

## Challenges in big data adoption for Malaysian organizations: a review

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### ABSTRACT

Big data has played an ever-increasing role in various sectors of the economy. Despite the availability of big data technologies, many companies and organizations in Malaysia remain reluctant to adopt them. Numerous studies have been published on big data adoption; however, there is a lack of research focusing on identifying the challenges faced by Malaysian organizations. Therefore, this study will implement the technology-organization-environment (TOE) framework to examine the challenges faced by Malaysian organizations with regards to big data adoption. A systematic literature review (SLR) was conducted to examine the challenges. From the result of this study, it was found that the factors from technology context are deemed to be the major challenge faced in big data adoption followed by organization and environment factors. Furthermore, the insights derived from the TOE framework-based information can help address concerns that hinder big data adoption among organizations in Malaysia. Finally, this study concludes with several recommendations.

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## 1. INTRODUCTION

Big data is a technology that has been rapidly gaining popularity from organizations looking to seize advantage opportunities. There are three main key characteristics of big data evolution, volume, variety, and velocity. Big data can be qualified as any data that is onerous to be processed by the traditional data pipeline. Big data has huge application opportunities across all sectors of industries. Therefore, by adopting big data, organizations and companies can leverage its unique characteristics and functions to improve the performance of their businesses.

In the past decade, numerous countries have harnessed big data to bolster their economies. For instance, in 2022, the United States' general data protection (GDP) was positively influenced by approximately 2.1% due to big data applications. Similarly, China's GDP received a notable boost of around 2.99% in the same year, showcasing the global significance of big data in economic growth. In industries, such as manufacturing and healthcare, big data analytics have facilitated smarter decision-making, predictive maintenance, and improved resource allocation [1]. This has led to substantial cost savings and enhanced efficiency.

The Malaysian government has launched several initiatives in recent years to digitalize Malaysian economy sectors [2]. In 2021, Malaysia government has launched the Malaysia Digital Economy Blueprint (MyDigital) to strategically position Malaysia in a competitive position in the world economy. This initiative aims to accelerate the digital integration of Malaysian organizations to make them more competitive in

domestic and international market. Despite the government's effort, a study [3] have found that most Malaysian organizations especially the small, medium enterprises (SMEs) are reluctant to adopt big data technologies. A common reason to this is due to the high resources and time investment required for adopting big data technologies [4]. Besides that, maintaining big data capabilities requires a large pool of highly skilled workers, which smaller companies such as SMEs and startups do not have the financial resources to invest in [5]. There are several studies [6]–[12] conducted to study the factors and challenges influencing the adoption of big data technologies. However, there are limited studies concerning challenges faced by Malaysian organization. A study in 2021 [13], reviewed the challenges faced by Malaysian firm based on the Lessig's modalities which view the challenges based on the legal, architecture, social, and market factors. Although this study has provided several insights into the big data implementation in Malaysia, it is important to note that the information presented primarily focuses on a managerial and socioeconomic standpoint. This study will investigate the challenges face in big data adoption by conducting a systematic literature review (SLR) to review the challenges of big data adoption faced by Malaysian organizations based on the perspective of technology-organization-environment (TOE) framework.

## 2. TOE FRAMEWORK

The TOE, a framework proposed by Tornatzky has been widely used to predict the adoption of a recent technology as it views the adoption of a technology from three contexts, namely technology, organization, and environment [14]. Therefore, this study will review the big data adoption challenges faced by Malaysian companies based on the TOE framework. The framework views the adoption factors from 3 contexts as follow: i) technology: factors related to technology and innovation; ii) organization: factors related to companies or organization capabilities and supporting infrastructure; and iii) environment: factors related to external environment such as competitors, market, or government policy.

TOE framework has been widely implemented to investigate or review the challenges and factors affecting technology adoption. There have been several variations of factors assigned to the three different contexts throughout different studies. In this study, we adopt the factors of each context based on a study carried out in Korea investigating the influence affecting big data adoption in the country [8].

In the technology context, perceived benefits, system ease-of-use, compatibility, data security and privacy are selected as the factors affecting big data adoption. Perceived benefits is use to view how much value, potential and advantages technology can bring to a company [15]. System ease-of-use represents how easy it is to implement and operate the system. System ease-of-use is related to usability and how easy it is to train staff in using the system. Thus, it can significantly affect the adoption of technology [16], [17]. System compatibility represents how easy is to integrate data from the previous system. When upgrading or adopting new technology, a company will always prefer the new adopted technology to be compatible to the workflow or data from existing system to prevent work disruption [16]. The security and the privacy of data involve the risk of data breach and privacy risk. The risk of data security has been one of the primary concerns in adopting big data.

