Keywords: electromobility strategy, sustainable development, Hellwig's method

JEL classification: C15, Q56, R41

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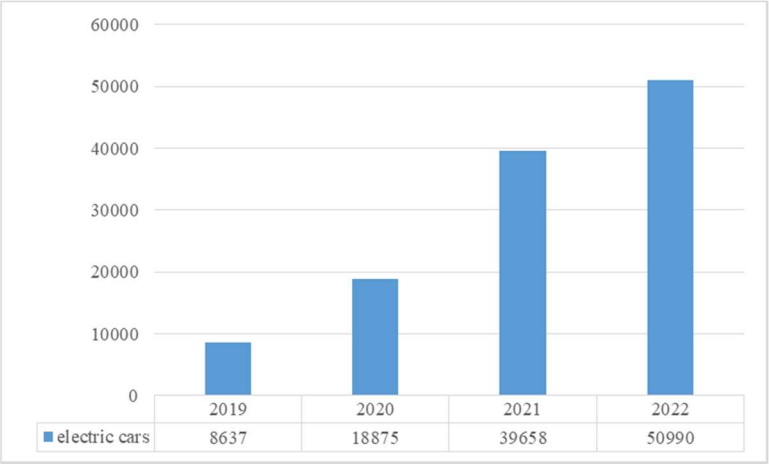
INTRODUCTION

The development of electromobility in Poland is increasingly accelerating, which is reflected in the growing sales of electric vehicles. According to data from the end of December 2021, a total of 39,658 passenger and commercial cars with electric drive were registered in Poland. In 2021, the electric cars park more than doubled (by 101% y/y). The upward trend also continues in 2022: at the end of the second quarter, the fleet of electric cars had grown to 50,990 units - 45% more than in the same period in 2021 [Morgan 2022].

A quantitative summary of the electric car market in Poland in 2019-2022 is shown in Figure 1.

Figure 1. Number of electric cars in Poland in years 2019 – 2022



Source: own research based on [ACEA 2023]

The condition for further development of the fleet of electric cars is the expansion of the charging infrastructure. As of the end of 2021, there were 1,932 publicly available electric

vehicle charging stations in Poland (3,784 points). 30% of them were direct current (DC) fast charging stations, and 70% - slow alternating current (AC) chargers with a power of less than or equal to 22 kW [International Renewable Energy Agency 2022].

The year 2022 was another year in a row full of challenges. War in Ukraine, disruptions to global supply chains, rising prices of key raw materials, galloping inflation and the risk of a return of the COVID-19 pandemic. Limited supply in the automotive sector caused by, among others, shortage of semiconductors or the COVID-19 pandemic did not stop the very dynamic development of electromobility in 2022.

Many markets saw a record number of registrations of electric cars with significant declines in sales of combustion vehicles. In 2022, the number of registered electric passenger cars in the European Union countries was approximately 3.2 million and in the world 10.5 million [IEA 2022]. Zero-emission transport has been recognized by the EU institutions as one of the priorities as part of the economic recovery after the COVID-19 pandemic.

As a result, electromobility on the European market is developing very dynamically, and in these specific conditions, electromobility in Poland is developing unexpectedly well.

The aim of the article is to analyze the predispositions of cities in Poland to develop electromobility. The research includes the analysis of predispositions using the method of multidimensional comparative analysis, based on the results of our own expert research.

The article contains an introduction, a review of the literature, a discussion of research methods and results, as well as a discussion and conclusions. Detailed results are presented for electric cars in selected cities in Poland.

LITERATURE REVIEW

In accordance with the nomenclature presented in literature, it is postulated that one of the possible measures of the level of electromobility is the number of electric and hybrid cars registered in a given area. Authors [Bartłomiejczyk, Kołacz 2020], [Połom 2021] and [Fernández 2021] note that the introduction of electric cars is the main sign of the development of electromobility and sustainable transport in cities.

Authors [Habib, et al. 2020] and [Kimbrell 2021] write about the electrification of the transport sector as a determinant for reducing direct greenhouse gas emissions and the burden of fossil fuels. Authors [Benveniste et al. 2018] and [Frenzel et al. 2011] point out that the share in the market of electric and hybrid vehicles is growing with the development of electromobility. The experience of other countries, such as Norway and France, with the implementation of electromobility, understood as a high rate of registered electric vehicles, is described by [Holden et al. 2020].

The electromobility strategy should therefore be understood as creating conditions for the development of electromobility in cities, through the adaptation of existing infrastructure and other adjustment activities aimed at improving its functioning and developing the market for low-emission vehicles in private and public transport. It is expected that as a result of the implementation of the electromobility, there will be a partial reduction in the emissions of harmful substances and noise generated by communication in cities. In the long run, this will improve the quality of life, including the health of residents and the natural environment.

The literature review and considerations made it possible to clarify the scope of the empirical study. Therefore, the electromobility examined in this work concerns the market of low-

emission cars (electric and hybrid). The study omitted low-emission buses and elements of micromobility in cities, such as public bicycles, scooters and scooters, which will be subject to further research.

DATA AND METHODS

Methods of multidimensional comparative analysis enable comprehensive research on various complex phenomena, thus creating the possibility of a broad and objective view of these phenomena. In Poland, Hellwig [Hellwig 1968] made the first attempt to describe complex phenomena using a synthetic feature. An important issue when building a ranking due to the level of complexity of the phenomenon is the choice of ordering method.

At the beginning of the analysis, the nature of each variable taken into account should be determined. It is necessary to determine whether "large" values of a variable have a beneficial impact on the examined issues (such variables are called stimulants) or whether small values favor development (then such a variable is a destimulant.

A description of the properties of methods and more important normalization formulas was provided by, among others authors [Borys 1978, Grabiński 1984 and Abrahamowicz 1985]. The latter work suggests that the choice of normalization formula should be combined with the choice of aggregation formula.

Analyzes presented in the literature show that the best formal properties have: the classic standardization method and the unitarization method, in which the distance of a given value from the observed "worst" value is divided by the range. This second method also satisfies the non-negativity condition postulated by some authors. Normalization follows the formulas:

For stimulant:

$$x'ij = \frac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}}, \quad (1)$$

For destimulant:

$$x'ij = \frac{\max\{x_{ij}\} - x_{ij}}{\max\{x_{ij}\} - \min\{x_{ij}\}}, \quad (2)$$

where:

- i - object number
- j – feature number
- $\max\{x_{ij}\}$ and $\min\{x_{ij}\}$ we are looking for a given feature in a set of objects.

In particular, in linear ordering methods based on a synthetic variable, an important step is the standardization of diagnostic features and the method of constructing the synthetic variable.

In the article, it was decided to use an aggregate measure, which provides for the calculation of the arithmetic mean of diagnostic variables, which were made comparable through unitarization, and expressing this mean on a point scale in the range <0;100>.

Therefore, the formula for the aggregate measure takes the form:

$$W_i = \frac{100}{m} \sum_{j=1}^{m} \alpha_i \cdot x'_{ij}. \quad (3)$$

where:

- m- number of features (criteria) taken into account
- α_i – weight of the i-th feature (criterion)

The reasons why in this article it was decided to use the previously presented procedure for obtaining an aggregate measure using the linear ordering method:

- unitarization in the postulated form and averaging using the arithmetic mean are methods to which there are no formal reservations,
- they meet a number of detailed conditions for synthetic measures [Abrahamowicz 1985],
- the weights obtained by experts (on a scale of 1-5) regarding the impact of a given criterion were averaged,
- the proposed measure combines the features of a non-standard and standard measure. Averaging normalized values is an approach typical of patternless procedures. On the other hand, the adopted method of normalization and aggregation is to calculate the urban distance from the "anti-pattern", averaged over one feature,
- the superiority of the recommended measure over the most popular Hellwig measure in Polish literature [Hellwig 1968] results from the fact that the postulated indicator is strictly normalized in the range <0;100>, while the Hellwig measure can assume negative values.

RESULTS

An ordered set of sustainable urban mobility indicators that have been identified by experts in the field of electromobility as having the greatest impact on the number of electric cars, along with information on whether it is a stimulant or destimulant and the average weight obtained from the experts, are presented in table 1.

From the Arthur D. Little Urban Mobility Index 3.0 indicator database [Little 2018], experts in the field of electromobility, both practitioners - car manufacturers, city authorities, electricity distributors in Poland, and theoreticians publishing in the field of electromobility - were asked to have a broad view of the examined problem. The experts task was to

indicate the variables that, in their opinion, have a significant impact on the possibility of developing electromobility, i.e. the predispositions of cities to its development. 15 experts responded, the results are presented in the table 1.

Table 1. Determining the weights and nature of selected indicators

Indicator	Stimulant	Distimulant	Weight
Monthly salary per inhabitant	x		5
Number of charging stations in relation to the city area	x		5
Diesel price	x		3
Average annual value of PM2.5 concentration	x		3
Energy price per inhabitant		x	4
Dedicated bus lane in km in relation to the city area	x		5

Source: own research

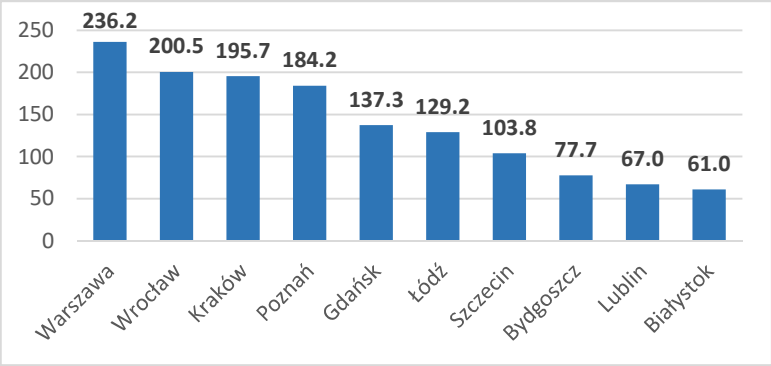
Analyzing Table 1, it can be seen that one of indicators was adopted as destimulatory - desired values in a decreasing direction, and the remaining five as stimulants. Determining the nature of the variables and the average rating given by the experts was used to conduct further analyses. The set of indicators obtained in the expert study became the basis for determining the rankings of the examined cities in the analyzed time period using the linear ordering method.

The prepared rankings concern the predispositions for the development of electromobility in individual cities due to the number of low-emission cars in use over the years 2017-2021. The positioning results are presented in Figures 2 - 6.

Taking into account all the separate indicators of sustainable urban mobility for the development of the low-

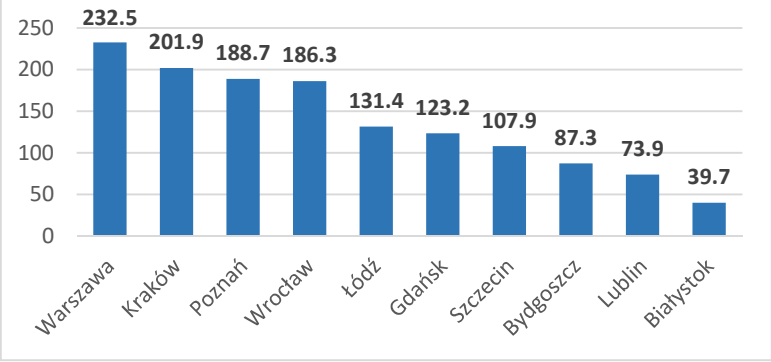
emission car transport subsystem, in 2017 the highest measures are taken by the largest cities in Poland, i.e., Warsaw, Wrocław, Kraków, and vice versa, the lowest can be observed for those with the smallest ones.

Figure 2. Predispositions for the development of electromobility in selected cities in Poland – results for 2017



Source: own research

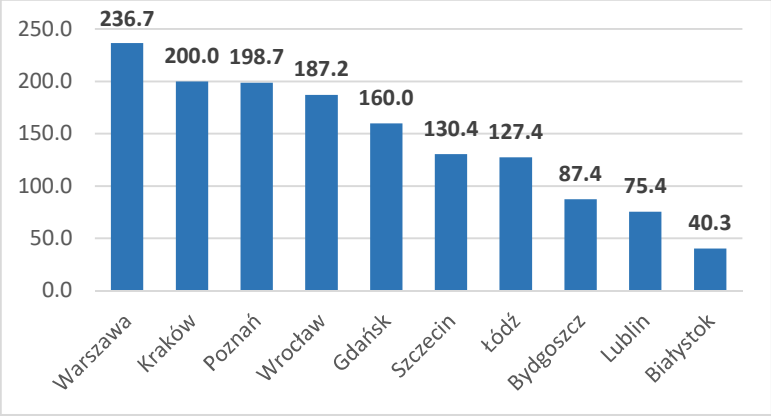
Figure 3. Predispositions for the development of electromobility in selected cities in Poland – results for 2018



Source: own research

In 2018, behind Warsaw, which takes first place every year, we can see growing conditions for the development of electromobility strategies in Krakow and Poznań, which may result from the growing awareness of its positive impact among both city authorities and residents.

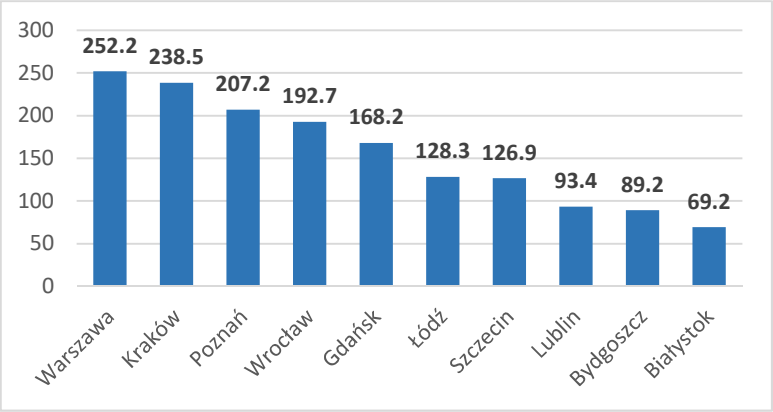
Figure 4. Predispositions for the development of electromobility in selected cities in Poland – results for 2019



Source: own research

The same trend for the surveyed cities continued in 2019.

Figure 5. Predispositions for the development of electromobility in selected cities in Poland – results for 2020



Source: own research

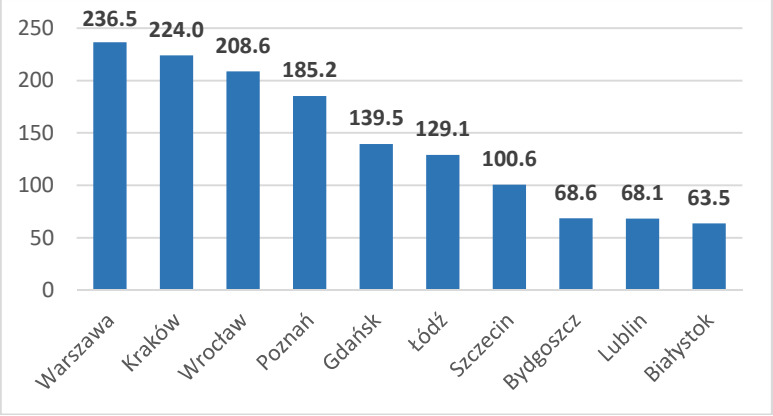
The year 2020 was marked by the fight against the COVID-19 pandemic, which not only significantly hampered the everyday life of city residents and limited access to a number of services. On the one hand, there was a decline in income with a simultaneous increase in expenses, including: provision of public services, expenditure on health care or education. The pandemic also changed residents perception of urban space.

Functioning in an environment full of restrictions related to COVID-19: restrictions on the operation of educational institutions, cultural institutions and services as well as the change to remote working in many enterprises had an impact on the change in the lifestyle and activity of residents in urban space. Access to green areas turned out to be important from the point of view of residents' health, and travel difficulties meant that public spaces were perceived as places that should be attractive and encourage people to spend free time and relax. Residents of large cities began to attach more importance to the

environment in which they live. It has been noticed that low-emission transport can impact comfort and improve the quality of life.

Analyzing the results obtained for the last analyzed year, it is possible to confirm the correlation between the city size and the predisposition to develop an electromobility, which may result from many aspects. In urban agglomerations, the occurrence of increased concentrations of pollution related to transport has been observed for many years. An opportunity to improve the situation is created, among others, by the development of the low-emission vehicle market, and the awareness of residents is increasing in this respect.

Figure 6. Predispositions for the development of electromobility in selected cities in Poland – results for 2021



Source: own research

The development of the electromobility is also closely related to the availability of charging points for electric cars and encouraging solutions, such as a dedicated bus lane on which electric cars can move without any obstacles, and in the largest cities there is the largest number of them. A higher

monthly salary may influence the purchase of more low-emission cars, the price of which is still higher than a combustion car, which in the case of cities with lower wages may constitute a significant barrier to development.

CONCLUSIONS

Undoubtedly, the subject of electromobility is extremely interesting in terms of the potential for scientific exploration and practical implementation. At the same time, it is a very complex, current and multidimensional issue. The proenvironmental approach to city management redefines the traditional approach, forcing the implementation and support of solutions that reduce external costs, especially carbon dioxide emissions. The concept of electromobility seems to be such a solution. It should be noted that the environmental factor should become an important variable supporting the development of the electromobility market in cities in Poland, like in the global trends.

Comparing the ranking results is not only an instrument for measuring progress in Polish cities efforts to develop electromobility, but also allows for assessing the progress of implementing investments, activities and goals over time. The ranking may therefore become a helpful tool in determining the goals of further development of cities electromobility. An indicator providing analytical and synthetic information about the position of a specific city compared to other cities in terms of predispositions to the development of electromobility, can support and inspire changes in the way the city is managed in accordance with the principles of sustainable development.

What is new and a contribution to the development of the discipline is the use experts answers in the development of electromobility and the assessment of cities in Poland in the implementation of their development. The originality of the

considerations and their novelty lies in the use of expert knowledge to assess the predispositions of cities to the development of electromobility. Until now, issues have not been presented in this way. Identifying predispositions can have practical implications, particularly in a governance context, providing guidance particularly for local authorities. Understanding the factors of electromobility development according to their stimulants and destimulants may constitute the basis for further future activities and their extension to other areas related to transport. The main limitation of the study is that only individual motorization was taken into account. This approach results from the fact that this is a preliminary study examining the predispositions of individual electromobility in cities and the destimulant and stimulant indications were indicated as the first step in the study. This is a major limitation, but subsequent research and research considerations will include further types of transport and considerations to show a holistic view of the subject.

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QUANTITATIVE METHODS IN ECONOMICS
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DIFFERENCES IN AMOUNTS OF SAVING GENERATED BY SELECTED EUROPEAN COUNTRIES

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Abstract: The aim of the paper is to estimate – for twenty-four selected European countries – the influence of the deviations of two factors on the deviation of annual gross national saving per capita. In order to do so, causal analysis has been conducted. The amount of annual gross national disposable income per capita and the average propensity to save have been adopted as the variables affecting the value of saving per capita. Three research hypotheses have been verified in this paper. Data concerning 2021 and 2022 have been used for calculations.

Keywords: saving per capita, income per capita, propensity to save

JEL classification: C65, E21, O11

INTRODUCTION

Saving is regarded by economists as one of the foundations of economic growth and development. Research tasks associated with saving can be considered in the micro-, meso- and macroeconomic dimensions, as well as at the global level. Saving is – to a larger or smaller extent – the subject of interest of many scientific disciplines, which investigate this matter from various perspectives [Alam et al. 2023; Costa-Font et al. 2018; Heckman, Hanna 2015; Rudzinska-Wojciechowska 2017]. The issue of saving is particularly important for governments and economic policymakers. Problems related to saving also have a special place in the field of practical and theoretical economics and finance.

