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A Qualitative Investigation into the Challenges of Implementing Big Data Analytics in Sri Lankan Supply Chain Operations

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Abstract

Big data analytics (BDA) has gained immense attention from several industries because of its ability to generate data-driven insights for organizational efficiency. Previous studies have explored the relationship of BDA with firm performance, the benefits of using BDA in supply chain management, and the challenges of successful implementation. Despite recognizing the benefits of BDA and the challenges to implementing it, there is a lack of understanding of ways to address the challenges. Thus, this study primarily investigates the perceptions of supply chain professionals on barriers to BDA implementation and strategies to overcome them. Our findings are based on a qualitative analysis of data gathered from 12 interviews with industry professionals. Through thematic analysis, we identified supply chain professionals' perceptions of barriers, such as financial barriers, organizational culture and change resistance, regulatory and government barriers, human resource expertise, and competitive pressure. For strategies, we recognized building support and consensus, increased awareness and demonstrating value, fostering a culture of support and development, strategic planning, and getting government support in promoting digitalization. The findings of this research will aid industrial managers in understanding the barriers to the implementation of BDA, the benefits of the BDA, and the pathway to build strategies regarding BDA implementation in the manufacturing supply chains in developing countries.

Keywords: Big Data Analytics; Barriers; Supply Chain Operations; Manufacturing Supply Chain; Strategies.

1. Introduction

Today's businesses believe in data driven decisions. The use of Industry 4.0 technologies such the Internet of Things (IoT), blockchain, and artificial intelligence (AI) has impacted supply chain management. The advanced technologies have proven to improve supply chain visibility, optimization of resource utilization, and real- time monitoring of environmental performance, presenting new prospects for supply chain sustainability (Al Rakib, 2024). In this process big data (BD) and big data analytics (BDA) have taken a significant place in different business industries. Big data (BD), is known as large volume of data, derived from various sources to generate actional insights. The integration of BDA greatly speeds up decision-making processes, which boosts operational and financial performances of organizations. Hence most of the businesses are interested in adapting it into their businesses. BDA has the ability to produce meaningful insights from unstructured data, which has gain interest of organizations and stakeholders (Mikalef & Krogstie, 2020). Further businesses are able to save cost, increase effective production, and develop new products and services to satisfy their customers by using BDA (Dubey, R., et al 2020). For this reason, managers and decision-makers are interested in using data to make decisions, rather than depending on their own personal insights

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for an effective decision-making process. Chatterjee et al. (2023) suggests that combining BDA with AI can improve operational performance by improving service quality, reducing costs, manufacturing innovative products at cheaper costs, and mitigating market risks. Further Galeh & Sahraei, (2024) identified using blockchain technology increases both transparency and agility in supply chain, improving customer satisfaction and maximise the benefits of employing these technologies. The study Lin & Tsai, (2025) reveals the significance of using BDA to test corporate strategy and improve service quality by analyzing social media data, which helps firm uncover gaps and prioritize customer satisfaction. Several studies have claimed that BDA is useful to enhance the firm performance by implementing BDA and which help in decision making (Chatterjee et al., 2023; Fosso Wamba et al., 2015; Maroufkhani et al., 2019).

With changing market trends, manufacturing industries are evolving from traditional manufacturing to data-driven manufacturing to achieve greater efficiency and effectiveness, and competitive advantages. Several studies have explored the benefits of BDA in firm performance, while others have analyzed how BDA adoption aid various supply chain operations. The study of Xu et al. (2023) demonstrate that BDA can be used to enhance various supply chain planning activities, which will help in sustainability of supply chain operations. The same claim of BDA enhance decision making and overall efficiency of supply chain operations have done by Hasan et al. (2024), where the study emphasize on current supply chain businesses should equip businesses with valuable insights that can be generated through BDA tools. While several studies have analyzed the benefits of BDA, others have also highlighted the challenges of its implementation.

The study of Sun et al. (2018),depict using technology- organization- environment (TOE) framework and diffusion of innovation theory (DOI), the factors such as relative advantages, cost of adoption, complexity, human resources, management support, technology resources, firm size, security, privacy, ethical concerns and regulatory environment as affecting factors to the organizational adoption of BD. Similarly, studies done in context of UAE and Bangladesh have recognized technical, cultural, ethical, operational, tactical, procedural, and organizational challenges as some of main factors hindering the BDA adoption (Khan, 2019; Moktadir et al., 2019). In Sri Lankan context a study done for private sector companies which investigates the readiness to adopt shows low tendency for adoption of BDA (Lasanthika & Wickramasinghe, 2020), which bring focus to the current study. Despite the evidence from various studies on the benefits of BDA, and challenges of implementation, some businesses remain hesitant to adopt it. The current study intent to understand the perception of supply chain professionals on barriers to BDA adoption and to recommend strategies to successful implementation of BDA adoption. This work aims to answers the following research questions:

1. How do the perceptions of supply chain professionals influence the barriers to the adoption of Big Data Analytics?

2. How to overcome these barriers and facilitate Big Data Analytics adoption in the supply chain industry in Sri Lankan manufacturing companies?

To address these questions, we used qualitative approach with an inductive approach. This approach is appropriate for our study as the purpose of the study is to understand and form new concepts regarding the perceptions and strategies involving BDA adoption in supply chain operations for Sri Lankan manufacturing sector. The analysis is based on interview data which was collected by 12 supply chain professionals in manufacturing industry. Thematic analysis is used to generate themes. This study enhances the understanding of supply chain professionals on perception on barriers to BDA adoption and the strategies to overcome them in a successful way.

This paper structured as follows: Section 2 discusses the literature review on big data analytics and big data use in supply chain operation; Section 3 provides a discussion on data collection and methodology; section 4 presents the results and discussion and finally section 5 concludes with limitations of the study and suggestions for future research.

2. Literature Review

2.1. BD and BDA

“Big data” is attracting significant attention worldwide (Fosso Wamba et al., 2015). Big data is a massive volume of data from various data sources used to make decisions (Jha et al., 2020). Advancements in social networking, e-commerce websites, mobile technologies, search engines, and new technologies have produced an increasing amount of data. This opens the door for businesses to generate and collect data that capture the 3Vs of data, variety, velocity, and volume (Lutfi et al., 2022) ‘Variety’ is known as the different type of data which can be structured, semi-structured and structured (Lee et al., 2020). ‘Velocity’ is referred to as the speed, frequency, or frequency at which data is

generated and/or delivered (Fosso Wamba et al., 2015). 'Volume' refers to large amount of data. Now the data volume or size has surpassed terabytes and petabytes (Sagiroglu & Sinanc, 2013). Other than these 3Vs there are two more Vs, such as value and veracity (Fosso Wamba et al., 2015). 'Value' refers to the procedure that uncovers neglected BD values to aid in decision-making (Ghofrani et al., 2018). 'Veracity' highlights the accuracy and transparency of data, which is essential to guaranteeing the validity and utility of the information acquired from big data (Aprijal et al., 2024).

