

Financial dynamics and strategic growth in sugar industry: Comparative analysis of Central and Eastern Europe (2013–2022)

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Abstract

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Introduction. It is explored the financial dynamics and strategic growth of the sugar production sector focusing on six countries: the Czech Republic, Austria, Germany, Poland, Hungary, and Slovakia, over the period 2013–2022.

Materials and methods. To analyze the performance of sugar-producing companies in the Czech Republic and neighboring countries, it was employed a two-stage analytical approach, involving the calculation of normalized linear trends and Principal Component Analysis of company characteristics averages and normalized trends.

Results and discussion. The first principal component accounted for 46.43% of the total variance, which clearly indicates that company size plays a dominant role in defining their financial profiles. Larger companies such as Suedzucker AG and Agrana Zucker GMBH score highly on this component, reflecting their substantial financial resources, capital, and operating revenue. The second principal component (PC2), which accounted for 23.10% of the total variance, was crucial in highlighting the growth potential of sugar-producing companies. While large firms like Suedzucker AG demonstrated limited growth (negative PC2), smaller companies demonstrated considerable growth potential. For example, Pfeifer & Langen Polska S.A. The third principal component (PC3), which explained 12.75% of the variance, offered insights into the equity development and financial health of companies. This component is especially important because it highlights how companies manage their liabilities (creditors) and working capital to maintain financial stability. The analysis highlights regional and company-level variations in financial performance, identifying key drivers such as company size, equity management, and growth potential. At the company level, larger firms demonstrate stability but limited growth, while smaller firms show strong development potential, emphasizing strategic adaptability as a critical factor for success. At the country level, the Czech Republic and Poland emerge as dynamic markets with robust financial bases, while Germany and Austria reflect mature industries with lower growth potential. Hungary and Slovakia, despite financial challenges, exhibit opportunities for development. This study underscores the importance of balancing financial health, innovation, and sustainability for the long-term resilience of the sugar sector. Principal Component Analysis (PCA), while powerful for identifying patterns, does not capture all the underlying causes of financial dynamics, such as market competition, consumer preferences, or regulatory changes.

Conclusion. It is highlighted diverse dynamics affecting financial stability, growth, and sustainability. Larger firms dominate the market but show limited growth potential, while smaller firms demonstrate stronger growth trajectories. Countries like the Czech Republic and Poland have strong financial positions, whereas Hungary needs improved financial strategies to enhance competitiveness.

Introduction

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 and its neighboring countries—Austria, Germany, Poland, Hungary, and Slovakia—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 and 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 complexity to the sector, highlighting the interconnectedness of CEE economies (European Commission, 2017; Nes et al., 2021).

Sustainability has emerged as a critical concern for the sugar industry, with increasing emphasis on reducing its environmental footprint (Garcia-Bustamante et al., 2018). The sector faces scrutiny for its significant carbon emissions, high water usage, and energy demands (Aguilar-Rivera, 2022; Formann et al., 2020; Meghana and Shastri, 2020).

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 and 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 (Diggle and Giorgi, 2024; Hamilton, 2020), making it particularly valuable for industries like sugar production, which are influenced by cyclical market dynamics and external shocks.

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 (Crepey 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, 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.

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.

Given the broad historical and economic context, this paper's central objective 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, Austria, Germany, Poland, Hungary, and Slovakia.

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.

Materials and methods

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 and 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).

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.

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).

$$Nb_i = \frac{b}{AverageValueofY_i}$$

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.

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 companies 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, and Slovakia,
- All countries combined.

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

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 employers, Operating revenue, Sales, and Working Capital.

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. 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 database was used for relevant above mentioned data collection.

Principal component analysis

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 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 and Odoroff, 1990).

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.

Results and discussion

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, and 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	Company
-0.96591	-1.79322	-2.95359	Agrana Zucker GMBH
-1.61952	-1.48201	1.86055	Moravskoslezke Cukrovary
-1.65217	0.28348	1.44341	Cukrovar Vrbatky a.s.
-2.26005	-1.33810	0.96678	Litovelska Cukrovarna
0.06189	1.98233	0.13341	Tereos a.s
6.92069	-2.24695	1.01244	Suedzucker AG
3.07329	-0.46317	-0.39555	Nordzucker AG
-1.59659	0.29054	-1.41489	Magyar Cukorgyarto es Forg
1.93971	1.13487	-1.30579	Krajowa Grupa Spozywcza S.A.
1.27704	4.77504	0.65072	Pfeifer and Langen Polska
-0.55261	0.02023	-1.34400	Sudzucker Polska S.A.
-1.03807	0.25494	0.10056	Nordzucker Polska S.A.
-1.71824	-0.31222	0.42547	Povazsky Cukor a.s.
-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

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.