The management support, information technology (IT) infrastructure and financial capability are considered as factors in the organization context. Management support represents how the management in a company and organization view the importance of big data [18]. The recognition of the benefit of big data by the top management of a company can significantly affect the drive to adopt big data. The IT infrastructure in a company is related to the capability of a company's IT infrastructure to support the adoption of big data [17], [19] Companies with good IT infrastructure that can utilize the full potential of big data tend to be more successful in adopting big data. Financial capability represents how much investment a company can make in adopting big data. Big data require a lot of financial investment thus a company with a good financial strength can make the adoption process smoother [16], [19].

The factors of environment context are related to external factors such as competition pressure, partner influence and government support. Competition pressure refers to the pressure asserted by a rival company to push a company to adopt big data to keep up with the competition [20]. Partner influence is an influence cause by a company in partnership adopting big data. Competition pressure and partner influence are view as a primary motivation in adopting big data. Government support refer to the degree of influence from government economy stimulant to adopt big data. The government support of data regulatory can be seen as a factor to push big data adoption [21], [22].

## 3. SYSTEMATIC LITERATURE REVIEW METHOD

This study employed preferred reporting items for systematic reviews and meta-analyses (PRISMA) method to conduct comprehensive online repository search and literature review on big data adoption by

Malaysian organizations. PRISMA is a methodology for reporting systematic reviews by using evidence-based minimum set of items [23]. This literature study also highlights the challenges of big data adoption faced by Malaysian organization based on the contexts in TOE framework.

**3.1. Selection method**

The literature was collected from Google Scholar using keywords such as: “big data”, “challenges” and “Malaysia”. To identify the recent challenges faced in big data adoption in a relevant perspective, this study selected the literature from the past 4 years from the date of this study (2019 until 2022) for investigation [24]. Figure 1 shows the PRISMA flowchart of this study. There are a total of 200 articles found in the identification phase. One article is excluded due to duplication. In the screening phase, 13 articles are not retrieved due to not having access to full text article. When assessing for eligibility, 101 articles before 2019 are excluded and 25 articles are excluded due to not being related to big data adoption. Another 20 articles were excluded because it was not specifically related to Malaysia, therefore leaving 30 articles to be included in this study.

