Analysis of Barriers and Driving Factors for the Application of Mathematical Economic Models in the Decision-Making Process of Manufacturing Enterprises in Vietnam

Le Dieu Huong
VNU University of Economics and Business,
Vietnam National University, Hanoi, Vietnam
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Abstract
This study aims to deeply explore and interpret the barriers and driving factors in the process of applying mathematical economic models to decision-making within Vietnamese manufacturing enterprises. To achieve this objective, the research employed an exploratory qualitative method, with semi-structured in-depth interviews with 12 senior and middle managers directly involved in strategic and operational decision-making as the primary tool. The analysis reveals a clear contrasting picture: the main barriers include (1) a crisis in data quality and availability, (2) a gap in human resource capabilities and an organizational culture that prioritizes experience, and (3) the burden of investment costs; while the critical driving factors are (1) survival pressure from market competition, (2) the decisive role of visionary leadership, and (3) the persuasive power of successful pilot projects. From these findings, the study proposes important practical implications, recommending that enterprises adopt a step-by-step approach of "starting small, proving efficiency," and suggesting that educational institutions should enhance industry collaboration and focus on soft skills for students. The novelty of this work lies in its use of a qualitative lens to delve into the specific context of Vietnam, interpreting cultural and behavioral nuances often overlooked by previous quantitative studies, thereby enriching the theory of technology adoption for developing economies.

Keywords: *Mathematical Economics, Decision-Making Models, Manufacturing Enterprises, Vietnam.*

1. Introduction

In recent decades, the manufacturing sector has affirmed its role as one of the main pillars of Vietnam's economic growth. However, the process of deep integration into the global and regional economy has created an increasingly fierce competitive environment, requiring businesses to continuously innovate and improve operational efficiency (World Bank, 2022). In this context, data-driven and scientifically-backed decision-making has become a vital competitive advantage. Mathematical economic models, including techniques for optimization, forecasting, simulation, and risk management, provide a powerful toolkit for solving complex business problems, from production planning, supply chain management, and inventory optimization to product pricing (Hillier & Lieberman, 2015). Theoretically, the application of these models can help businesses reduce costs, maximize profits, and respond more flexibly to market fluctuations. Nevertheless, a notable paradox exists: there is a significant gap between the theoretical potential of mathematical economic models and their actual application level in Vietnamese manufacturing enterprises.

Previous studies in Vietnam on technology application in enterprises have tended to focus on the adoption of information technology in general or broad-scale digital

transformation, primarily using quantitative survey methods to measure influencing factors (e.g., Nguyen & Dang, 2025). While these studies provide a useful overview, they often fail to delve into the complex nuances behind the decisions to adopt or reject a specialized analytical tool like a mathematical economic model. Although isolated case studies exist, they lack generalizability. Therefore, a significant research gap remains: the lack of studies that deeply investigate "why" and "how" from the perspective and experience of managers—the direct decision-makers. The application of a model is not just a technical issue but is also profoundly influenced by contextual factors such as organizational culture, leadership perception, and behavioral barriers (Tornatzky & Fleischer, 1990). For this reason, a qualitative study is necessary to explore and interpret these complex aspects, which quantitative methods can hardly capture in their entirety (Creswell & Poth, 2018).

Stemming from the aforementioned research gap, the main objective of this paper is to deeply explore and interpret the barriers and driving factors in the process of applying mathematical economic models to decision-making in Vietnamese manufacturing enterprises. To achieve this objective, the research will focus on answering the following questions:

- RQ1: What are the main barriers that Vietnamese manufacturing enterprises face when attempting to apply mathematical economic models to their decision-making processes?
- RQ2: What factors act as the main drivers motivating these enterprises to seek and apply mathematical economic models?
- RQ3: How do these barriers and driving factors interact with each other within the specific context of the enterprises?

2. Literature Review

2.1. Theoretical Foundation of Applying Mathematical Economic Models in Enterprises

Mathematical economic models, or more broadly, the methods of Operations Research, provide a systematic and scientific approach to decision-making in organizations. These models use quantitative analysis to find optimal or near-optimal solutions to complex problems (Hillier & Lieberman, 2015). In the manufacturing sector, the main groups of models commonly applied include: (1) Optimization models, such as Linear Programming, used to plan production output to maximize profit or minimize cost under resource constraints; (2) Forecasting models, which use time-series and regression techniques to estimate market demand as a basis for planning; (3) Inventory management models, such as the Economic Order Quantity (EOQ) model, which help determine optimal inventory levels; and (4) Simulation models, which allow businesses to test different operational scenarios without risking the real system (Taha, 2017). Linking these models to specific operational and strategic decisions such as logistics coordination, production scheduling, or pricing is the foundation for transforming data into value and competitive advantage.

