

MARKET STRUCTURE ANALYSIS OF THE CZECH MACHINERY MANUFACTURING INDUSTRY

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Abstract: *This research examines the market structure of the Czech engineering industry using the Herfindahl-Hirschman Index and other microeconomic indicators to identify the degree of competition and market concentration in the sector. The analysis covers 1,876 active engineering companies in the Czech Republic from 2014 to 2023. The HHI values found indicate very low market concentration. Combined with estimates of price elasticity of demand, the price parity model, and the return on investment indicator, the results suggest that the sector exhibits characteristics of a highly competitive and fragmented market. In such a highly competitive environment, technological innovation by individual companies appears to be a key determinant of their long-term competitiveness.*

Keywords: CZ-NACE 28, market structure, market concentration, competitiveness

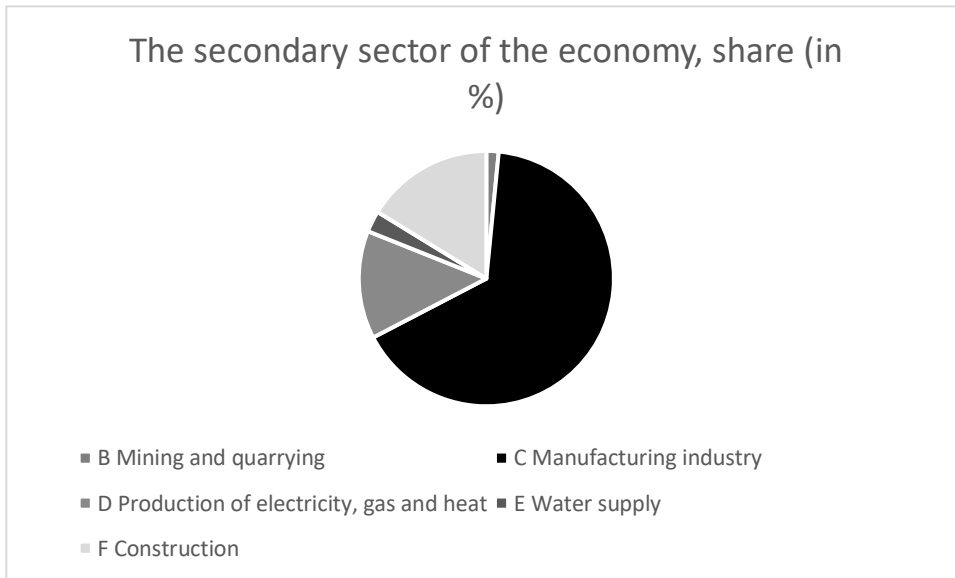
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1 INTRODUCTION

This research focuses on identifying the market structure of the Czech engineering industry and determining the degree of competition in this sector. The structure of a specific industry market can be identified using selected models, which can be used to determine the market's concentration, the number of companies operating in the industry, their market shares, the barriers to entry into the industry, and the behaviour of companies. Following on from this statement, the research question is as follows: "What is the degree of competition and market concentration in the engineering industry in the Czech Republic?"

From the perspective of the Czech economy, this research focuses on the secondary sector, within which the manufacturing industry represents the largest share of production, as, according to available data, it accounts for 65% of production within the secondary sector of the economy (Czech Statistical Office [CSO], 2024). This share is illustrated in the chart below.