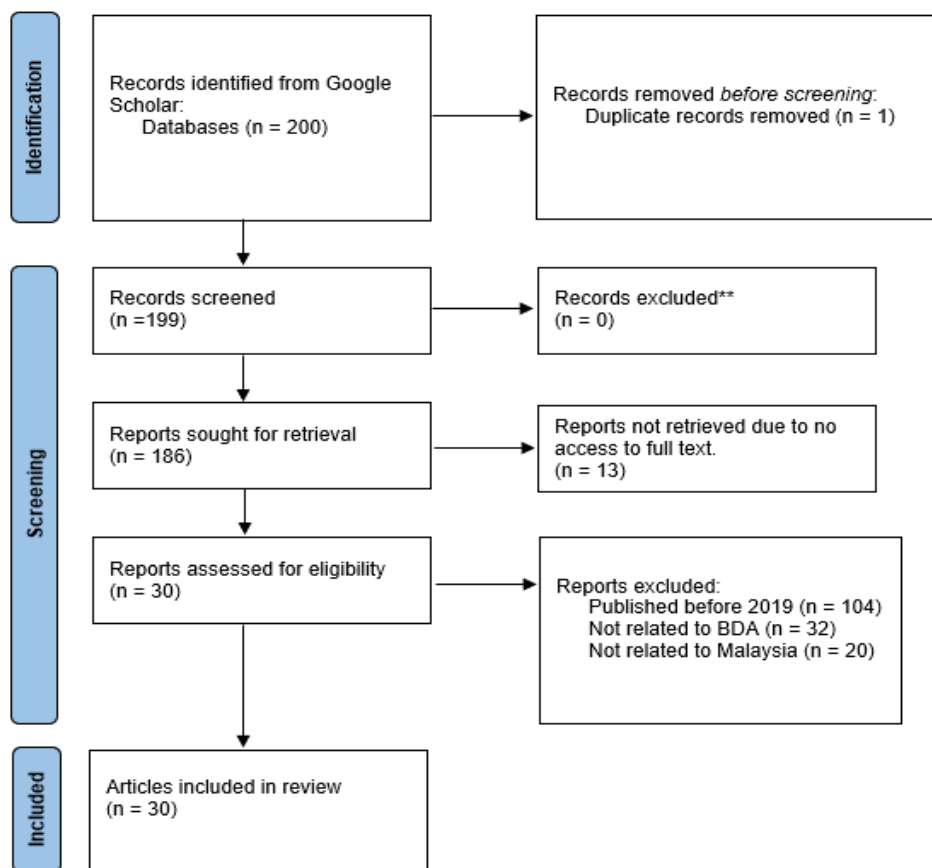


Figure 1. PRISMA flowchart

**4. FINDINGS AND DISCUSSION**

The studies reporting big data adoption challenges faced by Malaysian companies and organizations based on the contexts of TOE framework is shown in Table 1 and Figure 2 respectively. Among the reviewed articles there are a total of 23 articles stating the factors from technology context as challenge while 11 articles acknowledge the challenges come from organization context. Meanwhile, 8 articles noted that the factors from environment context posed a challenge for big data adoption among Malaysian companies and organizations. There were 9 articles found in the year 2019. A total of 8 articles were found in each year of 2020 and 2021. There were 5 articles found in 2022 respectively. Based on these literature findings, the taxonomy of challenges pertinent to Malaysian organization is shown in Figure 3. From Table 1 and Figure 3, it is obvious that the major challenge comes from technology factors followed by organization and environment factors. The following subsections will further discuss the findings from each contexts.

Table 1. Summary of article discussing challenges faced in big data adoption

Contexts	Number of articles	Challenges	Articles
Technology	23	Complexity and compatibility	[25]–[40]
		Lack of experience and talent in workforce	[38], [41]–[45]
Organization	11	Data security	[31], [46]
		Influence of top management	[30], [35], [38], [44], [46]–[50]
		Financial capability	[35], [38], [48]–[51]
Environment	8	IT infrastructure	[38], [44], [47]–[49]
		Legal challenges	[35], [41], [46]–[48], [50], [52], [53]
		Government regulation	[46], [50]

