TELKOMNIKA Telecommunication Computing Electronics and Control
Vol. 23, No. 1, February 2025, pp. 192~200
ISSN: 1693-6930, DOI: 10.12928/TELKOMNIKA.v23i1.26497

Predicting big data analytics adoption intention among small and medium enterprises in the Philippines

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Article Info

Article history:

Received Jul 24, 2024
Revised Oct 24, 2024
Accepted Nov 26, 2024

Keywords:

Artificial intelligence
Big data analytics
Philippines
Small and medium enterprises
Technology acceptance model

ABSTRACT

Big data analytics (BDA) has increasingly become popular both in theory and practice in recent years. Globally, larger businesses have used BDA to collect, study, and evaluate vast volumes of data to identify market trends and insights that lead to sound and intelligent business decisions. However, its adoption in small and medium enterprises (SMEs) is not fully maximized because of a variety of factors, including a lack of expertise and financial repercussions. As such, this paper seeks to delve into the predictors of BDA adoption intention among SMEs in a developing nation by extending the technology acceptance model (TAM). The quantitative surveys obtained from 438 SMEs were analyzed using partial least squares and structural equation modeling (PLS-SEM). The results revealed that perceived benefits, namely system quality, information quality, and predictive analytics accuracy, had positive relationships with perceived ease of use and usefulness, subsequently leading to attitude towards using BDA. Likewise, perceived security significantly influences perceived benefits, perceived ease of use, and attitude towards use of BDA. Further, attitude towards use was the most significant predictor of intention to adopt BDA among SMEs. Generally, the study indicates a positive interest in adopting BDA among Philippine SMEs.

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1. INTRODUCTION

With the emergence of digital transformation, data has become a valuable asset for businesses, and its amount is increasing tremendously on a daily basis. This massive amount of data is known as big data. Technically, big data can be characterized using three variables such as volume, variety, and velocity [1]. Decision-makers believe that big data can provide timely insights while also generating a high amount of revenue. Further, it reflects employee and customer interactions stored in the organization's system, resulting in actionable, predictive, descriptive, and prescriptive outcomes [2].

The overall amount of data globally has significantly expanded in recent years. In 2020, data usage reached 64.2 zettabytes, and this voluminous amount may exceed 180 zettabytes by 2025 [3]. Smart devices, IoT devices, cloud computing, artificial intelligence, and wearable devices have all contributed to this enormous increase. In addition, advancements in social networking sites, e-commerce platforms, and search engines contributed to the growth of data [4]. This enormous data set can be characterized as having a more

complex and varied structure. Semi-structured and unstructured data, like social media posts, credit card purchases, science data surveys, and customer feedback, are also included in these massive data sets, along with the structured data [5]. Recently, large enterprises have employed analytics to understand hidden patterns, customer preferences, and market trends to formulate informed and sound decisions using big data. This innovation refers to big data analytics (BDA).

BDA is a set of tools and methods that gather and derive insights from various data sources [6]. It enables enterprises to harness data, which may lead to improved business decisions, more effective operations, higher profit, and more satisfied customers. However, its implementation is currently limited to large organizations, and its full adoption by small and medium enterprises (SMEs) is still scarce [7]. Thus, to further investigate the predictors of BDA adoption in SMEs, the present study extended the technology acceptance model (TAM), which included additional variables such as perceived benefits with system quality, predictive analytics accuracy, information quality, and perceived security. This contributes to the growing interest in BDA adoption in SMEs, which is still relatively unexplored, especially in developing countries.

2. RELATED LITERATURE

2.1. Big data analytics and small and medium enterprises in the Philippines

The overwhelming and exponential increase of big data necessitates that enterprises relinquish traditional analytical and storage technology in favor of a shift in management and decision-making mechanisms known as BDA [8]. This emerging technology has been receiving significant attention since it increases productivity and profitability. It is widely utilized in different industries, such as education, healthcare, insurance, retail, and manufacturing, to enhance their systems and generate profits [9]. However, its adoption is comparatively low in SMEs despite the competitive advantage it offers.