Figure 1: Composition of the secondary sector of the Czech economy



Source: Own processing

The manufacturing industry (CZ-NACE C) encompasses a broad spectrum of activities categorized into groups CZ-NACE 10 to 33. Within these groups, the largest share is held by the engineering sector, which mainly comprises groups CZ-NACE 25 to 33. The specific sector CZ-NACE 28, which is the subject of this research, represents the third largest group within this focus. The largest representative is CZ-NACE 28, followed by CZ-NACE 25. This group, therefore, represents one of the key pillars of industrial production in the Czech Republic, and its performance has a direct and significant impact not only on the stability of the domestic economy but also on the country's export performance and competitiveness in international markets. This sector accounts for a significant part of the gross value added of the Czech industry. In the face of increasing global pressures, technological change, and the challenges associated with sustainable development, it is now more important than ever to understand its

internal economic structure and the competitive relationships that prevail within it. (CSO, 2024)

Although the performance of individual companies in a given industry is often analyzed by many authors in the literature, for example (Chaithanapat et al., 2022), (Ozmutlu & Can, 2022), (Çelik & Uzunçarşılı, 2023), and (Baby et al., 2024), and many others, less attention is paid to the structural characteristics of the market. Foreign and domestic literature mostly focuses on modelling market structures primarily in connection with regulatory interventions, which has already been addressed by (Joskow & Rose, 1989). However, the literature searched on this topic lacks publications that deal with the use of microeconomic analyses to determine market structure, specifically in the engineering sector. However, knowledge of market structure is an important aspect of understanding how the industry operates. Market structure fundamentally influences the behaviour of firms, their investment strategy, and has a significant impact on the long-term efficiency and innovativeness of the sector.

The purpose of this research is to explore the market structure of the engineering sector in the Czech Republic by employing selected microeconomic models. The research also seeks to identify the factors that most influence the maintenance of competitiveness in Czech engineering, based on previous findings about market structure. The study thus contributes to a deeper understanding of the economic nature of the Czech engineering industry.

The introduction to the article represents the issue in question. This chapter will be followed by a literature review, which provides the theoretical basis for the issue. The following chapter describes the data, the process of obtaining it, and the methods used to identify and verify the characteristics of the market structure of the sector. The next chapter will present the results, and the article will end with a conclusion.

2 LITERATURE REVIEW

Understanding the market structure is fundamental to sector-level economic analysis. It shapes firm behaviour, pricing strategies, innovation incentives, and the efficiency of resource allocation. The structure of a market provides a

conceptual framework for analyzing the nature of competition, the distribution of market power, and overall sector performance. The traditional distinction lies between models of perfect and imperfect competition, although real-world markets typically fall somewhere along this continuum. Identifying the prevailing market structure in a given industry and its defining features is thus essential for assessing competitive dynamics and policy implications. Economic literature offers a range of theoretical models.

Perfect competition, as rigorously defined by Robinson (1934), is a market structure in which the demand for an individual seller's output is perfectly elastic. This aligns with (Chamberlin, 1933) notion of pure competition, which is narrower than broader interpretations that propose multiple market conditions. Contemporary economic theory tends to adopt these broader interpretations, such as Chamberlin's conditions of perfect competition, which consist of four core assumptions: (1) numerous buyers and sellers participate in the market; (2) firms offer homogeneous products; (3) there are no market barriers to entry or exit; (4) all participants have perfect information. While this theoretical framework provides essential insights into market efficiency and behaviour, Robinson acknowledged that perfect competition is impossible in practice, making it a limiting case for analytical purposes, such as ours. (Mankiw, 2023) The model of perfect competition is therefore only a theoretical concept with very strict assumptions that are practically impossible to fulfil in a real economic environment.

At the other end of the spectrum are market structures that deviate from the assumptions of perfect competition. Monopolistic competition, as formalized by Chamberlin (1933), preserves the condition of many sellers but introduces product differentiation, allowing firms to exercise some degree of market power. Oligopoly is characterized by a small number of dominant firms whose decisions are interdependent, often analyzed through game theory. Monopoly represents the extreme case, where a single firm supplies the entire market, typically protected by legal protection or high entry costs. Table 1 summarizes the degree to which each structure aligns with assumptions of perfect competition.