"Big Data Analytics" can be defined as the tool or the approach that transform the data into find trends or patterns that is beneficial in business world to take data driven decisions (Ammar et al., 2021). BDA is useful to increase the speed of data analysing to make effective decision in various sectors, especially to increase operational and financial performance, which eventually increase overall performance of the company. But BDA's influence in firm performance goes beyond decision-making effectiveness (Sivarajah et al., 2024). BDA can assist businesses in finding ways to lower the cost of inventories, bridging the communication gaps, observing equipment using the analysed data and increase supply chain (SC) transparency facilitating in making data driven decision (Ammar et al., 2021). To make data driven decisions and to utilize the advantages of BD, there are special tools that have the capability to analyse, visualize and store data. The data analysis tools are Hadoop, Hive, Pig, Platform, Rapidminer and data visualization tools are R, Tableau, Infogram, ChartBlocks and Tangle. As BD involve large amount of data, for an effective and efficient management of data, storage technologies such as HBase, SkyTree and Non-Relational Databases can be necessary (Mahmoudian et al., 2023) .

While BDA is constantly expanding, the mechanisms to capture the ever-evolving abilities to create business value need to be investigated through empirical research. This is because only a small percentage of firms are able to derive real business value from BDA, and the true business value of BDA in many organizations remain unexplored (Yoshikuni et al., 2023) due to the barriers and lack of addressing the matter.

2.2. BDA in Supply Chain Operations

The broad use of BDA in supply chain management (SCM), includes supply chain traceability, rapid reaction assessment, innovative techniques, and a capacity maturity model of big data analytics (He et al., 2020). The increasing size and complexity of datasets has led to a substantial impact on demand and sales planning activities through the use of BDA. In the big data era, environmental and organizational data are highly valued, and predictive and prescriptive BDA approaches are used to customer-centric and customer-generated data to produce more accurate forecasts (Xu et al., 2023). Based on the findings of a comprehensive survey conducted among SCM professionals, the authors demonstrate that senior management support and personal belief in the value of BDA techniques are the main drivers behind the usage of BDA in firms (Jha et al., 2020). In terms of using BDA, SCM has drawn the interest of academics and practitioners more and more. Supply chains in a variety of industries can now gather a vast amount of data and information through the use of sensors, barcodes, radio frequency identification (RFID), and automated systems. This data is valuable for identifying areas that need improvement in several SCM processes, such as demand management, purchasing management, production management, inventory management, and distribution management. Because of this, data is becoming a vital source of competitive advantage (Patrucco et al., 2023).

In SCM, the use of BDA is proven to be beneficial, in demand planning, production, inventory, procurement and other processes. In supply chain demand forecasting has a large influence on the processes such as inventory management, customer satisfaction and production scheduling. In the modern world, traditional forecasting methods are failing address complexity and dynamic changes that are happening in modern supply networks. On the other hand, Seyedan and Mafakheri. (2020), mentioned BDA has the ability to effectively merge machine learning, predictive analysis, and real-time processing for rational forecast assessments. This advanced method offers a comprehensive understanding of market changes, allowing firms to predict shifts in demand patterns with exceptional accuracy. Further in the process of production, which is utterly important in manufacturing industry, BDA allow the organizations to take data-driven decisions, and real time insights to improve manufacturing efficiency. As BDA analyses existing production line data, operational systems, and equipment, it allows the organizations to discover inefficiencies, predict maintenance needs, and optimize resource utilization (Mageto, 2021). According to Koot et al. (2021), integrating BD with the Internet of Things makes further improvements in overall operational efficiency by allowing real-time monitoring and adaptive control of production systems, which proves that BDA is very effective in production processes to increase operational efficiency. Another important process would be procurement which is known as the process of buying products or services from an outside supplier. Hasan et al. (2024), through the research work have

mentioned that there are several aspects to improve procurement performance by using technologies/tools such as BDA, especially in decision-making. As an example, the use of predictive analytics in procurement helps to plan demand, avoid hazards. Also, it helps in overstocking, understocking, reducing cost, and to increase customer satisfaction. Overall BDA can help procurement process by managing suppliers, quality, delivery, pricing strategies, in stocking the supplies, and to make important decisions related to costs by analysing and negotiating with the suppliers and forecasting the risks involved in this process. Further, inventory management in supply chain operations, is important for organizations that deals with physical goods. The problem of using the traditional warehouse method is the delay in information, that excess the number of supplies or demands and may increase the wastage or have no supplies for the required demand. Which may lead to loss to the company, increasing the costs. The primary objective of BDA in inventory is to increase the traceability and responsiveness. Because of that it is important to use BDA to get real time information on warehouse management, transportation, where the demand of the products will be addressed accurately, risks will be addressed, just in time inventory can be achieved through when information are provided in real time.

In conclusion of this literature review, we can state that existing research reveals that BDA has capability to enhance the supply chain operation effectively. Despite of benefits, the adaptability rate of BDA in Sri Lanka seems to be lacking. This lack of interest can be due to challenges or the barriers which are related to BDA implementation. In this, study we intend to fill this gap using an inductive qualitative approach.

3. Research method

We have used qualitative method as it has been considered most suitable approach to explore new phenomena and insights. Thematic analysis was chosen as the method of analysis. In this paper, our aim is to explore the perceptions of supply chain professionals regarding BDA barriers and the strategies for adopting BDA in the Sri Lankan manufacturing sector. Therefore, we chose a qualitative method to gain a deeper understanding of the area.

3.1. Design of the study and data collection

Semi-structured interviews were conducted with key informants from manufacturing industry, such as IT managers, data analysts, senior executives, supply chain managers and top management where BDA has successfully adopted. The interview questions were designed to explore the views and perceptions of the participants regarding the barriers to BDA implementation, investigate how these barriers influence on decision making process and suggest strategies and recommendations to overcome them. The interviews provided in-depth qualitative insights into the specific challenges and contextual factors affecting BDA implementation in Sri Lanka.

