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An Integrated Approach for Evaluating Lean Innovation Practices in the Pharmaceutical Supply Chain

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Abstract: *Backgroung:* Lean innovation focuses on minimizing waste in the product development stages in order to increase productivity by obtaining customer feedback more quickly and efficiently. The usage of lean innovation practices in product development stages in the pharmaceutical supply chain is the topic of an increasing amount of research on the critical question of how lean innovation practices can be implemented in a pharmaceutical supply chain or logistic sector. To answer this question, we first identified lean innovation practices by reviewing the literature. *Methods*: the identified practices were screened using the fuzzy Delphi method (FDM). The expert panel included eight persons working in pharmaceutical supply chain fields. In the next step, the causal relationships between practices were analyzed using the Gray DEMATEL (GDEMATEL) technique. *Results*: show that technological knowledge was the most crucial factor in lean innovation practices in the pharmaceutical supply chain. *Conclusions:* Actualizing lean innovation in the supply chain is more than just utilizing the correct strategies and instruments. To execute lean innovation effectively, a reevaluation must be accomplished: A culture that recognizes requirements for change and is set up for consistent change is essential. Methodological strategies such as the value system cannot be set up as a one-time strategy. To execute lean innovation on a long-haul premise, members must be included and become acclimated to a proceeding with the progress process. Changes in forms are frequently used because of an absence of association of suppliers, regardless of whether measures are sensible.

Keywords: lean innovation; lean innovation practice; prototyping; gray DEMATEL

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1. Introduction

As a vital and integral component of modern life, medicine is used to treat human and animal diseases [1]. Due to their different chemical structures and physical properties, research on and investigations into medicines face many challenges and issues [2]. Having experienced difficult conditions and undergone fluctuations over the past few decades, the pharmaceutical supply chain is now considered to be one of a country's most essential and strategic industries [1]. Drug manufacturing and health logistics are attractive fields in which to study different strategies of commerce and innovation [1]. Currently, organizational transformation is the biggest issue facing firms, and innovation is vital to the survival of any organization. In addition, supply chain innovation provides an essential competitive advantage [3]. Innovation is a critical factor in the success of supply chains in line with economic progress and better access to commercial markets [4]. According to experts, innovative technologies play vital roles in countries' economic growth and development. Research and development groups are key factors in the realization of such technologies [5]. Innovation is a way of creating value by developing new knowledge or using knowledge in new ways [6]. According to Peter Drucker, "innovation" is the only real competitive advantage for the organization. If a company can only have one great ability, it must be innovativeness [7]. Innovation is a prerequisite for success and survival and found its way through organizations around the world [6]. Data from Statista [8] suggest that expenditure on drug research and development will continue to grow worldwide. As of 2018, approximately USD 1.2 trillion has been spent on medicines, with an expected increase to USD 1.52 trillion by 2023. Furthermore, the total amount of medical waste was estimated to be worth USD 13.3 billion in 2020, which includes the high level of wastage associated with pharmaceuticals and contributes to an increase in the overall cost of healthcare [9]. The healthcare literature suggests that the adoption of improvement approaches and innovative interventions could enhance healthcare supply chains and help to reduce waste and provide improved services [10].

The success of knowledge-based organizations is guaranteed by innovation [11]. Lean innovations support the lean review of innovation, which is a relatively new concept that can be used to upgrade the innovation process [12]. Lean thinking has recently become the preferred management philosophy used by organizations to enhance operational performance. Although leanness has historically focused on well-structured processes, its focus has shifted towards less-structured processes with an innovative [13] and lean launch or startup [14].

The literature shows that lean innovation occurs incrementally when applied to R&D [6] or production processes [15]. According to Nicoletti (2018), lean innovation aims to reduce waste, improve effectiveness, reduce the time required to introduce new products into the market, minimize operating costs, and add value to customers [16]. Lean innovation enables organizations to turn their structural cultures into open and dynamic cultures that promote learning about and innovation of supply chains [17]. However, the number of publications on leanness and innovation remains limited [18]. The use of innovation in production is a new issue, particularly in the pharmaceutical industry. This leads to an analysis of the impact of lean innovation in a service context. In this study, the pharmaceutical supply chain was selected as a case study because this industry holds a strategic position in the world. The pharmaceutical industry is committed to finding sustainable solutions for the future to reduce negative environmental impacts and meet the highest ethical standards.

The literature on pharmaceutical supply chains shows that the application of innovative techniques can reduce pharmaceutical waste, enhance the quality of healthcare services, improve the effectiveness of inventory control, increase supply chain innovativeness, and enhance the reliability of information. Similarly, from a practical perspective, reports have been published by healthcare institutes that aim to provide guidance to the healthcare supply chain on how best to implement lean innovative approaches to improve the delivery of medicines. However, the adequate implementation of lean innovation within the pharmaceutical supply chain has not yet been achieved; there appears to be a lack of experience and knowledge of how such initiatives should be implemented.

