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Exploration of Dynamic Model-Based Decision Support Systems in Various Sectors: Systematic Literature Review and Visual Analysis

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A B S T R A C T

Dynamic model-based decision support systems can be used to assist strategic decision making in various sectors in facing complex and uncertain environmental challenges. The main problem in the development and application of dynamic model-based decision support systems is the lack of comprehensive mapping of research trends, challenges, and opportunities. This study aims to explore the application of dynamic model-based decision support systems to identify trends, as well as theoretical and practical contributions in various sectors. This study uses a systematic literature review method. Data collection techniques involve a visual filtering and analysis process to understand the pattern of decision support system application. The results of the study indicate that dynamic model-based decision support systems, such as simulation, system dynamics, and real option theory, are effective in supporting strategic decision making in the industrial, public policy, and management sectors. The integration of artificial intelligence (AI) technology and data analytics also strengthens the flexibility and accuracy of the system

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INTRODUCTION

Effective and data-driven decision making has become a key pillar in various sectors, including government, business, healthcare, and education (Kovari, A, 2024). According to a report by McKinsey & Company (2024), more than 50% of global organizations identify data-driven decision making as a strategic priority to improve efficiency and competitiveness. In a global context, exponential data growth is estimated to reach 180 zettabytes by 2025 (Thangam et al., 2024). This further drives the need for systems that are able to dynamically process and analyze data to produce optimal decisions, thus placing dynamic model-based decision support systems as a solution to face these challenges. Decision support systems have been widely used to support decision making in various complex situations (Zakeri et al., 2024; Jung et al., 2020). For example, in the healthcare sector, decision support systems are used to model disease spread and resource allocation (Ordu et al., 2023; Sutton et al., 2020). In supply chain management, decision support systems help optimize logistics and distribution of goods, especially during the COVID-19 pandemic (Li et al., 2023; Illahi & Mir, 2021). The application of dynamic model-based decision support systems has its own advantages compared to traditional approaches, especially in its ability to simulate complex variable interactions and their impact on decision outcomes. However, research shows that only 40% of organizations have successfully implemented dynamic model-based decision support systems effectively, mostly due to lack of technical understanding and adequate resources (Soori et al., 2024).

LITERATURE REVIEW

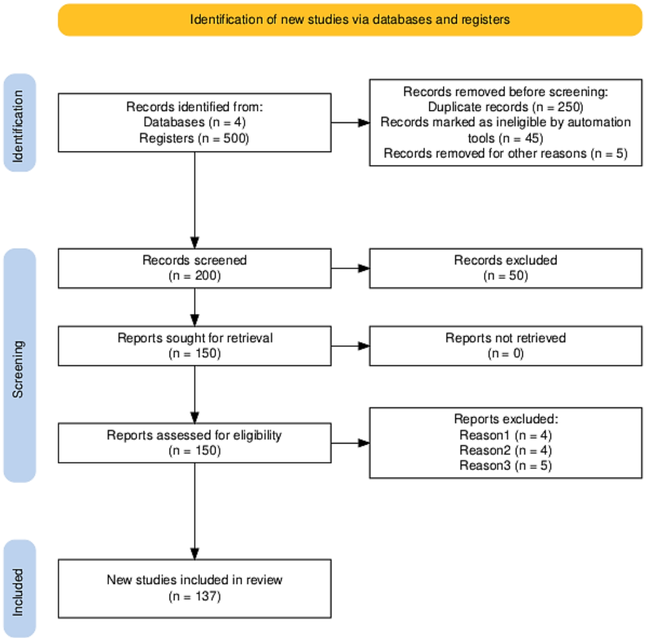
Several previous studies have shown various applications of dynamic models in various sectors. Studies by (Korder et al., 2024; Bayu et al., 2022; 2024; Garay-Rondero et al., 2020) examined the use of dynamic models in supply chain management and found that scenario simulation can significantly improve operational efficiency. This dynamic model allows companies to be more flexible in dealing with challenges such as changes in demand, logistics disruptions, or price fluctuations. In addition, scenario simulation can help improve operational efficiency because companies can identify risks, optimize resources, and design more effective strategies. In the healthcare sector, studies by (Brüggemann et al., 2021; Fattahi et al., 2023; Karthikeyan et al., 2021) show how a dynamic model-based decision support system helps in the allocation of healthcare resources during the COVID-19 pandemic. In healthcare during the pandemic, this model takes into account factors such as the number of COVID-19 cases, the level of hospital bed availability, the need for medical devices, and healthcare workers. This healthcare resource allocation includes the distribution of resources such as hospital beds, ventilators, medical personnel, medicines, and vaccines to ensure optimal healthcare services.

