The Application of Big Data on The Performance of MSME Businesses in Batam City

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Article Information	Abstract
	This study investigates the influence of Big Data implementation on the business performance of Micro, Small, and Medium Enterprises (MSMEs) in Batam City. The research examines three characteristics of Big Data—Data Volume, Data Velocity, and Data Variety—and their impact on MSMEs' business performance. Data were collected through questionnaires distributed to MSME owners or managers in Batam. Statistical analysis, including descriptive statistics, validity tests, reliability tests, and hypothesis testing using T-tests, was conducted to analyze the data. The findings indicate that the implementation of Big Data with Data Volume and Data Velocity characteristics does not significantly influence the business performance of MSMEs in Batam City. However, the implementation of Big Data with Data Variety characteristics shows a significant positive influence on MSMEs' business performance. This suggests that the diverse information encompassed by Data Variety aids MSMEs in improving their business performance by identifying and addressing various aspects of their operations.

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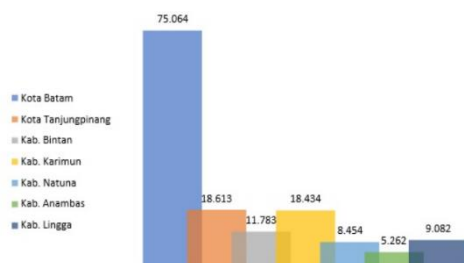Hardibahar86@gmail.com

INTRODUCTION

In the current industrial era, every sector is closely tied to the utilization of digital technology advancements. The rapid development in technology has had a positive impact on various industries, particularly micro, small, and medium-sized enterprises (MSMEs) in Indonesia. Alongside technological progress, the potential for increasing income has grown, leading to significant expansion and positive contributions to Indonesia's economy by MSMEs. Notably, they create numerous job opportunities and enhance overall economic performance.

According to data released by the Ministry of Cooperatives and Small and Medium Enterprises (Kementerian KUKM, 2021), the MSME sector in the Riau Islands ranks 19th with a total of 76,217 units. While economic growth in this region is driven by the dominance of the Manufacturing Industry, particularly in the production of metal goods, electronics, optical fibers, maritime transport equipment, and related sectors, MSMEs also play a crucial role in stimulating the economy with significant growth. In 2022, there was a remarkable surge in the number of MSME players in the Riau Islands, reaching 146,638 units—an increase of 192% within one year. This phenomenon underscores the substantial potential within the MSME sector, possibly influenced by factors such as government support policies, changes in consumer behavior, or technology adoption. With this rapid growth, the role of MSMEs in the Riau Islands becomes increasingly vital in supporting the regional economy. Here are the specific improvements in MSMEs across different areas:

Figure 1. The number of MSMEs in the Riau Islands in 2021

Source: Data from the Ministry of Cooperatives and Small and Medium Enterprises (2021)

However, based on surveys conducted by Hery (2022), MSMEs in Batam City engaged in electronic goods and services experienced decreased productivity, work efficiency, and income since the beginning of the pandemic. These businesses did not engage in digital promotions or marketing. A similar survey by Shereen et al. (2023) revealed that the decline in business product sales in 2021 was due to the Covid-19 pandemic and intense competition among fellow entrepreneurs. Additionally, the marketing systems applied were relatively simple. These survey results indicate that MSMEs in Batam City have not achieved high performance.

The cause lies in the fact that many MSME operators still feel unfamiliar with technology, leading to what is commonly referred to as "technological hesitancy" or "tech-shy" behavior. They choose to continue selling through conventional methods due to a

lack of understanding or uncertainty related to digital technology. Consequently, there is a significant difference in how MSMEs respond to and adopt technological advancements, which ultimately affects their business performance in the ever-evolving e-commerce era (Liputan, 2020). A similar challenge is faced by the residents of Batam City, who struggle to understand how to promote and distribute their products digitally, resulting in difficulty keeping up with technological developments used as a medium for product promotion (Riady et al., 2021).

In a study by Ghasemaghaei (2019a), three primary dimensions—data velocity, data volume, and data variety—pose challenges in data management. These three "Vs" are key characteristics of big data. Data velocity refers to the speed of data processing within systems, data volume relates to the amount of processed data, and data variety encompasses the diversity of data types.

