Integrating Big Data Analytics into Business Process Modelling: Possible Contributions and Challenges

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Abstract—**Business Process Modelling (BPM) is a set of organised, structured, and related activities that boost the development and evolution of an organisation's success by understanding, improving, and automating existing business processes. Recently, the integration of Big Data Analytics (BDA) into BPM has widely gained more attention as a unique opportunity for organisations to enhance their efficiency, effectiveness, added value, and competitive advantage. However, some organisations still rely on old data-driven strategies and are late in integrating BDA into their BPM. This study aims to explore the possible contributions and challenges of integrating BDA into BPM. This study discovered that better decision making, embracing the organisation's performance, upgrading business process capabilities, and supporting supply chain management are the main contributions of BDA to BPM in organisations. However, poor data quality, shortage of BDA professionals, and data security and protection are the main challenges that hinder organisations from implementing BDA. This study provides valuable insights for organisations that intend to implement big data technologies in their business processes.**

Keywords—Big data analytics; business process modeling; BPM; organisation's performance

I. INTRODUCTION

Business Process Modelling (BPM) is a set of organised, structured, and related activities that operate together to accomplish an organisation's end goals. BPM is an essential factor in developing and evolving an organisation's success since it encourages understanding, improving, and automating existing business processes [1]. Additionally, Business process models must be efficiently modelled to generate a good functioning of the organisations [2].

BPM assures that the business processes are consistent and pushes business execution toward accomplishing the overall strategy and goals of the organisation. BPM enables the communication and documentation of an organisation's business processes [3]. It gives a united language and methodology for communicating procedures, information, and guidelines about the business processes within organisations. Also, BPM helps to ensure that business processes and rules are well-designed by formalising existing processes that may not be well-documented and adjusting them to be well-designed [4]. That leads to getting rid of the guesswork and confirming that these documented processes match the organisation's guidelines and legal regulations. BPM gives a clear understanding of the process's flow that influence

decision making process [5]. That helps managers figure out if there is a chance for further optimisation by improving the process's cycle time, utilising better resources, and allowing testing models before implementing them [6].

Big data provides excellent advantages for organisations as it gives accurate and consistent business insights, automated decisions for real-time processes, and the detection of fraud operations [7]. Besides that, big data helps organisations gain more leverage and return on investments and risk qualifications. Big data is currently a significant factor in the world of technology. Organisations use big data to increase revenues by targeting specific customers and retaining existing customers [8]. With the proper integration of big data, organisations can determine precisely what their customers are looking for, which gives them leverage to meet customers' needs. In addition, big data nowadays is used to target specific markets instead of spending tremendous money on advertising which reduces the costs for the organisations. Identifying risks and foreseeing potential opportunities are now possible by using big data [9]. Eventually, big data will be in almost every industry with significant advantages [10].

In recent years, using Big Data Analytics (BDA) to operate and manage business processes properly has widely gained more importance [11]. Therefore, integrating BDA into BPM represents a unique opportunity for organisations to enhance their efficiency and effectiveness along with the business to achieve added value and competitive advantage [12]. BDA can make a remarkable improvement in multiple aspects of BPM. One of the benefits BDA can bring to organisations is wastage management. According to previous studies, wastage consumes a massive chunk of an organisation's resources. BDA can help organisations develop efficient and effective waste management strategies [13]. As the measurement is at the centre of data analytics for waste management, it facilitates observing the business processes and, consequently, identifying the processes that generate the most waste. Based on that, the organisation can take actions to reduce wastage which leads to greater BMP. In addition, integrating BDA into BPM can develop powerful talent management for the organisations [14]. It can identify the problems in the production processes and propose solutions based on data analytics. Also, it can help the organisations in the process of recruitment and acquire talents that fit the business's needs and values. Besides that, it enables the organisations to foresee any turnover changes in process modelling.

Moreover, big data can generate patterns based on data to BPM to enhance customer management. When these generated patterns are integrated with business processes, they can evaluate the quality of customer services, bring up an accurate customer classification, acquire new customers and retain the current customers, predict customer behaviours, and improve customer value [15]. All these benefits will be significant advantages for the organisations.

