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The Impact of Scalability and Consistency Management on Database Management System Performance in Big Data Environment in Indonesia

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ABSTRACT

The swift expansion of technology start-up enterprises in Indonesia demands a deep comprehension of the variables impacting the functionality of Big Data Environments (BDE) and Database Management Systems (DMS). In the context of Indonesian start-ups, this study examines the effects of scalability and consistency management on DMS and BDE. Data from 134 participants were examined using Structural Equation Modeling (SEM-PLS) in a quantitative manner. The findings showed a strong favorable correlation between DMS -> BDE, Scalability -> DMS, and Consistency Management -> DMS. Strong reliability was exhibited by the measurement model, and discriminant validity was verified. While the model fit indices revealed places for improvement, the R Square values indicated an effective explanation of variation. An overview of Indonesian start-up characteristics that is representative was given by the demographic sample study. This research adds knowledge for improving big data and database operations in the dynamic startup environment.

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1. INTRODUCTION

Effective data management is crucial for technology startups to achieve continued growth and competitiveness in the ever-evolving landscape. Database Management Systems (DBMS) and Big Data Environments (BDE) play a critical role in operational efficiency and strategic decision-making. Understanding the impact of scalability and consistency management on system performance is essential in a dynamic startup ecosystem where agility and scalability are paramount [1]–[3].

The digitization of business operations and the increase in data generation have led to startups playing a crucial role in technological innovation [4]–[6]. The efficiency of data management systems, including traditional DBMSs and contemporary BDEs, directly impacts an organization's ability to leverage insights, streamline processes, and dynamically respond to market changes [7]–[9]. These advancements have created a need for organizations to optimize their enterprise landscape by implementing modern technology solutions, such as Edge Computing Platforms, which enable real-time processing of massive amounts of data at the edge of devices [10]. Extracting actionable insights from data in a timely manner empowers enterprises to be more efficient and effective in their operations [11]. The interplay between data, technology, and business transformation is crucial for organizations to address their top challenges and create value for both the enterprise and its customers. Managers in the field of business informatics must understand and actively participate in these digital innovations to effectively direct strategies in the changed business environment.

Scalability and consistency management in tech start-ups, particularly in the Indonesian landscape, is an area that lacks specific implications in the literature. Start-ups face challenges in scaling operations and maintaining data integrity, making the delicate balance between scalability and consistency management crucial for their continued success. However, there is a noticeable gap in the literature regarding the implications of scalability and consistency management in tech start-ups, especially in the Indonesian context [12], [13].

Previous studies have examined these elements independently, including descriptions of consistency tactics, scalability models, and performance measures. Nevertheless, a thorough examination that breaks down the relationships between these scalability metrics, consistency management techniques, and overall system performance in the particular setting of Indonesian startups in a quantitative manner is still lacking. In addition to being intriguing from an academic standpoint, filling this research vacuum will help technology-based businesses make wise decisions, allocate resources effectively, and optimize their systems. The goal of this study is to shed light on the complexities of consistency and scalability management by offering empirical data that is specifically customized to the requirements and difficulties experienced by Indonesian entrepreneurs navigating the country's rapidly changing technology ecosystem.

2. LITERATURE REVIEW

2.1 Scalability in Database Management Systems

Scalability in database management systems (DBMS) refers to the system's ability to handle increasing volumes of data, users, and transactions without compromising performance. There are two primary scalability models: vertical scaling, which involves increasing the capacity of a single server, and horizontal scaling, which focuses on distributing the workload across multiple servers. Studies have explored the implications of scalability on different types of databases, including traditional relational databases and modern NoSQL databases. Adopting horizontal scaling in cloud-based relational databases has been found to significantly improve system performance and response times, particularly under high user loads [14]. On the other hand, research has also highlighted the scalability challenges specific to NoSQL databases, particularly the trade-offs between consistency and partition tolerance in distributed systems [15].

2.2 Consistency Management in Database Systems

Consistency management in a DBMS is crucial for ensuring data accuracy and reliability. Traditional relational databases adhere to the ACID property, which emphasizes strict consistency guarantees [5]. However, the emergence of NoSQL databases has introduced alternative consistency models, with eventual consistency becoming more prevalent. This approach trades off direct consistency for improved system availability and fault tolerance. It is important to match the consistency requirements with the specific demands of the application [16]. Tunable consistency is a popular feature in many data stores, allowing clients to specify the desired consistency level for each operation [16], [17]. Different consistency models, such as causal consistency and serializable transactions, have been proposed to address the tradeoffs between consistency, availability, and latency [18]. This research underscores the importance of choosing the appropriate level of consistency based on the specific use case. In contrast, the challenge of maintaining consistency in a distributed database, emphasizes the impact on system performance and the need for adaptive consistency mechanisms.

