2

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Content

Financial Dynamics, Development and Innovation in the Sugar Industry of Central and Eastern Europe (2013–2022)

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Abstract

This study explores the financial dynamics, strategic growth, and innovation within the sugar production sector in Central and Eastern Europe (CEE) over the period 2013–2022. It focuses on six countries—Czech Republic, Austria, Germany, Poland, Hungary, Slovakia and analyzes 14 major sugar-producing companies using a combined methodological approach based on time-series trend analysis and Principal Component Analysis (PCA).

Key financial metrics such as capital structure, working capital, operating revenue, profitability, and employment are examined to assess differences in performance across firms and countries.

The research is framed by three central questions that investigate the interaction between company size, financial stability, national market context, and development potential.

A major turning point for the sector—the abolition of the EU sugar quota system in autumn 2017—marked the beginning of a fully liberalized market environment, intensifying global competition and reshaping regional production strategies.

The results indicate that larger firms tend to provide financial stability but exhibit limited growth trajectories, while smaller companies are more adaptable and often demonstrate stronger development potential.

National differences are also significant: the Czech Republic and Poland emerge as dynamic and competitive markets; Austria and Germany reflect mature industries with constrained growth prospects; Hungary and Slovakia show financial challenges yet offer opportunities for development.

By identifying structural trends and regional disparities, the study contributes to a deeper understanding of the post-quota sugar market. It offers relevant insights for policymakers and industry leaders aiming to balance financial health, innovation, and sustainability in order to ensure the sector's long-term competitiveness in a volatile global economy.

Keywords

principal component analysis, dynamics of the sugar market, financial stability, company development, equity, Central and Eastern Europe.

JEL Classification : L66, G30, C38, Q13

1.   Introduction

Terms such as dynamics, growth, innovation, competitiveness, and development have become something of a mantra in today's discourse. In general, development is a headline topic in both professional and academic life. In this paper,[1] however, it is specifically narrowed down to the sugar industry segment.

This is not only because former Czechoslovakia had been for decades a powerhouse in this sector, but also because the sugar production sector in Central and Eastern Europe (CEE) plays a pivotal role in the region's agricultural and industrial economy (Swinnen et al., 2010). Its importance is underscored by its contribution to rural development, employment, and trade (Kotyza et al., 2019). This study focuses on the dynamics of the sugar market in the Czech Republic (AA-) and its neighboring countries—Austria (AA+), Germany (AAA), Poland (A-), Hungary (BBB-), and Slovakia (A+)[2]—during the period from 2013 to 2022. The aim is to examine the factors influencing market fluctuations, the financial performance of major sugar producers, and strategies for sustainable growth amid market volatility.

The market for sugar in the region has been shaped by significant regulatory and economic changes over the past decade (Řezbova et al., 2015). A key turning point was the European Union's sugar market reform and the abolition of production quotas in 2017 (Muir, Anderson, 2022). These changes liberalized the market, exposing producers to heightened global competition and price volatility (Kotyza et al., 2018). Studies indicate that global price dynamics, driven by major sugar-exporting countries like Brazil and India, have had a profound impact on the CEE region, influencing profitability and market stability (Soare et al., 2021). Additionally, regional trade policies and cross-border supply chain dynamics have added

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[1] This working paper served as the background material for a peer-reviewed article accepted by the Ukrainian Food Journal (indexed in Web of Science and SCOPUS) and scheduled for publication in 2025.
[2] Credit rating assessments of selected countries by Standard & Poor's. Available at: https://www.cnb.cz/cs/o_cnb/mezinarodni-vztahy/srovnavaci-tabulka/

complexity to the sector, highlighting the interconnectedness of CEE economies (European Commission, 2017; Nes et al., 2021).

Given the broad historical and economic context, the main objective of this study is to analyze the sugar business within the Central and Eastern European region, focusing on both company-level and country-level dynamics. At the individual company level, the study aims to investigate the causes of changes in financial indicators and their impact on the competitiveness and financial stability of sugar-producing firms operating within six countries: the Czech Republic (1,7%), Austria (1,3%), Germany (0,8%), Poland (2,7%), Hungary (4,7%), and Slovakia (2,0%).[3] At the aggregated level, the research seeks to compare the financial characteristics of sugar production across these countries, providing insights into their respective market positions and development trajectories.

By examining key financial characteristics—including capital structure, working capital, operating revenue, and profitability—at both levels, the study aims to identify trends and patterns that illuminate the underlying drivers of changes in financial indicators. This dual-level approach enables a comprehensive understanding of how individual companies navigate financial challenges and how national industries collectively adapt to economic and regulatory changes. These insights contribute to a deeper understanding of the factors influencing the sustainability and resilience of the sugar sector in Central and Eastern Europe.

This article, although it primarily focuses on production for the domestic market (i.e., EU countries for the EU market), can be generalized to the context of commodities on global markets. Sugar itself is a commodity, and it is advisable to strengthen vertical production in sugar companies, that is, to produce foods and products with higher added value.

For European policymakers, a question arises whether sugar, which is viewed negatively in Europe and is even proposed to be taxed due to its link to obesity, could be used for humanitarian aid. This aid could be directed at feeding people in countries suffering from famine, war conflicts, and natural disasters. In such extreme situations, purchases are made through international humanitarian organizations and the non-profit sector, which means that they are not solely governed by market supply and demand. Consequently, a substantial portion of the commodity or its products can be redirected to those in need at virtually any cost.

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[3] Share of selected countries in agriculture, forestry, and fishing in GDP according to the World Bank. Available at: https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

With regard to the main goal of this paper are formulated the following research questions:

- How do sugar-producing companies of different sizes perform in terms of financial stability and development potential?

- To what extent do national contexts influence the financial strength and growth trajectories of the sugar industry?

- Is there evidence that smaller companies can outperform larger ones in terms of growth potential and adaptability?

These questions are addressed in the Discussion chapter, Sections 5.1–5.4, with supporting implications in Section 5.5.

2.　　Theoretical background

Financial performance analysis is central to understanding the resilience of sugar producers in the region (Firlej et al., 2024). Metrics such as EBITDA, operating revenue, working capital, and the number of employees are critical for assessing corporate health (Smutka et al., 2018). Research reveals that the abolition of EU quotas and market liberalization forced companies to adopt strategies aimed at improving efficiency and reducing costs (Badan, Petre, 2018). However, challenges such as fluctuating energy prices, rising labor costs, and climate-related risks continue to exert pressure on financial stability (Severini, Sorrentino, 2017). Recent studies also emphasize the importance of debt management, investment in technology, and adaptation to environmental standards as key factors influencing long-term profitability (Wimmer, Sauer, 2020; Pawlak, Smutka, 2022; Smutka et al., 2019).

