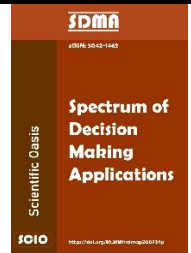




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Navigating the Digital Road: Unveiling and Prioritizing Barriers to Digital Transformation in Pakistani Courier Supply Chains

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ABSTRACT

The digital transformation of supply chains has become a critical area of research in recent years. This study delves into this domain by analysing relevant literature published within the past decade. The research explores how various digital tools and technologies, such as Artificial Intelligence (AI), Machine Learning (ML), Blockchain, and the Internet of Things (IoT), are being leveraged to optimize operations across the entire supply chain network. The research aims to identify key trends and challenges associated with digital transformation in supply chains. By understanding these factors, organizations can make informed decisions about adopting and implementing digital technologies to gain a competitive advantage and enhance their supply chain resilience. To prioritize these hurdles for a smoother DSC transition, the study utilizes a combined approach: Fuzzy AHP and Fuzzy TOPSIS. Fuzzy AHP assigns weights based on the importance of each barrier, while Fuzzy TOPSIS ranks them to guide effective resource allocation by management. The research identified and ranked the top five barriers, such as No Clear & Well-Defined Goals, Ill-Equipped Workforce, Integration with Existing Systems, Where to Start, and High Investment, providing valuable insights for leaders to prioritize and allocate resources for a successful DSC transformation.

1. Introduction

Due to global competition and technological advancements businesses have experienced rapid growth. The increased availability of the internet across the world has led changes in customers' buying methods and demand patterns. This revolution in e-commerce has created substantial challenges for supply chain managers [1]. Managers in supply chain organizations must explore the best approaches and techniques based on modern technology to meet the market demands and must establish modern processes that ensure agility and success.

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The availability of online and social media platforms has reshaped customers' preferences and expectations in terms of interaction with organizations and quick responses [2]. DSC is a way forward to ameliorate the organization's efficiency in terms of response time and customer interaction. DSC encompasses a layer of digital technologies such as the Internet of Things (IoT), end-to-end digital connectivity, cloud computing, blockchain, predictive analysis, artificial intelligence, machine learning, 3D printing, augmented reality [3,4].

In short, supply chain is the backbone of an organizations i.e., the success of the supply chain and the organization are correlated. The main aim of DSC is to get the products into the hands of the customers efficiently (with lower costs) and as rapidly as possible [5]. Unless the supply chain is fully integrated and effortlessly connects suppliers, manufacturing, logistics, warehousing, and customers, and is controlled by a central cloud command centre, this goal will be difficult to achieve [6].

While digitalizing the supply chain offers significant benefits, businesses in developing countries face several hurdles in implementing these advancements. Many businesses, particularly smaller ones, lack a clear understanding of the potential benefits of digital supply chains (DSC). They might not see the value proposition of DSC compared to traditional methods [7]. Pakistan's existing infrastructure, like internet connectivity and reliable power supply, may not be robust enough to support advanced DSC technologies [8]. Businesses may lack access to the necessary hardware and software required for a digital transformation [9]. Implementing a DSC can be expensive, with upfront costs for new technologies, software licenses, and potentially system upgrades [10]. Businesses might struggle to secure financing or have limited budgets for such investments. Implementing and managing a DSC requires a skilled workforce with expertise in areas like data analytics, digital logistics, and cyber security [11].

There may be a lack of readily available talent with these specific skillsets in the Pakistani market [12]. There might be resistance from employees accustomed to traditional methods. Implementing a new system can lead to concerns about job security or the need to learn new skills [13]. These challenges create a significant barrier for Pakistani businesses looking to adopt digital supply chain solutions. Addressing these issues through government initiatives, skills development programs, and awareness campaigns can pave the way for a smoother transition towards a more efficient and competitive digital future [14].

The recent literature on DSC produced several research articles that covered variety of barriers that organizations faces while implementing DT in the supply chain [15]. Existing research likely focuses on general barriers faced by various organizations globally. Digging deeper will allow us to identify challenges specific to our industry, company size, or even the region (like Pakistan a developing country) [6,9]. The digital landscape is also constantly changing. New technologies emerge, and the way we implement them evolves [10]. Further research is needed to consider the most recent barriers and how they might affect our specific context. Furthermore, prior research is either theoretical in nature or based on the systematic literature review. This research, grounded in a rigorous and practical approach, will equip businesses with the tools and strategies required to succeed.

The purpose of this research is to identify and analyze the list of barriers that significantly impacts the implementation of digital transformation in a supply chain [3]. More precisely the research will focus on using analytics, artificial intelligence and internet of things to enable digital transformation in the supply chain. It is pertinent to mention that each barrier has its importance that impacts on the integration of DSC and the organization must know the degree of influence of each barrier to take the appropriate measures during implementation [5]. Prioritizing these barriers will empower supply chain managers to tackle the most critical ones first; paving the way for successful implementation [8]. The research adds to the current literature by deploying the novel hybrid fuzzy

AHP and fuzzy TOPSIS approach. The research also adds to the literature by considering Pakistani courier companies supply chain as a real-world case study [14]. Moreover, the developed research framework will analyse the factors beyond traditional dimensions, incorporating new factors for a more critical examination of the situation [15].