Based on prior research, BDA assists SMEs in decreasing the product development lifecycle as well as the cost of development [10]. As an evolving technology, it may improve the operational and strategic performance of SMEs. Even though Philippine SMEs account for more than 99% of registered enterprises and generate 62.4% of total employment, there is still a scarcity of literature on SMEs and BDA adoption [11]. This substantial contribution that SMEs provide, as well as the potential benefits of SMEs adopting BDA, underscore the significance of examining adoption intention factors. Hence, further elaboration is required on the compelling factors of BDA adoption intention among SMEs in developing countries.

2.2. Hypothesis development

The researchers employed TAM as the guiding framework of this paper, which is a renowned framework in information systems that describes and predicts the user's intention to accept an innovative technology [12]. In addition, the authors integrated additional variables into the model, as shown in Figure 1.

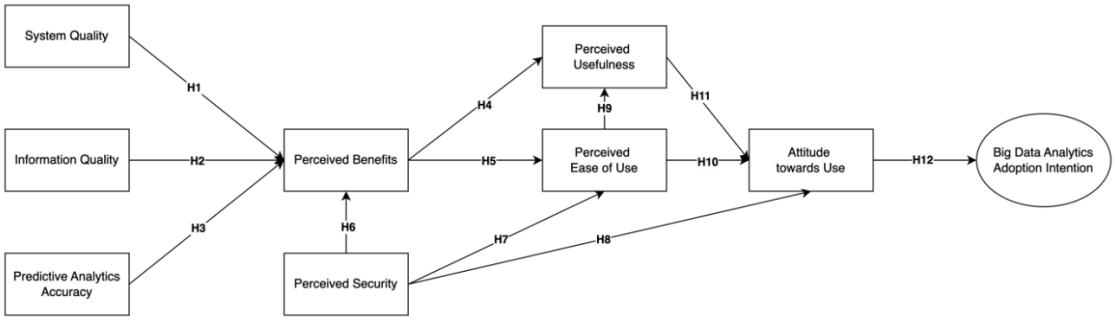

Figure 1. Proposed model on BDA adoption intention among SMEs in the Philippines

System quality (SQU) entails a well-developed system that is critical to maximizing organizational benefits, leading to higher revenue, enhanced process efficiency, and cost savings [13]. This is evaluated based on the quality of the system it delivers through system features, functionality, flexibility, and accuracy. Previous studies highlighted that before adopting a new system, enterprises must ensure its efficiency, accessibility, and availability to achieve value creation for the business [14]. Furthermore, high system quality improves users' perceptions of the advantages of BDA. The study suggests that:

H1: System quality positively influences the perceived benefits of the BDA adoption intention of SMEs.

Information quality (IQU) is the quality of content and the suitability of the information delivered by an information system [15]. Organizations tend to adopt new technology when an information system is tailored to the demands of the users to maximize its benefits. The quality of information is determined by its accuracy, reliability, completeness, and timeliness. Previous research has shown that high BDA information quality provides significant benefits to enterprises, such as internal organizational efficiency and strategic decision-making [16]. As a result, high information content contributes to BDA adoption; hence, this study asserts that:

H2: Information quality positively influences the perceived benefits of the BDA adoption intention of SMEs.

Predictive analytics accuracy (PAA) is the accurate utilization of statistical and modeling approaches to forecast potential outcomes, activity, and trends using current and historical data [17]. This kind of data analytics uses data science and algorithms from vast volumes of datasets to combine descriptive data with additional predictions. It encompasses various techniques, including machine learning, modeling, and data mining. Moreover, predictive analytics accuracy is critical for organizations to translate vast amounts of data that allow them to make proactive decisions [18]. Consequently, when the predictions of a system are more accurate, organizations continuously enhance their understanding of customer expectations, which may increase the possibility of BDA adoption. The study hypothesizes that:

H3: Predictive analytics accuracy positively influences the perceived benefits of the BDA adoption intention of SMEs.

