DIAGNOSIS OF INTERNAL DETERMINANTS OF COMPETITIVENESS OF FOUNDRY ENTERPRISES

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Abstract

The study aimed to present a model for the analysis of internal conditions and key factors for the competitiveness of a foundry, taking into account the principles of the Toyota quality system and development variables. The model was based on a modification of the BOST method and its practical implications were tested. The analysis of the results provided knowledge for effective resource management and maintaining market position. The model indicated key areas of development: technology (automation, quality) and brand recognition (relationships with customers). The results of the analysis can support the construction of a development strategy that increases efficiency and reduces costs. Further research will focus on extending the model with a detailed analysis of additional competitiveness factors in the foundry industry.

Keywords: mechanical engineering, foundry industry, process improvement, metallurgy

1. INTRODUCTION

In business management, success is sought, often resulting from the effectiveness of operations, the use of opportunities and the multiplication of benefits. Success is understood and assessed in various ways [1-3]. For employees, it means job security, wages and quality of life [4]. Management staff identifies it with, among others, product quality, innovation, production efficiency, financial results, market share, customer satisfaction, low costs and image [5,6]. This shows the complexity of the success of industrial enterprises; a company can be successful in one aspect and fail in another [7]. Therefore, a multidimensional approach to development is crucial, where successes synergistically reinforce each other. It is assumed that the basis for an organization's success is achieving and maintaining a favorable position in the sector, competitive advantage and a relatively large market share [8,9]. Identification of the determinants of success (resources and skills) requires a detailed analysis of individual functional areas of enterprises [10,11].

In order to cope with the global market, foundries should implement modern forms of production [12]. Technological progress and production typification are important, but they should not limit reengineering or the development of external relations and brand [13,14]. The key is to identify areas of improvement and development planning, which is the basis for foundry management and implementation of its mission [15]. The literature widely discusses factors of competitiveness of manufacturing companies, often focusing on marketing, human resources [16], internal value chain and external supply chain [17]. Various analytical tools, such as the Analytic Hierarchy Process (AHP) [18], and the value grid model [19], are commonly employed to identify determinants of success. However, a comprehensive review of existing literature reveals a distinct lack of in-depth analyses specifically tailored to the internal determinants of competitiveness within the foundry industry. Crucially, there is a gap concerning development factors related to technology and market perception, which are vital for modern foundry enterprises.

The success/failure of an industrial enterprise depends on the adjustment of possibilities to market changes. The basis of success is its specificity [20]. The aim of the work was to present an original model for the analysis of internal conditions and key factors of the competitiveness of a foundry. The assessment was carried out taking into account Toyota's quality principles, focusing on development variables.

The research presented in this article, focusing on the analysis and improvement of foundry competitiveness, has links to several broader areas of industrial research and practice. The emphasis on efficiency, cost reduction and quality improvement are consistent with the principles of circular economy [21,22], which seek to optimize resource utilization and minimize waste. In addition, the exploration of new production forms and technologies, as well as the potential for material improvements in foundries, may include techniques such as special coatings [23] or special alloys [24] to improve product properties. Energy efficiency of foundry processes, a critical aspect of operational efficiency, also intersects with the area of improving energy transfer [25]. Given the increasing emphasis on sustainable development, environmental impact assessments, particularly of manufacturing processes, are highly relevant to improving energy efficiency also at the building scale [26,27] considerations. Advanced manufacturing techniques, such as laser sintering and laser machining [28-30], can be used to improve the precision and quality of foundry products. The pursuit of consistent product quality and process optimization requires the use of DOE [31] methodology to monitor and control variability. Finally, the modification of material properties and surface treatments to increase performance and durability involves the study of special material properties [32].

2. METHODOLOGY

The identification and diagnosis of internal factors of the foundry's competitiveness required a structured approach. A three-stage model for the analysis of internal determinants of success was developed: preparation, diagnostic study, and analysis and interpretation of results (**Figure 1**).