In total we conducted 12 interviews with industry professionals. There is no defined guideline for determining the maximum number of experts who can be involved while examining data. In general, researchers believe that a minimum of 10 experts is required to obtain accurate conclusions. The researcher has recommended that 10 to 18 expert viewpoints be examined in order to get a reliable mutual consensus (Okoli & Pawlowski, 2004). Generally, a small number of key informants is enough to reach theoretical saturation. Hence, the data collected from 12 experts considered as sufficient sample size for this study. Furthermore, we ensured diversity in our sample by selecting participants from various industry sub-sectors within the Sri Lankan manufacturing sector. This approach allowed us to capture a broad spectrum of perspectives, ensuring that our findings reflect the experiences of organizations across various industries within the Sri Lankan manufacturing sector.

In our study, we interviewed 12 key informants representing the supply chain division in manufacturing industry who hold senior position. Our data represent several manufacturing industries. To collect data, we conducted semi-structured interviews, as this approach allows for gathering diverse perceptions on the topic that structured interviews or questionnaires may not capture. We used purposive sampling to ensure the interviewees possessed required knowledge of the research area. Before conducting the interviews, we sent a short survey to potential interviewees via LinkedIn, primarily asking the question whether their organization use BDA or BDA tools. The survey introduction included the definition of BD and BDA, along with explanations of what we meant by BDA tools, such as open-source programming, visualization tools such as PowerBI, Tableau and in-memory computing like SAP, HANA.

Based on the responses received regarding BDA utilization, we proceeded with the subsequent steps to conduct interviews. The selection criteria for interviewees were as follows: First, the utilization of BDA was considered a mandatory criterion. Secondly, the interviewees had to be from manufacturing industry and hold a position in supply

chain management. Thirdly, they needed to have more than four years of industry experience with involvement in decision- making related to technology, either directly or indirectly. Finally, interviewees were required to provide consent to share information about the factors and strategies related to BDA adoption.

The interviewees were contacted through e-mail and LinkedIn. After confirming BDA usage in their firms, interviews were conducted through physical or virtually, based on the interviewee's preference. Physical interviews were held at their respective offices, while virtual interviews were conducted via Microsoft Teams platform. During the interviews, all the participants were assured with confidentiality and anonymity. Semi-structured interviews were conducted, with questions pre-planned according to the research questions to ensure comprehensive coverage of the study's topic. This interview format allowed natural flow pf conversation, enhancing the quality of information shared by interviewees. The interview questions covered a basic introduction about themselves, the challenges they faced when implementing BDA, their perception on those challenges and lastly the steps they took to overcome them. Table 1 provide the information of the participants. The diversity in firms and years of experience provided with interesting insights.

Table 1. Details of interviews

Interview Information					
Respondent	Date	Discipline	Years of Industry Experience	Interview Length (in minutes)	Industry
RES_01	18/10/2024	Senior Manager	23	35 min	Aluminium Extrusions Manufacturing
RES_02	23/10/2024	Assistant Manager	11	36 min	Apparel and Textile
RES_03	01/11/2024	Assistant Manager	8	30 min	Sail Manufacturing
RES_04	05/11/2024	Senior Manager	29	30 min	Food and Beverages
RES_05	17/11/2024	Senior Manager	7	35 min	Apparel and Textile
RES_06	28/11/2024	Senior Manager	5	30 min	Automotive and Engineering
RES_07	05/12/2024	Senior Executive	17	35 min	Apparel and Textile
RES_08	12/12/2024	Assistant Manager	9	40 min	Electronics Manufacturing
RES_09	07/01/2025	Assistant Manager	8	30 min	Apparel and Textile
RES_10	16/01/2025	Assistant Manager	6	35 min	Food and Beverages
RES_11	19/01/2025	Senior Manager	10	25 min	Apparel and Textile
RES_12	24/01/2025	Senior Manager	7	30 min	Chemical Manufacturing

The length of the interview was up to the expected time length which is 30-45 minutes. The data collected through interviews are recorded using iPhone recorder and the transcripts are generated through Microsoft Word, and NVivo software to analyze and code data. The names of the organizations and participants have not been revealed to protect the identity and anonymity. To ensure the accuracy of the process of the interview, first interview was considered as

a pilot test. The main goal of assessing the first interview as a pilot test was to see whether the interview questions are understandable for interviewee, assess how the interviewee answers and whether the answers are relevant to the questions, to as well as to assess whether the structured questions are enough to satisfy the research objectives and research questions. At the same time, pilot test confirmed the approximate length of the interview, quality of the recording and accuracy of the transcribing instruments. After confirming the accuracy, other interviews were conducted. The table depict that most of the respondents were from senior level with more than 5 years of experience showing most of the respondent were well experienced and seasoned professionals.

3.2. Data coding

We focused on semantic themes, which are surface level patterns explicitly stated by participants to capture the straightforward meaning of the data. The collected data from interviews were analyzed by using thematic analysis, which is a widely used method for identifying, analyzing, and interpreting patterns or themes. While conducting the interviews researchers moved back and forth with the process of interviewing and data interpretation. For a successful thematic analysis, we followed Braun and Clarke, (2006), six steps. Which are familiarizing with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes and producing the report. Figure 1 presents the process of thematic analysis. Throughout the steps, the process of interviewing and transcribing was ongoing. To ensure consistency, the first ten interviews were transcribed and coded. During this phase, it became evident that the emergent codes and themes remained consistent across the interviews, with only minor variations. This consistency indicated that a high level of saturation had already been reached. Nonetheless, we continued conducting interviews to strengthen the findings and investigate the possibility of discovering new insights. As the analysis progressed, new themes appeared seldom and to a limited extent, providing further confirmation that saturation was being approached. This observation is consistent with the findings of Guest et al. (2006) who discovered that data saturation can be achieved with a sample size of twelve interviews. The process of interviewing happened between the month of October 2024 to January 2025. Between December 2024 and January 2025 final transcription and coding were performed. The qualitative finding is used to interpret the perceptions of industry professionals and the influence of the barriers on BDA adoption process. Practical strategies and recommendations are derived from the results of qualitative analysis.