Sustainability has emerged as a critical concern for the sugar industry, with increasing emphasis on reducing its environmental footprint (García-Bustamante et al., 2018). The sector faces scrutiny for its significant carbon emissions, high water usage, and energy demands (Meghana, Shastri, 2020; Formann et al., 2020; Aguilar-Rivera, 2022). In response, companies are adopting precision farming, renewable energy solutions, and circular economy principles to minimize their ecological impact (Gopinath, 2018). The European Union's Common Agricultural Policy (CAP) plays a crucial role in incentivizing sustainable practices through subsidies and eco-schemes, driving the adoption of innovative technologies and practices across the region (Kaszycki et al., 2021).

The methodological approach combining time-series analysis and Principal Component Analysis (PCA) is a powerful tool (Chowdhury et al., 2017) for evaluating the financial

performance (Liu, Bai, 2021) of sugar-producing companies. Time-series analysis is widely recognized for its ability to identify trends, seasonal patterns, and structural changes in financial data (Hamilton, 2020; Diggle, Giorgi, 2024), making it particularly valuable for industries like sugar production, which are influenced by cyclical market dynamics and external shocks. In the context of sugar industries, this method has been used to analyze production outputs, price volatility, and revenue trends, providing insights into the impacts of regulatory reforms and market liberalization (Zainuddin et al., 2017; Kumar, Sharma, 2021).

PCA complements time-series analysis by reducing the dimensionality of complex datasets while preserving the essential characteristics of the data (Huang et al., 2022). This technique is particularly effective in identifying and prioritizing key financial indicators (Crépey et al., 2022), such as EBITDA, working capital, operating revenue, and creditor management. By focusing on these critical metrics, PCA enables a nuanced comparison of sugar producers, accounting for differences in company size and operational environments. Studies have demonstrated how PCA can reveal patterns in financial performance and group companies based on similar characteristics, facilitating strategic decision-making and benchmarking (Xue et al., 2018).

The evaluation of key financial indicators is central to understanding corporate performance and resilience (Singh et al., 2019). Metrics like EBITDA and operating revenue are essential for assessing profitability and operational efficiency, while working capital and creditor management provide insights into liquidity and financial stability. Normalizing financial trends to account for variations in company size and market conditions ensures a fair and meaningful comparison across firms (Schroeder et al., 2022; Vernimmen et al., 2022). This normalization process is particularly relevant in the sugar sector, where companies operate under diverse regulatory, environmental, and economic contexts.

At an aggregated level, the analysis of financial trends across sugar-producing companies and countries offers a broader perspective on the industry's health and development trajectories. Aggregate-level studies highlight industry-wide patterns in production, exports, and financial performance, providing insights into the collective impact of policy changes, market integration, and global competition (Juhász et al., 2023). Research in this area often emphasizes the role of EU market reforms and sustainability initiatives in shaping the economic development of sugar industries (Fazrakhmanov et al., 2018) in Central and Eastern Europe.

The combination of time-series analysis and PCA represents an innovative and robust approach for assessing the financial health and strategic positioning of sugar producers. Time-series analysis captures temporal changes and underlying trends, while PCA identifies the principal factors driving performance and facilitates cross-company and cross-country comparisons. Together, these methods provide a comprehensive understanding of the financial dynamics at both individual and aggregate levels, offering valuable insights into the overall development and sustainability of the sugar industry in the region.

3.   Methodology

To analyze the performance of sugar-producing companies in the Czech Republic and neighboring countries over the period 2013–2022, we employed a two-stage analytical approach, involving the calculation of normalized linear trends and Principal Component Analysis (PCA) of company characteristics (Labrin, Urdinez, 2020). This methodology allows for the comparison of trends in various business metrics while ensuring the results are scale-independent and interpretable across countries. Below are the steps involved in our analysis (Deutsch et al., 2019).

3.1.   Calculation of Normalized Linear Trend

For each company, we calculated the normalized trend (Mahoney, 2005) of a simple linear regression model (De Jong et al., 2012) over the period from 2013 to 2022. The model is represented as:

$Y_i = a + b \cdot X_i$

Where:

-   Y_i is the enterprise characteristic at time i (such as sales, EBITDA, or working capital),

-   X_i represents the years (2013 to 2022),

-   a is the estimated value of the characteristic in 2013 (the intercept),

-   b is the slope of the trend (the rate of change per year).

The regression analysis is performed separately for each enterprise, where the characteristic Y may represent different company metrics such as sales, operating revenue, number of employees, working capital, creditors, capital, or EBITDA.

3.2.   Normalization of Trends

The calculated trend (b) represents the yearly change in the enterprise characteristic. To standardize the results and ensure comparability across companies of different scales, we normalize this trend by dividing it by the average value of the characteristic over the entire period (2013–2022). This gives us a normalized trend Nb, which represents the percentage increase (or decrease) of the characteristic per year, divided by 100 (Mahoney, 2005).

$$Nb_i = \frac{b}{Average\,Value\,of\,Y_i}$$

This step ensures that trends are comparable on the same scale regardless of the absolute values of the enterprise characteristics, allowing us to focus on the relative performance of companies.

3.3.   Weighted Average of Normalized Trends

Next, we compute the weighted average of normalized trends (Purushothaman, 2011) for each country and for blocks of countries. The weight of each company in the calculation is based on their Averaged Working Capital (AWC). The weighted average is calculated for each country and for specific groups of countries:

-    Austria and Germany,

-    Czechia, Hungary, Poland and Slovakia,

-    All countries combined.

$$Nb(Germany)$$
$$= \frac{AWC(Suedzucker) * Nb(Suedzucker) + AWC(Nordzucker) * Nb(Nordzucker)}{AWC(Suedzucker) + AWC(Nordzucker)}.$$

This weighting ensures that larger enterprises, as measured by their working capital, have a greater influence on the overall trend of the country or country block.

Further we have performed principal component analysis of companies from average time series and trends of the following characteristics: Capital, Creditors, EBITDA, Number of employes, Operating revenue, Sales, and Working Capital.

3.4.   Data Collection and Variables

This research focuses on 14 sugar-producing companies from six countries within Central and Eastern Europe: Austria (AT), Germany (DE), Czech Republic (CZE), Hungary (HU),

Slovakia (SK), and Poland (PL). The financial data used in this analysis are based on average values over a period of five years (2018-2022), ensuring stability in the analysis and reflecting long-term performance trends. While the trend analysis described in previous sections utilizes the full time-series data from 2013 to 2022, the Principal Component Analysis in Section 3.5 is based on five-year averages, reflecting only the current magnitude of the characteristics rather than their historical development, which has been captured through the trend component.[4] The key financial variables used for the Principal Component Analysis (PCA) are:

- Capital (in EUR thousands): Represents the financial resources available to the company.

- Creditors (in EUR thousands): The total amount of liabilities a company owes to external creditors.

- EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization, in EUR thousands): A measure of a company's operational profitability.