The lack of focus on the combination of lean innovative practices that are considered to be the most effective ways to manage the pharmaceutical supply chain has been emphasized in the literature. Here, we attempt to make a rigorous and relevant contribution by considering both a theoretical and a practical problem when designing research questions and proposing contributions. This study makes an incremental contribution in the sense that we identify what knowledge already exists and further develop what is currently known.

In light of the above discussion, the main problem we address in the present study is that of identifying the practical actions necessary for the implementation of lean innovation in the pharmaceutical industry. The current study was conducted for the purpose of identifying and assessing lean innovations in the pharmaceutical industry. Accordingly, we pose three questions by which to identify and prioritize the factors that influence the implementation of lean innovations in the pharmaceutical industry:

1. What are the practices of lean innovation in the pharmaceutical supply chain?
2. How are lean innovation practices prioritized in the pharmaceutical supply chain?
3. How are the cause-and-effect relationships of lean innovation practices implemented in the pharmaceutical supply chain?

This article aims to achieve the goal and answer the posed questions in two sections. In the first section, critical factors in lean innovation practices in the pharmaceutical supply chain area are determined by reviewing the literature. In the second section, these practices are screened and localized using the Fuzzy Delphi method. Finally, these practices are assessed, and the innovation actions are prioritized using the gray DEMATEL technique.

2. Literature Review

Innovation has been a subject matter of research projects for several years. In the past decade, the scientific literature has begun to report an affiliation between leanness and innovation. Hoppmann et al. (2011) stated that only 27 publications were found regarding lean-driven innovation. In these publications, general lean principles, such as "creating a price for the customer", "thinking systematically", "flowing and pulling" and "continuous improvement" [19], are frequently employed to guide the implementation of lean thinking. In a production context, Smeds [20] argued that reorganizing production in step with lean principles would trigger a techno-organizational modification towards a lean enterprise, with a brand-new structure, strategy, and culture. Within the analysis and development (R&D) domain, Schuh et al. (2011) discussed the merits of implementing lean thinking principles in innovation management to develop progressive methods and to achieve innovations [21]. Besides businesses, lean can additionally be applied within healthcare and pharmaceutical supply chains [22].

Schuh et al. (2011) outlined the idea that that the lean innovation system represents the systematic interpretation of lean thinking principles concerning innovation and development. There are various reasons behind the impact of lean on innovation [22]. Firstly, it analyzes the root-cause issues and provides a modern and constructive input for brand-new ideas. Secondly, it increases individuals' autonomy and adaptability, resulting in their active role in solving issues and providing uninterrupted reflective values for learning and research.

These merits attest to lean innovation's role in making innovation processes more efficient [12]. Sonnenberg and Sehested (2011) further define lean innovation as a group of specific information sharing and innovation management techniques. Lean innovation can support access to information and information integration through unique mechanisms. Investigating the formation of these mechanisms and the advantages and risks involved in their implementation is undoubtedly rewarding. One major criticism is related to the competitive advantages of a company. According to critics, given their vital role as the company's final target in its quest for innovation, competitive advantages should have a much larger share of the research literature [23]. This apparent failure of the lean management literature to provide material on ways to boost the competitiveness of companies may bring about adverse outcomes, such as demotivation on the part of employees who feel the time and effort taken to enhance innovation approaches has been in vain. The need for management support introduces another risk related to lean innovation [12]. The risk may also be created, and engaged customers within the innovation processes will increase the prospect of lean innovation. Nevertheless, it simultaneously displays the weakness of the business or the corporation to the customer. These negative aspects of lean innovation are not investigated and discussed in detail in the respective literature, making further investigation on the subject urgent.

Generally speaking, retaining a competitive advantage in analysis and development needs not only an increase in effectiveness, but also in potency of R&D. Vital product differentiation must also be achieved through the preparation of resources. This is often the central objective of lean innovation by applying lean thinking principles to R&D management.

Within the given research constraints, innovations are made by internal R&D as a reaction to business restrictions, issues, and the core of the new application, the most innovation-demanding portion of the company [13]. Sehested and Sonnenberg (2011) provided their vision of lean, innovation, and lean Innovation as follows:

> "Working with lean means working systematically to eliminate all non-value-adding processes to obtain your goals with the least possible hard work. Innovation is about creating values by solving the problem. Furthermore, they see Innovation as the complex process of finding the solution to the situation that starts with imagination; nevertheless, the step that comes after creativity demands fast usage of available knowledge."

Radeka (2012) also claims that "the ability to innovate is merely worth something if those innovations generate values". This indicates that lean is a necessary and even integral part of innovations made within an organization [24].

Unwinding the various guidelines of thought about lean innovation makes it possible to underline two general statements:

1. Lean innovation is a beneficial and compatible method for managing some critical corporate competitive resources.
2. Lean innovation has faced many barriers in implementation. Nevertheless, the difficulties may be projected by an individual company's mode of business.

We systematically analyzed the scientific and management literature in a wide selection of databases [25].

Gayialis et al. (2018) developed an advanced cloud-based vehicle routing and scheduling system for use in urban freight transportation. The scope of the paper was to describe the concept and methodological approach for the development of such a routing and scheduling system operating in a cloud environment. The definition of its requirements and the development of the system is the primary purpose of an ongoing research project, being in its first stages of the system's analysis and design [26].