Saving is called a flow variable because it is measured per unit of time. In contrast, savings are a stock variable and – as such – defined at a point in time. It can be said that the flow of saving equals the rate of change in the stock of savings.

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In deciding how much to consume and save, a household must weigh the benefits of enjoying more consumption today against the benefits of putting aside some of its income as saving for the future. In making this trade-off, households must take into account their expectations about the future of the economy, including expectations about government policy.

In general, the value of saving in any country is the country's current income minus its spending on current needs. From the point of view of the economy as a whole, the importance of national saving is that it provides the funds needed for investment. Investment, in turn, is critical in increasing average labor productivity and then improving living standards [Frank, Bernanke 2013]. If an economy is to grow, it must invest, and funds for investment come from saving. But to raise standards of living over time, an economy must devote some fraction of its current output to increase future output. McConnell and others [2012] aptly point out that increased saving can only come at the price of reduced current consumption.

Investment can be financed either by domestic saving or funds from savers abroad [Colander 2013]. If capital were perfectly mobile, changes in domestic investment would be independent of changes in domestic saving [Feldstein, Horioka 1980]. However, Rodrik [2000] stresses that in practice, foreign capital flows can serve only to a limited extent as a substitute for domestic saving. Excessive reliance on foreign saving, he argues, would imply running a persistent current account deficit. Moreover, if national saving is not sufficient to meet the investment needs of enterprises and to finance the budget deficit, the economy becomes increasingly dependent on foreign investors, which poses significant risks. Furthermore, there is no certainty that foreigners would not, at some point, refuse to lend more money.

It is also worth adding that national saving is one of the automatic stabilizers that protect economies from extremes of business cycles, in particular from recession and inflation. Slavin [2011] notes that saving, as an automatic stabilizer, can help the economy to cruise along fairly smoothly during severe economic turbulences.

AIM OF THE PAPER AND HYPOTHESES

The aim of this study is to determine the influence of specific factors on the diversity of selected[1] European countries in terms of the scale of annual national saving per capita. The article will analyze two factors affecting the value of gross

[1] Eurostat data regarding the value of gross national saving in 2021 and 2022 are available for twenty-four countries. These countries are as follows: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden.

national saving per person[2], namely gross national disposable income per capita[3] and the share of saving in income. The first factor measures the wealth of a given country, and the latter represents the average propensity to save in the economy of the examined country [Turczak 2017]. Mean values for a group of twenty-four European countries have been adopted as the basis for all comparisons.

Three research hypotheses have been formulated in this paper. The first one states that European countries achieving a level of saving per capita higher than the mean are also characterized by a higher level of income per capita. This means that among the discussed countries, there will not be any country capable of generating higher saving per person than average, despite the fact that such a country is relatively poor compared to other European countries.

According to the second research hypothesis, the fact that a given European country has a level of saving per capita above the average is mainly affected by its wealth, and the second factor – the propensity to save – is of less influence.

The third research hypothesis claims that the wealthiest European countries, with income per capita considerably higher (i.e. at least 40% higher[4]) than the average, also have a larger propensity to save than the average in the set of twenty-four countries taken together. This hypothesis will be considered true when none of the analyzed economies has income per capita at least 1.4 times higher and, at the same time, a smaller propensity to save than the average in the whole group of discussed countries.

METHODOLOGY USED

In order to establish appropriate ratio equality, it was assumed that the examined variable, denoted as a (annual gross national saving per capita), can be presented as the product of two factors, b (annual gross national disposable income per capita) and c (the quotient of saving and income). The mean value of variable a for the group of twenty-four countries considered in this study will serve as the reference point and shall be marked as $\bar{a}$. In turn, the value of this variable computed for the i-th economy will be denoted as a_i. Since a_i can be expressed as $b_i \cdot c_i$ and $\bar{a}$ as $\bar{b} \cdot \bar{c}$, when dividing a_i by $\bar{a}$, the obtained result is:

[2] Further in this paper terms ‘gross national saving’, ‘national saving’ and ‘saving’ will be used interchangeably.

[3] Further in this paper terms ‘gross national disposable income’, ‘national income’ and ‘income’ will be used interchangeably.

[4] The decision was made to set a ceiling of 40% in order to ensure that this hypothesis would not be applicable solely to the three countries with the highest deviation in income per capita from the average (i.e., Luxembourg, Ireland, and Denmark). Selecting the 40% threshold allowed for the inclusion of an expanded set of five countries in the considered category, thereby also categorizing Sweden and the Netherlands among the wealthiest European nations.

$$A_i = B_i \cdot C_i, \quad (1)$$

where $A_i = \frac{a_i}{\bar{a}}$, $B_i = \frac{b_i}{\bar{b}}$, and $C_i = \frac{c_i}{\bar{c}}$.

Taking the logarithms[5] of both sides of equation (1), the following expression can be obtained:

$$1 = \log_{A_i} B_i + \log_{A_i} C_i, A_i \neq 1. \quad (2)$$

The final step is to multiply both sides of equation (2) by the deviation $\Delta_i = a_i - \bar{a}$ calculated for the *i*-th country. This results in the equation:

$$\Delta_i = \Delta_i \cdot \log_{A_i} B_i + \Delta_i \cdot \log_{A_i} C_i, \quad (3)$$

where:

$\Delta_i \cdot \log_{A_i} B_i$ – the deviation of the *a* variable caused by the deviation of the *b* factor,

$\Delta_i \cdot \log_{A_i} C_i$ – the deviation of the *a* variable caused by the deviation of the *c* factor.

The methodological procedure proposed in the paper has a broad range of applications and is valuable for researchers across various fields. Specifically, it can be beneficial for those involved in comparative studies and causal analysis. Decomposing the deviations in annual gross national savings per capita using the logarithmic method and categorizing countries into four groups based on the obtained results is the author's original concept.

RESULTS

Comparing the gross national saving per capita

The first task is to assess the scale of saving per capita in each of the studied countries in relation to the mean value calculated for the group of twenty-four European countries taken together. Table 1 contains results of the relevant calculations.

Table 1. Annual gross national saving per capita (in euro per person)

Country	2021	2022
Ireland	31 860	34 488
Denmark	19 347	24 109
Luxembourg	25 744	23 226
Sweden	16 900	17 856
Netherlands	16 732	16 513
Austria	12 876	13 683
Germany	13 480	13 622
Belgium	11 482	11 998
Finland	11 191	11 769
Mean (24)	9548	10 002
Malta	8254	8891
France	8647	8729
Estonia	7225	7635
Czechia	6329	7107
Slovenia	6301	6639
Spain	5762	6226
Lithuania	4182	5070
Hungary	4247	4592
Portugal	4095	4500
Croatia	3661	4384
Latvia	3686	4023
Poland	3204	3750
Cyprus	2927	3296
Slovakia	3640	3191
Bulgaria	2101	2830

Source: own computation based on Eurostat database (access: 12.10.2023)

[5] The logarithm with the base A_i was taken.

The highest value of saving per capita of all the studied countries has been observed in Ireland – in 2021, saving per capita in Ireland was 3.3 times (in 2022 – 3.4 times) higher than the mean value obtained for the whole group of countries. The lowest saving per person was recorded in Bulgaria – in 2021, the value of this variable in Bulgaria equaled only 22% of the European mean (in 2022 – 28%).

Poland generated less saving in relation to the number of its inhabitants than it was on average in the set of twenty-four European countries selected for the study. In 2021, the annual saving per capita in Poland amounted to 3204 euro (in 2022 – 3750 euro) and that was approximately 1/3 of the European mean.

Comparing the gross national disposable income per capita

The second task carried out is the evaluation of the gross national disposable income per capita in each of the analyzed countries against the mean value computed for the whole group of them. The calculation results are listed in Table 2.

Table 2. Annual gross national disposable income per capita (in euro per person)

Country	2021	2022
Luxembourg	79 412	80 189
Ireland	63 277	69 841
Denmark	59 940	66 036
Sweden	52 863	54 607
Netherlands	50 075	53 299
Austria	45 296	49 088
Finland	45 460	48 290
Germany	44 519	47 396
Belgium	43 126	47 161
France	37 073	38 781
Mean (24)	34 393	37 131
Malta	26 259	28 717
Spain	25 726	28 011
Slovenia	24 054	27 245
Cyprus	24 069	26 995
Estonia	23 228	26 199
Czechia	21 483	24 417
Portugal	21 233	23 533
Lithuania	19 367	22 797
Latvia	17 613	20 581
Slovakia	17 985	19 766
Croatia	15 405	18 053
Hungary	15 214	16 972
Poland	14 517	16 958
Bulgaria	10 005	12 930

Source: own computation based on Eurostat database (access: 12.10.2023)

Among all the examined countries, the highest value of gross national disposable income per capita has been observed in Luxembourg – income per person in this country was more than twice the mean value computed for the entire group of twenty-four countries taken together. In turn, Bulgaria recorded the lowest value of gross national disposable income per capita at that time – in 2021, income per capita in Bulgaria was 71% lower (in 2022 – 65% lower) than the European mean.

In 2021, in Poland, the annual income per capita amounted to 14 517 euro (in 2022 – 16 958 euro), while the average income equaled 34 393 euro (in 2022 – 37 131 euro). It means that the value of the variable in Poland was less than a half of the mean value regarding the set of twenty-four European countries.

Comparing the propensity to save

The third task is to compare the saving value in relation to the income value in the economies of the discussed countries. The obtained results are presented in Table 3.

Table 3. Gross national saving in relation to gross national disposable income (in %)

Country	2021	2022
Ireland	50.4	49.4
Denmark	32.3	36.5
Sweden	32.0	32.7
Netherlands	33.4	31.0
Malta	31.4	31.0
Estonia	31.1	29.1
Czechia	29.5	29.1
Luxembourg	32.4	29.0
Germany	30.3	28.7
Austria	28.4	27.9
Hungary	27.9	27.1
Mean (24)	27.8	26.9
Belgium	26.6	25.4
Finland	24.6	24.4
Slovenia	26.2	24.4
Croatia	23.8	24.3
France	23.3	22.5
Lithuania	21.6	22.2
Spain	22.4	22.2
Poland	22.1	22.1
Bulgaria	21.0	21.9
Latvia	20.9	19.5
Portugal	19.3	19.1
Slovakia	20.2	16.1
Cyprus	12.2	12.2

Source: own computation based on Eurostat database (access: 12.10.2023)

The highest saving-income ratio was observed in Ireland – in 2021, the quotient of saving and income was as high as 181% of the average value (in 2022 – 184%). In turn, the lowest flow of saving in comparison with the flow of income was noted in Cyprus – in 2021, the considered quotient was only 44% of the value of the relevant measure calculated for the entire group of twenty-four European countries (in 2022 – 45%).

It is worth emphasizing that in 2021 in Ireland only 49.6% of the national income was spent on consumption, and the remaining 50.4% constituted saving (in 2022 – 50.6% and 49.4%, respectively)[6]. The proportion for Europe as a whole was as follows: in 2021, 72.2% of the income was consumed and 27.8% saved (in 2022 – 73.1% and 26.9%, respectively). In the case of Cyprus, as much as 7/8 of the income was spent on current consumption, and only 1/8 was put aside.

Poland had a slightly lower propensity to save (and a higher propensity to consume) than it was on average in the group of twenty-four countries constituting the basis of reference. In 2021, Poland saved 22.1% (in 2022 – 22,1%) of its national disposable income, whereas the mean based on the whole set of twenty-four countries was 5.7 percentage points more (in 2022 – 4.8 percentage points more).

Estimating the impact effects of the two discussed factors

The last task to be carried out is the evaluation of the influence of deviations of the two factors on the deviation of gross national saving per capita in the examined countries from the European mean. Table 4 presents the equations (1) and (3) estimated for each of the twenty-four countries considered.

[6] Assuming that the sum of the propensity to consume and the propensity to save is equal to one [compare Bohdalová, Pažický 2019].

Table 4. The importance assigned to the causes of the occurring deviations regarding the response variable

Higher income per capita and higher part of saving in income			
Ireland:	I	3.337 = 1.840 · 1.814	(+22 313) = (+11 288) + (+11 024)
	II	3.448 = 1.881 · 1.833	(+24 485) = (+12 497) + (+11 988)
Luxembourg:	I	2.696 = 2.309 · 1.168	(+16 197) = (+13 664) + (+2533)
	II	2.322 = 2.160 · 1.075	(+13 224) = (+12 085) + (+1138)
Denmark:	I	2.026 = 1.743 · 1.163	(+9799) = (+7708) + (+2091)
	II	2.410 = 1.778 · 1.355	(+14 107) = (+9232) + (+4875)
Sweden:	I	1.770 = 1.537 · 1.152	(+7352) = (+5535) + (+1817)
	II	1.785 = 1.471 · 1.214	(+7854) = (+5227) + (+2627)
Netherlands:	I	1.752 = 1.456 · 1.204	(+7184) = (+4811) + (+2374)
	II	1.651 = 1.435 · 1.150	(+6511) = (+4694) + (+1817)
Germany:	I	1.412 = 1.294 · 1.091	(+3932) = (+2942) + (+990)
	II	1.362 = 1.276 · 1.067	(+3620) = (+2860) + (+759)
Austria:	I	1.349 = 1.317 · 1.024	(+3328) = (+3065) + (+263)
	II	1.368 = 1.322 · 1.035	(+3681) = (+3279) + (+401)
Higher income per capita and lower part of saving in income			
Belgium:	I	1.203 = 1.254 · 0.959	(+1934) = (+2373) + (−438)
	II	1.200 = 1.270 · 0.944	(+1996) = (+2623) + (−627)
Finland:	I	1.172 = 1.322 · 0.887	(+1643) = (+2887) + (−1244)
	II	1.177 = 1.301 · 0.905	(+1767) = (+2854) + (−1088)
France:	I	0.906 = 1.078 · 0.840	(−901) = (+682) + (−1583)
	II	0.873 = 1.044 · 0.836	(−1273) = (+407) + (−1680)
Lower income per capita and higher part of saving in income			
Malta:	I	0.865 = 0.763 · 1.132	(−1294) = (−2398) + (+1104)
	II	0.889 = 0.773 · 1.149	(−1111) = (−2425) + (+1313)
Estonia:	I	0.757 = 0.675 · 1.120	(−2323) = (−3270) + (+948)
	II	0.763 = 0.706 · 1.082	(−2368) = (−3057) + (+689)
Czechia:	I	0.663 = 0.625 · 1.061	(−3219) = (−3684) + (+465)
	II	0.711 = 0.658 · 1.081	(−2895) = (−3551) + (+656)
Hungary:	I	0.445 = 0.442 · 1.006	(−5300) = (−5337) + (+37)
	II	0.459 = 0.457 · 1.004	(−5410) = (−5441) + (+31)
Lower income per capita and lower part of saving in income			
Slovenia:	I	0.660 = 0.699 · 0.944	(−3247) = (−2793) + (−454)
	II	0.664 = 0.734 · 0.905	(−3363) = (−2540) + (−823)
Spain:	I	0.603 = 0.748 · 0.807	(−3786) = (−2176) + (−1610)
	II	0.622 = 0.754 · 0.825	(−3776) = (−2245) + (−1531)
Lithuania:	I	0.438 = 0.563 · 0.778	(−5365) = (−3733) + (−1633)
	II	0.507 = 0.614 · 0.826	(−4933) = (−3541) + (−1392)
Portugal:	I	0.429 = 0.617 · 0.695	(−5453) = (−3106) + (−2347)
	II	0.450 = 0.634 · 0.710	(−5503) = (−3142) + (−2361)
Latvia:	I	0.386 = 0.512 · 0.754	(−5861) = (−4122) + (−1740)
	II	0.402 = 0.554 · 0.726	(−5979) = (−3874) + (−2105)
Croatia:	I	0.383 = 0.448 · 0.856	(−5886) = (−4933) + (−954)
	II	0.438 = 0.486 · 0.901	(−5619) = (−4912) + (−707)
Slovakia:	I	0.381 = 0.523 · 0.729	(−5908) = (−3972) + (−1936)
	II	0.319 = 0.532 · 0.599	(−6811) = (−3759) + (−3052)
Poland:	I	0.336 = 0.422 · 0.795	(−6344) = (−5011) + (−1333)
	II	0.375 = 0.457 · 0.821	(−6252) = (−4994) + (−1258)

Table 4. The importance assigned to the causes of the occurring deviations regarding the response variable *(continued from previous page)*

Lower income per capita and lower part of saving in income			
Cyprus:	I	0.307 = 0.700 · 0.438	(−6621) = (−1999) + (−4623)
	II	0.329 = 0.727 · 0.453	(−6707) = (−1926) + (−4781)
Bulgaria:	I	0.220 = 0.291 · 0.757	(−7446) = (−6074) + (−1372)
	II	0.283 = 0.348 · 0.812	(−7173) = (−5993) + (−1180)

I – results for 2021 II – results for 2022

Source: own computation based on Tables 1, 2, and 3

As an example, the values obtained in 2022 for Poland shall be interpreted. Poland saved per capita 6252 euro less (i.e. 62.5% less) than saved on average the twenty-four European countries. Had Poland generated income per capita at the mean level, the annual saving per capita in this country would have been 1258 euro lower than it was on average in the European countries, only due to the lower propensity to save. If, however, the part of saving in income had been in Poland at the mean level, the annual saving per person in Poland would have been 4994 euro lower than the mean value obtained for all the discussed countries, which would have been a result solely of the lower income per capita.

DISCUSSION

Saving is a key economic variable because it is closely related to the rate of wealth accumulation [Fenton-O'Creevy, Furnham 2022]. To save means to reduce consumption today in order to raise income and consumption in the future. The more a country saves, the more it invests [Buzatu 2015], and countries that invest more have higher standards of living. The importance of national saving in the process of economic development has been emphasized by many outstanding economists [see Aghion et al. 2009]. One of the central problems of their interests was to understand the relationship between saving and income. According to the Solow growth model[7], if a nation devotes a large fraction of its income to saving and investment, it will benefit the economy by a great capital stock and a high level of income per capita. Conversely, if a nation saves and then invests only a small fraction of its income, its capital stock and income will be low [Zhang 2012].

[7] The Solow model was developed by the Nobel Prize Laureate Robert Solow, a researcher at the Massachusetts Institute of Technology, who received the Nobel Prize in 1987. The key conclusion drawn from Solow's work is that an increase in the saving rate leads to a permanent rise in the level of output per capita, but it does not result in a sustained increase in the economy's growth rate. The elevated saving contributes to the growth of the capital stock, causing an increase in capital depreciation that necessitates replacement. Consequently, larger amounts of gross investment are required merely to maintain the capital stock at its new, higher level.

Nevertheless, the Solow model implies, and it is worth emphasizing, that a higher saving rate affects a higher future standard of living but does not influence long-term growth – the increase in the growth rate is only temporary. The long-term growth of the economy can be caused exclusively by faster technological progress [Carlin, Soskice 2006].

FINAL CONCLUSIONS AND RECOMMENDATIONS

As presented in Table 1, there are huge differences between European countries when it comes to the scale of saving they have achieved. Moreover, based on Tables 2 and 3, it can be stated that the countries form a very heterogeneous group as far as the flow of income and the propensity to save are concerned.