Perceived benefits (PBE) is recognized as an eminent predictor of technology adoption. The primary premise of the diffusion of innovation theory (DOI) asserts that the adoption rate is associated with the perceived benefit of an innovation [19]. Understanding the perceived benefits of an information system, such as BDA, raises the likelihood of adoption. BDA benefits encompass more efficient communication, better decision-making, enhanced data accuracy, and improved coordination and productivity [20]. Furthermore, an organization is more likely to adopt BDA because of its accessibility and effectiveness in executing specific tasks. Thus, the study suggests that:

H4: Perceived benefits and the perceived usefulness of the BDA adoption intention of SMEs have a significant relationship.

H5: Perceived benefits and the perceived ease of use of the BDA adoption intention of SMEs have a significant relationship.

Perceived security is the belief that an innovative technology successfully transmits, stores, and protects sensitive data or personal information. Furthermore, it is seen as a crucial driver of all information systems, as privacy and security are the primary concerns of users when weighing the benefits of adopting a system [21]. Regarding BDA adoption, security includes authentication, permission, data protection, and recovery to guarantee business continuity. On the other hand, BDA adoption is hampered by information piracy, data hacking, and other forms of digital theft. Previous studies on BDA adoption emphasized the role of perceived security. Likewise, recent studies discovered that positive perceptions of BDA security influenced ease of use and usefulness, leading to its adoption [22]; hence:

H6: Perceived security and the perceived benefits of the BDA adoption intention of SMEs have a significant relationship.

H7: Perceived security and the perceived ease of use of the BDA adoption intention of SMEs have a significant relationship.

H8: Perceived security and the attitude towards use of the BDA adoption intention of SMEs have a significant relationship.

Perceived ease of use (PEU) is the notion that it would be effortless to embrace a new technology. Similarly, it is characterized as the user's ability to handle and engage with the system to achieve the necessary task [23]. Enterprises may profit from BDA adoption by reducing costs, managing risks, and making better decisions. Prior studies on BDA adoption indicated a clear association between ease of use and usefulness and their positive correlation to the user's performance [24]; hence:

H9: Perceived ease of use and the perceived usefulness of the BDA adoption intention of SMEs have a significant relationship.

H10: Perceived ease of use and the attitude towards use of the BDA adoption intention of SMEs have a significant relationship.

Perceived usefulness (PU) is acknowledged to drive technology adoption significantly. It is believed that adopting a new technology may improve their performance [25]. According to previous studies, usefulness is crucial in understanding the uptake of technological breakthroughs. BDA can be characterized as the extent to which people perceive that this technology is a driving force behind intelligent business decision-making [26]. In TAM, perceived usefulness is a significant driver of attitude towards BDA adoption; hence, the study asserts that:

H11: Perceived usefulness and the attitude towards use of the BDA adoption intention of SMEs have a significant relationship.

Attitude towards use (ATT) is the assessed value of using a new technology. Previous research on adopting BDA has demonstrated that ease of use and usefulness have an essential influence on the decisions of users to adopt [27]. Recent studies have revealed that enterprises have a positive attitude towards BDA adoption intention (ADI) in their operations because of its holistic and beneficial impact. Therefore, this study hypothesizes that:

H12: Attitude towards use and the BDA adoption intention of SMEs have a significant relationship.

3. MATERIALS AND METHODS

3.1. Survey development

The survey instrument used in the study is based on established literature on BDA adoption intention among SMEs [28], [29]. The instrument comprises the profile of the respondents as well as items related to predictors of BDA adoption intention. The respondents' agreement or disagreement with the BDA variables was gauged using a 7-point Likert scale. It was first administered to a small number of SMEs to assess their comprehension and collect feedback to enhance the questions. After this, the second version of the survey was distributed to management and technology adoption study experts to gather their insights and recommendations. The final version includes 27 items covering the BDA adoption intention factors.

3.2. Participants

The researchers communicated with the leaders of SME organizations in the National Capital Region (NCR) to identify SMEs engaged in various business activities, representing individuals from diverse sectors in the region. Each city was represented by SMEs that offer product development, professional services, retail and marketing, information technology, health and personal wellness, accommodation and food service, transport and storage, construction, and manufacturing. The researchers invited at least 100 individuals from each SME type to participate in the survey, for a total of 900 among five cities in the NCR. However, only 438 people showed their intention to participate, with 183 (42%) male and 255 (58%) female. The respondents' educational levels are as follows: high school (n=101, 23%), bachelor's (n=328, 75%), and master's or Ph.D. (n=9, 2%). The respondents were owners, co-owners, and managers of SMEs with at least one year and up to twenty years of experience.