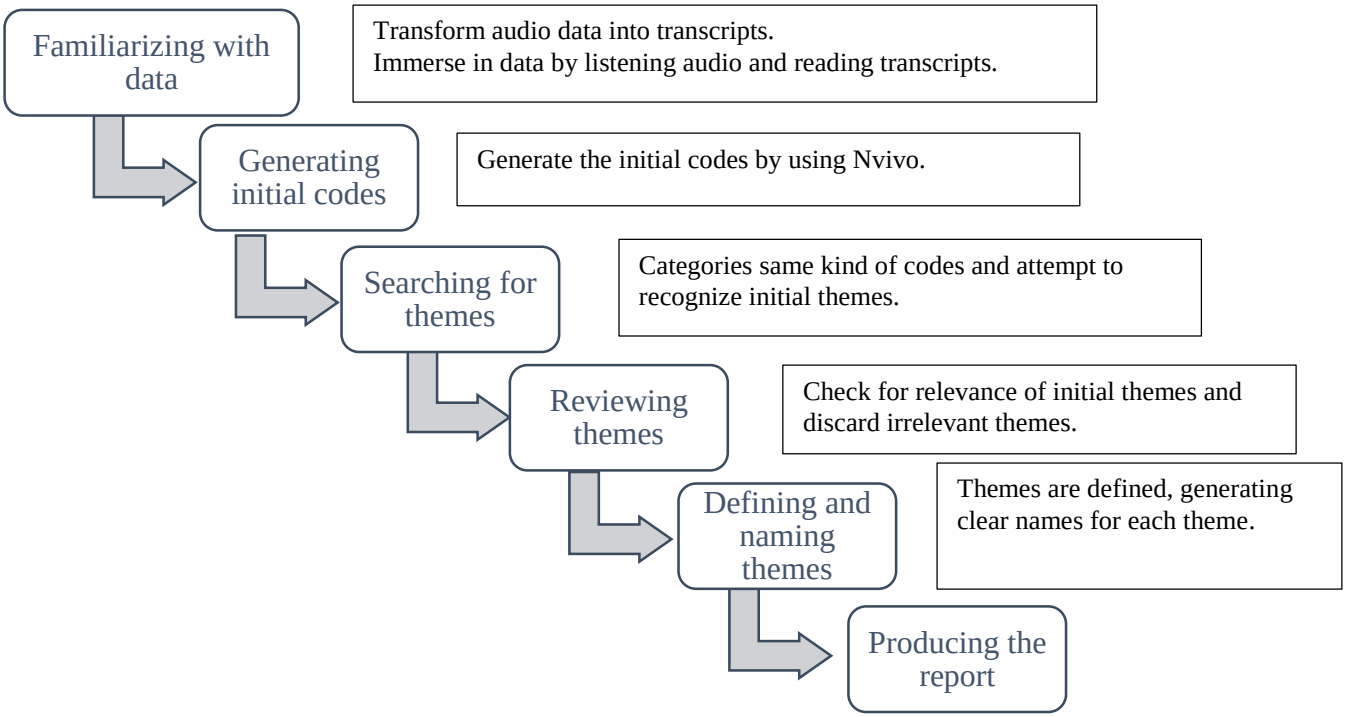


Figure 1. Thematic analysis steps

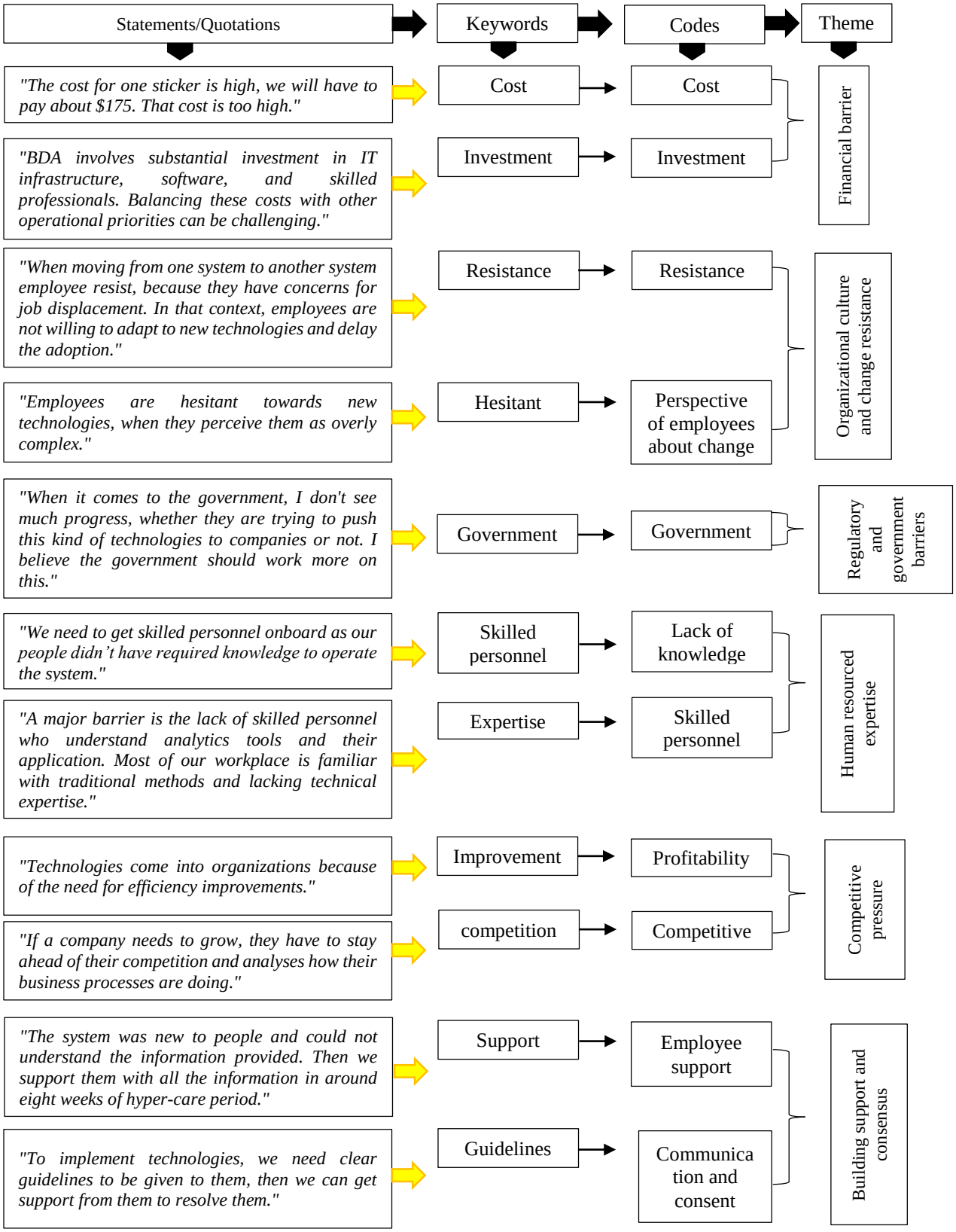
3. Findings

This section presents the results of the analysis, that we derived from the codes. The first part presents the different perceptions of supply chain professionals on barriers to BDA adoption. The second part presents strategies to overcome the challenges related to BDA adoption. Table 2 show the initial coding categories and sub coding categories.