Three research hypotheses have been formulated in this paper. According to the first hypothesis, the European countries generating saving per capita higher than the European mean are also characterized by higher income per capita[8]. This hypothesis has been positively verified, as there was no country among the examined ones that generated higher saving per person than mean despite the fact that such a country is relatively poor compared to the whole group of European countries. All nine economies with saving per person above average[9] ($A_i > 1$) also had the income per capita higher than the average level in the set of twenty-four countries ($B_i > 1$).

The aforementioned statement is equivalent to the following: the European countries characterized by income per capita below average also generate lower saving per capita. This hypothesis is still true, as there was no country among the twenty-four examined that was, compared with the European mean, relatively poor and at the same time achieved higher saving per person than the European mean level. All fourteen economies[10] with income per person lower than the mean ($B_i < 1$) also had saving per capita lower than it was on average in the studied European countries ($A_i < 1$).

The second hypothesis stated that if a given European country has the flow of saving per capita above average, it is mainly a result of wealth, and the impact of the second factor – namely propensity to save – is smaller. This hypothesis can be verified positively, as for each of the nine countries with saving per capita higher than the mean, the impact effect of the first factor under consideration was larger than the impact effect of the second factor[11]. In the group of these nine countries,

[8] However, countries with higher income per capita do not necessarily generate higher saving per capita than the European average (as in the case of France).

[9] These countries are: Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, Netherlands, and Sweden.

[10] These countries are: Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia, Spain.

[11] Mathematically, this can be written as follows: $\left|\Delta_i \cdot \log_{A_i} B_i\right| > \left|\Delta_i \cdot \log_{A_i} C_i\right|$.

there was not a single exception where the impact of the first factor (i.e., income per capita) was weaker than the impact of the second factor (propensity to save).

According to the third research hypothesis, the wealthiest European countries, with income per capita considerably higher than the European mean (i.e., $B_i > 1.4$), also have a propensity to save bigger than it is on average in the entire group of twenty-four countries (meaning C_i for them was never lower than 1). This hypothesis may be deemed true, as none of the five economies[12] for which $B_i > 1.4$, had propensity to save smaller than the European mean.

Poland is relatively poor and this is the main obstacle to increasing the amount of its flows of saving. In the case of Poland, the income per person is much lower than average, which results in saving per person also lower than the average in the group of twenty-four countries taken together (as the first hypothesis states). Thus, the only way to raise national saving in that country is the above-average increase in the propensity to save, facilitating the growth of income in the long-term perspective (see Solow model of economic growth [Solow 1956]). Poland is on track to achieve this goal, as the propensity to save in that economy is approaching the European average. The only proper recommendation for that country seems to be a constant stimulation of the growth of its national saving rate, which would result in the increase of national income in the subsequent periods, followed by further growth in national saving[13] and other positive changes in income. The data analysis shows that ratios A_i and B_i for Poland were growing. It is justified to expect that its national income will become closer and closer to the mean European level.

The lowest value of saving per capita of all the studied countries has been observed in Bulgaria. There are two reasons for the modest value of the country's saving – both the relatively low income and the small propensity to save compared to other countries. Income growth will not accelerate if Bulgaria does not limit current consumption for the sake of raising the amount of saving.

The highest saving per person was recorded in Ireland. Thus, it is clear that Ireland also recorded income per capita higher than average (as the first hypothesis provides for). In 2021, the level of income per capita in Ireland was over 1.8-fold higher (in 2022 – nearly 1.9-fold higher) than in Europe as a whole, which also means that the propensity to save in that country was above average. This relationship – as the third hypothesis statement – has already been identified. Additionally, the fact that saving per capita in Ireland was higher than the average mostly resulted from its being wealthier than the others[14].

However, it should be clarified that higher saving leads to faster growth in the Solow model, but only temporarily. An increase in the rate of saving raises growth

[12] These countries are: Denmark, Ireland, Luxembourg, Netherlands, and Sweden.

[13] Keynes [1936] argued that "(...) a higher absolute level of income will lead, as a rule, to a greater proportion of income being saved". For detailed explanations, refer to Kahn [1984].

[14] This is a general principle identified in the countries discussed in this paper (see the verification of the second hypothesis).

until the economy reaches the new steady state – the point where the additional saving is devoted entirely to maintaining the higher level of output. Thus, if the economy maintains the increased saving rate, it will sustain the larger capital stock and the higher level of output, but it will not sustain the higher rate of growth forever.

In summary, according to the Solow model, a change in the saving rate has a level effect rather than a growth effect. And indeed, as practice shows, only alterations in the rate of technological progress exhibit long-term growth effects, while all other changes merely manifest as level effects.

It is essential to stress that the research carried out is only a certain contribution for the sake of conducting further studies on the role of saving in the long-run development of the European economies. The article analyzed two factors directly influencing the amount of national saving per capita, i.e. national disposable income per capita and the average propensity to save. These factors, in turn, are affected by a multitude of various determinants which – indirectly – also shape the value of national saving. Such determinants include: fiscal policy of governments, distribution of wealth and income within societies, interest rates, existing investment opportunities, ease of access to banking facilities, financial market sophistication, and many other sub-factors that saving depends on. In further studies, the author is going to address the question of whether relationships exist between the level of saving and the severity of turbulences caused by economic and other crises.

The novelty of this paper is manifested in the employed methodological concept. The primary strength of the proposed methodology lies in its potential for theoretical development and its applicability to the detailed identification of various research problems. It is noteworthy that, instead of comparing deviations from the average, one can juxtapose deviations from values in previous periods. In this case, the denominators for ratios A_i, B_i, C_i will not feature average values but values for the same country in previous years. An additional possibility is that changes over time can be analyzed using either individual or aggregate indices. Furthermore, equations (2) and (3) presented in this paper can be extended to incorporate more than just two factors.

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VERIFICATION OF THE WEAK-FORM INFORMATIONAL EFFICIENCY OF FUEL MARKETS IN THE VISEGRAD GROUP

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Abstract: The paper aims at examining the weak-form informational efficiency of fuel markets in the Visegrad Group (V4) countries: the Czech Republic, Hungary, Poland and Slovakia from January 2016 through December 2020. For this purpose, the following statistical tests were applied: the runs test, the variance ratio test, the autocorrelation tests, the unit root tests. The tests provided mixed results not giving a definitive answer to the question of whether V4 fuel markets were informationally efficient in a weak form. The only exception is Slovakia where gasoline and diesel prices followed random walk, providing evidence in favor of the weak-form informational efficiency of the market.

Keywords: informational efficiency, fuel market, Visegrad Group

JEL classification: G14, C12, Q02

INTRODUCTION

The concept of the market informational efficiency is a key element of the theory of efficient capital markets, as formulated and conceptually developed by Eugene Fama

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[Fama 1965, 1970, 1991, 1998][1]. According to the theory of informational efficiency, the prices of financial instruments at any time reflect all available information, both current (including historical) and rationally anticipated. Thus, forecasting financial assets prices for the next period is impossible because assumptions about the broadly understood future (in the sense of rational anticipation) are reflected in the current price [Starzeński 2011]. In other words, on an informationally efficient capital market the prices of financial instruments fully and quickly reflect all available information.

To make the empirical verification of informational efficiency possible, Fama [1970] proposed three hypotheses referring to three forms of informational efficiency:

– weak-form efficient market hypothesis, according to which the information set refers to historical prices only,
– semi-strong-form efficient market hypothesis, in which – additionally – publicly available information (e.g., coming from corporate balance sheets) is considered,
– strong-form efficient market hypothesis, where not only publicly but also privately available information (e.g., by investors having monopoly access to information relevant for price formation) is accounted for.

The rejection of the weak-form efficient market hypothesis implies the lack of semi-strong and strong efficiencies.

Since Fama's pioneering work, many studies have been conducted on the efficiency of financial markets, with the main focus dedicated to the stock market. However, in the 1980s, research on the informational efficiency of commodity markets, primarily the oil market, were initiated. In the last decade, this issue has been explored, for example, by Zahng et al. [2014], Górska, Krawiec [2016], Dimitriadou et al. [2018], Ghazani, Ebrahimi [2019], Bohl et al. [2021], Espinosa-Paredes et al. [2022] or Moyo et al. [2023], who mostly focused their research on the Brent and WTI oil markets. To our best knowledge relatively little work has been done on examining fuel domestic retail markets ([Hunter, Tabaghdehi 2013], [Valadkhani 2013], [Rosado et al. 2021]).

The aim of this paper is to verify the hypothesis of the weak-form informational efficiency of fuel markets in the Visegrad Group. The dataset consists of weekly average prices of basic fuels (gasoline Pb95 and diesel) in the Czech Republic, Hungary, Poland and Slovakia from January 2016 through December 2020. The following statistical tests verifying the randomness of the time series were used for the purpose of the analysis: runs test, variance ratio tests, autocorrelation tests, unit root tests. They are commonly used in examining the weak-form informational efficiency.

[1] The origins of the theory are admittedly disputed. Osińska [2006] states that the concept of the efficient market was first proposed by Bachelier back in 1900, and only after several dozen years reactivated by Fama, whose works are most frequently cited in the literature.

METHODOLOGY

To verify the weak-form efficient market hypothesis, different statistical tests investigating the randomness of price changes may be applied. The popular tests that examine whether the time series is a random walk series include: unit root test, test for autocorrelation coefficients, test for variance ratios, and runs test [Witkowska et al. 2008].

Runs test

A run in the market is defined as a sequence of changes in quotations in the same direction (i.e. a series of increasing values, or a series of decreasing values) of any length. In this case, fractions are compared to the distribution that the data would follow if the investigated process was a random walk. If price changes are random, the probability of a further decline after a price decline should be equal to the probability of an increase. This would mean that a similar number of runs and sign changes should be expected in a large sample of observations.

When modeling the behavior of commodity prices, it is assumed that there are sequences of positive values, negative values and zeros. Then, in order to perform the runs test, an auxiliary variable R_t^* is introduced, such that:

$$R_t^* = \begin{cases} 1, & \text{if} \quad R_t > 0 \\ 0, & \text{if} \quad R_t = 0 \\ -1, & \text{if} \quad R_t < 0 \end{cases}.$$

The null hypothesis H_0: "R_t^* is a white noise" is tested against H_1: "R_t^* is not a white noise".

To verify the hypothesis, K statistic is used, which for large samples is approximately asymptotically normally distributed.

Statistic K is given by:

$$K = \frac{H - E(\widetilde{H})}{\sqrt{War(\widetilde{H})}}, \tag{1}$$

where: H is conditional realization of a random variable $\widetilde{H}$ and denotes the total number of runs.

To perform the runs test, a distinction is made between continuous sequences of positive, zero and negative returns R_t^*. To this end, an auxiliary variable h_t is introduced:

$$h_t = \begin{cases} 0, & \text{if } R_t^* = R_{t+1}^* \\ 1, & \text{if } R_t^* \neq R_{t+1}^* \end{cases}.$$

Accordingly, if $h_t = 1$, R_{t+1} starts a new run.
Finally, the total number of runs is:

$$H = 1 + \sum_{t=1}^{n-1} h_t, \tag{2}$$

where n is the length of a run.

If the investigated series consists of n_1 positive returns, n_2 with values of zero and n_3 negative returns, then the mean and variance of the random variable $\tilde{H}$ are defined by the formulas [Taylor 1986]:

$$E(\tilde{H}) = n + 1 - \frac{\sum_{j=1}^{3} n_j^2}{n}, \tag{3}$$

$$Var(\tilde{H}) = \frac{\sum_{j=1}^{3} n_j^2 \left(\sum_{j=1}^{3} n_j^2 + n + n^2\right) - 2n \sum_{j=1}^{3} n_j^3 - n^2}{n^3 - n}. \tag{4}$$

If $|K| > 1.96$, then the null hypothesis is rejected at the 0.05 level. When $K < 0$, there are trends in the data. $K > 0$ implies the mean reversion [Taylor 1986].

Variance ratio tests

When performing the variance ratio test, it is assumed that there are $nk + 1$ spot prices. The variance ratio test is used to verify whether the equation:

$$p_t = \mu + p_{t-1} + \varepsilon_t, \qquad t = 1, \ldots, nk \tag{5}$$

where p_t is price at time t, μ is a constant term and ε_t is the error term, is a proper model for the analyzed price series. Specifically, the null hypothesis of this test states that equation (5) is the right model for the series of prices of assets.
The model can be tested in two variants:

- ε_t are independent and follow the same normal distribution with the expected value of zero and the same variance (assumption 1),
- ε_t are uncorrelated and have a finite variance (assumption 2).

By verifying these two assumptions, it is possible to determine the reason for the potential rejection of the null hypothesis: Is it heteroscedasticity of ε_t or rather autocorrelation?
Assuming that the assumption 1 is true and transforming the model (5), we have:

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \mu + \varepsilon_t. \tag{6}$$

This means that the continuously compound returns r_t follow a normal distribution with expected value μ and variance ε_t. Also, assuming that individual returns are independent, the sample variance of *k*-period return is *k* times the sample variance of one-period return. Thus, if H_0 is true, i.e. prices are generated by a stochastic process given by the formula (5) and ε_t satisfies assumption 1, then:

$$\frac{var(r_k)}{k \cdot var(r_1)} = 1, \tag{7}$$

where r_k is a logarithmic return from *k* moments.
Therefore, the test of the null hypothesis can be based on the quotient of the variance, given by the left side of equation (7). If H_0 is true, the variance ratio calculated from the sample should be equal to unity.
The distribution of the test statistics (variance ratio):

$$z(k) = \frac{IW_k - 1}{\sqrt{L(k)}}, \tag{8}$$

where:

$IW(k) = \frac{\overline{var}(r_k)}{k \cdot \overline{var}(r_1)}$,

$\overline{var}(r_1) = \frac{1}{nk-} \sum_{t=1}^{nk} (p_t - p_{t-1} - \overline{p})^2$,

$\overline{var}(r_k) = \frac{1}{(nk-k-1)(1-1/n)} \sum_{t=k}^{nk} (p_t - p_{t-k} - k\overline{p})^2$,

$\bar{p} = \frac{1}{nk} \sum_{t=1}^{nk} (p_t - p_{t-1})$,

$L(k) = \frac{3nk^2}{2(2k-1)(k-1)}$,

follows standard normal distribution asymptotically [Lo, MacKinlay 1989].

Assuming that the assumption 2 is true, the null hypothesis can be verified using the statistic:

$$z^*(k) = \frac{IW_k - 1}{\sqrt{L^*(k)}}, \tag{9}$$

where:

$L^*(k) = \sum_{j=1}^{k-1} \left[\left(\frac{2(k-j)}{k} \right)^2 \cdot V(j) \right]$,

$V(j) = \frac{\sum_{t=j+1}^{nk} (p_t - p_{t-1} - \overline{p})^2 \cdot (p_{t-j} - p_{t-j-1} - \overline{p})^2}{\left[\sum_{t=1}^{nk} (p_t - p_{t-1} - \overline{p})^2 \right]^2}$.

It also follows standard normal distribution.

Statistics $z(k)$ and $z^*(k)$ allow the verification of the null hypothesis, answering the question of whether equation (5) may properly model the analyzed prices.

Autocorrelation tests

The autocorrelation test examines whether the data in the time series are correlated or not. The portmanteau test (Box-Pierce) and adjusted portmanteau test (Box-Ljung) examine whether the price changes are independent random variables with identical distributions.

Autocorrelation test verifies the following null hypothesis:

H_0: $\rho = 0$ (returns are not correlated with each other)

against

H_1: $\rho \neq 0$ (returns are correlated).

To verify the null hypothesis, the autocorrelation coefficient of returns given by the following formula may be used:

$$\hat{\rho}(k) = \frac{\sum_{t=1}^{T-k} (R_t - \bar{R}_T)(R_{t+k} - \bar{R}_T)}{\sum_{t=1}^{T} (R_t - \bar{R}_T)^2}, \tag{10}$$

where:

$\hat{\rho}(k)$ is the autocorrelation of order *k*,

$\bar{R}_T$ is the mean return ($\bar{R}_T = \frac{1}{T} \sum_{t=1}^{T} R_t$),

T is the number of observations,

R_t is the rate of return at time *t*,

R_{t+k} is the rate of return of prices that are k moments distant from each other. Assuming the truth of the null hypothesis H_0, the statistic

$$S = \sqrt{T}\hat{\rho}(k) \tag{11}$$

follows standard normal distribution [Taylor 1986]. The null hypothesis is rejected at 0.05 level, when the absolute value of the statistic S is greater than 1.96.

The aim of the Box-Pierce and Box-Ljung tests is to verify the following null hypothesis:

H_0: $\rho_1 = \rho_2 = \ldots = \rho_m = 0$ (rates of return are uncorrelated)

against

H_1: $\rho_i \neq 0$, i={1, …, m} (rates of return are correlated).

These tests examine the significance of the subsequent correlation coefficients.

In the case of the Box-Pierce test, the statistic is:

$$Q_m = T\sum_{k=1}^{m}\hat{\rho}(k)^2, \tag{12}$$

and in the Box–Ljung test, it is:

$$Q'_m = T(T+2)\sum_{k=1}^{m}\frac{\hat{\rho}(k)^2}{T-k}, \tag{13}$$

where:

$\hat{\rho}(k)$ – autocorrelation coefficient of order k, for k = 1,…, m as in equation 10,

T – the length of the time series,

$m \approx ln(T)$ – maximum delay.

Statistics Q (Q') consist of numerous autocorrelation coefficients, and follow the χ^2_m (chi-squared) distribution with m degrees of freedom [Mills 1999]. When the value of empirical statistic Q exceeds the value of χ^2_m representing the theoretical distribution, H_0 can be rejected at the pre-specified significance level. According to equations (12) and (13), the number of degrees of freedom m is the number of autocorrelation coefficients, which are taken into account when calculating statistics Q or Q'.

Unit root tests

Unit root tests may be applied to verify whether the time series follow random walk, which means they are nonstationary[2].

A time series is stationary if its mean and variance do not vary systematically over time and the covariance between two time periods depends only on the distance (or gap or lag) between the two time periods and not on the actual time at which the covariance is computed. Such a series is also referred to as the series that is integrated of order zero or as $I(0)$. Most economic time series are nonstationary. However, it is possible to convert them to a stationary series by taking the first differences. Thus, a nonstationary series is integrated of order d, denoted $I(d)$ if it becomes stationary after being first differenced d times [Greene 2018].

[2] According to Gujarati [2003], the terms nonstationarity, random walk, and unit root can be treated as synonymous.

There are several tests of stationarity. One of the most popular is the augmented Dickey-Fuller test (ADF). It is carried out in the context of the model:

$$y_t = \boldsymbol{\beta'} \boldsymbol{D}_t + \phi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t, \tag{14}$$

where y_t represents the time series of the phenomenon under investigation, ϕ and ψ_j are the estimated coefficients on the lagged values of y, $\boldsymbol{D}_t$ is a vector of deterministic terms (constant, trend, etc) and $\boldsymbol{\beta'}$ is a vector of the corresponding estimated coefficients. The number of lagged difference terms to include is often determined empirically[3], the idea being to include enough terms so that the error term in (14) is serially uncorrelated. The error term ε_t is also assumed to be homoscedastic.