Touboulic et al. (2020) examined the relationship between critically engaged research and the process of theorizing in supply chain management (SCM). The essay presented an expanded model of knowledge production for the field of SCM. It explored opportunities for the demonstration of new knowledge types, emphasizing knowledge produced through a critical engagement with practice. They offered a discussion on how critically engaged research may be applied in SCM research to build, elaborate, and test theory [27].

Kechagias et al. (2020) analyzed the application of an urban freight transportation system to allow for reduced environmental emissions. An application of the system was performed for validation purposes, concerning the comparison of the system's results with corresponding real-life data provided by a medium-sized logistics company. The testing results revealed its significant contribution to the reduction in the environmental impact of the company's distribution services [28].

Yang et al. (2020) investigated the supplier selection for the adoption of green innovation in sustainable supply chain management practices in the Chinese textile manufacturing industry. The findings indicated that economic criteria were the most vital green innovation criteria. These findings will help managers, practitioners, and policymakers implement green innovation criteria in sustainable manufacturing supply chains [29].

Breen et al. (2020) carried out the management of pharmaceutical logistics to sustainability and beyond. Within pharmaceutical logistics, sustainability can mean business survival, addressing resource depletion, manufacturing conscientiously and responsibly, contributing to our economy, and doing no harm to our society and communities. Sustainability is a challenge in a supply chain that continues to grow organically, responding to changing patient needs, technological innovation, competition, political and regulatory governance, and austerity. This research highlights key areas of interest within the sustainability conversation as applied to pharmaceutical logistics [30].

Argiyantari et al. (2020) investigated the literature review of pharmaceutical supply chain transformation by applying the lean principle. This study provides a systematic literature review that proposes an analysis and classification of the previous literature as falling within four categories: the supply chain area, research approach, research objective, and lean supply chain elements [31].

Bullón Pérez et al. (2020) investigated the traceability of ready-to-wear clothing through blockchain technology. The goal of the paper was to introduce more recent traceability schemes into the apparel industry together with the proposal of a framework for ready-to-wear clothing which allows transparency in the supply chain, clothing authenticity, reliability and integrity, and the validity of the retail final products to be ensured, as well as the validity of the elements that compose the whole supply chain [32].

Cannon et al. (2020) carried out out a study entitled "complements or conflicts: R&D and lean innovation approach". Analysis of more than 850 firm years' worth of data showed that the relationship between lean and R&D productivity is nonlinear, specifically an inverted U shape (concave). Leanness provided some early R&D productivity improvement benefits, but R&D productivity leveled then declined over time [33].

Talukder et al. (2021) designed a multi-indicator supply chain management framework for food convergent innovation in dairy logistics. The developed framework can serve as a decision support tool to evaluate and improve dairy logistics [34].

In her research, Florida-Benitez (2021) concluded that airport promotes an increase in the establishment of companies in the city and showed how this plays an essential role in the tourist, air cargo, and logistics development and Málaga's local economy [35]. Additionally, in another study, she analyzed the effects of COVID-19 on airlines, airports, and the destination of Andalusia. On that basis, the study assessed the bankruptcy of some airlines, closure, the reduction in the frequency of air routes, COVID-19 measures at airports by governments, etc., to adapt to new circumstances, be efficient, and plan their resources according to the tourist demand [36].

Papalexi et al. (2021) analyzed the implementation of innovative plan within the pharmaceutical supply chain. The analysis led to the creation of the innovative pharmaceutical supply chain framework (IPSCF) that guides the healthcare system in how SCM problems could be solved using innovative approaches [37].

The trend of research on lean innovation management is growing (Figure 1).

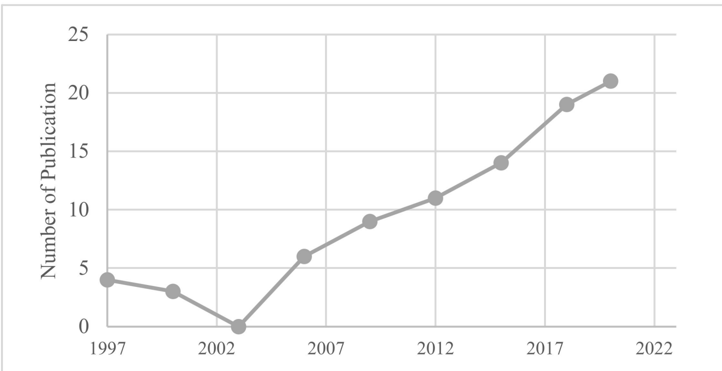

Figure 1. Research trend between 1997 and 2020.

Out of the 83 sources reviewed, 47 percent were qualitative case studies, and 18 percent were conceptual research. Multi-method studies, surveys, systematic literature reviews, interviews, and content analyses constituted 14, 10, 8, 2, and 1%, respectively.