- Number of Employees (both average and total): Reflects the size of the company's workforce and can give insight into operational scale.

- Operating Revenue (Turnover, in EUR thousands): Represents the total income generated by the company from its regular business activities.

- Sales (in EUR thousands): The total value of products sold, indicative of the company's market share.

- Working Capital (in EUR thousands): A measure of a company's short-term financial health and operational efficiency.

Each company's data was standardized to ensure comparability across companies of varying sizes and financial profiles. ORBIS (an international database of corporate financial information) was used for relevant above mentioned data collection.

3.5. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a statistical technique used to reduce the dimensionality of large datasets while retaining as much variance as possible. This allows for a more manageable set of variables (principal components) that explain the major patterns within

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[4]The 2017 abolition of EU sugar quotas ended a long-standing regulatory framework, triggering liberalization.

the data. The main steps of the Principal Component Analysis (PCA) applied in this research are as follows (Deutsch et al., 2019).

Standardization of Data: Each financial variable was standardized to have a mean of zero and a standard deviation of one. This step is crucial for ensuring that variables with different units (e.g., revenue in EUR vs. number of employees) contribute equally to the analysis.

Covariance Matrix Calculation: A covariance matrix was computed to explore the relationships between the financial variables. This matrix provides insight into how the variables co-vary with each other.

Eigenvalue and Eigenvector Calculation: The eigenvalues and eigenvectors of the covariance matrix (Lin et al., 2020) were calculated. The eigenvalues represent the variance explained by each principal component, and the eigenvectors define the direction of the components.

Component Selection: The number of components to retain was determined based on the eigenvalues (e.g., components with eigenvalues greater than one were retained).

Interpretation of Results: After, the components were analyzed to determine which financial variables contributed most to each component. The companies' scores on the principal components were calculated, allowing for the assessment of their relative positioning within the financial landscape, using biplot (Gabriel, 1971; Gabriel, Odoroff, 1990).

3.6. Data Analysis

The results of the Principal Component Analysis (PCA) were analyzed at two levels:

Company-Level Principal Component Analysis (PCA): Principal Component Analysis (PCA) was applied to the individual companies to identify how their financial characteristics contribute to their overall financial performance, size, and growth potential. Each company was represented by a point in a multidimensional space, where the position of each company reflected its financial attributes.

Country-Level Principal Component Analysis (PCA): In addition to the company-level analysis, Principal Component Analysis (PCA) was also applied to the aggregated data of companies in each country to understand broader regional trends. This allowed for comparisons across countries, revealing how the financial dynamics of the sugar production sector differ in each state.

The analysis identified the main components that explain the financial variance across companies and countries. The results were visualized using scatter plots and component loading charts, allowing for easy interpretation of the relationships between the financial variables and the principal components.

The companies are plotted in a 3D space based on their scores in the first, second, and third principal components. This allows for a visual representation of the companies' performance across the most important business dimensions. The resulting figure helps identify patterns, such as clustering of companies with similar growth or equity profiles and provides a clear overview of how companies from different countries or country blocks compare.

4.   Results

4.1.   Principal Component Analysis of Companies

The Principal Component Analysis (PCA) of the companies yielded insightful results, with the first three principal components (PC1, PC2, and PC3) explaining 82.28% of the total variance. The breakdown is as follows:

PC1 explained 46.43% of the total variance, representing the size of the company. Larger companies generally exhibited higher values on PC1, while smaller companies demonstrated lower values. See the rotations in the Table 3 for the given interpretations of the components.

The size of the company may be related to the variables that have a big rotation coefficient in Table 3 for PC1 (average values of capital, creditors, number of employees, operating revenue, sales, working capital).

PC2 accounted for 23.10% of the variance, reflecting the growth or development potential of the company. Companies with a positive PC2 value demonstrated significant growth, while those with negative values exhibited stagnation or shrinkage.

The label growth or development potential of PC2 we obtained from big rotations of PC2 in variables trend of operating revenue, trend of sales, trend of number of employees.

PC3 explained 12.75% of the variance, capturing the equity development trends of the companies.

The trend in the label development of PC3, which we derived from significant rotations of PC3, includes variables such as the trend of capital, the trend of working capital, and the negative trend of creditors.

Table 1 Importance of components

	PC1	PC2	PC3
Standard deviation	2.5497	1.7982	1.3360
Proportion of variance	0.4643	0.2310	0.1275
Cumulative proportion	0.4643	0.6953	0.8228

Source: own processing

Table 2 PCs with respect to key sugar producing companies

	PC1	PC2	PC3	
1	-0.96591	-1.79322	-2.95359	AGRANA ZUCKER GMBH
2	-1.61952	-1.48201	1.86055	MORAVSKOSLEZKE CUKROVARY
3	-1.65217	0.28348	1.44341	CUKROVAR VRBATKY A.S.
4	-2.26005	-1.33810	0.96678	LITOVELSKA CUKROVARNA
5	0.06189	1.98233	0.13341	TEREOS A.S.
6	6.92069	-2.24695	1.01244	SUEDZUCKER AG
7	3.07329	-0.46317	-0.39555	NORDZUCKER AG
8	-1.59659	0.29054	-1.41489	MAGYAR CUKORGYARTO ES FORGALMAZÓ ZRT
9	1.93971	1.13487	-1.30579	KRAJOWA GRUPA SPOZYWCZA SA
10	1.27704	4.77504	0.65072	PFEIFER & LANGEN POLSKA
11	-0.55261	0.02023	-1.34400	SUDZUCKER POLSKA S.A.
12	-1.03807	0.25494	0.10056	NORDZUCKER POLSKA S.A.

| 13 | -1.71824 | -0.31222 | 0.42547 | POVAZSKY CUKOR A.S. |
| 14 | -1.86943 | -1.10576 | 0.82047 | SLOVENSKE CUKROVARY S.R.O. |

Source: own processing

Table 3 Rotations

	PC1	PC2	PC3
Capital average	0.32328	-0.05179	-0.20187
Capital trend	-0.02968	-0.21616	0.38770
Creditors average	0.37279	-0.11678	0.01899
Creditors trend	-0.01975	0.17736	-0.64081
EBITDA average	0.06270	0.37823	-0.24664
EBITDA trend	-0.30572	0.24338	-0.16893
Number of employees average	0.37624	0.00287	-0.07696
Number of employees trend	0.17618	0.33108	0.29225
Operating revenue (Turnover) aver.	0.37757	-0.12615	-0.05940
Operating revenue trend	0.14876	0.48733	0.05491
Sales average	0.37767	-0.12325	-0.06129
Sales trend	0.15537	0.48363	0.11081
Working capital aver.	0.37302	-0.10467	-0.09038
Working Capital trend	0.12092	0.28304	0.43182

Source: own processing

4.1.1. Company-Specific Interpretations

The scores for each company on the principal components provide a snapshot of their financial health and growth prospects:

- Suedzucker AG (point 6) is the largest company in the region (high score on PC1) but exhibits minimal development potential (negative PC2 value). This indicates that the company is in a mature stage, focusing on maintaining market dominance rather than pursuing aggressive expansion.