Several research findings have explored the impact of BDA on MSME performance. For instance, Ghasemaghaei (2019a) analyzed the effects of big data on firm performance using variables such as data volume, data velocity, data variety, data value, and data veracity. The results indicated that data variety positively influenced data value, while data volume and data velocity had no significant impact on it. Interestingly, despite data volume having a negative effect on data value, both data velocity and data variety positively affected data veracity. Ultimately, data veracity was found to positively influence firm performance, mediated by data value.

Another study (Ghasemaghaei, 2019b) highlighted that data variety and data velocity positively enhance innovation performance in companies, whereas data volume does not significantly impact it.

Based on these research findings, it can be concluded that BDA holds potential for improving MSME performance. Therefore, MSME operators should understand and develop BDA characteristics within the e-commerce systems they use. By doing so, BDA can be optimally leveraged by MSMEs to enhance their performance.

Performance is a critical indicator for measuring MSME success. There are two types of performance: financial performance and non-financial performance. Financial performance encompasses profitability and short-term goals, while non-financial performance focuses on long-term objectives.

However, when measuring MSME performance, not all profitability parameters applicable to large corporations can be directly applied to MSMEs. Many MSMEs do not maintain comprehensive financial records, with most only tracking gross revenue. Therefore, various indicators, such as financial return (based on sales revenue), customer perspective (customer satisfaction), and operational excellence (operational productivity), can be used to assess MSME performance.

In summary, previous research highlights the importance of Big Data Analytics in the context of e-commerce-based accounting systems for enhancing MSME performance in Batam City. Big Data Analytics serves as an independent variable in this study, while MSME performance in Batam City acts as the dependent variable.

The researchers hope that this study will provide deeper insights into e-commerce-based accounting information systems and their impact on the performance of Small and Medium-sized Enterprises (SMEs) in Batam City. Additionally, they aim to understand the effects of implementing Big Data Analytics (BDA) with different data characteristics (Volume, Velocity, and Variety) on the business performance of SMEs in Batam.

In summary, the study investigates the relationship between BDA and SME performance, considering various data characteristics. It also aims to provide empirical evidence for practical implementation in SMEs.

LITERATURE REVIEW
Organizational Learning Theory

According to Huber (1991) in the study by Ghasemaghaei (2019a), Organizational Learning Theory is based on a resource-based perspective, which asserts that a company's learning capability is not easily imitated by other firms. This theory refers to an organization's ability to gather, store, and utilize knowledge from past experiences to enhance future performance. It emphasizes the importance of continuous and collaborative learning across all organizational levels.

The concept of Organizational Learning Theory focuses on how organizations acquire new knowledge, skills, and capabilities to adapt and improve their performance. In the context of your research, it involves examining how organizations, particularly Small and Medium-sized Enterprises (UMKM) in Batam

City, can learn from the utilization of big data analytics within e-commerce-based accounting information systems. By integrating this technology, organizations aim to foster positive organizational learning, facilitate adaptation to changes, and enhance business performance.

Big Data Analytic

According to Maryanto (2017), Big data refers to a term given to a collection of data that is extremely large and complex, making it impossible to process using conventional database management tools or other data processing applications.

According to Appelbaum et al. (2017), Big Data Analytics involves analyzing data with significant variation, high velocity, and very large volume. This data originates from sources such as spreadsheets, sensors, videos, audio files, tweets, and other textual social media content.

Furthermore, big data analytics has the capability to handle various data formats. Generally, there are two main data groups that need to be managed:
1. Structured data
   Structured data is a group of data that has data types, shapes, and structures that have been defined. The data sources can be transactional data, OLAP data, traditional RDBMS, CSV files, spreadsheets.
2. Unstructured data
   Unstructured data is a group of textual data with an erratic format or no inherent structure, so to make it structured data requires more effort, tools, and processing time. This data is generated by internet applications, such as log URL data, social media, e-mail, websites, videos, and audio.

In the study by Ghasemaghaei (2019a), Big data is defined as data characterized by high velocity, large volume, and significant variation. It requires advanced technology for data collection, storage, distribution, and analysis.
1. Data Volume
   Data Volume refers to the amount of data. Processing large volumes of data enables companies to enhance their insights into consumer behavior, thereby improving their financial performance compared to their competitors. Advances in data management (such as cloud computing and virtualization) facilitate the development of platforms to effectively collect, process, and analyze large-sized data (Ghasemaghaei, 2019a).

