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The relationship between big data analytics and financial performance in the Vietnamese banking sector

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ABSTRACT

The rise of big data has brought both significant advantages and challenges, as nearly all research fields now face large, unpredictable volumes of data at varying speeds. The banking sector, in particular, has gained attention from researchers due to its reliance on data, driven by advancements in computer science. Although big data presents numerous opportunities and challenges across industries, research on this topic in banking remains limited and requires further exploration. To address this gap, this study investigates the relationship between big data analytics (BDA) factors and banks' financial performance, while offering managerial recommendations to improve the use of BDA in managing bank performance. A quantitative research method was applied, using convenience sampling to distribute survey questionnaires to 250 bank employees in Ho Chi Minh City, from junior staff to senior managers. The results indicate that BDA factors, including technological capability, talent capability, and bank capability, have a significant impact on banks' financial performance. This study contributes to raising research awareness on BDA methodologies and provides insights into the relationship between these factors and financial performance.

1. Introduction

The concept of 'big data' is garnering significant global attention. A Google search for the terms "big data" and "analytics" yielded 822 million and 154 million results, respectively (Agarwal and Dhar, 2014). Because of its potential to boost productivity and profitability by 5-6%, big data analytics (BDA) has become a major focus for corporate agendas in recent years. A study of Fortune 1000 companies reveals that 91% are investing in BDA projects, which is an increase from 85% the previous year (Kiron et al., 2014).

The era of Big Data has introduced both significant opportunities and challenges, as nearly all scientific fields face an overflow of information at unpredictable volumes and speeds (Mayer-Schönberger and Cukier, 2013). Over the past few decades, banking has become a key area for research within the information science revolution, due to its data-intensive nature. Banks now recognize that intelligence, rather than financial capital, is their most valuable asset (Kharote and Kshirsagar, 2014). The expansion of both e-banking and mobile banking has led to exponential growth in real-time banking data. Consequently, mastering specific big data analytics tools has become crucial for the banking industry.

Today, many banking, financial services, and insurance (BFSI) companies are striving to enhance their services through data mining. As with many other industries, big data analytics can be a transformative force in these sectors. The storage and analysis of vast amounts of data, including personal and sensitive information, simplifies the process of tracking and reviewing bank and financial institution customers. A unique aspect of banking is the generation of massive amounts of data, from structured data such as transaction logs and customer accounts to unstructured data such as online and mobile banking transactions. Utilizing big data to analyze this information can provide significant competitive advantages and improve efficiency in the banking and finance sectors.

The era of Big Data has brought tremendous benefits and obstacles along with it, as nearly all fields of research are now facing an onslaught of data at unpredictable quantities and speeds (Mayer-

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Schönberger and Cukier, 2013). Banking has become a common application area for researchers over the past few decades of the computer science revolution because it is a data-intensive topic. Banks have also accepted that information, rather than financial capital, is currently most the important commodity (Kharote and Kshirsagar, 2014). Furthermore, the growth and popularity of e-banking and mobile banking contribute to the exponential growth of banking knowledge. These ongoing advances, along with the ever-growing feasibility of big data, make mastering applicable big data analytics tools a critical task for the banking sector.

In Vietnam, big data and AI are driving financial institutions to diversify their products, enhance efficiency, and reduce costs to better meet customer needs (Tran, 2024). With a rapidly growing, digitally savvy population and a financial services industry unburdened by legacy systems, Vietnamese banks are more readily embracing these advancements compared to those in more developed countries. The COVID-19 pandemic has accelerated the adoption of new technologies. Economists concur that Big Data and AI will fundamentally transform Vietnam's banking industry. Although big data presents a variety of opportunities and challenges across all markets, the following issues, which have been raised as research questions, remain unexplored and unresolved, especially in the Vietnamese banking sector, throughout the previous literature.

- What are the BDA-related factors that can influence a bank's financial performance in Vietnam?
- What is the relationship between BDA-related factors and a bank's financial performance in Vietnam?
- What is the relationship between general bank performance and a bank's financial performance in Vietnam?
- What are the managerial implications that can enhance the applicability of BDA in managing bank performance?

This study explores the relationship between factors related to BDA and the financial performance of banks in Vietnam. From a theoretical perspective, it examines the impact of research models on the connection between big data and financial performance. The study enhances researchers' understanding of research methodologies and helps clarify the relationships between key variables. Its findings can benefit other researchers by providing insights that may support and expand their own studies. Despite certain limitations, the results can be applied across various industries and national contexts.

From a practical perspective, this research addresses existing gaps by using a case study approach to analyze the benefits banks gain from big data, the challenges they encounter in its implementation, and the strategies used to overcome these difficulties. The study's findings offer bank managers a deeper understanding of the factors influencing big data adoption and its effects, allowing them to make more informed decisions that can enhance their organizations' performance.

2. Literature review

2.1. BDA in the financial sector

Although there is no precise definition for Big Data, Manyika et al. (2011) described it as "data sets whose size is beyond the ability of typical database software tools to capture, store, manage and analyze." Big Data is characterized by three main features: Volume (the large amount of data), velocity (the speed at which data is generated), and variety (the wide range of data sources). In finance and business environments, Big Data can be utilized where vast amounts of information from stock exchanges, banking, and online and in-store transactions are continuously processed, captured, and stored to monitor stocks, customer behavior is analyzed and market dynamics are understood.

