Nano World Journal

https://doi.org/10.17756/nwj.2023-s1-007

Research Article

Open Access

Analysis of Barriers in Implementation of IoT in New Product Development Using ISM and DEMATEL Method

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Received: November 24, 2022
Accepted: March 10, 2023
Published: March 12, 2023

Citation: Biswas S, Gupta M, Sahu N. 2023. Analysis of Barriers in Implementation of IoT in New Product Development Using ISM and DEMATEL Method. *NanoWorld J* 9(S1): S29-S33.

Published by United Scientific Group

Abstract

The entire process of bringing a new product to market is known as new product development. It includes a number of phases, from idea generation through commercialization, to bring a new product to market. As a result, this is not a simple task. In this situation, we may use the Internet of Things (IoT) idea to simplify all of these processes and gain greater insights into customer behavior and market performance. The pre-development stages of the new product development (NPD) process, which primarily deal with understanding client needs and creating ideas, have been found to have the most influence. As a result, the front end is where businesses must exert the most effort in order to finish the entire process. However, when we try to analyze this phase, we run into difficulty. It takes time to come up with fresh concepts to meet the needs of customers and to replace an old product with a more marketable alternative. This is a difficult task to complete. As a result, this study demonstrates the areas of NPD that can be enhanced through the use of IoT, as well as the barriers that are preventing IoT implementation in this process. Using ISM methodology, this study analyses the barriers to IoT implementation in NPD, classifies them based on their dependence and driving power, and levels their hierarchy in the Interpretive Structural Modeling (ISM) model. Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach was also used in this work to identify cause-effect components of this complex system.

Keywords

Internet of Things, DEMATEL, New product development, ISM, Barriers

Introduction

Companies nowadays compete not only on cost, but also by distinguishing their products from those of competitors. For organizations, being innovative is a must. Every organization must go through the process of developing new items. According to research, great business performers make a lot of money when they introduce new items. This figure clearly illustrates how effective the new product development process is for businesses. A high-quality NPD process is a crucial factor of corporate success. An important factor of good company performance is process. Many businesses, however, fail to launch new products on the market. For example, a delayed product development process or a failure to identify changing customer needs. As the technology period progresses, a variety of strategies can be used to speed up the development of new products. The Internet, which enhances the information flow among stakeholders, sensors, which offers data, and automation, which reduces production cost and improves efficiency, are all well-known. In this case we can use a new technology IoT to improve the NPD process [1]. IoT makes connection between the physical world and virtual world. Sensors are incorporated in physical devices in the IoT, which are interconnected via wired and wireless networks, often utilizing the same Internet Protocol (IP), which is connected to the Internet. These smart products can generate and share data without the need for considerable human involvement [2]. Many opportunities occur as a result of connecting products, users, and producers via the Internet. The IoT will play an important role in future businesses. The deployment of IoT is not an easy task, as it must overcome numerous obstacles related to data privacy and security. Several actions must be taken in order to integrate IoT into the NPD process. The appropriate stages of the NPD process must be defined, and solutions to overcome the hurdles must be established. Firms perceive NPD and the IoT as potential, but it is unclear how to incorporate them and the barriers which are affecting the implementation of IoT in NPD need to be discussed. So, this study shows the gap between NPD process and implementation of IoT.

In this study, we analyzed the various dimensions of barriers in implementation of IoT in NPD by using ISM and DEMATEL method to fill the previous research gap because it is a challenging task to enter a market while projecting customer behavior and analyzing his purchasing habits for a market-driven product design.

Literature Review

This section contains literature on the new product development process, the use of IoT in new product development, and the various barriers to IoT implementation in this process.

NPD process

There are two categories of new products. The first is a product that the company has never produced or sold before but that has been introduced to the market by another company. The second is a brand-new product that is being offered to the market. They could be wholly new products or upgraded versions of existing products. This process is generally divided into 8 steps which need to be discussed. The idea generation stage is the first step in the product development process. During this stage, the company generates a variety of original ideas from both internal and external sources. Internal idea sources are usually the company's in-house research and development teams, while external sources are things like opponent innovations, client wants, requirements, etc. The next step is to filter this large group of ideas. The main goal of this stage is to concentrate on concepts that align with the company's customer value and financial objectives. Concept development and testing is the third step in the product development process. Good product ideas must be developed into detailed product concepts that are communicated in consumer-friendly ways at this level. In the fourth stage the organization tries to come up with ways to launch a potential product into the market at this stage. After that a thorough business analysis or test is conducted on the product concept in order to determine predicted sales and revenue, as well as assess risk and determine whether the product's production is financially possible. This is the stage that follows when a company's management determines a product concept to be in line with the company's aims and gives it the green light to be produced. The company's research and development department then work on the product concept for months, if not years, to create a working and functional prototype of the product concept. This is the 7 step which entails putting the product and the suggested marketing program through its pace in real-world scenarios. This stage gives the company insight into how the product will be launched to the market, advertised, produced, packed, distributed, and eventually sold to clients, allowing for any necessary optimizations. The process of commercialization is the last step in the product development process. The business management may opt to proceed with the product launch or put it on the backburner based on the information obtained throughout the test marketing phase. The product is finally introduced into the market if the go-ahead is given, and this procedure is known as commercialization.

