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SỬ DỤNG PHƯƠNG PHÁP ISM ĐÁNH GIÁ CÁC RÀO CẢN KHI ỨNG DỤNG IOT VÀO QUẢN LÝ KHO TRONG NGÀNH FMCG TẠI VIỆT NAM

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Tóm tắt

Việc triển khai công nghệ IoT trong quản lý kho hàng có tiềm năng cách mạng hóa ngành FMCG tại Việt Nam nhưng hiện đối mặt với nhiều rào cản. Bài nghiên cứu này có mục tiêu xác định, phân tích mối quan hệ giữa các rào cản và đề xuất giải pháp khắc phục. Từ phân tích nghiên cứu trước đó và khảo sát ý kiến chuyên gia, tám rào cản chính được xác định. Kết quả từ mô hình ISM cho thấy "sự hỗ trợ từ lãnh đạo cấp cao" và "chính sách, quy định" là những rào cản dễ giải quyết. Trong khi đó, "thiếu nhân lực chuyên môn", "vấn đề về hạ tầng công nghệ thông tin" và "vấn đề dữ liệu" là các rào cản "phụ thuộc", chịu tác động từ yếu tố khác và có ảnh hưởng không đáng kể. Ngược lại, các rào cản "độc lập" gồm "chi phí IoT" và "nhận thức về lợi ích của IoT" có ảnh hưởng lớn, quyết định sự thành công của việc ứng dụng IoT trong kho FMCG. Nghiên cứu này cũng đề xuất các giải pháp để khắc phục các rào cản này, đồng thời cung cấp nền tảng cho các nghiên cứu sâu hơn, hỗ trợ nhà quản lý kho, nhà cung cấp IoT và chính phủ trong việc ứng dụng công nghệ vào quản lý kho hàng FMCG.

Từ khóa: ứng dụng công nghệ IoT, rào cản, quản lý kho hàng, hàng tiêu dùng nhanh, Việt Nam

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ISM APPROACH FOR BARRIERS OF IOT APPLICATION TO WAREHOUSE MANAGEMENT IN THE FMCG INDUSTRY IN VIETNAM

Abstract

The implementation of IoT technology in warehouse management has the potential to revolutionize the FMCG sector in Vietnam, but currently faces numerous barriers. This study aims to identify these barriers, analyze their relationships, and propose actionable solutions. Based on prior research and expert opinions, eight key barriers have been identified. The ISM model is also applied and reveals that "top management support" and "policies and regulations" are relatively easy to address. However, "lack of skilled personnel", "IT infrastructure issues", and "data issues" are considered "dependent barriers", strongly influenced by other factors yet having minimal impact on them. In contrast, "independent barriers", including "IoT costs" and "awareness of IoT benefits", have a considerable impact on other barriers. This study also suggests strategic solutions to overcome these barriers for warehouse managers, IoT service providers, and policymakers, enabling them to successfully apply technology to warehouse management in the FMCG sector.

Key words: IoT adoption, barriers, FMCG, warehouse management, Vietnam

1. Introduction

The rapid growth of Vietnam's Fast-Moving Consumer Goods (FMCG) sector, fueled by a booming warehousing industry and increasing demand for cold storage solutions, necessitates the adoption of efficient warehouse management strategies to meet evolving market demands and maintain a competitive edge (EMR, 2024). According to Giulia Interesse (2024), this market is a significant source of revenue for both the government and private businesses operating within the country. The FMCG sector contributes to economic activity through the production, distribution, sale, and advertising of a wide array of products (Ruth Stanat, 2024). As reported by Source of Asia (2021), the warehousing industry in Vietnam is experiencing remarkable growth, characterized by an 80% occupancy rate and a Compound Annual Growth Rate (CAGR) of 11.2%. In this context, effective warehouse management within the FMCG sector is essential for adapting to the rapidly evolving market demands.

This sector is characterized by high demand, short product life cycles, and intense competition, demanding efficient and agile warehouse management systems (Elsherbiny, 2023). Traditional manual processes often struggle to keep pace with these demands, often struggling with issues like inefficiencies, increased costs, and reduced customer satisfaction (Kamali, 2019). The advent of the Internet of Things (IoT) presents a transformative opportunity to address these challenges and enhance warehouse management in the FMCG industry. It emerges as a game-changer, offering real-time data capture, automation, and enhanced visibility throughout the supply chain, (Nicole Dyess, 2018). The adoption of IoT in

FMCG warehouse management in Vietnam is gaining momentum, with companies realizing its potential to optimize operations and gain a competitive edge (Nguyen, 2024). For instance, a report by Statista (2024) found that the IoT market in Vietnam is anticipated to follow a consistent growth path. Specifically, it is projected to achieve an annual growth rate (CAGR) of 13.07% from 2025 to 2029, with revenues expected to reach approximately US$5,117 million by 2029. This upward trend underscores the growing implementation of IoT solutions across various sectors in Vietnam, including FMCG.

However, despite the clear benefits, the widespread adoption of IoT in FMCG warehouses in Vietnam faces several barriers. This gap is attributed to a multitude of barriers, including cost, a lack of technical expertise, and concerns about data security.

This report focuses on the ISM (Interpretive Structural Modeling) approach to identify and analyze the barriers that hinder the effective implementation of IoT applications in FMCG warehouse management in Vietnam. Interpretive Structural Modeling (ISM) methodology is a methodological approach used to identify and analyze the relationships among various elements within a particular field through expert knowledge (Shalamzari, 2023). The study will identify and define these key barriers, analyze their interrelationships to establish a hierarchical structure that reveals their dependencies and influence on each other, and ultimately develop a framework for prioritizing and addressing these barriers. This framework will provide actionable recommendations for stakeholders, enabling them to overcome challenges and facilitate the successful adoption of IoT in FMCG warehouse management in Vietnam.

Research Questions

1. What are the specific barriers hindering the adoption of IoT in FMCG warehouse management in Vietnam?

2. How do the identified barriers interact and influence each other? Which barriers are considered more critical and have a greater impact on overall adoption?