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.

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	
-2.97677556	2.0364548	1.1019787	AT
0.06452467	-1.4647739	-0.9606211	DE
4.31375674	1.9115372	-0.6420512	CZE
-2.33420439	-0.6708318	0.3685516	HU
2.63897485	-1.5528708	1.6564579	SK
-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

Visualizing the results

The visualizations below illustrate the relationships between the size, development, and equity development of companies and countries.

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.

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 Moravskoslezské cukrovarny demonstrate comparable equity development potential, indicating that equity management plays a key role in smaller companies' financial strategies.

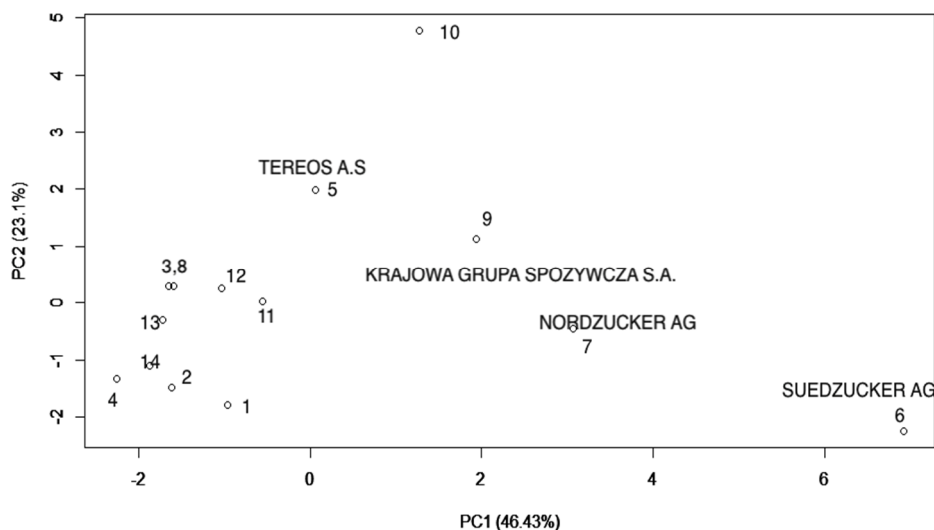


Figure 1. Size of the Company vs. Development (PC1 vs. PC2)

Source: own processing

The legend: 1 – Agrana Zuker 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 forgalmazozartk, 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.

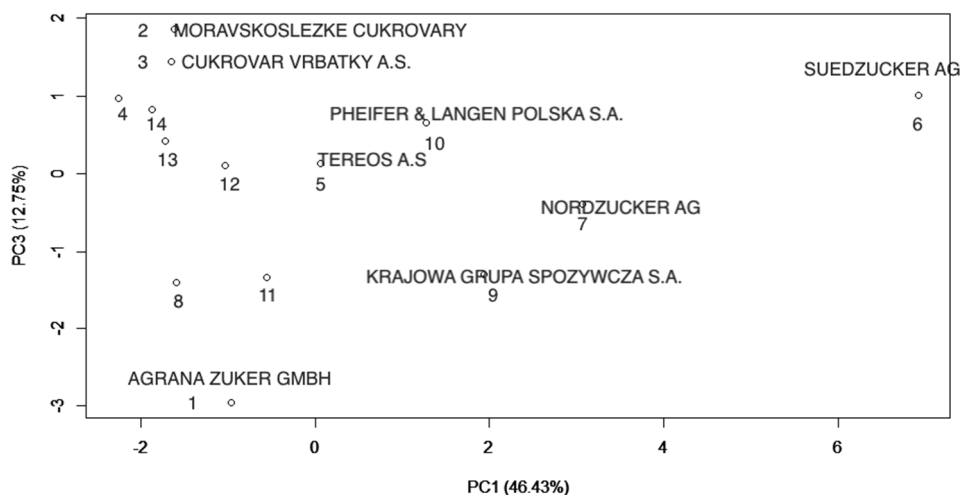


Figure 2. Size of the Company vs. Equity Development (PC1 vs. PC3)

Here, the size of the company (PC1) is compared with its equity development (PC3).

Source: own processing,

The legend: 1 – Agrana Zuker 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 Forgalmazozartk, 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.