When BDAs are available, they can radically alter how companies are created and work. Numerous large firms seek to grow supply chains (SCs) through BDAs in order to remain competitive in the industry. BDAs allow businesses to use sophisticated analytical capabilities to access high-quality data from BD, thus increasing operating productivity and ensuring long-term success. BDAs ensure that an organization's sincere dedication is reflected by its superior results. According to McKinsey Company's 2018 Global Banking Report, companies that are more analytically oriented rise three times faster than their less analytically oriented counterparts. Across all industries, including pharmaceuticals, insurance, oil, manufacturing, and agriculture, the banking industry was a leader in exploiting BDAs. Nonetheless, the banking industry's traditions, decision-making procedures, and corporate practices are insufficiently integrated with BDAs.

BDAs have also evolved into a critical method for the banking industry in terms of identifying fraud and combating financial crime, managing credit risk, and marketing. Banks are now transitioning from product-centric to customer-centric business models, which was accomplished by BDAs. For instance, the Overseas Chinese Banking Corporation (OCBC), one of the largest banks in Singapore and Malaysia, has successfully analyzed historical customer data to ascertain their desires. BDAs also contribute significantly to financial inclusion, microfinance, and creditworthiness analysis by processing organized and unstructured consumer data collected across various platforms.

2.2. Digital transformation in the Vietnamese banking sector

To remain competitive in the banking industry, traditional banks must enhance their agility,

cultivate an innovative culture, and focus on streamlining services to ensure they are available to clients anytime and anywhere (Ha and Nguyen, 2022). To accomplish these goals, banks are increasingly relying on modern big data technologies. For many organizations, especially banks, big data and data analytics provide a new source of competitive advantage. The shift to digital banking involves integrating data, advanced analytics, and digital technologies throughout all areas of financial institutions, transforming how work is conducted, priorities are set, and services are delivered.

Over the past five years in Vietnam, banks have shifted away from branch-based expansion as a primary strategy, instead focusing on improving access to core banking services (Ha and Nguyen, 2022). This shift, along with the opportunities provided by technologies like mobile, has led to innovative reimagining of how banking can be more seamlessly integrated into smart cities. The current state of digital transformation in banking offers a clear snapshot of how Vietnamese banks are positioned in their journey toward technological adoption. Vietnam is well-positioned for the growth of digital banking, with a population of 96 million and a favorable demographic structure, including 56 million people active in the labor market. According to the State Bank of Vietnam 2020, payment department, there were 64 million internet users in the country in 2019. E-commerce has been growing at an annual rate of 30%, and while 72% of the population owns a smartphone, 69% of adults still do not have a bank account. Vietnam also has a solid infrastructure for digital banking, with nearly 19,000 ATMs and 270,000 point-of-sale (POS) terminals in 2019. Currently, 78 banks provide internet payment services, mobile payment is offered by 47 banks, and 29 banks support QR code payments, with 30,000 QR code transactions that year.

There are three primary approaches to banking digital transformation in Vietnam (Ha and Nguyen, 2022). The first approach focuses on the digitalization of front-end channels, encompassing innovations such as mobile banking, electronic Know Your Customer (eKYC), QR code payments, virtual assistants/chatbots, and 24/7 call centers (front-end only). The second approach emphasizes transforming internal processes, including advancements like real-time online trading systems, robotic process automation, and the use of artificial intelligence and third-party data for risk management (wrap and digitize). Although technologies such as big data warehousing, automated data collection, cloud computing, data analytics, AI, open APIs, and blockchain are still in their early stages, they offer substantial potential for future growth. The third approach integrates both front-end digitalization and internal process transformation, alongside the development of fully digital, stand-alone banks (go digital native) (Ha and Nguyen, 2022). TPBank and Vietinbank represent the first approach, while Vietcombank and Techcombank demonstrate the second. TPBank and Vietinbank employ omni-channel platforms to ensure a seamless customer experience, with a strong emphasis on enhancing their capability to analyze customer behavior and extract insights. This allows them to deliver personalized products and services, giving them a competitive advantage in the market.

The current state of banking transformation highlights that Vietnamese banks are evolving to meet the demands of the digital era by minimizing friction and improving utility, resulting in better margins, enhanced customer satisfaction, and increased scalability (Ha and Nguyen, 2022). However, data shows that the majority of Vietnamese banks remain in the early phases of digital transformation, in the first and second stages. Reaching the highest level—becoming fully digital-native—poses considerable challenges for these institutions. Such challenges are related to main issues including the legal framework, network security, and the participation of Fintech and Bigtech Companies.

2.3. Theoretical background

The Resource-Based View (RBV) theory explains how organizations can gain a competitive advantage by developing and utilizing strategic resources and capabilities. In the realm of BDA, tangible resources such as connectivity and intangible resources like information sharing are essential for building BDA capabilities (Gunasekaran et al., 2016). Gupta and George (2016) emphasized that fundamental resources, technology, data, and human skills (both technical and managerial) are vital for establishing BDA capabilities, especially within a big data-driven culture.

This study employs the RBV framework to analyze the factors influencing the performance of small-scale firms. According to RBV, a company's internal resources and competencies create comparative advantages (Barney, 1991). Firm performance hinges on a unique set of resources that are difficult to replicate or substitute. RBV provides a theoretical foundation to understand how various factors impact business performance (Rahman and Ramli, 2014).

In accounting and finance literature, firm resources have been defined in multiple ways. For instance, Barney (1991) divided resources into human, physical, and organizational capital. Human capital encompasses the experience, training, technical knowledge, relationships and expertise of management and staff. Physical capital includes technology, machinery, location, and access to productive inputs (Essel et al., 2019). Commitment, honesty and competence are also valuable assets, and Radzi et al. (2017) categorized tangible assets as human, physical, financial, and technical resources.