The literature review is covered in Section 2. The research method is discussed in Section 3. The exploratory investigation of barriers prioritizing digital supply chain adoption is covered in Section 4. The results and discussion are explained in Section 5. In section 6 the study ends with a conclusion and implication. Section 7 outlines the restrictions & limits and upcoming directions.

2. Literature review

The Pakistani courier industry is experiencing a boom, fueled by the growth of e-commerce and a rising demand for efficient delivery solutions. However, to maintain a competitive edge in the global market, embracing digital transformation (DT) in supply chains is no longer optional. DT refers to the integration of digital technologies throughout the supply chain network, aiming to optimize processes, improve efficiency, and enhance customer satisfaction. To ensure the most up-to-date foundation, this research has examined the literature published within the last five years. A substantial volume of literature has been published on the topic of digital transformation in the context of supply chains.

Lee *et al.*, [16] and Dubey *et al.*, [17] identified the challenges faced in implementing digital technologies in supply chain specifically in developing economies. Their study highlighted the barrier “*lack of financial resources*” as an important factor in the technology integration process. Khan *et al.*, [18] stated that advanced digital technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) can be cost-prohibitive, especially for smaller Pakistani courier companies. Studies by Ali *et al.*, [19] and Kamal *et al.*, [20] emphasized the crucial role of government support and public-private partnerships in facilitating technology adoption. Beyond financial constraints, limited technological infrastructure presents another hurdle. Iqbal *et al.*, [21] stated that Pakistan faces challenges with reliable internet connectivity and access to stable electricity, hindering the smooth operation of digital solutions.

Furthermore, according to Aziz *et al.*, [22] implementing and maintaining these sophisticated technologies requires skilled personnel with specialized knowledge. In Pakistani workforce, significant skill gap exists which is also a hurdle. Cultural resistance to change was also highlighted as a barrier by Bachtiar *et al.*, [23]. They further stated that “*Organizational Inertia*” and “*Lack of Awareness*” about the long-term benefits of DT can create resistance among employees at various levels within the company. Addressing these internal cultural factors is crucial for successful implementation of DT.

With the increase in digitalization, several other challenges such as “*Data Privacy & Security*”, “*Data Managing & Processing*” and “*Regulations & Compliance*” were also discussed in the literature by Ali *et al.*, [24] and Admass *et al.*, [25]. Furthermore, the prevalence of an informal sector within the courier industry can make implementing standardized digital solutions difficult, as noted by Ahmed *et al.*, [26]. The above discussed challenges are compounded by factors specific to the Pakistani context. Despite the challenges, there are several positive developments in the Pakistani landscape. Recent government initiatives promoting digital literacy and fostering innovation hubs offer a glimmer of hope [27]. Additionally, successful case studies of Pakistani companies embracing DT, particularly in sectors like banking and telecommunications, provide valuable insights and inspiration for the courier industry [28]. Learning from these successful implementations can pave the way for a smoother transition for courier companies.

The current study has used Fuzzy AHP - Fuzzy TOPSIS hybrid methodology for analyzing the primary data. AHP and TOPSIS both are decision making techniques used in complex situation to analyse the different alternatives based on defined criteria. AHP was developed by Thomas Saaty [29]. AHP breaks down complex decisions into a hierarchy of smaller, more manageable parts. TOPSIS technique was developed by Hwang and Yoon in 1981 [30]. TOPSIS aims to choose the alternative that is closest to the ideal solution and farthest from the worst solution. It then allows for the comparison and weighting of different factors to arrive at a final decision.

Several research studies have deployed AHP and TOPSIS techniques to solve complex decision-making problem which includes: Maksimović [31] used AHP technique to solve the problem of emergency managers selection; Baek [32] used AHP technique to analyze the external and internal environmental factors for the health information website; Arican and Kara [33] developed the chemical tanker selection model based on AHP and TOPSIS; Amiri *et al.*, [34] developed a strategic multi-criteria decision-making framework based on AHP and TOPSIS for renewable energy source selection in Saudi Arabia. Çalikoğlu and Łuczak [35] used TOPSIS technique for multidimensional assessment of SDI and HDI.

To understand the specific impact of DT on Pakistani courier companies, further research is required. Studies exploring the barriers in implementing various digital solutions and measuring their impact on performance metrics like delivery times and customer satisfaction can provide valuable guidance for industry leaders. Furthermore, investigating how Pakistani courier companies can adapt existing digital technologies to their specific context, considering factors like the informal sector and security concerns, will be crucial for successful and sustainable DT implementation.

Existing research highlights the advantages of digital transformation in supply chains (DT-SC) using technologies like AI and IoT, but there's a gap in understanding the most critical barriers to implementation, especially in developing economies. This research aims to address this gap by prioritizing the barriers faced by Pakistani courier companies through a novel hybrid fuzzy AHP-TOPSIS approach. By focusing on a real-world Pakistani case study and utilizing a more comprehensive framework, this research will provide valuable insights for overcoming implementation challenges and contribute to a more effective DT-SC adoption strategy in developing economies. Below in Tables 1 and 2, the list of impediments in implementing digital transformation of supply chain and their sub classified barriers can be seen respectively. These barriers were extracted from the published literature which includes scholarly research articles, reports of private and public research institutes. After extracting these barriers, most relevant to the scenario of ZAC Courier Company were shortlisted. Initially 10 major barriers and 20 sub barriers were identified. Later on, with the help of experts four main barriers and eleven sub classified barriers were shortlisted.