2.2. Barriers to Technology and Model Application in Organizations

Despite the clear theoretical benefits, the successful transfer of models from academic settings to business practice faces many significant barriers. The Technology-Organization-Environment (TOE) framework by Tornatzky and Fleischer (1990) provides a comprehensive lens for analyzing these barriers. In terms of Technology, the complexity of the models and the initial investment costs for software and experts are often seen as major obstacles. In terms of Organization, the barriers are often the most multifaceted and profound. Many studies point to the lack of personnel with sufficient skills to analyze and interpret model results as a leading challenge (Davenport & Harris, 2007). Furthermore, data quality—the foundation of any model—is often a critical weakness, manifested through a lack of, inaccuracy, or fragmentation

of data (Wixom & Watson, 2010). Equally important are human and cultural barriers. Organizational inertia, resistance to change, and a management culture that prioritizes experience and intuition over quantitative analysis create an invisible but solid barrier. This mindset can be partly explained by theories of cognitive bias, where managers tend to trust "fast thinking" (intuition) over "slow thinking" (analysis) which requires more effort (Moore, 2013). Finally, the Environment factor, such as competitive pressure, can be both a barrier (if the company is too focused on short-term operations) and a driver of change.

2.3. Driving Factors for Application

Parallel to the barriers, research has also identified several important driving factors that promote the application of analytical models. Among them, commitment and sponsorship from top leadership (a leadership champion) are considered prerequisites, capable of creating a vision, providing resources, and fostering a data-driven decision-making culture throughout the organization (Davenport & Harris, 2007). Besides, external competitive pressure, as an element in the TOE model, often acts as a powerful push, forcing businesses to turn to analytical tools to survive and grow (Porter, 2008). Another highly practical driver is the ability to demonstrate a return on investment (ROI). When pilot projects or initial applications show clear financial benefits, it builds trust and momentum to scale up the model within the enterprise (Rogers, 2003). Finally, the continuous development of technology, with the advent of more user-friendly and affordable software, is also gradually lowering the entry barrier for businesses.

2.4. The Vietnamese Context and Research Positioning

Applying international theoretical frameworks to the Vietnamese context requires consideration of its socio-economic specificities. The Vietnamese economy is characterized by the dominance of small and medium-sized enterprises (SMEs), which account for a large proportion of the number of businesses and labor force (General Statistics Office of Vietnam, 2021). Many of these businesses operate under a family-owned governance model, where decisions are often centralized in the hands of the leader and can be heavily influenced by personal relationships and experience rather than formal analysis. At the same time, Vietnam is in a phase of accelerating its national digital transformation program, creating both opportunities and challenges for businesses in accessing new technologies. These characteristics suggest that the barriers and drivers identified in international theory may manifest differently or have different levels of influence in Vietnam. Therefore, this study reaffirms the identified gap: a deep exploration using qualitative methods is needed to test and enrich existing theories, thereby providing a realistic and contextualized picture of the application of mathematical economic models in Vietnamese manufacturing enterprises.

3. Research Methodology

3.1. Research Design

To answer the stated research questions, this study employs a qualitative research method with an exploratory design. This approach was chosen because it is particularly suitable for deeply exploring "why" and "how" questions, allowing for the collection of rich and in-depth data on the perspectives, experiences, and complex contexts of the participants (Creswell & Poth, 2018). Instead of measuring causal relationships, the goal of this design is to build a comprehensive understanding and interpret phenomena from the perspective of the subjects themselves, something that quantitative methods can hardly achieve.

3.2. Sampling

The study applies purposive sampling to select information-rich cases that can provide the deepest understanding of the research problem (Patton, 2014). The selection criteria were defined as follows:

- For enterprises: Must be a business operating in the manufacturing sector in Vietnam; with diversity in scale (including both medium and large enterprises), industry (textiles, food, mechanics, etc.), and level of application of mathematical economic models (from the initial exploration stage to partial successful implementation).
- For participants: Senior or middle managers with a direct role in strategic and operational decision-making, such as Chief Executive Officer (CEO), Plant Manager, Head of Planning, or Head of Research and Development (R&D).

The study planned to interview 10 to 15 managers. The data collection process would stop upon reaching theoretical saturation, i.e., when new interviews no longer provide significant new information or themes (Glaser & Strauss, 2017). The final sample of the study consisted of 12 participants.

3.3. Data Collection

The primary data collection tool was semi-structured in-depth interviews. An interview guide was developed based on the literature review and research questions, serving as a guideline to ensure that the main topics were covered while allowing flexibility to delve into issues that arose during the dialogue (Kvale & Brinkmann, 2009). The interviews, with an average duration of 60 to 90 minutes each, were conducted between April 2025 and August 2025, either in person or online, depending on the convenience of the participants. All interviews were audio-recorded with the consent of the participants and carefully transcribed to facilitate the analysis process.