Intangible assets, on the other hand, encompass knowledge, talents, skills, and reputations. Companies aim to manage resources that offer a

competitive edge, either in the short term or the long term (Radzi et al., 2017). Differences in the ability to access, and being able to control, diverse resources can result in unique products and services. Thus, a firm's success depends on how well it utilizes its resources and competencies (Saffu et al., 2012), as these are essential for innovation and maintaining a competitive edge (Radzi et al., 2017).

RBV provides an ideal framework for analyzing the performance of small companies in emerging countries, where businesses often face resource and experience constraints (Saffu et al., 2012). Consequently, this study adopts the RBV perspective, positing that a firm's resources and skills are the key drivers of performance.

Besides, management theory helps to explain that the focus on building and sustaining relationships with key stakeholders can lead to better overall results (Hackman and Oldham, 1980). As a result, this theory links bank performance to sustainability efficiency. According to good management theory, good bank performance may have an effect on financial results because it allows a company to cut costs and increase cost efficiency while improving its image (Deephouse et al., 2016).

2.4. Proposed hypotheses and research model

The proposed research model is based on the RBV theory. The components of the ECM as discussed as follows.

2.4.1. BDA management capability (BDAMC)

BDAMAC is a crucial element of BDA, ensuring that sound business decisions are made via an effective management framework. The following four primary themes shape the perceptions of BDAMAC: BDA planning, investment, coordination, and control. The process begins with thorough BDA planning, which identifies business opportunities and assesses how big data models can enhance financial performance (FPER) (Barton and Court, 2012). Additionally, BDA investment decisions are crucial to BDAMAC, involving cost-benefit analyses to ensure the viability of the investments. As Ramaswamy (2013) stated, "We found that companies with huge investments in Big Data are generating excess returns and gaining competitive advantages, putting companies without significant investments in Big Data at risk." Organizations must develop dynamic strategies and relevant management capabilities to maximize the benefits of their investments (Gao and Sarwar, 2024). It is important for firms to recognize the necessity of cultivating management skills and capacities to effectively utilize big data analytics. It is also argued that management capabilities—like planning, investment, coordination, and control—are vital for making quick and informed decisions (Gao and Sarwar, 2024). In this regard, BDAMC empowers firms to recognize and take advantage of market opportunities while facilitating the transformation of current processes, ultimately improving their innovation performance.

H1: BDAMC has a positive impact on financial performance.

2.4.2. BDA technology capability (BDATEC)

Public policy plays a crucial role in shaping and impacting the competitive capability of enterprises in the tourism sector. BDATEC refers to the flexibility of the BDA platform, encompassing aspects such as cross-functional data connectivity, multi-platform compatibility, and modularity in model building. This flexibility enables data scientists to develop, deploy, and support a bank's resources rapidly. Perceptions of BDATEC are shaped by the following three core themes: Connectivity, compatibility, and modularity.

Adapting to volatile business conditions such as changes in competition, market dynamics, or consumer behavior, and aligning resources with both long-term and short-term business strategies (e.g. new product development, diversification) is crucial. A flexible BDATEC allows banks to source and connect various data points, create compatible data-sharing channels across different functions; and develop models and applications to address evolving needs. Therefore, a bank's BDA flexibility relies on two key components: Connectivity amongst different business units for sourcing and analyzing diverse data from various functions (e.g. supply chain management, customer relationship management) and the ability to adapt to changing requirements.

BDATEC is widely recognized as crucial for enhancing business and FPER (Akter et al., 2016). Research highlights a connection between BDATEC and FPER in various areas, including price optimization and profit maximization as well as improvements in sales, profitability, and market share. Additionally, BDATEC is linked to a higher return on investment (ROA) (Akter et al., 2016).

H2: BDATEC has a positive impact on financial performance.

2.4.3. BDA talent capability (BDATLC)

BDATLC refers to the ability of analytics professionals to perform tasks within a big data environment. This expertise, along with other types of knowledge, is viewed as a capability that can establish or maintain a competitive advantage (Constantiou and Kallinikos, 2015). Based on Delphi studies and literature, the study suggests that analysts should be proficient in four distinct yet equally important areas: technical knowledge, technology management knowledge, business knowledge and relational knowledge.

Firstly, technical knowledge includes understanding operational systems, statistics, programming languages, and database management systems. McAfee and Brynjolfsson (2012)

emphasized that the data-driven world demands new skills and management styles. The study by Waller and Fawcett (2013) identified essential skills for big data and predictive analytics professionals, such as statistics, forecasting, optimization, discrete event simulation, applied probability, mathematical modeling, finance, economics, marketing, and accounting. Previous IT capability research highlights technical and management skills as crucial qualities in the IT industry (Bharadwaj, 2000; Chae et al., 2014). Gupta and George (2016) suggested that human resources are vital for building BDA competence, characterized by experience, knowledge, business acumen, problem-solving ability, leadership, and interpersonal skills (Wade and Hulland, 2004; Akhtar et al., 2018).

Technology management knowledge involves overseeing big data resources to support business goals. For instance, Netflix analytics professionals use visualization and demand analytics tools to understand consumer behavior and preferences, contributing to the success of their "House of Cards" program in the United States (Ramaswamy, 2013).

Business knowledge requires an understanding of various business operations and the company environment. At Intuit (an American multinational business software company that specializes in financial software), analytics specialists are encouraged to comprehend business challenges and empathize with consumers. Relational knowledge pertains to the ability of analytics experts to interact and collaborate with colleagues from different business areas. Close relationships within the company have been crucial for LinkedIn, helping them to develop the "people you may know" feature, which resulted in a 30% higher clickthrough rate. Overall, balanced competency in project management, infrastructure, and knowledge must be created through continual training and mentoring (Barton and Court, 2012). The following hypothesis is a result of the investigation in this area:

H3: BDATLC has a positive impact on financial performance.

