The Role Of Virtualization Technology To Increase Operational Cost Efficiency Of Indonesian Smes: Case Study Of Internet Service Providers

Arnastya Iswara Sanantagraha[1*], Erlina Puspitaloka Mahadewi[2]

[1]Department of Doctor of Computer Science, Bina Nusantara University, Jakarta, Indonesia
[2] Universitas Esa Unggul, Jakarta, Indonesia
[*]Corresponding Author:
Email: arnastya.sanantagraha@binus.ac.id

Abstract.
This research investigates the role of virtualization technology in enhancing operational cost efficiency for Indonesian Small and Medium-sized Enterprises (SMEs), specifically Internet Service Providers (ISPs). A quantitative approach, utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) version 2.0, was employed to analyze data collected from 68 respondents representing 216 Indonesian SME ISPs. The study focused on the relationship between virtualization technology planning, adaptation capability, server consolidation services, and operational cost-effectiveness. The findings demonstrate that adaptability to virtualization technology is the most significant factor influencing operational cost efficiency. Effective implementation requires careful planning and a proactive approach to adapting to the technology's demands. Server consolidation services play a crucial role in optimizing resource utilization and reducing costs while virtualization technology offers substantial benefits, SMEs should carefully assess their specific needs and resources before implementation. Infrastructure, skills, and business objectives should be evaluated to ensure successful adoption and maximize cost savings. This research provides a foundation for further exploration into the impact of virtualization technology on SMEs. Future studies could investigate the applicability of these findings in different contexts, such as other industry sectors or regions. Additionally, examining the long-term effects of virtualization technology adoption and the potential for scalability could offer valuable insights. Further research could also focus on the challenges and opportunities associated with virtualization technology adoption in SMEs with varying sizes and resources.

Keywords: *Cloud computing, operational cost efficiency, server consolidation, smes, virtualization technology.*

I. INTRODUCTION

In keeping with the rapid development of business and increasing competition in today's business landscape, Small and Medium Enterprises (SMEs) are faced with the challenge of keeping up with the latest technological advancements. Aligned with this, it is known that the primary objectives of businesses are profitability and sustained growth (Ercan, 2010). To achieve these objectives effectively, businesses should be supported by Information Technology (IT) by leveraging the latest technologies that result in benefits such as providing fewer resources while ensuring that the infrastructure offered always meets customer needs (Baig, 2013). One of the latest technologies is virtualization technology through Cloud Computing services, which can be used to reduce operational costs through efficient server procurement in IT infrastructure (Mueen Uddin, 2012).Small and Medium-sized Enterprises (SMEs) should have sound planning and good adaptability so that when implementing virtualization technology, they can achieve effective operational costs (Mueen Uddin, 2012). He also states that to obtain the benefits of implementing virtualization technology, companies must have thorough planning. Furthermore, (Ercan, 2010) states that technological transitions require companies to continuously evaluate the capabilities of their IT teams, for example, through IT training (Li et al., 2012), so that this can bring benefits by reducing operational costs in developing IT infrastructure (Ruffini & Slyne, 2019).

Based on data from the Indonesian Internet Service Providers Association (APJII) as of July 25, 2013, 361 companies have registered as companies engaged in the provision of internet services, or known as Internet Service Providers (ISPs), and 60% of them are SMEs. This research targets SME-scale ISPs in Indonesia - hereafter referred to as 'Indonesian SME ISPs'. An ISP will give more consideration to factors that affect the performance and structure of internet services to customers. These are the feasibility of

implementing IT and Information Systems infrastructure oriented towards the speed of internet service flow, affordable costs, the size of the network that can be used, the level of internet availability, a high level of security, network reliability, and network topology reliability (Cisco, 2014).Related to Cloud Computing services through the implementation of virtualization technology, the performance of computer process elements no longer uses the assumption of Moore's Law, which states that computer development, in terms of processor speed, will double every 18 to 24 months (Ahuja, 2014), so this is more than previously assumed and means that the acceleration of computing technology will trigger more dynamic business movements. (Marston et al., 2011) presents a paradoxical picture that the Cloud Computing phenomenon, which has a multiplied computing capability, is in fact accompanied by a decreasing price per unit of computation. To adapt to the Cloud Computing era, Indonesian SME ISPs need to strive to keep up with the latest technological developments by conducting thorough planning, evaluating the ability to adapt to the latest technology during the transition period, and implementing measurable technology with the hope of obtaining business benefits through the effectiveness of company operational costs.