2. Data Velocity
   Data Velocity is the speed at which data is generated and analyzed. Digital advancements, such as sensors and smartphones, have significantly increased the rate of data production, thus increasing the need for real-time data analysis. For instance, real-time analysis of customer data, such as their purchasing patterns and geospatial locations, can create tangible value for companies (Ghasemaghaei, 2019a).
3. Data Variety
   Data Variety refers to the diversity of data types, which includes structured data (e.g., numbers) and unstructured data (e.g., images, customer reviews, audio, sensor data). The variety of data is generated not only internally but also from external sources.

Collecting various types of data will increase the opportunities for SMEs to discover new customer insights, thereby enhancing their ability to continuously improve their product offerings. Having access to customer data in e-commerce helps companies generate previously unknown insights, enabling them to better understand their customers. For example, SMEs that extract consumer comments about their products from e-commerce reviews and combine them with consumer purchase history can better identify consumer preferences, which can help SMEs develop new products that meet consumer needs. Similarly, store performance data and sales data, along with the volume, type, and speed at which SMEs process and access their data, will also affect their ability to evaluate it.

SMES Performance

SMEs (Small and Medium Enterprises) are officially regulated by the Republic of Indonesia Law No.20 of 2008, which briefly states:
1. Micro Enterprises are individual businesses with a maximum wealth of Rp.50,000,000 and annual sales of up to Rp.300,000,000.
2. Small Enterprises are individual businesses with assets ranging from Rp.50,000,000 to Rp.500,000,000 and annual sales ranging from Rp.300,000,000 to Rp.2,500,000,000.
3. Medium Enterprises are individual businesses with assets between Rp.500,000,000 and Rp.10,000,000,000 and sales from Rp.2,500,000,000 to Rp.50,000,000,000.

Nowadays, the development of accounting information systems is available in digital form. For instance, APIK provided by Bank Indonesia can be used for financial recording in SMEs. Accounting offers various benefits to SMEs. Among these benefits are providing a basis for information in decision making, determining business development strategies, evaluating business performance, facilitating business activities, and effective planning (Sriwardany et al., 2023).

The series of results obtained by an organization or an individual is called performance. Performance measurement is carried out over a certain period, after which the company's progress is visible from the essential information provided to decision makers (Wahyuni et al., 2018). There are two types of performance: financial performance and non-financial performance. In the study by Fatimah & Azlina (2021), financial performance is defined as a performance measure that includes profitability and short-term goals, while non-financial performance focuses on long-term goals. Financial statements are an essential source of data for calculating financial ratios in a company and predicting future financial performance. In this context, profit margins or profitability ratios are the most commonly used metrics to evaluate a company's success over time (Prastika & Purnomo, 2019).

When measuring the performance of SMEs, not all profitability ratio parameters used by large companies can be applied to SMEs. This is because not all SMEs have recorded financial statements, and the majority only record gross income (Syah & Karen, 2022). Therefore, this study considers various categories of performance, namely financial returns, customer perspective, and operational excellence, to measure the overall performance of SMEs (Ghasemaghaei, 2019b).

Conceptual Framework of the Research

The author presents the conceptual framework in the form of a paradigm scheme of thought as follows:
1. Research Model

Figure 2. Research Model
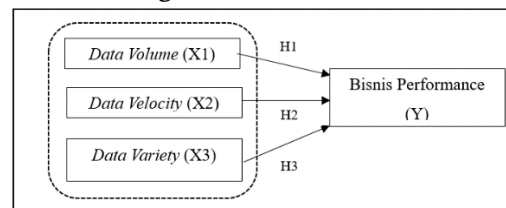
2. Research Hypotheses

The research hypotheses are temporary answers to the research problems to be tested. These hypotheses are derived from previous research and theoretical studies. The hypotheses to be investigated and developed are:
a. The application of big data analytics with the characteristic of Data Volume on the business performance of MSMEs in Batam City.
   - H01: The application of big data analytics with the characteristic of Data Volume has no impact on the business performance of MSMEs in Batam City.
   - Ha1: The application of big data analytics with the characteristic of Data Volume affects the business performance of MSMEs in Batam City.
b. The application of big data analytics with the characteristic of Data Velocity on the business performance of MSMEs in Batam City.
   - H02: The application of big data analytics with the characteristic of Data Velocity has no impact on the business performance of MSMEs in Batam City.
   - Ha2: The application of big data analytics with the characteristic of Data Velocity affects the business performance of MSMEs in Batam City.
c. The application of big data analytics with the characteristic of Data Variety on the business performance of MSMEs in Batam City.
   - H03: The application of big data analytics with the characteristic of Data Variety has no impact on the business performance of MSMEs in Batam City.
   - Ha3: The application of big data analytics with the characteristic of Data Variety affects the business performance of MSMEs in Batam City.