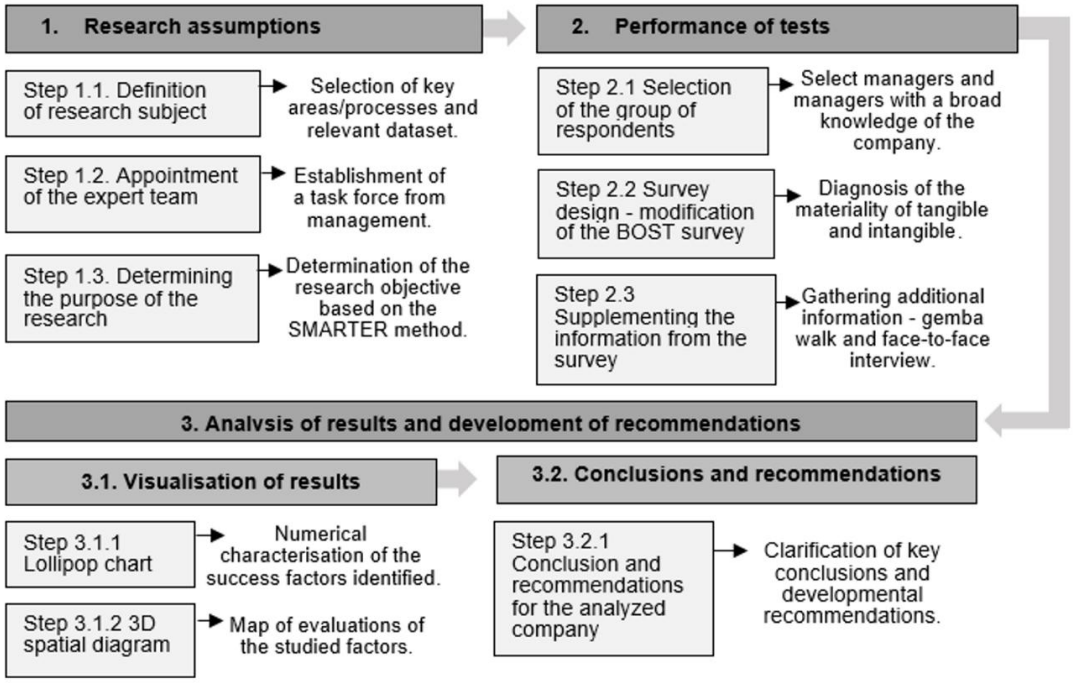

Figure 1 Diagram of a model for the identification of competitiveness determinants of casting companies

Phase 1. Research assumptions

The production processes of the enterprise are studied in the context of the purpose and implications of the model. The data and information that govern their implementation must be determined. An interdisciplinary

team, consisting of management staff, will provide a broad picture of production activities. The research objective should be constructed in accordance with the SMARTER technique (Specific, Measurable, Attractive, Realistic, Time-based, Exciting, Recorded), which supports its precise definition and facilitates its implementation.

Phase 2. Performance of tests

The group of surveyed employees should include management and executive staff with extensive knowledge of the company. The diagnostic part used a modified BOST questionnaire, which was specifically adapted to the context of foundry competitiveness by incorporating key elements from the Toyota Production System (TPS). This adaptation involved taking into account the components of the "Toyota house roof" and selected principles of the Toyota Way: Principle 1 (Long-Term Philosophy), Principle 2 (The Right Process Will Produce the Right Results), Principle 3 (Add Value to the Organization by Developing Your People), Principle 4 (Continuously Solving Root Problems Drives Organizational Learning), Principle 6 (Standardized Tasks are the Foundation for Continuous Improvement), Principle 7 (Use Visual Control So No Problems are Hidden), and Principle 14 (Become a Learning Organization Through Relentless Reflection and Continuous Improvement) [33]. These principles were selected because they directly underpin operational excellence, foster innovation, improve product quality, and promote a culture of continuous improvement—all of which are identified as crucial internal determinants of competitiveness in high-tech manufacturing, particularly within the foundry sector. The BOST method itself primarily concerns the intangible resources of the company (innovation, technology, autonomy, customer well-being, cooperation, culture). Complementing the questionnaire, in-depth interviews were conducted. These interviews focused specifically on the internal competitive potential (technology, including automation and product innovation) and its external perception (trust and brand recognition), aligning with the broader scope of the model.

Phase 3. Analysis of results and development of recommendations

Graphical representation of numerical results facilitates quick identification of key success determinants and dependencies, supporting their analysis and interpretation. It should present assessments of factors related to technological progress and brand trust and recognition. Based on the data analysis, conclusions and recommendations should be formulated to support effective development and success of the company.

3. METHODOLOGY TESTING AND RESULTS

The foundry industry strongly depends on technological advancement generated by the staff. Its development requires responsibility and conscientiousness of employees, which builds trust and brand recognition. Diagnosis of the determinants of market success in terms of competitiveness (potential, technology) and brand perception is crucial for the foundry development strategy.

