BSC-Based Digital Transformation Strategy Selection and Sensitivity Analysis

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The digital transformation era is ushering in a revolution in how businesses operate, communicate, and compete. This seismic shift is driven by technological advancements, changing customer expectations, and the need for greater efficiency and agility. In 1992, David Norton and Robert Kaplan introduced the Balanced Scorecard (BSC) as a component of a strategic project management framework. The Kaplan–Norton BSC model emphasizes four well-rounded perspectives: financial, customer, internal business processes, and learning and growth.

Keywords: fuzzy AHP ; spherical fuzzy sets ; decision making ; sensitivity analysis ; balanced scorecard

1. Introduction

The digital transformation era is ushering in a revolution in how businesses operate, communicate, and compete. This seismic shift is driven by technological advancements, changing customer expectations, and the need for greater efficiency and agility. Companies should respond with urgency and innovation to successfully navigate this evolving landscape. However, this adaptation process is far from straightforward [1].

One of the primary challenges enterprises face during the digital transformation journey is aligning their existing practices with the new technological paradigms [2]. Often, this struggle arises from a lack of understanding, clarity, or a coherent strategy. Companies may find themselves overwhelmed by the magnitude of change required, leading to resistance and inefficiencies within the organization.

In this complex and multifaceted context, exploring innovative approaches to address these challenges is essential. One such promising approach is integrating strategic planning with lean manufacturing techniques. Lean principles, derived from manufacturing, emphasize the elimination of waste, continuous improvement, and a focus on delivering value to customers. When applied beyond the shop floor and extended into the digital realm, these principles can help streamline processes, reduce inefficiencies, and enhance the overall agility of the organization [3].

Furthermore, the use of strategic planning and performance evaluation tools such as the Balanced Scorecard (BSC), Objectives and Key Results (OKR), SWOT analysis, and its extension TOWS can play a pivotal role [4]. The Balanced Scorecard provides a comprehensive framework for translating the company's strategic objectives into actionable measures, ensuring alignment across the organization. OKR enable clear goal setting and the transparent tracking of progress, fostering accountability and adaptability. SWOT analysis helps in identifying strengths, weaknesses, opportunities, and threats, which is critical for informed decision making, while TOWS extends this analysis by suggesting strategies to capitalize on strengths and opportunities while mitigating weaknesses and threats [5].

Lean manufacturing techniques offer a robust foundation for adapting to the challenges posed by digital transformation [6]. They are rooted in principles prioritizing efficiency, flexibility, and continuous improvement, essential attributes for thriving in the rapidly evolving technological landscape. These principles align well with the objectives of digital transformation, as they empower organizations to streamline processes, reduce waste, and respond swiftly to changing customer demands and market dynamics [7].

However, the successful integration of lean manufacturing techniques into the context of digital transformation is not a standalone solution. It requires a comprehensive approach, encompassing various facets of decision making and strategic planning. One indispensable process that can significantly enhance the effectiveness of this integration is the Fuzzy Analytic Hierarchy Process (FAHP). FAHP is a decision-making methodology that stands out for its ability to address the inherent human subjectivity, uncertainties, and complexities associated with digital transformation efforts [8].

One of the fuzzy sets' most advanced and recent extensions is the spherical fuzzy sets (SFS) proposed by Kutlu Gundogdu and Kahraman [9]. The concept of SFS involves allowing decision makers to extend other variations of fuzzy sets by establishing a membership function on a spherical surface and independently assigning the function inputs with a larger area. This approach enables the independent assignment of parameters within a broader domain to better capture nuances in decision making [10].

2. BSC-Based Digital Transformation Strategy Selection and Sensitivity Analysis

In 1992, David Norton and Robert Kaplan introduced the Balanced Scorecard (BSC) as a component of a strategic project management framework [11]. The Kaplan–Norton BSC model emphasizes four well-rounded perspectives: financial, customer, internal business processes, and learning and growth. This model was developed to address the limitations of traditional project management approaches. BSC has gained widespread acceptance among researchers [12][13][14] and has been applied across various industries, including food [15], financial services [16], education [17], energy [18], healthcare [19], the sports sector [20], tourism [21], and transportation [22]. Today, the Balanced Scorecard is one of the most prominent and influential performance management systems [23][24].

Selection problems can be applied in the context of the BSC to help organizations choose the most appropriate KPIs and strategic objectives to include in their scorecard. Selection problems can be used in BSC for identifying relevant KPIs [25][26][27][28], resource allocation [29][30][31], balancing perspectives [32][33][34], and prioritizing strategic objectives [32].

When developing a BSC, organizations often have a wide range of potential KPIs to measure performance in each perspective. A selection problem can be used to determine which KPIs are the most relevant and meaningful for measuring progress toward strategic objectives. Various criteria, such as alignment with the strategy, feasibility of measurement, and impact on overall performance, can be considered in the selection process [25][26][27][28]. Birdogan and Abuasad [28] proposed an integrated performance evaluation approach using the Balanced Scorecard-DEMATEL approach. The first stage involves determining performance indicators based on the Balanced Scorecard dimensions, while the second stage prioritizes these dimensions and indicators using DEMATEL. Lin et al. [27] explored the application of the BSC to service performance measurements of medical institutions using the AHP and DEMATEL. Four evaluation dimensions and twenty-two indicators of medical service performance measurements were developed based on the BSC concept.