2.3 *Big Data Environments and Scalability Challenges*

Big Data environments have unique challenges due to the large volume, variety, and velocity of data. Scalability in these environments goes beyond traditional databases to include distributed storage and processing frameworks. Apache Hadoop and Apache Spark have been extensively studied in the literature as frameworks for Big Data processing [19]. Research by emphasizes the importance of stream processing frameworks for handling high-speed data in real-time, as this significantly impacts system responsiveness [20]. Effective resource management and data partitioning are essential to achieve optimal performance in large-scale data processing using Apache Hadoop [21].

2.4 *Research Gap*

While the existing literature offers valuable insights into scalability models, consistency management, and the challenges of Big Data Environments, there is a discernible research gap concerning their collective impact on the performance of DBMS and BDE within technological start-up companies in Indonesia. Most studies focus on individual aspects, and comprehensive analyses of how scalability and consistency management intersect in the specific context of start-ups are notably absent. This research aims to fill this void by conducting a quantitative analysis that systematically explores these interdependencies and provides a nuanced understanding tailored to the dynamics of the Indonesian start-up ecosystem.

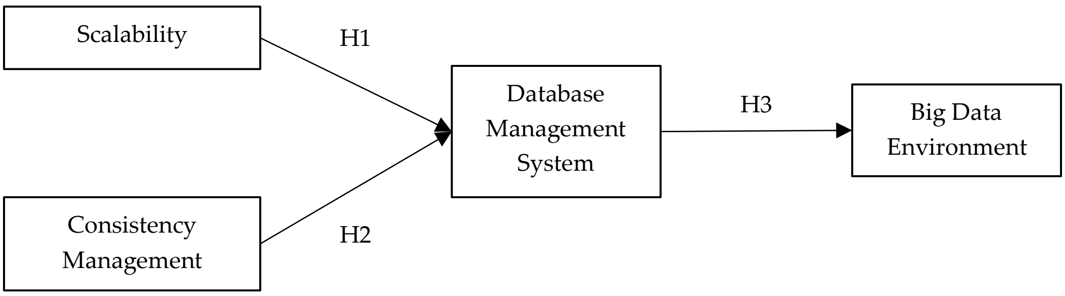

Figure 1. Conceptual and Hypothesis

3. METHODS

This research adopts a quantitative approach to systematically collect and analyze numerical data. The chosen research design involves surveys and objective performance metrics to assess scalability measures, consistency management strategies, and overall system performance in technology start-up companies. The target population consists of technology start-up companies in Indonesia. A stratified random sampling technique will be used to ensure a representative sample across different industries and company sizes. The sample size of 134 participants was determined based on statistical considerations in SEM-PLS.

3.1 Data Collection

Data was collected through primary methods:

a. Questionnaires are distributed to IT professionals, database administrators, and decision makers within the sampled start-up companies.
b. The survey will be designed to collect information on scalability measures, consistency management strategies, and perceptions of overall system performance.
c. Likert-scale questions will be included to capture both quantitative.

3.2 Data Analysis

The collected data will undergo rigorous analysis using Structural Equation Modeling with Partial Least Squares (SEM-PLS). This statistical technique was chosen for its suitability in analyzing complex relationships between latent and observed variables, making it suitable for assessing the diverse interdependencies between scalability measures, consistency management strategies, and system performance.

4. RESULTS AND DISCUSSION

4.1 Results

a. Demographic Sample

A sample of 134 participants was drawn from Indonesian tech startups. This distribution of demographics guarantees a picture that is typical of Indonesia's startup scene. Of the participants, 29.85% were small enterprises, 50.75% were medium-sized companies, and 19.40% were major companies. The participants' industries ranged widely: 41.04% were from the Information Technology (IT) sector, 20.90% were from the E-commerce sector, 13.43% were from the Health Tech sector, 14.93% were from the Fintech sector, and 9.70% were from other industries. Regarding technological stacks, 20.90% of participants utilize on-premises stacks, 43.28% use hybrid stacks, and 35.82% use cloud-based stacks.

b. Measurement Model

The measurement model assessed the reliability and validity of the constructs, confirming that the chosen variables accurately represent the underlying constructs.