3. What specific recommendations to overcome the identified barriers and promote the adoption of IoT in FMCG warehouse management in Vietnam?

The paper is structured as follows: Chapter 2 presents a literature review highlighting the research gap; Chapter 3 outlines the research methodology, including the Interpretive Structural Modeling (ISM) approach and expert interviews; Chapter 4 presents the results of the ISM analysis and discussions; Chapter 5 concludes the paper, summarizing the key findings, implications and outlining limitations and future research directions.

2. Literature Review

2.1. Overview

The Internet of Things (IoT) has become an essential component of contemporary society, with its presence expanding across various domains of daily life. IoT is defined as a networked infrastructure that facilitates the interconnection of physical objects with the Internet through standardized communication protocols and information-sensing technologies (Alem Čolaković, Mesud Hadžialić, 2018). This interconnected system enables seamless data exchange and communication, thereby supporting advanced functionalities such as intelligent recognition, real-time positioning, tracking, monitoring, and automated administration. The IoT application covers “smart” environments/spaces in domains such as: Transportation, Building, City, Lifestyle, Retail, Agriculture, Factory, Supply chain, Emergency, Healthcare, User interaction, Culture and tourism, Environment and Energy (Keyur K Patel, 2016). Furthermore, IoT is conceptualized as a framework in which all entities possess a digital representation and maintain a presence within the Internet ecosystem. More specifically, IoT aims to facilitate the integration of the physical and virtual worlds by enabling innovative applications and services. At the core of this technological paradigm lies Machine-to-Machine (M2M) communication, which establishes the foundational mechanism for interactions between interconnected devices and cloud-based applications, thereby enhancing system interoperability and automation (Radouan Ait Mouha, 2021).

The fast-moving consumer goods (FMCG) sector faces significant supply chain management challenges, including fluctuating consumer demands, complex inventory management, and the need for rapid delivery (Adekunle Toromade, et al, 2024). The integration of Internet of Things (IoT) and cloud computing offers a solution by enabling real-time data collection, analysis, and decision-making (Adekunle Toromade, et al, 2024). IoT devices facilitate continuous monitoring of goods, providing insights into inventory, product conditions, and consumer behavior, while cloud computing offers scalable storage and processing power for the vast amounts of data generated1. IoT involves a network of interconnected devices that communicate and exchange data, allowing organizations to gain insights and make informed decisions based on real-time information (Reza Tavakkoli-Moghaddam, 2022). These devices, ranging from simple sensors to advanced analytics platforms, collect, transmit, and process data without human intervention (Adekunle Toromade, et al, 2024). By embedding IoT technology throughout the supply chain, companies achieve greater visibility and control over their operations, leading to improved efficiency and reduced costs (Adekunle Toromade, et al, 2024).

In the field of Warehouse Management, the adoption of the Internet of Things (IoT) is increasingly being recognized and explored for its potential applications. The integration of IoT into Warehouse Management systems is transforming operational processes by enhancing efficiency, accuracy, and overall productivity (Mohamed Abomhara and Geir M. Køien, 2015). Through the interconnection of various devices and sensors with the Internet, warehouses can facilitate real-time data acquisition and automation, resulting in substantial improvements in inventory management and logistics operations (Yasaman Mashayekhy, 2022). Despite the numerous advantages associated with IoT implementation in warehouse management, organizations may encounter several challenges in its adoption. Key concerns include issues related to data privacy, security, and system safety, as the extensive network of interconnected devices generates vast amounts of data, increasing the risk of cyber threats and potential system vulnerabilities. The susceptibility of IoT-enabled warehouse systems to hacking and unauthorized access underscores the necessity for robust security measures and comprehensive risk management strategies to ensure the integrity and resilience of such technological frameworks (Walaa Hamdy, Noha Mostafa, Hesham Alawady, 2020).

2.2 Research Gap

The literature review table is conducted with a systematic approach. By identifying the key words in the research topic and objectives, including “IoT adoption”, “barriers”, “warehouse management”, the group of authors then focused on the specific context of Vietnam’s FMCG sector. Publications from credible sources and academic databases namely Science Direct, Research Gate, Emerald Insight, industry reports and international journals were collected and refined by using targeted keywords. The time frame of all references dates back no further than seven years to maintain credibility and ensure the information is current. Two main categories are identified to provide structural findings from a broad perspective of barriers in implementing IoT in the Supply Chain to a smaller scale in warehouse management.

Table 1. Previous Research Review

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
1	Barriers of implementing IoT in Supply Chain	Tharaka de Vass, Himanshu Shee, Shah Miah (2, 2021)		Qualitative method (interviews approach)	Socio-technical factors challenge the proliferation of IoT in SC operations	Australia	The analysis is not in-depth because the research topic is quite broad. Barriers to using IoT have not been systematically and thoroughly evaluated or properly prioritized
2		Reza Tavakkoli-Moghaddam , Javid Ghahremani-Nahr, Paria Samadi Parviznejad, Hamed Nozari, Esmaeil Najafi (2022)		A review study	Internet technology allows the FSC to use dynamic permutation in operations management processes	Iran	Only point out the essential role of IoT in Supply Chain

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
3	Barriers of implementing IoT in Supply Chain	Kazrin Ahmad, Md. Saiful Islam, Md. Abrar Jahin, M. F. Mridha (12, 2024)	Qualitative method (ISM-MICMAC and DEMATEL approach)		13 barriers of applying IoT in CSC and identify 3 mains challenges	International	Analyzing the relationship between factors is not clear and assessing the level of importance is not really applicable because there are other factors such as size of firm
4		Amarachi Queen Olufemi-Phillips, Onyeka Chrisanctus Ofodile, Adekunle Stephen Toromade, Nsisong Louis Eyo-Udo, & Titilope Tosin Adewale (11, 2024)	Qualitative method		The vital role of IoT in optimizing FMCG Supply Chain Management and some challenges when applying	The US	Lack of deep analysis while challenge factors are listed separately