Meanwhile, research by (Grander et al., 2021; Chatterjee et al., 2023; Brewis et al., 2023; Li et al., 2024) discusses the integration of big data technology and dynamic models for strategic decision making in the manufacturing industry to simulate production processes, optimize supply chains, and predict demand and operational performance based on real-time data. With the help of big data and dynamic models, companies can make more accurate data-based decisions, such as production planning, resource allocation, and operational cost reduction. In the environmental field, studies by (Portela et al., 2020; Keyhanpour et al., 2021; Alamanos et al., 2021; Naeem et al., 2023) highlight the application of dynamic models in sustainable water resources management to simulate how factors such as rainfall, water use, population growth, and climate change affect future water availability. These models enable data-driven predictions and scenarios to support more accurate decision-making. Therefore, based on the above studies, this study extends these findings by combining systematic analysis and bibliometric visualization to identify thematic relationships between studies that have not been fully disclosed. This study aims to provide a comprehensive understanding of the trends, contributions, and challenges in the application of dynamic model-based decision support systems in various sectors. Thus, this study can support the development of more effective solutions in decision-making in various sectors based on dynamic models.

METHODOLOGY

This study uses a qualitative method with a systematic literature review approach through the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to systematically filter relevant literature. This process involves four main stages, namely identification, screening, eligibility, and inclusion of literature based on predetermined criteria. Relevant articles were identified through databases such as Scopus, Web of Science, ScienceDirect, and Google Scholar, including publisher sources such as Elsevier, Sage, Taylor & Francis, MDPI, and Emerald to ensure broad research coverage and high quality. The search process was carried out using keywords such as "Dynamic Model", "Decision Support System", and "System Dynamics" which were specifically designed to capture the most relevant literature to the research topic.

In the identification stage, the initial search process resulted in 500 articles. The screening stage was carried out by removing duplicate articles, leaving 200 articles. Furthermore, in the selection stage, the abstracts of the articles were evaluated to separate articles that were not relevant to the inclusion criteria, leaving 150 articles. The final stage was eligibility, where the full texts of the remaining articles were thoroughly examined to ensure methodological quality and relevance to the research topic. At this stage, 137 articles were obtained that met all criteria and were included in the final analysis. The inclusion criteria in this study included peer-reviewed articles published between 2020–2024, written in English, and focused on the application of dynamic models in decision support systems.



Source: Adapted from Haddaway et al., (2020)
Figure 1. PRISMA SLR Logic Flow Diagram (2020-2024)

Data analysis in this study uses a bibliometric approach and thematic analysis. Bibliometric analysis was carried out with the help of VOSviewer software to identify relationships between research themes, authors, and institutions. VOSviewer is used to visualize scientific networks, including keyword analysis and relationships between research topics, thus providing more comprehensive insights. Thematic analysis was carried out to identify key contributions, challenges, and opportunities in the development of dynamic model-based decision support systems in various sectors

RESULT

Analysis of publications published between 2020 and 2024 shows a trend that shows a significant increase in the number of studies on dynamic model-based decision support systems. In 2020, the number of publications reached 12%, while in 2021 it increased slightly to 15%. In 2022, the contribution of publications increased further to 18%. The peak number of publications occurred in 2023, with 28% of the total publications, indicating a surge in attention to this topic. Although there was a slight decrease in 2024 to 26%, this proportion still shows high relevance to the application of dynamic models in decision support systems. Figure 2 shows the distribution of the number of publications per year in the period 2020 to 2024, which illustrates a consistent increasing trend throughout the last five years.