- Pfeifer & Langen Polska S.A. (point 10), despite being smaller, demonstrates strong development potential with a positive PC2 score, indicating a dynamic market strategy.

- Agrana Zucker GmbH (point 1), while large, demonstrates weak growth potential, reflected in its negative PC2 score, signaling possible challenges in adapting to market changes.

- Litovelská Cukrovarna A.S. (point 4), the smallest company, demonstrates similar development potential to Suedzucker AG, indicating that size alone does not determine a company's growth trajectory.

- Companies such as Tereos A.S. (point 5) and Magyar Cukorgyártó és Forgalmazó Zrt. (point 8) display a balance of size and equity development, with moderate scores across PC1 and PC3.

4.1.2. Rotated Component Loadings

The rotation of the components revealed further insights into the relationships between financial variables:

Capital and Operating Revenue consistently correlated with PC1, confirming their importance in determining the overall size and financial stability of companies.

EBITDA and Working Capital were linked to PC2 and PC3, reflecting the need for profitability and efficient resource management to support growth.

4.2. Principal Component Analysis of States (Countries)

To understand regional trends, Principal Component Analysis (PCA) was also applied at the state level, based on the aggregated data from companies in each country. The first three components accounted for 90.61% of the variance, broken down as follows:

PC1 explained 61.14% of the variance, reflecting the overall financial strength of each country's sugar production sector (size).

PC2 accounted for 18.39% of the variance, representing the developmental trends and market growth in each state. Negative value of growth or development potential.

PC3 explained 11.08% of the variance, capturing equity development trends. Negative value of development trend.

The interpretation of PCAs for companies and countries differs slightly because they are calculated from different input data. We analyze 14 companies but only 6 states (narrower sample).

Table 4 Importance of components

	PC1	PC2	PC3
Standard deviation	2.9257	1.6047	1.2452
Proportion of variance	0.6114	0.1839	0.1108
Cumulative proportion	0.6114	0.7953	0.9061

Source: own processing

Table 5 PCs with respect to selected countries under the analysis

	PC1	PC2	PC3	
1	-2.97677556	2.0364548	1.1019787	AT
2	0.06452467	-1.4647739	-0.9606211	DE
3	4.31375674	1.9115372	-0.6420512	CZE
4	-2.33420439	-0.6708318	0.3685516	HU
5	2.63897485	-1.5528708	1.6564579	SK
6	-1.70627631	-0.2595154	-1.5243158	PL

Source: own processing

Table 6 Rotations

	PC1	PC2	PC3
Capital average	0.31714	0.05563	0.25026
Capital trend	0.08068	0.15132	-0.32843
Creditors average	0.30383	0.27303	-0.06121
Creditors trend	-0.19562	0.18136	0.60144
EBITDA average	0.20498	-0.29848	0.43607
EBITDA trend	-0.26384	-0.36947	0.13133
Number of employees average	0.32664	0.01613	0.22277
Number of employees trend	0.25642	-0.30909	-0.11048
Operating revenue (Turnover) aver.	0.31208	0.24993	0.02845
Operating revenue trend	0.23489	-0.40079	0.11399
Sales average	0.31323	0.24522	0.03043
Sales trend	0.25430	-0.38271	0.04184
Working capital aver.	0.32077	0.20029	0.09148
Working Capital trend	0.24493	-0.27450	-0.41223

Source: own processing

4.3. Visualizing the Results

The visualizations below illustrate the relationships between the size, development, and equity development of companies and countries:
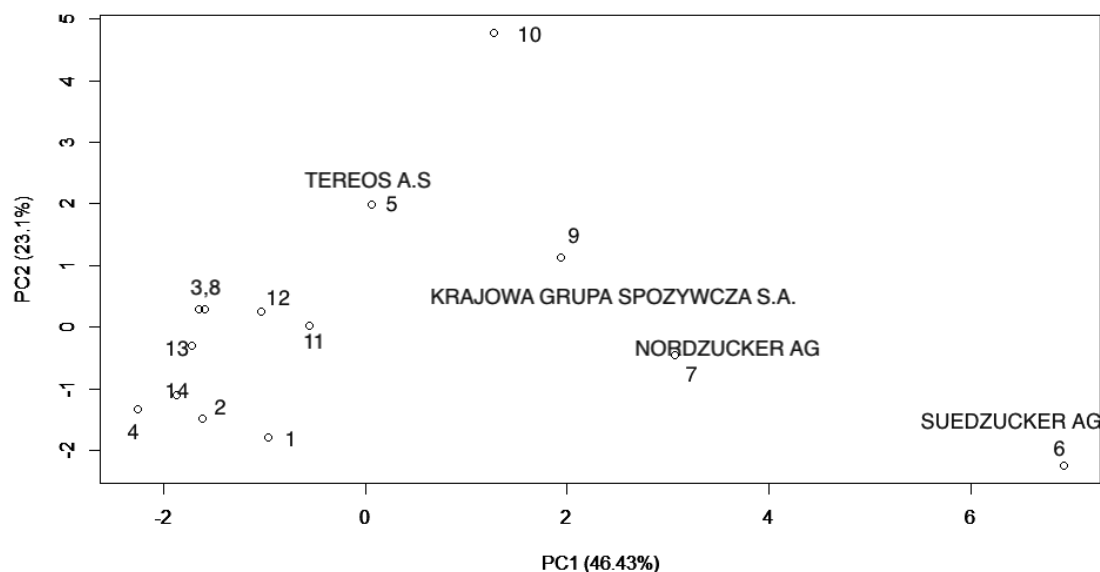
Fig. 1 Size of the Company vs. Development (PC1 vs. PC2)

The legend: 1- Agrana Zucker GmbH, 2- Moravskoslezke Cukrovary s.r.o., 3- Cukrovar Vrbatky a.s., 4- Litovelska Cukrovarna A.S., 5- Tereos a.s., 6- Seuzucker AG., 7- Nordzucker AG, 8- Magyar Cukorgyarto es forgalmazo zrt, 9- Krajowa Grupa Spozywcza a.s., 10- Pfeifer & Langen Polska s.a., 11- Sudzucker Polska s.a., 12- Nordzucker Polska s.a., 13- Povazsky Cukor a.s., 14- Slovenske Cukrovary s.r.o.

Source: own processing

This plot demonstrates that Suedzucker AG (point 6) dominates in size (high PC1 score) but demonstrates minimal development potential (low PC2 score). Pfeifer & Langen Polska S.A. (point 10), on the other hand, demonstrates strong growth despite its smaller size.