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
5	Barriers of implementing IoT in Supply Chain	Ifadhila Affia, Luh Putu Eka Yani, Ammar Aamer (2019)		Systematic Literature Review (SLR)	Point out 9 barriers of applying IoT in Supply Chain	International	Analyze each barrier separately and do not show the connection among them
6		Vaibhav S. Narwane, Angappa Gunasekaran, Bhaskar B. Gardas (2022)		DEMATEL methodology	Point out causal relationship among some groups of factors in 24 challenges total	India	Groups of similar or mutually influencing factors have not been grouped
7		S. Khan, R. Singh, S. Khan et al (2023)		The fuzzy Delphi method	12 barriers ranging from operational level to policy level		Discrete analysis. Only identify the barriers of IoT adoption and not analyse the strength of their intensity or interrelationship

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
8	Barriers of implementing IoT in Warehouse Management	Aldona Jarasuniene, Kristina Čižiūnienė and Audrius Čereška (Feb, 2023)	Qualitative empirical research approach		IoT has positive impacts on the management of warehouses of all sizes; Present some challenges including data security breach, data privacy, and data management	International	Simply stating pros and cons, lacking in-depth evaluation of factors as well as the relationship or importance of each challenge
9		K. Aravindaraj, P. Rajan Chinna (2022)	Systematic Literature Review (SLR)		Various issues and challenges were presented	International	There is a lack of assessment of the relationship between factors and there is no clear ranking

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
10	Barriers of implementing IoT in Warehouse Management	Mohammad Kamrul Hasan, Ma Junjie, A. K. M. Ahasan Habib, Abdullah Al Mamun, Taher M. Ghazal, Rashid Saeed (October, 2022)		Increment Development	IoT plays an important role in warehouse management while providing a warehouse design that applies IoT technologies	The US	The difficulties in applying IoT to warehouse management have not been assessed
11		Hui Zhou (2024)		Qualitative method	Simply evaluating the importance of IoT in warehouse management without providing specific barriers when applying	China	The barrier factors of applying IoT in warehouse management have not been specifically pointed out

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
12	Barriers of implementing IoT in Warehouse Management	Sara Perotti, Roman Felipe Bastidas Santacruz, Peik Bremer and Jakob Emanuel Beer (2022)		Systematic Literature Review (SLR)	Examining the relationship among influencing factors, barriers, and benefits of Logistics 4.0 technologies in warehousing contexts	International	Relevant contributions by potentially overlooking works under different labels may have been missed
13		Liu, X., Cao, J., Yang, Y., & Jiang, S. (2018)		Qualitative	Analysing 4 issues when applying CPS (cyber-physical system) techniques and challenging issues in smart warehouses	International	The study focuses on technology in smart warehouses, potentially overlooking organizational and human factors

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
14	Barriers of implementing IoT in Warehouse Management	Marteen van Geest, M., Tekinerdogan, B., & Catal, C. (2022)		Qualitative method	Identifying that the key subdomains and challenges where smart warehouse technology has been adopted	International	The study limits itself to configurations with selected parameters on capacity and location
15		Fernández-Caramés, T.M.; Blanco-Novoa, Ó.; Suárez-Albela, M.; Fraga-Lamas, P. (2019)		Qualitative empirical research approach	Proposing and implementing a UAV-based architecture for cybersecurity, evaluating decentralized database performance in warehouse	International	The paper does not thoroughly address how the system would perform under varying scales of operation

NO.	CATEGORY	AUTHORS	YEAR OF PUBLICATION	METHODOLOGY	OUTCOME/FINDINGS	COUNTRY	LIMITATIONS
16	Barriers of implementing IoT in Warehouse Management	Ud Din, F., Paul, D., Ryan, J., Henskens, F., & Wallis, M. (2021)		Qualitative method	Analysing AOSR 2.0, an agent-based storage planner optimizing warehouse management system for SMEs	International	The focus on technology may overlook other factors influencing warehouse efficiency, such as workforce training, organizational culture
17		Fatima, Z., Tanveer, M. H., Waseemullah, Zardari, S., Naz, L. F., Khadim, H., Ahmed, N., & Tahir, M. (2022)		Qualitative method	Underscore the transformative potential of IoT combined with Industry 5.0 to advance automation in warehouse management	International	The study does not extensively address potential challenges and their interrelationships and lack of practical evaluations

Source: Research Authors, 2025

After a comprehensive review of existing papers, our group of authors observed that prior research has predominantly concentrated on the Food Supply Chain domain. Studies related to Warehouse Management have largely underscored the significance of the Internet of Things (IoT); however, they have primarily provided a superficial discussion of the barriers, lacking in-depth analysis or empirical evidence. Moreover, existing research has largely been limited to the mere identification of challenges associated with IoT adoption, without conducting a thorough assessment of their interrelationships or establishing a framework for prioritizing these barriers in the implementation process. Besides, we realized that there are limited papers researched in the Vietnam and Asia area as well.

In light of these gaps, this study aims to investigate the barriers to IoT adoption in Warehouse Management within the FMCG Sector and their relationships in warehouse operations. Furthermore, this paper seeks to identify commonalities among these barriers to streamline the development of targeted solutions, thereby facilitating the decision-making process for firms in overcoming these challenges. In addition, this research is also the mark of the base for future research in the same or related topic.

3. Research Methodology

3.1 Research Framework

The research methodology flows from the research objectives the authors have discussed above. Given that the primary goal is to explore the barriers to IoT adoption in warehouse management within the FMCG sector in Vietnam, research authors have applied a comprehensive and systematic approach to understand the full range of perspectives and factors influencing the process. Figure 2 below shows the research framework used to step-by-step achieve the set purposes.