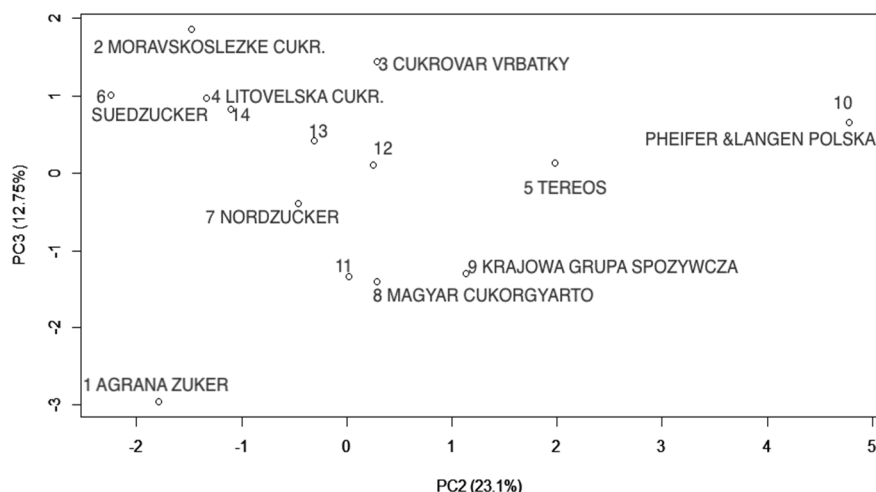


Figure 3. Development potential of the Company vs. Equity Development Trend (PC2 vs. PC3)

Source: own processing

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 Forgalmazó Zrtk, 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.

Principal Component Analysis 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, 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 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.

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.

Rotated component loadings for states

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.

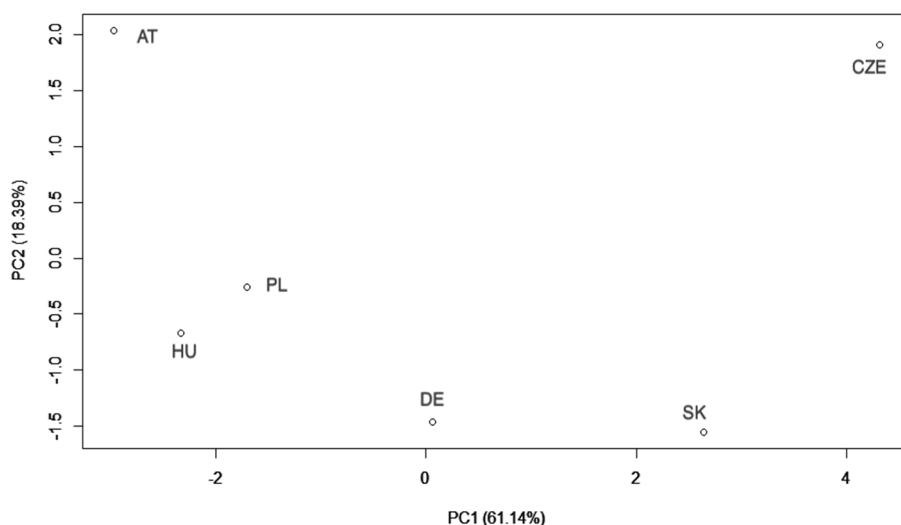


Figure 4. Strength of each State vs. Development trend of the market (PC1 vs. PC2)

Source: own processing

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

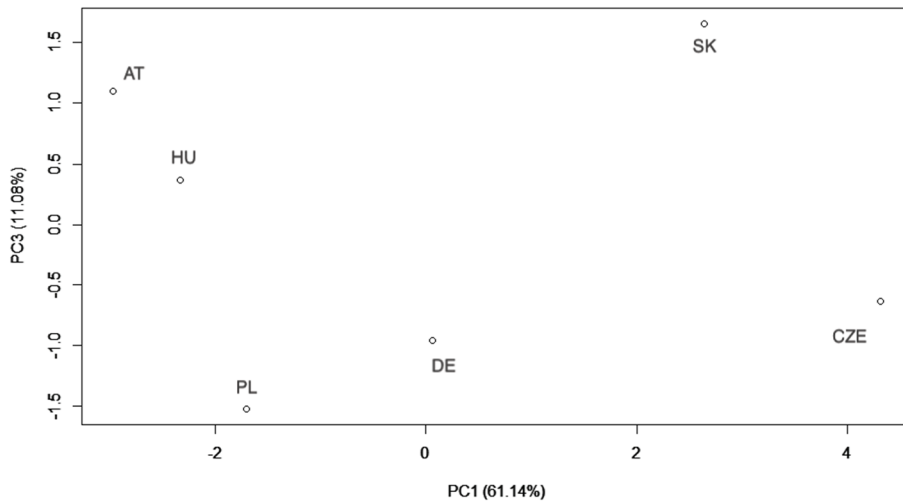


Figure 5. Strength of each State vs Equity Development trend (PC1, PC3)