Another application of selection problems in BSC is related to resource allocation. Once the strategic objectives and associated initiatives are identified, organizations may need to decide how to allocate limited resources, such as budget, manpower, and time, among these initiatives. A selection problem can help optimize resource allocation to maximize the achievement of strategic goals while staying within resource constraints [29][30][31]. Lyu et al. [31] discussed using integrated approaches such as BSC and Fuzzy TOPSIS for performance evaluation in various domains. Herath et al. [29] presented a mathematical model for allocating limited resources in implementing a BSC strategy to prioritize strategic initiatives and calculate the optimal set of BSC targets.

The BSC is designed to provide a balanced view of an organization's performance from various perspectives. A selection problem can be used to ensure that the selected KPIs and strategic objectives adequately represent each perspective. This helps maintain the balance and comprehensiveness of the scorecard [32][33][34]. Danesh et al. [33] proposed a novel approach that integrates BSC and a three-stage data envelopment analysis model to select appropriate measures for organizational performance evaluation. The BSCs measures were used as input and output variables in the DEA model, and the efficiency variations in different stages helped determine the most suitable measures for each perspective of the BSC. Stavs et al. [32] prioritized four BSC measures using ANP. They designed a conceptual framework to evaluate green transport performance and supported the implementation of green transport strategies in industrial companies and supply chains.

Organizations may have multiple strategic objectives within each perspective of the BSC. A selection problem can help prioritize these objectives based on their strategic importance, the potential impact on the organization's success, and the available resources [35][36]. This ensures that the most critical objectives are included in the scorecard and receive the necessary attention and resources. Dodangeh et al. [37] proposed a model that determines the measures and objectives in the BSC by using the consensus of the organization's managers and experts' opinions. It then prioritizes the performances of strategic plans in the BSC using the TOPSIS method, a group decision-making model. Nurcanyo et al. [38] developed the BSC strategy map using the AHP method, with input from faculty leaders through ranking and triangulation methods. Fontes et al. [39] integrated AHP and goal programming. They used AHP to evaluate the relative

importance of initiatives based on financial indicators and the goal-programming model to select a set of initiatives that maximize earnings and minimize the capital employed.

These studies assume crisp values for criteria weights and performance ratings. However, real-life strategy selection problems include uncertainty and imprecision [39]. This study improves traditional strategy selection problems in BSC with a recent fuzzy extension of AHP, spherical fuzzy AHP. Strategies were determined with SWOT and TWOS by considering the strengths and opportunities of each strategy. Moreover, SFAHP results were discussed with sensitivity analysis to expand the experiments. As a result of the AHP, this study established a relationship to lean principles for business improvement. None of the previous studies have focused on the strategy selection problem in BSC holistically.

In recent developments within the field, spherical fuzzy sets combined with AHP have been increasingly adopted for diverse selection problems. However, a crucial aspect that is often overlooked in these studies is the integration of sensitivity analysis. For instance, Alossta et al. [40] addressed a location selection problem using an integrated AHP-RAFSI approach but did not delve into the sensitivity analysis aspect, which could have further validated their findings. Similarly, Irfan et al. [41] applied AHP and G-TOPSIS approaches to overcome biomass energy barriers, yet the absence of sensitivity analysis in their methodology left room for potential subjectivity in their results. This trend is further evidenced in studies such as those of Bakır and Atalik [42] on e-service quality in the airline industry using Fuzzy AHP and Fuzzy MARCOS, and Li et al. [43] in their failure analysis of offshore wind turbines.

Building upon this foundation, the integration of the Balanced Scorecard (BSC), SWOT, and TOWS analyses with SFAHP is identified as another layer of innovation in strategic planning and decision-making processes. The BSC, developed by Kaplan and Norton, is recognized for its effectiveness in assessing organizational performance from various perspectives [44], while SWOT and TOWS analyses serve as powerful tools for dissecting an organization's internal and external environments [45]. Furthermore, the benefits of deploying BSC within healthcare organizations have been systematically reviewed, highlighting its applicability across different sectors [46]. Additionally, the SWOT-FAHP-TOWS analysis methodology, as applied by Savari and Amghani [47] for developing adaptation strategies among farmers, showcases the potential of these methodologies when integrated. This approach, through its comprehensive and multifaceted analysis, contributes significantly to enhancing the efficacy and strategic depth of decision-making processes.

A few studies adopted the spherical fuzzy sets in AHP for different selection problems. For example, Otay et al. [48] proposed a single-valued SFAHP-WASPAS method to evaluate three outsourcing manufacturers. Kutlu Gundogu and Kahraman [10] applied SFAHP to decide the best site selection for wind power farms among four alternatives. Both studies neglected sensitivity analysis and thus included more subjectivity.

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