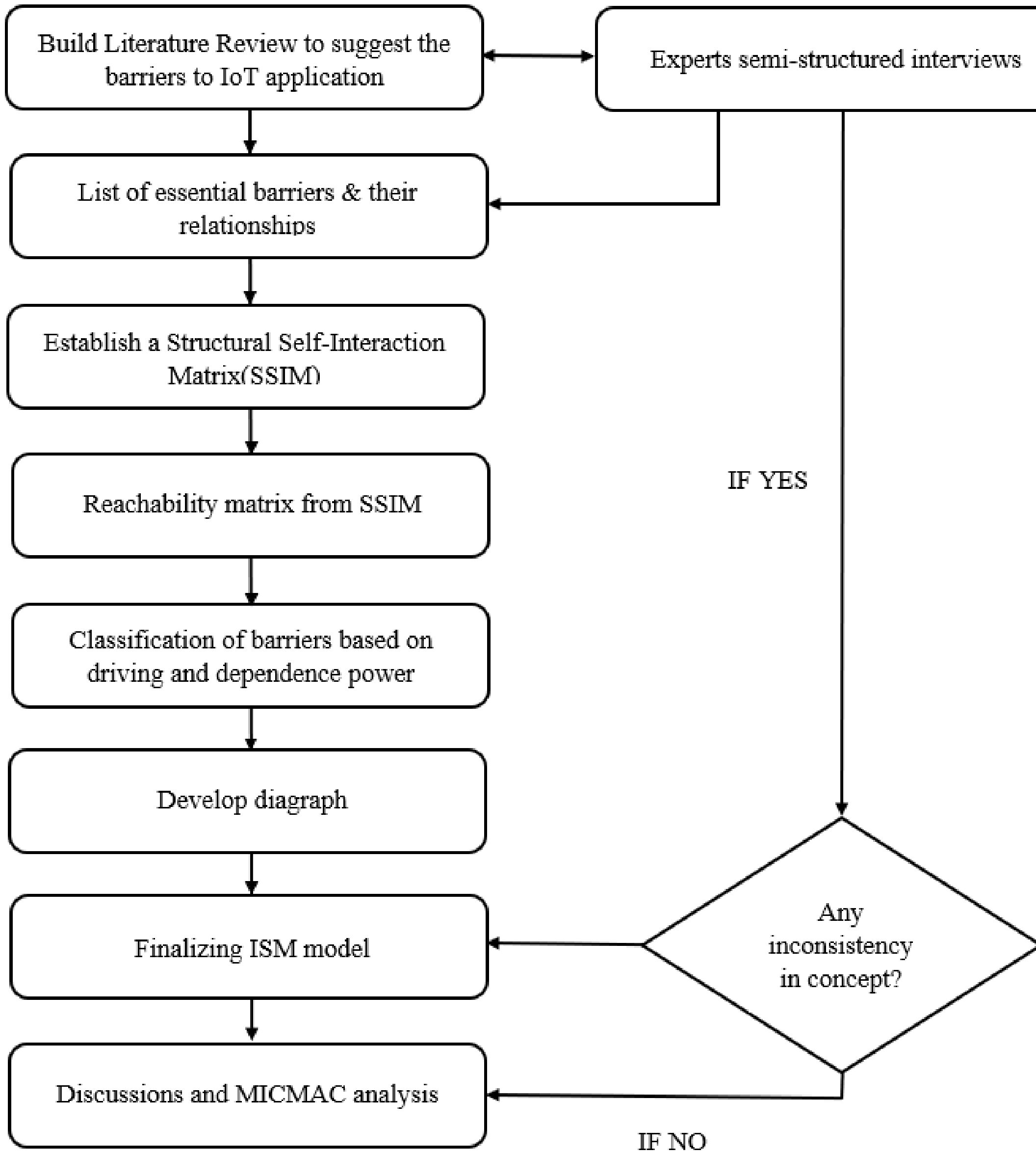

Figure 1. Research Framework

Source: Research Authors, 2025

3.2 Semi-structured Interviews

The objectives of this research were to identify barriers to apply IoT in the FMCG warehouse management in Vietnam and to structure the relationship between these barriers to provide a better understanding for enterprises and investors in the industry, guiding a more effective approach and application of technology in the near future. Since the study was exploratory in nature and little was known about the subject under investigation, it was essential to select qualitative methods because they produce a wealth of detailed data on a small sample (Amaratunga et al., 2002; Hyde, 2000). Six semi-structured interviews were conducted from industrial experts to help obtain the highest reliability and variety, as presented in Table 1. All the interviewees have considerable experience (at least 5 years) of managing the warehouses used for agriculture products and they would be considered the decision-makers for this research.

The research authors analysed data manually by identifying emerging themes from the interviews to identify the barriers to the IoT application. The interviews were transcribed, and the authors carefully analyzed and organized the content into categories. The categories have been cross-checked on group discussions between the authors. Interpretive Structural Modelling (ISM) was employed to construct a visual representation of the identified barriers, highlighting their interrelationships.

Table 2. Summary of expert's information

Expert ID	Current Situation	Working experience
E1	Operations Head	10-15 years
E2	Key Account Manager	5-10 years
E3	Production Manager	5-10 years
E4	Warehouse manager	17 years
E5	Warehouse Manager	5-10 years
E6	Senior Supply Chain Manager	More than 5 years

Source: Research Authors, 2025

3.3 Interpretive Structural Modelling (ISM) approach

Vietnamese FMCG firms have realized the effectiveness and profits from an IoT. But they struggle to identify and remove obstacles to adopting technology to leverage production and cut costs (Ho, et al., 2025). Besides, various cross relationships are existing among these barriers, which may affect the IoT application in the warehouse management of these firms. Thus, the authors employed the Interpretive Structural Modeling (ISM) technique to address these research objectives.

The ISM methodology helps to impose order and direction on the complexity of relationships among elements of a system. It is interpretive because judgement of the group decides; whether and how the variables are related. It is structural because an overall structural relationship among the factors is extracted from the complex set of variables (Mandal and Deshmukh, 1994). According to Attri et al. (2013), various steps involved in the ISM method are extracted as follows:

Step 1: Structural Self-Interactive Matrix (SSIM). Using expert opinion, the relationship (V, A, X and O) that exists among the variables are obtained in the form of a matrix and this matrix is known as SSIM matrix.

Step 2: Initial Reachability Matrix (IRM). The expert opinion (V, A, X and O) of the SSIM matrix is transformed into binary numbers (1s and 0s) in this step. Then it is reviewed for transitivity (1*) between variables.