Source: own processing

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

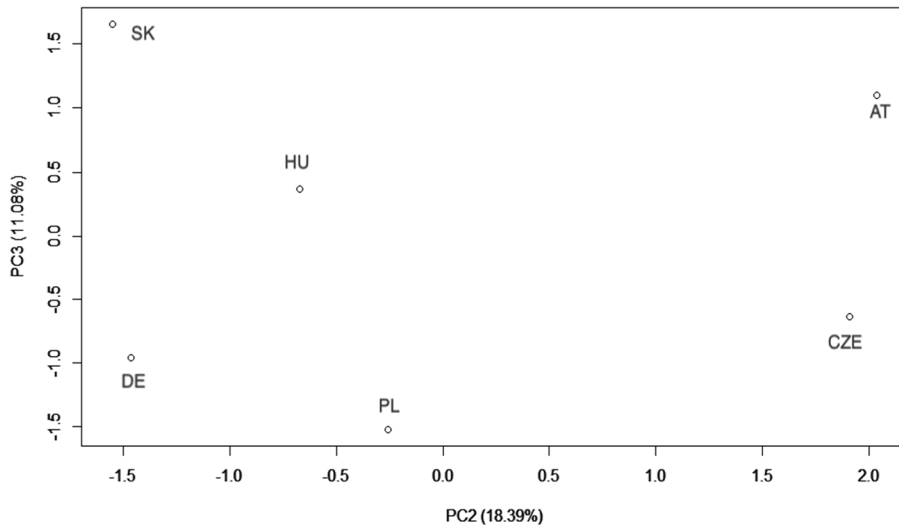


Figure 6. Development Trend of the Market vs Equity Development Trend (PC2, PC3)

Source: own processing

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

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).

Financial size and stability

The first principal component (PC1) accounted for 46.43% of the total variance, which clearly indicates that company size plays a dominant role in defining their financial profiles. Larger companies such as Suedzucker AG and Agrana Zucker GmbH score highly on this component, reflecting their substantial financial resources, capital, and operating revenue. These companies benefit from economies of scale, a strong market presence, and the ability to leverage significant capital for long-term stability.

However, the results indicate that simply being large does not guarantee sustained growth or market leadership. Suedzucker AG, despite its size, demonstrates minimal development potential as indicated by its negative score on the second principal component (PC2). This highlights a trend observed in larger companies across various industries: maturity can result in stagnation.

This trend is evident in the company-level Principal Component Analysis, where larger firms generally demonstrate less aggressive growth patterns. Companies like Pfeifer & Langen Polska S.A., despite their smaller size, score higher on PC2, reflecting their more dynamic and growth-oriented strategies. This observation challenges the traditional view that larger companies automatically outperform smaller ones and indicates that strategic adaptability is key to fostering growth.

Growth potential and development

The second principal component (PC2), which accounted for 23.10% of the total variance, was crucial in highlighting the growth potential of sugar-producing companies. While large firms like Suedzucker AG demonstrated limited growth (negative PC2), smaller companies demonstrated considerable growth potential. For example, Pfeifer & Langen Polska S.A.

This finding is consistent with broader trends in the food and beverage sector, where smaller, more agile companies often demonstrate greater flexibility in adapting to market changes and emerging consumer preferences. They are also more likely to experiment with new products, production methods, and marketing strategies, providing them with a competitive edge.

Interestingly, Agrana Zucker GMBH, despite being one of the larger companies, scored low on PC2, signaling that size alone does not guarantee development. It indicates that some companies in the sugar production sector may be facing challenges in adapting to changing

market conditions or may be overly reliant on established practices. In contrast, companies with more aggressive growth strategies, like Tereos a.s.

Equity and financial health

The third principal component (PC3), which explained 12.75% of the variance, offered insights into the equity development and financial health of companies. This component is especially important because it highlights how companies manage their liabilities (creditors) and working capital to maintain financial stability.