3.3. Data gathering and analysis

The researchers posted the invitation to participate in the survey on social media platforms. The link to the survey, together with their informed consent, was sent through email. Each participant completed the survey in 10–15 minutes, providing their profile and complete answers on the factors investigated. For data analysis, this study utilized SmartPLS 4.0 software to analyze the extended model, the relationship of the factors, and the predictive capability of the model.

4. RESULTS AND DISCUSSION

4.1. Measurement model

The study evaluated the construct's reliability and validity, as indicated in Table 1. Cronbach's alpha (CA) and composite reliability (CR) were used to evaluate the internal reliability. The results indicate that all constructs fall between the benchmark values of 0.6 to 0.95 [30], implying high internal consistency and reliability. Moreover, the factor loadings (FL) and average variance extracted (AVE) were also examined to check the convergent validity of the constructs. Accordingly, the results demonstrate that every FL value was higher than the expected threshold of 0.7 [31]. Concurrently, the AVE of all the constructs is more than the 0.5

rule of thumb [32], denoting that they explain more than 50% of the variance. Therefore, the measurement model is reliable and valid.

Table 1. Construct's reliability and validity

Construct	Cronbach's Alpha (0.6-0.95)	AVE (>0.50)	CR (0.6-0.95)	FL (>0.7)
SQU	0.709	0.629	0.835	0.738-0.820
IQU	0.765	0.681	0.865	0.818-0.833
PAA	0.799	0.713	0.881	0.823-0.861
PBE	0.786	0.700	0.875	0.825-0.854
PSE	0.835	0.752	0.901	0.839-0.892
PEU	0.756	0.672	0.860	0.802-0.837
PU	0.772	0.687	0.868	0.798-0.844
ATT	0.851	0.771	0.910	0.863-0.891
ADI	0.822	0.737	0.894	0.846-0.871

Furthermore, the constructs' heterotrait-monotrait ratio was tested to guarantee their discriminant validity, and based on the results, all constructs are below the conservative threshold values of <0.85 [33], confirming their discriminant nature, as shown in Table 2. Additionally, the study evaluated the mean values of each construct. System quality was found to have the highest mean ($\bar{x}$=6.093, σ=0.855), whereas predictive analytics accuracy had the lowest mean ($\bar{x}$=5.768, σ=1.002). Meanwhile, the descriptive statistics of the remaining constructs are as follows: information quality ($\bar{x}$=5.936, σ=0.951), perceived benefits ($\bar{x}$=5.929, σ=0.923), perceived security ($\bar{x}$=5.773, σ=1.034), perceived ease of use ($\bar{x}$=5.782, σ=1.025), perceived usefulness ($\bar{x}$=5.963, σ=0.953), attitude towards use ($\bar{x}$=5.867, σ=0.966), and adoption intention ($\bar{x}$=5.906, σ=0.972).

Table 2. Heterotrait-monotrait ratio (<0.85)

	$\bar{x}$	σ	ADI	ATT	IQU	PBE	PEU	PAA	PSE	PU	SQU
ADI	5.906	0.972									
ATT	5.867	0.966	0.793								
IQU	5.936	0.951	0.674	0.704							
PBE	5.929	0.923	0.781	0.770	0.798						
PEU	5.782	1.025	0.690	0.741	0.686	0.848					
PAA	5.768	1.002	0.675	0.772	0.815	0.793	0.749				
PSE	5.773	1.034	0.675	0.723	0.752	0.757	0.800	0.792			
PU	5.963	0.953	0.756	0.847	0.810	0.845	0.799	0.789	0.748		
SQU	6.093	0.855	0.630	0.597	0.831	0.641	0.540	0.602	0.506	0.740	

4.2. Predictive capability analysis

The accuracy of the prediction is assessed by extracting the r^2 values to understand the degree of explained variance of the endogenous constructs [34]. Based on the r^2 value, 45% of the variance in terms of the adoption intention of BDA (r^2=0.445) is explained in the model. Moreover, variance in terms of attitude towards use (r^2=0.574), perceived benefits (r^2=0.525), usefulness (r^2=0.498), and ease of use (r^2=0.529) are also explained. The study also considered the effect size f^2, which indicates the substantive impact of a construct on another one [35]. Although all hypotheses have significant relationships, attitude towards use (f^2=0.803) has the most considerable effect size f^2 on adoption intention, as shown in Table 3.