Step 3: Final Reachability Matrix (FRM). This matrix comprises of necessary transitivity links which was reviewed in the initial reachability matrix.

Step 4: Level Partitions. The final reachability matrix is computed into reachability set, antecedent set and interaction of this set was derived as interaction set. Hierarchical level of each factors is obtained by repeating this iterative process.

Step 5: Digraph From level partition, each factor level is obtained, and digraph was drawn with transitive links. After eliminating indirect link, final digraph was obtained.

Step 6: ISM model.

3.4. Matrics d'Impacts Croises-Multiplication Applique a Classement (MICMAC) Analysis

In line with our research objective, Matrics d'Impacts Croises-Multiplication Applique a Classement (MICMAC) was used to cluster the barriers - basically cross-impact matrix multiplication applied for the purpose of classification. MICMAC analysis is done on the basis of obtained driving and dependence powers. With MICMAC analysis, barriers can be categorized into four parts i.e. linkage, autonomous, independent and dependent barriers. (Sohani, et al., 2012)

Each barrier can then be plotted on a two-dimensional graph having Dependence Power and Driving Power as the X and Y coordinates respectively; they can then correspond to one of the four quadrants (clusters) (Kumar et al., 2021; Rathore et al., 2022):

(1) Autonomous (Quadrant I) – Barriers in this quadrant have weak driving power and weak dependence power.

(2) Dependent (Quadrant II) – Barriers in this quadrant have weak driving power but strong dependence power.

(3) Linkage (Quadrant III) – Barriers in this quadrant have strong driving and dependence power.

(4) Driver or Independent (Quadrant IV) – Barriers in this quadrant have strong driving power but weak dependence power.

4. Results

4.1 Identifying Essential Barriers of IoT Application in FMCG Warehouse Management In Vietnam

The adoption of IoT in FMCG warehouse management in Vietnam faces several critical barriers that hinder its implementation and effectiveness. Each playing a significant role in shaping the success of IoT integration. With the support of experts, the research group has finally chosen appropriate barriers and below is a detailed overview of the essential barriers identified, along with their descriptions and supporting references. This analysis aims to provide a comprehensive understanding of the challenges and their implications for IoT adoption in the FMCG sector

Table 3. List of essential barriers of IoT application to FMCG warehouse management in Vietnam

No.	Barriers	ID	Description	Sources
1	IoT Cost	IC	Despite good performance on return on assets, inventory turnover, and reduced labor cost, there are financial issues of IoT adoption associated with implementation, maintenance, skilled labour force, facilities, and vulnerability. Main obstacles identified were high cost of installation, data privacy issues, and training a skilled workforce.	Jarašūnienė, A., et al. (2023) Kamali, A. (2019) Ahmad K., et al. (2024)
2	Top management support	TMS	The support of top-level managers stemming from understanding the benefits and encouraging management information systems in IoT adoption by setting the company's strategy to focus on digitalization, overcome internal challenges and create momentum for the company. Yet the level of support in Vietnamese firms or warehouses is still low.	Nguyen, D.H., et al. (2024) Gupta, S. (2018).
3	Policy/Regulation	P&R	Organizational policies and regulations strongly influence technology adoption. Large firms with abundant financial resources and skilled labor adopt IoT more easily, but all companies need efficient processes for speed, accuracy, and effectiveness in new initiatives.	Nguyen, D.H., et al. (2024)

No.	Barriers	ID	Description	Sources
4	Lack of skilled and awareness personnel	LAS	The adoption of IoT requires relatable technological skills to enhance operational efficiency and accuracy, and also high awareness about the potential value of IoT adoption. In this research, the group of authors concentrate on the labor's adaptability and the leader's vision.	Narwane, V.S., et al. (2022) Aravindaraj, K., et al. (2022)
5	IT infrastructure	II	This factor mentions the ability of current infrastructure at firms that enables devices to communicate and exchange data, optimizing various processes. In this research, the scope is limited in warehouse management	Narwane, V.S., et al. (2022) Aravindaraj, K., et al. (2022)
6	Data issues	DI	The potential risks linked to data breaches, cyberattacks, unauthorized access and information leaks, etc, which discourage firms from embracing new technologies. Huge volume of data regarding internal information of goods, warehouse conditions to monitor various climatic conditions, perishability, etc and urgent situations requiring minimal loss of data during transmission for managers.	Kawasaki, T., et al. (2011) Jarašūnienė, A., et al. (2023) Kurnia, S., et al. (2015)
7	Stakeholder pressure	SP	Primary stakeholders, which can influence organizational goals to create value include supply chain partners (suppliers and customers), competitors, shareholders, the government, creditors, and employees. In the digital era, primary stakeholders have become increasingly empowered to implicitly or explicitly exert pressure on organizations to call for IoT application.	Kamal, M., et al. (2011) Y, J., et al. (2024)

No.	Barriers	ID	Description	Sources
8	Perceived IoT benefits	PIB	The adoption of IoT is related to the attributes of the innovations as perceived by potential adopters. Five attributes, including relative advantage, compatibility, complexity, observability, and trialability are suggested.	Kuan, et al. (2001) Saunders, C.S., et al. (1992)

Source: Research Authors, 2025

4.2 Developing Structural Self-Interaction Matrix (SSIM)

Based on the perspectives of the experts, the research group clarified the contextual relationships among the eight barriers. The experts identified these relationships as "Bi influences Bj." As a result, a Structural Self-Interaction Matrix (SSIM) was created for all eight proposed barriers related to the implementation of IoT in FMCG warehouse management in Vietnam. The matrix uses four symbols - V, A, X, and O - to represent different types of relationships, which are explained as follows: V: Barrier *i* influences barrier *j*;

- A: Barrier *j* influences barrier *i*;
- X: Barriers *i* and *j* influence each other;
- O: Barriers *i* and *j* have no relationship;
- *i* and *j*: Barriers in row and column, respectively.