Thematic analysis was used, following these steps: (1) Familiarizing with the data, (2) Generating initial codes, (3) Searching for themes, (4) Reviewing themes, (5) Defining and naming themes, (6) Writing the report.

4. Research Results

The analysis of in-depth interview data with 12 managers in manufacturing enterprises has highlighted a set of core themes that explain the gap between the potential and the practice of applying mathematical economic models. This section will present the main findings, focusing on the most common barriers that businesses are facing.

4.1. Theme 1: Core Barriers in Model Application

One of the most prominent and consistent findings from the interviews is the poor state of data, which is seen as a fundamental and prerequisite barrier. The problem is not only the lack of historical data but also the fragmentation, lack of synchronization, and low reliability of existing data. Many managers reported that operational and business data are often stored in disparate individual files, with no centralized management system, leading to a state of "data chaos." As a Planning Director at a food company bluntly described: *"We really want to do forecasting, but the sales data is in a different Excel file in every department, no one consolidates it, and it's full of errors, so how can we run a model?"*. This situation creates a vicious cycle: unreliable data makes model building meaningless, and because there are no models, there is no motivation to improve data quality.

Besides the tangible barrier of data, another intangible but equally profound challenge is the gap in human capabilities and organizational perception. The analysis shows a severe shortage of human resources capable not only of building models but also of interpreting the

results and translating them into persuasive business proposals. At the same time, a management culture that relies heavily on experience and intuition is still prevalent, especially at the highest leadership levels. Mathematical models, with their complex formulas and numbers, are often seen as a "black box," lacking transparency and being less trustworthy than experience proven over many years. An analyst at a textile company shared: *"The top bosses are still used to making decisions based on decades of experience. If you give them a complex spreadsheet, they don't trust it and don't have the time to understand it."*. This skepticism creates an inertia that discourages pioneering efforts in applying quantitative analysis.

Finally, financial and technological infrastructure barriers are a practical obstacle that many businesses face. The initial investment costs for specialized software, hardware upgrades, and especially the cost of hiring consultants are perceived by managers as very high. More importantly, the return on investment (ROI) from applying these models is often unclear and long-term, making investment proposals difficult to compete with other urgent spending needs. Many businesses are still operating on old Enterprise Resource Planning (ERP) systems that lack the ability to integrate and extract data efficiently for modern analytical tools. A Chief Financial Officer in the mechanical engineering industry stated: *"Proposing a project worth several billion VND for a software system where the benefits might only be seen in 2-3 years is very difficult to get approved, especially when the immediate cost pressure is immense."*. This shows that investment decisions are not only based on potential but also heavily dependent on the company's short-term financial picture.

4.2. Theme 2: Game-Changing Driving Factors

Parallel to identifying barriers, the data analysis also points to the existence of game-changing driving factors. These are catalysts capable of breaking through inertia and paving the way for the application of mathematical economic models in enterprises.

If internal factors often create barriers, external environmental pressure is identified as the most powerful driver forcing businesses to change. The increasingly fierce competitive pressure from both domestic rivals and foreign-invested enterprises, which often have advantages in technology and modern management processes, has pushed companies into a position where they must seek breakthrough solutions to survive. This pressure is not just about price, but also about speed, flexibility, and resource efficiency. Optimizing production costs, reducing inventory, and shortening delivery times are no longer options but have become survival requirements. As a CEO of a logistics company frankly admitted: *"Our competitor delivers in 24 hours, their inventory is half of ours. If we don't find a way to optimize our supply chain with tools, we can't compete."*. This survival pressure has become the primary driver, forcing leadership to seriously consider new approaches, including quantitative analysis models.

In the context of increasing market pressure, the role of the leader becomes decisive. The analysis shows that in enterprises that are beginning to make progress in applying models, there is always the presence of a "champion"—a senior leader with vision and determination. This could be the emergence of a new generation of leaders, who are well-educated abroad and possess a data-driven management mindset. They not only recognize the potential of mathematical economic models but are also decisive enough to sponsor projects, provide resources, and, most importantly, communicate the message of change throughout the organization. An R&D Manager at a mechanical engineering company shared: *"The previous generation managed by experience; we have to manage by numbers. I identified this as a strategic project, accepted the initial risks for the long run, and I am directly supervising it to ensure it doesn't 'die prematurely' due to old doubts."*. This commitment creates a "shield" that protects project teams from cultural barriers and organizational inertia.