2.4.4. Big data analytics capability (BDAC)

BDAC is broadly defined as the ability to derive business insights through data management, technological infrastructure, and talent, thereby transforming a business into a competitive force (Kiron et al., 2014).

Institutional theory suggests that firms operate within a social framework of norms, values, and assumptions that define appropriate economic activities (Oliver, 1997; Peng et al., 2009). According to Tatoglu et al. (2016), despite institutional variations, embeddedness is crucial when evaluating BDA adoption at the organizational level. Thus, institutional differences among organizations influence all aspects of their operations (Tatoglu et al., 2016). By integrating these principles, we can demonstrate how organizational BDPA capability has developed, serving as a precursor to cost and operational performance.

BDAC is widely recognized as being essential for enhancing business and financial performance (Wixom et al., 2013). The literature supports a relationship between BDAC and financial performance, citing benefits such as price optimization and profit maximization (Davenport and Harris, 2007); sales, profitability, and market share (Manyika et al., 2011); and return on investment (ROA) (Barton and Court, 2012; McAfee and Brynjolfsson, 2012; Ramaswamy, 2013). For example, Srinivasan and Arunasalam (2013) found that BDAC helps banks in healthcare by reducing costs (e.g. minimizing waste and fraud) and improving the quality of care (e.g. safety and efficacy of treatment). Wixom et al. (2013) showed that BDAC enhances financial performance by boosting productivity, yielding both tangible benefits (e.g. reduced paper reporting) and intangible benefits (e.g. improved company reputation). Therefore, a firm that develops superior BDAC can maximize financial performance by leveraging insights gained from its BDAC.

The RBV suggests that an organization can achieve competitiveness by integrating strategic resources and/or talents into cohesive bundles. Both connectivity (a tangible resource) and information exchange (an intangible resource) can contribute to the development of BDA capability (Gunasekaran et al., 2017).

H4: BDAC has a positive impact on financial performance.

2.4.5. Bank performance (BPER)

Management theory and international stakeholder pressure may explain the directional connection between company sustainability performance and financial success (Yin, 2014), although empirical research on the influence of policy and international pressure is still limited. In addition to other effects such as competitive considerations and markets, an organization's behavior is influenced by rules, laws, regulations, norms, or cultures (Zhilong et al., 2009). Coercive, normative, and mimetic mechanisms are some of the notions used (Amran and Haniffa, 2011; Li and Parboteeah, 2015), and the institutional theory explains why organizations behave in predictable ways, and why strategic responses to institutional pressure can range from organizational resistance to passive acquiescence to aggressive manipulation.

Banks typically invest depositors' funds on their behalf in various ventures and companies, making the depositors co-responsible for the economic impact of their money (Werner, 2014). Sustainable banking involves a coordinated effort between the depositor and the bank (de Clerck, 2009), where the bank keeps the depositor informed about how their money is being utilised. It also involves communication between entrepreneurs and banks,

where entrepreneurs assure banks that the funds will be used sustainably. Transparency is essential (Cornée et al., 2016) and forms the basis of sustainable banking. Moreover, sustainable banking focuses on coordination and accountability as well as on the ethical use and management of the actual funds (de Clerck, 2009).

H5: The bank performance of Vietnamese banks has a positive effect on their financial performance.

2.5. Research model

The proposed research model, as illustrated in Fig. 1, is based on the RBV theory. The model includes five independent variables (BDA management capability, BDA technology capability, BDA talent capability, BDA capability, and bank performance) and one dependent variable (financial performance). The relationships between these variables are hypothesized to influence the financial performance of banks in the Vietnamese banking sector.

3. Research methodology

3.1. Sampling techniques and data collection

A quantitative research method enables the best representation and investigation of the relationship between variables in order to draw conclusions regarding the study's objectives. Therefore, a quantitative method was applied in this study. Due to time constraints, the researchers applied the convenience sampling technique, which employs respondents who are readily available and willing to answer questionnaires. The study applies EFA (exploratory factor analysis), which, according to Hair et al. (1998), requires a sample size of at least 50, preferably 100, with a variable ratio of 5:1 with the formula (3.2):n>=5*q, where n is the sample size and q refers to the number of questions.

The research had a total of 24 questions. As a consequence of the formula (3.2), the minimum sample size for EFA is n>=5*30=150 samples. As a result, the minimum number of samples needed to integrate EFA and regression analysis is 150. To mitigate risks and errors during the survey's execution and to improve the topic's accuracy, the research team surveyed 250 people who work at banks in Ho Chi Minh City, ranging from juniors to senior management, to ensure the significance of the research findings. Survey questionnaires were distributed via Google Forms to officers at banks in Ho Chi Minh City with a sampling size of 250 items.

3.2. Survey questionnaires

The research applies a five-point Likert scale ranging from "strongly disagree" to "strongly agree," which is a widely used scale in business research (Bell et al., 2022).

The measurement scales of the BDAMC included 4 questions, proposed by Boynton et al. (1994), Karimi et al. (2001), and Kim et al. (2012). The measurement scales of the BDATEC included 4 questions, proposed by Duncan (1995), Kim et al. (2012), and Byrd and Turner (2000). The measurement scales of the BDATLC included 4 questions, proposed by Kim et al. (2012) and Byrd and Turner (2000). The measurement scales of the BDAC scale included 4 questions, proposed by Karimi et al. (2001), Kim et al. (2012), and Li et al. (2003). The measurement scales of the BPER scale included 4 questions, proposed by Tippins and Sohi (2003) and Wang et al. (2016). Last but not least, the measurement scales of the FPER scale included 4 questions, proposed by Tippins and Sohi (2003) and Wang et al. (2016).