Based on what has been discussed above, this study reviewed the literature by studying the lean innovation practices, which are the most essential practices, shown along with their sources in Table 1.

Table 1. Perspectives on lean innovation.

Perspective on Lean	Author(s)	Types of Innovation	Methodology
Lean as process management/improvement initiative	[38]	Product innovation	Quantitative (Survey)
	[39]	Product and process innovation	Theory-based
Lean six sigma	[40]	Not distinguished	Theory-based
	[22]	Not central to the investigations	Theory-based
	[41]	Product and process innovation	Qualitative (Interviews)
Lean design and lean supply chain management	[42]	Not distinguished	Quantitative (Survey)
	[43]	Not distinguished	Quantitative (Survey)
Lean enterprise	[44]	Not central to the investigations	Theory-based
General lean attributes, principles, and aims	[45]	Not distinguished	Theory-based
	[46]	Not central to the investigations	Theory-based
	[47]	Product and process innovation	Qualitative (Interviews)
Lean innovation practice	[48]	Not clearly distinguished	Qualitative (Questionnaire and Interviews)
	[49]	Product innovation	Qualitative (Questionnaire and Interviews)

Each syndication was analyzed independently by the solitary designers in order to extract the various tools, methodologies, or organizational alternatives suggested in the materials for the lean transformation of operations' innovation. Then, this group of tools and techniques was analyzed in a crisscross design to integrate the many perspectives found and create a construction that identifies the most internationally known elements of lean innovation [25]. This work reviewed 27 lean innovation practices, reported in Table 2.

Table 2. Lean innovation practices.

No.	Practices	References
1	Deep understanding of customer needs	[12,50–53]
2	Early identification of production problems	[12,50,51,54,55]
3	Integration of suppliers in the design and development process	[18,51,55]
4	Modular design and reduction of components	[18,51,53,55]
5	Supermarket of technical knowledge	[18,51,53,55]
6	Generation of alternative product concept	[51,53,55]
7	Systematic problem solving	[18,50,51,53,55,56]
8	Heavyweight project leader	[18,51–53,55,56]
9	Integrated team of responsible experts	[18,50–53,55]
10	Visual project board	[12,18,51,52]
11	Visual pull planning	[12,18,50,52,53]
12	Integration events	[18,51–53,57]
13	One-piece flow in the daily work	[12]
14	Working on a single project	[51,52,57]
15	Project portfolio	[12,57]
16	One-piece flow in the project portfolio	[12,18,57]
17	Integrated problem solving	[57]
18	Anticipated prototyping	[18,53]
19	Value stream mapping	[52,53]
20	Road mapping for technologies	[12]
21	Project added value	[12,18,51,52]
22	Product design style	[12,18,50,52,53]
23	Design management	[18,51–53,57,58]
24	Optimization of the event processes	[12]
25	High dependableness of IT systems	[12,18,51,52]
26	Use standardized controlling charts	[12,18,57]
27	Innovation dominant supported	[57]

3. Methodology

This research utilized the Fuzzy Delphi method to explore the lean innovation practice. Another technique used herein was gray DEMATEL, which is useful for calculating the cause-and-effect relationships between lean innovation practices. To ascertain the analysis gap, we tended to conduct a scientific search for articles in communicative journals. The bibliographical databases searched include Science Direct, Springer, Emerald, Taylor and Francis, Wiley, Google Scholar, and Scopus. This search confirmed that no study was published thus far with a spotlight on lean innovation practice. The data for this research were collected through many sources: depository data, including organization guidance, books and documents, and interviews with experts. Within the information assortment method, an expert team of eight specialists was assembled; their backgrounds are shown in Table 3.

Table 3. Background of experts.

Expert ID	Specialty	Positions	Work Experience (Years)
1	R&D	Chief	14
2	Industries	MD	22
3	HR	Chief	18
4	R&D	MD	11
5	Industries	MD	19
6	Management	MD	21
7	Assurance quality	Chief	18
8	Management	Production manager	26

The experts selected for the panel were chosen due to their expertise and position in their organizations. Attributable to the beta nature of this analysis, the authors used qualitative information assortment strategies, specifically semi-structured interviews, as they supply a more prosperous information supply than quantitative strategies. When finalizing the expert panel, we began the information assortment method. Finally, the experts' responses were collected. Data gathering tools included a literature review, semi-structured interviews, and a questionnaire. The primary tool was used to uncover an initial associated set of lean innovation practices. The methodology framework is shown in Figure 2.

3.1. The Fuzzy Delphi Method

Dalkey and Helmer developed the Delphi method, and Helmer developed the Delphi method in 1963 [59]. This technique is similar to the experts' opinion survey technique, with 3 essential characteristics: anonymous response, iteration and controlled feedback, and applied math cluster response. In several real situations, experts' judgment cannot be exactly given quantitative values and crisp information area unit is meagre in comparison to model natural systems thanks to the unclearness, inexactitude, and subjective nature of human thinking and the subjective nature of human thinking and judgment and preferences. Due to this, fuzzy numbers was suggested by Zadeh as a robust tool to beat these drawbacks [60]. Initially designed by Ishikawa, the fuzzy Delphi method (FDM) is a combination of fuzzy pure mathematics and the Delphi method. The steps of the FDM area unit are as follows [61–64]:

Step 1: Distinguishment of the analysis criteria associated with the study. First, the attainable criteria ought to be found through a careful literature review.