RESEARCH METHODS
Research Approach

This research is designed using a quantitative descriptive research method,

which aims to describe a situation objectively using numbers, from the stages of data collection, interpretation of the data owned, to the presentation/display of data and the results of its processing (Suharsimi, 2019).

Research Population and Sample

1. The population is a generalization area consisting of objects or subjects with certain qualities and characteristics determined by the researcher to be studied and then conclusions drawn (Sugiyono, 2019). In the research by Buulolo & Buulolo (2023), it is stated that the population of SMEs in Batam City amounts to 854 SMEs. In this study, the target population that will be used by the researcher as the subject of this study is SME entrepreneurs domiciled in Batam City.

2. The sample is part of the number and characteristics possessed by the population. The sample taken from the population must be truly representative. The sample size is the number of samples to be taken from a population (Sugiyono, 2019). There are many types of sampling processes that can be applied. In this research, the researcher will use purposive sampling technique to take samples from the population with criteria of SME entrepreneurs in Batam City who have used e-commerce (Shopee and Tokopedia) in their business activities. The researcher chooses to use Shopee and Tokopedia as the objects of this research based on the consideration of the ease of obtaining research samples.

In this study, the researcher uses the formula proposed by Hair et al. In the research by Finthariasari et al. (2020), it is stated that according to Hair et al. in determining the sample size, it is taken from the number of indicators used, then multiplied by 5-10 to get the right sample size to use. Thus, in this study, a minimum of 108 respondents are needed.

Data Collection Method

The data collection method used is the distribution of questionnaires using Google Form to the predetermined subjects, which are the first reference from the sector and addressed to SME entrepreneurs in Batam City. The compilation of the questionnaire will be based on the indicators of each research variable that has references from theoretical studies and previous research from various journal and book sources.

The form of responses to this questionnaire will utilize a Likert scale, a psychometric scale commonly used in surveys and the most used scale in survey research. With the Likert scale, the variable to be measured is broken down into variable indicators. These indicators will become the starting point for the formulation of statements or questions in the research instrument (Sugiyono, 2019).

Table 1. Likert Scale

Likert Scale	Likert Scale Measurement
1	Strongly Disagree (STS)
2	Disagree (TS)
3	Agree (S)
4	Strongly Agree (SS)

Data Analysis Method

The data analysis method used by the researcher is data processing based on the use of Microsoft Excel and data processing using the R programming language through Google Colaboratory.

1. Descriptive analysis is statistics used to analyze data by describing or depicting the collected data as they are without intending to make general conclusions or generalizations. The measurements used in this study include the maximum value, minimum value, average, and standard deviation (Sugiyono, 2019).

2. Inferential statistics is a method used to draw conclusions and generalize them to the population, while the data used to make conclusions use samples from the population. The analysis carried out can involve relationships, influences, differences between two or more variables (Sugiyono, 2019).

   a. Outer Model Test
      According to Hair et al. (2017), the outer model test consists of validity and reliability tests explained as follows:

      1) Validity Test. The validity test is used to measure whether an instrument or questionnaire used is valid (Sugiyono, 2019). According to Hair et al. (2017), the validity test consists of:

         a) Convergent Validity
            This measurement is related to the principle that statement items in a construct should have a high correlation (Ghozali, 2014). This convergent measurement shows whether each indicator measures the same dimension of the construct.

Therefore, only indicators that have a high significance level, which is greater than twice the standard error in measuring the research variable indicators.