Table 2. Initial codes generated

Initial Codes Generated		
Codes	**Categories**	**Themes**
Research Question 1: Understanding Barriers to BDA Adoption		
Cost, Investment	Financial constraints	Resource and financial barriers
Limitations, Complexity	Technical challenges	Technical and operational barriers
Resistance, Perspective of employee about change	Organizational resistance	Organizational culture and change resistance
People need, Relational need	Workforce requirement	Human resource and relational needs
Government	Regulatory environment	Regulatory and governmental barriers
Lack of knowledge, Skilled personnel, Training	Skills and knowledge gap	Skill gaps and training needs
Profitability, Competitive	Business impact	Competitive advantage and profitability
Research Question 2: Strategies to Overcome Barriers to BDA Adoption		
Employee support, Employee consent	Stakeholder engagement	Building support and consensus
BDA benefits, Educating	Knowledge empowerment	Increasing awareness and demonstrating value
Leadership, Training	Supportive leadership	Fostering a culture of support and development
Preparation	Planning and strategy	Strategic planning

Below Figure 2 represents the thematic analysis process and the final themes we generated, along with the sample statements from industry professionals.


Statements/Quotations
Keywords
Codes
Theme
"The cost for one sticker is high, we will have to pay about $175. That cost is too high."
Cost
Cost
"BDA involves substantial investment in IT infrastructure, software, and skilled professionals. Balancing these costs with other operational priorities can be challenging."
Investment
Investment
Financial barrier
"When moving from one system to another system employee resist, because they have concerns for job displacement. In that context, employees are not willing to adapt to new technologies and delay the adoption."
Resistance
Resistance
"Employees are hesitant towards new technologies, when they perceive them as overly complex."
Hesitant
Perspective of employees about change
Organizational culture and change resistance
"When it comes to the government, I don't see much progress, whether they are trying to push this kind of technologies to companies or not. I believe the government should work more on this."
Government
Government
Regulatory and government barriers
"We need to get skilled personnel onboard as our people didn't have required knowledge to operate the system."
Skilled personnel
Lack of knowledge
"A major barrier is the lack of skilled personnel who understand analytics tools and their application. Most of our workplace is familiar with traditional methods and lacking technical expertise."
Expertise
Skilled personnel
Human resourced expertise
"Technologies come into organizations because of the need for efficiency improvements."
Improvement
Profitability
"If a company needs to grow, they have to stay ahead of their competition and analyses how their business processes are doing."
competition
Competitive
Competitive pressure
"The system was new to people and could not understand the information provided. Then we support them with all the information in around eight weeks of hyper-care period."
Support
Employee support
"To implement technologies, we need clear guidelines to be given to them, then we can get support from them to resolve them."
Guidelines
Communication and consent
Building support and consensus