Step 2: Collection of expert opinions through a mistreatment call cluster.

After distinguishing relevant performance criteria, consultants associated with the analysis area unit were invited to work out the importance of the known criteria through the mistreatment of the linguistic variables conferred in Table 4.

Figure 2. Research framework.

Table 4. Linguistic scales.

Linguistic Term	Fuzzy Number
Very low (VL)	(0, 0, 0.25)
Low (L)	(0, 0.25, 0.5)
Medium (M)	(0.25, 0.5, 0.75)
High (H)	(0.5, 0.75, 1)
Very high (VH)	(0.75, 1, 1)

Step 3: Identification of necessary criteria.

The final step within the FDM is to characterize the necessary criteria, which is finished by scrutinizing the burden of every criterion with the threshold'S˜. The value of S˜ is calculated by the type of all criteria weights. In this regard, we should always find the (TFNs) τ for every criterion, as outlined in (1)–(5).

$$\widetilde{a}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right) \quad \text{for} \;\; i = 1, \ldots, n, \; j = 1, \ldots, m \tag{1}$$

$$\widetilde{\tau}_j = \left(a_j, b_j, c_j\right) \tag{2}$$

$$a_j = min\left\{a_{ij}\right\} \tag{3}$$

$$b_j = \left(\prod_{i=1}^{n} b_{ij}\right)^{\frac{1}{n}} \tag{4}$$

$$c_j = max\{c_{ij}\} \tag{5}$$

In the above equations, index i corresponds to the knowledgeable, and index j corresponds to the criterion. The notation $\tilde{a}_{ij}$ is the fuzzy linguistic every of every criterion that is obtained from each knowledgeable, and $\tilde{\tau}_j$ is the fuzzy average worth of every criterion.

In addition, this fuzzy average worth of every criterion is defuzzied into a crisp value as follows:

$$Crisp\ value = \frac{a+b+c}{3} \tag{6}$$

3.2. Gray Dematel

The fundamental meaning of gray is used in the incompleteness of information [65]. From the perspective of information, any system lacking information such as communication structure, performance mechanism, and behavioral characteristics is seen as a gray system. Gray theory can be a fuzzy condition. In other words, gray theory works well in fuzzy conditions [66]. Fuzzy theory requires the recognition of a membership function based on the experience of experts or extensive data. Still, the theory of gray does not operate based on the available information range. According to the above, a gray number is a number whose exact value is unknown, but the field in which it is located is specified [67]. In general, the inclusion of gray theory over fuzzy conditions and its flexibility in dealing with issues is uncertain. This method is based on Gray Systems Theory with the following main steps [4,68]:

Step 1: Establishing a direct fuzzy relationship matrix: this step is composed of three sub-steps:

Sub-step 1: Defining the gray linguistic scale.

In this analysis, a five-level scale was used in line with Table 5: no impact, very low impact and low impact, high impact, and very high impact. Table 5 summarizes the gray numbers of those linguistic expressions.

Table 5. Lingual expressions and gray number.

Verbal Terms	Gray Numbers
Non-effect	[0,0]
Very Low (VL)	[0,1]
Low (L)	[1,2]
High (H)	[2,3]
Very High (VH)	[3,4]

Sub-step 2: Formation of direct relationship matrix.

For measurement of the link among the standards, a group consisting of five consultants was asked to compare the known factors in line with the outlined linguistic expressions. Therefore, five gray matrices area units were obtained as arrays akin to every one of the experts' opinions. Gray matrix Z^k is termed initial direct relation gray matrix. For simplification, Z^k is shown as:

$$Z^k = \begin{bmatrix} [0,0] & \cdots & \otimes Z^k_{1n} \\ \vdots & \ddots & \vdots \\ \otimes Z^k_{n1} & \cdots & [0,0] \end{bmatrix} \tag{7}$$

where $\otimes Z^k_{ij}$ is the gray range of the ith result of the known issue on the jth consequence of the known problem. The specialists analyzed the relationships between the effect of gray pairs and $\otimes Z^k_{ij}$ among the known factors during a 9 × 9 matrix to establish an immediate gray matrix Z^k. All the arrays of the diagonal of the direct gray matrix Z^k are gray zero initially ([0,0] = affectless).