The criteria used to assess convergent validity is the value of outer loadings greater than 0.7. In this research, a loading factor of 0.5 to 0.6 is considered sufficient, because it is the initial stage of measurement scale development and the number of indicators per construct is not large, ranging from 3 to 7 indicators. AVE (Average Variance Extracted) is the percentage of variance extracted between items or indicators of a latent construct set, which is a summary of convergent indicators. For good requirements, if the AVE of each construct is greater than 0.5.

b) Discriminant Validity. This measurement is related to the principle that statement items in one construct that are different do not have a high correlation. The way to test discriminant validity is by comparing the cross-loading value, which can be said to meet discriminant validity if the indicator value of cross-loading against its variable is the largest compared to other variables (Ghozali, 2014).

2) Reliability Test. The reliability test is used to measure the reliability of a questionnaire and the information used can be trusted as a data collection tool. According to Hair et al. (2017), data reliability is analyzed through internal consistency reliability, which is seen from the composite reliability value greater than 0.7 and Cronbach's alpha value greater than 0.7.

b. Inner Model Test

The inner model test, often referred to as the structural model test, is a test conducted to examine the relationship between latent constructs. The inner model in this study uses the coefficient of determination test explained as follows:

1) Coefficient of Determination Test (R² Test)

The coefficient of determination test or R² test functions to test whether the independent variables studied can measure and explain well each dependent variable. The criteria of this test are results with values of 0.75, 0.50, and 0.25 indicating that the model is categorized as strong, moderate, and weak.

2) Hypothesis Testing

The hypothesis testing used in this study is bootstrapping and path coefficients tests, which allow for data to be distributed freely (distribution-free), so it does not require normal distribution assumptions and does not require a large sample size, but a minimum sample size of 30 is still recommended.

The criteria used for bootstrapping hypothesis testing is that the independent variable is declared to have an effect on the dependent variable if the T-Statistics value is greater than the T table value of 1.98 with a 5% significance level. According to Gudergan et al. (2008), in the path coefficients test, if there is no 0 (zero) value between the range of lower percentile (perc.025) and upper percentile (perc.075), then it can be stated that the independent variable has a significant effect on the dependent variable being tested.

RESULTS AND DISCUSSION
General Description of Research Objects and Respondent Characteristics

In this section, the researcher will describe the results and discussion based on the hypotheses formed in the previous chapter. From the sample collection conducted through primary data collection instruments, namely questionnaires, there are 109 respondents as SME entrepreneurs in Batam City who have used e-commerce.

1. Respondent Characteristics by Gender

The findings show that of the total 109 respondents who responded to the distributed questionnaires, the majority are female. There are 66 female respondents or 60.6% and 43 male respondents or 39.4%, as shown in Table 2.

Table 2. Respondent Characteristics by Gender

Gender	Count	Percentage
Male	43	39.4%
Female	66	60.6%
Total	109	100%

Source: Processed Data by Researcher

2. Respondent Characteristics by Business Type

The findings show that of the total 109 respondents, the number of respondents running a fashion business is 18 respondents or 16.5%, and the number of respondents running a culinary business is 64 respondents or 58.7%. The number of respondents running businesses other than fashion and culinary is 27 respondents or 24.8%, as shown in Table 3. Therefore, it can be concluded that the majority of respondents participating in the questionnaire are engaged in culinary business.

Table 3. Respondent Characteristics by Business Type

Business Type	Count	Percentage
Fashion	18	16.5%
Culinary	64	58.7%
Others	27	24.8%
Total	109	100%

Source: Processed Data by Researcher

3. Characteristics of Respondents Based on Type of Business

The findings indicate that out of a total of 109 respondents, 18 respondents or 16.5% are involved in the fashion business, and 64 respondents or 58.7% are in the culinary business. Furthermore, 27 respondents or 24.8% are engaged in businesses other than fashion and culinary, as shown in Table 3. Thus, it can be concluded that the majority of respondents participating in the questionnaire are involved in the culinary industry.

4. Respondent Characteristics (Type of Business)

Table 4. Respondent Characteristics (Type of Business)

Type of Business	Number	Percentage
Fashion Business	18	16,5%
Culinary Business	64	58,7%
Others	27	24,8%
Total	**109**	**100%**

Source: Data processed by Researchers

5. Characteristics of Respondents Based on Business Location

The findings show that out of a total of 109 respondents, all respondents operate their businesses in Batam City, accounting for 100%, while none operate outside Batam City, as shown in Table 4. Therefore, it can be concluded that the majority of respondents participating in the questionnaire operate their businesses in Batam City.