However, the IT industry has significantly improved BDA's scope, while BPM societies haven't been really up to date with the massive jump in IT. BPM's societies keep relying on old modelling-based approaches, which are at a disadvantage [16]. In addition, a high percentage of companies feared the disruption of data-driven competitors, which led them to forge the adoption of embracing BDA. Besides that, many organisations believe that if they don't utilise the data appropriately and nimble, data analytics might compromise threats to them instead of being assets [17]. Additionally, some companies hesitate to change into data-driven companies due to the possibility of failure in changing business culture transformation. Hence, no accomplishments will be achieved with old BPM approaches to manage an organisation's processes because data is always limited.

Consequently, with the old BPM, the value of information is often insufficient for decision making, long time to analyse behaviours of products, services or customers, requires more cost for hardware, software and maintenance, and is always a step behind the other modernised organisations [18]. Moreover, as technology is constantly evolving, BPM faces the pressure of keeping up with the latest data and upgrades in terms of social media and unstructured data [19]. So, all of this must be put in perspective in pursuing a better rapport with the new technical world so that better decisions result in more outstanding outcomes.

BDA has raised the profit edges of businesses that have embraced it by enhancing efficiency and reducing costs. Indeed, the world is moving toward the Internet of Things (IoT) [20] and data analytics; organisations must integrate BDA into business process modelling before it's too late [21] [22]. Also, organisations should use BDA in BPM to enhance data-driven decisions which improve business-related outcomes [23]. That would come up with more new revenue opportunities, effective marketing strategies, customer's personalisation, and improved operational efficiency. Therefore, this study aims to explore (i) integration of BDA into BPM and (ii) related possible contributions and challenges.

II. LITERATURE REVIEW

Various studies have been conducted, with the main focus being on why a diverse number of companies are not interested in embracing BDA to support BPM. In this section of the study, multiple arguments from different perspectives will be presented to demonstrate why some companies support adopting BDA in BPM and other companies do not support that.

Some companies believe the intense, increasing volume of data from new sources – mostly unstructured data – requires new approaches to process management [24]. Acquiring these approaches requires a new storage level, a higher level of computing power, and very skilled analytical expertise if companies want to reap valuable information and insights. For some companies, this is considered as a complexity that requires both talents and experience [25]. It can be a valid argument here if there was an abundant amount of data, and it would require much more work to filter the valuable data from the invaluable data.

In contrast, companies had the challenging mission to dig deep to explore the opportunities and the effect on the business of big data in managing business processes. Big data is evolving as a corporate criterion for business modelling. Big data is considered a tool that provides opportunities for creativity and innovation due to its high agility for the companies [26]. It can load a large amount of data, recognise links and understand patterns. Embracing big data to make digital transformation in organisations enables them to add digital content to the business processes [27]. This enhances the quality of decision-making based on real customers' relationship data. Furthermore, digital transformations will improve the management processes that allow the business to expand and gain more outstanding production and distribution.

On the other hand, moving to the digitisation of business modelling concerns companies worldwide [28]. Digitalisation has ruined the business management ways in several industries. For instance, in retail, companies such as Amazon strongly damaged the classic commerce like shopping malls. In some cases, business processes in companies require a tremendous amount of data to gain value rather than the size [28], [29]. Companies are allocating a lot of resources to collecting a massive amount of data that might not be as valuable as expected once they seek the correct data. Many barriers make organisations hesitate to chase big data related opportunities [30]. These barriers might include outdated IT infrastructure, complexity of processing big data, messiness and randomisation of big data, lack of data experiences and skills to coordinate with business processes, privacy concerns, and eventually, the organisation's cultures, which may not be conducive operationally for data-driven decision making.

According to previous research, businesses need quicker and more precise insights into growing volumes of transactional data [31]. BDA technology serves to achieve high efficiency in business processes and raises organisations' effectiveness to another level [32]. Digitalising organisations with BDA technology will add value to the organisations. To clarify, analysing big data in real-time supports the organisation to optimise the organisational vision by reviewing the past and foreseeing the future [33]. Besides that, acquiring BDA and coordinating it with BPM speeds up the processes like modelling, monitoring, measuring, redesigning, reengineering, process analysis, process enactment, enterprise application integration, and business intelligence [34]. Overall, these qualities possess great benefits for the organisations in various aspects.