Sub-step 3: Using an averaging technique, all the matrices of the direct gray relationship (Z^k) are combined, and the experts' opinions additive matrix (Z) is calculated.

$$Z = (\sum_{i=1}^{k} Z^k)/k \quad (8)$$

Step 2: To support the additive matrix Z, the traditional direct relationship matrix N is calculated, consistent with the following Equation:

$$\otimes S = [\underline{S}, \overline{S}] = \frac{1}{max \sum_{j=1}^{n} \otimes Z_{ij}} \quad (9)$$

$$N = \otimes S.Z \quad (10)$$

$$\otimes n_{ij} = \left[\underline{S}.Z_{ij}, \overline{S}.\overline{Z_{ij}} \right] \quad (11)$$

Step 3: Total correlation matrix (T) is determined by the following:
where I is the matrix $n \times n$.

$$T = N + N^2 + N^3 + \cdots = N(I - N)^{-1} \quad (12)$$

Step 4: Establishing a digraph of causal and effect in GDEMATEL:

Sub-step 1: Using matrix (T) for each row i and column j, the sum of ($\otimes R_i$) and ($\otimes D_j$) is determined. This means that:

$$\otimes R_i = 3 \sum_{j=1}^{n} \otimes t_{ij} \quad (13)$$

$$\otimes D_j = \sum_{i=1}^{n} \otimes t_{ij} \quad (14)$$

The raw values of $\otimes R_i$ depict the direct and indirect effect of ith factor on the other elements. Similarly, the columnar values of $\otimes D_j$ show the sum of direct and indirect effects of jth factor on the other elements.

Sub-step 2: Using the following relations, the importance of $\otimes P_j$ of the ith factor and the jth factor's net impact are determined.

$$\otimes P_j = \{\otimes R_i + \otimes D_j \,|i = j\} \quad (15)$$

$$\otimes E_i = \{\otimes R_i - \otimes D_j \,|i = j\} \quad (16)$$

The values are indicators of general cause and effect, and rises in these values are indicators of known cause and effect. A rise in enhances the importance of jth issue in step with total relations with alternative factors—the values of $\otimes E_i$ depict the net result of ith factor. The following formula was used to verify the weights; the calculated weights are normalized in exploitation Euclidian standardization [7].

$$W_j = [(D_i + R_i)^2 + (D_i - R_i)^2]^{0.5} \quad (17)$$

$\overline{W}_j$ is the final weight of the criteria for decision makers. Therefore, the new exploitation approach of the DEMATEL technique for the indicator's weights calculating, weights conniving, and weights are estimated.

Sub-step 3: Finally, the causative and overall importance diagram of DEMATEL is drawn.

4. Results

In this stage, the FDM is applied to select the most essential practices from the ones listed in the previous step. The output of FDM is presented in Table 6.

Table 6. Outputs of fuzzy Delphi method.

Practices	l	m	u	Defuzzified	Decision
Profound understanding of customer needs	0	0.908	1	0.636	accept
Early recognition of creation problems	0.25	0.721	1	0.657	accept
Integration of suppliers in the look and development process	0.25	0.75	1	0.666	accept
Modular design and ∣lowering of components	0	0.572	1	0.524	reject
Supermarket of technological knowledge	0.5	0.908	1	0.802	accept
Generation of substitute product concept	0	0.314	0.5	0.271	reject
Organized problem-solving with set-based approach	0.25	0.629	1	0.626	accept
Heavyweight task leader	0	0.825	1	0.608	accept
Integrated team of accountable experts	0.5	0.908	1	0.802	accept
Obey room and aesthetic project board	0	0.360	0.75	0.370	reject
Visual yank planning	0.25	0.572	0.75	0.524	reject
Integration events	0.5	0.825	1	0.775	accept
One-piece stream in the daily work to be able to reduce the inefficiencies of multi-tasking	0.5	0.825	1	0.775	reject
Take of solitary project conference	0	0.572	1	0.524	reject
Project stock portfolio take	0.25	0.655	1	0.635	accept
One-piece circulation in the task portfolio	0	0.360	0.75	0.370	reject
Integrated problem handling anatomist	0.25	0.572	0.75	0.524	reject
Anticipated prototyping	0.5	0.825	1	0.775	accept
Value stream mapping	0.5	0.825	1	0.775	accept
Road mapping for merchandise and technologies	0.75	1	1	0.916	accept
Place needs clearly and project goals to precisely meet the customer's price perception	0	0.396	0.75	0.382	reject
Product design style supported integrated product and production structures	0.5	0.825	1	0.775	accept
Design Space Management based on design sets	0.25	0.572	0.75	0.524	reject
optimization of the event processes	0.5	0.825	1	0.775	accept
High dependableness of IT systems	0.25	0.75	1	0.666	accept
Use standardized controlling-charts for visual management of project standing	0.25	0.793	1	0.681	accept
Innovation dominant supported closed-loop system management	0.25	0.721	1	0.657	accept

According to the experts, lean innovation practices were selected using the fuzzy Delphi method (see Table 7).

Following the steps of the GDEMATEL described above, in the first step, the experts were asked to rate the effectiveness of the identified factors by linguistic expressions, from which the cumulative aggregated matrix of the experts' opinions was then calculated. After calculating the mentioned matrix, the initial direct relations matrix and total relation matrix (T) were calculated according to steps 2 and 3 of the GDEMATEL. Finally, to determine the causal and dependent criteria, the sum of the row and column of the matrix T was calculated, and the importance of the factors $(\widetilde{D}_i + \widetilde{R}_i)$ and relationship among factors $(\widetilde{D}_i - \widetilde{R}_i)$ were determined. The results are shown in Table 8.