Table 3. Path coefficient and hypothesis testing

Hypothesis	Path	Coefficient (β)	t-value	p-value	f^2	Result
H1	SQU→PBE	0.134	2.226	0.026	0.023	Supported
H2	IQU→PBE	0.208	2.757	0.006	0.038	Supported
H3	PAA→PBE	0.269	4.276	0.000	0.072	Supported
H4	PBE→PU	0.480	8.254	0.000	0.254	Supported
H5	PBE→PEU	0.448	8.503	0.000	0.266	Supported
H6	PSE→PBE	0.260	4.489	0.000	0.074	Supported
H7	PSE→PEU	0.361	6.725	0.000	0.172	Supported
H8	PSE→ATT	0.217	3.336	0.001	0.058	Supported
H9	PEU→PU	0.288	4.652	0.000	0.091	Supported
H10	PEU→ATT	0.161	2.555	0.011	0.031	Supported
H11	PU→ATT	0.485	7.213	0.000	0.306	Supported
H12	ATT→ADI	0.667	15.301	0.000	0.803	Supported

Note: significant at p-value <0.05

Likewise, the study examined the model's predictive relevance (Q^2), revealing that perceived benefits have the most considerable Q^2 value among the endogenous constructs. Meanwhile, the predictive relevance of other constructs is as follows: adoption intention (Q^2=0.320), attitude towards use (Q^2=0.442), usefulness (Q^2=0.475), ease of use (Q^2=0.448), and perceived benefits (Q^2=0.505) [36]. Thus, the model establishes the predictive relevance of the endogenous constructs, as illustrated in Figure 2.

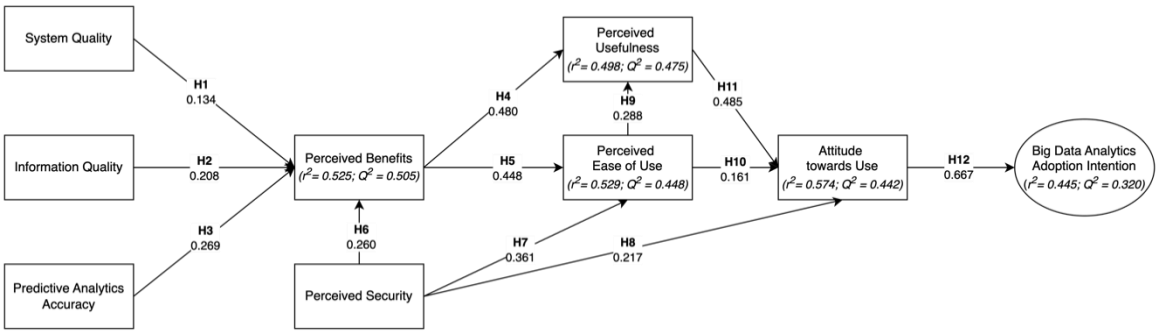

Figure 2. Research model on BDA adoption intention among SMEs in the Philippines

4.3. Structural model

The study assessed the compelling factors of BDA adoption among Philippine SMEs through the extended TAM. Table 3 presents the structural relationships, path coefficients, and hypothesis test results. First, the study found that system quality (β=0.134, p=0.026), information quality (β=0.208, p=0.006), and predictive analytics accuracy (β=0.269, p=0.000) had a positive relationship with the perceived benefits of BDA adoption intention in SMEs. These findings are consistent with earlier studies on BDA [37], which show that a high-quality system, rich information content, and accurate system prediction improve users' perceptions of the benefits of BDA; thus, H1, H2, and H3 are supported.