Furthermore, the financial benefits of BDA in marketing and business increasingly rise year after year compared to the other organisations that are not implementing BDA technology

[35]. They also mentioned that the percentage of failure of embracing BDA is low, and it is caused by the lack of proper strategies to implement BDA. Thereupon, acquiring BDA technology requires companies to enhance their business process management.

Based on the conducted arguments, integrating BDA technology in an organisation is a risk that companies should take due to the intense pace of advanced technology. Accordingly, it might be a privilege and advantage if it is properly utilised, or it might be a loss of money if misused. BPM is a system that is based on data. Therefore, feeding up this system with more valuable and accurate data will strengthen the outcome of the system and produce supportive approaches that enhance business processes. In addition to that, based on the statistical studies, organisations that operate their business processes based on data analytics are exceptionally ahead of other organisations that don't use BDA until now.

III. Contributions of BDA to BPM

A. Better Decision Making

BDA can assist in better decision-making by collecting, storing, and analysing data across a collaborative network [36]. Integrating BDA in BPM enhances the user's experiences with a powerful realisation of what has happened in the past. It assesses what is happening currently and predicts the process's behaviours in the future [33]. Besides that, decision-making with BDA provides organisations with more accurate process models and better performance. BDA plays a prominent role in improving decision-making for organisations [37].

Four types of BDA enhance business processes to ensure efficiency in decision-making [38] [39] (Table I). BDA works majorly to provide a clearer insight to model the organisation's processes, which helps the organisations enhance their productivity and creativity. Modelling business processes based on clear visions and accurate patterns support the organisation's growth and stability [40].

TABLE I. Four Types of BDA to Enhance Business Processes

Data Analytics Type	Description
Descriptive Analytics	Describe what happened and what went wrong, and at which stage? Based on the provided answers, organisations can detect obstacles and avoid mistakes during process modelling.
Diagnostic Analytics	Historical data can be measured against other data to answer why something happened. Comparing old data and recent data helps to give organisations a greater idea of their business's growth and stability.
Predictive Analytics	Predicting what is likely to happen in the future based on the data analysed. Creating patterns based on predictions gives the organisations a very supportive advantage to plan for improvement in every aspect of the business. Also, predicting what issues the organisations may face greatly benefits the organisations.
Prescriptive Analytics	Prescribing what action to be taken to eliminate a future problem. Make probabilities for each situation that might happen and create a backup plan to handle it.

B. Embracing BDA in BPM Shapes the Organisation's Performance

BDA significantly boosts customer deployment and superior organisational performance. BDA plays a vital role in shaping organisations' performance [41]. One of BDA's benefits is that it differentiates between high and low-performing organisations; therefore, those firms that apply BDA become proactive and future-oriented. In addition, big data can increase the likelihood of innovation performance, leading to the creation of patterns and behaviours in business processes [42]. Furthermore, BDA can build benefits for any organisation by improving its performance (process performance, financial performance, production performance, marketing performance, and partnership performance) and competitive advantage. Also, decisions in data-driven organisations are more likely to outcome positively and give more insights into business processes [43]. Hence, big data gives extra leverage for improving organisation performance. An organisation's performance is measured by various factors such as finance, quality, improvement, and value of the organisation in the market [44]. BDA is a major participant in each of these factors once it helps to enhance them in various ways [45]. Process modelling using BDA will strengthen the organisation's strategies, resulting in better revenue and financial stability.

Additionally, organised models in business enhance the quality and lead to improvement of the organisations [46]. Besides that, when the organisation is financially improving and its quality is enhanced, its value is raised in the market. Hence, the organisational performance is supported by using BDA.

C. BDA Upgrades Business Process Capabilities

Big Data Analytics Capabilities (BDAC) is defined as the company's capabilities to influence technology and talented skills to take advantage of BD regarding the generation of perceptions essential to overperform competitors. To clarify, BDAC is the ability of organisations to come up with insights that support organisations using big data management [47].

Managing BDA is a challenging and complicated task for companies due to the variety of resources and types of data. Still, when the company is capable of managing that big data and utilising the outputs of BDA to enhance modelling business processes, then the organisations are taking greater advantages compared to others who can't manage BDA [48]. The ability to manage big data and extract value data differentiates successful firms from non-successful ones. Based on an organisation's financial welfare, big data is defined and evolved more technologically in organisations. In addition to that, BDA's capabilities assist in offering advantages such as optimising the data generation process, suggesting data integration from diverse sources, incorporating different types of findings into the business process, and data visualisation capability to facilitate the decision-making process [49].