6. Respondent Characteristics (Business Location)

Table 5. Respondent Characteristics (Business Location)

Business Location	Number	Percentage
Batam City	109	100%
Outside Batam City	0	0%
Total	**109**	**100%**

Source: Data processed by Researchers

7. Characteristics of Respondents Based on Type of E-Commerce

The findings indicate that out of a total of 109 respondents, 80 respondents or 73% use Shopee, and 29 respondents or 27% use Tokopedia, as shown in Table 6. Thus, it can be concluded that the majority of respondents participating in the questionnaire have utilized e-commerce platforms in their business operations.

8. Respondent Characteristics (Type of E-Commerce)

Table 6. Respondent Characteristics (Type of E-Commerce)

E-Commerce Type	Number	Percentage
Shopee	80	73%
Tokopedia	29	27%
Total	**109**	**100%**

Source: Data processed by Researchers

Description of Research Variables

The description of research variables in descriptive statistics used in this study includes the minimum value, maximum value, mean, and standard deviation of two independent variables and one dependent variable.

1. Description of BDA

Variable For the next stage, which involves further analyzing data obtained from respondents' choices regarding each variable

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under study indicators, it can be observed in the descriptive results as follows in Table 7.

Table 7. Description of BDA

Variabel (X1)	Count	Mean	Min	Max	Standard Deviation
BDA.Vo_1	109	3.85	2	4	0.38
BDA.Vo_2	109	3.86	2	4	0.37
BDA.Vo_3	109	3.80	2	4	0.43
BDA.Ve_1	109	3.88	3	4	0.33
BDA.Ve_2	109	3.87	3	4	0.34
BDA.Ve_3	109	3.84	2	4	0.41
BDA.Va_1	109	3.88	2	4	0.35
BDA.Va_2	109	3.87	2	4	0.39
BDA.Va_3	109	3.84	2	4	0.45

Source: Data processed by Researchers

From the table data, it can be concluded that the second independent variable (X1), namely big data analytics, consists of 9 statements in the questionnaire. The minimum value ranges from 2, indicating disagreement among respondents, to 4, indicating strong agreement with the statements in the questionnaire. The mean or average response from the questionnaire indicates that the majority of respondents agree with the 9 statements, selecting option 3 in the questionnaire. The standard deviation values for each indicator are above zero, indicating variability in respondents' responses to the big data analytics variable.

2. Description of UMKM Performance Variable

The processing of respondent response data for UMKM performance variables can be observed in descriptive form in the following table.

3. Description of UMKM Performance Variable

Table 8. Description of UMKM Performance Variable

Variabel (Y)	Count	Mean	Min	Max	Standard Deviation
K.FR_1	109	3.33	1	3	0.88
K.OE_1	109	3.74	2	4	0.57
K.OE_2	109	3.72	1	4	0.58
K.CP_1	109	3.80	2	4	0.49
K.CP_2	109	3.73	1	4	0.63

Source: Data processed by Researchers

From the table data, it can be concluded that the dependent variable (Y), namely UMKM performance, consists of 5 statements in the questionnaire. The minimum value varies from 1, indicating strong disagreement among respondents, to 4, indicating strong agreement with the statements in the questionnaire. The maximum mean value is 3, indicating respondents agree with the statements in the questionnaire, up to 4, indicating strong agreement with the statements in the questionnaire. Continuing with the mean or average of respondents'

answers in the questionnaire, which states that the majority of respondents agree with 5 statements in the questionnaire. Standard deviation values for each indicator are above zero, indicating that respondents' responses vary and are not the same for UMKM performance variables.

Inferential Analysis

Inferential Analysis consists of two parts, namely outer model analysis and inner model analysis. Further testing was conducted using the R programming language with Google Colaboratory application.

1. Outer Model Test Analysis

   a) Validity Test

   Validity testing is a measurement to prove whether each statement in the questionnaire is able to represent each variable under study and whether the questionnaire is valid for use as a reference. This test includes convergent validity and discriminant validity, which will be further explained as follows.

   1) Convergent Validity

   The results of convergent validity measurement can be observed in the table below.