Table 1
 Strategies for countering the barriers in implementing DT of supply chain

Sr. No.	Strategies for Countering the Barriers	References
1	Strategy and Planning	[36,37]
2	Efficient Resource Allocation	[38]
3	Technological Advancements	[39,40]
4	Positive Environment and Culture	[41,42]

3. Research methodology

In this research, I will follow a multi-stage approach to delve into the barriers hindering digital transformation (DT) in the supply chain of ZAC Couriers, a Pakistani courier company. First, I'll embark on a comprehensive literature review, scouring research published within the last decade (2014-

2024) to gain insights. Next, I'll justify my selection of ZAC Couriers as a real-world case study. Here, I'll explain why this particular Pakistani courier company is a relevant choice for investigating actual DT implementation challenges. Once the case study is established, I'll delve into data collection using a mixed-methods approach. This will involve conducting semi-structured interviews with key personnel across various ZAC Couriers departments (e.g., logistics, IT, management) to gain their perspectives on DT barriers.

Following data collection, I'll analyse the interview data using thematic analysis to identify recurring themes and categorize the specific barriers faced by ZAC Couriers (Table 2). By combining insights from the literature review and case study analysis, I'll then develop a research framework specifically tailored to prioritizing DT barriers. This framework, potentially utilizing the Fuzzy AHP and Fuzzy TOPSIS approach, will be applied to the collected data to prioritize the identified barriers based on their relative importance and impact on ZAC Couriers' DT journey. The overview of research stages can be seen in Figure 1 below.

Table 2

List of sub-classified barriers in implementing digital transformation of supply chain

Sr.No	Barriers in Implementing Digital Transformation of Supply Chain	References
1	No clear, well-defined goals.	B1 [43,44]
2	Ill-equipped workforce.	B2 [45,46]
3	High Investment.	B3 [47,48]
4	Integration with existing systems (OLD and New).	B4 [49]
5	Where to start.	B5 [50,51]
6	Scarcity of Digital Talent and Capabilities.	B6 [52,53]
7	Security concerns.	B7 [54,55]
8	The plan stays on paper.	B8 [56,57]
9	High Sustainability Cost.	B9 [58,59]
10	Buying and implementing the right technology.	B10 [60,61]
11	Organizational and Cultural Barriers	B11 [62,63]

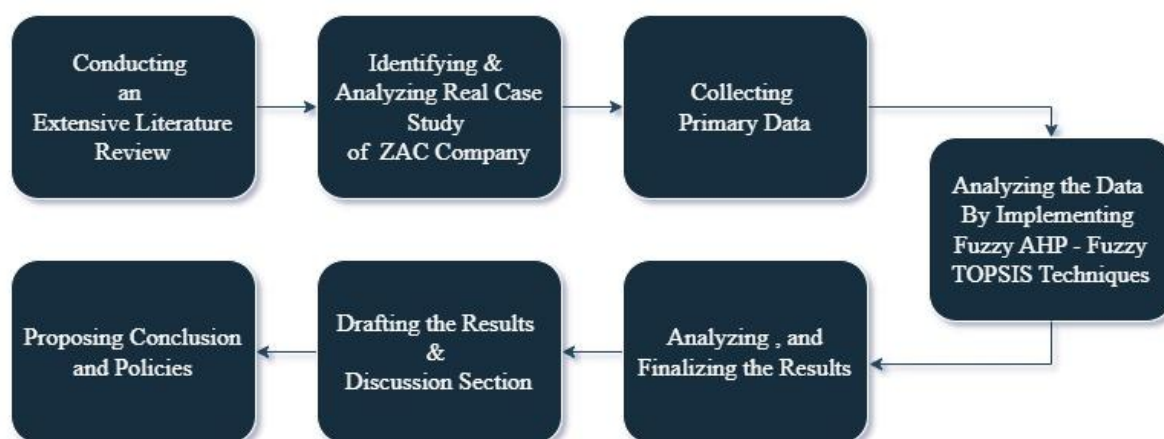


Fig. 1. Research stages

3.1 Case study of ZAC courier company

3.1.1 AC couriers: A Pakistani leader at a digital crossroads

ZAC Couriers, a leading Pakistani courier company, has carved a niche for itself through its expansive network and established reputation. However, the winds of change are blowing through the logistics landscape. The meteoric rise of e-commerce and the agility of new startups have placed

immense pressure on ZAC Couriers to optimize its operations and elevate customer satisfaction. Embracing digital transformation (DT) has become a strategic imperative, but the path forward is not without its hurdles.

While the potential benefits of DT are undeniable, ZAC Couriers faces a complex web of challenges hindering its implementation. At the core lies the lack of strategic clarity. The company's DT goals remain ambiguous and unquantifiable, making it difficult to prioritize investments and measure progress. This ambiguity creates a ripple effect, impacting other aspects of the transformation journey.