Based on the expert's experience in using BDA techniques, organisations can precisely predict the market's needs and requirements and then develop their strategies and structures to accomplish the best insights about market needs and reveal future market objectives [50].

D. BDA Supports Supply Chain Management (SCM) in Organisations

Embracing big data support supply chain management (SCM) in an organisation reflects significant advantages on business process models [51]. Applying big data improves existing business processes by focusing on current business needs and challenges, and data can be investigated to create saleable products and services as new value propositions. As the range of supply chains is global, the volume of data collected from its various processes and the rate at which it is being generated can be qualified as Big Data [52]. Also, marketing and sales are now counting on analysis of the unstructured and structured data to get more significant insights into customer needs and improve the cost aspects of supply chain processes [53]. The utilisation of BDA provides an incredible value in product development, market demand predictions, supply decisions, distribution optimisation, and customer feedback [54].

Moreover, big data can be applied in SCM for operational and development purposes, value discovery, value creation, and value capture [55]. There are several areas primary for applying big data for SCM. Fig. 1 illustrates the areas as the source, make, move, and sell [56].

BDA and SCM in Organizations.

Source	Big data may be used to integrate with suppliers, evaluate sourcing channel options, and portion supplier negotiations.
Make	It involves reduction of capacity constraints, wherehousing optimisation, performance reporting, facility location\layout, and workforce analytics.
Move	The application of big data involves routing, scheduling, using transportation alternatives, optimising, and maintaining vehicles.
Sell	Big data enables micro segmentations of customers, the capture and prediction of customers demand and behaviours, as well as the price and the assortment optimisation.

Fig. 1. Main Areas for BDA in SCM.

IV. CHALLENGES OF INTEGRATION OF BD INTO BPM

Initially, organisations will need to gather vast amounts of data through mobile, social networks, digital videos, and sensors. Organisations then will need to integrate them into their business processes [57]. Therefore, they must be aware of the challenges of big data to have an intelligent and efficient BPM that aims to bring great value to process decision-makers and process modellers. Organisations have to manage many challenges and obstacles when they decide to integrate BDA into BPM, as explained in the following sections.

A. Poor Data Quality

One of the most common challenges to embracing BDA in business organisations is poor data quality. When business organisations intend to be data-driven, data quality must be concerned cautiously because data quality directly impacts business outcomes [58]. Poor data quality leads to poor insights, which lead to poor decisions, and vital decisions based on low-quality data can have disastrous effects [59]. Poor data quality causes inefficiencies in business processes that rely on it. Instead of focusing on essential activities, these inefficiencies may result in very costly redo efforts validating and correcting data inaccuracies. Besides that, poor data quality leads to distrust [60]. Maintaining high-quality data might differ between complying with regulations and paying millions

in fines. Time, money, and reputations can be wasted if the data is incorrect, negatively impacting business organisations and eroding client confidence [61]. Therefore, it is critical to be aware of the importance of data quality because good data quality will enhance BPM, and poor data quality will lead to significant damage to BPM in any business organisation.

B. Shortage of Professionals who Understand BDA

Business organisations that seek to integrate BDA into BPM will have to deal with large data sets that keep growing in size and variety. Incorporating data sets into an analytical platform becomes increasingly difficult because the volume and variety of data available today can overwhelm even the most experienced data engineers [62]. Therefore, the market has significantly demanded big data scientists and analysts. Because the position of a data scientist is multidisciplinary, businesses organisations must select someone with a diverse set of talents related to BDA. Another big issue that organisations confront is a shortage of professionals who are familiar with BDA [63]. Compared to the vast amount of data created, data scientists have a severe scarcity. For instance, when someone who is not an expert data engineer tries to merge unstructured and inconsistent data from several sources, mistakes occur and wrong insights are produced, resulting in missing data, inconsistent data, logic conflicts, duplicate data, and bad decisions [64]. Therefore, if there are no expert professionals to deal with this massive volume of big data efficiently and effectively, then integrating them with BPM is not helpful and it may bring wrong insights and false signals for business modelling, which will impact business organisations negatively as all the decisions will be based on inaccurate and useless insights.