Implementation of IoT in NPD

The IoT has the capacity to gather data in real time according to instances and experts. Businesses thus receive a constant flow of data that may be analyzed, leading to new insights, suggestions, and connections. Businesses can save time by collecting data immediately rather than conducting focus groups or interviews. The procedure must be successful, and the company must have enough analytics tools. Real-time data allows a business to gather feedback continually throughout the process, enabling the development of new ideas throughout the product's life cycle[3] The linked devices also have the ability to adopt a "fail fast" approach. IoT can therefore identify issues with current products at an early stage. Smart gadgets have the capacity to identify flaws early on [4]. As a consequence, companies may use remote maintenance services to create new and improved products. Remote support can add value to a product and set it apart from rivals. In addition to giving a producta unique identity, IoT influences how long its life cycle is. It's crucial to understand where a product has a bottleneck. Consumer behavior and product usage can offer important information about prospective improvements or even new products[5]. Every product has sensors built in, creating a vast data stream that alerts firms to potential opportunities or obstacles that frequently arise. Since sensor data is informedby actual activities, it is said to be more accurate. This new way of data collecting might be seen as more credible because bias can appear while observing individualsor interviewing focus groups. Screening is essential because "bad" ideas should be eliminated as soon as feasible to avoid incurring costs. The development of smart products may be useful when creating a product concept. Constant communication via smart gadgets might be utilized to obtain input on concepts [6]. For instance, gathering input directly from the device itself or via messaging on smart phone touchscreens. One-way IoT-oriented NPD companies may move away from a generic strategy and toward a creative process for customers is by using unique data provided by a client and his usage pattern. Marketers and advertisers can focus on particular segments of their audience. Marketing teams may create tailored offers that keep clients interested in and thrilled with the product rather of barraging them with the same offer. Lower marketing expenses are the result of core focused, successful marketing campaigns. Due to data-driven insights from connected devices, businesses may know from the beginning of their campaign how and where to position their new product lines on social media and elsewhere to get the best response from the market of customers and prospects.

Barriers in IoT implementation

The parameters for the adoption IoT in NPD were determined using a literature search, published interviews with industry professionals, and industry reports. These dimensions are then evaluated by experts to establish their significance, and they are selected in a way that allows a connection to be created between them.

Research Methodology

This study has used two approaches ISM and DEMATEL. The ISM method was used to find out relationship among the barriers and make the complex system very simple. The DEMATEL method was used to identify the cause-effect relationship among all barriers. ISM reveals interrelationship among factors while DEMATEL gives the ranking of interdependent factors. It lowers the computational burden of complex systems by analyzing hierarchical structure and casual relationships among factors due to the common property of DEMATEL and ISM approach. The explanation of ISM and DEMATEL method are discussed below.

ISM

Using academic research, published interviews, and industry reports to identify impediments, the next step is to determine a link between them. The approach of Interpretive Structural Modeling (ISM) will be applied. The ISM technique transforms data that is poorly articulated into data that is visible and clearly defined.

The steps in the ISM technique are as follows. The variables that the system takes into account are listed.

Step 1: Once the variables have been identified, the contextual link between them and the other pair of variables must be established.

Step 2: Structural Self-Interaction Matrix (SSIM) construction to show pairwise relationships between variables. The matrix is given in the form of V, A,O, X. These symbols were used to determine how the components i and "j" related to one another.

(1) V: Factor i influences j: (Forward relation).

(2) A: Factor j influences factor i. (Backward relation).

(3) X: The interaction between factors I and j (Relation in both directions).

(4) O: Factors I and j don't interact with one another (No relation).

Step 4: Based on the following rule, a reachability matrix is created using the SSIM byinserting V, A, X, and O.