One critical challenge is the workforce skill gap. ZAC Couriers' existing workforce might not possess the technical know-how required to operate and maintain sophisticated digital tools. This necessitates a two-pronged approach: upskilling the current workforce or attracting new talent with specialized expertise in AI, IoT, and data analytics. However, the scarcity of digital talent in the Pakistani market presents another hurdle. Attracting and retaining these highly sought-after professionals can be a significant challenge for ZAC Couriers.

Financial constraints are another major roadblock. Implementing advanced DT solutions like AI-powered route optimization or real-time tracking through IoT sensors can be a costly endeavor. ZAC Couriers needs to meticulously evaluate the return on investment (ROI) and secure the necessary budget for technology acquisition and integration. Further complicating matters is the issue of legacy system integration. Seamlessly integrating new digital tools with ZAC Couriers' existing, potentially outdated systems can be a complex and time-consuming task.

Furthermore, deciding where to begin can be overwhelming. The vast array of DT options available can leave ZAC Couriers feeling paralyzed by indecision. A lack of clear starting point hinders the ability to prioritize initiatives and develop a roadmap for successful implementation. Beyond the technical challenges lie organizational hurdles. The transition from paper-based processes to a digital workflow can create resistance among employees accustomed to traditional methods. Addressing these cultural and organizational barriers is crucial for ensuring a smooth transition and maximizing the benefits of DT.

Security concerns also loom large. Integrating new technologies raises legitimate questions about data security and privacy. ZAC Couriers needs to invest in robust cybersecurity measures to protect sensitive customer information and build trust in its digital ecosystem. Moreover, maintaining and updating DT solutions can incur ongoing costs, raising concerns about long-term sustainability. ZAC Couriers needs to develop a sustainable financial plan to support its long-term DT vision, ensuring that initial investments translate into lasting benefits.

Finally, selecting the right technology solutions that seamlessly integrate with ZAC Couriers' existing infrastructure is crucial. A careful evaluation process and due diligence are necessary to avoid compatibility issues or wasted investments in technologies that don't align with the company's specific needs. This highlights the importance of technology selection as a crucial step in the DT journey.

3.1.2 The challenge: Prioritization

ZAC Couriers' leadership recognizes the necessity of DT, but they are unsure of which barriers to tackle first. Without a clear understanding of the relative importance and interdependencies of these challenges, effective resource allocation and successful implementation become difficult. This research aims to address this challenge by analyzing these barriers and prioritizing them using a Fuzzy AHP-TOPSIS approach. By providing a data-driven roadmap, this research can empower ZAC Couriers to navigate the digital transformation landscape and emerge as a leader in the new era of logistics.

3.2 Data collection

Primary data was used and collected by conducting interviews, surveys, and circulating questionnaires among the experts. The experts included (Industrial Experts, Supply Chain Managers, and academicians). These experts had vast experience of working in the supply chain sector and were holding senior positions in various national and multinational organizations. Many of them were Ph.D. degree holders. Out of all responses, 52 responses were obtained, all of which passed the consistency test and were utilized in pairwise analysis of DSC. Summary of the experts' profile can be seen in Table 3 below.

Table 3
 Experts information

Sr.No.	Educational Background	Age	Marital Status	Industry
1-15	Bachelor's	20 -35	Married/Un-Married	
16-30	Masters/M.Phil.	35 – 40	Married	Logistics & Transportation
31-52	PhD	40 – 45	Married	

3.3 Fuzzy set theory

Lotfi A. Zadeh is widely recognized as the originator of fuzzy set theory, Zadeh (1965). Since then, it has been frequently implemented to deal with ambiguity. Fuzzy set theory is mostly used in qualitative decision making, which relies on decision-makers' qualitative perceptions, Narang et al. (2023). As the accumulated experts' opinion takes the shape of linguistic variables, their judgments are inherently fuzzy, Marinkovic et al. (2023). Fuzzy set theory, which emphasizes relative rather than absolute values for the attributes, may be used to eliminate this fuzziness.

In this study, fuzzy numbers in triangular form as shown in Table 4 were used to fuzzify the data collected from the experts. When an expert assigned "very high" linguistic variable to a flood risk factor or mitigation strategy, the opinion was converted into fuzzy triangular number in order to reduce the uncertainty in the data. Similarly, all the data received from the experts was converted into fuzzy triangular numbers. The fuzzy triangular numbers were further utilized in AHP and TOPSIS techniques.

Table 4
 Relation of linguistic terms and fuzzy sets [64]

Linguistic Variables	Attribute Grade	Fuzzy Numbers in Triangular Form
Very Low	1	(0.0, 0.1, 0.3)
Low	2	(0.1, 0.3, 0.5)
Moderate	3	(0.3, 0.5, 0.7)
High	4	(0.5, 0.7, 0.9)
Very High	5	(0.7, 0.9, 1.0)

3.4 Analytical hierarchy process (AHP)

AHP is an MCDM technique that organizes complex concerns in a systematic order and simplifies the evaluation of all-important decision factors. In a judgment context, it helps the embodiment in determining the relative relevance of the traits. The primary reason for choosing AHP is that it helps to solve complex, disorganized, and multi-attributed challenges. AHP makes it easier to break down complex problems into smaller, more manageable parts.

Below is a brief description of the steps in the AHP method.

- i. Establish an objective and hierarchy.
- ii. Create pairwise comparison matrices showing the relative relevance of each element as stated in Table 4.