II. METHODS

Recently, cloud computing technology has been widely adopted and adapted by companies in the telecommunications industry and ISPs through one of the cloud computing services, namely IaaS. ISPs manage IT infrastructure by implementing server consolidation services through server virtualization techniques. The benefits of virtualization for businesses are quite significant in terms of cost savings, but some research suggests that the benefits of this virtualization technology cannot be felt by Indonesian SME ISPs considering the insignificant need for servers of an SME ISP.This research aims to prove that there is a significant influence of planning, adaptability, and server consolidation services of virtualization technology on the operational costs of small and medium-sized enterprises. Planning and adaptability of virtualization technology are the main variables influencing the variable of operational cost-effectiveness, but this is also influenced by the variable of server consolidation services. Therefore, it is necessary to first look at the correlation between variables in the research model using a correlation matrix. To answer the research hypothesis questions, it is necessary to compile and classify the variables and sub-variables into the five relationships of these research variables to ensure that the variables are suitable for their research functions.The study posits that virtualization implementation planning directly influences the decision to implement server consolidation services, which in turn indirectly affects operational cost-effectiveness. The planning variable comprises two key factors: (1) the planned number of servers and (2) the planned server capacity.

Additionally, the ability to adapt to virtualization technology, characterized by concern about implementation costs and technical proficiency, also directly influences the decision to implement server consolidation services. This decision, as a mediating variable, subsequently impacts operational cost-effectiveness.This research is an applied study using a quantitative-descriptive approach through a survey research method and aims to test the initial hypothesis (Sekaran & Bougie, 2009), which is referred to as non-experimental hypothesis-testing research where the independent variable is not manipulated by the researcher (Kothari, 2004). The unit of analysis to be studied is a group/organization where the characteristics of the unit of analysis are company employees who are involved in and/or participate in decision-making regarding the implementation of virtualization through server consolidation services. In terms of organizational structure, the employees referred to are at the managerial and non-managerial levels with at least a bachelor's degree. Regarding the employees' knowledge and skills related to the research objectives, employees with a diploma degree are characteristic of the unit of analysis but with the support of having an International Certification issued by one of the virtualization technology principals (e.g., VMware). Meanwhile, the observation units targeted are IT Managers or Finance Managers, General Managers, or IT Professionals at the managerial level, and IT Supervisors or IT Staff at the non-managerial level. Based on the unit of analysis to be studied, this research is conducted using a cross-sectional survey method.The ultimate goal of this research is to empirically explore how the operational cost-effectiveness of

SMEs is influenced by virtualization technology planning and adaptability, mediated by server consolidation services, through five proposed hypotheses.

The population in this study is Indonesian ISPs with SME characteristics, where the number of employees in the company does not exceed 250 people (Kuswanto et al., 2012). Due to time and resource constraints, this study will take a sample that represents the population of Indonesian SME ISPs based on the potential number of IT workers in a company, the capabilities of IT workers, the authority of IT workers, and the involvement of IT workers in the implementation of server consolidation services. The population of ISPs obtained from APJII data as of July 25, 2013, is 361 companies in Indonesia, and 60% of them are SMEs. The figure of 60% was obtained through both direct and telephone interviews since January 2013 and confirmation from APJII. The research population will consist of 216 Indonesian SME ISPs. Based on a 90% confidence level and a 10% margin of error, the planned minimum sample size is 68 respondents.The characteristics of the SME population are heterogeneous when viewed from the number of employees. Micro businesses have fewer than 10 employees, small businesses have fewer than 50 employees, and medium businesses have fewer than 250 employees (Kuswanto et al., 2012). However, if the population is concentrated on ISPs, the number of employees does not become a determining factor in choosing the sampling technique to be used. Conversely, considering that 60% of the 361 ISP companies in Indonesia have been considered to have similar characteristics or homogeneous related to SME characteristics, this research will be conducted using a probability sampling technique with a simple random sampling type (Sekaran & Bougie, 2009).Based on the research design, considering distance and time, the data collection technique to be used in this research is a questionnaire, both directly and through email.