Larger companies, which typically have more access to financing and larger capital bases, generally display a stronger capacity to manage their equity development. However, this is not always the case. Companies such as Pfeifer & Langen Polska S.A., despite their smaller size, demonstrate impressive scores on PC3, indicating that effective management of equity and liabilities can also help smaller companies maintain financial health and foster sustainable growth.

The presence of smaller companies like Litovelská Cukrovarna A.S. with a strong performance on PC3 challenges the assumption that larger companies are inherently more stable. In fact, the ability to manage working capital effectively and maintain a healthy balance between equity and liabilities appears to be a key driver of financial success, regardless of company size.

Country-level analysis: regional market dynamics

The analysis at the country level reveals interesting regional variations in the financial dynamics of the sugar production sector. Countries like the Czech Republic (CZE) and Poland (PL) score highly on PC1, reflecting a strong financial base and competitive sugar industries. These countries appear to have a balanced combination of capital availability, operating revenue, and profitability, which positions them well for sustained market leadership.

In contrast, countries like Hungary (HU) and Slovakia (SK) exhibit lower scores on PC1, which may reflect weaker financial positions or less mature dynamics of the sugar markets. However, Slovakia, in particular, stands out with a positive score on PC2, indicating that while its market may be smaller or less financially robust, it is demonstrating potential for growth and development. (Penrose (2009)).

Germany (DE) and Austria (AT) are two countries with lower scores on PC1, indicating that their sugar industries are more mature. This indicates that companies in these countries might face challenges in growing or adapting to rapidly changing market conditions. The low growth potential reflected in PC2 for both countries further supports the idea that these markets may be in a consolidation phase, with companies focusing on maintaining existing market share rather than pursuing significant expansion.

Implications for strategy and policy

The findings of this study have important implications for both sugar-producing companies and policymakers in Central and Eastern Europe.

For Companies: The analysis indicates that while large companies benefit from financial stability and market dominance, they must be vigilant about potential stagnation. To sustain growth, even the largest companies must explore new market opportunities, invest in innovation, and diversify their product offerings. Smaller companies, on the other hand,

may be able to leverage their agility and growth potential to disrupt the market, provided they manage their financial resources effectively and adapt to changing consumer demands.

For Policymakers: The analysis also has important policy implications. Countries with strong financial positions, such as the Czech Republic and Poland, should focus on fostering innovation and supporting the growth of smaller companies that demonstrate potential for expansion. In contrast, policymakers in countries with less robust markets, like Hungary and Slovakia, should focus on improving the financial health of local sugar-producing companies, particularly by offering support for equity development and efficient resource management.

Additionally, there is a clear need for regionally tailored policies that consider the different stages of market maturity across countries. Policymakers should encourage investment in technology, sustainable practices initiatives, and market diversification, particularly in more mature markets where growth has plateaued.

Limitations and future research

While the Principal Component Analysis provided valuable insights, several limitations should be considered. The study focused on financial data over a five-year period (2018-2022), which may not fully capture short-term market fluctuations or sudden shifts in the global dynamics of the sugar market. Additionally, Principal Component Analysis, while powerful for identifying patterns, does not capture all the underlying causes of financial dynamics, such as market competition, consumer preferences, or regulatory changes.

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.

Discussion

The Principal Component Analysis results provide important insights into the financial structure and strategic positioning of sugar-producing companies in Central and Eastern Europe. The first principal component (PC1) explains 46.43% of the variance and is strongly associated with company size, confirming prior research by Kotyza et al. (2019), which found that larger firms benefit from economies of scale, greater capital resources, and stronger market positions. However, despite their financial stability, large companies such as Suedzucker AG and Agrana Zucker GMBH exhibit limited growth potential, as indicated by their negative scores on the second principal component (PC2). This aligns with Muir and Anderson (2022), who demonstrated that post-2017 EU sugar quota abolition led to reduced expansion incentives for established market leaders. In contrast, smaller firms such as Pfeifer & Langen Polska S.A. exhibit higher PC2 scores, suggesting that they are more agile and responsive to market changes, a trend consistent with findings by Severini and Sorrentino (2017), who highlighted the role of flexible business models in adapting to policy shifts.

Growth potential (PC2) accounted for 23.10% of the variance, reinforcing the notion that financial expansion is not solely dictated by company size but by equity management and strategic reinvestment. Similar to observations by Schroeder et al. (2022) in food supply chain financial studies, firms with robust EBITDA trends and efficient working capital management demonstrate higher growth trajectories. This suggests that strategic adaptability

and financial health are key determinants of expansion rather than just scale. Moreover, equity management (PC3), which explains 12.75% of the variance, highlights critical differences in financial stability across firms, reinforcing Labrin and Urdinez (2020) and Nes et al. (2021), who found that effective creditor-liability balancing is fundamental for long-term sustainability in capital-intensive industries. While large companies may rely on financial reserves to sustain operations, mid-sized firms showing strong PC3 scores, such as Tereos a.s., illustrate that dynamic investment in capital and efficient debt structuring are key drivers of sustainable growth.