Under the null hypothesis that y_t is $I(1)$, which implies $\phi = 1$, there are two approaches to carrying out the test. The conventional *t* ratio:

$$ADF_t = \frac{\hat{\phi} - 1}{SE(\phi)} \tag{15}$$

with the revised set of critical values that may be used for a one-sided test.
The second approach is based on the statistic:

$$ADF_n = \frac{t(\hat{\phi} - 1)}{1 - \hat{\psi}_1 - \cdots - \hat{\psi}_p} \tag{16}$$

Dickey and Fuller [1979] computed the critical values based on Monte Carlo simulations and later MacKinnon [1991] presented more extensive tables [Gujarati 2003].
An alternative formulation in first differences may prove convenient:

$$\Delta y_t = \boldsymbol{\beta'} \boldsymbol{D}_t + \pi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t, \tag{17}$$

where:
$\pi = \phi - 1$.
The unit root test is carried out as before by testing the null hypothesis $\pi = 0$ against $\pi < 0$ and the *t* test, ADF_t, may be used [Greene 2018].

Kwiatkowski et al. [1992] devised an alternative to the Dickey-Fuller test. They start with the model:

$$y_t = \boldsymbol{\beta'} \boldsymbol{D}_t + \mu_t + u_t \tag{18}$$
$$\mu_t = \mu_{t-1} + \varepsilon_t, \varepsilon_t \backsim WN(0, \sigma_\varepsilon^2),$$

where $\boldsymbol{D}_t$ contains deterministic components, u_t is $I(0)$ and may be heteroscedastic. Notice that μ_t is a pure random walk with innovation variance σ_ε^2. The null hypothesis that y_t is $I(0)$ is formulated as H_0: $\sigma_\varepsilon^2 = 0$, which implies that μ_t is constant. The KPSS statistic is the Lagrange multiplier (LM) or score statistic for testing $\sigma_\varepsilon^2 = 0$ against the alternative that $\sigma_\varepsilon^2 > 0$ and is given by:

$$KPSS = \frac{\sum_{t=1}^{T} \hat{S}_t^2}{T^2 \hat{\lambda}^2}, \tag{19}$$

[3] On the basis of large number of simulations, Schwert [1989] found that $p_{\max}$ set as the integer part of $[12 \times (T/100)^{0.25}]$ gave good results.

where $\hat{S}_t = \sum_{j=1}^{t} \hat{u}_j$, $\hat{u}_t$ is the residual of a regression of y_t on $\boldsymbol{D}_t$ and $\hat{\lambda}^2$ is a consistent estimate of the long-run variance of u_t using $\hat{u}_t$ [Zivot, Wang 2006].

It has been argued that tests with stationarity as null can be used to confirm the results of the usual unit root tests. If both tests reject their nulls, then we have no confirmation of stationarity. However, if test 1 rejects the null, but test 2 does not (or vice versa) we obtain confirmation [Maddala 2005].

EMPIRICAL DATA AND RESULTS

The dataset used for the purpose of the research covers weekly prices (260 observations) of basic fuels: gasoline Pb95 and diesel in the Czech Republic, Hungary, Poland and Slovakia from January 2016 through December 2020. The prices are expressed in domestic currencies per 1 liter. The data is provided by e-petrol.pl (www.e-petrol.pl). The quantitative analysis is based on logarithmic prices (log-prices) and their first differences – logarithmic returns (log-returns).

Runs test

Table 1 presents the values of *K* statistic (equation (1)), calculated for each country for gasoline and diesel logarithmic returns. The results show that we cannot reject the null hypothesis at 0.05 in the case of the Czech Republic and Slovakia for both fuels. Thus, we can expect R_t^* to be generated by the white noise ($|K| < 1.96$). In consequence, both fuels markets in the Czech Republic and Slovakia are found to be informationally efficient in a weak-form. Additionally, negative values of *K* suggest the existence of trends in fuels returns.

Table 1. Values of *K* statistic

Country	Fuel	
	Gasoline	Diesel
Czech Republic	-0.71	1.70
Hungary	-2.89*	-4.97*
Poland	-5.45*	-5.79*
Slovakia	-1.43	-0.34

Source: own calculations Note: *H_0 rejection at the 0.05 level

Variance ratio test

Results of variance ratio test are reported in Table 2 (the tests were performed for logarithmic returns from 1 up to 10 weeks (k = 1, …, 10)). All *z(k)* statistics given in Table 2 are not significant at 0.05. Thus, the null hypothesis cannot be rejected and fuel prices are likely to be generated by the stochastic process fulfilling assumption 1. Moreover, model (5), fulfilling assumption 2, is not a good approximation of analyzed fuels prices (in the case of gasoline in the Czech Republic, Hungary and Poland (for $k > 2$), in the case of diesel in the Czech Republic and Poland).

Table 2. Results of the variance ratio test

Fuel	Country	k	2	3	4	5	6	7	8	9	10
Gasoline	Czech Rep.	IW(k)	0.78	0.59	0.51	0.51	0.51	0.52	0.53	0.51	0.51
		z(k)	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02
		z*(k)	-2.90*	-3.56*	-3.43*	-2.95*	-2.63*	-2.37*	-2.18*	-2.09*	-2.37*
	Hungary	IW(k)	1.11	1.27	1.40	1.50	1.58	1.64	1.71	1.75	1.81
		z(k)	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03
		z*(k)	1.50	2.52*	3.05*	3.28*	3.32*	3.32*	3.33*	3.29*	3.87*
	Poland	IW(k)	1.18	1.41	1.61	1.76	1.87	1.99	2.10	2.18	2.26
		z(k)	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.04	0.05
		z*(k)	1.19	2.01*	2.55*	2.87*	3.07*	3.30*	3.48*	3.59*	6.07*
	Slovakia	IW(k)	1.05	1.05	1.06	1.08	1.11	1.12	1.13	1.13	1.12
		z(k)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
		z*(k)	0.64	0.40	0.42	0.45	0.53	0.55	0.54	0.50	0.53
Diesel	Czech Rep.	IW(k)	0.52	0.47	0.42	0.39	0.36	0.35	0.33	0.32	0.31
		z(k)	0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03
		z*(k)	-3.87*	-3.09*	-2.89*	-2.70*	-2.65*	-2.53*	-2.49*	-2.41*	-3.72*
	Hungary	IW(k)	1.00	1.00	0.98	0.98	0.98	0.98	0.98	0.99	1.00
		z(k)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		z*(k)	0.04	-0.02	-0.12	-0.11	-0.08	-0.09	-0.09	-0.06	-0.01
	Poland	IW(k)	1.44	1.83	2.09	2.28	2.43	2.56	2.66	2.74	2.82
		z(k)	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.06	0.07
		z*(k)	4.01*	5.23*	5.68*	5.95*	6.11*	6.24*	6.30*	6.29*	8.63*
	Slovakia	IW(k)	1.01	1.05	1.04	1.07	1.11	1.14	1.15	1.18	1.19
		z(k)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
		z*(k)	0.21	0.65	0.36	0.54	0.70	0.85	0.82	0.90	1.08

Source: own calculations Note: *H_0 rejection at the 0.05 level

Autocorrelation tests

Table 3 presents results of the autocorrelation test for logarithmic returns, where autocorrelations of order $k = 1, 2,\ldots,10$ are verified.

Table 3. Values of autocorrelation of order k (rho) and S statistics

		Gasoline				Diesel			
k		Czech Rep.	Hungary	Poland	Slovakia	Czech Rep.	Hungary	Poland	Slovakia
1	rho(1)	-0.22	0.09	0.16	0.03	-0.22	-0.01	0.42	0.00
	S	-3.57*	1.44	2.64*	0.54	-3.57*	-0.18	6.83*	-0.05
2	rho(2)	-0.18	0.18	0.26	-0.03	-0.18	-0.01	0.37	0.05
	S	-2.86*	2.86*	4.14*	-0.49	-2.86*	-0.16	5.92*	0.82
3	rho(3)	0.02	0.10	0.15	0.03	0.02	-0.02	0.14	-0.07
	S	0.39	1.62	2.35*	0.48	0.39	-0.27	2.24*	-1.17
4	rho(4)	0.14	0.04	0.06	0.01	0.14	0.03	0.12	0.09
	S	2.17*	0.66	0.91	0.20	2.17*	0.41	1.95	1.45
5	rho(5)	-0.01	0.01	0.04	0.03	-0.01	0.00	0.04	0.04
	S	-0.10	0.13	0.68	0.50	-0.10	0.04	0.64	0.67
6	rho(6)	0.02	0.05	0.12	-0.03	0.02	-0.02	0.06	0.02
	S	0.29	0.85	1.89	-0.45	0.29	-0.37	0.94	0.30

		Gasoline				Diesel			
k		Czech Rep.	Hungary	Poland	Slovakia	Czech Rep.	Hungary	Poland	Slovakia
7	rho(7)	0.00	0.04	0.06	-0.01	0.00	0.00	0.01	-0.09
	S	-0.05	0.59	0.95	-0.17	-0.05	0.07	0.16	-1.37
8	rho(8)	-0.07	-0.02	-0.02	-0.04	-0.07	0.02	-0.04	0.08
	S	-1.11	-0.39	-0.25	-0.64	-1.11	0.38	-0.61	1.29
9	rho(9)	0.04	0.04	0.01	-0.03	0.04	0.03	-0.02	-0.04
	S	0.71	0.71	0.20	-0.48	0.71	0.40	-0.38	-0.58
10	rho(10)	-0.06	-0.08	-0.09	-0.05	-0.06	0.01	-0.05	-0.06
	S	-0.91	-1.31	-1.39	-0.74	-0.91	0.12	-0.84	-0.92

Source: own calculations Note: *H_0 rejection at the 0.05 level

Results in Table 3 suggest rejection of the null hypothesis H_0: „fuel prices are independent random variables" for both gasoline and diesel in the Czech Republic and in Poland in the case of autocorrelation of orders $k = 1$ and $k = 2$, and also (only in Poland) when $k = 3$ and in the Czech Republic when $k = 4$ ($S > 1.96$). On the contrary, we cannot reject the null hypothesis for both of them in the case of autocorrelation of order $k = \{5, 6, 7, 8, 9, 10\}$. Although in most cases the null hypothesis cannot be rejected, values of coefficient of correlation $\hat{\rho}(k)$ differ from zero. However, their absolute values are small. Thus, we expect fuels prices to be autocorrelated, but the autocorrelations are too weak to let us draw definite conclusions.

Box-Pierce and Box-Ljung tests

Results of Box-Pierce and Box-Ljung tests, performed on logarithmic returns, are shown in Table 4. Different numbers of lags (m): 10, 20 and 30 were considered. Empirical values of Q_m and Q'_m statistics are compared to the theoretical values of chi-squared distribution: 18.31, 31.41 and 43.77, respectively.

Table 4. Values of Q and Q' statistics

		Fuel					
		Gasoline			Diesel		
Country	m	10	20	30	10	20	30
Czech Rep.	Q_m	28.43*	37.78*	44.73*	68.96*	92.36*	100.11*
	Q'_m	28.93*	38.96*	46.74*	69.93*	94.96*	103.69*
Hungary	Q_m	16.76	43.20*	49.36*	0.77	11.55	15.74
	Q'_m	17.12	45.30*	52.23*	0.79	12.34	17.02
Poland	Q_m	37.44*	61.18*	69.85*	93.00*	118.56*	134.54*
	Q'_m	38.17*	63.51*	73.51*	94.37*	121.90*	139.99*
Slovakia	Q_m	2.46	8.98	14.84	9.45	18.50	28.60
	Q'_m	2.54	9.53	16.08	9.74	19.46	30.63

Source: own calculations Note: *H_0 rejection at the 0.05 level

Results in Table 4 suggest rejection of the null hypothesis regardless the number of lags in case of gasoline and diesel in the Czech Republic and Poland. All values of Q_m and Q'_m statistics are greater than respective theoretical values of chi-squared distribution. This lets us state that returns are correlated. Again, the correlations are too weak to draw definite conclusions. In the case of Slovakia, for both fuels, H_0 cannot be rejected as well as for diesel in Hungary.

Unit root tests

The last step of the research aims at examining the stationarity of the time series under consideration. Results of the ADF and KPSS tests performed on logarithms of prices (log-prices) and their first differences (log-returns) are reported in Table 5. The lag length is set to 15.

Table 5. Unit root tests results

Fuel	Country	ADF		KPSS	
		log-prices	log-returns	log-prices	log-returns
Gasoline	Czech Rep.	-2.26	-12.10*	0.27*	0.04
	Hungary	-3.31	-7.18*	0.21*	0.03
	Poland5	-3.00	-7.95*	0.28*	0.04
	Slovakia	-1.99	-15.44*	0.27*	0.04
Diesel	Czech Rep.	-2.19	-27.24*	0.32*	0.06
	Hungary	-2.25	-16.18*	0.30*	0.04
	Poland	-2.37	-7.00*	0.30*	0.05
	Slovakia	-1.15	-16.18*	0.31*	0.05

Source: own calculations Note: *H_0 rejection at the 0.05 level

Results presented in Table 5 show that in the case of logarithmic prices, we are unable to reject the null hypothesis of presence of a unit root at the 0.05 level of the significance. For first differences (log-returns), we reject the null hypothesis. Hence, the results of the ADF test reveal that all series are $I(1)$ in nature. It means that log-prices of Pb95 gasoline and diesel are nonstationary, but their first differences are stationary. Results of the KPSS test confirm the findings based on the ADF test, so the original series (log-prices) are integrated of order 1. We may conclude they follow a random walk as a series that follows a random walk is clearly $I(1)$ (see [Ramanathan 2002]).

CONCLUDING REMARKS

Fuels are major products whose prices influence prices of numerous goods and services.That is why investigating mechanisms determining fuel prices and their behavior is of great importance. This study is a contiuation of a former research that was aimed at detecting seasonal patterns (calendar effects) in the performance of fuel markets in the Visegrad Group [Krawiec, Górska 2024]. These results did not reveal

the significant calendar effects, such as the Halloween effect, reverse Halloween efect or gasoline seasonal transition effect, which would be suggestive of the informational efficiency of these markets.

The focus of this paper was to explore the weak-form informational efficiency of fuel markets in the Visegrad Group (V4) countries (the Czech Republic, Hungary, Poland and Slovakia) from January 2016 through December 2020 using several statistical tests: the runs test, the variance ratio test, the autocorrelation tests, the unit root tests. The results obtained, however, do not provide a clear answer to the question of whether V4 fuel markets were informationally efficient in a weak-form. An exception here is Slovakia, where prices of gasoline and diesel followed random walk. This provides evidence in favor of the weak-form informational efficiency. The tests provided mixed results for the other investigated fuel markets.

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APPLICATION OF THE EMOTIONAL INDEX IN THE STUDY OF THE IMPACT OF TELEVISION ADVERTISING ON THE RECIPIENT

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Abstract: This paper explores the possibility of using an emotional index to study the impact of television advertising on the viewer. The empirical data have been collected in a neuroscience study using GSR (galvanic skin response) and HR (heart rate) techniques. They enable us to read and analyse the skin surface and myocardium while watching advertisements. Emotion monitoring makes it possible to verify which parts of an advertisement have evoked positive and negative emotions. The analysis uses the AIDA model of advertising influence as a blueprint for audience behaviour in the marketplace.

Keywords: advertising, cognitive neuroscience, emotional index

JEL classification: M37, C91

INTRODUCTION

Advertising plays a significant role in the life of societies as a means of promoting and facilitating the sale of products and services. The origins of advertising can be traced back to the early days of commerce. The first traces of outdoor advertising, as described in a brief history of advertising by C. McDonald and J. Scott, were found in the monuments of the ancient civilizations of Babylonia, Egypt, Pompeii, Athens and Rome. Even then, advertising performed the same functions as it does today: it informed, assisted sales, and reminded customers of vendors. It was, of course, much less widespread than today due to the limited number of products in the trade and the small number of media available [McDonald, Scott 2007, 18]. For almost a century [Harvey 2016], television has been a very

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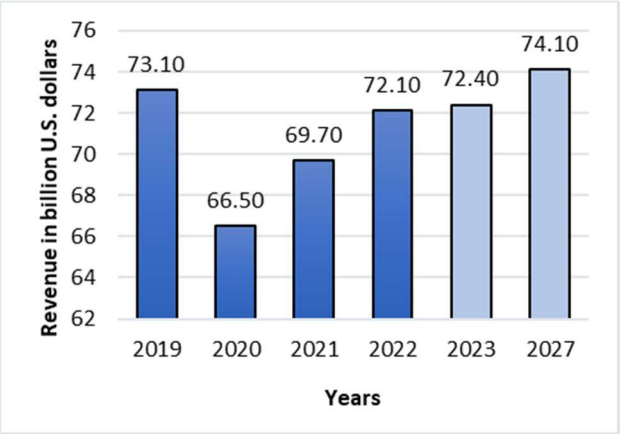
popular and successful medium for advertising. Worldwide consumers still have a lot of faith in it. It was expected that TV advertising revenue in the United States would grow from 72.4 billion U.S. dollars in 2023 to 74.1 billion in 2027 [Statista 2023a]. Global TV advertising spending stands at $132 billion [Statista 2023b]. After the market collapsed in 2020 due to the COVID-19 pandemic, the projected growth in advertising expenditures is shown in Figure 1.

Figure 1. TV advertising revenue in the United States from 2019 to 2027



Source: own research based on [Statista 2023a]

The abundance of information, resulting in the existence of competition among advertisers [Nan, Faber 2004, 7-30], means that with increasing expenditures, advertisers need reliable assessments of the effectiveness of the impact of advertising on the viewer. On the one hand, numerous indicators and tools are known to measure the effectiveness of advertising, but on the other hand, it is difficult to tailor them to the specific needs of a given advertiser [Kingsnorth 2016, 260]. Technological developments are taking place not only on the side of the media but also on the side of research tools, which can include cognitive neuroscience techniques that enrich existing methods, such as surveys, with the ability to measure evoked emotions. Measuring physiological reactions that cannot be controlled avoids casting doubt on the results obtained. The use of non-invasive methods, such as pulse or skin resistance measurements, does not raise ethical objections, although the very use of neuromarketing to influence buyers already raises such objections [Flores et al. 2014, 77-91; Morin 2011, 131-135]. Neoclassical economics propagated the idea that human behaviour is predictable and logical for a long time. But because human behaviour, particularly in the context of advertising, is difficult to describe, currents emerged that gave rise to the idea of behavioural economics. This discipline focused on understanding real human behaviour while accounting for human limitations, allowing for the use of psychology, sociology, and cognitive neuroscience to partially explain observed behavioural anomalies. For many years there have also

been attempts to describe the impact of advertising, which have led to the development of models of the impact of advertising on audiences. Models are some kind of formulas or schemes that identify ways in which audiences behave in the market. They differ in their assumptions, the number of stages that audiences go through or sequentiality. They have been created and developed since the mid-19th century. The oldest, fully functional model AIDA was created by Elias St. Elmo Lewis [Lewis 1899, 65-66]. Other well-known models of advertising influence are e.g. AIDCAS, AIDMA, DIPADA, DAGMAR, Lavidge-Steiner, EKB or Ray [Wijaya 2012, 73-85]. All advertising is directed at people, and the models are meant to describe their reactions to these ads. The disadvantage of many models is that they do not indicate depending on which factors to build a communication strategy. Therefore, it is important to describe human behaviour in the context of these interactions.