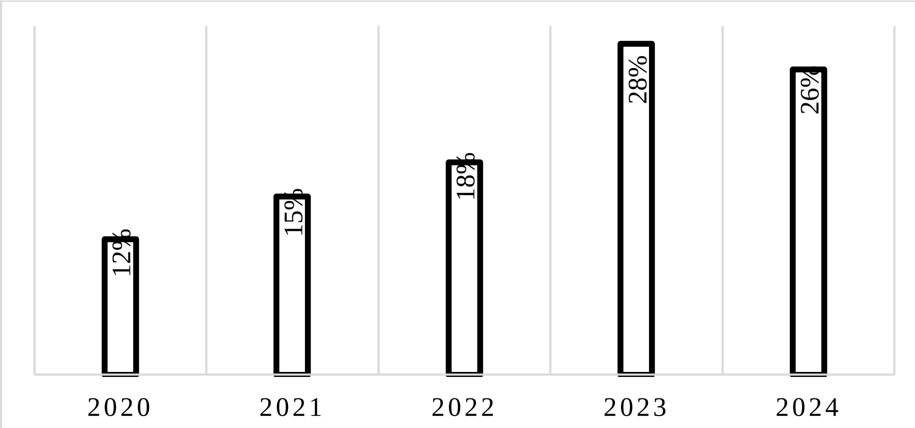


Figure 2. Number of Publications Per Year (2020–2024)

Figure 3, shows the network visualization for all keywords extracted from the title and abstract using the VOSviewer tool. This map illustrates the relationships between keywords divided into several groups (clusters) with different colors. Keywords such as "decision", "system", and "application" (marked in red) form the core of the network, indicating that the main theme of the research focuses on the decision-making process and the implementation of technology-based systems such as machine learning and artificial intelligence. On the other hand, the green cluster includes keywords such as "organization", "implementation", "implication", and "covid" and "pandemic", highlighting the relevance of decision-making in the context of organizations and pandemics. The blue cluster includes keywords "strategy", "development", "sustainable development", and "business", focusing on sustainable development and strategy development in the context of business. Meanwhile, the yellow cluster contains keywords such as "simulation", "problem", "data", and "optimization", emphasizing the role of simulation and optimization in data-driven problem solving. This network shows a close relationship between keywords, with connecting lines indicating the degree of co-occurrence between the terms. The dominance of themes such as technology, simulation, decision-making, and sustainable development is the main focus in the analyzed studies. This reflects the research trend that integrates systems, technology, and optimization approaches in decision-making across sectors.