Table 1. Measurement Model Test

Variable	Indicators	Code	Loading Factor	Outer VIF
Scalability	Cronbach's Alpha = 0.878, Composite Reliability = 0.913, AVE = 0.679.	SL		
	1. Response time	SL.1	0.863	2.481
	2. Throughput	SL.2	0.917	3.376
	3. Availability	SL.3	0.896	2.792
	4. Reliability	SL.4	0.852	2.294
Consistency Management	Cronbach's Alpha = 0.855, Composite Reliability = 0.9, AVE = 0.693.	CM		
	1. Data Consistency	CM.1	0.874	3.05
	2. Compliance Consistency	CM.2	0.866	3.325
	3. Performance Consistency	CM.3	0.809	2.267
	4. Quality Consistency	CM.4	0.779	1.378
Database Management System	Cronbach's Alpha = 0.867, Composite Reliability = 0.904, AVE = 0.654.	DMS		
	1. Performance	DMS.1	0.828	2.074
	2. Reliability	DMS.2	0.771	1.768
	3. Scalability	DMS.3	0.868	2.446
	4. Security	DMS.4	0.810	1.929
	5. Maintenance	DMS.5	0.803	1.973
Big Data Environment	Cronbach's Alpha = 0.773, Composite Reliability = 0.867, AVE = 0.685.	BDE		
	1. 3V's of Big Data	BDE.1	0.817	1.334
	2. Evaluation Index System	BDE.2	0.854	2.024
	3. Credit Evaluation	BDE.3	0.835	1.921

Source: Results processing data (2023)

All of the assessment models for large data environments, consistency management, scalability, and database management systems have acceptable convergent validity and high internal consistency. The loading factors show strong correlations between the latent variables and their observable indicators, while the outside VIF values are within acceptable boundaries, indicating no multicollinearity issues. The scalability measurement model shows high Cronbach's Alpha and Composite Reliability with a good Average Variance Extracted. The consistency management measurement approach also demonstrates convergent validity and high internal consistency. The database management system measurement model demonstrates excellent internal consistency and good convergent validity. Lastly, the huge data environment measurement model shows outstanding internal consistency and convergent validity.

Table 2. Internal VIF

Variable	VIF Values
Consistency Management → Database Management System	1.736
Database Management System → Big Data Environment	1
Scalability → Database Management System	1.736

Source: Results processing data (2023)

Table 2 displays the values of the Variance Inflation Factor (VIF) for the internal correlations between the three main study variables: Scalability, Database Management System (DMS), and Consistency Management. It also shows the correlation between DMS and Big Data Environment (BDE). The VIF values shed light on how the study's major factors interact with one another. The associations between Scalability and Consistency Management with the Database Management System exhibit considerable multicollinearity; nonetheless, the total VIF values fall within an acceptable range. This suggests that there isn't much correlation between the internal relationships, which makes it possible to assess the effects of Scalability, Database Management System, Consistency Management, and Big Data Environment separately with confidence.

Table 3. Discriminant Validity

Variable	BDE	DMS	CM	SL
BDE	0.836			
DMS	0.718	0.833		
CM	0.807	0.745	0.817	
SL	0.69	0.651	0.686	0.882

Source: Results processing data (2023)

The study's latent variables, including Big Data Environment (BDE), Database Management System (DMS), Consistency Management (CM), and Scalability (SL), are shown with their association coefficients displayed in Table 3. These coefficients guarantee that every latent variable in the model is unique from the others and offer insights into the discriminant validity of the constructs. Table 3's correlation coefficients shed light on the latent variables' discriminant validity. Even though there are some significant correlations, especially between BDE-DMS and BDE-CM, the general pattern points to adequate discriminant validity. But when analyzing the data, researchers should proceed with caution, keeping in mind that there might be some overlap between BDE and DMS as well as BDE and CM.