LITERATURE REVIEW

Representatives of behavioural economics will prove that in decision-making people are less rational than they think and that the sources of human behaviour should be sought in the functioning of the brain. Kahneman and Tversky began to compare their cognitive models of decision-making under risk and uncertainty to economic models of rational behaviour. They have demonstrated that for people the negative value of the loss is greater than the positive value of profit [Kahneman, Tversky 1979, 263-292]. Economists were prompted by these developments to reevaluate the potential use of psychology in economic theories and models [Camerer et al. 2004, 4-6]. An emotion (latin *e movere*, in motion) is a state of significant agitation of the mind. Precisely defining the concept of emotion, however, is not straightforward. As early as the early 1980s, researchers counted about a hundred definitions of the concept [Solomon 2008, 3]. A characteristic feature of emotion is its sudden appearance associated with somatic arousal. Emotions can reach considerable intensity, but are transient [Monge et al. 2012, 43]. The study of emotions is hampered by the possibility of hiding them in interpersonal interactions. In order to fully understand them, it is necessary to be able to separate the emotions felt from those shown. Perceived emotions are a person's actual emotions, whereas displayed emotions are those required by the organisation and considered appropriate in a given setting [Robbins 2004, 81]. Therefore, the question can be asked to what extent the theoretical models of advertising impact are effective, and how to measure them. The most popular models of advertising impact are linear. Models of advertising impact on the recipient present also a hierarchy of advertising effects in various combinations of such elements as comprehension, emotions, and behaviour. Each of them assumes, that advertising audiences go through different phases (cognitive-thinking, affective-feeling and behavioural) [Barry, Howard 1990, 121-135]:

- Cognitive – related to the level of knowledge of the customer which is the result of information carried by an advert message.
- Affective (emotional) – related to shaping a customer's attitude toward a product being influenced by an advert.
- Behavioral (actions) – associated by inducing the customer to act [Fennis, Stroebe 2020].

The power of advertising to influence the viewer is not only due to its nature and the way it works but also equally due to how we choose and buy brands. It is a consequence of innate, natural mental processes, and therefore we are not influenced by it [Heath 2003]. AIDA example model consists of four stages, Attention, Interest, Desire, Action and three phases, Cognitive, Affective and Behavioral, as shown in Table 1.

Table 1. AIDA model

Stage	Description	Phase
Attention	To attract the viewer's attention, make a positive presence in the viewer's mind, and offer the benefits of watching the rest of the ad. The consumer becomes aware of a category, product or brand	Cognitive
Interest	To arouse the viewer's interest through the developed content of the message. The audience must be interested in the advertisement or part of it. The consumer becomes interested in learning about brand benefits & how the brand fits with the lifestyle	Affective
Desire	Desire involves emotions that need to be stimulated. The consumer develops a favorable disposition towards the brand	Affective
Action	Make the audience aware of their emotions or desires to elicit an immediate response. The consumer forms a purchase intention, shops around, engages in a trial or makes a purchase	Behavioral

Source: own research based on [Rawal 2013]

MATERIALS AND METHODS

Galvanic skin response and heart rate were measured using the Neurobit Optima 4, a device for physiological measurements. The galvanometer's functions allow measurements of changes in skin conductivity based on generic modelling of the sympathetic nervous system. GSR measurement was performed using reusable electrodes worn on the fingers. Because physiological stimulation and autonomic nervous system activation are linked, variations in skin electrical resistance may indicate the occurrence of emotions or an involuntary response to the stimuli [Boucsein et al. 2012, 1017-1034; Dawson et al. 2007]. The heart rate (HR) measurements were taken with disposable ECG electrode taped to the left wrist and

registered to establish the frequency of heartbeats per minute [Dulleck et al. 2014]. The Neurobit Optima device has 4 channels for voltage, resistance, conductance and temperature measurements. Data transmission was carried out using Bluetooth digital communication, and the recording of GSR and HR signals was done in CyberEvolution's BioExplorer application, recommended by the equipment manufacturer, Neurobit Systems. The measurement data was recorded with a resolution of 0.5 s, then after transferring to a spreadsheet and calculating the emotional index, a graph of the flow of changes in the emotional index was made [Piwowarski 2018]. Emotional indices were calculated based on test results (GSR and HR) to assess the effect of advertising on receivers. Results of emotion tests show the level of emotions excited by analysed advertising in their subsequent scenes, presented in Figure 2.
The emotional index (*EI*) was determined according to the formula:

$$EI = 1 - \frac{\beta}{\pi}, \tag{1}$$

where

$$\beta = \begin{cases} \frac{3}{2}\pi + \pi - \vartheta & \text{if } GSR_Z \geq 0,\ HR_Z \leq 0 \\ \frac{\pi}{2} - \vartheta & otherwise \end{cases}. \tag{2}$$

GSR_Z, HR_Z represent the Z-score variables of GSR and HR respectively;

$$\vartheta - arctg(GSR_Z, HR_Z).$$

The β angle is defined in order to obtain the EI varying between [-1, 1].

According to (1) and (2), negative $HR_Z < 0$ and positive $HR_Z > 0$ values of EI are related to negative and positive emotions [Mauss, Robinson 2009, 209-237; Vecchiato et al. 2014].

EMPIRICAL DATA

The data were collected in the cognitive neuroscience laboratory of the University of Szczecin. All participants gave written informed consent to participate in the study prepared under the 2013 Declaration of Helsinki, approved by the Bioethics Committee at the Regional Medical Chamber in Szczecin (code 02/KB/VII/2020). The experiment was conducted for a group of 32 persons (19 women and 13 men) of different ages, from 22 to 68 years old. The mean values and the standard deviations are listed in Table 2.

Table 2. The mean values and the standard deviations for participant's age

	N	M	SD
Whole sample	32	41.75	12.68
Women	19	39.95	11.35
Men	13	44.38	14.94

Source: own calculations

The statistical data analyzed for the population under study should be based on random samples large enough to provide a basis for quantitative inference so that the results can be generalized to the entire population [Borkowski et al. 2004, 12]. In the field of behavioural neuroscience, as in all fields of science, determining the sample size is an important factor in ensuring the reliability and accuracy of the results obtained in a study, as well as the reproducibility of the study itself. In studies using advertisements as stimuli, the average number of recruited participants is 33 [Bazzani et al. 2020]. A study conducted to determine how reducing the sample size would affect the results identified thresholds above which the results still showed significance. Assuming a reference population of 36 samples, it was acceptable to reduce the sample size to 24 for a 30-second commercial [Vozzi et al. 2021].

Participants in the study watched a commercial television advertisement for ice cream - a spot with a typical length of 30 seconds. The film frames (seconds) are shown in Figure 2.

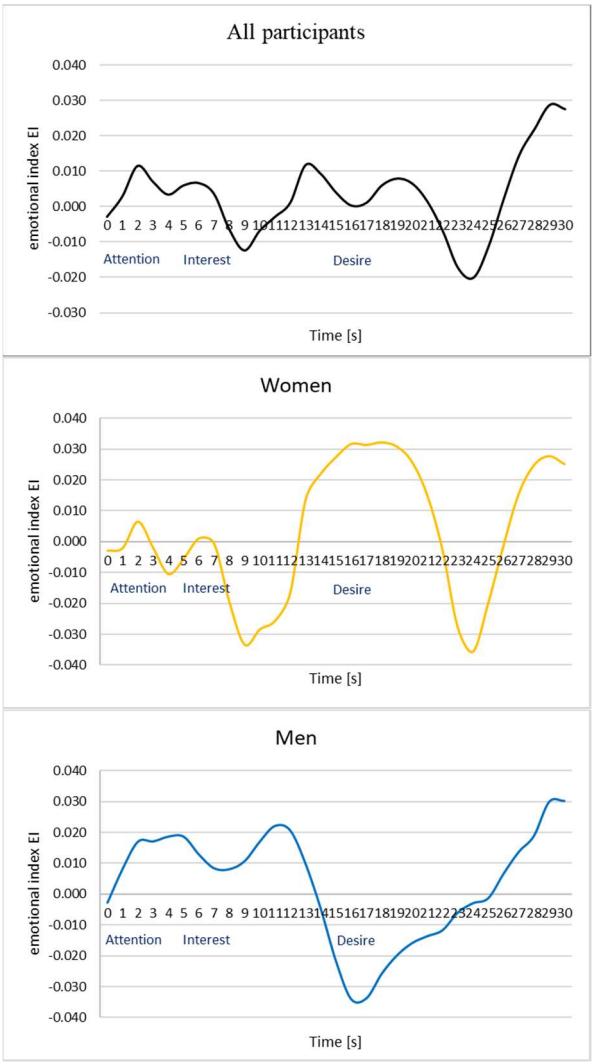
Figure 2. Film frames of the analyzed advertisement

Source: https://vimeo.com/269621878

RESULTS

After calculating the emotional index for the entire study cohort and for women and men separately, the corresponding charts were made. The results are shown in Figure 3.

Figure 3. *EI* emotional index charts



Source: own calculations

The unified index for all participants remains low (most of the time in the [-0.02 to 0.02] range). The index for men and women takes on values with a much higher amplitude than the average. The charts show that women and men may feel different emotions when watching the same scenes. Until the 13th second, the *EI* for men is higher than average, while for women it is lower. After that, the situation is reversed: the *EI* for women increases, reaching a value of 0.032, and for men, it decreases to -0.034. The final drop in the emotional index to a minimum at the 24th second is -0.036 for women and 0.003 for men. Referring to the AIDA model, the

Attention stage elicited almost no emotions in women, while men experienced moderately positive emotions. In the Interest stage, women initially experienced negative emotions and then strongly positive emotions, while men experienced the opposite. Only the last seconds of the commercial (the Desire stage) were received equally positively by both men and women. It can also be noted that according to Solomon's theory of opposing emotions, after the onset of negative emotions, the nervous system compensates with positive emotions, increasing, however, more slowly [Solomon 1980, 691-712].

SUMMARY

The purpose of the article was to present cognitive neuroscience techniques (GSR and HR) for the study of emotions and to verify whether there is a correlation with the corresponding stages of models of advertising influence on the viewer. The study was based on the AIDA model. The results of the analysed advertisement showed that it is possible to assess with a high degree of accuracy whether the advertisement was properly designed (for the adopted model). By analysing the *EI* determined from the GSR and HR studies, it is possible to make appropriate adjustments at the stage of advertising implementation. Referring directly to the analysed advertisement, it should be noted that positive and negative emotions can appear in different situations, depending on gender. The same scenes can be perceived positively by women and negatively by men, and vice versa. Such insights should be taken into account during design and preliminary testing even before broadcasting.

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QUANTITATIVE METHODS IN ECONOMIC RESEARCH
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MACROECONOMIC DETERMINANTS OF BUSINESS MEETINGS WORLDWIDE

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Abstract: The article focuses on trying to explain the cross-sectional variation in the number of business meetings relative to countries. The author subjects to empirical analysis a group of macroeconomic factors that can objectively determine the phenomenon under study. The basic research tool is an econometric model on the basis of which specific conclusions were formulated. The study uses source data from widely published reports, mainly by the ICCA, an association that conducts research on the structure and size of the business meetings market.

Keywords: MICE, business meeting tourism, business tourism, econometric modeling, number of business meetings, macroeconomic determinants of business tourism

JEL classification: Z3, Z32, F2, L83, C01, C5

INTRODUCTION

Tourism is an important and rapidly growing branch of many countries' economies. "The dynamics of both quantitative and qualitative structural changes testify to the rapid development of this sector and its flexible adaptation to global challenges, such as adapting to the needs of the global consumer, or creating innovative solutions in the provision of services and the creation of new tourism products" [Dabrowska 2014]. One of the new types and forms of tourism is the business meetings industry, or business tourism. In Poland, one can most often encounter the term MICE tourism, which is derived from the first letters of the words Meetings, Incentives, Conferences, and Events, however, due to the ambiguous meaning of the word, especially in English, the term is replaced by the aforementioned terms [Anas, Maddiah, Noor Eizamly, Sulaiman, Wee 2020]. The issue under discussion "Includes trips of a professional nature, during which travelers

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enjoy basic tourist services, and in their leisure time satisfy the needs for rest, cognition, entertainment, etc. Its development is associated with the economic flourishing of countries, international economic relations, cooperation between different nations" [Golembski 2009; cf. Bhatia 2006; Sidorkiewicz 2011]. At the same time, the development of the economy significantly promotes the growth of business travel and contributes to the development of the industry of business meetings of professionals, congresses and conferences, which leads to the occurrence of feedback and escalation of the process. Tourism depends very much on the globalization processes taking place [Zelenka 2009; Hall, Coles 2008]. Key changes in consumption patterns, great advances in the fields of communications technology and transportation, and changes in the global economy and politics are having an extremely significant impact on the volume and structure of business trips [Levitt 1983; Davidson 1994; Niezgoda, Zmyślony 2006; Stiakakis, Georgiadis 2011; Reshetnikova, Magomedov 2019]. There is no doubt that the most important role in business destination planning is played by macroeconomic indicators, which have a key impact on demand for MICE-related services and facilities. Business tourism in many countries has now become an important segment of the tourism market largely due to the high expenses accompanying trips of a professional nature. According to estimates conducted by the United Nations World Tourism Organization (UNWTO), over the last decade of the 20th century the meetings industry was the area of tourism showing the greatest degree of progression. It accounts for about 15% of the global tourism market, while the daily spending of business tourists exceeds that of leisure travellers by almost 50% [UNWTO 2015]. Similarly, data collected by international organizations such as the International Congress and Convention Association (ICCA) and the Union of International Associations (UIA) on the number of international conferences and congresses held by each country show the dynamic growth of the industry [ICCA 2013]. From an economic point of view, the area of business meeting tourism represents the most promising and interesting part of the tourism market (Zbyrowska, 2017). This is evidenced by both a significant number of arrivals and higher average spending relative to other segments of the tourism market. It is worth noting that despite the global crisis at the turn of 2007-2009, the turmoil caused by chaotic changes in currency exchange rates, the introduction of onerous airport security measures for travelers, sharp increases in fuel prices and the pressure to increase the efficiency of business meetings held, the global meetings market industry has prospered and recorded continuous growth. There has been no decline in supply on the part of cities and countries still interested in acting as business travel destinations. On the other hand, there has been growing interest from new countries wishing to actively engage in this form of tourism, while conducting effective promotion of their own country, its natural assets, rich cultural background, the quality of infrastructure and services offered, and the attractiveness of the prepared offer [Balakrishnan 2009]. The business meetings industry is an extremely complex system consisting of many interrelated organizations and activities that are subject to the processes of the global

market, and changes in the customer sector [Kulendran, Wilson 2000; Bradley, Hall, Harrison 2002; Hall, Coles 2008]. Understanding these phenomena, continuous monitoring of the processes taking place and the effectiveness of adaptive measures within a turbulent environment are prerequisites for a country's success internationally [Blanco, Rey-Maquieira, Lozano 2009].

The purpose of the study is to verify what factors influence the development of business meeting tourism including the number of meetings held in each country. Exogenous variables that can affect the explanatory variable are: country size, country GDP, GDP per capita, EU membership, exports of goods, exports of services, imports of goods, imports of services, foreign direct investment inbound, foreign direct investment outbound. The study formulated the following research hypothesis: The study posits the following research hypothesis: A set of macroeconomic determinants, including country size, country GDP, GDP per capita, EU membership, exports of goods, exports of services, imports of goods, imports of services, inbound foreign direct investment, and outbound foreign direct investment, plays a significant role in influencing the prevalence of business tourism meetings in each country worldwide.

SOURCE DATA AND ITS CHARACTERISTICS

There is a significant deficit of ongoing empirical research on business tourism and business travel worldwide. The most important international federations specializing exclusively in tourism market analysis and research, responsible for collecting data on global business tourism, conferences and business travel are the International Congress and Convention Association and the Union of International Associations, mentioned earlier. It is possible to point out differences between them in their research both in terms of methodological assumptions and subject matter. The scope of the subject matter is related, among other things, to the objectives of the organization's operation and its nature [Godlewski 2008].

Table 1. Criteria for estimating the number of business meetings by international organizations

International organizations	ICCA	UIA
Ranking realization criteria	– the meetings are held periodically, – minimum of fifty meeting participants, – minimum of three countries present at the meeting.	– meetings last at least three days, – bring together a minimum of three hundred participants, – participants come from a minimum of five countries, – a minimum of 40% are participants are foreigners.

Source: UIA Report (2015); ICCA Report (2014)

For the purposes of this study, a number of reports were used, including one of the most important published by ICCA - the world's largest association dedicated to conducting research on the structure and size of the business meetings market, with more than a thousand members (organizations and companies) from ninety countries around the world. ICCA publications are the most common and respected reports treating the size of the market in question.

The statistics are from 2014 and were gathered from reports published by the following organizations:

- ICCA Statistics Report 2014,
- The World Bank,
- United Nations Conference On Trade And Development UNCTAD,
- Central Intelligence Agency.

Based on the characterization of the business meetings industry, the main focus was on obtaining and analyzing macroeconomic data identified by many experts and the literature as key to the development of the tourism sector, especially business tourism. The data analyzed includes 90 countries and 11 variables (the research sample contains 90 observations). Due to the fact that the data is for 90 countries, but from a single time period, a sample of so-called cross-sectional data was obtained. For the purpose of the analysis, data covering countries classified in ICCA statistics was used. The explained variable was the number of business tourism meetings held per year (endogenous variable). Countries holding fewer than five meetings per year were omitted from the statistics. For some countries, not all the economic data included in the model was available. Hence, in creating a balanced sample, cross-sectional units for which there were data gaps were removed. The final convention adopted for the empirical study includes a set of variables to be characterized as follows:

Business meetings - the number of international conferences, congresses and seminars held in each country during the year, classified based on the assumptions in Table 1;

Country size - the total land area of each country excluding the area of inland waters (rivers, lakes) and continental shelves (expressed in square kilometers);

A country's GDP - the sum of the value added by all resident producers in the economy, plus any taxes imposed on products and minus any subsidies not included in the value of products (data expressed in U.S. dollars). The values have been converted to dollars from national currencies using the annual official exchange rate;

GDP per capita - a country's GDP divided by the intra-country population, data expressed in U.S. dollars;

EU membership - a binary variable indicating whether a country subsumes membership in the European Union;

Exports of goods and services - represents the value of all market goods and services transferred to the world by a country. These include the value of goods, freight,

insurance, transportation, travel, royalties, license fees and other services such as communications, construction, finance, information. Prices exclude employment-related costs and investment income and transfer payments (expressed in millions of dollars);

Imports of goods and services - the value of all market goods and services received by a country from the rest of the world. These include the value of goods, freight, insurance, transportation, travel, royalties, license fees and other services such as communications, construction, finance. Prices exclude employment-related costs and investment income and transfer payments (expressed in millions of dollars);

Inward and outward foreign direct investment - data on flows of Foreign Direct Investment, expressed in net amounts, understood as a category of international investment, made by a resident of one country with the intention of exercising long-term control in the enterprise of another country (expressed in millions of dollars).

MODELING INSIGHTS AND RESEARCH FINDINGS

Estimation of the correlation matrix for the quantitative variables under study was taken as a preliminary step in assessing the relationship. In fact, only one variable i.e. EU membership has a binary nature, hence it was excluded from the correlation analysis.