The collected data will be used as primary data. Meanwhile, data obtained from company records, vendor publications, government publications, and reports from various parties related to server virtualization techniques will be used as the basis of the research as secondary data (Sekaran & Bougie, 2009). Several questions and statements are directed to respondents based on the operationalization of the research variables. In parallel, the identification of information sources or respondents based on the research unit of analysis is carried out. Considering that the research population is ISPs in Indonesia and to ensure legal and valid data, the initial data source explored is APJII. The author will contact ISPs on the official APJII list to obtain representative and competent respondents related to the research objectives.The four variables mentioned above are concepts that need to be operationalized into a measurable understanding (Sekaran & Bougie, 2009). The author has operationalized these four variables, resulting in a questionnaire as a research instrument with a total of 26 questions.To obtain respondent information and filter out unqualified respondents, this research requires several screening questions. These screening questions will then be processed and analyzed to produce a descriptive research report. The screening questions in this research are divided into two parts: Company Profile and Respondent Profile.This study employed a questionnaire-based approach to collect data from IT decision-makers in SME ISPs. Quantitative analysis, involving both descriptive and inferential statistics, was used to analyze the data. A multivariate analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM) version 2 was conducted to examine the relationships among the study variables.

III. RESULT AND DISCUSSION

The study examined the relationships between virtualization technology planning, adaptation capability, server consolidation services, and operational cost-effectiveness. A total of 77 completed questionnaires were collected from SME ISPs, primarily through email and in-person distribution. Data analysis involved descriptive statistics and structural equation modeling (PLS-PM) using software such as Microsoft Excel, SPSS, and Smart PLS.

Respondent Demographics

Out of the 77 respondents, the majority were male, with 71 respondents or 92%. The remaining 6 respondents were female, accounting for 8% of the total respondents. The most dominant age group of respondents was between 25-44 years, comprising 64 individuals or 83%. Those under 25 years old accounted for 7 individuals (9%), and the remaining respondents were aged 45-64 years (8%). Respondents

with a Master's degree (S2) had the highest number, with 64 individuals (83%). The dominant position among respondents was IT Manager, with 62 individuals (81%), followed by IT Supervisor with 8 individuals (10%), and the remaining 7 individuals (9%) were IT Directors. The work experience of respondents involved in the study was dominated by those with 1-2 years of experience, totaling 43 individuals (56%). Following this were those with 2-4 years of experience, numbering 17 people (22%), followed by those with less than 1 year of experience, at 16 individuals (21%). The remaining 1 individual (1%) had more than 4 years of experience.

Company Profiling

Regarding the level of virtualization technology implementation by companies, it was recorded that the majority had already reached the implementation, management, and monitoring stage, with 44 companies (57%). This was followed by 19 companies (25%) that had reached the design stage. There were 6 companies (8%) in the testing phase and 1 company (1%) in the design phase. Interestingly, the study found that 7 companies (9%) had not yet initiated any level of virtualization. The majority of companies, 46 (60%), had between 10-50 IT employees. This was followed by companies with 50-250 IT employees, which numbered 26 (34%). A smaller number of companies, 5 (6%).In terms of the length of virtualization implementation, it can be seen that the majority, 38 companies, implemented it within 1-2 years. Meanwhile, 24 companies implemented it within 2-4 years. The remaining 7 companies implemented it very quickly, less than 1 year, while 8 companies had not yet implemented it. Overall, the number of physical servers used as hypervisors ranged from 3 to 5 units for most companies. Specifically, 35 companies (45%) used this range. There were 26 companies with 6-10 physical servers as hypervisors, 5 companies with 1-2 units, and 11 companies that did not have any physical servers serving as hypervisors.It was recorded that 39 companies had built between 6-10 virtual machines or virtual servers on a single physical server as a hypervisor. This was followed by companies with 3-5 virtual servers per physical server, and only 3 companies had 1-2 virtual servers per physical server. Additionally, 8 companies were recorded as not building any virtual servers.

Descriptive Statistics

Eight instruments were used to measure the response to the virtualization technology planning variable (X1). Respondents gave responses to server utilization (Q1-Q3), power resources (Q4), system reliability (Q5-Q7), and space saving (Q8) with scores greater than 3, indicating a level of agreement to strongly agree. The overall mean score was 3.4078 with a standard deviation of 0.4823. This indicates that virtualization technology planning is necessary to achieve optimal results.There were six instruments used to assess the variable of virtualization technology adaptability (X2). The overall average response was 3.4827. This mean score, exceeding 3, indicates that respondents generally agreed or strongly agreed with the ease of operating virtualization technology and that, as IT personnel, virtualization technology improved performance and efficiency. The overall standard deviation of 0.6203 suggests that respondents' answers to the instruments measuring the variable of virtualization technology adaptability (X2) were relatively homogeneous. Furthermore, the first instrument, which assessed the ability of virtualization technology to enhance system development and ease of testing, exhibited even greater homogeneity among respondents, with a standard deviation of 0.4789, lower than that of the other instruments.