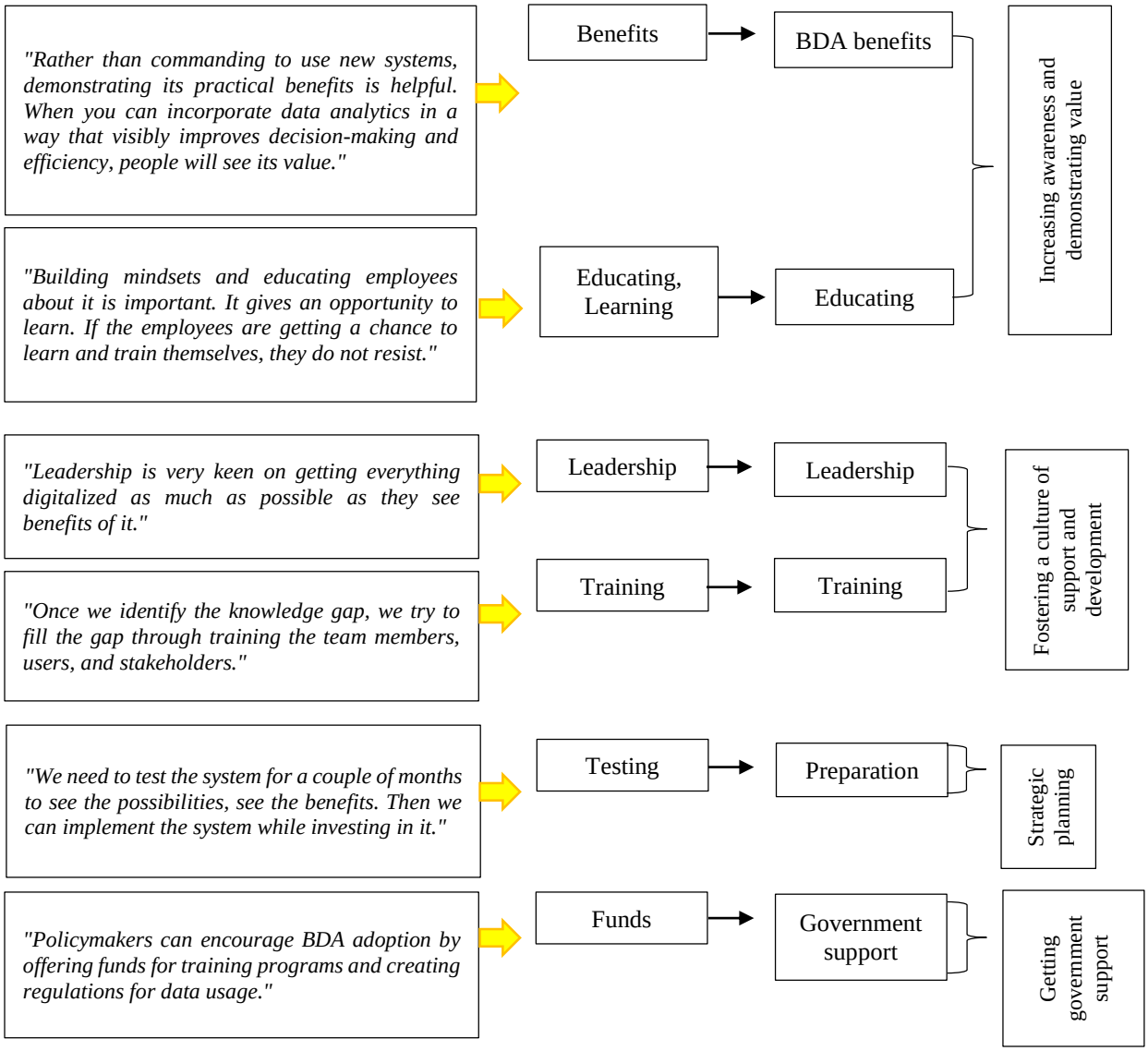


Figure 2. Inductive thematic analysis process

Afterwards, we developed a conceptual framework by conceptualizing and interpreting the themes. Below Figure 3 illustrates the conceptual framework of the thematic analysis conducted on the challenges of implementing BDA in supply chain operations.

Perception of Supply Chain Professionals on BDA Barriers

Through interviews, the focus was on gaining insights of supply chain professional on their perception of barriers to BDA adoption. Throughout the interview we were able to gain knowledge about them, and below the results are presented.

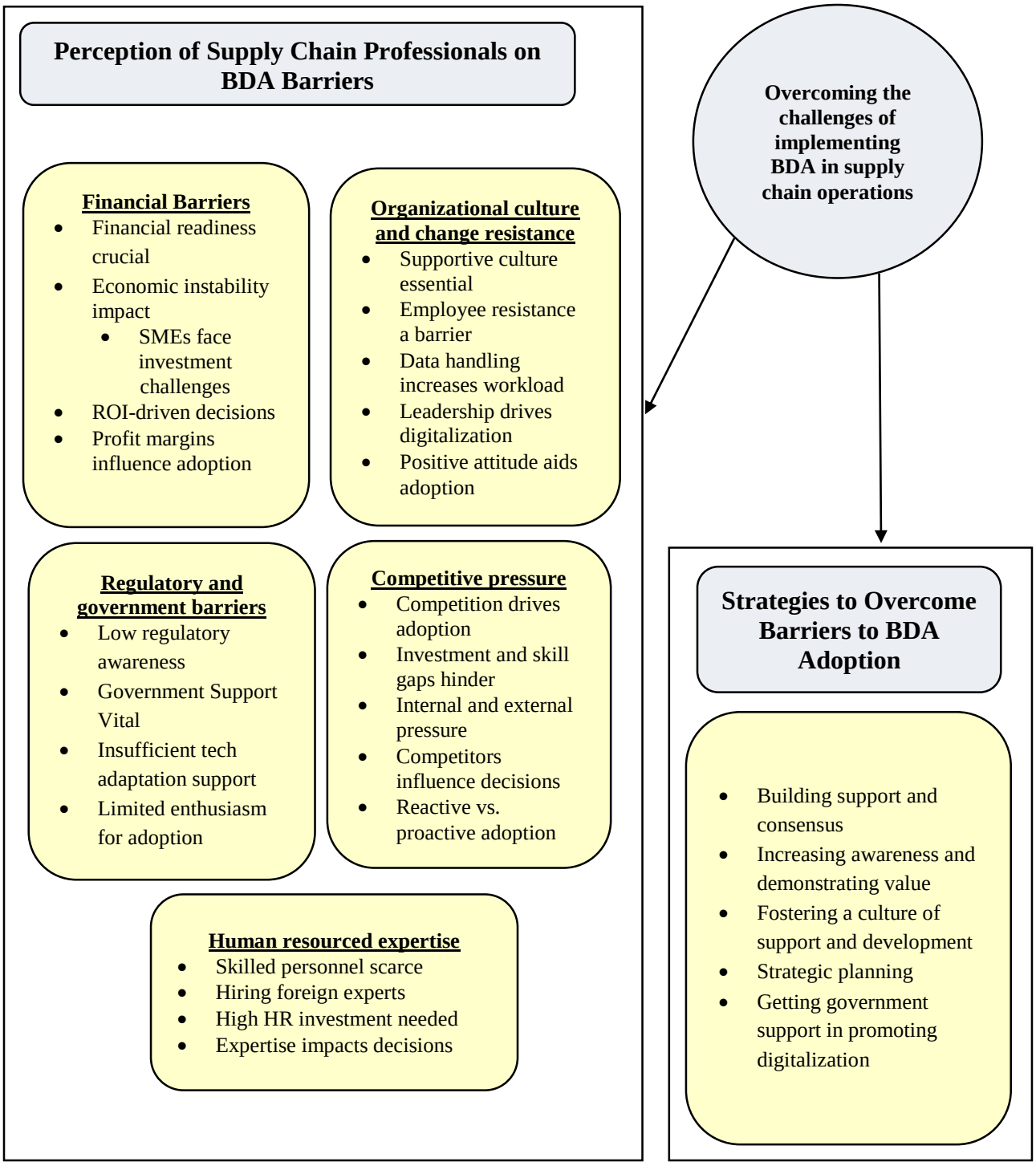


Figure 3. Conceptual Framework

Financial barrier

In term of financial readiness for BDA adoption emerged multiple times. As, to implement BDA in the organizations, the need for good financial capability is important. Most of the participants have point out that the organizations are hesitant towards technology advancement because of the financial capability, although they acknowledge the technological advancement is beneficial for the organization. Specially in countries like Sri Lanka, finance has been playing an important role. Participants mentioned that one of the main reason companies are unable to fully explore technologies is the unstable economy of the country, which directly affects their revenue. Another significant reason is the inflation. When companies do not achieve the expected profit from their business, it becomes difficult for them to invest in new technologies, even if they are aware of the potential benefits. Regardless of this issue, a participant pointed out that large-scale companies are, to some extent, able to invest in the technologies, tools, and infrastructure needed for BDA. In contrast, small and medium scale companies may take longer to adapt due to investment constraints. Moreover, companies often research these tools to ensure their investment are worthwhile, implementing the technologies, only if they are genuinely needed and provide effective and efficient results.