- iii. Normalize the pairwise comparison matrix.
- iv. Analyse the matrix consistency by using the following formulas.

$$CI = \frac{(\Lambda_{max} - n)}{(n - 1)} \tag{1}$$

Where n is the number of barriers and Λ_{max} is the greatest eigenvalue. Finally, the consistency ratio can be found by using Eq. (2).

$$CR = \frac{CI}{RI} \tag{2}$$

By using Eq. (2) the values of random consistency index (RI) for all barriers is calculated and can be found in (Table 5) below.

Table 5
 RI values based on number of attributes

Random Consistency Index (RI)	Number of Barriers
0	1
0	2
0.58	3
0.9	4
1.12	5
1.24	6
1.32	7
1.41	8
1.45	9
1.49	10
1.52	11

The range of allowed consistency ratios varies for each matrix, depending on the order of the matrix. According to [9] the acceptable range of CR for the 3x3 matrix is 0.05, for the 4x4 matrix is 0.08 and for matrix order equal to 5 and greater is 0.1.

3.5 Technique for order preference by similarity to the ideal solution (TOPSIS)

TOPSIS is a very well-known MCDM technique used and was developed by Hwang and Yoon [30]. TOPSIS criterion is reduced to a simple notion that allows for a coherent and logical evaluation. It is based on selecting the most suitable option with the smallest distance from the positive ideal solution and the largest distance from the negative ideal solution. The larger the advantage of the positive ideal solution, the smaller the advantage of the negative ideal solution. Afterward, obstacles are graded according to how close they are to the best solution. The goal is to identify which obstacles are close to the positive ideal in preference and which are far from the negative ideal solution. TOPSIS has proven to be one of the most efficient MCDM methods of addressing the priority problem because the order of options changes when suboptimal options are introduced.

TOPSIS can be formulated by following these steps.

Step 1

First, calculate the normalized decision matrix by using Eq. (3).

$$X_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^N X_{ij}^2}} \tag{3}$$

Where $j=1, 2, 3, 4, \dots, J$; $i = 1, 2, 3, 4, \dots, n$;

Step 2

Now calculate the weighted normalized decision matrix (Z_{ij}) by using Eq. (4). Where W_{ij} is the weight of the J th barrier and $\sum_{j=1}^n W_j = 1$.

$$Z_{ij} = x_{ij} * W_j \tag{4}$$

Where $j=1,2,3, 4, \dots, J$; $i= 1,2,3, 4, \dots, n$;

Step 3

Find positive ideal and negative ideal solutions by using Eq. (5) and (6).

$$I^+ = \{ Z^+, \dots, Z_n^+ \} = \{ (\max_j Z_{ij} | i \in B'), (\min_j Z_{ij} | I \in B') \} \tag{5}$$

$$I^- = \{ Z^-, \dots, Z_n^- \} = \{ (\min_j Z_{ij} | i \in B'), (\max_j Z_{ij} | I \in B'') \} \tag{6}$$

B' Corresponds to advantageous criteria while B'' corresponds to non-beneficial criteria.

Step 4

Using n-dimensional Euclidean distance computes the separation measurements. The formulas shown in Eq. (7) and (8) to find the separation of each barrier from the ideal best solution.

$$S_i^+ = \sqrt{\sum_{j=1}^m (Z_{ij} - Z_j^+)^2} \quad i = 1,2,3,4, \dots, I \tag{7}$$

$$S_i^- = \sqrt{\sum_{j=1}^n (Z_{ij} - Z_j^-)^2} \quad j = 1,2,3,4, \dots, J \tag{8}$$

Step 5

Finally, compute the efficiency order based on how near you are to the optimum solution. The degree to which the barrier $B_i \quad i = 1,2,3, \dots, 11$ is like a positive ideal solution is formulated below in Eq. (9)

$$\text{(Performance Score) } P_i = \frac{S_i^+}{S_i^+ + S_i^-} \tag{9}$$

3.6 Experimentation, applying fuzzy AHP and fuzzy TOPSIS techniques

This section of the research shows the stepwise implementation of fuzz AHP – fuzzy TOPSIS approach. The research framework can be seen in Figure 2 below.

It is evident from the figure that impacts of all the four major strategies would be analyzed on the sub classified impediments in order to prioritize them under single umbrella.

3.6.1 Analytical hierarchy process

The pairwise comparison of the barriers is carried out by using the data collected from the survey. The pairwise comparison matrix is then normalized and can be seen in Table 6 below.

Table 6
 Normalized pairwise comparison matrix of barriers

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	Weights
B1	0.17	0.15	0.17	0.50	0.11	0.14	0.13	0.04	0.12	0.06	0.26	0.17
B2	0.17	0.15	0.51	0.17	0.11	0.14	0.13	0.13	0.04	0.06	0.03	0.15
B3	0.056	0.016	0.057	0.056	0.318	0.138	0.043	0.042	0.124	0.064	0.09	0.09
B4	0.019	0.049	0.057	0.056	0.106	0.415	0.384	0.042	0.124	0.064	0.03	0.12
B5	0.170	0.148	0.019	0.056	0.106	0.046	0.128	0.127	0.124	0.064	0.26	0.11
B6	0.056	0.049	0.019	0.006	0.106	0.046	0.043	0.382	0.290	0.191	0.09	0.12
B7	0.056	0.049	0.057	0.006	0.035	0.050	0.043	0.127	0.041	0.191	0.03	0.06
B8	0.170	0.049	0.057	0.056	0.035	0.005	0.014	0.042	0.041	0.064	0.14	0.06
B9	0.056	0.148	0.019	0.018	0.035	0.006	0.043	0.042	0.041	0.191	0.03	0.06
B10	0.056	0.049	0.019	0.018	0.035	0.005	0.005	0.014	0.005	0.021	0.03	0.02
B11	0.019	0.148	0.019	0.056	0.012	0.015	0.043	0.008	0.041	0.021	0.03	0.04
UM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