Second, perceived benefits (β=0.480, p=0.000) and the usefulness of BDA had a significant relationship. Likewise, perceived benefits (β=0.448, p=0.000) and the ease of use of BDA adoption also had a direct relationship. These findings are similar to prior research [38], which found that perceived benefits of BDA are essential for SMEs, such as intelligent decision-making, enhanced efficiency, and increased usability and functionality. Therefore, H4 and H5 are supported.

Third, perceived security (β=0.260, p=0.000) and the perceived benefits of BDA had a significant relationship. The result is comparable with previous research on BDA adoption in SMEs, which discovered that security is a crucial attribute for users when considering the benefits of a new technology such as BDA; thus, H6 is supported. Likewise, perceived security had a significant relationship with ease of use (β=0.361, p=0.000) and attitude towards using BDA (β=0.217, p=0.001) in SMEs. These findings are consistent with previous investigations [39], which have found that as long as the system is secure, BDA becomes more accessible and functional. Therefore, H7 and H8 are supported.

Fourth, ease of use (β=0.288, p=0.000) and usefulness were directly associated. This is consonant with previous research, which shows an association between these variables while evaluating an innovative system such as BDA [40]. Furthermore, ease of use (β=0.161, p=0.011) and attitude towards BDA adoption intention had a significant relationship. Therefore, H9 and H10 are supported.

Finally, perceived usefulness (β=0.485, p=0.000) and attitude towards using BDA in SMEs had a positive relationship. Based on the literature, usefulness plays a crucial role in understanding user perceptions when adopting new technology. Additionally, attitude towards use (β=0.667, p=0.000) significantly influenced BDA adoption intention in SMEs. Recent studies on BDA adoption revealed that SMEs are optimistic about adopting this technology because of its overall impact on SMEs, including informed decision-making, operational efficiency, customer understanding, and a competitive advantage for long-term growth in the data-driven business landscape [41]. Thus, H11 and H12 are supported.

4.4. Implications

The study advances the practice of BDA among SMEs in developing nations. First, the study presents baseline evidence of BDA adoption intention in Philippine SMEs, with results indicating favorable interest among SME owners, co-owners, and managers. Second, the findings of the study may be utilized in developing frameworks and crafting relevant policies to further the uptake of BDA. However, despite these positive findings, developing countries like the Philippines still face significant barriers to BDA adoption, including

limited human and technological resources as well as financial constraints. Government intervention is crucial in initiating programs that promote the adoption of new and innovative technologies among SMEs. Additionally, given the current economic instability, policymakers must prioritize mechanisms to support SMEs. Hence, further research is necessary to develop models and policies that will enhance BDA adoption in the country. Lastly, managers and owners of SMEs must enhance their knowledge about its effective adoption, thereby leading to intelligent decision-making, enhanced efficiency and productivity, and profitability in SMEs.

5. CONCLUSION

BDA adoption is increasingly growing in large enterprises around the world. However, its adoption among SMEs in many developing nations is still in its early stages. This research presents the first evidence of BDA adoption intention among SMEs in the National Capital Region, Philippines, using an extended TAM based on a survey analyzed with PLS-SEM. Based on the findings, system quality, information quality, and predictive analytics accuracy have shown a positive influence on the perceived benefits of BDA, thus affecting adoption intention among Philippine SMEs. Likewise, perceived security significantly influences perceived benefits, perceived ease of use, and attitude towards use of BDA. Further, perceived benefits have significant relationships with perceived ease of use and usefulness, which subsequently led to attitude towards the use of BDA, which emerged as a significant predictor of intention to adopt BDA among SMEs in the Philippines. In general, this study indicates a positive interest in adopting BDA among Philippine SMEs.

Despite its significant findings, this paper presents some limitations that require further investigation to extend its contribution to the literature and practice of BDA adoption. First, the study only considered the dimensions of TAM with external variables, which might be broadened by including other relevant models to explain adoption intention better or even use behavior. Second, the study solely concentrated on specific SME sectors, leaving out other industry types (e.g., agriculture) that may have offered valuable and insightful information into the findings of this study. Finally, future work may include in-depth interviews with SME experts to validate and expand the results of this preliminary research.

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