Table 2. Pearson linear correlation matrix for the variables under study

Variable	business meetings	country size	a country's GDP	GDP per capita	exports of goods	exports of services	imports of goods	imports of services	inward foreign direct investment	outward foreign direct investment
business meetings	1.00									
country size	0.31	1.00								
a country's GDP	0.71	0.55	1.00							
GDP per capita	0.35	0.01	0.16	1.00						
exports of goods	0.73	0.49	0.84	0.21	1.00					
exports of services	0.43	0.21	0.49	0.12	0.41	1.00				
imports of goods	0.79	0.48	0.94	0.21	0.96	0.49	1.00			

Variable	business meetings	country size	a country's GDP	GDP per capita	exports of goods	exports of services	imports of goods	imports of services	inward foreign direct investment	outward foreign direct investment
imports of services	0.42	0.23	0.48	0.12	0.49	0.24	0.51	1.00		
inward foreign direct investment	0.52	0.56	0.65	0.20	0.70	0.31	0.72	0.33	1.00	
outward foreign direct investment	0.60	0.43	0.85	0.22	0.75	0.44	0.85	0.43	0.57	1.00

Source: own elaboration

The correlation coefficients included in Table 2 have relatively high values given the sample size of n = 90. The minimum threshold for a significantly different from zero correlation that can be determined in GRETL or R is 0.2072 for n = 90 in this case (with a two-sided 5% critical area). Hence, virtually any of the variables analyzed can significantly affect the number of business meetings. Note that the estimates of correlation coefficients indicate the possibility of only a positive relationship. In addition, the quantitative variables are from the same year creating a cross-sectional sample relative to the 90 countries analyzed. For this reason, it seems possible to propose a linear regression model with a carefully performed assessment of the homoskedasticity of the residual component. The classical least squares MNK method was used to estimate the structural parameters of the model using Eviews and R. As an auxiliary, the GRETL program was also used. Construction of the regression model required meeting the applicability conditions of the MNK estimator and the basic assumptions of MNK [Gajda 2004], a broader discussion of which is necessary as part of the evaluation of the estimated model.

Table 3. A preliminary model describing the number of business meetings by country

Dependent Variable: business meetings				
Method: Least Squares				
Included observations: 90				
	Coefficient	Std. Error	t-Statistic	Prob.
country size	0.0000	0.0000	0.9284	0.36
a country's GDP	0.0000	0.0000	0.5331	0.60
GDP per capita	0.0009	0.0004	2.4473	0.02

Table 3. Continued

	Coefficient	Std. Error	t-Statistic	Prob.
EU membership	86.7313	21.8436	3.9706	0.00
exports of goods	-0.2956	0.1146	-2.5788	0.01
exports of services	0.0363	0.0694	0.5232	0.60
imports of goods	0.6572	0.1243	5.2890	0.00
imports of services	0.0397	0.0778	0.5102	0.61
inward foreign direct investment	-0.0006	0.0006	-0.9725	0.33
outward foreign direct investment	-0.0009	0.0005	-1.8227	0.07
C	10.1845	13.6549	0.7459	0.46
R-squared	0.760447	Mean dependent var		121.5222
Adjusted R-squared	0.730124	S.D. dependent var		158.6511
S.E. of regression	82.418650	Akaike info criterion		11.7756
Sum squared resid	536633.8	Schwarz criterion		12.0811
Log likelihood	-518.9012	F-statistic		25.0781

Source: own development in Eviews program / R

The model estimated on the basis of a cross-sectional sample that consists of relatively heterogeneous units understood as 90 countries proved susceptible to the presence of heteroskedasticity in the residual component (white heteroskedasticity test statistic 132.45). Hence, the formulas from which the variance of the estimators is calculated are loaded. In this situation, confidence intervals and hypothesis testing based on T and F tests may not be reliable leading to erroneous conclusions and, consequently, an incorrectly specified model [Borkowski 2007]. The model was brought to its final form using robust estimators of the variance-covariance matrix (White, Newey-West) implemented in Eviews or R packages. In addition, during modeling, the residual component was found to be inconsistent with the normal distribution and the so-called "fat tails" of the model's residual distribution. Especially the latter property (i.e., fat tails of residuals) could adversely affect the reliability of the statistical tests performed. In this situation, the conformity of the distribution of the residual component to the normal distribution was achieved by switching to nonlinear relationships, where the Ramsey RESET test F-statistic value was equal to 6.1559 for the linear model. Injecting natural logarithms for selected variables had the effect of limiting the sample to 77 countries for which the variable "outward foreign direct investment" (i.e., foreign direct investment flowing out of the country) takes only positive values. The final estimated model has a disturbance distribution with the desired properties without the so-called "fat tails". Moreover the Ramsey RESET test F-statistic value is 2.0628 for the nonlinear model. In the

final model some variables had been removed based on the t-Statistic value and robust estimators of the variance-covariance matrix (White, Newey-West). After removing variables that do not affect the number of business meetings from the model, the following estimation table was obtained:

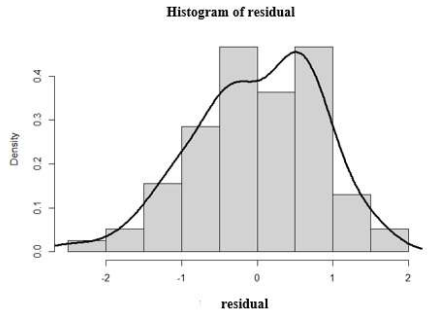
Table 4. The final model to explain the number of business meetings by country.

Dependent Variable: LN (business meetings)				
Method: Least Squares				
Sample(adjusted): 1 89				
Included observations: 77				
Excluded observations: 12 after adjusting endpoints				
Newey-West HAC Standard Errors & Covariance (lag truncation=3)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EU membership	1.075440	0.191311	5.621433	0.0000
LN (outward foreign direct investment)	0.245519	0.050509	4.860928	0.0000
imports of goods	0.000947	0.000313	3.029897	0.0034
C	1.717967	0.290555	5.912708	0.0000
R-squared	0.671960	Mean dependent var	3.95651	
Adjusted R-squared	0.658479	S.D. dependent var	1.44689	
S.E. of regression	0.845564	Akaike info criterion	2.55292	
Sum squared resid	52.19341	Schwarz criterion	2.67468	
Log likelihood	-94.28757	F-statistic	49.8446	

Source: own development in Eviews program / R

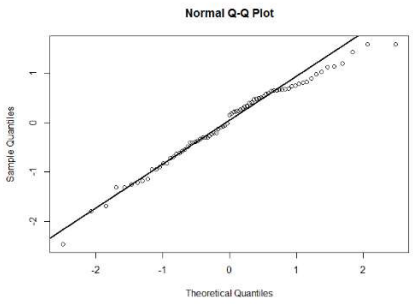
As mentioned earlier, an important issue for evaluating the model built is the distribution of the residual component. Figure 1 shows the histogram of the model's random perturbations and the probability density curve.

Figure 1. Distribution of the residual component of the model



Source: developed in R program

Figure 2. Empirical and theoretical quantiles for the residual component



Source: developed in R program

The study focused attention on the contours of the tails of the disturbance distribution and the associated probability of extreme values of the residuals. When the extreme values of a di stribution occur with similar frequency to that of a normal distribution, it can be assumed for the purposes of statistical testing that the residual component has a distribution close to normal [Mycielski 2009]. Figure 2 shows the discussed issue.

Table 5. Summary of tests of the consistency of the model's residuals with the normal distribution

Shapiro-Wilk normality test	Jarque Bera Test	Anderson-Darling normality test
W = 0.97973 p-value = 0.2565	X-squared = 2.4612 p-value = 0.2921	A = 0.49313 p-value = 0.2109

Source: own development in R software

Notation of the analytical form of the model equation:

$\ln(\text{business meetings}_i) = 1.7197 + 1.0754\ \text{EU membership}_i + 0.2455 \ln(\text{outward foreign direct investment}_i) + 0.0009\ \text{imports of goods}_i$

Intercept term is generally not subject to interpretation, but in the case of the model presented here, a certain number of business meetings can be expected to occur in the countries studied even when the values of the explanatory variables are close to zero. The evaluation of the parameter with the variable EU membershipi was 1.0754, and means that if a country is characterized by its membership in the European Union, the number of business meetings held by this country will be almost three times higher on average (de-logarithmic value of 2.9313) compared to a non-member country, while keeping the influence of other variables unchanged. This is in line with existing trends in business tourism, as globally most business travel is to Europe [Davidson 1993].

Foreign investment "flowing out" of the country also has a positive effect on the number of meetings discussed. In this case, a 1 percent increase in the value of the variable outward foreign direct investment$_i$ results in an increase in the expected number of business meetings by an average of 24.55 percent under the ceteris paribus assumption.
In addition, the parameter next to the imports of goods$_i$ variable (value 0.0009) indicates that if the value of a country's imports of goods increases by a unit (10 million USD) then the number of business meetings held by that country should be expected to increase by an average of 0.0947 percent, based on a ceteris paribus assumption. Thus, a country that imports more goods is becoming a more willing destination for business meetings.

The adjusted R-square of the estimated model took a value of about 0.66, so the equation was able to explain almost 66% of the variation in the number of business meetings held in the countries studied. This is not a particularly high result, but it is important to note the properties of the model, which has parameter estimates that are significantly different from zero based on a check of the Student's t-test. In addition, the correct distribution of the residual component, together with the use of a robust matrix of Newey-West parameter error estimates, leads the researcher to trust the results obtained for a research sample that is diverse and cross-sectional with respect to many countries.

CONCLUDING REMARKS

An empirical study based on an econometric model confirmed the influence of selected objective macroeconomic factors on the number of business meetings held around the world. The set of factors finally distinguished includes: membership in the European Union, outward foreign investment from each country and the volume of imports of goods. It should be noted that the research hypothesis formulated at the beginning of the study has been confirmed. However, not all the variables initially defined, proved adequate to describe the variability of the phenomenon under study. All parameters accompanying the variables in the final presented model have a positive sign, and their estimates are consistent with the economic conditions and dependencies present in the studied sphere of the tourism sector. Possible directions for future research include the possibility of extending the model to a larger sample size and a new set of explanatory variables. In addition, in terms of the number of business meetings discussed, it is planned to conduct fair comparisons of the data collected by the two organizations, i.e. ICCA and UIA, along with the formulation of conclusions of a general and cross-sectional nature. The main limitations of this study related to the data used. The potential for further research is to estimate an econometric model based on the latest dataset with a special concern to the COVID-19 global crisis. Moreover the research lays the groundwork for continued exploration and remains a pertinent reference point for understanding the complexities of global business tourism.

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COMPETITIVENESS OF INTERMODAL TRANSPORT IN THE OPINION OF EXPERTS FROM THE BALTIC SEA REGION

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Abstract: The article presents the results of a survey conducted among experts in the field of transport research, from the Baltic Sea region, on the competitiveness of intermodal transport in relation to road transport. The study aimed to identify factors that positively and negatively influence the choice of intermodal transport as an alternative to road transport along the entire transport route. The available literature was reviewed, and attention was paid to the problem of differences in the perception of intermodal transport by experts from different countries. It was also indicated that, depending on the approach to this problem and the local point of view, significantly different results can be obtained regarding the factors influencing the choice of intermodal transport as an alternative to road transport.

Keywords: intermodal transport, road transport, competitiveness, Baltic region

JEL classification: F0, R5, L9

INTRODUCTION

Due to the fact that transport is essential in the functioning and development of the modern economy [Bylinko 2018], it seems necessary to eliminate its negative effects. Air pollution, noise and congestion referred to in the literature as external costs of transport [Pawłowska 2018], have become the target of European Union activities, the ultimate goal of which is the complete decarbonization or significant reduction of emissions of this branch of the economy [Clean and sustainable mobility 2023; The European Green Deal 2019]. According to Eurostat data, in the European Union, transport as the cumulative value of the category „transportation and storage"

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represents ≈ 10% of total greenhouse gas emissions in 2023 [Statistics: Eurostat]. Analyzing the above data in relation to previous years, it can be concluded that in the years 2015-2023, excluding the years in which restrictions caused by the Covid19 pandemic were in force, transport is the only category that records a systematic annual increase in total greenhouse gas emissions. On a year-to-year basis, the average annual growth was ≈ 0.85% in the full period of 2015-2023 and ≈ 6.77% excluding time of the pandemic lockdowns. The impact of the pandemic on the economy is significant, although transport saw a significant decline in transshipments, in practice the value of emissions in thousands of tones in years 2015-2023 practically did not change, which is an exception for other industries where emissions are reduced. One of the tools that can reduce the overall transport emissions is to move away from the currently dominant road transport in favor of more environmentally friendly solutions, such as rail transport or inland navigation. [Efficient and Green Mobility; Psaraftis 2016; Shah et al. 2021]. In the assumption of EU transport policy, this can be achieved by utilizing intermodal transport, [Miklińska 2017] i.e. the use of one standard transport unit (container, semi-trailer or swap body) and moving it without dismantling by utilizing at least two modes of transport [Kine et al. 2022] in order to make the best use of their strengths. Observing changes in the European transport market, in the context of EU plans, we can notice a significant problem, which is the systematic increase in the share of road transport in the total land transport in Europe. [Freight transport statistics - modal split]. Naturally, this occurs at the expense of inland navigation and rail transport, where a systematic decline in their share within European transportation is observed. Simultaneously, the number of transported cargo units and the overall transport performance in Europe are increasing. However, the tendency to increase the share of road transport in Europe is contrary to the adopted assumptions of the EU's transport policy and is raising concerns about the possibility of achieving the planned climate goals. Hence, the question arises regarding the reasons for the lesser competitiveness of alternative to road transport cargo transportation methods. The answer to the above is necessary to be able to make changes in the organization of transport or in regulations and transport laws, which will lead to better utilization of intermodal transport. In this article, an expert-based response to the aforementioned question is presented by identifying areas where the competitiveness of intermodal transport relative to road transport (for the entire route) manifests both positively and negatively.

LITERATURE REVIEW

First and foremost, it should be noted that for the purposes of this study, the following definition of competitiveness was adopted: “competition is understood as the ability of entities to achieve success in conditions of competition between them. This concept is referred to as a method of action, a struggle for specific economic benefits, competition, a process [Grzybowska 2012]”. In the sense

of taking an entity as a form of transport. In the literature of the subject, two basic divisions of sources can be distinguished. The first is a collection of sources resulting from orders such as reports and analyses, while the second consists of sources in the form of books and articles. It is important to separate these two sets due to different approaches adopted. Scientific articles generally describe a specific problem, while reports aim to describe a certain issue and reach a wider audience (such as experts from other fields than the subject of the report). In the context of the article, it is possible to adopt a general approach that reports and analyses will focus mainly on the positive aspects of intermodal transport competitiveness, while scientific publications will tend to focus on negative issues. Due to the adopted limitations, only a few sources outlining the general approach to the topic will be described below.

One of the most important reports is the one prepared periodically by UIC experts (Fr. Union Internationale des Chemins de fer, Eng. International union of railways) [railways 2023]. In the document from 2020 [2020 Report on Combined Transport in Europe 2020], many factors that affect intermodal transport competitiveness, both positively and negatively, were identified, selected of them are presented in Table 1

Table 1. Selected factors affecting the competitiveness of intermodal transport from the UIC 2020 report

Having a positive impact	Affecting negatively
Reduction of greenhouse gas emissions	Lesser flexibility
Higher energy efficiency of transport	Bottlenecks
Increased safety in road transport associated with fewer accidents	Lower infrastructure density in rail and inland waterway transport than in road transport
Noise reduction	Additional reloading time
Bypassing transport restrictions related to legal regulations	Additional cost of reloading operations

Source: chosen, from: 2020 Report on Combined Transport in Europe

Currently available reports and analyzes also include the UN (United Nations) report analyzing market changes caused by the Covid19 pandemic [Intermodal Transport in the Age of COVID-19: Practices, Initiatives and Responses 2020]. In that report it is shown that the most significant market aspects influencing the development of intermodal transport are the progressive computerization (development of telematics, progressive digitalization), the simplification of procedures in freight transport and, among others, the trend of creating "green transport lines".

Looking at selected scientific publications, authors such as Kurtulus E. and Çetin I. B. [Kurtuluş, Çetin 2020] are writing that according to their model based on survey research and interviews with entrepreneurs, intermodal transport is most often chosen due to its competitiveness in terms of time (including the regularity

of connections) and transport costs. A high correlation coefficient was also attributed to the size of the enterprise (those with fewer than 50 employees more often prefer road transport) and whether it already uses intermodal solutions. The authors also indicated a certain correlation in terms of the amount of fees for handling and storing cargo units, but this coefficient was not assigned a high value (compared to the others). The article also briefly covers the impact of transport policy, but the authors point out that the strength of its impact depends on the existence of specific legal solutions. Zając M. and Świeboda J. [Zajac, Swieboda 2017] point out the high importance of transport policy (ecological policy, deregulation of the rail transport market and subsidy programs for intermodal transport). As the main positive factors, they indicate the technological development of railway wagon constructions, various management possibilities within intermodal transport chains (the company does not have to have its own means of transport) or increased flexibility of intermodal transport compared to exclusive rail transport along the entire transport route. As one of the conclusions, the authors conclude that for intermodal transport to be fully competitive, it must offer flexibility and prices similar to road transport (throughout the transport route), and investments should also be made to improve the quality of infrastructure (in the most popular and frequently used transport routes, at the expense of less significant ones) Mindur L. [Mindur 2021] also points to the importance of transport policy in terms of, for example, reducing the negative effects of transport and EU (European Union) overall support for intermodal transport. However, referring to Asian examples, he also draws attention to factors that negatively affect the development of intermodal transport, such as uneven cargo flows in rail transport or low competitive potential within the railway transport sector. The most important positive factors, indicated by the author, include the progressive standardization in the technical and technological aspects of transport (loading units, reloading devices, terminals, etc.) as well as the unification of intermodal systems in economic and organizational terms. On the negative side, uneven development, and sometimes low density of transport infrastructure (rail, water, road, or terminal) were indicated. The last of the authors listed in this article is Antonowicz M. [Antonowicz 2018], who describes insufficient support for the development of railway infrastructure (low commercial train speed or network capacity), and at the same time, negligible support for the development of the road segment of intermodal transport chains (in terms of expanding the fleet to handle container transport, modern trailers, or swap bodies). On the positive side of intermodal transport development, the increasing containerization of cargo and the adopted direction of transport policy were indicated. At the same time, the author discusses many elements of transport programs and policy that should be undertaken, such as improving the flow of information within the transport chain, reducing or eliminating certain fees (such as viaTOLL or fees for using the railway network), increasing priorities for intermodal trains, or introducing bans (following other EU countries) on the operation of heavy road vehicles.

METHODOLOGY

The results presented in this study are based on a survey conducted among European transport experts. The selection of experts was purposive and was carried out using the citation tracking method by analysis of scientific databases aggregating publications and the ReasearchGate portal. Experts with publications in the field of intermodal, rail and inland transport, transshipment terminals (including seaports), as well as issues of transport and logistics networks and chains were searched for. The focus was on these topics in the context of European freight transport. The survey was conducted using the CAWI method (Computer Assisted Web Interview) in the form of surveys in English. For the purposes of this study, three questions from a broader survey were used. The first of them is a single choice closed question aimed at determining whether intermodal transport is a real alternative to road transport (the entire transport route) in relation to the country of residence of the respondents. The second and third questions were open-ended and encouraged respondents to indicate factors that, in their opinion, positively, and negatively affect the competitiveness of intermodal transport (in relation to road transport). In this way, opinions of thirty-one experts from countries such as Poland, Sweden, Norway, Estonia, Lithuania, and Finland were obtained. The results are broken down by country and presented in the next part of the article.

RESULTS

Poland

Due to its location, Poland is an important link in the transport network of the Baltic Sea region, functioning as a connector for other regions of Europe. Ten experts took part in the study, three of whom believe that intermodal transport in Poland is not a real alternative to road transport along the entire transport route, while seven have a different opinion. Selected most frequently indicated factors having a positive and negative impact on the competitiveness of intermodal transport are presented in Table 2.