Fig. 2 Size of the Company vs. Equity Development (PC1 vs. PC3) Here, the size of the company (PC1) is compared with its equity development (PC3).

The legend: 1- Agrana Zucker GmbH, 2- Moravskoslezke Cukrovary s.r.o., 3- Cukrovar Vrbatky a.s., 4- Litovelska Cukrovarna A.S., 5- Tereos a.s., 6- Seuzucker AG., 7- Nordzucker AG, 8- Magyar Cukorgyarto es forgalmazo zrt, 9- Krajowa Grupa Spozywcza a.s., 10- Pfeifer & Langen Polska s.a., 11- Sudzucker Polska s.a., 12- Nordzucker Polska s.a., 13- Povazsky Cukor a.s., 14- Slovenske Cukrovary s.r.o.

Source: own processing

Here, the size of the company (PC1) is compared with its equity development (PC3). While larger companies like Suedzucker AG have minimal equity development, smaller companies like Litovelská Cukrovarna A.S. or Cukrovarna Vrbatky, a Moravskoslezké cukrovary demonstrate comparable equity development potential, indicating that equity management plays a key role in smaller companies' financial strategies.
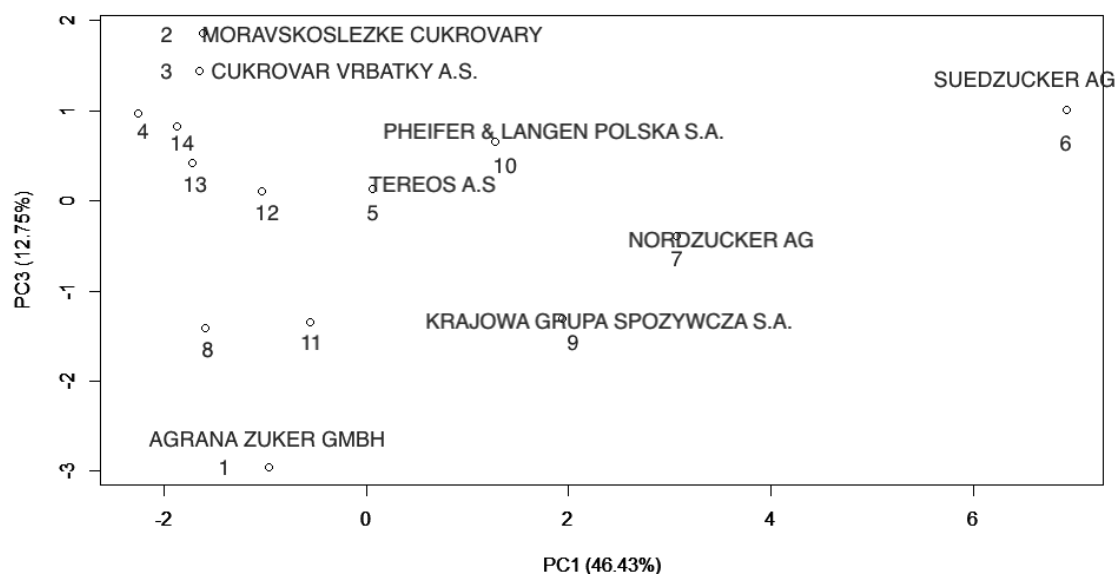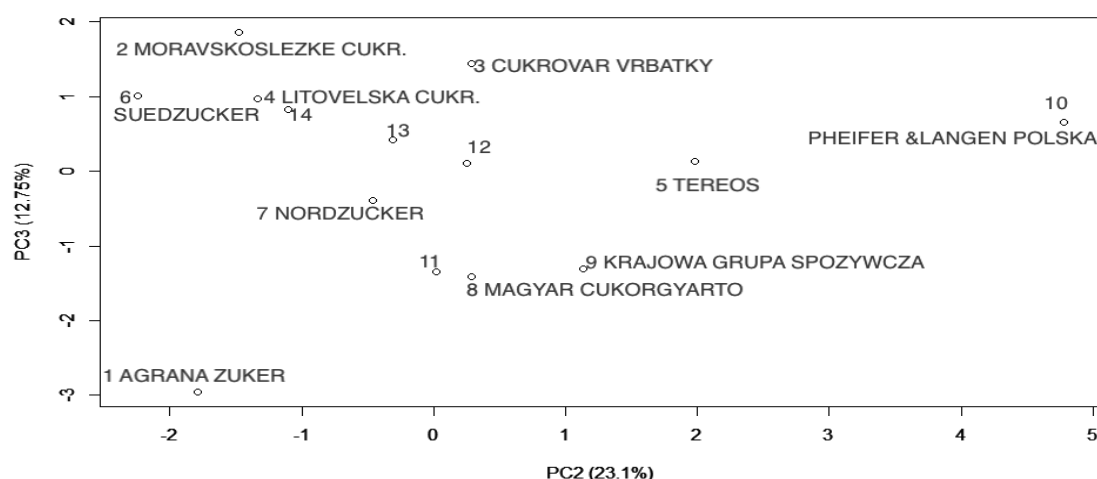
Fig. 3 Development potential of the Company vs. Equity Development Trend (PC2 vs. PC3)

The legend: 1- Agrana Zucker GmbH, 2- Moravskoslezke Cukrovary s.r.o., 3- Cukrovar Vrbatky a.s., 4- Litovelska Cukrovarna A.S., 5- Tereos a.s., 6- Seuzucker AG., 7- Nordzucker AG, 8- Magyar Cukorgyarto es forgalmazo zrt, 9- Krajowa Grupa Spozywcza a.s., 10- Pfeifer & Langen Polska s.a., 11- Sudzucker Polska s.a., 12- Nordzucker Polska s.a., 13- Povazsky Cukor a.s., 14- Slovenske Cukrovary s.r.o.

Source: own processing

Principal Component Analysis (PCA) components linked to variables like EBITDA, sales, and working capital indicate that there are differences in operational efficiency and financial health among companies. However, these components do not provide direct insights into the technological or operational practices that may underlie these financial results. The financial variables examined in the Principal Component Analysis (PCA), do not account for potential shifts in sustainable practices or environmental regulations, which are becoming increasingly important in the sugar production sector.

The Principal Component Analysis (PCA) results demonstrate that some companies, like Südzucker (Germany) and Agrana Zucker GmbH (Austria), have significantly higher performance in terms of PC1 (size), but their development potential seems limited according to PC2. The findings indicate these companies are large but may not exhibit the same growth trajectory as smaller firms, indicating a potential issue of market concentration or lack of innovation.

4.3.1. Country-Specific Insights

PCA analysis reveals notable differences: while Austria and Germany demonstrate financial stability characteristic of mature markets, Poland and Hungary show growth potential indicative of dynamic, developing industries.