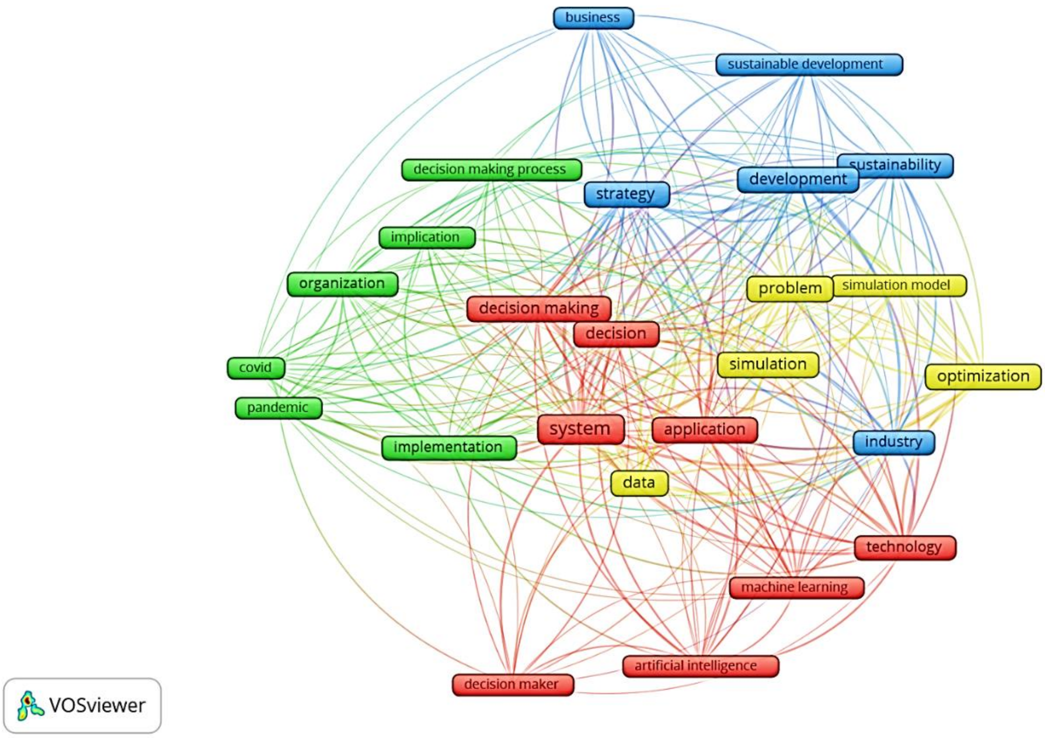


Figure 3. Network Visualization for All Keywords Based on Title and Abstract

Then, Figure 4 shows a bibliographic keyword network divided into three clusters with a total of nine items. This network illustrates the relationship between keywords that often appear in research. Cluster 1 consists of the keywords decision-making, multi-objective optimization, and sustainable development. These three keywords indicate the focus of research on decision-making involving multi-objective optimization to achieve sustainable development goals. Furthermore, cluster 2 includes discrete event simulation, healthcare, and optimization. This cluster highlights the application of discrete event-based simulation and optimization in the healthcare sector, which aims to improve the efficiency and effectiveness of the healthcare system. Meanwhile, cluster 3 consists of the keywords simulation, machine learning, and renewable energy. This cluster illustrates the use of simulation and machine learning technologies in the development of renewable energy, which is currently an important trend in technology-based and sustainability research.

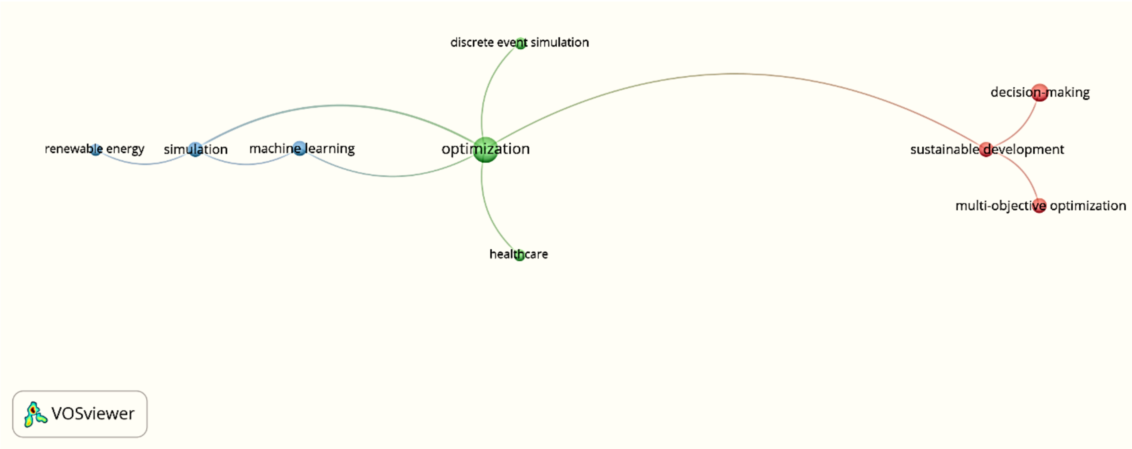


Figure 4. Bibliographic Keyword Network

This network has 9 links with a total link strength of 10, indicating the level of connectivity between keywords in the network. These relationships are not only strong within each cluster, but also show cross-cluster connectivity, such as the integration of decision-making, optimization, and simulation approaches in various research fields. The main focus of research seen in this visualization is on the application of technology to solve complex problems systematically, especially in the context of sustainability, renewable energy, and improving the efficiency of health services.

DISCUSSION

The results of various literatures that have been analyzed through three main interrelated concepts, namely: optimization, simulation, and strategic decision making. These three concepts are often used together in various research contexts, especially those related to complex planning and management in various industrial sectors.