C. Data Security and Protection

Integrating BDA in BPM requires business organisations to seek massive data sets to develop enhanced business models and visions. More data brings more opportunities and potential threats simultaneously, especially when the data sets are less organised [65]. As businesses expand and add new tools to their software stacks and install new technologies to make sense of their data, the risk of security breaches increases. Therefore, business organisations that indiscriminately collect data from many sources may be gathering fraudulent (and so invalid and perhaps damaging) data [66]. Fake and inaccurate data will impact any analysis that a company can perform. Additionally, when businesses gather data without using precautions like encryption, access control, and firewalls, the data becomes subject to leaks, viruses, and data harvesting, which may be incredibly destructive to businesses and compromise customer privacy [67]. Thus, if the data are not well-protected and secured, the business will be damaged and lose its value in the market. As a result, data protection and security are important conditions to integrate BDA into BPM.

D. Confusing a Variety of Big Data Technologies

Nowadays, there are many technologies specialised for BDA in the market. Acquiring the right technology for big data is a real challenge for organisations [68]. Each BDA technology has different processing, storing, cleaning, and reporting features. For instance, the speed of processing big data is essential for organisations. Therefore, some companies

will choose Spark technology to process because of its high speed, while others will be settled with Hadoop MapReduce's speed. Hence, if an organisation has less data and embraces Spark technology, it would lead to money wastage and vice versa [69]. Also, data storage makes a big difference in the organisation's big data processing. For instance, some organisations tend to go for Cassandra to store their data, while others would prefer to embrace Hbase to store their data. Therefore, the features of BDA technology may significantly impact organisations either positively or negatively, depending on selecting the right technology [70]. Choosing an appropriate technology for big data plays a significant role in enhancing the BPM. When the suitable technology is adopted, the business processes will be well strategised and organised, resulting in optimised business insights [71]. On the other hand, if the BDA technology is poorly chosen, the business processes will have unexpected outcomes and false foreseen.

E. Managing Large Volume of Data

Managing large volumes of data is the first challenge for organisations to consider when integrating BDA into BPM [72]. These large volumes of data which are extracted from customer relationship management (CRM), enterprise resource planning (ERP), and other data sources, need to be consolidated and pulled into a unified manageable big data [73]. Besides that, the correct storage of these vast amounts of knowledge is one of the most critical concerns of big data. Data saved in data centers and company databases are continually growing [74]. Thus, it becomes difficult to manage large data sets as they increase rapidly over time. The majority of the data is unstructured and comes from various sources, including documents, movies, audio, text files, and other media. [75].

V. CONCLUSION

This study discussed the possible contributions and challenges of integrating BDA into BPM. It illustrated the importance of BPM and how organisations pose the BPM as the backbone for their businesses to succeed. Also, how BPM participates in ensuring the business processes modelling is a consistent technique and pushes business execution toward accomplishing the overall strategy and goals of the organisation. Besides that, this study demonstrates the roles of BPM and how it organises and operates all the processes in an organisation to come out with the best possible performance. Another part of this study had closer attention to the value of BDA in today's technology world and how organisations embrace it to support their businesses. It explained how data is the core component of any organisation's success. More of BDA was illustrated in terms of the enhancement and encouragement BDA brings to any organisation. Multiple studies with different perspectives were argued in this study to demonstrate why some organisations strive to embrace BDA and others consider it a waste of time and effort. These studies concluded that embracing BDA strongly supports BPM and enhances the value of the organisations. Next, the study provides multiple contributions of BDA in BPM, such as how integrating BDA into BPM helps to understand the business and support decision-making efficiently and effectively. Another contribution was that the relationship between BDA

and business performance had been illustrated precisely. Furthermore, how BDA can support SCM and optimise its process lifecycle to enhance the operations in an organisation. It generally concentrates on implementing BDA with BPM to improve existing business processes by focusing on current business needs and challenges. In this way, data can be investigated to create saleable products and services as new value propositions. Then, BPM's capabilities with the existence of BDA were indicated to be at a very different level with BDA than without BDA. This study demonstrated that BDA's capabilities support BPM to provide advantages such as incorporating different types of findings into the business process, optimising the data generation process, data visualisation capability facilitating the decision-making process, and suggesting data integration from diverse sources. Additionally, the study explained the challenges of embracing BDA in organisations to support BPM. Three significant challenges were identified in this study to predict what organisations may need to manage if they decide to integrate BDA in BPM.