Phase 1. Research assumptions

The model test was conducted in a foundry in southeastern Poland (a region with a dominant casting industry), for the company's leading product: an aluminum engine block for light vehicles. To ensure a broad perspective on key processes, a dedicated task force was established, comprising a product auditor, a technology manager, a quality control manager, and a marketing manager. Their work focused on identifying success factors (technological advancement, trust, and brand recognition) as well as marginal and critical factors that could disrupt development.

Phase 2. Performance of tests

The survey group comprised 49 employees, primarily mid-level and lower-level staff from key operational departments including production, construction, technology, and quality control, alongside a marketing manager. This diverse selection of respondents was deliberate: their direct involvement in daily operations provided a comprehensive understanding of both the technical and market-related aspects of the company's

competitiveness. These individuals possess intimate knowledge of the processes, potential issues, and customer interactions, making their insights crucial for identifying internal success determinants. The group's size was limited primarily due to the pilot nature of this study, which aimed to test the feasibility and effectiveness of the proposed diagnostic model within a single organizational context. Furthermore, the survey was specifically tailored for employees with direct operational and managerial oversight concerning the production of a specific product (the aluminum engine block), thereby ensuring the relevance and depth of collected data. The study was conducted in Q4 2024.

The survey asked about the company's development factors using the example of engine block production, assessing them on a scale of 1-9 (1 - the least impact, 9 - the greatest). The category of technological advancement included: technology development, product innovation, automation, product modernity, employee independence and responsibility, product quality, product price, reliable machines. The categories of trust and brand recognition were: customer service, customer well-being, company reputation, company culture, implemented strategy, loyal customers, recognition of market needs, product personalization. The factors assessed included intangible and tangible resources that build competitiveness.

Direct in-depth interviews were also conducted with middle management to obtain detailed information about the company’s potential, product competitiveness, and technological and market advantages, as well as to learn about employees’ opinions, experiences and hidden motivations.

Phase 3. Analysis of results and development of recommendations

In the third stage of the analysis, the strength of the impact of the determinants of success in the areas of technological advancement (score 320.88) and brand trust and recognition (score 291.75) was numerically assessed, as illustrated in **Figure 2**. Respondents considered technological features as key to competitiveness, especially: (8) reliable machines, (3) automation, (9) customer service and (6) product quality (detailed distribution in **Figure 3**). The distribution of scores between categories is different (**Figure 3**). Technological factors were assessed mainly on a 5-9 scale, which gave a high total score (**Figure 2**). The second category was characterized by more distributed scores, except for the intangible factor (9) customer service, which received the highest score.

However, it should be remembered that full market success can only be achieved through a synergy effect influenced by a large number of variables and factors, and therefore seemingly less important factors should not be neglected. The attributes of success are prioritized by companies and considered separately for each of them.