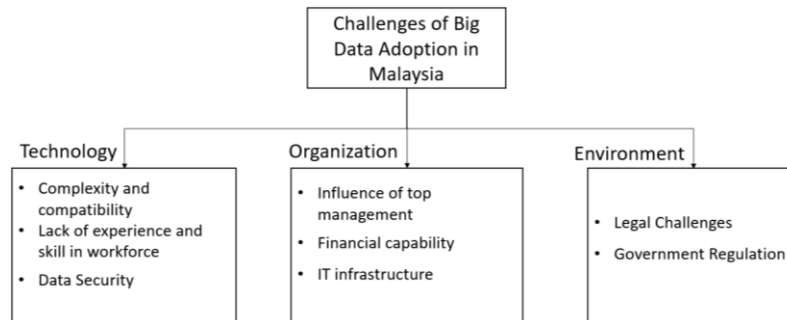


Figure 2. Challenges of big data adoption in Malaysia

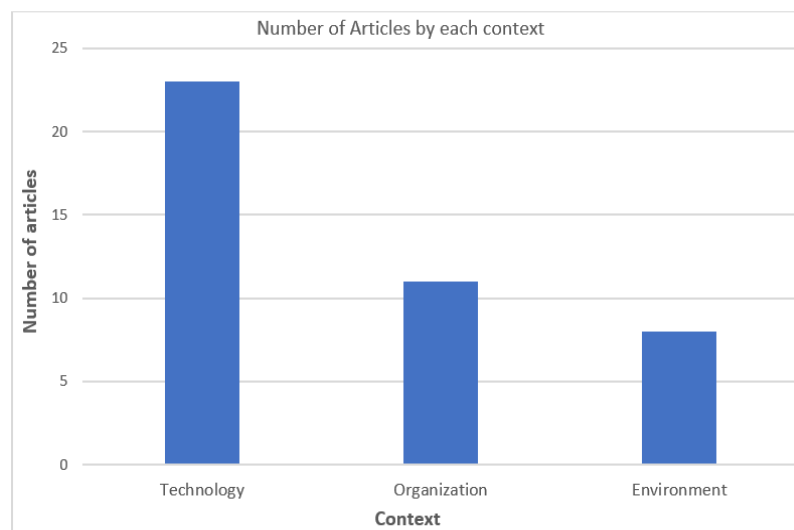


Figure 3. Number of articles by each context from TOE framework

#### 4.1. Challenges from technology context

##### 4.1.1. Complexity and compatibility

Big data common characteristics are defined by 3 Vs (volume, velocity, and variety) [54]. Data complexity is related to the “Variety” of data which include high dimensionality, complex relationships, and many other factors in a data [55]. Preparing data for analytic is the core process of big data analytics. Data analytics is a technique that is used to access and extract useful information from large-scale raw data to support decision making [56]. Therefore, data analyst is required to understand the relationship between feature in data set to obtain optimal analytic result. The rapid growth of data had contributed to the complexity barrier in big data adoption in Malaysia as shown in Table 1. This barrier comes from the uncertainty from incomplete information which causes noise in the dataset which can hamper the accuracy of analytic results [57]. Data compatibility has also become a primary concern in the process of data integration and interoperability between 2 different data architecture [40]. According to Adnan *et al.* [34], the use of data

from 2 different systems can cause problems in data integration due to diversity in data type and lack of harmonization between different data. A study had proposed the use middleware to integrate the spatial and non-spatial data in National Lake Database of Malaysia (MyLake) [40]. The proposed middleware model can improve the interaction between integration layer and provider. Moreover, the proposed middleware can protect the heterogeneity of the database. Therefore, it is important for organizations to recognize and familiarize with data processing pipelines.

#### **4.1.2. Lack of experience and skill in workforce**

Big data technologies require a considerable amount of knowledge and skill to take its full advantage [58]. Thus, operating big data technology requires staffs with technical expertise [44]. One of the challenges faced by Malaysian organizations is finding the right talent to implement big data for their organization. The lack of access to experienced workforce causes some companies to divert more resources and time in training inexperienced staff [35]. The lack of experienced staff can lead to difficulties in solving technical issues which can ultimately lead to the failure of implementing such technologies. This is also supported by prior studies stating that the difficulty of workforce recruitment has discouraged organization management on making decision on adopting big data [9], [58]. According to the finding in our study, the high skill requirement to operate big data has also made recruitment of talent workforce become a challenge among organizations [59].

#### **4.1.3. Data security**

Data security is always a concern in big data due to the ability of big data to process a large volume of data which may contain sensitive data. The main use of big data for an organization is to process the collected information such as customer information into useful insight which can benefit the organization. Such data are prone to integrity attacks; such as modifying user data or transaction which can mislead operational decision and cause security and legal implications [60].

The huge volume of valuable data from organization data centers often attracts hacker attack and other cybercriminal activity. The stolen data can lead to widespread data breaches [9]. For example, a data breach from Malaysian Election Commission, Suruhanjaya Pilihan Raya (SPR) has caused more than 800,000 data being exposed which include details such as identification number, email, residential address and identification image. These types of security issues often require system update to patch security holes [45]. Therefore, the ability to recognize cyber security threats is crucial. It is also important to raise awareness on how the attacks are carried out and its consequences to make big data adoption more approachable.

### **4.2. Challenges from organization context**

#### **4.2.1. Influence of top management**

The top management of an organization can greatly influence how an organization functions [49]. Thus, it is important for the top management to understand the fundamentals of big data to ensure its smooth adoption. Technology readiness indicates how ready is an organization to deal with new technologies and therefore the management of an organization have to support the needs towards big data adoption.

The top management of an organization often make decision on technology investment. This is further supported by studies stating that the interest of top management in big data can influence the financial investment in big data adoption such as staff training and infrastructure that can support big data. In Malaysia too, the obstacle comes from the reluctants of top management towards technological changes [38]. This will cause the whole organization to follow the decision, which can slow the adoption process. Tasmin and Huey [49] stated that top management support is exceptionally important for smaller organizations such as SMEs. It is therefore important for top management to understand the benefits of these technologies and take necessary actions to ensure a smooth adoption process.

#### **4.2.2. Financial capability**

Even when companies show interest in big data, adopting the technology requires a significant amount of financial commitment which consists of initial cost of IT infrastructure set up, software development and staff training [58]. Therefore, smaller organizations with limited financial resources may be reluctant to adopt these technologies. The financial capability of an organization is one of the factors that drive the adoption of new technology [61]. However, one of the primary reasons that make the organizations reluctant to invest in new technology and IT infrastructure is the uncertainty in new technology itself [61]. Thus, making smaller companies in Malaysia with limited financial capability to be very cautious in adopting new technology such as big data [50]. Organizations with strong financial resources can invest more in capable IT infrastructure to support big data adoption as weak IT infrastructure can lead to the failure of big data adoption. Moreover, big data requires technical skills to operate effectively so organizations will also need to invest in staff training or even hiring competent staffs.