- Czech Republic (CZE) demonstrated the highest score on PC1, indicating a strong financial position with high capital availability and strong operating revenue. The country's dynamics of the sugar market appears to be dynamic, with a substantial potential for growth.

- Poland (PL) and Slovakia (SK) also scored highly on PC1, signaling robust financial bases in their sugar industries, though Slovakia demonstrated stronger growth potential (positive PC2 score).

- Germany (DE) and Austria (AT), with lower PC1 scores, indicate that these markets are more mature, with less room for expansion but strong financial stability.

- Hungary (HU) exhibited a lower PC1 score, indicating weaker financial fundamentals in its sugar sector, though the country demonstrated some growth potential in PC2.

4.4.   Rotated Component Loadings for States
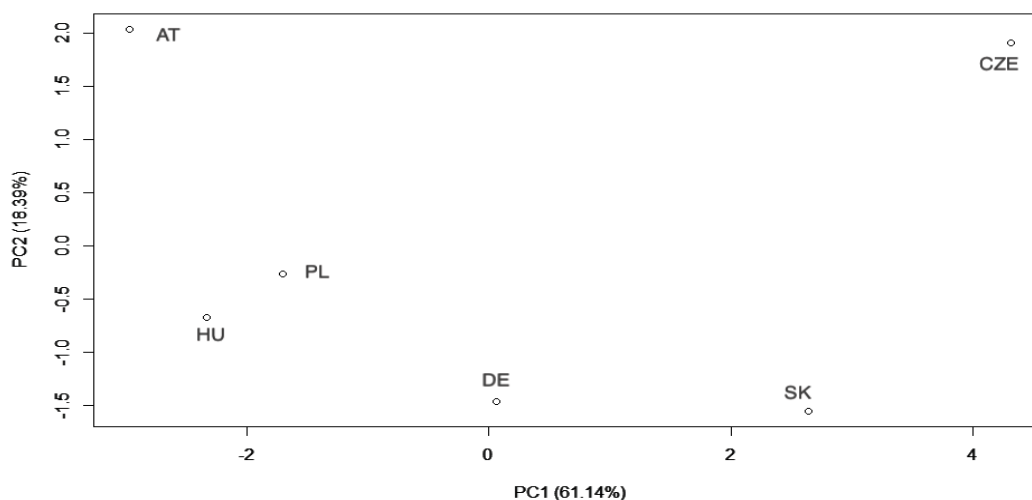
Fig. 4 Strength of each State vs. Development trend of the market (PC1 vs. PC2)

The legend: Czech Republic (CZE), Poland (PL), Slovakia (SK), Germany (DE) Austria (AT), Hungary (HU)
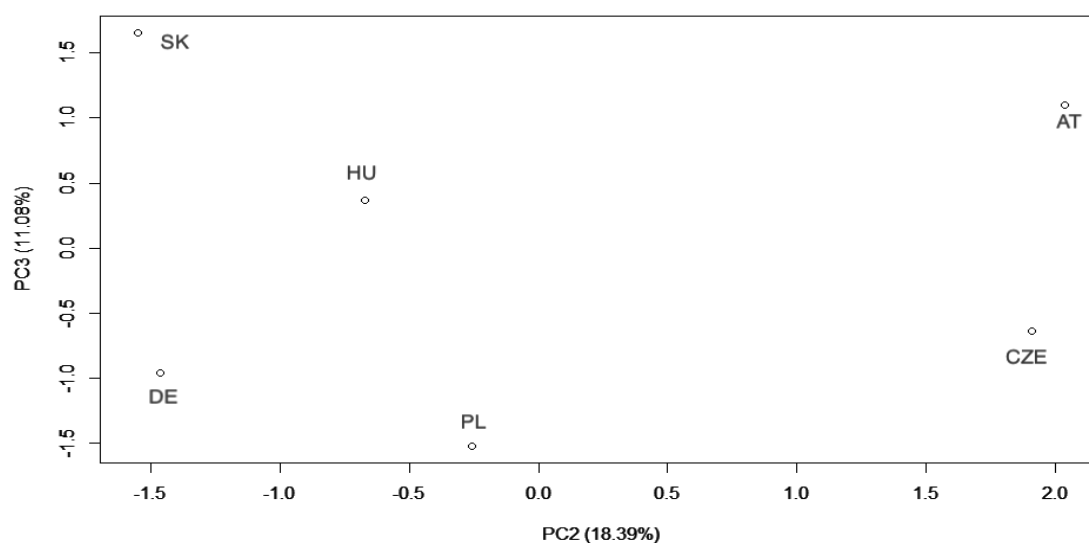
Source: own processing
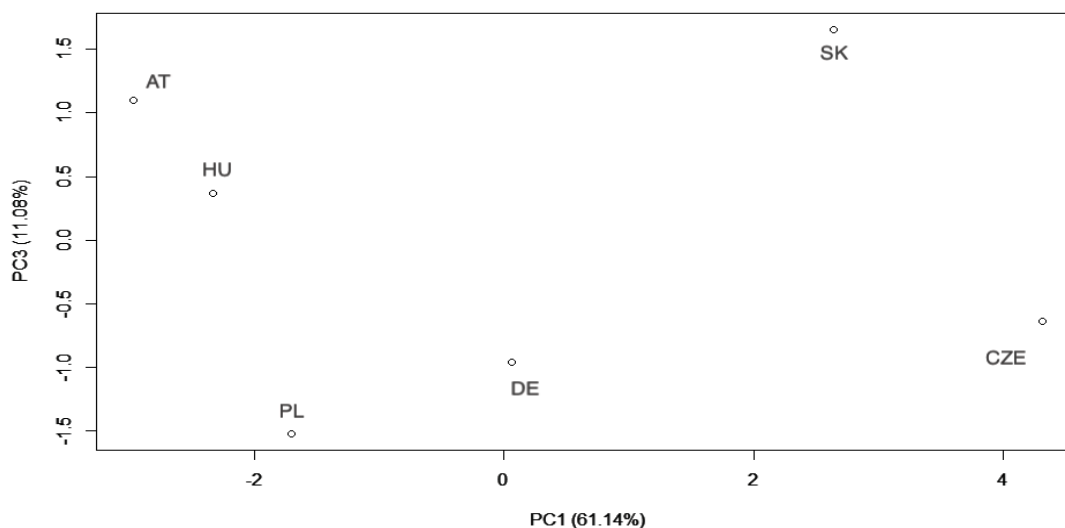
Fig. 5 Strength of each State vs Equity Development trend (PC1, PC3)

The legend: Czech Republic (CZE), Poland (PL), Slovakia (SK), Germany (DE) Austria (AT), Hungary (HU)

Source: own processing

Fig. 6 Development Trend of the Market vs Equity Development Trend (PC2, PC3)

The legend: Czech Republic (CZE), Poland (PL), Slovakia (SK), Germany (DE) Austria (AT), Hungary (HU)

Source: own processing

The Principal Component Analysis (PCA) revealed distinct country-specific performance patterns, especially between countries like Austria and Germany versus Czechia, Hungary, and Slovakia. However, the underlying drivers behind these country-level disparities are not fully explained in the Principal Component Analysis (PCA). For example, the variance captured by PC1 (representing company size) and PC2 (representing company development) indicates certain countries' firms exhibit larger size or growth potential.