Here, **i** and **j** refer to the barriers represented by the respective rows and columns in the matrix

Table 4. Structural self-interaction matrix (SSIM)

i	*j* **Barriers**	**B2** **TMS**	**B3** **P&R**	**B4** **LSA**	**B5** **II**	**B6** **DI**	**B7** **SP**	**B8** **PIB**
B1	IC	V	O	V	V	V	V	O
B2	TMS		O	V	V	V	A	A
B3	P&R			V	O	V	A	O
B4	LSA				O	V	O	O
B5	II					X	O	A
B6	DI						O	O

i	*j* Barriers	B2 TMS	B3 P&R	B4 LSA	B5 II	B6 DI	B7 SP	B8 PIB
B7	SP							A

Source: Research Authors, 2025

4.3. Establishing Reachability Matrix

The binary matrix would be considered in this stage, which has transformed from the SSIM (see Table 5).

Table 5. Initial reachability matrix

i	*j* Barriers	B1 IC	B2 TMS	B3 P&R	B4 LSA	B5 II	B6 DI	B7 SP	B8 PIB
B1	IC	1	1	0	1	1	1	1	0
B2	TMS	0	1	0	1	1	1	0	0
B3	P&R	0	0	1	1	0	1	0	0
B4	LSA	0	0	0	1	0	1	0	0
B5	II	1	0	0	0	1	1	0	0
B6	DI	0	0	0	0	1	1	0	0
B7	SP	0	1	0	0	0	0	1	0
B8	PIB	0	1	0	0	1	0	1	1

Source: Research Authors, 2025

In the initial reachability matrix (IRM), the four symbols (V, A, X, O) representing relationships determined by the ISM technique are converted into binary values "1" and "0" according to these rules:

- If the SSIM displays a "V" for the relationship between elements i and j (D(i, j)), then the IRM will have D(i, j) = 1 and D(j, i) = 0.
- If the SSIM displays an "A" for D(i, j), the IRM will have D(i, j) = 0 and D(j, i) = 1.
- If the SSIM displays an "X" D(i, j) translates to D(i, j) = 1 and D(j, i) = 1 in the IRM.
- If the SSIM displays an "O" for D(i, j), the IRM will have D(i, j) = 0 and D(j, i) = 0.

However, given the interconnected nature of IoT application barriers within FMCG warehouses in Vietnam, the transitivity integration phase becomes important for obtaining the final reachability matrix (FRM). The entries marked as "1*" in Table … indicate transitive relationships between these barriers. Furthermore, two key indicators, "driving power" and "dependence power," can be calculated. These are determined by summing the values in each barrier's row and column, respectively, including the entry for the barrier itself.

Table 6. Final reachability matrix

	j	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	
i	**Barriers**	**IC**	**TMS**	**P&R**	**LSA**	**II**	**DI**	**SP**	**PIB**	**Driving Power**
B1	IC	1	1	1*	1	1	1*	1	0	**7**
B2	TMS	0	1	0	1	1	1	0	0	**4**
B3	P&R	0	0	1	1	0	1	0	0	**3**
B4	LSA	0	0	0	1	0	1	0	0	**2**
B5	II	0	1*	0	0	1	1	0	0	**4**
B6	DI	0	0	0	0	1	1	0	0	**3**
B7	SP	0	1	0	1*	1*	1*	1	0	**5**
B8	PIB	0	1	1*	1*	1	1*	1	1	**7**
Dependence Power		**1**	**4**	**2**	**5**	**6**	**8**	**2**	**1**	**32/32**

Source: Research Authors, 2025

4.4 Partitioning of Reachability Matrix

The research team conducted level partitioning using the final reachability matrix (FRM) to identify the intersection of the reachability and antecedent sets for eight barriers related to IoT application in FMCG warehouse management in Vietnam. According to the ISM methodology, the reachability set for a barrier includes the barrier itself and all other barriers it directly or indirectly influences (represented by its row in the FRM). Conversely, the antecedent set comprises the barrier itself and all other barriers that directly or indirectly influence it (represented by its column) (Menon, 2021). By comparing these two sets for each of the eight barriers, the intersection sets were determined. Furthermore, the ISM model dictates that barriers with identical "reachability and intersection set" values are grouped into the same level, thus defining the stratification of the model. As a result, the final level partitioning (FLP) process yielded five iterations, categorizing all eight selected barriers into five distinct levels.

Table 7. Partitioning of reachability matrix

No	Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
B1	IC	1	1	1	1
B2	BM	2	1, 2, 5, 7, 8	2	4
B3	P&R	3	1, 3, 8	3	3
B4	LSA	4	1, 2, 3, 4, 7, 8	4	4
B5	II	5, 6	1, 2, 5, 6, 7, 8	1, 5, 6	4
B6	DI	5, 6	1, 2, 3, 4, 5, 6, 7, 8	5, 6	5
B7	SP	7	7, 8	7	2
B8	PIB	8	8	8	1

Source: Research Authors, 2025

4.5 Finalizing ISM Model

The interconnectedness of various obstacles hindering the adoption of IoT in FMCG warehouse management in Vietnam is visually represented in the following chart. By developing the final ISM model from the final reachability matrix (FRM), the research team has illustrated the relationships among these barriers. Directional arrows within the model indicate the nature of the influence between barriers *i* and *j* across different hierarchical levels.