Table 1: Market structures and their compliance with perfect ompetition assumptions

Market Structure	Many Buyers and Sellers	Identical Products	Perfect Information	No Entry/Exit Barriers
Perfect competition	✓	✓	✓	✓
Monopolistic competition	✓	differentiated	some asymmetry	✓
Oligopoly	few sellers	can be identical	strategic uncertainty	high barriers
Monopoly	one seller	unique product	likely asymmetric	blocked entry

Source: Own processing

Regardless of whether the models are perfect or imperfect competition, the determination of market structure is based on a set of general assumptions, as is evident from the table above. The present research, therefore, focuses on a detailed analysis of these structural characteristics of the selected industry to identify and interpret conclusions specific to the industry under study.

The first characteristic is the assumption of *numerous buyers and sellers*. This implies that no individual actor can influence market prices. This is usually operationalized through concentration indices. The most commonly used quantitative indicator of market concentration is the Herfindahl–Hirschman Index (HHI). A low HHI and a large number of firms are indicative of competitive environments, as evidenced by empirical work linking structure to pricing power (Bresnahan, 1989; De Loecker & Warzynski, 2012).

The Herfindahl-Hirschman Index (HHI) is the most used tool to consider the concentration of a particular market and allows for an analysis of the distribution of market power between industry players (Kvalseth, 2021). This index measures the degree of market concentration and is often used to classify a market according to the degree of competition. The values of the Herfindahl-Hirschman index allow an empirical determination of whether an industry is close to the competitive model or low concentration, or whether it shows signs of dominance by a few large players, indicating high concentration. In the context of this study, the Herfindahl-Hirschman index will be used as an analytical tool for identifying the first key characteristic determining the

resulting market structure of the engineering sector in the Czech Republic. (Carlton & Perloff, 2015)

The Herfindahl-Hirschman index, based on (Hirschman, 1945) and (Herfindahl, 1950), is seen as a tool for estimating the potential of market power, according to (Kanagala et al.,2004). It is considered a suitable tool for assessing market concentration. A paper dealing with the construction sector also analysed market concentration using the HHI. Other authors, for example (Peleckis, 2022), perceive HHI as a practical tool for strategic decision-making by companies. The relationship between market structure, using HHI to identify market concentration. and the performance of construction firms has also been investigated by (Kim & Reinschmidt,2012). The Herfindahl-Hirschman index has been seen as a methodological basis in assessing competitive market structure, according to (Rhoades, 1993). The only research dealing with the intensity of competition in the engineering industry from an international market perspective was developed according to (Zhao et al.,2019).

The second characteristic is *product homogeneity*, which can be assessed by examining the price elasticity of demand. In competitive markets, identical goods exhibit high substitutability and minimal price variation (Chamberlin, 1933; Stigler, 1961). A high price elasticity of demand suggests that consumers readily switch to alternatives in response to price changes, indicating product homogeneity and market competition. In a perfectly competitive market, elasticity should be very high, ideally approaching infinity. In monopolistically competitive markets, demand remains elastic due to the presence of close substitutes, but not perfectly so, reflecting some degree of product differentiation. The price elasticity of demand in an oligopolistic market can vary significantly due to the complex interplay of competition. In a monopoly market, there is no close substitute, and demand tends to be more inelastic compared to other market structures (Frank & Bernanke, 2004).

The third characteristic, *free entry and exit*, can be tested using dynamics in profitability, firm turnover rates, or evaluating capital requirements as structural entry barriers, which measure capital costs or sunk costs. Empirical approaches also include analysis of return on investment (ROI) and persistent profitability trends to assess entry restrictions (Blažková & Hálová, 2022). This research will assess barriers to entry and exit in the industry using capital

intensity for entry into the industry and subsequent analysis of the return on these initial investments.

The final characteristic is *perfect information*, which implies that market participants possess full knowledge of prices and product quality. As direct measurement is difficult, researchers often use proxies including observed price transparency, consumer search cost indicators, and mechanisms of price discovery – building on foundational insights on information asymmetries (Akerlof, 1970; Stigler, 1961).