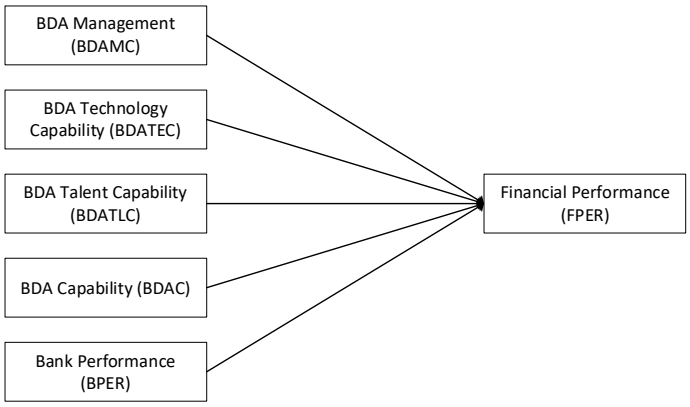

Fig. 1: Research model

3.3. Data analysis

The study utilizes Cronbach's Alpha Analysis, EFA, and Linear Regression Analysis, conducted with SPSS 20 software. The Cronbach's Alpha coefficient method is applied to assess the scale's reliability, with higher consistency indicating greater reliability. This method aims to eliminate unsuitable variables. Table 1 presents the KMO and Bartlett's test results, confirming the adequacy of data for factor analysis and supporting the structural validity of the research model. EFA is a statistical technique used to reveal the underlying structure amongst a large set of variables, aiming to identify the relationships

between these variables (Norris and Lecavalier, 2010). Meanwhile, regression analysis is used to determine the best-fit line representing the relationship between dependent and independent variables. Table 2 presents the rotated component matrix, which displays the factor loadings for the independent variables, ensuring the validity and reliability of the measurement constructs. Table 3 provides the KMO and Bartlett's test results for the dependent variable scale, ensuring its suitability for factor analysis and validating its role in the research model. Table 4 presents the rotated component matrix for the dependent variable, confirming the factor structure and reliability of the financial performance measurement scale. Table 5 summarizes the linear regression results, highlighting the relationships between BDA capabilities, bank performance, and financial performance, and confirming the significance of the proposed model. Table 6 presents the ANOVA results, verifying the overall significance of the regression model and supporting the robustness of the statistical analysis. Table 7 provides the regression coefficients, indicating the strength and direction of the relationships between independent variables and financial performance, further validating the research hypotheses.

4. Research findings

The number of initial soft questionnaires was 250 taken from online surveys using Google form documents. In the questionnaires collected, there were 35 questionnaires that were not valid. Therefore, the number of questionnaires used for the study is 215. Cronbach's Alpha coefficients of BDAMC, BDATEC, BDATLC, BDAC, and BPER, which are 0.796, 0.859, 0.803, 0.842, and 0.831, respectively, are all greater than 0.7. In addition, the Corrected Item-Total Correlation of all the variables in the scales is greater than 0.3. Therefore, the scales are reliable and the observed variables were preserved for the EFA analysis. Cronbach's Alpha coefficient of financial performance is higher than 0.7. In addition, the Corrected Item-Total Correlation of the variable in the scale is greater than 0.3. Therefore, the scale of the variables is reliable and the observed variables for this component were preserved for the EFA analysis. The Independent Variable Scales consists of 5 components with 20 observed variables. After passing the reliability test of the scale using Cronbach's Alpha coefficient, all of these observed variables were conducted in the EFA analysis.

Table 1: The result of KMO and Bartlett's test for independent variables

Kaiser-Meyer-Olkin measure of sampling adequacy		.810
Bartlett's test of sphericity	Approx. Chi-square	2041.938
	df	190
	Sig.	.000

The results of the factor analysis show that the coefficient KMO=0. 810>0.5, Sig.=0.000<0.5 (rejecting the Ho hypothesis: The observed variables are not correlated in the whole), so the hypothesis of the factor model is not appropriate and will be rejected. In conclusion, the data used for factor analysis is perfectly adequate.

Based on the results, at the Eigenvalue value=1.444>1, the total extracted variance is 67.569%>50%. This means that these 20 observed variables can explain 67.569% of the data variability.

Table 2: Rotated component matrix of independent variables

	Component				
	1	2	3	4	5
BDATEC4	.824				
BDATEC2	.819				
BDATEC3	.800				
BDATEC1	.788				
BPER2		.896			
BPER3		.869			
BPER4		.696			
BPER1		.623			
BDAC3			.867		
BDAC4			.835		
BDAC1			.803		
BDAC2			.745		
BDAMC3				.784	
BDAMC2				.781	
BDAMC4				.779	
BDAMC1				.718	
BDATLC2					.789
BDATLC3					.777
BDATLC4					.772
BDATLC1					.631

Using the Principal Components extraction method with Varimax procedure rotation, a loading coefficient of greater than 0.5 is considered to be of practical significance. This result shows that all variables are accepted and the components are in line with the proposed research model.

The Dependent Variable Scale (financial performance) consists of 4 observed variables. After passing the reliability test of the scale using Cronbach's Alpha coefficient, all the observed variables of the dependent variable were conducted in the EFA analysis.

Table 3: The result of KMO and Bartlett's test of the dependent variable

Kaiser-Meyer-Olkin measure of sampling adequacy		.764
Bartlett's test of sphericity	Approx. Chi-square	182.326
	df	6
	Sig.	.000

The results of the factor analysis show that the coefficient KMO=0.764>0.5, Sig.=0.000<0.5 (rejecting the Ho hypothesis: The observed variables are not correlated in the whole), so the hypothesis of the factor model is not appropriate and will be rejected. In conclusion, the data used for factor analysis is perfectly adequate.