Optimization

Dynamic model-based decision support systems offer an integrated approach to optimization, simulation, and strategic decision making in various sectors. Through this approach, decision makers can analyze the interactions of complex variables, simulate various scenarios, and identify optimal solutions that support the achievement of organizational or policy goals. Optimization refers to the process of finding the best solution based on predetermined parameters. By using certain algorithms, such as rule-based optimization, genetic algorithms, or other heuristic approaches, dynamic model-based DSS allows users to explore various policy alternatives and choose the option that provides the maximum results within limited resources. Previous studies relevant to the optimization theme have provided various insights and developments in various industry contexts and applications. Studies by (Roldán Bravo et al., 2023; Khawka et al., 2024; Antonio et al., 2022) discuss the application of optimization strategies to manage uncertainty in the supply chain. These studies focus on reducing lead time and inventory costs using lean and agile supply chain models, which aim to improve supply chain efficiency and responsiveness under uncertain conditions.

On the other hand, (Wang et al., 2023; Laghari et al., 2023; Kim & Chung, 2023) applied simulation-based optimization to improve operational performance. These studies utilized Monte Carlo simulation to identify optimal solutions in an uncertain environment, allowing companies to anticipate various possible outcomes and make better decisions. Utku (2023) developed a production schedule optimization model that considers time efficiency and resource utilization. This model was applied in the automotive and electronics industries, as also discussed by Zanella & Vaz (2023). This provides important insights into how optimization can be applied in production planning to improve operational efficiency. Fattahi et al. (2023), and Yinusa & Faezipour (2023), applied optimization models to medical resource allocation during public health emergencies, such as a flu pandemic. The results showed significant benefits in improving clinical outcomes despite limited resources, and provide important contributions to managing global health crises.

In addition, Xu et al. (2024) and Gasset et al. (2024) developed a heuristic algorithm to solve the Vehicle Routing Problem (VRP), which focuses on saving distribution costs by optimizing transportation routes. This algorithm offers an efficient solution to complex goods distribution problems, considering various constraints, such as vehicle capacity and delivery time. Research conducted by Stofkova et al. (2022) and Canco et al. (2021) introduced the Analytic Hierarchy Process (AHP) method to help decision makers choose the best alternative with conflicting criteria. This method is widely used in decision making involving many interacting factors and objectives, such as in choosing an investment strategy or project planning. Filippou et al. (2023), Schmitt (2023), and Moharil et al. (2024) developed an AutoML approach for hyperparameter optimization in machine learning that can provide an automated solution to improve the performance of machine learning models, thereby facilitating the process of developing more effective and efficient models. In addition, Tripathi et al. (2022) used an optimization approach to improve the efficiency of production processes in the food industry, focusing on waste reduction and output increase. These studies demonstrate a variety of optimization approaches that can be applied in different contexts, with the main goal of improving efficiency, reducing costs, and optimizing resource use in various sectors, from goods distribution, industrial production, to energy and natural resource management.

Simulation

Simulation is a key component in dynamic model-based decision support systems due to its ability to model both long-term and short-term system behavior. By using simulation, decision makers can visualize the impact of various policies or actions without having to take real-world risks. Simulation has been widely used in various studies to optimize system management and support more effective decision making in various sectors. Research by (Badakhshan et al., 2024; Bozdoğan et al., 2023; Kim et al., 2023), utilizes agent-based simulation to optimize supply chain management. This study highlights how simulation can be used to model dynamic behavior in the distribution flow, enabling more efficient decision making in managing inventory and customer demand. In addition, research by (Terning et al., 2022; Donelli et al., 2022) develops agent-based simulation for pandemic management, such as allocation of medical resources and handling of patient flow in hospitals, enabling more responsive decision making during a health crisis.