### 4.2.3. IT infrastructure

Big data IT infrastructure refers to both software and hardware requirements to operate big data technology. Furthermore, it requires storage system and network infrastructure that can support high bandwidth while processing data. Therefore, organizations need to have proper infrastructure to support the use of the technology as most of the legacy hardware and software may not support big data implementation [62]. Lacking the required infrastructure is still one of the major factors for most of the companies in Malaysia.

IT infrastructure forms the basis of computation capabilities which is required for business and functional capabilities when adopting big data. The key success of an organizations in this current digital era is to achieve it intended objectives using the available information from various sources [63]. Therefore, the IT infrastructure of an organization must be flexible in handling all types of information. In the case of operating big data, the infrastructure must ensure the data quality does not compromise in the entire data analytics pipeline.

## 4.3. Challenges from environment context

### 4.3.1. Legal challenges

Big data poses common legal risk to organizations and companies due to the sensitive nature of the data circulating in the big data ecosystem. The data may contain personal information such as names, addresses, bank details or other identifier that can compromise individual privacy. Thus, specific laws are required to sensitive personal information of individuals. This example can be seen in some countries where organizations and companies are not allowed to track customer digitally [64].

The ability of big data to process and gather insight from large volumes of data has brought many advantages and new opportunities. Despite the advantages, data such as customer and personal data has sparked some controversy regarding the legal aspect in Malaysia. This study found that there are some inconsistencies in data privacy law had make some organizations in Malaysia cautious in adopting big data [49]. The study stated that big data has caused controversy to some principles of personal data protection act 2010 (PDPA 2010). The inconsistencies in the legal aspect can complicate data security problems which can turn away some companies from using big data. We had compared Malaysian PDPA 2010 to general data protection regulation (GDPR) of European Union [46], [65] in section 3.4.

### 4.3.2. Government regulation

Government through its regulation can enact policies to encourage organizations towards big data adoption [66]. However, organizations may still be reluctant to adopt big data if the legislation and technological standards does not favor them [9]. Thus, it is crucial for Malaysian government to work together with legislative bodies in integrating big data into the nation's technology regulation to incentivize and stimulate the use of big data in various industry sectors including government agencies.

Furthermore, the ability of the government to support big data ecosystem is important to promote economic growth as big data movement has the potential to transform business productivity. This factor had been discussed in several studies which stated that government plays an ever-increasing role in digital transformation [46], [50]. The government has a big responsibility in reducing the digital gap between technology developed regions [67]. Moreover, government support can also be beneficial for smaller organizations such as SMEs where the government can provide assistance to help them overcome barriers that prevent big data adoption [66]. As a summary, government can be the precursor to drive the adoption of new technology as regulation in big data can result in a more transparent and better management of digital information.

## 4.4. Comparison of challenges faced by organizations in Malaysia to other countries

This section compares the result of this study with the studies conducted in other countries. It was found that there is a similarity in the composition of challenges based on the TOE framework. The composition of the challenges is lead by technology challenges and then followed by organization and environment challenges. In the technology challenges, the complexity and compatibility factor are the most discussed factor in several studies [68], [69]. This main concern in this factor is the difficulty to integrate big data into existing systems. For example, the major barrier in adopting big data in the health care sector is due to data compatibility issues in integrating big data into electronic health records (EHR) [70], [71]. This concern was discussed in studies carried out in the health care sector of Malaysia, United States and Europe [34], [41], [70].

The challenges of finding talents and expertise are also widely discussed in other studies. Based on a study conducted in Iran, the difficulty in finding talents has become the main obstacle for small organizations in adopting big data [72]. Both studies have found out that companies and organizations are unlikely to adopt

big data if it does not have sufficient talent to implement the technologies. Therefore, employee with the appropriate skills plays an important role in influencing companies and organizations in adopting big data.

Besides that, data security factor is also a major concern, globally [62], [72]–[74]. One of the studies stated that the lack of technological capabilities for big data security was the major cause for this problem [73]. Most of the data protection method are based on traditional method such as traditional anonymization, fuzzy and cryptography technology which has little success in protecting data in large scale [75]. Thus, cyber-attack toward major data centre can be devastating for personal data privacy and national security [74] which can be seen in the SPR data breach in Malaysia and also other major global cyber-attack [76].

