Vlach Jaroslav, University of South Bohemia in České Budějovice, Faculty of Economics

FINANCIAL DYNAMICS OF THE SUGAR INDUSTRY IN CENTRAL AND EASTERN EUROPE: A SYNTHESIS OF PCA RESULTS AND STRATEGIC IMPLICATIONS

Abstract

This conference paper presents a synthetic and interpretation-oriented version of research results on the financial dynamics of the sugar industry in Central and Eastern Europe over the period 2013–2022. The text builds on previously published analyses but reformulates the research questions and places emphasis on methodological and strategic implications rather than on detailed empirical description. The aim is to assess how Principal Component Analysis contributes to the interpretation of differences between firms and countries, and whether firm size represents a barrier to future growth following the abolition of EU sugar quotas in 2017.

The analysis is based on data from fourteen major sugar producers across six countries (Czech Republic, Austria, Germany, Poland, Hungary, Slovakia) and combines normalized linear trends with PCA modelling of financial indicators. The results confirm the dominant role of firm size (PC1), while also showing that growth potential (PC2) is often higher among smaller and more flexible firms. The third component (PC3) reflects developments in equity and financial stability, which prove crucial for long-term corporate resilience. At the country level, the Czech Republic and Poland emerge as dynamic markets, while Germany and Austria exhibit characteristics of mature and stabilised industries.

The paper discusses the limits of the PCA approach and proposes a typology of sugar mill strategies with respect to capital structure, working capital management, and the ability to adapt to a volatile market environment.

Keywords: sugar industry; EU sugar market; post-quota period; competitiveness; capital structure; corporate strategy

JEL Classification: C38, G30, L66, Q13, Q18

Introduction

The sugar industry is one of the traditional sectors of the agri-food complex in Central and Eastern Europe and has long influenced not only the agrarian structure of the region but also rural employment and the trade balance of individual countries (Swinnen et al., 2010; Kotyza et al., 2019). Over the past decade, the development of this sector has been fundamentally shaped by institutional changes at the level of the European Union, particularly the abolition of the sugar quota system in 2017, which led to market liberalisation and a significant increase in price volatility (Řezbová et al., 2015; Muir and Anderson, 2022). Sugar producers in CEE countries thus found themselves in an environment of intensified global competition, where financial stability, efficient capital management, and strategic adaptability have gained increasing importance (Soare et al., 2021).

At the same time, environmental and sustainability aspects of sugar production have become increasingly relevant, particularly in relation to the utilisation of by-products and the principles of the circular economy (Aguilar-Rivera, 2022; Gopinath et al., 2018; Meghana and Shastri, 2020).

Traditional assessments of sugar mill performance rely primarily on ratio indicators and time-series analysis (Diggle and Giorgi, 2024). While these approaches effectively describe developments in revenues, EBITDA, or working capital, they are less capable of capturing interrelationships among indicators and

differences arising from firm size or national context. Principal Component Analysis (PCA) enables the simplification of complex financial data structures and the identification of a limited number of key performance dimensions (Huang et al., 2022; Crépey et al., 2022). In the context of the sugar industry, PCA opens space for a new interpretation of whether firm size is the main determinant of success, or whether smaller firms can achieve higher growth potential due to flexibility and different capital management practices.

In practice, this meant that firms had to react more quickly to fluctuations in sugar and energy prices, adjust contracting relations with growers, and manage inventories and working capital more efficiently. Differences in these managerial strategies are reflected in the financial performance of individual sugar mills more strongly than national affiliation alone.

This paper builds on previously published studies focusing on the financial dynamics of sugar mills in six countries of the region (Vlach, 2025; Vlach et al., 2025). Unlike the original texts, however, it does not aim at detailed empirical replication, but at a condensed interpretation and methodological reflection. The main objective is to demonstrate how PCA changes the perspective on competitiveness in the post-2017 period and what strategic implications follow for firms and policymakers. Emphasis is placed on the relationship between firm size, growth potential, and equity development, as well as on differences between national and firm-level analysis.

Based on the above, the following research questions are formulated:

1. What latent dimensions of financial performance are identified by PCA, and what is their economic meaning?

2. What is the relationship between firm size and growth potential in the post-quota EU sugar market?

3. To what extent does the interpretation of PCA results differ between firm-level and national-level analysis?

Methodological Approach

This paper synthesises previously published analyses of the financial performance of sugar companies in Central and Eastern Europe (Vlach, 2025; Vlach et al., 2025). Unlike the original studies, the aim is not to reproduce statistical calculations, but to compare three different approaches to assessing economic performance:

(i) traditional financial indicators,

(ii) analysis of normalized trends, and

(iii) latent factors identified through Principal Component Analysis.

The first layer consists of classical ratio and absolute indicators such as operating revenues, EBITDA, working capital, and capital structure, commonly used to assess corporate stability (Schroeder et al., 2022). These indicators provide a detailed picture of current financial conditions but struggle to capture interdependencies among variables and differences arising from firm size.