(1) Cells (i,j) in the SSIM are replaced with 1 and cells (j,i) with 0 if cell (i,j) is "V".

(2) Cells (i,j) and (j,i) in the SSIM are replaced by 0 and 1, respectively if cell (i,j) in the SSIM is "A".

(3) If cell (i,j) in the SSIM is "X," cell (i,j) and cell (j,i) are both replaced by 1.

(4) Cells (i,j) and (j,i) in the SSIM are replaced by 0 if cell (i,j) in the SSIM is "O".

The matrix shown in this step has been built using the procedures mentioned.

Step 5: The completed reachability matrix is level-partitioned into several levels.

Step 6: A digraph is drawn, and transitivity linkages are removed following level partitioning. As a result, digraph is transformed into an ISM model as shown in .

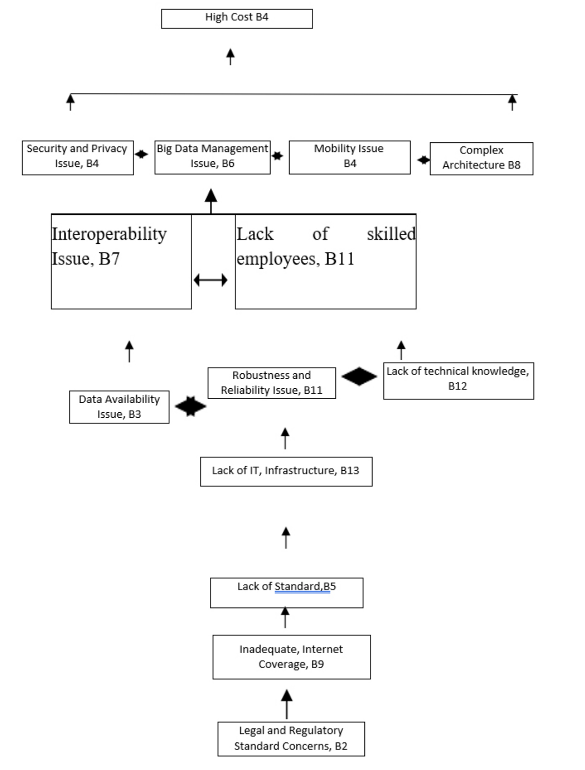

Figure 1: ISM model.

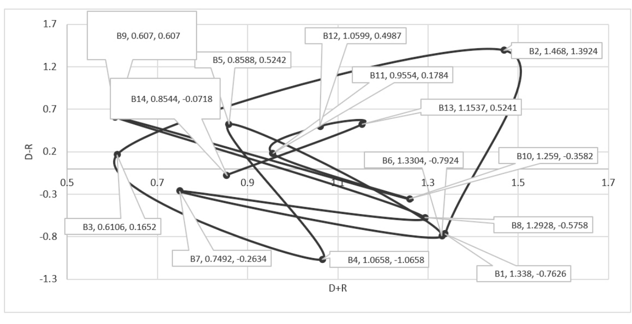

Figure 2: Influential Relationship diagram.

Table 1: Frequency of citation.

Sl. No.	Barriers	Notation	References
1	Security and Privacy Concerns	**B1**	[7, 8]
2	Legal and Regulatory Standard Concerns	**B2**	[8]
3	Data Availability Issue	**B3**	[7]
4	High Cost	**B4**	[8, 9]
5	Lack of Standard	**B5**	[7, 9]
6	Big Data Management Issue	**B6**	[8]
7	Interoperability Issue	**B7**	[9, 10]
8	Mobility Issue	**B8**	[7, 9]
9	Inadequate Internet Coverage	**B9**	[8]
10	Complex Architecture	**B10**	[9]
11	Robustness and Reliability Issue	**B11**	[7, 9]
12	Lack of Knowledge of the Management	**B12**	[7, 8]
13	Lack of IT Infrastructure	**B13**	[7]
14	Lack of Skilled Employees	**B14**	[8, 9]

DEMATEL

The Geneva Research Center of the Battelle Memorial Institute was the first to establish the DEMATEL approach to illustrate the structure of complex causal interactions using matrices or digraphs. The DEMATEL approach determines criteria that require greater attention and simplifies complex problem structures. The following are the steps needed for the DEMATEL technique.

Step 1: After identifying the dimensions, the criteria are compared in pairs to determine the direct relationships between the obstacles.

Step 2: Using a five-point linguistic scale, a Direct Relationship Matrix (DRM), Z is created to show pairwise connections among dimensions.