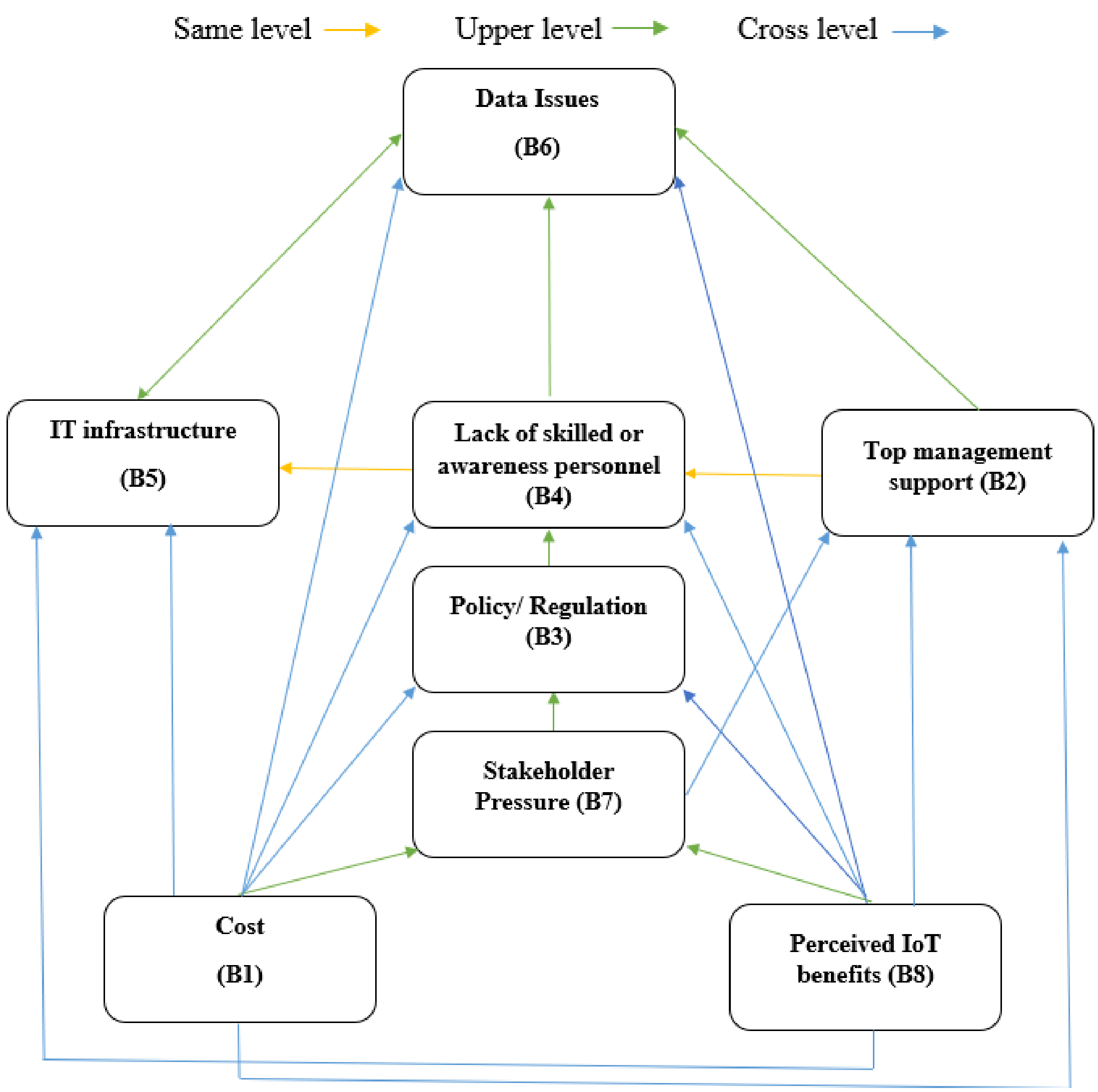

Figure 2. The ISM model of barriers of IoT application in FMCG warehouse management in Vietnam

Source: Research Authors, 2025

Following the results of the FLP stage, eight barriers of IoT application in FMCG warehouse management in Vietnam have been classified into five levels and arranged from the lowest to the highest level, respectively. At the lowest level are two barriers: IoT Cost (IC) and Perceived IoT benefits (PIB). It shows that these two barriers (IC and PIB) drive all other obstacles in this regard. However, there is no correlation between them. The fourth level is Stake Pressure (SP) and the third level is Policy/Regulation (P&R) barrier. At the second level, three barriers are IT Infrastructure (II), Lack of Skilled and Awareness Personnel (LSA) and Top Management Support (TMS). Notably, in this line, TMS both affects LSA and II. All the barriers in the second level link to the barrier in the first level - Data Issues (DI).

4.6 MICMAC Analysis and Discussion

In the case of the Vietnamese FMCG warehouse management, the research group has successfully identified eight obstacles, which are the most significant challenges that the firms should remove to successfully apply IoT in their warehouse effectively. However, the difference in the warehouse's capacity and the cross relationships among barriers are the reasons for the confusion of firms to implement. Therefore, based on the two important values as "driving power" and "dependence power" from the FRM, the research group conducted the MICMAC analysis, which indicates the necessity of each challenge and also clarifies which barriers to prioritize. Consequently, all eight barriers are divided into four separate areas on the diagram.