Table 9. Convergent validity

Variabel	Indikator	Loadings	AVE
Data Volume	BDA.Vo_1	0.902	0.8282818
	BDA.Vo_2	0.927	
	BDA.Vo_3	0.901	
Data Velocity	BDA.Ve_1	0.954	0.8943426
	BDA.Ve_2	0.910	
	BDA.Ve_3	0.972	
Data Variety	BDA.Va_1	0.871	0.8457183
	BDA.Va_2	0.934	
	BDA.Va_3	0.952	
Kinerja UMKM	K.FR_1	0.523	0.6755677
	K.OE_1	0.847	
	K.OE_2	0.838	
	K.CP_1	0.922	
	K.CP_2	0.913	

Source: Data processed by Researchers

Observing Table 9, *Convergent validity* it can be noted that the values produced by the indicators Data volume, Data Velocity, Data Variety, and UMKM performance have met the standard convergent validity criteria as all factors have values greater than 0.5. Therefore, it can be concluded that all indicators are valid.

Variables are considered to have high reliability if the AVE (Average Variance Extracted) value is above 0.5. Based on Table 4.8, it is stated that all

variables meet this criterion as their values are above the recommended threshold of 0.5, thus satisfying the reliability criteria.

2) Discriminant Validity

The results of Discriminant Validity measurement evaluated through cross-loadings can be observed in the table below.

Tabel 10. Discriminant Validity

	Vo	Ve	Va	K
BDA.Vo_1	0.90238580	0.5775051	0.5829980	0.1843438
BDA.Vo_2	0.92653495	0.6076134	0.5998322	0.3351107
BDA.Vo_3	0.90115377	0.5297432	0.5627674	0.2275799
BDA.Ve_1	0.56349524	0.9540240	0.6587861	0.3744791
BDA.Ve_2	0.62820380	0.9097703	0.6394124	0.2994225
BDA.Ve_3	0.61056759	0.9722057	0.7433659	0.4377955
BDA.Va_1	0.56053054	0.6726447	0.8705219	0.3555316
BDA.Va_2	0.57607339	0.7161891	0.9339791	0.4203438
BDA.Va_3	0.62647792	0.6219159	0.9523809	0.4785877
K.FR_1	0.05597332	0.1333086	0.0885150	0.5231800
K.OE_1	0.18442866	0.3343682	0.3673514	0.8473139
K.OE_2	0.24327264	0.2937477	0.3429132	0.8382559
K.CP_1	0.30106865	0.4125218	0.5098782	0.9223135
K.CP_2	0.30272256	0.3708897	0.4136821	0.9126034

Source: Data processed by Researchers

In Table 10, through cross-loading tests, which compare the correlations between indicators with their constructs and with constructs of other indicators, it can be observed that the correlation of each indicator and the variables under study—Data Volume, Data Velocity, Data Variety, and UMKM performance—with their constructs is higher than the correlation with constructs of other indicators. This demonstrates that these constructs can predict measures within their block better than other blocks, thus fulfilling the discriminant validity requirement.

b) Reliability Test

Reliability testing is used to measure the consistency of a questionnaire and whether the information used can be trusted as a data collection tool. The reliability of the data is analyzed through internal consistency reliability, namely Cronbach's alpha and composite reliability, the results of which are shown in the following table.

Table 11. Cronbach's Alpha & Composite Reliability

Variabel	Cronbach's_Alpha	Composite Reliability
Data Volume	0.901	0.938
Data Velocity	0.941	0.962
Data Variety	0.909	0.942
Kinerja	0.877	0.912

Source: Data processed by Researchers

In Table 11, it can be observed that all variables have Cronbach's alpha values greater than 0.7, indicating that each variable is reliable for its questionnaire. Additionally, with composite reliability values also exceeding 0.7, it is evident that all variables exhibit good reliability. Therefore, it can be concluded that the statements representing each variable in the questionnaire meet the criteria and are reliable for use in further data processing.

2. Inner Model Test Analysis

a) Coefficient of Determination (R^2)

Test This test is used to examine whether the independent variables under study can explain their dependent variables and to measure the amount of variance in the dependent variable explained by the independent variables.

Table 12. Koefisien Determinasi (R^2)

Variabel	R-Squared
Kinerja	0.222

Source: Data processed by Researchers

From the observations in Table 12, the R-Square value is 0.222. This value indicates that the influence of the variables Data Volume, Data Velocity, and Data Variety on the Performance variable is 22.2%, with the remainder being influenced by other variables outside the scope of this study.

b) Hypothesis Testing

Hypothesis testing is a statistical procedure aimed at helping researchers determine whether hypotheses derived from previously researched data can be accepted or rejected.