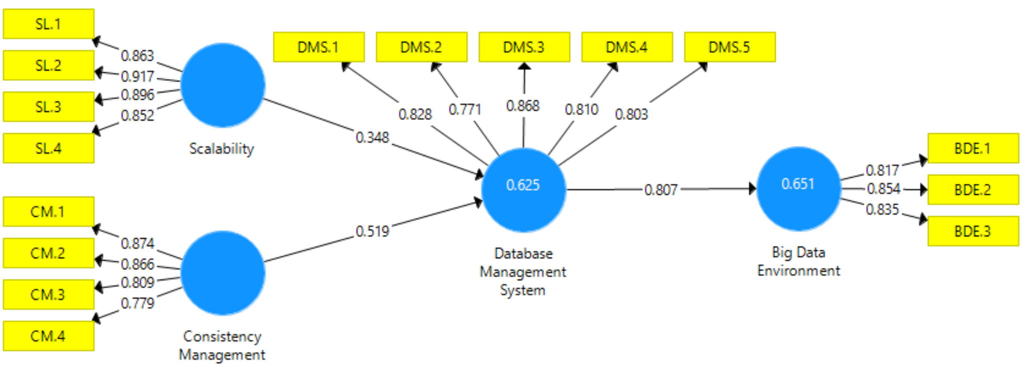

Figure 2. Model Internal Assessment

c. Model Fit Evaluations

Table 4 presents various indices comparing the model fit between the Saturated Model and the Estimated Model. These indices are crucial in evaluating how well the estimated model aligns with the saturated model, which represents perfect fit.

Table 4. Model Fit

	Saturated Model	Estimated Model
SRMR	0.105	0.111
d_ULS	1.689	1.883
d_G	0.575	0.608
Chi-Square	533.78	553.582
NFI	0.753	0.744

Source: Results processing data (2023)

The SRMR measures the average absolute difference between the observed and predicted correlations. While the estimated model (0.111) has a slightly higher SRMR than the saturated model (0.105), both values are generally acceptable. The d_ULS index assesses the discrepancy in the unweighted least squares estimation between the saturated and estimated models. A value closer to 1 indicates better fit. In this case, the estimated model (1.883) has a higher d_ULS compared to the saturated model (1.689), suggesting a larger discrepancy. Bentler's Comparative Fit Index, d_G, compares the fit of the estimated model to a model with perfect fit. Similar to d_ULS, a value closer to 1 indicates better fit. The estimated model (0.608) has a higher d_G compared to the saturated model (0.575), suggesting a larger deviation from perfect fit. The Chi-Square statistic assesses the difference between the observed and expected covariance matrices. In both models, a higher Chi-Square value indicates poorer fit. The estimated model (553.582) has a higher Chi-Square than the saturated model (533.78), suggesting a degree of misfit . The NFI compares the fit of the estimated model with a null model (a model with no relationships among variables). A value closer to 1 indicates better fit. The estimated model (0.744) has a slightly lower NFI compared to the saturated model (0.753), suggesting a decrease in fit.

Table 5. R Square

	R Square	R Square Adjusted
Big Data Environment	0.642	0.64
Database Management System	0.599	0.594

Source: Results processing data (2023)

Table 5 displays the R Square and R Square Adjusted values for the Big Data Environment (BDE) and Database Management System (DMS), which are the latent variables in the model. The percentage of each endogenous latent variable's variance that can be attributed to its predictors is expressed by these coefficients. Big Data Environment (BDE) has a R Square value of 0.642, meaning that the model's predictors account for 64.2% of the variation in BDE. After taking into consideration the sample size and number of predictors, the R Square Adjusted is 0.64. Based on the variables mentioned, this implies a comparatively high degree of explanation for the variability in BDE. With a R Square value of 0.599, the predictors in the model account for around 59.9% of the variance in the Database Management System (DMS). In light of the intricacy of the model, the R Square Adjusted is 0.594. Based on the variables provided, this implies a significant degree of explanation for the variability in DMS.

d. Structural Model

The results of the structural model's hypothesis testing are shown in Table 6, with particular attention paid to the path coefficients, sample mean, standard deviation, t-statistic, and p-values. The significance of the connections between the latent variables in the model is evaluated by this study.

Table 6. Bootstrapping Test

Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-statistic	p-Values
Consistency Management -> Database Management System	0.452	0.455	0.076	5.975	0
Database Management System -> Big Data Environment	0.801	0.802	0.028	28.642	0
Scalability -> Database Management System	0.382	0.382	0.087	4.402	0

Source: Results processing data (2023)

The t-statistics for all three relationships are well above the threshold for significance (commonly set at 1.96 for a 95% confidence level), and the p-values are extremely low (0), providing strong evidence against the null hypotheses. This suggests that the relationships are not likely due to random chance and are robust in the population.

1. The path coefficient of 0.452 from Consistency Management to Database Management System is statistically significant ($p < 0.05$), as indicated by the t-statistic of 5.975. This indicates that Consistency Management has a positive and significant impact on the Database Management System. The small p-value (0) indicates strong evidence for the hypothesis, supporting the hypothesis that there is a meaningful relationship.
2. The path coefficient of 0.801 from Database Management System to Big Data Environment is highly statistically significant ($p < 0.05$), with a t-statistic of 28.642. This shows a strong positive relationship, indicating that improvements or changes in the Database Management System significantly affect the Big Data Environment. The very low p-value (0) underscores the strength of this relationship.
3. The path coefficient of 0.382 from Scalability to Database Management System is statistically significant ($p < 0.05$), as indicated by the t-

statistic of 4.402. This indicates that an increase in Scalability has a positive and significant impact on the Database Management System. The p-value of 0 supports the rejection of the null hypothesis, providing strong evidence of a meaningful relationship.