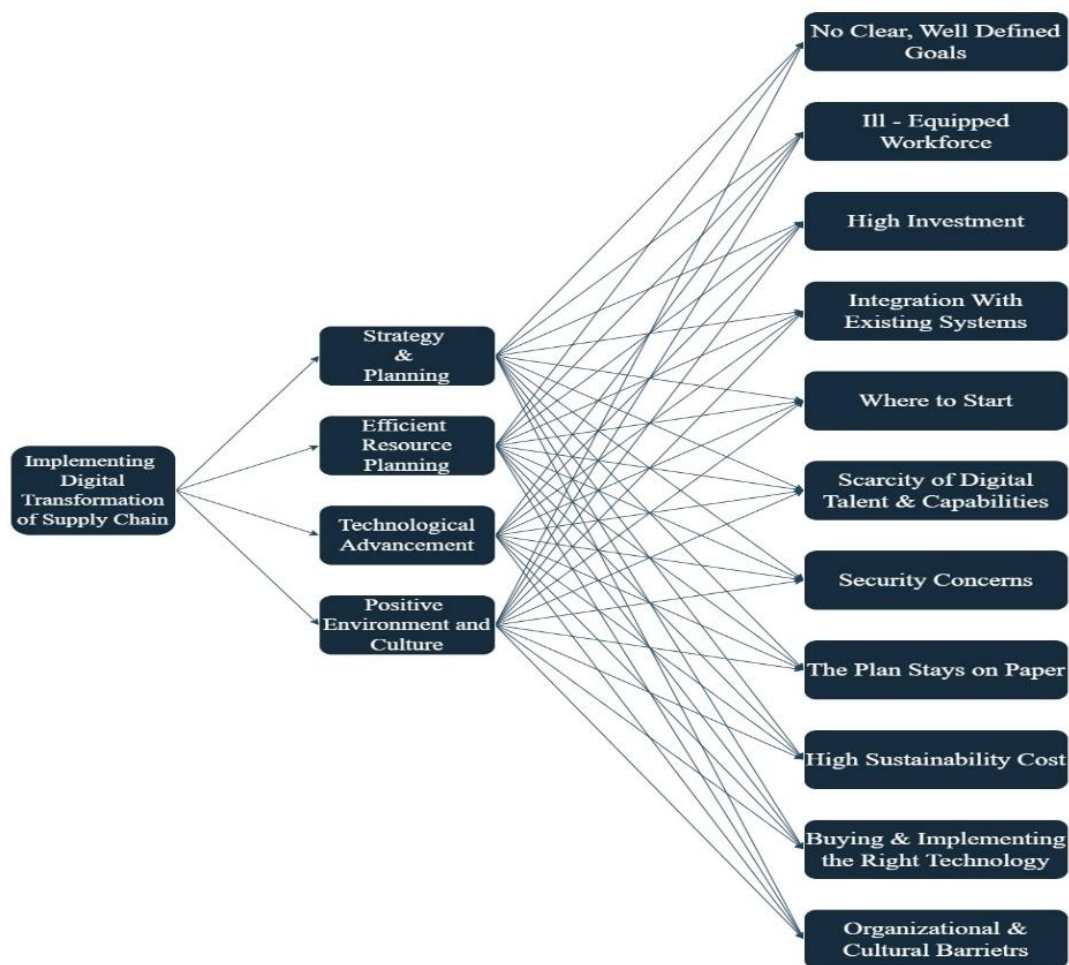


Fig. 2. Research framework

The consistency test was performed using equations (1) and (2) and can be seen in Table 7 below. The CR value is 0.098, which is less than 0.1, so the collected data is acceptable.

Table 7
 Consistency test results

Maximum Eigen Value	CI	RI	CR
12.59	0.15	1.52	0.098

3.6.2 Technique for Order of Preference by Similarity to Ideal Solution

The priority weightages resulted from the fuzzy AHP method will be utilized in fuzzy TOPSIS method. So, based on the previous weightages, normalized decision matrix of the barriers is constructed and is shown in Table 8.