The results of hypothesis testing using bootstrapping and path coefficients can be observed in the following table.

Table 13. Hypothesis Testing

	T-Statistic	perc.0.25	perc.975	Description
Volume -> Kinerja	-0.28642	-0.26898791	0.1983933	Ha1 Rejected
Velocity -> Kinerja	1.320665	-0.07112423	0.4018835	Ha2 Rejected
Variety -> Kinerja	3.0645902	0.13764859	0.6533438	Ha3 Accepted

Source: Data processed by Researchers

Observing Table 4.12, it can be noted that the first hypothesis stating that the implementation of big data analytics with Data Volume characteristics does not affect the performance of MSME businesses in Batam City is rejected. Similarly, the second hypothesis stating that the

implementation of big data analytics with Data Velocity characteristics does not affect the performance of MSME businesses in Batam City is also rejected. These results show that the t-statistic values are smaller than the critical t-value of 1.982, and there is a value of 0 between the lower percentile (perc.025) and upper percentile (perc.975).

On the other hand, the third hypothesis stating that the implementation of big data analytics with Data Variety characteristics affects the performance of MSME businesses in Batam City is accepted. This is indicated by the t-statistic value being larger than the critical t-value of 1.96, and there is no value of 0 between the lower percentile (perc.025) and upper percentile (perc.975).

Discussion of Research Results

1. The influence of big data analytics with Data Volume characteristics on the performance of MSME businesses in Batam City Based on the hypothesis testing results, it is shown that the implementation of big data analytics with Data Volume characteristics does not affect the performance of MSME businesses in Batam City (Ha1 rejected). According to the research findings, the average percentage of respondents for the data volume indicator is 86%, indicating strong agreement. This suggests that the amount of sales data in e-commerce per month is adequate for analyzing business performance. However, positive attitudes or evaluations of sales data do not guarantee improved business performance. This is because the ability to analyze data accurately to generate useful insights is limited, requiring professional expertise to efficiently analyze it, and the analytic needs of MSMEs are simpler and do not require complex approaches (Alrumiah & Hadwan, 2021).

2. The influence of big data analytics with Data Velocity characteristics on the performance of MSME businesses in Batam City Based on the second hypothesis testing results, it is shown that the implementation of big data analytics with Data Velocity characteristics does not affect the performance of MSME businesses in Batam City (Ha2 rejected). According to the research findings, the average percentage of respondents for the data velocity indicator is 87%, indicating

strong agreement. This implies that performance data of stores in e-commerce can be accessed quickly. However, positive attitudes or evaluations of store performance data do not guarantee improved business performance due to challenges in effectively utilizing rapid data access, which many MSMEs are not prepared to anticipate in the face of fast-paced technological advancements and shortening product lifecycles (Mantik & Awaludin, n.d.).

3. The influence of big data analytics with Data Variety characteristics on the performance of MSME businesses in Batam City Based on the third hypothesis testing results, it is shown that the implementation of big data analytics with Data Variety characteristics affects the performance of MSME businesses in Batam City (Ha3 accepted). According to the research findings, the average percentage of respondents for the data variety indicator is 91%, indicating strong agreement. This suggests that store performance data encompasses various information such as store ratings, store performance, and store health. Thus, MSMEs using e-commerce in Batam City can assess and improve their business performance and take necessary corrective actions by identifying store ratings, performance, and health (Ad-Ins, 2023).

CONCLUSION
Conclusion

Based on the analysis and data processing, the author draws the following conclusions from this study:

1. The implementation of big data analytics with Data Volume characteristics does not affect the performance of MSME businesses in Batam City.
2. The implementation of big data analytics with Data Velocity characteristics does not affect the performance of MSME businesses in Batam City.
3. The implementation of big data analytics with Data Variety characteristics affects the performance of MSME businesses in Batam City.

Recommendations

Based on the findings and discussions above, the researcher suggests the following recommendations: Before data collection, provide training or a brief orientation to MSME owners or managers on the key concepts discussed in the questionnaire. This

can enhance their understanding and lead to more accurate responses.

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