Based on the results, at the Eigenvalue value=2.279>1, the total extracted variance is 56.977%>50%. This means that the 4 observed

variables of the dependent variable can explain 56.977% of the data variability.

Table 4: Rotated component matrix of dependent variables

Component matrix	
	Factor 1
FPER4	.773
FPER2	.768
FPER1	.760
FPER3	.717

Using the Principal Components extraction method with Varimax procedure rotation, a loading coefficient of greater than 0.5 is considered to be of practical significance. The result shows that all variables are accepted and the component is in line with the proposed research model.

Table 5: Linear regression summary

Model	R	R-squared	Adjusted R-squared	Standard error of the estimate
1	.770	.593	.583	.43476

Table 6: ANOVA results

Model	Sum of squares	df	Mean square	F	Sig.
Regression	57.581	5	11.516	60.926	.000[b]
Residual	39.505	209	.189		
Total	97.086	214			

Dependent variable: FPER; Predictors: BDAMC, BDATEC, BDATLC, BDAC, BPER

R2=0.593 (F=60.926; Sig.=0.00<0.05) so the coefficient of determination, R2, is completely statistically significant. The results of the analysis show that the R2 value is 0.593, which indicates that 5 independent variables, namely, BDA Management, BDA Technology Capability, BDA Talent Capability, BDA Capability, and Bank Performance explain 59.3% of the total variation in financial performance, while the remaining 40.7% depend on extrinsic variables and random errors. Therefore, this model is a good model because it can explain the correlation between Big data analysis and financial performance through 5 predictor variables as the initial hypothesis. Thus, the model can be a "predictive" model.

4.1. Hypothesis testing

The regression coefficient and "t" test with a significance level of 0.05 show that 5 out of 6 factors passed, for which: Variable BDAMC=-0.010 (-0.158; significance level=0.875>0.05) did not meet the requirement of statistical significance to accept H1. Therefore, the relationship between BDAMC and FPER is not statistically significant. The normalized regression coefficient shows that the important variable in the model is the BDAC variable, the second is the BDATLC variable and the third is the BPER variable. The unstandardized linear regression equation is as follows:

$$\text{FPER} = 0.568 + 0.369 \times \text{BDAC} - 0.01 \times \text{BDAMC} + 0.122 \times \text{BDATEC} + 0.292 \times \text{BDATLC} + 0.124 \times \text{BPER}$$

This can be rewritten as:

Financial Performance = 0.568 + 0.369*BDA Capability – 0.01 BDA Management Capability + 0.122*BDA Technology Capability + 0.292*BDA Talent Capability + 0.124*Bank Performance.

Table 7: Coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Standard error	Beta			Tolerance	VIF
1	(Constant)	.568	.276		2.057	.041		
	BDAC	.369	.053	.380	6.977	.000	.657	1.523
	BDAMC	-.010	.062	-.008	-.158	.875	.742	1.348
	BDATEC	.122	.045	.149	2.703	.007	.641	1.559
	BDATLC	.292	.055	.310	5.277	.000	.563	1.777
	BPER	.124	.050	.150	2.474	.014	.527	1.896

B: Unstandardized regression coefficient; Beta: Standardized regression coefficient; VIF: Variance inflation factor; t: Regression coefficient

Based on the unstandardized linear regression equation:

- BDAC: Beta=0.369 indicates that when BDAC increases by 1 unit, financial performance increases by 0.369 units on condition that the remaining factors do not change.
- BDATEC: Beta=0.122 indicates that when BDATEC increases by 1 unit, financial performance increases by 0.122 units on condition that the remaining factors do not change.
- BDATLC: Beta=0.292 indicates that when BDATLC increases by 1 unit, financial performance increases by 0.292 units on condition that the remaining factors do not change.
- BPER: Beta=0.124 indicates that when BPER increases by 1 unit, financial performance increases by 0.124 units on condition that the remaining factors do not change.

The standardized linear regression equation is:

$$FPER = 0.380 \times BDAC - 0.008\,BDAMC + 0.149 \times BDATEC + 0.310 \times BDATLC + 0.150 \times BPER$$

This can be rewritten as:

$$Financial\ performance = 0.380 \times BDA\ Capability - 0.008 BDA\ Management\ Capability + 0.149 \times BDA\ Technology\ Capability + 0.310 \times BDA\ Talent\ Capability + 0.150 \times Bank\ Performance$$

The standardized linear regression equation shows that BDAC, BDATLC, and BPER all significantly affect financial performance with a higher effect in comparison to BDATEC. The research results support four hypotheses:

H2: BDA technology capability has a positive impact on financial performance;
H3: BDA talent capability has a positive impact on financial performance;
H4: Big data analytics capability has a positive impact on financial performance;
H5: The bank performance of Vietnamese banks has a positive effect on their financial performance.

Meanwhile, H1 is not accepted, indicating that the relationship between BDAMC and FPER is not statistically significant.

5. Discussion

From a theoretical perspective, this study enhances our understanding of the relationship between BDA and financial performance in several ways; firstly, the study develops a scale of primary constructs with one dependent variable and five independent variables, along with their related measurement items, in the context of BDA research. This helps to answer the question, "What competencies (technical and non-technical) should an organization acquire in order to excel in big data initiatives?" This is a critical issue in current big data research (Phillips-Wren and Hoskisson, 2015).