Given the importance of the engineering sector for the Czech economy and its traditionally strong export orientation, the study of its market structure and competitive dynamics is relevant from both academic and practical perspectives. The aim of the research is therefore to empirically identify the level of competition and the degree of market concentration in the engineering industry in the Czech Republic through the application of quantitative indicators that define the characteristics of its market structure.

3 METHODS AND DATA

3.1 Research database

Data for the machinery and equipment manufacturing firms were sourced from the ORBIS database. The data were selected from the database based on selected criteria¹. The necessary accounting data was obtained for the last 10 years, for the period 2014–2023. This selection has provided a detailed database of the necessary data for a robust analysis. The research through this selection process obtained data on a total of 15,728 engineering enterprises. However, these enterprises have the status of active or not terminated, but records established around 1990 and are no longer operating or established in 2024, hence not yet active in 2023. These are new enterprises that do not yet report accounting data and are not relevant for the calculation. After the reduction of these incorrect data, the total number of relevant enterprises

¹ The engineering sector in the Czech Republic is very large, therefore, the research focused on a specific group of the sector, namely active enterprises in the Czech Republic falling under the category CZ-NACE 28, manufacture of machinery and equipment, including micro-enterprises. For market concentration, it is necessary to consider all enterprises in the calculation.

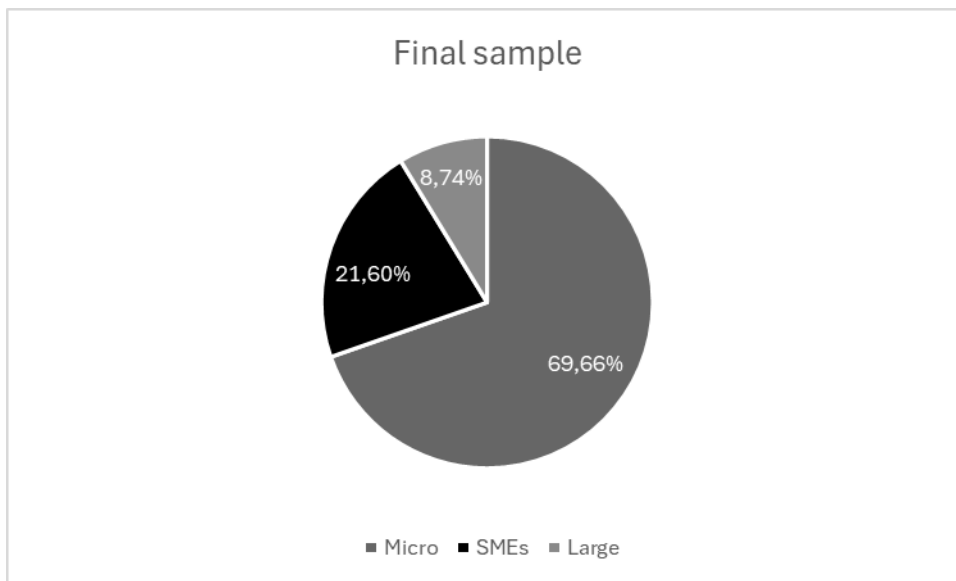
remains 1876 enterprises with relevant data. It should be noted that 70% of these are micro-enterprises. This is compounded by the fact that micro-enterprises are not obliged under Czech accounting to report data to the same extent as other categories of enterprises. The data show a lot of fluctuations or N/A values; for this reason, it is necessary to eliminate these extremes in the calculations for the integrity of the data. This can be achieved by using a Winsorised mean with a 40 % trimming, which means a 20 % trimming of outliers from each side. This will make the data more transparent.