Table 7. Accepted practices in lean Innovation.

Index	Practices
C1	Technological knowledge
C2	Profound understanding of customer needs
C3	Early recognition of creation problems
C4	Integration of suppliers in the look and development process
C5	Organized problem-solving with a set-based approach
C6	Heavyweight task leader
C7	The integrated team of accountable experts
C8	Integration events
C9	Project stock portfolio takes
C10	Anticipated prototyping
C11	Value stream mapping
C12	Road-mapping for merchandise and technologies
C13	Product design style supported integrated product and production structures
C14	optimization of the event processes
C15	High dependableness of IT systems
C16	Use standardized controlling charts for visual management of project standing
C17	Innovation dominant supported closed-loop system management

Table 8. The $(\widetilde{\mathbf{D}}_{\mathbf{i}} + \widetilde{\mathbf{R}}_{\mathbf{i}})$ and $(\widetilde{\mathbf{D}}_{\mathbf{i}} - \widetilde{\mathbf{R}}_{\mathbf{i}})$.

Index	D − R	D + R	Relative Weight	Final Weight	Rank
C1	0.28	2.90	2.91	2.92	1
C2	0.01	2.40	2.41	2.40	2
C3	0.13	1.86	1.87	1.86	6
C4	−0.30	1.26	1.26	1.30	15
C5	−0.24	1.00	1.05	1.03	17
C6	0.43	1.60	1.60	1.66	9
C7	0.08	1.29	1.29	1.29	16
C8	−0.23	1.37	1.37	1.39	14
C9	−0.32	1.88	1.90	1.91	5
C10	−0.79	1.43	1.43	1.63	10
C11	−0.09	2.18	2.18	2.18	3
C12	0.20	2.16	2.16	2.17	4
C13	0.43	1.61	1.61	1.66	8
C14	0.25	1.45	1.45	1.47	13
C15	0.07	1.55	1.55	1.55	12
C16	−0.01	1.61	1.61	1.61	11
C17	0.08	1.76	1.77	1.76	7

5. Discussion

Firm innovation, front-end, and back-end forms, and coaching leadership were inspected by considering the level of natural dynamism. Firms that work in situations characterized by higher rates of advancement are likely to be more imaginative. To refine the calculation strategy, the blunder terms were clustered around five levels of natural dynamism (i.e., the rate of development). In addition, incline development forms were deemed to have a substantial effect on firms' innovativeness as a framework. Particularly, back-end forms influence firm innovativeness.

This effect is more than twice as expensive as the standardized effect of the front-end form. This may well be due to the Dutch societal and organizational culture (as elaborated through comparison with other societies by Hofstede, 2011). Firms show a standard and homogeneous set of incline front-end hones. Consequently, less variety can be seen, in this research manifested in a smaller standardized coefficient. These lead one to infer that although synergistic, back-end processes are a more viable lever for the incline to extend firms' innovativeness. Without disposing of or undermining front-end forms, more consideration to and venture into back-end forms can upgrade a firm's innovativeness.

To determine the network relations map, the threshold must be calculated. In this study, the T-matrix's average values were estimated to calculate the value of the relationship threshold in the GDEMATEL. The partial relationships could be omitted, and a network of significant relationships could be drawn this way. According to Table 8 and Figure 3, the relationships whose values in the T matrix are greater than or equal to the threshold value are shown in the network relationship map. All the matrix T values smaller than the threshold is zero (i.e., they are not considered to be in causal relations). The results of GDEMATEL showed that technological knowledge was identified as the most critical factor in lean innovation practices. The profound understanding of customer needs, value stream mapping, road mapping for merchandise and technologies, and project stock portfolio take practices are ranked second, third, fourth, and fifth. In this method, the numerical value and position of each criterion in terms of importance are specified as follows:

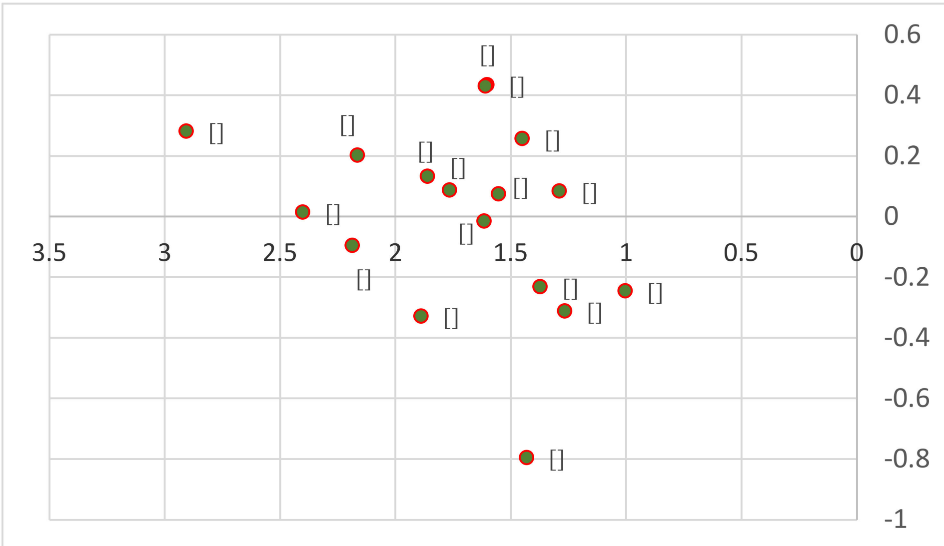

Figure 3. The GDEMATEL cause and effect graph.