The country-specific results of Principal Component Analysis (PCA), particularly the differences between Poland and Slovakia, indicate that there may be unique economic or regulatory environments influencing the dynamics of the sugar market outcomes. However, Principal Component Analysis (PCA) alone cannot explain why Poland's sugar-producing companies, despite demonstrating favorable trends in capital and working capital, might perform differently compared to their counterparts in Slovakia or Hungary.

4.5.   Implications for the Sugar Market

The Principal Component Analysis (PCA) results highlight several key trends in the sugar production sector:

Larger companies, such as Suedzucker AG, dominate the market in terms of size but have limited development potential, reflecting a more mature business model that prioritizes market stability.

Smaller companies like Litovelská Cukrovarna A.S. may exhibit similar equity development potential despite their smaller size, indicating that growth is possible in smaller markets with the right management strategies.

The Czech Republic and Poland stand out as dynamic markets with high growth potential, while Germany and Austria demonstrate signs of maturity and lower growth potential.

The findings indicate that smaller, developing markets may offer more opportunities for innovation and growth, while more mature markets focus on maintaining profitability and managing operational efficiency. (Motta (2004)).

5.   Discussion

The Principal Component Analysis (PCA) conducted on the financial data of sugar-producing companies in Central and Eastern Europe reveals several insightful patterns and trends. These results offer a clearer understanding of the underlying financial dynamics that define the competitiveness and growth prospects of these companies, as well as the broader implications for the sugar production sector in the region.

5.1.   Firm Size as a Determinant of Financial Stability

Relates to Research Question: "How do sugar-producing companies of different sizes perform in terms of financial stability and development potential?"

The first principal component (PC1), which explains 46.43% of the total variance in the dataset, clearly confirms that firm size plays a crucial role in shaping a company's financial profile. Companies such as Suedzucker AG and Agrana Zucker GmbH score highly on this component, reflecting their substantial financial resources, capital base, and operating revenue. These firms benefit from economies of scale, strong market positions, and the ability to mobilize capital to ensure long-term stability.

However, the analysis also reveals that size alone does not guarantee sustained growth or market leadership. For instance, Suedzucker AG, despite its large size, exhibits minimal growth potential, as indicated by its negative score on the second principal component (PC2). This phenomenon is typical of large enterprises across sectors: maturity often leads to stagnation.

This trend is clearly evident in the company-level Principal Component Analysis (PCA), where larger firms generally demonstrate less dynamic and less aggressive growth patterns. In contrast, companies such as Pfeifer & Langen Polska S.A., despite their smaller size, achieve higher scores on the second principal component (PC2), reflecting their more flexible, dynamic, and expansion-oriented growth strategies. This observation challenges the conventional assumption that larger firms inherently outperform smaller ones and instead emphasizes that strategic adaptability is a key determinant of development and long-term competitiveness.

5.2.   Growth Potential in Relation to Enterprise Scale and Development

Relates to Research Question: "Is there evidence that smaller companies can outperform larger ones in terms of growth potential and adaptability?"

The second principal component (PC2), which explains 23.10% of the total variance, is essential in assessing the growth potential of sugar-producing companies. The results show that large firms, such as Suedzucker AG, generally exhibit negative values on this component, indicating limited growth trajectories. In contrast, smaller enterprises tend to achieve positive scores, suggesting greater strategic flexibility and stronger development orientation.

A prominent example is Pfeifer & Langen Polska S.A., which, despite its smaller scale, demonstrates a notable capacity for growth. This finding is consistent with broader trends in the food and beverage industry, where smaller, more agile firms often show a greater ability to respond to changing market conditions and consumer preferences. Such firms are typically more willing to experiment with new products, technologies, and marketing strategies, thereby gaining a competitive advantage.

Interestingly, even among large firms, low PC2 scores are observed—for instance, in Agrana Zucker GmbH—underscoring that size alone does not determine development potential. On the contrary, organizational rigidity or overreliance on traditional models may hinder growth. Conversely, companies like Tereos A.S., which pursue proactive and innovation-driven strategies, highlight the importance of adaptability and strategic focus on development, regardless of firm size.

5.3.   Equity Structure and Financial Health Indicators

Supporting analysis for all research questions. Focuses on the role of equity, liabilities, and working capital as explanatory variables of stability and growth.

The third principal component (PC3), which explains 12.75% of the total variance, provides meaningful insights into the development of equity and the overall financial health of the examined companies. This component is especially important as it reflects how businesses manage their liabilities—particularly those owed to creditors—and how efficiently they utilize working capital to maintain financial stability.

Larger companies often benefit from broader access to capital and stronger leverage in managing liabilities, typically resulting in a higher capacity for equity development. However, this relationship is not absolute. For example, Pfeifer & Langen Polska S.A., although smaller in size, performs strongly on PC3, indicating sound financial governance and effective resource management. These findings emphasize that robust financial control can play a critical role in supporting growth regardless of company size.

Another notable case is Litovelská Cukrovarna A.S., a smaller firm that nonetheless shows comparable equity development to much larger competitors. This challenges the commonly held notion that financial stability is exclusive to large-scale enterprises. Rather, the ability to manage working capital effectively and to balance equity with liabilities emerges as a fundamental driver of financial success across firm sizes.

5.4.   Regional Market Dynamics: A Cross-Country

Relates to Research Question: "To what extent does the national context influence the financial strength and growth trajectory of the sugar industry?"

The country-level analysis reveals substantial differences in the financial standing of the sugar production sector across the observed states. Countries such as the Czech Republic and Poland demonstrate high scores on the first principal component (PC1), reflecting strong capital bases, high operating revenues, and a competitive industrial framework. These indicators suggest that both countries represent dynamic and expanding markets with significant development potential.

In contrast, Hungary and Slovakia show lower PC1 scores, which may point to weaker financial conditions or less developed market environments. Despite their more limited starting positions, Slovakia distinguishes itself by achieving a positive score on PC2, indicating a

potential for future growth, provided that appropriate policy support and investment incentives are in place.

Germany and Austria, by comparison, show relatively low values on both PC1 and PC2. These results confirm the characteristics of mature markets, where stability and financial certainty dominate, but opportunities for further expansion are limited. In such cases, the industry appears to be in a phase of consolidation rather than growth, with strategic attention focused on maintaining profitability and operational efficiency within existing capacities.

5.5. Strategic and Policy Implications for Sector Development

Related to the research questions: Implications of the findings for corporate strategy and public policy in the context of sugar industry development in Central and Eastern Europe.