The study's empirical findings address this question and align with the conceptual findings of Kiron et al. (2014), who stated that "An effective analytics culture is built on advanced data management procedures, technology, and people." Secondly, despite the limited empirical modeling in big data research, our study focuses on this area by creating a BDAC model grounded in socio-materialism, confirming that BDAC significantly affects company performance.

This study uses a unifying paradigm to merge various concepts (such as socio-materialism and IT capability) and offers a lean framework for multiple theoretical perspectives. Based on this, our study develops a model for integrating diverse capabilities into a single framework to assess their relative and synergistic effects on FPER. The emerging BDA research has struggled to establish the relevance of BDAC, BDATLC, BDATEC, and BPER as performance sources. Our study explicitly addresses this by proposing a BDA model that captures differences in FPER. Furthermore, the study explores the dimensions and sub-dimensions of BDA, offering potential solutions to their challenges. The model demonstrates its effectiveness both in proving structural simplicity and also in explaining theorized interactions at the first-order construct level. Additionally, the study adds theoretical rigor by evaluating the moderating influence of qualitative variables on FPER, suggesting that aligning capability and strategy helps big data businesses to understand and respond to their environments more efficiently (Constantiou and Kallinikos, 2015). Overall, the findings on the moderating effect of BDA clarify the conceptual model and expand theoretical contributions by detailing BDA's impact on financial performance (Iacobucci, 2009).

We conclude that integrating bank performance into the financial sector enhances financial performance. Therefore, credit policies can improve banks' corporate performance and foster a more stable and successful financial sector. Consequently, our findings suggest that Vietnamese banks should focus on enhancing corporate performance to help them achieve financial success and reinvest surplus resources into performance-enhancing activities.

The directional relationship between corporate sustainability performance and financial performance can be explained through institutional theory and international stakeholder pressure (Yin, 2014). However, empirical research on these policies and pressures remains limited. Besides competitive factors and markets, a firm's behavior is influenced by rules, laws, regulations, norms, and cultures (Zhilong et al., 2009). Institutional theory, through concepts like coercive, normative, and mimetic mechanisms (Amran and Haniffa, 2011; Li and Parboteeah, 2015), explains why firms often act similarly and also how they respond to institutional pressures through various strategies, including organizational resistance, passive conformity or proactive manipulation (Oliver, 1991).

The finding of the positive impact of bank performance on financial performance can be explained through the lenses of management theory and institutional theory. Management theory and international stakeholder pressure can help reason the link between a company's sustainability performance and its financial success (Yin, 2014). Organizational factors associated with management decisions such as liquidity, leverage, asset utilization, market share position, and firm size can create an impact on the financial performance of service firms. In addition to competitive dynamics and market conditions, an organization's behavior is influenced by rules, laws, regulations, norms, and cultural factors. The concepts of coercive, normative, and mimetic mechanisms are applied to describe these influences (Amran and Haniffa, 2011; Li and Parboteeah, 2015). Institutional theory provides insight into why organizations behave in predictable manners and demonstrates that their strategic responses to institutional pressure can range from resistance to passive acceptance and even to active manipulation. Many institutional theorists highlight the benefits of regulations and the impact of corporate performance on financial performance (Cheung et al., 2009; Dobers and Halme, 2009; Dutta et al., 2012; Xun, 2013). These theorists suggest that organizations respond to financial pressures by enhancing bank performance (Oliver, 1991; Shrivastava, 1995). Besides, the RBV theory can also be utilized to support this study's findings about the

positive impacts of BDA-related factors on banks' financial performance. According to RBV, a company's internal resources and capabilities generate competitive advantages (Barney, 1991), and firm performance depends on a unique set of resources that are difficult to replicate or substitute. RBV offers a theoretical foundation for understanding how various factors impact business outcomes (Rahman and Ramli, 2014). BDA-related factors such as BDA technology capability, BDA talent capability, and Big data analytics capability can be viewed as internal strengths or intangible assets that create competitive edges that can drive banks' financial performance.

It is clear that activities aimed at improving bank performance are resource-intensive (Orlitzky et al., 2011). Vietnamese banks are no exception; they need to implement management systems and develop expertise in the relatively new area of performance banking (Jin and Mengqi, 2011; Zeng et al., 2010). Thus, banks will only engage in performance-related activities if they foresee financial benefits, have the necessary resources, and respond to pressure.

Research indicates a correlation between bank size, measured by assets, and performance. Therefore, it is recommended to develop implementation guidelines tailored to banks of different sizes. Smaller banks, with fewer resources for performance activities, require more support to succeed. In line with Zhang et al. (2011), we suggest there should be more guidelines for organizations to consider regional differences, business models, capacity, and size of financial institutions to ensure the application of effective performance regulation in the financial sector.

Previous studies have established a positive correlation between IT capability and financial outcomes, which also supports this research's findings. For instance, the study by Lu and Ramamurthy (2011) found a significant positive relationship between IT capability and organizational agility, specifically market capitalizing agility and operational adjustment agility, through a matched-pair field survey of business and information systems executives. Similarly, Chen et al. (2014), using survey data from 214 Chinese IT and business executives in manufacturing firms, determined that IT capability positively impacts financial performance and that the dynamic capability of business processes mediates this relationship. In a cross-sectional sample of 155 banking firms, Lin (2007) demonstrated that IT capability and human capital investment directly enhance the overall value-creation performance of banking firms.