"Their turnover and profitability are too high, billions, so they can invest, our management also willing to invest all these different infrastructure and developments. But the problem is our revenue, and the profit is not matched with that. So that's why even now at the time of implementing the SAP system, we thought two, three times and we consulted A List management, and they insisted us to do it, otherwise we won't do it because the cost is billions."

Thus, from the interviews the insights from the supply chain professionals indicated that the regarding BDA implementation financial capability plays an important role. The decision to implement new technologies, lies in the aspect of the scale of the company, how important the tools are and what benefits that bring to the company, the profit margin of the company.

Organizational culture and change resistance

A supportive organizational culture and mitigating the resistance to change are essential when implementing new technologies. When decision-makers focus on introducing new technology to the company, gaining support from both the organization and employees becomes a critical aspect of the process. Without this support, implementing new technologies is unlikely to be successful. Similarly, a participant has mentioned that employee resistance had become a significant barrier to implementing and introducing new systems.

"The first impression was really bad for the SAP. The main concern was people do not like to change. They were using the previous system, and they had only little amount of data entries. I mean when we compare with the percentages earlier, we were entering only 5% to 10% of data into the system. Now we have to enter 80 to 90% of data into the system. So that's a gap."

The employee's resistance, or the negative attitude toward change, particularly when transitioning from one system to another that requires handling large amount of data, makes it challenging for organizations to implement new technologies. As the resistance can lead to low productivity, internal conflicts and dissatisfaction and discomfort in the organization. Hence, when implementing new technologies, the organizations focus on improving the attitude of the employees, for a successful implementation of technologies. While employees play an important role in making decisions regarding the adoption of technologies, top management or leadership holds a particularly significant position. The interviewees mentioned that the top management or the leadership is very enthusiastic when it's come to introducing new technologies to the company and they continuously encourage to conduct research and bring the benefactive tools, systems to the organization.

"When it comes to digitization, it is at the forefront of our strategy. The leadership is very keen on getting everything digitalized as much as possible. Because they see the benefits of it. They are cascading down that same message to the lower teams as well."

When the leadership and the attitude of the employees are positive, the professionals in the supply chain are encouraged to make decisions regarding implementation of technologies like BDA.

Regulatory and government barriers

In a country it is vital to have the support of government and follow the regulatory related to technology for an effective decision making process for implementation of technologies. In Sri Lanka, the awareness of regulatory related to technology implementation seemed to be less, as the participants did not have a proper idea. The government support and regulatory had different perspectives from the interviewees. As some of them have mentioned that the government involvement is at a 50-50 and some have mentioned that the government have no effect in any process of the implementation. The participants have expressed the support of government, "*That is 50, 50. There are some. There are some situations where we cannot import some material, especially this kind of technology",* suggested that the government can invest in these technologies. Similarly, a manager mentioned that "*when it comes to the government, I don't see a much progress, whether they are trying to push this kind of technologies to companies or not. I Believe the government should work more on this".* Through the interviews it was confirmed that the government support or support through regulatory is not sufficient. The less involvement in supporting technology adaption, leads companies to overlook the benefits of technologies and not being enthusiastic about it.

Human resourced expertise

The participants have explained, as much as BDA is a beneficial tool for organizations especially for supply chain operations, special skills are needed to handle this tools/software. The skilled personnel in the industry or the market is very less, making it hard to take decisions regarding implementation of technologies. In some situations, the companies have to recruit specialists from foreign countries to use these technologies, or recruit absolutely new employees to the company, as respondents have mentioned, *"we recruited one guy from the UK to fight with the international market"* and *"we had to recruit around 120 people only to run this system as I could recall".*

To fill this gap, the organizations need to invest more on human resources, again a financial aspect of implementation. Further some organizations will not be able to fully capture the benefits of BDA and will consider the gathering or encouraging of human resources as a positive investment. Only few of professional will support to fill the skill gap and only IT professional or data professionals will understand the full capability of BDA and boost the process of giving training or gathering human expertise to the company. Further, the lack of expertise in BDA, will influence the decision-making process, when expertise is not available, they will have to come with some strategies to make sure the success of technology implementation.

Competitive pressure

The participants have emphasized that competitive pressure work both as a motivator and a barrier to implement BDA. As the companies wants to maintain to be in the competitive market by adapting to new trends, at the same time they are conflicted with the amount of investment and lack of skilled personnel in the industry. A participant has mentioned that *"Technologies come into organizations because of the need for efficiency improvements. The real challenge is how organizations use these systems and their willingness to embrace such opportunities. The difference between in how each organization use them. What is the willingness of employees to take these opportunities?"* The interview revels that competitive pressure does not only come from external competitor, but also from internal drives such as employee adaptability and organizations willingness. While competitive pressure motivates organizations adopt new technologies and creates sense of urgency, the final decision to adopt BDA lies in the hand of a supportive organizational culture where employees are open to learn and adapt to new technologies.

Further it has become clear that organizations often get influence by their competitors, when it comes to adaption of technologies. Particularly, a senior manager has mentioned that *"Even our competitors are using this barcode system. Now we got contact the supplier who implement the barcoding at the competitor. Now we are in the process of discussing with them and we will try to implement that."* This statement highlights how competitors influence the decision making and how it not only raises awareness about the technologies but also provided with possible path to implementation. The analysis highlights how competitive pressure accelerate the adoption of technology process. However, this might lead to reactive nature, rather than proactive nature, where the company will not be able to explore full capabilities of the technology. The statements provide a critical insight that competitive pressure as a barrier alone is not sufficient to drive the technological adoption, it should be aligned with strong commitment to embrace change.

Figure 4. Word cloud of the responses received from supply chain professionals

Strategies to Overcome Barriers to BDA Adoption

Focusing on the next research question related to qualitative, the findings are focused on potential strategies to overcome the barriers related to BDA adoption.

Building support and consensus

The participant frequently highlighted the importance of internal understanding and alignment when it comes to overcoming these barriers. Having consensus and building support across all the level of organization have been recognized as a key strategy. The participants have mentioned that the open communication and participation in decision making mitigate the possibility of resistance among employees. As this creates a shared sense of purpose and build a strong foundation for implementation among employees, aligning their goals and organization goal together.