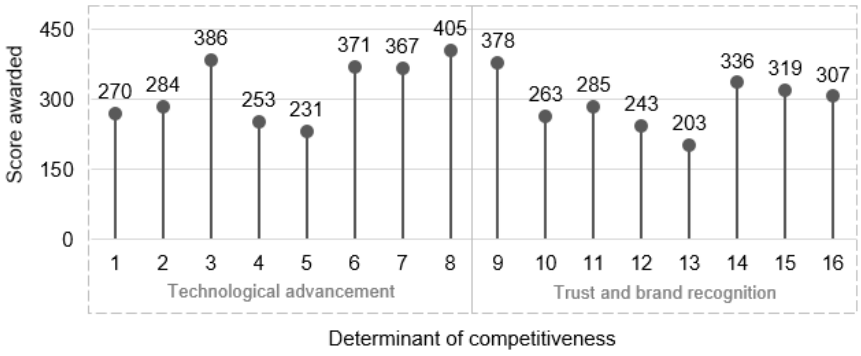

Figure 2 Level of influence of analyzed competitiveness factors

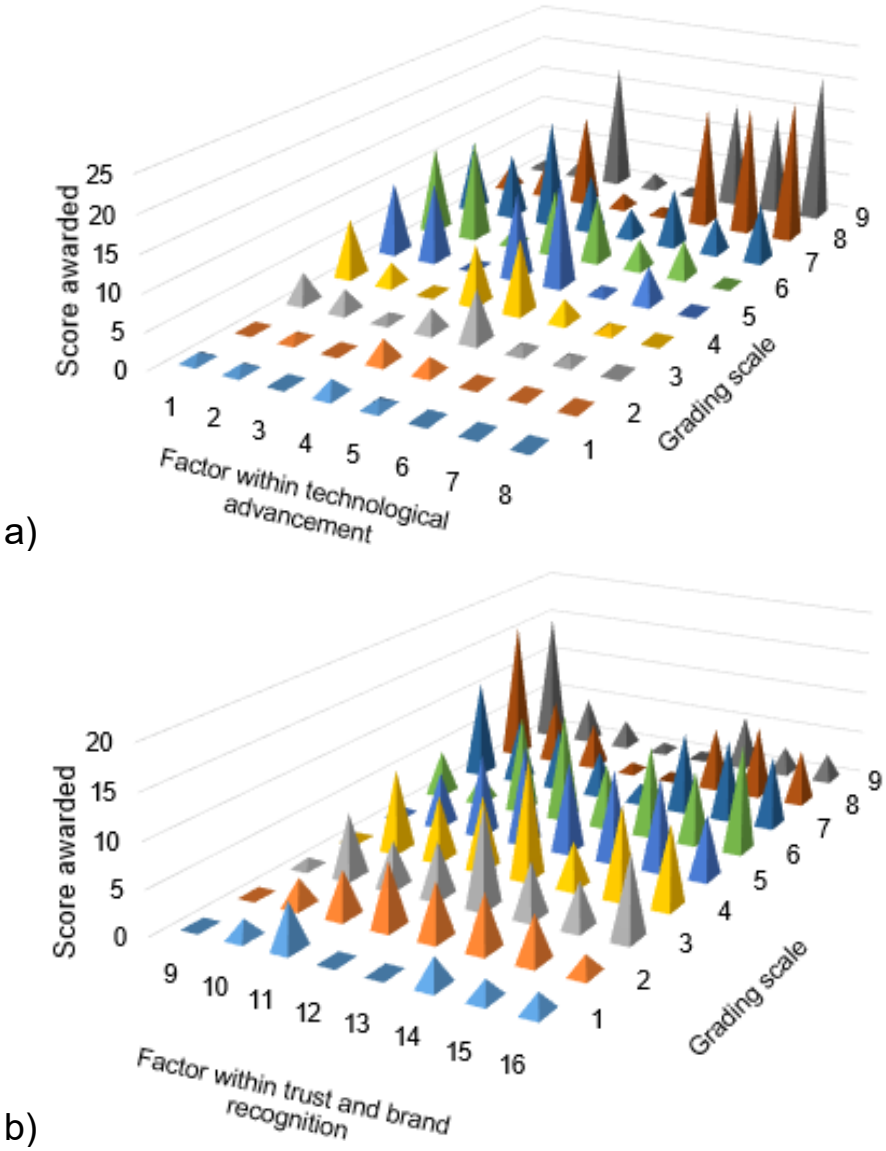

Figure 3 Structure of respondents' ratings of the relevance of competitive factors relating to (a) technological advancement, (b) trust and brand recognition

4. CONCLUSION

Our findings, derived from the assessment of competitive potential factors, clearly highlighted technological advancement and trust/brand recognition as primary areas. Specifically, the analysis of respondents' ratings on the relevance of these factors revealed a total score of 320.88 for technological advancement and 291.75 for trust and brand recognition. This quantitative insight underscores the perceived importance of technological capabilities. The results further identified several key factors crucial for ensuring and fostering development: automated and reliable machinery, high-quality customer service, and consistently high product quality. These elements emerged as direct contributors to the foundry's competitive standing.

The developed model for analyzing the determinants of foundry success offers a robust framework that can significantly support the creation of effective competition and growth strategies. It provides a clear roadmap for allocating resources and focusing improvement efforts.

Beyond this initial application, the designed methodology holds significant potential for generalization and repeatability. Future research opportunities include:

- Extending the model's application to a larger sample of foundries across different geographical regions or with varying operational scales, to validate its robustness and identify broader industry trends.

- Incorporating a detailed analysis of additional external competitiveness factors, such as supply chain resilience, market demand fluctuations, and regulatory impacts, to provide a more holistic view.

- Further refining the quality-related aspects of the model, by delving deeper into specific quality control metrics, defect analysis, and the impact of quality management systems beyond the scope of this pilot study.

- Exploring the long-term impact of implementing the model's recommendations on financial performance and market share, providing a return on investment perspective.

By pursuing these avenues, the model's utility can be further enhanced, providing actionable insights for the entire foundry industry.

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