Table 2: Structural Self-Interaction Matrix.

	B14	**B13**	**B12**	**B11**	**B10**	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**
B1	A	A	A	A	V	A	V	A	A	A	O	A	A	
B2	V	V	A	V	V	V	V	V	V	V	V	V		
B3	V	V	A	O	A	O	V	V	V	V	V			
B4	A	A	A	O	A	A	O	O	A	A				
B5	V	V	A	V	V	A	V	V	V					
B6	A	A	A	A	A	A	A	A						
B7	A	A	A	A	V	A	V							
B8	O	A	X	A	A	A								
B9	O	V	O	V	V									
B10	V	A	X	A										
B11	A	A	A											
B12	V	V												
B13	O													
B14														

Step 3: The Direct Relationship Matrix is used to create a Normalize Matrix (NM), Y.

Step 4: The final Total Relation Matrix (TRM), T is created.

Step 5: After Total Relation Matrix, an Influential Relation Map (IRM) is created to find the cause-and-effect dimensions.

Results

ISM and Fuzzy MICMAC show that legal and regulatory standards and inadequate internet connectivity are crucial factors in the implementation of IoT in new product development because they are independent as they influence all the other factors. Then these factors are then followed by lack of knowledge, robustness and reliability issue, data availability issues, interoperability issues, complex architecture, mobility issues, lack of skilled employees, security, and privacy concerns,

Table 3: Influential Relationship Matrix.

Sl. No.	Notation	D	R	D+R	D-R	Outcome
1	**B1**	0.2877	1.0503	1.338	-0.7626	**Effect**
2	**B2**	1.4302	0.0378	1.468	1.3924	**Cause**
3	**B3**	0.4454	0.2802	0.6106	0.1652	**Cause**
4	**B4**	0	1.0658	1.0658	-1.0658	**Effect**
5	**B5**	0.6915	0.1673	0.8588	0.5242	**Cause**
6	**B6**	0.269	1.0614	1.3304	-0.7924	**Effect**
7	**B7**	0.2429	0.5063	0.7492	-0.2634	**Effect**
8	**B8**	0.3585	0.9343	1.2928	-0.5758	**Effect**
9	**B9**	0.6678	0.0608	0.607	0.607	**Cause**
10	**B10**	0.4504	0.8086	1.259	-0.3582	**Effect**
11	**B11**	0.5669	0.3885	0.9554	0.1784	**Cause**
12	**B12**	0.7793	0.2806	1.0599	0.4987	**Cause**
13	**B13**	0.8389	0.3148	1.1537	0.5241	**Cause**
14	**B14**	0.3913	0.4631	0.8544	-0.0718	**Effect**

which act as a link- age barrier. The last big data management problem is that high costs are dependent barriers, and they are influenced by all the other main barriers. All of these factors contribute to a mismatch between technology and expectations.

The result of DEMATEL also shows that legal and regulatory standards concern has the highest weightage among all the casual factors. Then it is followed by inadequate internet connectivity, lack of standards, lack of IT infrastructure, lack of knowledge, robustness, and reliability issues. In the case of the effect group, high cost has the maximum weightage, which means it is influenced by all the other barriers. It is followed by big data management issues, security and privacy concerns, mobility issues, complex architecture, interoperability issues, and complex architecture.

Discussion

IoT deployment is not a simple process to do. Since IoT generates a significant quantity of real-time data care must be taken to complete it. We must discover client wants and requirements at the pre-development stage of NPD in order to produce fresh concepts. IoT goods generate data depending on their usage patterns, and this data contains client information. It is managed by the business, and if there is any data leakage, it may raise ethical concerns. Companies must also inform customers of the type of data they are storing through communication. Companies must make sure there are no security or privacy concerns, and that no unauthorized individuals can access the information. In this situation, businesses must gain the client's confidence before they may collect information in the form of data. The consumer won't consent to share the data with the company if it has a poor reputation in the market. Therefore, implementing IoT offers many benefits for achieving a company's goals for revenue, growth, and customer pleasure, but it has also conquered certain obstacles, which is also a major problem.

Acknowledgments

We would like to express our deepest appreciation and thank for guiding us since it was assigned, sharing their insight, experiences, and endless wisdom. We are extremely grateful for all the knowledge they have given me.

Conflict of Interest

None

Credit Author Statement

Soubhik Biswas and Manish Gupta: Study design, Experimentation, Data analysis; Neeraj Sahu: Writing - original draft preparation, Writing - review and editing. All the authors read and approved the manuscript.

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