Faced with barriers of cost and skepticism, an effective strategy adopted by pioneering enterprises is to start with small-scale pilot projects. Instead of implementing a complex and expensive system company-wide, they focus on solving a specific, narrowly scoped problem that yields measurable results. This could be optimizing the production schedule for one workshop, forecasting demand for a few key product lines, or optimizing a single transportation route. When these "small wins" are demonstrated with concrete figures on cost savings or increased efficiency, they create a powerful ripple effect. A Plant Manager at a textile factory recounted: *"No one believed it at first. We just asked to run a trial to optimize the production schedule for one workshop. After 3 months, that workshop's productivity increased by 15%. From then on, other departments started coming to us."*. These initial successes are the most convincing evidence to build internal trust, thereby creating motivation and support for larger-scale projects in the future.

5. Discussion

5.1. Interpretation of Results

The research findings from the Vietnamese context show a strong resonance with international theoretical frameworks, while also highlighting important specific nuances. The core barriers identified, including the data crisis, lack of capacity, and cost burden, are fundamentally similar to the factors described in the Technology-Organization-Environment (TOE) model (Tornatzky & Fleischer, 1990) and classic studies on the application of analytics (Davenport & Harris, 2017). This confirms that the challenges in applying mathematical economic models are, to a certain extent, universal.

However, the subtle yet profound difference lies in how these barriers manifest and are reinforced by the socio-cultural context. The "perception gap" factor is not merely a lack of skills but also stems from a management culture where "intuitive experience" and "relationship-based decisions" are often valued more than objective data analysis. In an environment where a "culture of deference" is prevalent, challenging a superior's decision with a quantitative model might be seen as disrespectful rather than a constructive contribution. This is a nuance of the "Organization" factor that general theoretical models do not explicitly capture.

The analysis also reveals a complex and dynamic interaction between barriers and driving factors. They do not exist in isolation but constantly influence each other. For example, a visionary leader (a driving factor) can use "market pressure" (a driving factor) as leverage to justify the need for change. From there, this leader will be determined to invest (overcoming the cost barrier) to gradually resolve the "data crisis" and slowly change the "organizational culture" (overcoming the perception barrier) by sponsoring successful "pilot projects." This process shows that overcoming barriers is not a single event but a deliberate campaign, led by strategic driving factors.

5.2. Theoretical Implications

Theoretically, this study contributes to the body of knowledge on technology adoption and diffusion by providing deep insights from the context of a developing economy undergoing strong digital transformation, like Vietnam. It enriches the TOE model by pointing out that within the "Organization" factor, informal cultural aspects such as trust in intuition and relationship networks can act as important variables, with an influence comparable to tangible factors like size or structure.

Based on these findings, a preliminary framework of factors affecting the application of mathematical economics in Vietnam can be proposed. This model is an adaptation of the TOE model, in which:

- The Organization (O) factor is supplemented with a sub-dimension of "Culture - Perception," which includes variables such as "Priority of intuitive experience" and "Influence of relationship-based decisions."
- The Environment (E) factor is more specifically emphasized with "Competitive pressure from FDI enterprises" and "Impact of the national digital transformation program."
- The roles of "Visionary leadership" and "Success of pilot projects" are identified as moderating variables, capable of weakening the negative impact of barriers.

This adjusted theoretical framework is not only valuable for future research in Vietnam but can also be applied to countries with similar socio-economic contexts.

6. Conclusion and implications

6.1. Summary of Key Findings

This study has explored and systematized the driving factors and barriers in the application of mathematical economic models in Vietnamese manufacturing enterprises. The main results show a clear contrasting picture. On the one hand, businesses face three core barriers: (1) a crisis in the quality and availability of data; (2) a gap in human resource capabilities and an organizational culture that is still heavily reliant on experience and intuition; and (3) the burden of investment costs in a context where benefits are not clearly proven. On the other hand, change is driven by game-changing factors, including: (1) survival pressure from market competition; (2) the decisive role of visionary and determined leaders; and (3) the persuasive power of initial successful pilot projects.

6.2. Practical Implications

From these findings, the study proposes several important practical implications.

- For enterprises: Instead of pursuing large-scale and high-risk transformation projects, a step-by-step approach is recommended. Businesses should start with small, clearly defined problems to prove efficiency quickly. These "small wins" will serve as a solid foundation for building trust within the organization and justifying more strategic, long-term investments in people and data infrastructure.
- For educational institutions: The study reveals a significant gap between trained competencies and practical requirements. Universities and research institutes need to increase the use of real-world case studies and promote deep collaboration programs with businesses. Furthermore, the curriculum should not only focus on model-building skills but also equip students in Mathematical Economics and related fields with essential "soft skills" such as interpreting, visualizing, and presenting data, helping them become effective bridges between technical analysis and business decisions.

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