Table 2: Sample selection process

Step	Description	Number of companies
1	Initial dataset	15,728
2	Inactive firms	9,498
3	Newly established	4,354
4	Final sample	1,876

Source: Own processing

Figure 2: Percentage composition of the final sample of companies



Source: Own processing

3.2 Theoretical and methodological foundations

In our choice of methods, we follow conventions where applicable and select alternatives in cases where data is insufficient. To test the first characteristic,

which ultimately determines the structure of the market, i.e., the existence of a large *number of sellers and buyers*, we use a modification of the Herfindahl-Hirschman Index in our research. From the calculation procedure, it can be indirectly deduced whether a few or many companies are operating in the market. This data is obtained using the Orbis database, as presented above. Based on this step, the result of the first characteristic of the selected industry can be identified. The number of entities operating in the market is also linked to their market shares. This represents market concentration. Market concentration is another key feature of the market structure of the industry, and also the degree of competition in the industry. Using the full application of HHI, the level of market concentration can be estimated. HHI is calculated as the sum of the squared market shares of all firms operating within a given market:

$$HHI = \sum_{i=1}^n (s_i^2) \quad (1)$$

where s_i is the market share of firm i , i is a number from 1 to n , and n is the number of firms in the market². The interpretation of HHI values follows the conventional thresholds formalized by the U.S. Department of Justice and Federal Trade Commission (2010) and described in Table 2.

Table 3: Interpretation of the Herfindahl-Hirschman Index (HHI)

HHI Range	Concentration	Description
$HHI < 1,500$	Low	Many firms with similar market shares
$1,500 \leq HHI \leq 2,500$	Moderate	Several firms hold significant market shares
$HHI > 2,500$	High	A few dominant firms with large market shares

Source: Own processing

The Herfindahl-Hirschman Index (HHI) measures the degree of concentration, i.e., the distribution of market shares among companies. The result, therefore, serves as an indicator of potential competition or dominance in the market. For a more comprehensive determination of the market structure of a given

² The market share is calculated as a ratio of average sales to the total turnover of the industry; percentages are used as whole numbers, as in 25 instead of 0.25, to follow the conventions.

industry, it is therefore necessary to supplement the results with other indicators, such as price elasticity of demand and return on investment, which can better capture the competitive behaviour of companies.

We test *product homogeneity* by measuring the price elasticity of demand. Due to a lack of firm-level price and quantity data, we use the sales-to-relative-price relationship as a proxy. First, we estimate the quantity sold annually by dividing total industry sales by the average producer price indices for the manufacturing/engineering industry from the Czech Statistical Office. Then, we calculate the natural log of both the relative price and the estimated quantity:

$$\ln Q = \alpha + \beta * \ln P + e; \quad (2)$$

We plot a time-series graph of log(quantity) against log(price) and fit a trend line; $y = ax+b$, where a represents the estimated price elasticity of demand. If $a > 1$, demand is elastic and consistent with strong competition and product homogeneity. In the other case, it is indicative of some degree of market power or product differentiation.

The presence of *entry and exit barriers* can be evaluated by analyzing the capital requirements for a new venture. Entry into the engineering sector requires significant capital investment, which we can see using the ORBIS database for individual companies. The creation of a new enterprise entails costs associated with the purchase of production facilities and warehouses, the acquisition of machinery and equipment, software, investment in automated production lines or robotic systems, and other technologies, or the costs associated with obtaining the necessary licenses. Other costs are undoubtedly personnel costs or operating costs in the form of materials, energy, etc. However, within the barriers to entry into the sector, the most important are capital investments, which are undoubtedly high. However, they can be supported by various subsidy programmes. Despite these relatively high capital requirements, there are no significant barriers to entry, such as legal or government regulatory barriers. This fact also encourages the continuous emergence of new engineering micro-enterprises, as can be seen from the database obtained, where micro-enterprises account for 70 % of these enterprises, and 4 % of them have recorded their emergence in 2023. A possible explanation may be the high returns that these investments bring, which may attract new enterprises to enter the market. This statement can be verified by the return

on investment (ROI) indicator. If the indicator comes out above the recommended normal value, it means a high return and market attractiveness for the entry of new businesses. If the indicator comes out low, it will mean that these investments in new business are not worthwhile and not profitable. The research will use a modified calculation. The research considered the return on investment as a ratio of profit in the form of EBIT and the most capital-intensive investments that are required to be made when entering the market, and may hinder entry into the industry, in the form of fixed assets (such as machinery, buildings, equipment or technology) (Kumar & Li, 2016).