Increasing awareness and demonstrating value

Conducting awareness programs about BDA benefits and showing its value is another strategy. Participants highlighted that showcasing tangible outcomes reduce the resistance related to adaption. A senior manager has emphasized. *"I think we can show some data. How we can save money, how we can take real decision from the gathered data. Then employees are aware of the ultimate benefits of that."* Reaffirming the statement other participants said the same statement, that more the employees get exploration to the implementation process or the knowledge of the benefits of the usage of technologies, their willingness to accept the technologies increases. Further the participants mentioned to demonstrate the value, small-scale projects help as they build confidence and encourage the acceptance rate of BDA initiatives. Taking data-driven decision and showing the visible outcomes to employees build trust in the system and mitigate resistance.

Fostering a culture of support and development

Participants has emphasized on the importance of having a supportive organizational culture, to successfully implement new technologies. A key strategy participant has mentioned is changing the attitude of the employees and providing necessary skill training to them. The respondent mentioned, *"We are giving some financial benefit for them, and we try to convert their mindset to the positive side. Other than that, we provide training, this kind of attitude changes, and skilled personnel recruits."* The statement indicates the importance of fostering positivity and readiness within the working environment. Providing financial incentives, training programs and recruiting skilled personnel reduce the resistance and build the confidence among employees regarding adopting BDA. Supporting the above statement, another participant highlighted, *"We can focus on training and development, foreign training, expertise,*

resource requirement and what devices we need. Then people automatically become willing to implement this system." Addressing resource and knowledge gaps helps to create readiness and enthusiasm among employees. Further providing targeted training ensure the employees feel secure about the process. While the all the participants agreed on providing training and fostering a supportive environment is a key strategy, further participants, emphasized benefits of creating a specialized team within the organization and providing continuous training to digitalization and BDA adoption, *"we have separate teams that are solely focused on digitalization. We can take our requests to them, and they'll help us with that. These teams conduct frequent training on these tools and make teams aware."* This shows how the establishing a dedicated support team, providing regular training, filling knowledge gaps through recruiting skilled personnel, fostering an environment of collaboration, reduce organizational barriers and promote the adoption of BDA practices.

Strategic planning

The theme strategic planning emerged as a vital component to overcome barriers, with participants highlighting need for structured processes and traceability. A senior manager elaborated, *"We mapped all the operations and created a system to ensure traceability. For any upgrades or new implementations, we have a prepared map consisting of all the required points. This allows us to track progress and ensure each step meets our requirements."* Further it was highlighted that the implementation should happen parallel for a successful implementation. As it gives employees time to adjust, and the company will be able to conduct their daily operations without any hinder. If the new systems are implemented suddenly and older system is abruptly removed, it might decrease the performance of the organization, further it reduces resistance. It is also important that the organization to have strategic oversight to identify importance of digital transformation. *"Whatever data that we have done manually, we are trying to digitalize those. We are internally monitoring how many reports we have digitalized; how many reports we are doing."* This reflects a proper strategically structured approach where management is actively encouraging digitalization initiatives and track progress to ensure smooth transition. Through strategically planning the technological initiatives the management is able to mitigate most of the barriers related to implementation, proving it as a key finding.

Getting government support in promoting digitalization

Participants have acknowledged the role of external assistance, such as government in overcoming the barriers to adopt BDA. The participants have emphasized the government can play a crucial role in providing guidance, funding, or raising awareness regarding technological implement to encourage internal forces. *"Definitely we can beautifully manage this if we get support from the local body as well."* This emphasizes the role of collaboration with local authorities and government present as a bridge that reduce the gaps during the transition to BDA. Whether through policy incentives, funding, awareness programs, and advisory services, this kind of support from the government helps organizations to manage implementation challenges more effectively.

5. Conclusion

The adoption of BDA in supply chain operations is gaining attention globally, with businesses recognizing its potential to enhance decision-making, operational efficiency, and competitiveness. However, the manufacturing sector of Sri Lanka faces several barriers to implement BDA successfully. The study explored the perceptions of supply chain professionals on barriers to BDA implementation and identified strategies to overcome them. The finding highlights that while organizations acknowledge the importance of BDA, barriers such as financial barrier, organizational culture and change resistance, regulatory and government barriers, and competitive pressure significantly hinder the implementation efforts. Through this qualitative exploration, it was evident that overcoming these barriers requires combining support of internal organizational initiatives and external support. The study contributes to existing knowledge by providing a deeper understanding of challenges in BDA adoption and practical strategies that organizations can leverage for a smoother implementation.

5.1. Contribution to research

This paper extends understanding of factors influencing BDA implementation in supply chain operations within Sri Lanka's manufacturing sector. The qualitative approach allowed an in-depth exploration of supply chain professionals' perspectives, which revealed key barriers and their interconnected effects on BDA adoption. The study found that building support and consensus, increasing awareness and demonstrating value, fostering a culture of support and development, strategic planning, and getting government support in promoting digitalization play a vital

role in determining the success of implementation. This study provides an empirical basis for addressing the unique challenges Sri Lankan manufacturers face. The finding contributes to the theoretical discussion on BDA adoption, emphasizing the internal and external dynamics of an organization that influences decision-making processes in supply chain operations.

5.2. Contribution to practice

This paper offers insights into overcoming barriers to BDA implementation in manufacturing supply chain from a practical perspective. It highlights the importance of organization and leadership support, providing support and strategic planning as pivotal factors in mitigating resistance. Managers and decision-makers can use these insights to develop structured roadmaps for BDA implementation, by addressing the challenges through step-by-step approaches. This study also underscores the significance of partnerships with external support in effectively enhancing BDA capabilities. Organizations can create an innovative environment for BDA adoption by focusing on internal and external factors, ensuring long-term benefits for supply chain operation enhancing its efficiency.

5.3. Limitations and future work

Despite its contribution, this study has certain limitations. First, the research focuses only on the Sri Lankan manufacturing sector, limiting the generalizability of finding to other industries or regions. Future research could extend the study to other sectors, such as retail and logistics, identify industry-specific challenges and solutions. Second, as a qualitative study, the finding is based on subjective perceptions gathered through interviews. While thematic analysis ensured robustness, future studies could employ mixed-method approaches, incorporating quantitative techniques to measure the impact of identified barriers. Third, this study primarily captured insights from middle and senior management professionals. Further research could explore perspectives from operational-level employees and technology experts to gain more comprehensive understanding of barriers to implementing BDA.

By addressing these limitations, future studies can refine and expand the knowledge on BDA implementation strategies, contributing to more effective digital transformation in supply chain operations.

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