Table 8
 Normalized decision matrix of different barriers

B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
0.170	0.148	0.170	0.503	0.106	0.138	0.128	0.042	0.124	0.064	0.257
0.170	0.148	0.510	0.168	0.106	0.138	0.128	0.127	0.041	0.064	0.029
0.056	0.016	0.057	0.056	0.318	0.138	0.043	0.042	0.124	0.064	0.086
0.019	0.049	0.057	0.056	0.106	0.415	0.384	0.042	0.124	0.064	0.029
0.170	0.148	0.019	0.056	0.106	0.046	0.128	0.127	0.124	0.064	0.257
0.056	0.049	0.019	0.006	0.106	0.046	0.043	0.382	0.290	0.191	0.086
0.056	0.049	0.057	0.006	0.035	0.050	0.043	0.127	0.041	0.191	0.029
0.170	0.049	0.057	0.056	0.035	0.005	0.014	0.042	0.041	0.064	0.143
0.056	0.148	0.019	0.018	0.035	0.006	0.043	0.042	0.041	0.191	0.029
0.056	0.049	0.019	0.018	0.035	0.005	0.005	0.014	0.005	0.021	0.029
0.019	0.148	0.019	0.056	0.012	0.015	0.043	0.008	0.041	0.021	0.029

By using Equation (4), a weighted normalized decision matrix of barriers is also produced and documented in Table 9.

Table 9
 Weighted normalized decision matrix of different barriers

B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
0.468	0.424	0.309	0.922	0.263	0.284	0.282	0.094	0.316	0.173	0.665
0.468	0.424	0.926	0.307	0.263	0.284	0.282	0.282	0.105	0.173	0.074
0.154	0.047	0.103	0.102	0.789	0.284	0.094	0.094	0.316	0.173	0.222
0.051	0.140	0.103	0.102	0.263	0.853	0.846	0.094	0.316	0.173	0.074
0.468	0.424	0.034	0.102	0.263	0.095	0.282	0.282	0.316	0.173	0.665
0.154	0.140	0.034	0.011	0.263	0.095	0.094	0.846	0.738	0.520	0.222
0.154	0.140	0.103	0.011	0.087	0.103	0.094	0.282	0.105	0.520	0.074
0.468	0.140	0.103	0.102	0.087	0.010	0.031	0.094	0.105	0.173	0.369
0.154	0.424	0.034	0.034	0.087	0.013	0.094	0.094	0.105	0.520	0.074
0.154	0.140	0.034	0.034	0.087	0.010	0.010	0.031	0.012	0.058	0.074
0.051	0.424	0.034	0.102	0.029	0.031	0.094	0.019	0.105	0.058	0.074

Equations (5) and (6) are also used to calculate the positive and negative ideal solutions, as can be seen in Table 10.

Table 10
 Positive ideal and negative ideal solutions

Barriers	Positive ideal solutions	Negative ideal solutions
B1	0.080	0.009
B2	0.064	0.007
B3	0.083	0.003
B4	0.111	0.001
B5	0.087	0.003
B6	0.102	0.001
B7	0.051	0.004
B8	0.051	0.001
B9	0.044	0.005
B10	0.010	0.001
B11	0.027	0.003

Next, as indicated in Table 11, Equations (7) and (8) are used to calculate the gaps between positive ideal solution and a negative ideal solution.

Table 11
 Separation measures of barriers

Barriers	Ideal Best	Ideal Worst
B1	0.1223	0.1540
B2	0.1334	0.1350
B3	0.1759	0.0947
B4	0.1692	0.1188
B5	0.1753	0.1026
B6	0.1924	0.0760
B7	0.2033	0.0331
B8	0.1981	0.0749
B9	0.2070	0.0610
B10	0.2147	0.0235
B11	0.2108	0.0582

Finally, Equation (9) is used to calculate the final ranking and is shown in Table 12. Higher the value of the relative proximity coefficient, higher the ranking will be.

Table 12
 Relative closeness

Barriers	Relative Closeness	Rank
B1	0.5573	1
B2	0.5030	2
B3	0.3499	5
B4	0.4125	3
B5	0.3691	4
B6	0.2831	6
B7	0.1400	10
B8	0.2743	7
B9	0.2277	8
B10	0.0985	11
B11	0.2164	9

4. Results and discussions

The results from the combined Fuzzy AHP-TOPSIS approach can be seen in Figure 3. It is evident from the results; the most significant barrier that should be prioritized by the ZAC Courier Company is No Clear & Well-Defined Goals. Experts have assigned 0.55 weightage to this particular barrier. The second most important barrier that is prioritized by the experts is Ill Equipped Workforce. The third most important barrier in the list is Integration of New Technology with Old Technology.

The research prioritizing "No Clear & Well-Defined Goals" as the most critical barrier for ZAC Couriers aligns perfectly with established literature on digital transformation (DT). Several studies highlight the importance of clearly defined goals for successful DT initiatives. A seminal work by Berger *et al.*, [65] emphasizes the need for SMART goals (Specific, Measurable, Achievable, Relevant, and Time-bound) to guide DT efforts. Without clear goals, companies struggle to measure progress, prioritize resources effectively, and ultimately achieve the desired outcomes from DT investments. Additionally, recent research by Oliveira *et al.*, [66] underscores the importance of aligning DT goals with the company's overall business strategy. When goals are ambiguous or disconnected from the broader strategic vision, DT initiatives can become fragmented and fail to deliver significant value. By

prioritizing the definition of clear and measurable goals, ZAC Couriers can lay a strong foundation for its DT journey, ensuring alignment with its business objectives and maximizing the potential for success.