The first challenge is poor data quality, which generates false insights in modelling processes, resulting in wrong decisions. This challenge can be solved by fixing the data in the source system to correct data issues such as missing data and incomplete data. Therefore, data must be set and cleaned in the Extract, Transform and Load (ETL) phase before it is used to make any analytics and predictions [76]. Besides that, data analytics leaders must set data quality standards that can be applied across the organisation's business units. They must then establish a clear connection between business processes, organisational performance, and data assets [77]. Make a list of the organisation's current data quality challenges and how they affect the business. Then, data and analytics professionals may start creating a specific data quality improvement plan that is the "best fit" for the company [78].

The second challenge is the shortage of professionals who understand the BDA in BPM. This challenge can be solved by paying extra attention while interviewing BDA professionals to ensure these professionals understand the structures of the organisation's requirements and strategies in terms of business processing and data. In addition, automating data-related tasks is a new approach followed by companies to solve this challenge. Automated data management, data science, and analytics tools and platforms such as Alteryx and DataRobot have also come on to the scene. However, some experts have warned that inexperienced staff can pose a risk to data science automation [79]. Also, companies are looking into ways to democratise data science by upskilling and reskilling their staff to become less reliant on small teams of pricey experts to see a return on their data science investments [80].

The third challenge is data protection and security. It cannot be fully tackled, but organisations usually improve their safety to decrease the threat rate. Many companies take data discovery and classification as a new approach to protect their data. Data discovery and classification is a process that involves scanning data repositories for the types of data that organisations consider significant, sorting it into categories, and clearly labelling it with a digital signature indicating its classification [81]. Besides that, firewalls are very significant

tech to protect data in an organisation. To prevent unwanted traffic from entering the network, firewalls are used. Furthermore, organisations can only open particular ports, giving hackers less freedom to move to gain access to or download sensitive data [82].

In addition, there are other challenges, such as a variety of big data technologies in the market. This challenge can be avoided by understanding the needs and requirements of the organisations and then adopting a technology with specific features to meet the organisations' needs and requirements. Besides that, managing large volumes of data is considered a challenge in some organisations. This challenge can be avoided by targeting the correct data and focusing on the quality instead of the quantity of data. Eventually, the summary of this study supports the embracing of BDA in BPM to make organisations a better place in today's world. The efficiency and effectiveness that BDA brings to the organisations increase the value and enhance the performance of the organisations. Another finding in this study is that the fear and hesitation of embracing BDA by some organisations was because they think they may not be able to utilise the generated structured and unstructured data properly to support BPM. While in fact, the study proved how embracing BDA could strongly support BPM. Indeed, integrating BDA and BPM is a risk that should be taken due to its value to the organisations from different aspects. Furthermore, the study proved that BDA could increase productivity, encourage creativity, and enhance performance modelling. Additionally, the findings showed how integrating BDA and BPM assures understanding of the business processes and supports decision-making. To conclude, this paper recommends organisations take a step forward and embrace BDA to help positively organise process modelling and raise the business value.

Eventually, integrating BDA in BPM is an opportunity that every organisation should seek due to the valuable benefits it brings. BDA assists organisations in finding more efficient ways to organise businesses processes and increase their customer acquisitions and retention. Besides that, organisations will gain more opportunities to develop innovative new products to meet customers' changing needs with BDA. In addition, businesses use big data to plan their advertising by observing online activity, monitoring point-of-sale transactions, and assuring on-the-fly detection of dynamic changes in client behaviours. These are then utilised to determine the target group, the most crucial factor to consider while planning a campaign.

Moreover, reliance on BDA could manage an organisation's risk plan and create a clear vision to minimise potential risks. Also, businesses can achieve contextual intelligence across the supply chain by using BDA. Therefore, BDA will make a significant impact on BPM and these impacts will raise the quality of the organisation's performance.

The next phase of this technology development is a complete automation strategy. Researchers should conduct many studies to increase the automation of BDA within organisations. Automating BDA is an advanced strategy that can make a difference in the positive side of organisations. Some researchers have attempted to make theories about full automation for BDA in BPM. Still, they discovered that experts are not optimistic about this strategy because they believe that full automation in such an early stage may lead to many errors, negatively affecting BPM in organisations [83].

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