The conclusions of this study carry important implications for both the strategic orientation of sugar-producing companies and the formulation of public economic policy in the examined countries. The analysis shows that large companies exhibit greater financial stability and market dominance but are also characterized by limited growth potential—a feature typically associated with mature firms that focus more on maintaining existing positions than pursuing expansion. To remain competitive, such firms must increasingly invest in product diversification, innovation, and the exploration of new markets.

Smaller enterprises, despite having more limited resources, often display stronger flexibility and adaptability. With sound financial management and an innovation-oriented mindset, they can successfully compete with larger players. Strategic adaptability thus emerges as a key growth driver, regardless of firm size.

From a policy perspective, countries with developed sugar industries—such as the Czech Republic and Poland—should prioritize support for technological advancement, modernization, and the expansion of small and medium-sized enterprises. In contrast, countries with weaker financial foundations—such as Hungary and Slovakia—should focus on strengthening companies' equity structures, enhancing financial resource efficiency, and improving overall financial health.

The findings also underscore the need for regionally differentiated policy approaches. In economically mature markets such as Austria and Germany, policy efforts should concentrate on maintaining competitiveness through innovation and sustainable technologies. In contrast,

emerging markets require targeted support to enhance investment capacity, ensure financial resilience, and stimulate the development of smaller, growth-oriented enterprises.

5.6.   Limitations and Future Research

While the Principal Component Analysis (PCA) provided valuable insights, several limitations should be considered. The analysis was based on financial data covering the five-year period from 2018 to 2022, selected to enhance interpretability and reduce the influence of short-term fluctuations. In contrast, the trend analysis employed the full time series from 2013 to 2022, allowing for the identification of long-term development trajectories. This methodological distinction enabled the study to capture both the current financial positioning of companies (through PCA) and their historical dynamics (through normalized trend analysis). Nevertheless, the five-year average used in PCA may not fully reflect sudden shifts in market conditions or structural changes in the global sugar industry. Moreover, while PCA is effective in revealing statistical patterns, it does not account for all underlying drivers of financial performance, such as competition intensity, shifts in consumer preferences, or evolving regulatory frameworks.

Future research could explore the role of these external factors in shaping the financial performance of sugar-producing companies. Further analysis of the industry's responses to global sugar price trends, sustainable practices concerns, and technological advancements could provide a more comprehensive understanding of the market dynamics.

In addition, the inclusion of non-financial variables, such as consumer sentiment or regulatory factors, could offer a richer, more nuanced view of the sugar production sector in Central and Eastern Europe.

6.   Conclusion

This study analyzed the sugar production sector in Central and Eastern Europe (CEE), revealing diverse dynamics at both the company and country levels. The findings underscore critical factors that influence financial stability, growth potential, and sustainability within the industry.

At the company level, large firms such as Südzucker AG and Agrana Zucker GmbH dominate the market in terms of scale and financial resources, benefiting from economies of scale and solid capital bases. However, these companies demonstrate limited growth potential, which is typical of mature market players whose strategies are oriented more toward

maintaining stability than pursuing aggressive expansion. In contrast, smaller companies such as Pfeifer & Langen Polska S.A. and Litovelská Cukrovarna A.S. exhibit stronger growth trajectories, leveraging their agility to adapt to market changes and seize emerging opportunities. Firms like Tereos A.S., which effectively manage equity and internal resources, are well positioned for steady growth, regardless of their size.

The analyzed countries differ not only in the performance of their sugar-producing companies but also in overall economic credibility and the structure of their national economies. According to Standard & Poor's credit ratings (as of 2025), Germany holds the highest rating (AAA), followed by Austria (AA+) and the Czech Republic (AA-). Lower ratings are assigned to Poland (A-), Hungary (BBB-), and Slovakia (A+). Additionally, the share of the primary sector in GDP varies significantly across countries from 0.8% in Germany to 4.7% in Hungary (see credit ratings and GDP sector shares on pages 6–7). These differences indicate diverse economic backgrounds.

From a regional perspective, substantial differences among countries were identified. The Czech Republic and Poland emerge as strong markets with robust financial foundations and significant development potential, indicating dynamic and competitive sugar industries. Slovakia, while a smaller market, presents substantial opportunities for growth, pointing to the need for targeted investment and policy support. Germany and Austria, on the other hand, reflect mature markets characterized by financial stability but slower growth rates, signaling consolidation rather than expansion. Hungary displays weaker financial fundamentals, suggesting that improved capital management and strategic development are necessary to enhance its competitiveness.

Based on the findings presented above, it is also possible to clearly address the three research questions formulated in the introduction of this study.

First, firm size proves to be a key factor in ensuring financial stability, though it does not automatically translate into growth potential — several smaller enterprises demonstrated stronger development dynamics than their larger counterparts.

Second, the national context plays a significant role in shaping the financial strength and growth trajectories of sugar-producing companies.

Finally, the analysis confirms that smaller firms, due to their greater flexibility and adaptability, can successfully respond to market challenges and in some cases outperform larger, more established players.

These insights underscore that long-term competitiveness in the sugar sector depends not only on size or capital resources, but also on innovation, strategic agility, and the capacity to adapt to a changing economic and regulatory environment.

The main drivers of these dynamics include key financial indicators such as capital structure, operating revenue, and working capital, which determine firm size and stability. Growth potential is closely tied to effective equity management and the ability to adapt operationally. A pivotal moment occurred in the autumn of 2017 when the European Union abolished the sugar quota system, effectively deregulating the market and exposing producers to direct global competition. This liberalization of the sector, combined with global market pressures, reinforced the importance of efficiency, innovation, and sustainable development.

Sustainability has become an increasingly critical factor for long-term competitiveness in the sugar sector. Larger enterprises must integrate renewable energy solutions and adopt sustainable resource management practices. Smaller and medium-sized firms should focus on innovation and product diversification to capture new market segments. Policymakers play a crucial role in designing strategies tailored to the specific needs of national markets. In mature economies such as Germany and Austria, the emphasis should be placed on supporting innovation and ensuring environmental sustainability. In emerging markets such as Poland and Slovakia, policies should aim to strengthen financial health, promote capital investment, and support growth-oriented enterprises.

The study clearly demonstrates the importance of balancing firm size with strategic growth and innovation. Large companies must avoid stagnation by diversifying their portfolios and investing in new technologies, while smaller firms can exploit their flexibility to drive expansion. Effective financial management, sustainability-oriented practices, and targeted government support will ensure the sector's resilience and long-term competitiveness across the CEE region.

In conclusion, the sugar industry in Central and Eastern Europe faces distinct challenges and opportunities. By appropriately addressing market dynamics and integrating sustainable and innovative practices, both companies and policymakers can secure a successful future for the sector in an evolving global environment.

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