Kim et al. (2012) used a relational socio-materialistic conceptualization of IT capability and also found a significant positive relationship between IT capability and financial performance. Therefore, it is essential for operators and data leaders to understand the current state of the bank thoroughly, effectively utilize and process available data according to the bank's needs, foster a clear data-centric mindset, and provide regular training for employees. There are Vietnamese banks' unique challenges and opportunities in the BDA field which can be further discussed. Vietnamese financial institutions are in a strong position to leverage new technologies, thanks to a combination of factors including robust digital infrastructure, favorable demographics, and geographic advantages. Many Vietnamese banks benefit from the absence of deeply entrenched legacy systems, giving them a competitive edge. Demographics also play a key role. The growing, younger middle class in Vietnam is more tech-savvy and expects their banks to offer modern digital experiences. Geography is another factor in Vietnam's advantage. With a large land area, there is a strong need for excellent online and mobile banking interfaces to effectively serve customers in remote rural regions. However, challenges arise with customer data and digital risks. As banks expand their digital channels, the likelihood of cyberattacks and data breaches increases. It is essential for banks to implement robust security measures to protect client information and prevent unauthorized access. Additionally, organizations with an ill-aligned talent strategy may face risks due to a shortage of digital skills. Skill gaps or a lack of expertise are seen as major obstacles that could hinder organizations from achieving their digital transformation goals. Big data has already made a significant impact in the banking industry, moving beyond mere theory. There are real-world examples of how big data analytics is applied in banking and the benefits it offers to customers. Big data plays a crucial role in enabling banks to profile their customers. By analyzing a customer's banking history, personal information, and transaction data, and tracking spending patterns over time, banks can offer tailored financial solutions and personalized plans.

6. Conclusion

The primary objective of this research is to examine the relationship between BDA and the financial performance of banks in Ho Chi Minh City. Specifically, the study investigates how different aspects of BDA—such as management, technology capability, talent capability, overall BDA capability, and bank performance—affect financial outcomes. Understanding these dimensions of big data analytics is essential for identifying key factors that influence financial performance and providing valuable insights for banking professionals.

The findings of this study have important implications for the banking and finance sector in Ho Chi Minh City. The results indicate that various BDA-related factors, including technological capacity, skilled workforce, overall bank capability, and bank performance, significantly impact financial performance. Among these, BDA capability has the strongest influence, with a coefficient of 0.380. BDA talent capability follows with a coefficient of 0.310, while bank performance and BDA technology

capability have coefficients of 0.150 and 0.149, respectively. This suggests that a one-unit increase in BDA capability leads to a 0.369-unit increase in financial performance, assuming all other factors remain constant. Overall, the study demonstrates that all examined aspects of big data analytics positively contribute to the financial performance of banks in Ho Chi Minh City.

6.1. BDA capability

According to the results of this study, big data analysis capability plays a crucial role in consolidating financial performance, with Beta Standardise 0.380. This means that improving the BDA capability will help to improve financial performance. Moreover, banks now need to focus on implementing big data analytics planning processes in a systematic and formalized manner and then regularly adjust big data analytics plans to adapt to the constantly changing conditions of the world in a better way. Particularly within a bank's organization, analysts and staff members need to coordinate their efforts more harmoniously, and banks need to implement and clarify the operational criteria of big data in the organization.

6.2. BDA talent capability

According to the results of the survey, BDA talent capacity (beta=0.310) or human resource capacity on big data has a positive impact on financial performance at banks. Therefore, banks need to improve the capacity of employees, especially those who often use data in their work. This can be done through training sessions on big data so that employees improve their programming ability and flexibly use more mature processing tools. According to the author, executives can invite experts in the fields of finance and big data so that they can cultivate a superior understanding of technology trends, data processing skills, and data thinking. At the same time, banks need to clarify their organizational policies and plans and disseminate them to the people who work with the data and those involved. It is important to ensure that the analyst understands the organization's policies and plans at a very high level.

6.3 BDA technology capability

Again, according to the survey results, BDA technology capacity (beta=0.149) has a positive impact on banks' financial performance. Therefore, banks need to improve the capacity of their IT, especially those who often use and work with data. According to the author, operators need to organize connections flexibly and create a good environment for software applications to be easily transported and used on many analytical platforms. Hence, operators should know how to ensure that reusable software modules are widely used in developing new analytic models. This will help banks to reduce the human resources and effort needed to build a new system after each project.

6.4. Limitations and recommendations for future research

This study has certain limitations, and the author suggests several directions for future research.

First, increasing the sample size would improve the reliability of the results and ensure more accurate data analysis. A larger sample allows for more precise statistical processing and better representation of the population.

Second, future research should explore different industries, sectors, locations, and countries. Factors such as management practices, technological capability, and workforce skills may vary across different contexts, making the findings more generalizable.

Third, this study primarily used Cronbach's Alpha for reliability testing, EFA, correlation analysis, multiple linear regression, and ANOVA testing. To develop a more advanced theoretical model, future studies should consider using SEM. Finally, further research could examine the moderating effects of factors such as performance, individual characteristics, or prior experience. This would help determine whether these variables influence the relationship between independent and dependent variables.

List of abbreviations

BDA	Big data analytics
BDAMC	BDA management capability
BDATEC	BDA technology capability
BDATLC	BDA talent capability
BDAC	BDA capability
BPER	Bank performance
FPER	Financial performance
RBV	Resource-based view
BFSI	Banking, financial services, and insurance
SCs	Supply chains
OCBC	Overseas Chinese Banking Corporation
eKYC	Electronic know your customer
POS	Point of sale
ROA	Return on assets
SEM	Structural equation modeling
IT	Information technology
SPSS	Statistical Package for the Social Sciences
EFA	Exploratory factor analysis
ANOVA	Analysis of variance
KMO	Kaiser-Meyer-Olkin

Compliance with ethical standards

Ethical considerations

This study adhered to ethical research guidelines, ensuring informed consent, participant anonymity, and voluntary participation. No personally identifiable information was collected, and ethical

approval was not required under institutional regulations.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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