Sustainable energy management, (de la Torre et al., 2021; Silva et al., 2020) utilizes system-based simulation to design more sustainable energy management strategies. This study emphasizes the importance of simulation approaches to model energy demand and its impact on the environment. In logistics flow optimization, studies by (Castilla-Rodríguez et al., 2020; Chen et al., 2024; Tang et al., 2024; Pekarcikova et al., 2021) examine the application of system-based simulation to optimize logistics flows. This study highlights the benefits of simulation in identifying operational bottlenecks and developing more efficient solutions. In project management (Guo & Zhang, 2022; Dasović et al., 2020) found that by modeling time and cost dynamics, simulation can be used to improve operational efficiency in large-scale projects. These studies show that simulation has an important role in complex decision making across sectors. By using dynamic model-based simulations, various sectors can benefit from this approach to better understand interactions within systems, identify potential problems, and design more effective and efficient solutions.

Strategic Decision Making

Strategic decision making is the ultimate goal of implementing a dynamic model-based decision support system. Several recent studies have developed various methods and tools to assist decision makers in designing effective strategies. Research by (Sequeira et al., 2021) introduced the AHP (Analytic Hierarchy Process) method to assist strategic decision making in multi-criteria situations. Meanwhile, research by (Quesado et al., 2022; Yawson & Paros, 2023; Betto et al., 2022) developed the Balanced Scorecard as a tool for evaluating performance and setting strategic priorities, which is very important in decision making based on performance indicators. In addition, research by (Jonsdottir et al., 2024; Zanker et al., 2021) developed a system dynamics approach to model strategic decision making in various sectors, including industry and public policy, to understand the impact of long-term decisions on complex systems. In addition, (Zhang & Yin, 2023) put forward the real options theory as an approach to investment decision making under uncertainty, while (Cordova-Pozo & Rouwette, 2023; Strelkovskii et al., 2020; Gandrita, 2023) developed a scenario planning method to help organizations prepare strategic decisions in the face of future possibilities.

Research by (Biloslavo et al., 2024; Rodgers et al., 2023) explains the use of artificial intelligence in strategic decision making through predictive algorithms and data analytics. In the digital era, the integration of technologies such as artificial intelligence (AI) and big data analytics further strengthens the capabilities of dynamic model-based decision support systems. AI can be used to improve the accuracy of predictions in models, while big data analytics allows for faster and more efficient data processing. With the integration of these technologies, decision makers can respond to changes in real-time, optimize outcomes, and anticipate future challenges. Therefore, investment in the development of dynamic model-based decision support systems is not only a technical necessity, but also an important strategy to support innovative and sustainable decision making.

Research by (Abou Jaoude et al., 2022) explores the use of system dynamics to support strategic decisions in public policy. Using this approach, policymakers can understand the potential impact of their decisions in the long term and identify the indirect effects of a policy before it is implemented. Research by (Glette-Iversen et al., 2023) discusses the integration of risk management in strategic decision making which involves identifying, evaluating, and mitigating risks that can affect the strategic objectives of the organization. This research underlines the importance of considering risk at every stage of strategic decision making to ensure organizational sustainability and reduce potential losses due to environmental uncertainty. In addition, research by (Elkady et al., 2024; Kurpiela & Teuteberg, 2024) developed the initial concept of DSS (Decision Support Systems) to assist strategic decision making in large organizations through data integration and scenario simulation to help decision makers evaluate various alternatives. The goal is to improve decision quality by providing more accurate data-based information and in-depth scenario predictions

CONCLUSION AND RECOMMENDATION

Dynamic model-based decision support systems have been widely used in various sectors, including industry, public policy, and strategic management. Methods such as system dynamics, scenario simulation, real option theory, and predictive algorithm-based approaches play an important role in helping decision makers respond to complex challenges and uncertain environments. The findings of this study also show that the integration of technologies such as artificial intelligence (AI) and data analytics further enhances the effectiveness of DSS in developing flexible and adaptive strategies. With the integration of these technologies, decision makers can respond to changes in real time, optimize outcomes, and anticipate future challenges. Therefore, investment in the development of dynamic model-based DSS is not only a technical necessity but also an important strategy to support innovative and sustainable decision making. This study enriches the understanding of the role of dynamic systems in supporting strategic decision making and highlights the importance of model-based approaches in predicting the long-term impact of a policy or decision. Practically, this study contributes to policy makers in utilizing DSS to design more measurable, responsive, and innovative strategies, especially in the face of global disruption.

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