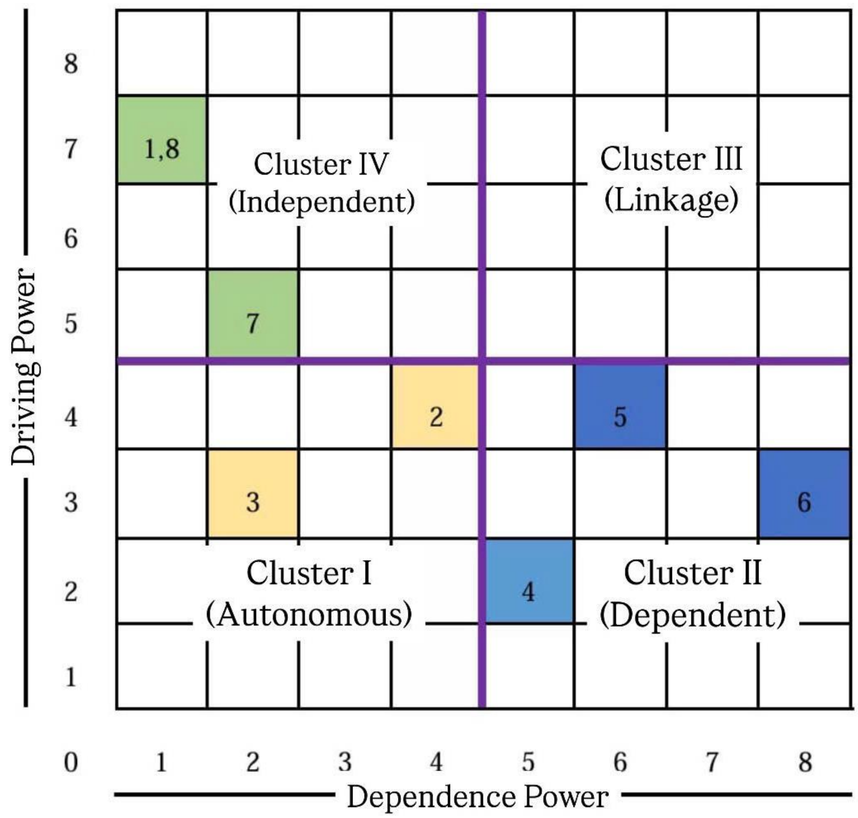

Figure 3. Diagram of driving power and dependence power of barriers

Source: Research Authors, 2025

In terms of the "autonomous" quadrant, this cluster consists of the barriers which are weak in both driving and dependence power. Two barriers included are: B2 Top Management Support and B3 Policy/Regulation. This group is in the middle of the identifying list for Vietnamese warehouses to be concerned with and is identified as not too hard to remove. However, in contrast, some studies we found have no barriers in the positions of autonomous clusters, which will open a deeper approach of the study in the future. In the category of "dependent" barriers, the research group observed that three variables: B4 Lack of skilled and awareness personnel, B5 IT Infrastructure and B6 Data Issues are gathered in this area. It indicates that having a weak driving power, but having a strong reliance power.

Regarding the "Linkage" cluster, which has been defined as the set of barriers that are strong in both driving power and dependence power. However, the research group found no presence of any obstacles in this quadrant. Finally, the variables considered independent are B7 Stakeholder pressure and the highest point of the map has realized two obstacles: B1 IoT Cost and B8 Perceived IoT benefits. This area describes the variables which have the most fabulous driving while lowest influencing power to others. Thus, the Vietnamese FMCG warehouses must overcome these challenges before addressing others.

5. Recommendations

This study, utilizing the ISM methodology, pinpointed cost and perceived risk as the primary obstacles hindering the adoption of IoT in warehouse management within the FMCG industry in Vietnam. These findings underscore the need for targeted solutions for businesses in the field to address these specific concerns. Research and consultations with the experts has yielded several actionable recommendations.

To confront the cost barrier, the research recommends implementing a Warehouse Management System (WMS) in conjunction with handheld devices. This combination can significantly enhance operational efficiency and reduce costs associated with manual processes. To alleviate the financial burden and encourage investment, the authors suggest offering deferred payment options and free trial periods for IoT solutions. Policymakers in the FMCG industry can further incentivize adoption by considering tax breaks or subsidies for businesses implementing IoT technologies in their warehouses.

Managing the perceived risk barrier requires a multi-pronged approach. Knowledge sharing workshops and training programs can empower businesses to understand the benefits and overcome the perceived risks associated with IoT adoption. The research group would like to emphasise the importance of facilitating collaboration and knowledge exchange among stakeholders to address specific concerns and build confidence in IoT technologies.

By addressing these key barriers through a combination of technological solutions, financial incentives, and knowledge sharing initiatives, the authors believe that a wider adoption of IoT in the FMCG industry in Vietnam can be achieved.

6. Conclusion

In this research, the barriers in IoT adoption in warehouse management in Vietnam have been investigated to identify the interrelationship between them and have their influences assessed. By initially analysing former papers and literature, eight impassable challenges in implementing IoT were identified including cost, management support, policies, lack of skilled and aware personnel, data issues, IT infrastructure, stakeholder pressure and perception of IoT benefits. These factors were also validated by experts in the field to adapt with Vietnamese warehouse management. Afterwards, the research highlights the influences of different barriers on each other using the ISM approach. Additionally, a cause-effect diagram was generated to demonstrate the connection between these factors.

From the results and discussions of the ISM approach, it is evident that all eight barriers are interdependent whether directly or indirectly, with some barriers having more impacts than others. The Autonomous quadrant highlights barriers like Top Management Support and Policy/Regulation, which are not too difficult to overcome. The "dependent" barriers, including a lack of skilled personnel, IT infrastructure issues, and data challenges, are weak in driving power but highly dependent on other factors. The "independent" barriers, such as IoT costs and perceived benefits, are identified as having high driving power but low influence on other variables. Addressing these barriers, especially in the independent category, is crucial for Vietnamese FMCG warehouses to make progress in IoT implementation.

By understanding the interdependencies of these barriers, researchers as well as stakeholders or company managers can utilize the results for further research as well as advancement in policy-making, novel strategies or models regarding the implementation of IoT technologies in FMCG warehouses. In addition, a targeted approach in investment decisions and technology development can also be taken to pave the way for a more digitized, efficient and competitive FMCG sector in Vietnam. Moreover, this research also wants to encourage more papers to be published in Vietnam as well as Asia in the future.

7. Limitations and Future Improvement

There are two major limitations in this study that could be addressed in future research. First, it is focused on the reference resource issues. Second, it is related to the survey process.

First of all, the group of authors would like to mention the issue of reference sources. Throughout the research process, it is seen that there is a scarcity of relevant reference materials within the investigated field. Currently, the authors mainly rely on online reference sources and there is a notable deficiency of offline references. In addition, several sources referenced in the study have been outdated and lack practical applicability. Some of the sources the group referenced were not complete because they had not yet had time to request copyright from the author. In this situation, if there is an opportunity to improve, the group will spend more time to be able to dig deeper into online research and access offline sources from experts in the industry.

Next, during the survey phase, the group encountered some difficulties related to contact and communication due to the experts' busy schedules. Had there been an extended timeframe, the research team would have had the opportunity to initiate contact with the experts much earlier in the process. This proactive approach would have allowed for timely follow-ups and reminders, thereby increasing the likelihood of securing participation from the experts. Furthermore, with additional time, the team could have arranged for direct surveys, either through in-person meetings or virtual sessions, which would have facilitated more meaningful interactions.

In summary, these are the two primary limitations that share a common characteristic related to temporal constraints. Therefore, in the future, given sufficient time, the group of authors believes that the aforementioned shortcomings will be effectively addressed.

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