Another aspect is the *level of market awareness*. To determine whether the market is perfectly informed, the price parity model can be used. In other words, compare the average price within individual firms with the average price of the industry. If the resulting deviations are small (close to the market average), it can be concluded that the market exhibits price parity. There is no data on the quantity sold in the database, so an alternative calculation must be used. Divide the sales of each firm by the average price of the product in the sector to obtain the estimated quantity. The research proceeded by estimating this average price through the usual prices of the most common representative in terms of production. For this article, the average price in the industry was set at 1 million crowns. Using the ratio of the sales of each enterprise to the average industry price, the quantity sold by each enterprise was estimated. Using the cost of goods sold, which must be deducted from the sales of the enterprise, and then dividing the difference by sales, the research obtained an indication of the gross margin percentage of the enterprise. The research calculated the average price of the product given enterprise as the cost of sales per unit, considering the gross margin calculated above. The research determined the percentage deviation from the industry average price. If these deviations are not too large and prices are around the industry price, the market shows price parity and is highly informed. Otherwise, the level of market information is low (Montag & Winter, 2020).

4 RESULTS AND DISCUSSION

4.1 Herfindahl-Hirschman index

In the first step, data on the number of companies operating in the sector were obtained. There are currently 1,876 companies operating in the engineering sector in the Czech Republic, which indicates a high number of sellers within the first characteristic. Subsequently, the concentration of companies in the sector was examined using HHI. This is because market concentration data is a key quantitative characteristic of the market structure of a sector and is also linked to the degree of competition in that sector.

The complete calculation is very extensive; only the resulting index for the entire industry will be interpreted within the scope of this paper. The calculation procedure has been commented on above. Due to the large amount of data, it is not possible to transfer the entire calculation to the article.

$$\text{HHI 2014-2023} = 95,35$$

The resulting index for the period is very low. At the same time, the determination of the individual market shares of firms in the total turnover of the sector shows that there are many firms with very similar market shares cooperating in the sector, with no firm showing a leading position with a significant market share. To check whether the index is indeed this low, the Herfindahl-Hirschman index was also calculated separately for 2023.

$$\text{HHI 2023} = 113,63$$

A very low Herfindahl-Hirschman Index indicates that the Czech engineering sector is highly fragmented, with many small enterprises holding minimal market shares. This reflects a high level of competition and very low market concentration.

The Czech engineering industry, focused on CZ-NACE 28, therefore, represents a market with many small companies with very small market shares. The large proportion of microenterprises in the sector also underpins this fact.

No firm is strong enough to influence the price, and the market share of each firm is only minimal. The degree of market concentration in the engineering sector in the Czech Republic, therefore, indicates the existence of high competitive pressure and market fragmentation. There were almost two

thousand firms in the comparison, so it is not possible to present relevant results within the scope of the paper. For if only a selection of firms were presented, it would not be relevant. The largest share was held by the engineering firm with a share of 0.042; the subsequent firms have a very similar decreasing share.

4.2 The price elasticity of demand

Elasticity was estimated based on the relationship between the producer price index and sales volume derived from revenues. It should be noted that the approximation used does not reflect actual consumer responses, but serves as an indicative measure of market sensitivity to price changes. The complete calculation procedure is described above. By substituting the data on total industry sales, the observed price indices, and the estimated quantity into the resulting log-linear equation, the resulting equations were then graphically represented by graphs. For illustrative purposes, the graph for the year 2023 has been selected.

Figure 3: The price elasticity in 2023



Source: Own processing

The resulting elasticities for each year are shown in the table below.