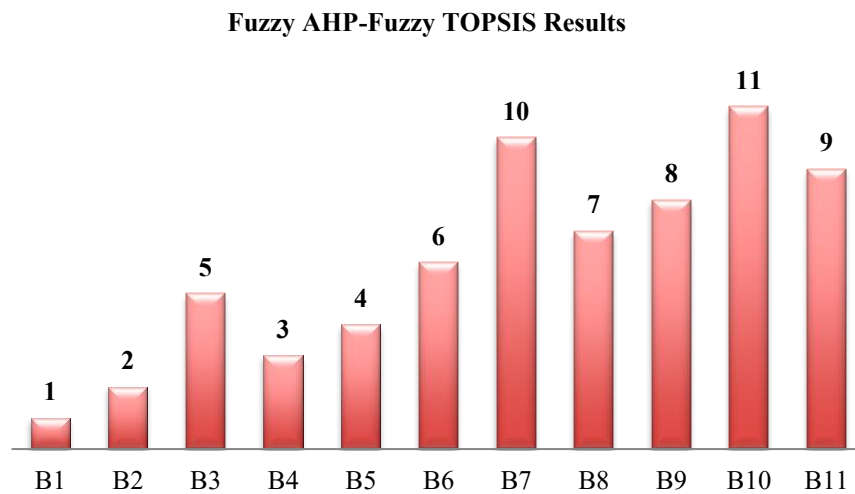


Fig. 3. Graphical representation of final results

The second most significant barrier identified, "Ill-Equipped Workforce," resonates with existing research on the critical role of human capital in DT. Numerous studies highlight the need for a skilled workforce to operate and maintain new technologies effectively. Talapatra *et al.*, [67] argue that a significant skills gap often exists between traditional workforces and the demands of digitalized operations. This gap can hinder the successful implementation and utilization of DT solutions. Similarly, research by Wright *et al.*, [68] emphasizes the importance of developing a culture of continuous learning within organizations undergoing DT. By prioritizing the development of its workforce through up skilling and reskilling initiatives, ZAC Couriers can bridge the skills gap and ensure its employees possess the necessary capabilities to navigate the complexities of new digital technologies. This will position them to extract maximum value from DT investments and contribute effectively to the overall transformation process.

The prioritization of "Integration of New Technology with Old Technology" as the third most critical barrier aligns with established literature on the challenges of legacy system integration. Studies by Weill and Ross [69] identify the difficulties associated with integrating new technologies with existing, often outdated, systems. These challenges can include data incompatibility, technical complexities, and the need for significant investments in system upgrades. Similarly, research by Bharadwaj *et al.*, [70] emphasizes the importance of developing a robust integration strategy during DT initiatives. This strategy should consider technical dependencies, data migration needs, and potential risks associated with system integration. By prioritizing the development of a well-defined integration roadmap, ZAC Couriers can overcome these challenges and ensure seamless integration of new DT solutions with its existing infrastructure. This will minimize disruption to core operations, optimize the utilization of existing investments, and pave the way for a successful digital transformation journey.

Experts have assigned least weightage i.e. 0.098 to the barrier "Buying & Implementing the Right Technology". This aligns with the emphasis on foundational aspects like clear goals and workforce skills. Once these are addressed, ZAC Couriers will be in a better position to evaluate and select the right technologies that align with their specific needs and goals, ensuring a more strategic approach to technology acquisition and implementation.

5. Conclusions and implications

The goal of this study was to help ZAC Courier Company in analysing the list of barriers they were facing in the process of digital transformation. Successful execution of digital transformation in the supply chain can focus on tackling the organization's problem, optimizing supply chain activities, more effectively using human resources, and speeding up the process of distribution of goods and services to consumers in the shortest time and a decreased price. All the feasible barriers were first identified. The major strategies which will help to counter these barriers were also identified. Afterwards, the list of barriers and strategies were analysed and prioritized with the help of Fuzzy AHP-TOPSIS approach. According to final results, the barriers No Clear, Well-Defined Goals, Ill-Equipped Workforce & Integration with the Existing System should be dealt first and prioritize by the ZAC Courier Company. So, this paper outlines a step-by-step plan for overcoming the obstacles that are limiting the adoption of the Digital Supply Chain.

5.1 Practical and theoretical implications

This research bridges the gap between theory and practice in digital supply chain transformation. By identifying and prioritizing key barriers faced by managers, the study provides a practical framework for prioritizing resource allocation and overcoming implementation hurdles. This not only improves the success rate of digital supply chain initiatives but also contributes to the theoretical understanding of critical factors influencing effective deployment. The proposed AHP-TOPSIS methodology offers a robust approach for evaluating and ranking barriers, ensuring a data-driven and scientifically sound foundation for practical decision-making. However, it's important to acknowledge that cultural, political, and economic factors can influence the relative importance of these barriers across different countries, necessitating contextualization when applying this framework in diverse settings.

6. Limitations and future directions

This study acknowledges limitations. While a comprehensive literature review identified major barriers, new ones might emerge as the field evolves. The ranking of barriers presented here could change with the discovery of new obstacles. Future research could focus on these potential new barriers and utilize fuzzy logic approaches like Fuzzy AHP or Fuzzy TOPSIS to analyse them in uncertain environments. Additionally, the study recognizes the challenges posed by high investment costs and the time required for digital transformation. Despite these limitations, this research offers a valuable roadmap for overcoming obstacles and achieving successful digital supply chain transformation.

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Conflicts of Interest

All the authors have no conflict of interest.

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