(C10 < C9 < C4 < C5 < C8 < C11 < C2 < C16 < C1 < C12 < C3 < C17 < C15 < C7 < C14 < C13 < C6).

The criteria located over the horizontal axis whose total effects are more significant than zero are grouped as cause-and-effect criteria. The criteria located lower than the horizontal axis is clustered as dependent criteria. Technological knowledge was identified as the most critical and influential practice in lean innovation influences other factors. Additionally, road mapping for business and technologies, the profound understanding of customer needs, the early recognition of creation problems, and innovation-dominant supported closed-loop system management were identified as influential factors. Anticipated prototyping and project stock portfolio take is considered the most effective practice in lean innovation. Finally, the research search results were explained, and executive solutions were proposed for the pharmaceutical supply chain.

6. Conclusions

Past research proves that the incline logic seeks an all-encompassing approach to item improvement, with both culture/people and tools/techniques at its center. Within the same vein, this contends that firms' innovativeness can be cultivated by an integrator incline approach, which calls for a pleasant transaction between front-end and back-end administration, that is, the administration of "soft" and "complex" processes (Bel, 2010). Although this consideration is preparatory, both problematic and delicate administration appears to reinforce the impact of one another in accomplishing the general commerce goals.

This paper identified the lean innovation practices and analyzed them. This is a ground-breaking strategy to execute and oversee esteem direction during the improvement procedure in the pharmaceutical supply chain. The value framework tends to a few basic angles in item advancement: a resulting utilization of the value framework implements a reasonable meaning of prerequisites concerning item and procedure toward the start of each venture. In this way, it requests contribution and responsibility, with everything being equal. Regarding the experience of the board, the value system offers dynamic alterations of changes in undertaking timetables and prerequisites, a fantastic arrangement apparatus, and a likelihood to gain from past activities.

Moreover, the value system gives straightforwardness of targets, necessities, and qualities explicitly for all partners. Actualizing lean innovation in the supply chain is more than just utilizing the correct strategies and instruments. To execute lean innovation effectively, a reevaluation must be accomplished: A culture that recognizes requirements for change and is set up for consistent change is essential. Methodological strategies such as the value system cannot be set up as a one-time strategy. To execute lean innovation on a long-haul premise, members must be included and become acclimated to a proceeding with the progress process. Changes in forms are frequently used because of an absence of association of suppliers, regardless of whether measures are sensible. In this way, the usage of lean innovation when all is said in done, and a value system must specifically be changed following organization clear conditions.

Perhaps more directly and informed by this research, lean practices can be implemented to prepare and design an innovative, robust, and accurate pharmaceutical delivery system, which leads toward continuous improvements (e.g., [69,70]). Additionally, it identifies the factors that could influence innovation adoption within healthcare logistics, which matches Westrick and Mount's (2009) recommendations for further research, arguing that a combination of improvement approaches, such as lean, with computerized methods, could be the basis for enhanced innovation uptake. The COVID-19 pandemic is a timely reminder that healthcare providers need to have well-designed and practical logistics to be resilient, responsive, and innovative when faced with threats. A lack of access to critical equipment and medicines can be exacerbated by poor processes and systems that are not streamlined or transparent [71]. This research can be used for pharmaceutical supply chains, drug distributors, and raw material suppliers, and upstream pharmaceutical logistics.

6.1. Practical Implications

In viable terms, the incline advancement administration framework proposed in this study provides rules on how productive and successful learning can be handled at person and collaborative levels. Incline advancement administration could be a socio-technical framework that points to advancing an explanatory mentality to invigorate ongoing change, seeking a systemic problem-solving approach to reach an effective learning approach in a perfect world inside a collaborative setting. Future inquiries can incorporate and assess the pertinence of other incline front-end and back-end standards and hones to either improve the illustrative control of the strategy or to invalidate it by showing that an overlooked incline guideline and/or hone can uniquely clarify more variation in a firm's innovativeness than the displayed integrator demonstrate does.

6.2. Limitation and Future Study

This research stated potential implications for logistics theory and practice. While the study itself gives insights into the factors that might affect the pharmacies' lean innovativeness, it more information is needed. A more reliable study could be carried out. This research's theoretical perspective also generates another avenue of future research, which would be to target and examine the performance of pharmacies' logistics where lean innovative approaches, such as RL practices, have been considered and implemented. As the current study focused on lean practices in developing countries, researchers are encouraged to investigate the aspects of the pharmacies' logistics adopted across European boundaries.

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