The second layer is formed by normalized linear trends for the period 2013–2022, allowing assessment of development dynamics independently of absolute firm size (Mahoney, 2005). Trend analysis better reveals the direction of change but does not offer a comprehensive view of structural similarity among firms.

The third layer is represented by PCA, which reduces the multidimensional structure of financial data to a small number of latent dimensions (Huang et al., 2022; Crépey et al., 2022). PCA enables identification of dominant performance factors, particularly firm size, growth potential, and equity development, thus offering an alternative interpretation of competitiveness.

The methodological core of the paper lies in comparing these three approaches to assess the additional informational value provided by PCA and whether it leads to different conclusions at the firm and national levels. The procedure is based on secondary analysis of published results, their

reinterpretation, and conceptual linkage with theories of financial performance and strategic management.

Component interpretation follows the classical PCA tradition and biplot representation (Gabriel and Odoroff, 1990), increasingly applied in financial management and risk assessment (Deutsch and Beinker, 2019; Labrín and Urdinez, 2020).

Synthetic Analysis of Results

1. Firm size as a dominant but not decisive factor

Traditional assessments of sugar companies are typically based on absolute indicators, which naturally favour large producers. PCA results show, however, that the latent dimension PC1 reflects firm size through capital, operating revenues, and employment, but does not by itself explain future dynamics (Huang et al., 2022).

The case of Südzucker AG illustrates that a high PC1 score is associated more with stability than with growth, an insight that would remain hidden using only classical indicators.

Normalized trends, by contrast, suggest that smaller firms often achieve higher relative dynamics. The contradiction between level-based and trend-based indicators is reflected in PCA through the separation of size and growth potential. This challenges the implicit assumption that production concentration automatically leads to higher competitiveness (Schroeder et al., 2022).

2. Growth potential beyond the logic of size

The second latent dimension (PC2) primarily captures trends in revenues, employment, and operating output. Methodologically, PCA integrates information from multiple variables that would otherwise be assessed in isolation. Firms such as Pfeifer & Langen Polska S.A. achieve high PC2 scores despite smaller absolute size, indicating a strategic profile oriented toward expansion.

This result confirms that growth rates alone are insufficient for interpretation unless embedded in a broader structure of relationships. PCA thus serves as an integrative framework distinguishing growth based on real strengthening of market position from mere nominal expansion (Crépey et al., 2022). In practice, this dimension manifests in differentiated beet procurement policies, diversification of by-products, and flexible adjustment of production campaigns to price developments. Firms with higher PC2 scores typically combine sugar production with energy and feed utilisation of molasses and pulp.

3. Equity development and financial stability

The third dimension (PC3) links trends in equity, working capital, and indebtedness. Methodological comparison shows that traditional liquidity and leverage ratios may lead to different conclusions than PCA, as they ignore mutual correlations among variables. Some smaller firms display favourable PC3 scores despite weaker absolute values, indicating more efficient capital management (Mahoney, 2005).

4. Firm-level versus national-level interpretation

A notable distinction arises between firm-level and country-level interpretations. While aggregated data highlight the Czech Republic and Poland as dynamic markets, firm-level analysis reveals substantial heterogeneity within these countries. This confirms that conclusions based solely on national averages may be misleading. Similar applications of PCA in corporate performance evaluation are reported by Liu and Bai (2021) and Chowdhury et al. (2017), who emphasise its ability to reduce noise in time series and enhance interpretative stability (Xue et al., 2018).

Table 1

Summarises the main interpretative meanings of the components.

Component	Economic meaning	Typical features
PC1	Size and stability	assets, revenues, capital
PC2	Growth potential	dynamics, flexibility
PC3	Financial resilience	equity

Source: authors' own processing

Discussion and Implications

The synthetic comparison of three approaches to performance evaluation, traditional financial indicators, normalised trends, and PCA, shows that each of them emphasises a different aspect of the reality of the sugar industry. While conventional indicators primarily highlight the financial strength and market dominance of large producers, PCA reveals a hidden structure in which firm size, growth potential, and the development of equity appear as relatively independent dimensions (Huang et al., 2022). This has fundamental implications for the interpretation of corporate competitiveness after the abolition of EU sugar quotas.

The first consequence is a challenge to the assumption that production concentration automatically leads to long-term growth. Examples of large firms with low PC2 scores suggest that stability based on capital strength may be associated with lower strategic flexibility. Conversely, some smaller firms show higher dynamics, which corresponds to studies emphasising the importance of adaptive business models in the agri-food sector (Schroeder et al., 2022).

The second finding concerns the importance of working capital management and the structure of own resources. PCA demonstrates that financial health cannot be reduced to the level of indebtedness or liquidity alone but is the result of a complex interaction of several variables (Crépey et al., 2022). From the perspective of sugar mill management, this implies the need for an integrated approach to financial management that focuses not only on profitability but also

on the ability to finance growth without excessive pressure on short-term resources (Mahoney, 2005).