At the regional level, the PCA analysis confirms significant disparities in financial health and market maturity across CEE countries. The Czech Republic and Poland exhibit high PC1 scores, reflecting their strong financial positioning, which aligns with Pawlak and Smutka (2022), who found that these countries have maintained a competitive edge in agri-food exports post-quota abolition. Conversely, Hungary and Slovakia score lower on PC1, highlighting weaker financial structures, consistent with Soare et al. (2021), who identified external investment constraints and structural inefficiencies as barriers to sugar market growth in these countries. Moreover, Meghana and Shastri (2020) emphasize that sustainability concerns and environmental costs are increasingly shaping financial strategies in the sugar sector, an area that could influence future profitability and competitiveness. These findings suggest that while larger markets emphasize consolidation, emerging markets require targeted policy interventions to enhance financial resilience.

The results reinforce previous literature by demonstrating that sugar market dynamics in CEE are driven by a trade-off between financial stability and growth potential. Larger firms exhibit strong capital bases but limited expansion, whereas smaller firms have higher agility but require strategic financial management to scale successfully. The study also highlights the importance of sustainable business models, as emphasized by Aguilar-Rivera (2022), who argued that resource efficiency and technological innovation will be crucial for future competitiveness in the sugar industry. Policymakers should consider these insights when developing strategies for sectoral sustainability, balancing financial growth with regulatory and environmental constraints.

Conclusions

The analysis of the sugar production sector in Central and Eastern Europe reveals diverse dynamics at both the company and country levels, highlighting critical factors influencing financial stability, growth potential, and sustainability.

At the company level, larger firms such as Südzucker AG and Agrana Zucker GMBH dominate the market in size and financial resources, benefiting from economies of scale and stable capital bases. However, these companies demonstrate limited growth potential, reflecting their mature market position and focus on maintaining stability rather than expansion. In contrast, smaller companies like Pfeifer & Langen Polska S.A. and Litovelská Cukrovarna A.S. exhibit stronger growth trajectories, leveraging their agility to adapt to market changes and seize new opportunities. Companies with effective equity and resource management, such as Tereos A.S., are better positioned for steady growth, regardless of their size.

At the country level, significant regional variations emerge. The Czech Republic and Poland stand out with strong financial positions and high development potential, signaling dynamic and competitive sugar industries. Slovakia, while smaller, demonstrates considerable growth opportunities, suggesting the need for strategic investments and policy

support. Germany and Austria reflect mature markets characterized by financial stability but slower growth rates, indicating a focus on consolidation. Meanwhile, Hungary's weaker financial fundamentals point to the need for improved financial strategies and capital management to enhance its industry's competitiveness.

Key drivers of these dynamics include critical financial indicators such as capital structure, operating revenue, and working capital, which determine company size and stability. Growth potential is closely tied to efficient equity management and operational adaptability. Additionally, the abolition of EU sugar quotas and global market pressures have shaped the sector, emphasizing the need for efficiency, innovation, and sustainability.

Sustainability practices are becoming increasingly important for long-term competitiveness. Larger firms must integrate renewable energy solutions and adopt sustainable resource management, while smaller and medium-sized firms should focus on leveraging innovation and diversifying their offerings to capture new market opportunities. Policymakers play a vital role in tailoring strategies to the specific needs of each country's sugar industry. In mature markets like Germany and Austria, efforts should prioritize fostering innovation and ensuring sustainability. For emerging markets such as Poland and Slovakia, policies should focus on improving financial health, increasing capital investment, and supporting growth-oriented firms.

The study highlights the importance of balancing size with strategic growth and innovation. Larger companies must avoid stagnation by diversifying their portfolios and investing in new technologies, while smaller firms can exploit their flexibility to drive growth. Effective financial management, sustainable practices, and tailored policies will ensure resilience and long-term competitiveness for the sugar production sector across the CEE region.

In conclusion, the sugar industry in Central and Eastern Europe faces distinct opportunities and challenges. By addressing market dynamics and integrating sustainable and innovative practices, companies and policymakers can secure the sector's continued success in an evolving global market.

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