Table 2. The most important factors influencing the competitiveness of intermodal transport in the opinion of Polish experts

Having a positive impact	Affecting negatively
Reducing congestion	Transport and reloading costs
Greater eco-friendliness	Flexibility
Cargo security	Time of the entire transport process
Economies of scale associated with the ability to transport more or heavier cargoes in one shipment	Poor quality of railway infrastructure

Source: own study

Sweden

Sweden functions as a local cargo distribution hub, in particular in relation to the European north-south transport corridor running from Mediterranean ports towards Scandinavia. Eight experts took part in the study, three of whom believe that intermodal transport in Sweden is not a real alternative to road transport along the entire transport route, while five disagree. The selected most frequently indicated factors positively and negatively influencing the competitiveness of intermodal transport in the opinion of Swedish experts are presented in Table 3.

Table 3. The most important factors influencing the competitiveness of intermodal transport in the opinion of Swedish experts

Having a positive impact	Affecting negatively
Reducing congestion	Time of the entire transport process
Energy efficiency of transport	Complexity of the transportation process
With good planning - lower cost	Flexibility
Greater eco-friendliness	Transport and reloading costs

Source: own study

Norway

Two Norwegian experts took part in the study, both of whom believe that intermodal transport in their country is a real alternative to road transport along the entire transport route. The selected most frequently indicated factors having a positive and negative impact on the competitiveness of intermodal transport in the opinion of the above-mentioned are presented in Table 4.

Table 4. The most important factors influencing the competitiveness of intermodal transport in the opinion of Norwegian experts

Having a positive impact	Affecting negatively
Greater eco-friendliness	Time of the entire transport process
Lower cost of long-distance transportation	Flexibility
	Service/handling time at the terminals
	Poor regularity

Source: own study

Estonia

Two Estonian experts took part in the study, one of whom believes that intermodal transport in Estonia is not a real alternative to road transport along the entire transport route, while the other has a different opinion. The selected most frequently indicated factors positively and negatively influencing the competitiveness of intermodal transport in the opinion of Estonian experts are presented in Table 5.

Table 5. The most important factors influencing the competitiveness of intermodal transport in the opinion of Estonian experts

Having a positive impact	Affecting negatively
The transport capacity of road transport is limited (permissible weight, driver availability and infrastructure capacity)	Low cooperation between entities
Transport policy	Social habits
Competitive for longer distances	Regulations not made in mind of new transport solutions
Lower personnel costs (drivers)	Three different rail gauges in Europe

Source: own study

Lithuania

Five experts from Lithuania took part in the study and all of them agree that intermodal transport in Lithuania is a real alternative to road transport along the entire transport route. Selected most frequently indicated factors positively and negatively influencing the competitiveness of intermodal transport in the opinion of Lithuanian experts are presented in Table 6.

Table 6. The most important factors influencing the competitiveness of intermodal transport in the opinion of Lithuanian experts

Having a positive impact	Affecting negatively
Lower cost	Poor development in the field of IT, which extends the time of cargo handling
Greater eco-friendliness, reducing congestion	Weather (difficult to use inland water transport in winter)
Demographic situation of the region (e.g. driver shortages)	Short transport distances in Lithuania, which often makes it impossible to use all available solutions
High road tolls	Requires larger loads (weight, quantity), reloading is necessary

Source: own study

Finland

The study involved four experts, half of whom believe that intermodal transport in Finland is not a real alternative to road transport along the entire transport route, while the other half has a different opinion. Selected factors most frequently indicated that have a positive and negative impact on the competitiveness of intermodal transport in the opinion of Finnish experts are presented in Table 7.

Table 7. The most important factors influencing the competitiveness of intermodal transport in the opinion of Finnish experts

Having a positive impact	Affecting negatively
Greater eco-friendliness	Transport and reloading costs
Reducing congestion	Low population density
Improving road safety	Ease of using road transport
Transport security	Time of the entire transport process

Source: own study

CONCLUSION

As shown in the article, both surveyed experts and literature sources agree that issues related to ecology are the most important factor positively affecting the competitiveness of intermodal transport compared to road transport. In this matter, often mentioned are: reducing road congestion, reducing emissions and higher energy efficiency of intermodal transport. Scientific articles more often raise the issue of transport policy, but also some experts pointed out its positive impact on the competitiveness of intermodal transport. Other positive factors include transport safety, possible economies of scale, lower personnel costs (drivers), and in the case of good planning, lower total transport costs. On the negative side, experts point to transport flexibility as the most important factor working to the detriment of intermodal transport. The total transport time can also be indicated as an important factor negatively affecting the competitiveness of intermodal transport compared to road transport. Other negative factors include: poor quality of railway infrastructure, low regularity, the impact of weather conditions, local, social, cultural, and demographic issues, outdated rules and regulations and different technical/technological requirements dependent on the country (e.g. different rail gauges). The presented results also show differences in the perception of intermodal transport by experts in the Baltic Sea region. Studying competitiveness factors is necessary if we want to achieve the goals set by EU transport policy. Such studies allow to understand differences between countries and to find basic problems and areas where current actions achieve the best effect. The above leads to a better understanding of the subject of intermodal transport, which then enables improvement in the cooperation of regions and the conduct of development activities and activities related to the implementation of the assumptions of the EU transport policy.

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QUANTITATIVE METHODS IN ECONOMIC RESEARCH
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USING THE OEE TOOL AS AN INDICATOR TO INCREASE PRODUCTION EFFICIENCY

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Abstract: The article presents the use of the OEE tool in a production plant. The aim of the article was to verify whether the use of the OEE indicator will indicate where time is wasted in production. Does the integration of individual programs: classes suchas; APS, MES, ERP, CMMS contribute to the production department achieving better production efficiency? Theoretical considerations were supplemented with an analysis of the production process of an injection molding machine in a plastics processing plant.

Keywords: production efficency, OEE, System integration: APS, MES, ERP, CMMS

JEL classification: C22, L11, L15

INTRODUCTION

Implementing the ERP (Enterprise Resource Planning), APS (Advanced planning and scheduling), MES (Manufacturing Execution System) or CMMS (Computerised Maintenance Management Systems) softwares into production shortens cycle times, and boosts company profits. However, a German study by IDC reveals that 90% of respondents spend excessive time aligning with different production process stages. Inefficient communication leads to production bottlenecks. Dmowski et al. suggest that deepening cooperation between people and manufacturing devices can increase productivity by 25% and departmental efficiency by 30%. The author emphasizes full integration of automated production parts for optimal resource use. The diagram in Figure 1 illustrates the software facilitating collaboration within the production department and the corresponding information flows.

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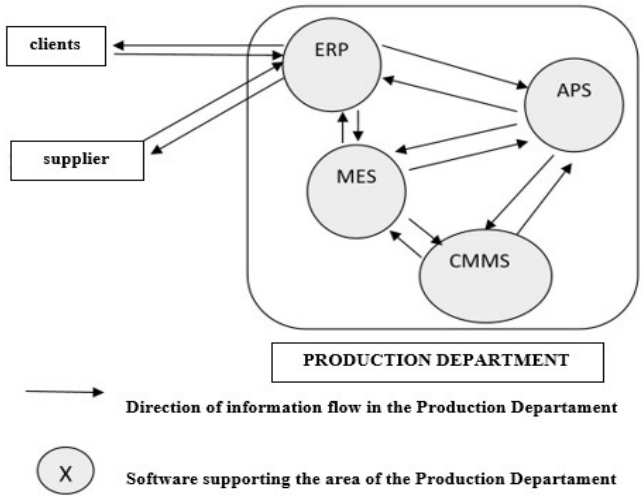
Figure 1. Individual parts of the production department supported by software: ERP, APS, MES, CMMS, and the direction of information flow between them



Source: own elaboration

Communication within the automated production departments (Figure 1.) primarily relies on telephone calls or emails with Excel-type sheets exchanged between the departments, facilitated by employees utilizing ERP-class software. Data, including HR details and warehouse status, is entered into ERP systems and then transmitted to those involved in production planning (APS).

However, this communication method often introduces significant noise, leading to potential information transmission issues. In one surveyed enterprise employing two planners, duplication of information regarding available semi-finished products in the warehouse occurs between the data handling department (ERP) and logistics department (ERP). Planners may lack information about reservations, potentially causing delays in order execution.

To prevent planning errors, planners must communicate with each other to determine the necessary raw material quantities based on actual warehouse availability. In cases of missing raw materials, planners (APS) must inform (ERP) to reserve or order semi-finished products, even from external sources. For internally produced items, ERP must log the execution of internal orders and transfer this information to planning employees (APS).

When placing orders with suppliers, those entering orders into (ERP) wait to ensure delivery profitability while maintaining minimum production costs. Timely information from the production department, such as raw material usage or machine downtime, reaches planning employees (APS) only after the shift or order completion, causing additional time and financial losses. The scheduler (APS) may

inquire about machine downtime reasons from the shift master (MES) after the fact, learning about issues like material color changes, failures, defects, or incorrect machine settings that impacted raw material consumption. Rapid dissemination of such information to planners and logistics (ERP) is crucial for material ordering in ongoing production orders.

THE IMPORTANCE OF THE OEE INDICATOR FOR ACHIEVING OPTIMAL USE OF PRODUCTION EQUIPMENT

The main determinant describing the effectiveness of the use of technical means in the enterprise is the indicator of the total efficiency of machines/use of equipment OEE (Overall Equipment Effectiveness - OEE), which can also have the meaning: Total Equipment Efficiency or Equipment Performance Index. This indicator allows you to make key decisions regarding the manufacturing process on an ongoing basis. Its main components are the availability of the machine, its use (efficiency), and quality [PN-EN 15341:2007 Maintenance 2007, MP2 IQ Solutions, company documents]. Its percentage result, which is the product of the components, informs how efficiently the machine or even the entire production line and the employees operating the devices work.

Machine availability is expressed as a ratio of machine working time, the so-called operational time, to the planned production time. Its value below 100% means that there has been an unforeseen stoppage of the machine, e.g. a failure or additional setting of the machine may have occurred [Mróz 2012; Biały, Hąbek 2016].

Performance (efficiency) is expressed as the ratio of the time the machine is available to the time it is working. This indicator informs what time is necessary to complete the order (number of valuable products produced in a given time). At the same time, if the obtained result is below 100%, it gives knowledge of what part of the assumed production volume was produced in a given time [Mróz 2013; Biały, Hąbek 2016].

Quality expressed in the form of machine working time informs about the efficiency of the use of time and its work. When the value of the obtained result is below 100%, it means that a certain time range of the machine's operation produced products of defective quality. Only the quick reaction of the operator can unravel what errors have caused the machine's production quality to deteriorate.

The main purpose of determining the OEE indicator is to find, and search for which of the three analyzed components of the machine's work, losses are generated. Table No. 1 below, shows the three components of the OEE indicator along with possible losses in the examined areas. According to World Class recommendations, machine availability should be at the level of 90%, its performance at the level of 95%, and the quality of products made at the level of 99%.After entering the individual results into formula No. (1) below, the manufacturing company should

obtain an OEE indicator of 85% [https://www.oee.com 2023, WMP SYSTEM, OEE 2023].

$$OEE = P \times Q \times A \tag{1}$$

where:

P – performance computed as: $P = \frac{wt}{tdp \times \text{number of machines}}$, (2)

where:

wt – working time of all machines in a given period,
tdp – time duration of the period,

Q – quality computed as: $Q = \frac{number\ of\ good}{number\ of\ all}$, (3)

where:

number of good – number of good pieces produced in the period,
number of all – number of all pieces produced in the period,

A – availability computed as: $A = \frac{\sum_{i=1}^{\text{number od cycle}} ct_i}{\text{number of cycle}}$, (4)

where:

ct_i – cycle time index computed as: $ct_i = \begin{cases} rc/tc & \text{if } rc < tc \\ 1 & \text{if } rc \geq tc \end{cases}$, (5)

rc - real time of a single cycle,
tc - assumed single cycle time based on technology.

This is a result that is extremely difficult to achieve, especially when the production line requires many machine changes. In the case when the machines work in a three-shift system and a single element, is mass-produced, a high index value can be obtained. According to World Class, this value is achieved by global producers, while a score of 70% proves to be an excellent producer, while a level of 50% proves to be a good producer. you. As a rule, most manufacturers declare achieving an OEE indicator of 60%. In addition, more manufacturing companies achieve 45% OEE than companies that oscillate around 85% [https://www.oee.com 2023, WMP SYSTEM, OEE 2023].

Table 1 Losses in machine operation assigned to the three components of the OEE indicator

Components of the OEE indicator	Losses in machine operation
Availability	– failures, – too long changeover time
Performance	– machine idle – minor short downtimes (up to 10 minutes), – reduced machine speed
Quality	– deficiencies – production losses during start-up

Source: https://leantrix.com/pl/wskaznik-oee/ [access: May 20, 2023]

According to Krasón P. [Krasón 2016] OEE is an extremely useful tool. However, it involves a certain risk, as the obtained result will be as valuable and reliable as the methods of its calculation were true and credible [https://leantrix.com/pl/wskaznik-oee/ 2023; Krasón 2016]. Reliability in providing the time when a given loss occurred and interpreting this event and answering questions, e.g. was the machine downtime part of the operational plan or did it result unexpectedly? Was the resulting amount of product quality losses taken into account during production and not recognized as a loss at that time? At what time did the operator record the machine stoppage? These are the factors that significantly affect the result of the obtained OEE and the entered data.

CASE STUDY

The subject of the research is a plastics processing company for the automotive industry. The company is located in the Podkarpackie Voivodeship and has two production halls, approximately 5 km apart. The total number of injection molding machines is 63 pieces. The company employs three planners. Production workers work in a three-shift cycle. The main product of the company is the so-called aesthetic elements, i.e. all elements made of plastic, constituting the internal equipment of a passenger car. Visible to the user inside the passenger car. The operating parameters of the injection molding machines vary depending on the size of the produced element: six small elements. Small parts are produced in 15-second cycles, four medium-sized parts in 25-second cycles and during this time the machine produces 6 elements. Medium elements in the amount of 4 pieces are created within 25 seconds. Big one big y element is 1 piece in cycles of 45 seconds.

The analyzed company does not have an integrated information flow system, but it has all the above-mentioned software supporting the work of people in the production department. The article aims to try to estimate the extent to which the integration of individual software, i.e. the APS, ERP, MES, and CMMS class, affects the efficiency of the production department compared to the conditions when the plant operates without such support. The OEE indicator, as the main tool for determining the effectiveness of the machine's operation, will be used for this purpose. The author of the article decided to analyze the work of one of the 63 injection molding machines that produce large elements. The pace of the machine's work is 1 finished element every 45 seconds. The order covered the production of a total of 5,400 right-hand car doors and doors. This order was planned for execution with one injection molding machine, operating in three shifts for three consecutive days. Assuming Theoretically, OEE at 100% should mean that the machine could produce 5,760 units at that time. This is an unrealistic result, if only due to the fact that you need to change the emblem in the mold that is already installed inside the injection molding machine. The scheduler assumes that it needs 30 minutes, or 1800 seconds, to complete this activity. This means that the machine will make 40 fewer

products already at the planning stage. However, this number is not counted as a loss, but only as part of the necessary production, and therefore not having this amount does not affect OEE. In the case of changing the previously used mold or the need to warm up the mold before production, and not just replacing the emblem, the estimated time is in the range of 2-4 hours. it is from 2 hours to even 8 hours. In the case of this order, in addition to this order, the planner added 4 hours of possible machine downtime, resulting, for example, from a potential failure or lack of communication between production departments. Such assumptions already reduce the machine performance by 26%, and yet the ego does not reduce the OEE indicator for the order.

The injection molding machine operator initiated a production order by changing the mold emblem, causing a 38-minute changeover instead of the planned 30 minutes, resulting in an 8-minute machine loss and 11 fewer pieces produced. The second shift, with a new operator, faced initial productivity issues, managing only 55 pieces in the first hour and needing an adjustment to machine working time. The mechanic's intervention extended the cycle time to 50 seconds per element, reducing production by approximately 8 pieces and introducing defects due to overheating.

The defective pieces went unnoticed during the second shift, contributing to a loss of 56 pieces and 25 defective ones. The issue persisted through the third shift, resulting in 29 defective pieces, detected only on the fourth shift by quality control. Restoring original settings took 20 minutes, causing a loss of 27 units. An unknown error in the last hour of the third shift led to 80 fewer pieces.

Maintenance attempted repairs during the fifth shift, replacing a damaged ejector and resulting in a 6-hour downtime, causing a loss of 480 pieces. The machine produced 22 more defective pieces in the first hour after repairs. The next three shifts were uninterrupted, but there were 2 hours of downtime due to issues like late carton placement, resulting in 192 defective products.

During the ninth shift, insufficient material preparation led to 5 defective pieces in the sixth hour, followed by machine stops due to raw material shortages. The second planner's oversight in updating the production schedule caused a conflict with raw material allocation for another order.Table 2 is a summary of one order with the resulting losses in production for one of the 63 machines.

Table 2. The course of order execution with the use of an injection molding machine along with emerging losses

shift	Causes of loss	Plan		Loss		Component of OEE
		assumed	real	time, min	number of units	
first	assembly of the emblem	30 min	38 min	8	11	availability
second	injection molding machine reprogramming	0 min	5 min	5	8	availability
	longer cycle work (7 hours)	45 s (560 pcs)	50 s (504 pcs)	42	56	performance
	defective products	0 pcs	25 pcs	19	25	quality
third	longer cycle time	45 sec (640 pcs)	50 sec (576 pcs)	48	64	performance
	demurrage	0 min	60 min	60	80	availability
	defective products	0 pcs	29 pcs	22	29	quality
fourth	longer cycle time (1 hour)	45 sec (80 pcs)	50 s (72 pcs)	6	8	performance
	injection molding machine reprogramming	0 min	20 min	20	27	availability
	defective products	0 pcs	25 s	19	25	quality
	failure	0 min	60 min	60	80	availability
fifth	failure, repair time	0 min	360 min	360	480	availability
	defective products	0 pcs	22	16'30	22	quality
sixth–eight (72 hours)	demurrage	0 min	120 min	120	160	availability
	defective products	0 pcs	192	144	192	quality
ninth	defective products	0 pcs	5 pcs	4	5	quality
	machine idle (lack of material)	0 min	120 min	120	160	performance
Sum				1057	1432	

Source: own elaboration

Using the above information about the operation of the injection molding machine, the author of the article made calculations in the field of use, quality, and availability of the machine. The obtained results are presented in Table 3.