Table 4: Price elasticity over the years

year	price elasticity
2014	19,586
2015	19,656
2016	19,721
2017	19,729
2018	19,747
2019	19,764
2020	19,732
2021	19,709
2022	19,517
2023	19,811

Source: Own processing

It is important to note that, although the individual products in the engineering sector appear to show considerable differences, their basic functions and uses are the factors that confirm product homogeneity. An example is a machine tool, the main purpose of which will always be the same. Price elasticity of demand is one of the key indicators of competition between companies, as it reflects how sensitive customers are to price changes. The more elastic the demand is, the stronger the competitive pressure between companies. The estimated results of price elasticity indicate a highly competitive environment in the sector, with significant market sensitivity to price changes. The results can be interpreted as confirmation of strong competition between companies.

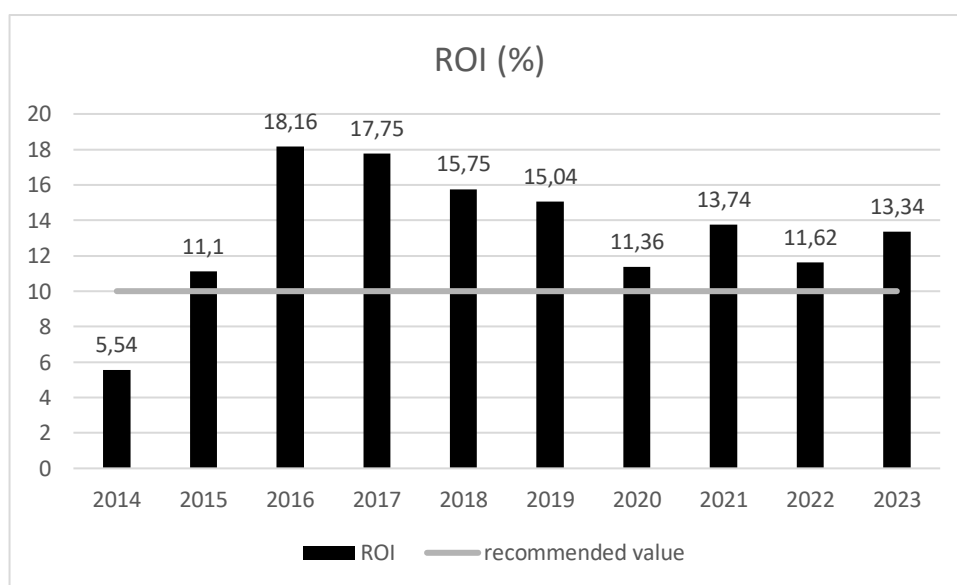
4.3 Return on investment

To verify the absence of barriers to entry into the sector, for example, an analysis of capital requirements can be provided. Capital investment at the start of a business is certainly challenging in terms of entering the engineering market, as a new business has to make large investments in terms of acquiring buildings, warehouses, machinery, equipment, technology, etc. Thus, entry into the industry is financially challenging. However, the number of new engineering enterprises shows that the market is still attractive for new enterprises. This attractiveness may stem from the high return on these initial investments, where the business will eventually be very profitable. To test market attractiveness, a modified ROI calculation for the industry was used, where a high value will imply a high return on investment, which implies a

significant attractiveness of new business entry. And a low value will represent an unprofitable investment and low attractiveness of entering this market in terms of high investment. Thus, if the value is low, the profitability of the investment would be low, and entry would not be worthwhile. The calculation procedure is again set out above. Below is a graph with the ROI calculations for the whole period under review and their comparison with the recommended value.

The ROI indicator serves here as a supporting tool for assessing the economic attractiveness of the sector and the possible existence of entry barriers. A higher average ROI suggests that investments in this sector are relatively profitable, which may attract new businesses and thus strengthen competitive dynamics.