4.2 *Discussion*

a. Consistency Management and Database Management Systems

Consistency management strategies play a crucial role in maintaining data integrity and reliability in Database Management Systems (DMS). These strategies can significantly impact the efficiency of DMS, especially in dynamic start-up environments. By analyzing existing consistency models and standard strategies, it has been concluded that an improved model of visible adaptive consistency is necessary for highly-distributed transactional databases in a hybrid cloud environment [22]. Additionally, the use of distributed database management mode can enhance the application value of computer database systems in information management, considering their expandability, high sharing, and structured storage capabilities [23]. Furthermore, a method for data model consistency management based on view cross-database type has been proposed, which enables dynamic monitoring of data model changes and ensures the healthy operation of daily data scheduling in DMS [24].

b. Database Management Systems and Big Data Environments

The optimization of Database Management Systems (DMS) has a significant impact on the overall performance of Big Data Environments. This relationship is particularly relevant for start-ups that need to handle and extract value from large data sets. By effectively managing and analyzing huge amounts of data, businesses can unlock the potential of big data and cloud computing integration, leading to improved data processing capabilities, increased scalability, and cost reduction [25]. Additionally, the integration of data mining methods with relational DBMSs is a topical issue, as it allows for efficient processing of transactions and SQL queries on very large databases [26]. Therefore, a well-optimized DMS can greatly enhance the performance and capabilities of Big Data Environments, providing start-ups with the tools they need to effectively handle and extract value from large data sets.

c. Scalability and Database Management Systems

Scalability is crucial for Database Management Systems (DMS) as it allows for an adaptable infrastructure that can accommodate data growth and increasing workloads. Start-ups aiming for flexibility and growth can benefit from understanding specific scalability measures and their implications on DMS performance. This includes metrics such as partitioning, replication, concurrency control, and consistency, which are important for achieving high throughput, low latencies, and data availability. Existing scalable DB vendors have made design decisions to address these challenges, and comparing their solutions can help identify modifications for future applications [27]. Additionally, the collaboration between database software, hardware, and storage devices plays a significant role in improving efficiency and performance. Research in this area has focused on minimizing disk accesses, leveraging memory, and ensuring sustainable and predictable use of hardware resources [28].

4.3 *Implications*

1. The findings underscore the critical role of Consistency Management, Database Management Systems, and Scalability in shaping the performance of Big Data Environments within technology start-ups. The positive relationships identified contribute to the understanding of the factors that influence database management and big data processes in the dynamic environment of start-up companies.
2. Practically, the results suggest that tech start-ups in Indonesia should prioritize effective Consistency Management practices, invest in robust Database Management Systems, and consider scalable solutions to optimize Big Data Environment performance.

4.4 *Limitations and Future Research*

It is imperative to acknowledge certain limitations, such as the cross-sectional nature of this study and potential bias in self-reported data. Future research could explore longitudinal designs and incorporate additional contextual factors for a more comprehensive understanding of the dynamics within start-up environments.

5. CONCLUSION

To sum up, this study sheds light on the complex interrelationships between Big Data Environment (BDE), Database Management System (DMS), Consistency Management, and Scalability in Indonesian technology start-ups. The empirical results corroborate the beneficial connections that have been postulated, emphasizing the essential role that scalability and good consistency management play in defining DMS performance and, in turn, impacting BDE. Together with the results of the confirmatory structural model, the measurement model's validity and reliability offer a strong basis for comprehending the dynamics of these start-ups. The analysis of the demographic sample guarantees that the study may be applied to a wide range of Indonesian start-up profiles.

Even when the model fit indices point to a reasonable fit, practitioners and academics should think about improving the model's accuracy. The study's findings enable decision-makers to enhance BDE performance by giving Consistency Management procedures top priority, making investments in robust DMS, and efficiently scaling their infrastructure. In addition to adding to the body of knowledge in academia, this research has applications for large data settings and database strategy management in the dynamic world of tech start-ups. Future studies may investigate longitudinal designs and dig further into certain contextual aspects to deepen our understanding of these intricate interactions in dynamic entrepreneurial environments.

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