Table 3. Components of the OEE indicator for the analyzed injection molding machine

Quality (pieces)		
all	5472	
good	5196	
Performance/cycle		
shift	assumed single cycle time based on technology, *ct*	Numer of cycle
first	492,3636363	584
second	471,2727273	576
third	618,9090909	632
fourth	640	640
fifth	640	640
sixth	640	640
seventh	640	640
eight	640	640
ninth	480	480
Sum	5262,545455	5472
Availability (working time)		
assumed	12960	
real	12267	

Source: own elaboration

By introducing individual values from Table 3 to the formula for the OEE indicator of a production order (1), a value of 86.44% was obtained, without taking into account the initial preparation of the machine. This indicator could be considered high, but if the calculation concerned the operation of all injection molding machines. However, the OEE indicator obtained in the analyzed example was calculated for not one machine, which had only one initial changeover and in addition was not taken into account during the injection molding machine's operation. In addition, the time of unforeseen machine downtime is added, which is also not added to the working time of the production department. In this way, the planner secures the execution of all products at a safe time. In the analyzed example, such a planned machine stoppage means 320 fewer units of production. With initial scheduling, the machine can produce 4,286 units, and with this schedule, the machine processes 580 fewer products than its capacity. If the changeover time and the planned downtime of the injection molding machine were taken into account, the OEE indicator would amount to 84.5%. Such a value for the operation of one injection molding machine working in three shifts, regardless of the other production equipment, is an unsatisfactory result. Based on this example, unforeseen failures and micro downtimes for one job and one injection molding machine are

approximately 14%, reducing machine productivity by approximately 14% when changeovers and planned downtimes are not included in the calculations, or by 15.5% after taking into account. As previously mentioned in the article, the analyzed company does not have an integrated communication system between individual departments and production areas. If the mechanic does not communicate with the planner about extending the working time of the machine, the planner may incorrectly plan subsequent orders, which will immediately be delayed in execution. If the planner does not receive information from the operator, he will learn about the production shift from employees operating ERP class software, who, after verifying the inventory, i.e. what has flowed from production after 24 hours, will provide information on this subject, usually on the next day. Reporting the failure to both (APS and CMMS) definitely eliminates time loss. The planner, having access to the system (CMMS), could track and see how long a given mold has been working in the injection molding machine. works in the injection molding machine. Scheduled cleaning or replacement could eliminate unexpected failures and the production of defective components. The planner could schedule the execution of the e-order at a different time or on a different injection molding machine. The current insight of employees operating the APS software into the ERP software would eliminate another error of duplication of the planned raw material from the warehouse.

It is also impossible to ignore the fact that the order has not been executed. 5,400 units were ordered, while. Capabilities of the machine is able to produce 5760 pieces at OEE= 100% for the order. Thus, the execution of the order was achievable. The machine produced 5,472 pieces, of which 5,196 were produced without defects. 204 pieces were missing to complete the task. At this point, another issue arises costs for failure to comply with the contract between the entrepreneur and the manufacturer. From the above description of this production information, the last shift machine was idle for two hours due to a lack of raw material. ERP employees. Ordering the right amount of raw material, employees (ERP) should also maintain the economic profitability of deliveries, i.e. the minimum order quantity that guarantees the profitability of delivery. The production company may negotiate the delivery time of the next batch of 204 items, e.g. on preferential terms for failure to meet the agreed deadline.

CONCLUSION

The OEE for a single order should be 100%, in the analyzed example OEE was 86.44%. This is a low value because a single order doesn't consider the entire company's production, e.g. planned maintenance or additional time needed for retooling. The obtained OEE shows that, yearly, the injection molding machine was either inactive or producing bad products for more than one month. A warehouse is not releasing all semi-finished products on the beginig of the order e.g. all semiproducts are being given in the stages. Automated APS, MES, and ERP could

raise the OEE result up to 9% for a given task. In the analyzed example, the injection molding machine produced a total of approximately 5% defective products (276 pieces). For a factory that has 12 injection molding machines, the potential loss could be over 3,300 products, which corresponds to a loss of over 60% for such an order. In companies where the essence of production is its scale, eliminating downtime per second is of great importance for financial results and, as a result, for entrepreneurs and their employees. Optimizing the production department is crucial for competitive advantage and profitability. Automated software integration minimizes communication errors, addressing delays, micro-changeovers, and communication gaps causing downtime and defects. Overcoming these challenges leads to substantial financial savings, providing a competitive edge. To enhance efficiency, gradual implementation of specialized IT systems for integrated automation is recommended, replacing manual OEE recording with cyclical form filling. Simulation indicates improved machine use time, enhanced supply chain control, and reduced losses. Detailed time-based data collection is vital, as short changeovers and delays significantly contribute to losses when handling multiple machines concurrently.

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INFLUENCER MARKETING – RESEARCHING CONSUMER INTEREST IN TOPICS DISCUSSED BY INFLUENCERS IN SOCIAL MEDIA

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Abstract: Growing competition and changing consumer behavior force companies to look for new ways to reach customers. The Polish market is a place of growing consumer interest in content created by influencers. The aim of the article is to isolate the topics discussed by influencers that attract the consumer's attention on social media. The article presents the results of own research conducted using the CAWI method in January 2022 on a representative nationwide random-quota sample of N = 776 adult inhabitants of Poland.

Keywords: social media, inflencer marketing, communication

JEL classification: M31, I23

INTRODUCTION

Influencer marketing is one of the popular forms of promoting brands and products in social media. In recent years, many influencer agencies have emerged on the market. There are also numerous divisions of influencers, most often grouped according to the number of people who follow them in social media.

Companies are increasingly collaborating with influencers. Based on the "Influencer Market in Poland – 2023" report, which was attended by a group of over 100 advertisers active in the field of influencer marketing (primarily marketers, but also representatives of advertising agencies, media houses, digital agencies, e-commerce platforms, startups, PR agencies, etc.), as many as 66% of respondents establish cooperation with influencers directly, looking for partners on Google or Social Media, and 33% search for them on their own, with

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the help of appropriate thematic groups (usually on Facebook). On the other hand, 44.3% of respondents do it on their own, but with the help of platforms (such as Reachablogger.pl), while 43.3% start working with influencers they know personally. Far fewer respondents declared that they would use a specialized advertising agency or media house for this purpose (19.6% and 3.1%, respectively). When it comes to the goals of activities with influencers, the surveyed advertisers most often indicated product/brand awareness – as much as 81.9%, followed by sales goals – 58.5%. The third place was taken by "traffic" (acquiring traffic for a website or store) -38.3%. [Report "Influencer Market in Poland – 2023"]

According to the numbers provided by StockApps.com, Influencer marketing saw spectacular growth between 2017 and 2021. The annual growth rate ranged from 34.6% to 46% over four years. However, the growth rate slowed to 20.4 percent in 2022. And the growth rate may decline until at least 2027. The annual growth rate in 2027 is projected to be only 10%. In 2022, a total of $27.5 billion was to be spent on influencer marketing, while in 2027 the spending is expected to increase to $51 billion. [StockApps Report 2022]

Influencer marketing is also already a well-known marketing activity among young consumers. As shown by the results of the "World of the Young 6" survey, as many as 87% of young Poles know an influencer even by hearsay. 81% follow such a character on social media. [Influencer influence on the young. IQS Survey 2022]

The presented data from the reports show the great importance of influencer marketing in the marketing activities of companies. However, it should be borne in mind that in order to get good results from this activity, you need to choose the right influencer for your audience and company profile.

LITERATURE REVIEW

The literature on the subject still lacks a single common definition and conceptualization of Influencer marketing.

The use of the image of the people by companies dates back to 1760, when Queen Sophie Charlotte gave permission to brand the tea set with the name Queen's Ware at the request of Josiah Wedgwood, the owner of a company producing ceramics and porcelain. [Gogłoza 2023]

With the development of technology, traditional advertising on television, praise has been replaced by advertisements on the Internet. Thus, famous people whose images were used in television or newspaper advertisements were displaced and partially replaced by famous people appearing on the Internet. Communication has also changed from one-way to two-way communication.

The emergence of web 3.0, the development of social media, but also the change in consumer behavior have made influencer marketing begin to develop dynamically.

An influencer is a person who has gathered a specific audience on their social media channels and shares their opinions and thoughts on specific products, having a real impact on the purchase decision of their followers. [Jaska et al. 2019] Most often, a distinction is made between influencers who are known for their profession (actors, singers, athletes) and people who have made their mark and gathered an audience online, based on showing their interests, passions, views, and life. An influencer is sometimes referred to in the literature as a digital influencer.

The most common criteria for classifying influencers include [Miller 2018; Kuchta 2016; Biegun 2019; Wyrwisz 2019]:

- Quantitative reach criterion (mega-influencer, macro-influencer, micro-influencer, nano-influencer),
- Brand relations (advocates, referrers, supporters),
- Value for fans (social butterfly, thought leader, early adopter, celebrity, expert, everyday user, sharer),
- Topics (lifestyle, industry expert, internet celebrities),
- Preferred content format (product placement, sponsorship of content and events, social media posts, contests, quoting influencers, unique content on the blog, joint project of several influencers),
- Communication platform,
- Motivation (idol, expert, activist, lifestyler, artist).

With the growing popularity of influencers in the literature, the concept of influencer marketing has developed.

Influencer marketing is the search for popular and influential people in a given field and working with them to promote a brand or product, using a community organized around this persona. [Wilusz 2017] Influencer marketing is a type of advertising where businesses work with well-known people on social media to advertise their goods or services. [Mishra et al. 2023]

Influencer marketing is one of the marketing tools that uses popular people in social media to achieve predetermined sales or marketing goals.

Influencers gain the trust of consumers compared to other online sources. Consumers try their best to avoid ads by using ad blockers. In such a scenario, influencer marketing is considered to be non-intrusive and more engaging than traditional online advertisements such as pop-ups, banners, etc. In the digital space, influencers on online platforms have become credible and trusted sources. [Chopra et al. 2021]

Influencer marketing can take its form in blog posts, videos or pictures on the influencer's social media channels, which means content cooperation, and it can be content for the company's marketing campaign with influencer's name or picture, which means providing content. It can also be operating as a brand ambassador, competitions for the end-users, cooperation in different social media channels, for example on the company's Instagram, Snapchat or Twitter, or involving consumers in product development and testing. Influencer marketing can also be events, trips and workshops, widgets and display advertising [Biaudet 2017].

Online influencer marketing is a strategy in which a firm selects and incentivizes online influencers to engage their followers on social media in an attempt to leverage these influencers' unique resources to promote the firm's offerings, with the ultimate goal of enhancing firm performance [Leung et al. 2022].

DATA AND METHODS

The research problem adopted for the study is whether the topics discussed on social media by influencers are of interest to their followers. The research problem adopted for the study is whether the topics discussed on social media by influencers are of interest to their followers. The study was conducted in January 2022 using the CAWI method on a representative nationwide, random-quota sample of N = 776 adult residents of Poland aged 15 to 60, where the total amounts were selected according to the representation in the population of Poles for the variables sex, age, size place of residence. In other words, the sample was divided into 50 strata resulting from the intersection of categories within variables 2 (gender), 5 (age), 5 (size of town) and the respondents were randomized for each of them. For the purposes of the study, a database was procured and utilized in accordance with the above guidelines.

The study used one of the most popular methods - an online survey, which guarantees reaching a representative sample in a short time. This method also has limitations - only people who use mobile devices can participate in the study. The research tool was an original questionnaire prepared. The omnibus survey consisted of open-ended, semi-open-ended, and closed-ended questions, with the majority of questions employing a Likert scale.

The answers to all questions were described using aggregate statistics, which include: mean (M), standard deviation (Sd), median (Me) and modal (Md). In addition, for variables measured on quantitative scales, the Kolmogorov-Smirnov (KS) test was performed to check whether the distribution of results deviates from the normal one. In order to increase the accuracy of the analysis of quantitative data, the occurrence of the level of statistical significance of the relationship between the variables was examined.

RESULTS

Survey participants were asked about their interest in particular topics that influencers discuss on social media. The answers are summarised in Table 1. The most interesting respondents are influencers (41.1%), followed by travel (40.5%). The respondents indicated that they are least interested in the private life of influencers (22.9%) and fooling around and joking around by influencers (12.2%).

Table 1. Respondents' interest in topics discussed by influencers in social media

Subject:	Interest				
	I'm not interested at all	Negligible	Average	I'm interested in	I'm very interested
private life of an influencer	22.9%	23.8%	29.1%	18.4%	5.7%
travel	4.0%	10.4%	26.5%	40.5%	18.6%
cooking	5.9%	12.8%	28.6%	38.7%	14.0%
clothing	7.3%	14.8%	28.6%	37.2%	12.0%
expertise in various fields	4.4%	10.1%	27.4%	41.1%	17.0%
nice shots	6.1%	15.9%	31.2%	36.1%	10.8%
music	5.7%	14.2%	28.2%	38.8%	13.1%
fooling around/joking	12.2%	21.3%	33.1%	24.1%	9.3%
comments on various events	6.8%	15.6%	36.9%	31.7%	9.0%
product reviews & recommendations	4.6%	13.7%	30.4%	38.1%	13.1%

Source: own research, n=776

Table 2 presents the answers to the question of the influencer's interest in the private life broken down by age group. To see if there are differences between age groups in relation to influencers' interest in private life, the statistical significance between the variables was examined.

Table 2. Respondents' interest in the influencer's private life and their age

Private life of an influencer:	n	Age (years)	
		Average	Standard deviation
I'm not interested at all	178	41.25	9.92
Negligible interest	185	40.32	9.43
Medium interest	226	40.88	9.83
I'm interested in	143	38.37	9.50
I'm very interested	44	36.57	9.66
Total	776	40.12	9.75
Statistical significance:		$r_s = –0.110274$, $p = 0.002096$	

Source: own research, n=776

The result of Spearman's correlation coefficient indicates the existence of a statistically significant ($p < 0.05$) relationship between the variables. As the respondents aged, their interest in the influencer's private life decreased. The value of the coefficient indicated that this correlation had a statistically weak impact.

Also in the case of the influencer fooling around/joking, the result of the Spearman correlation coefficient indicates the presence of a statistically significant ($p < 0.05$) relationship between the variables ($r_s = – 0.102376$, $p = 0.004307$).

On the other hand, in the case of travel, cooking, clothing, expertise in various fields, nice photos, music, comments on various events, reviews and product recommendations, the result of the Spearman correlation coefficient did not prove the existence of a statistically significant ($p > 0.05$) relationship between the variables.

Table 3 presents the answers to the question about the respondents' interest in the private life of ifnluecners broken down by gender. To check whether there are differences between the gender of the respondents and the interest in the private lives of influencers, a series of chi 2 tests were conducted.

Table 3. Respondents' interest in the influencer's private life and their gender

Private life of an influencer:		Sex		Total
		Women	Men	
I'm not interested at all	n	80	98	178
	%	18.3%	28.8%	22.9%
Negligible interest	n	112	73	185
	%	25.7%	21.5%	23.8%
Medium interest	n	123	103	226
	%	28.2%	30.3%	29.1%
I'm interested in	n	94	49	143
	%	21.6%	14.4%	18.4%
I'm very interested	n	27	17	44
	%	6.2%	5.0%	5.7%
Total	n	436	340	776
	%	100.0%	100.0%	100.0%
Statistical significance:	$\chi2 = 16.6234$. df = 4. p = 0.002287			

Source: own research, n=776

The result of the chi-square test proved the existence of a statistically significant ($p < 0.05$) relationship between the variables. Men showed less interest in the influencer's private life than women.

Other topics taken up in social media by influencers in relation to the gender of the respondents were also examined. The result of the chi-square test proved the existence of a statistically significant ($p < 0.05$) relationship between the variables:

- Women showed greater interest in the topic of travel discussed by influencers than men ($\chi2 = 23.4802$, df = 4, p = 0.000102),
- Women showed more interest in cooking topics raised by influencers than men ($\chi2 = 41.0590$, df = 4, p = 0.000000),
- Women showed more interest in the topic of clothing raised by influencers than men ($\chi2 = 44.9346$, df = 4, p = 0.000000),
- Women showed more interest in the subject of pretty photos raised by influencers than men ($\chi2 = 22.9037$, df = 4, p = 0.000132),
- Women showed greater interest in the topic of product reviews and recommendations raised by influencers than men ($\chi2 = 17.9363$, df = 4,

p = 0.001270).

On the other hand, the result of the chi-square test did not prove the existence of a statistically significant ($p > 0.05$) relationship between the variables in relation to the following topics: expertise in various fields, music topics, fooling around/joking, comments on various events.

Table 4 presents the answers to the question of the influencer's interest in the private life in relation to the place of residence. To see if there were differences between the place of residence and the interest in the private life of influencers, the statistical significance between the variables was examined.

Table 4. Respondents' interest in the subject of clothing raised by influencers and their place of residence

Clothing:		Size of the town				Total:
		village	city up to 100 thousand inhabitants	city of 100-500 thousand inhabitants.	city with more than 500,000 inhabitants	
I'm not interested at all	n	18	18	12	9	57
	%	6.7%	6.6%	8.5%	9.6%	7.3%
Negligible interest	n	38	41	19	17	115
	%	14.1%	15.1%	13.4%	18.1%	14.8%
Medium interest	n	70	79	49	24	222
	%	26.0%	29.2%	34.5%	25.5%	28.6%
I'm interested in	n	101	107	47	34	289
	%	37.5%	39.5%	33.1%	36.2%	37.2%
I'm very interested	n	42	26	15	10	93
	%	15.6%	9.6%	10.6%	10.6%	12.0%
Total	n	269	271	142	94	776
	%	100.0%	100.0%	100.0%	100.0%	100.0%
Statistical significance:		$r_s = – 0{,}071801$, $p = 0.045555$				

Source: own research, n=776

The result of Spearman's correlation coefficient proved the existence of a statistically significant ($p < 0.05$) relationship between the variables. Along with the increase in the size of the place of residence, the respondents' interest in the subject of clothing raised by influencers decreased. This correlation had a statistically negligible impact.

When examining the statistical significance between the topics discussed by the inspectors and the place of residence of the respondents, the result of the Spearman correlation coefficient did not prove the existence of a statistically significant ($p > 0.05$) relationship between any of the other variables.

CONCLUSIONS

The emergence of influencers on the market has caused major changes in consumer behavior and the choice of marketing tools used by companies.

Due to the emergence of agencies on the market specializing in the selection of an influencer for a product/service/company, platforms dedicated only to this issue, and even profiles of vlogging classes in high schools, it is safe to say that this issue will continue to grow.

The most interesting results of the presented research are those showing that the respondents are least interested in the private lives of influencers. Influencers, on the other hand, very often show viewing statistics in various social media and they clearly indicate the greatest interest in the subject of their private lives. The influencers themselves lament the fact that this topic is more important than sharing their expertise in particular fields.

It would be interesting to know the reasons why people in social media are interested in the private lives of influencers? Is it due to the "ideally" presented life, the desire to compare or equal, escape from one's own problems, jealousy? It would be equally interesting to know the reasons why people declare that they are not interested in it, and in fact the results shown by influencers are completely different.

Chopra, Avhad, and Jaju [2021] conducted research based on the Theory of Planned Behavior (TPB) and the Social Learning Theory authored by Bandura and Walters (1963). The study aimed to identify key factors in influencer marketing that influence consumer behavior. The study revealed that both attitude toward influencers and perceived behavior control that allows increase in domain knowledge had a favorable impact on consumer behavior while the influence of peers had no effect. Further additional constructs namely personal relevance, inspiration, and trust had a positive impact on behavior while perceived risk did not have any effect. Product influencer fitment was an important criterion for consumers, as they followed the specific type of influencers for different product categories. Depending on the posts shared by influencers, consumers are impacted at four levels: increase in brand awareness, subject matter expertise, brand preference, and preference. Successful influencer marketing involves identifying the right type of influencer who will offer curated advice, stories, and suggestions to create engagement with the audience.

The presented research results refer to a specific period and should be repeated, developed and improved in the future in order to learn about the needs,

attitudes and preferences as well as changes in the perception of interest in the topics raised by Influencers.

The result of the study can be used by marketers as a basis for improving their influencer marketing strategies by generating insights that would help them better reach their millennial cohort by understanding their expectations, barriers, and the type of influencer they prefer in different categories.

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