In the organization challenges, several studies found that the influence of top management factor plays a significant role in big data adoption [77], [78]. This finding is also supported by a study in China stating that top management readiness is the most important factor in big data adoption [79]. On the other hand, a study carried out in the agriculture sector in United States yielded different findings [80]. The study found that the age of a person can influence the adoption of big data. This is due to the fact that younger people having more exposure to new technologies and the older people are less comfortable to embark into new technologies. Thus, the study stated that companies with younger people in their management are more likely to adopt big data [80].

From the aspect of environment challenges, a study in Saudi Arabia stated that seeking big data compliance with data protection laws and regulations can be challenging due to unorganized large data [61]. This situation can also be seen in Malaysia, in the case of PDPA 2010 where data privacy law is vaguely defined for big data. On the factor of government regulation, most of the studies from other countries acknowledge the government regulation play an important role in big data adoption [58]. However, a study investigating SMEs big data adoption in Iran found that the investment of big data is too huge that government incentives are not enough to encourage big data adoption [77].

#### 4.5. Mitigation recommendations

There are several ongoing initiatives aimed at transforming Malaysia into a digital nation, with a strong focus on the adoption and utilization of big data. For example, Malaysia Digital Economy Corporation (MDEC) has spearheaded several initiatives, such as global online workforce (GLOW), aimed at providing training for gig workers in the digital economy. Another notable initiative is eLadang, driven by MDEC, which aims to fully digitalize Malaysia's agricultural economy using big data and the internet of things (IoT). Through eLadang, MDEC provides digital training and promotes collaboration between the agricultural community and technology partners. The Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), one of the prominent government agencies in Malaysia, that is responsible for 'modernising and reforming' the public sector, has implemented several public sector big data analytics plans. This includes improving government services delivery through data analytics and enhancing the landscape of information and communications technology (ICT) environment by leveraging public sector's existing data assets and integrating new data sources. In light of these efforts, we propose several strategies to address the current challenges and mitigate potential future challenges in big data adoption.

Education plays a crucial role in facilitating big data adoption. While the Malaysian government has made significant efforts to provide training in the digital economy, the existing coverage falls short of meeting the demand for skilled professionals. Hence, it is imperative for educational institutions in Malaysia to take an active role in fostering talent. This includes emphasizing the importance of developing a mutual understanding between industries and universities to ensure that students acquire the specific knowledge required for relevant tasks. Moreover, organizations can greatly benefit from providing training programs to their staff, driving innovation, and enabling employees to acquire new skills related to big data. Therefore, organizations should prioritize maintaining robust training programs and exploring the implementation of technologies to enhance staff familiarity and technical expertise in big data [81].

Technology providers can play a pivotal role in addressing the financial implications of adopting big data, particularly among smaller organizations such as SMEs. The uncertainty surrounding big data technology often deters SMEs due to high initial investment costs. To alleviate this concern, technology providers including software vendors should consider offering trial versions of their products. These trials allow organizations to assess the software's features and functionality, enabling them to determine its suitability for their intended tasks. Multiple studies have demonstrated that effective utilization of big data technology increases SMEs' likelihood of adoption [77], [82]. Lastly, it is worth reiterating the paramount importance of the local government's involvement in crafting policies that actively support organizations and companies in their endeavors to adopt big data technologies. In the prevailing age of widespread artificial intelligence, government regulations pertaining to big data can serve as a catalyst for instilling confidence in its adoption and alleviating concerns, doubts, and distrust surrounding the utilization of big data technologies [62].

## 5. CONCLUSION

This study has identified the challenges faced by Malaysian organizations in adopting big data, taking into account the context of the TOE framework. The challenges within the technology context primarily revolve around data processing requirements and the need for skilled talent to manage big data technologies. Within the organization context, the main challenges arise from limited financial capacity, leading to poor IT infrastructure. Regarding the environment context, challenges primarily stem from the legal aspects of data privacy, which can pose security risks. To address this, there is a need for improvement in Malaysia's regulatory framework for big data, ensuring greater transparency and boosting confidence in big data adoption. More information such as white papers, report or other sources from related agencies will be included in this study in the future. Thus, it can make the study more comprehensive on investigating the challenges of big data adoption in Malaysia. In conclusion, it is imperative for both the Malaysian government and organizations to recognize big data as a strategic economic asset. By assuming proactive roles in supporting big data adoption and addressing potential challenges, they can foster its successful integration into various sectors. Through collaborative efforts and an enhanced regulatory environment, Malaysia can leverage the power of big data to drive innovation and economic growth.

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