Figure 4: Return on investment



Source: Own processing

The chart above shows the ROI results for the years under review. According to the financial analysis of the corporate sector, the general value of return on investment should be around 10 %. Values above 15 % are then considered very attractive. From the above, since 2015, there has been considerable market attractiveness and stimulates the entry of new entities into the market, thereby increasing the competitive dynamics of the sector. This again supports

the claim that the engineering sector in the Czech Republic is a highly competitive environment. This is also confirmed by the constant entry of new micro-enterprises into the market.

4.4 The price parity model

The final aspect involved in defining market structure is market information, which is measured in this study using a price parity model. By the above calculation, the average price of the industry was compared with the average prices of individual firms, and then the percentage deviations of individual firms from the industry were determined. These deviations were given to all firms in the industry. For clarity and interpretation, it was chosen to interpret the average deviation across the industry. The average deviation for the whole industry is found to be -11,4 %. However, it should be noted that the data analysed is very large and inconsistent, with outliers.

The general deviations to confirm perfect information should be around 2–3 %, but here the interpretation needs to be approached with great care. Across the industry, we are comparing companies of different sizes and structures. For these reasons, this calculation is an estimate. Due to the absence of direct quantity data, the research employed an indirect method to approximate price parity across firms, using estimated unit prices derived from gross margins and a representative industry price benchmark. While this approach allows for a rough indication of market awareness, its validity is limited due to the product heterogeneity, estimation assumptions, and the use of a single average industry price.

Another argument indicates that the price in the sector is determined by the market is the already mentioned strong competition from many firms. Thus, if a company were to try to set its price independently of the market, it would risk losing customers, since the B2B sector has strong bargaining power and usually requires a bid from several suppliers in each area. Assuming price differentiation, the customer would choose the firm with the lowest price, whereas in the case of price similarity, the customer decides based on the quality or technological progress and innovation of the firm. In engineering, then, it is essential to compete precisely through continuous innovation and technological progress to maintain a competitive advantage. Here, the research comes up against another argument, namely the importance of

technological progress in the sector. Rapid technological progress and innovation can reduce barriers to entry into the sector, as new technologies can be more accessible to small enterprises, allowing more enterprises to enter the market. In a highly competitive environment with many companies, firms generally have very little opportunity to differentiate themselves from competitors based on price or quality, innovation and technological progress; therefore become a key factor in gaining competitive advantage (Schumpeter,1942). This fact can also be called Schumpeterian competition. Schumpeter placed great emphasis on the role of innovation as a driver of economic growth.

5 CONCLUSION

Based on the applied models and empirical evidence, the machinery and equipment manufacturing industry in the Czech Republic is characterized by very low market concentration and a high degree of competition. The market is dominated by numerous small firms with similar shares, leaving no single firm in a dominant position. The attractiveness of the industry lies in its competitive environment, where technological progress and innovation are essential for sustaining firm-level performance. The results of the research, therefore, suggest that Czech engineering represents a highly competitive, fragmented market with a significant role for technological innovation.

Based on the analysis, it can be concluded that the engineering sector in the Czech Republic is characterized by low market concentration, a high number of active companies, and a high degree of competition. The Herfindahl-Hirschman Index confirmed strong market fragmentation, price elasticity indicates high market sensitivity to price changes, and return on investment indicates attractiveness for new entrants. These factors indicate a highly competitive environment with limited market power for individual companies. This study provides a new perspective on the dynamics of the industry and highlights the strategic role of innovation in a fragmented market. The conclusions of this study thus provide an empirical basis for understanding the competitive dynamics of the Czech engineering industry.

However, given the inconsistencies in available data and the limited transparency of microenterprises' accounting, the conclusions should be viewed as a theoretical framework. Further research is needed to refine and

deepen our understanding of Czech engineering, ideally integrating company- and sector-level analyses with qualitative evidence. The conclusions of this study are further limited by data availability and the simplification of the models used. The HHI index, price elasticity, and ROI provide only a partial view of market dynamics and do not include aspects that should be considered in future research.

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