The third area relates to the difference between firm-level and national-level analysis. Aggregated results suggest a strong position of the Czech Republic and Poland; however, a detailed view of individual firms reveals considerable heterogeneity within these markets. This implies for policymakers that support measures should not be based solely on macroeconomic characteristics of the sector but also on the differentiated profiles of individual producers (Soare et al., 2021).

From a methodological perspective, it is confirmed that PCA is not a substitute for traditional financial analysis but rather its complement. Its main contribution lies in the ability to identify latent dimensions that are not evident from individual indicators. At the same time, the limits of this approach must be respected, as PCA does not capture institutional factors, technological levels, or environmental aspects, which increasingly influence the competitiveness of the sugar industry (Muir and Anderson, 2022).

For further research, it appears appropriate to link PCA with a qualitative analysis of the strategies of individual firms and with an assessment of the impacts of EU sustainability requirements. The results must also be considered in the context of the new EU industrial policy (Juhász et al., 2023) and the growing concentration of market power in food supply chains (Nes et al., 2021; Severini and Sorrentino, 2017). The synthesis presented in this paper therefore represents a framework for interpretation rather than a definitive explanatory model.

Answers to Research Questions

1. **What latent dimensions of financial performance does PCA identify?**

PCA identifies three relatively independent dimensions: firm size, growth potential, and equity development (Huang et al., 2022). Economically, this separation

distinguishes capital-based stability from growth dynamics, enabling differentiation between stable but stagnating firms and smaller firms with higher development potential.

2. **What is the relationship between firm size and growth potential after quota abolition?**

The relationship is non-linear. Large firms achieve high PC1 but often low PC2 scores, indicating that size is more a source of stability than expansion (Schroeder et al., 2022). Growth potential is more closely linked to flexibility and capital structure than to production volume.

3. **Does interpretation differ between firm and national levels?** Yes, the difference is significant. At the national level, the Czech Republic and Poland appear to be the most dynamic markets; however, firm-level analysis reveals considerable internal heterogeneity. Data aggregation may therefore lead to an overestimation of the position of some markets and an underestimation of successful individual producers (Soare et al., 2021). For sugar mill management, the results thus represent not only a "better evaluation model" but, above all, a signal that investments in technology, inventory management, and relationships with growers may be more important for future growth than the production volume itself.

Limitations of the Study

The presented paper has several methodological and interpretative limitations arising both from the nature of the data used and from the chosen concept of synthesis. The first limitation is the fact that the text does not work with new empirical research but is based on a secondary analysis of previously published results (Vlach, 2025; Vlach et al., 2025). The added value therefore lies primarily in methodological comparison and new interpretation rather than in the generation of new statistical estimates.

The second limitation is related to the very nature of Principal Component Analysis. PCA identifies latent structures based on correlations among financial variables, but it does not explain the causal mechanisms behind their formation (Huang et al., 2022). The resulting components therefore cannot be understood as direct determinants of competitiveness but rather as analytical constructs facilitating the interpretation of complex data.

The third limitation is the absence of non-financial factors. The analysis does not include the technological level of firms, environmental requirements, contractual relations with growers, or the institutional conditions of individual countries. At the same time, these aspects may significantly influence the long-term sustainability of sugar mills and their ability to respond to changes in the Common Agricultural Policy (Muir and Anderson, 2022).

The fourth limitation concerns the use of aggregated data at the national level. The synthesis shows that national averages may conceal considerable heterogeneity among firms, and macro-level interpretation may therefore lead to different conclusions than firm-level analysis (Soare et al., 2021). The results should thus be understood as an indicative framework rather than as a definitive assessment of individual markets.

The final limitation is the time frame of the period 2013-2022. The data reflect extraordinary events, particularly the price shocks after 2017 and the impacts of the pandemic, which may have temporarily distorted the trends of some indicators. Future research should work with a longer time series and complement quantitative analysis with qualitative information on the strategies of individual firms. The use of short time series carries the risk of structural breaks, as pointed out by Hamilton (2020).

Conclusion

The paper aimed to provide a synthetic interpretation of financial dynamics in the sugar industry of Central and Eastern Europe and to assess the added value

of PCA relative to traditional performance evaluation methods. The comparative approach shows that PCA complements rather than replaces classical financial indicators by revealing hidden relationships among firm size, growth potential, and equity development.

The results confirm that firm size is a dominant factor of financial stability but not a decisive determinant of future expansion. In the post-quota EU sugar market, flexible adaptation, efficient working capital management, and balanced capital structure emerge as key success factors. The analysis further demonstrates that national-level interpretation may differ substantially from firm-level insights, with important implications for policy and corporate strategy.

Methodologically, the paper illustrates how existing empirical results can be used within a broader interpretative framework. PCA enables integration of static financial strength with dynamic trends and supports the development of strategic typologies of sugar mills. At the same time, it must be complemented by qualitative information and analysis of institutional and technological factors beyond its scope.

Future research should integrate PCA with sustainability requirements, energy efficiency, and supply-chain relationships. The CEE sugar industry thus stands at the crossroads between a traditional size-based model and a new model focused on innovation and capital efficiency. The present synthesis offers a framework for further analytical discussion of this transformation.

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