There were five instruments used to measure the variable of server consolidation services (Y), with an overall average response score of 3.4805, which is greater than 3. This indicates that respondents generally agreed or strongly agreed. Communication between IT employees was considered very important both before and after the system transition. The provision of training for the implementation of this technology was deemed highly important by respondents, with the highest average score of 3.7792 compared to other instruments. The implementation of this technology was considered to be not difficult and, furthermore, was expected to make work more comfortable and save IT costs in the future.There were seven instruments used to measure the variable of operational cost effectiveness (Z), with an overall average score of 3.4286, which is greater than 3. Respondents provided positive responses regarding operational cost effectiveness. From the instruments measuring cost reduction, it is evident that the most significant benefit

perceived by respondents was the reduction in electricity costs. This is reflected in the average score of 3.6364, which is higher than the responses regarding the reduction in hardware and system management costs. Other perceived benefits, in addition to cost reduction, include the ease of system development and IT services, as well as reduced IT system management time.

PLS Path Modeling – Inter-Instruments Correlation

A correlation analysis was conducted to examine the relationships among the variables. While most of the correlation coefficients were below the 0.80 threshold, instrument Q1 exhibited a high degree of multicollinearity with instruments Q12 and Q13.

Variabel	Virtualization Technology Planning Variables (X1)								
	Instrumen	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Virtualization Adaptation Capability (X2)	Q9	0.362	0.116	0.442	0.446	0.402	0.048	0.278	0.290
	Q10	0.511	0.191	0.252	-0.004	0.079	-0.154	0.172	0.180
	Q11	0.103	0.156	0.454	0.427	0.296	0.006	0.564	0.690
	Q12	0.817	0.122	0.410	0.158	0.199	-0.005	-0.013	-0.012
	Q13	0.852	0.144	0.480	0.190	0.330	0.165	0.031	0.035
	Q14	0.799	0.167	0.452	0.229	0.338	0.144	0.061	0.067
Server Consolidation Service (Y)	Q15	0.476	0.133	0.246	0.067	0.130	-0.152	0.084	0.052
	Q16	0.070	0.134	0.227	0.225	0.262	-0.030	0.521	0.534
	Q17	0.536	0.244	0.327	0.003	0.208	-0.036	0.003	-0.026
	Q18	0.430	0.041	0.524	0.389	0.497	0.208	0.291	0.299
	Q19	0.312	0.209	0.158	-0.120	0.104	0.129	0.017	0.063

Fig 1. Correlation Between Planning Variable Instruments and Virtualization Technology Capabilities and Services

Given the strong correlation between these instruments (0.817 and 0.852, respectively), and by Gujarati's (2004) recommendation, instrument Q1 was excluded from the analysis. This decision was justified by the redundancy of information provided by Q1, as the measurement of the planning variable in the dimension of server utilization could still be captured by instruments Q2 and Q3.

Variabel	Virtualization Adaptation Capability (X2)						
	Instrumen	Q9	Q10	Q11	Q12	Q13	Q14
Server Consolidation Service (Y)	Q15	0.362	0.777	0.120	0.763	0.681	0.659
	Q16	0.504	0.588	0.633	0.306	0.312	0.369
	Q17	0.357	0.795	0.178	0.748	0.703	0.678
	Q18	0.719	0.417	0.477	0.443	0.512	0.546
	Q19	0.139	0.634	0.275	0.493	0.486	0.486

Fig 2. Correlation Between Variable Instruments, Capabilities, and Services

Partial Least Square Path Modeling – Outer Model

This test was conducted by examining the Loading Factor (LF) between the instrument and its corresponding research variable. A rule of thumb is that an LF value above 0.50 indicates a valid instrument. The results of the Smart PLS 2.0 processing are presented below.

Instruments ← Variabel	Loading Factor	Standard Error	T Statistic
Q2 ← Planning	**0.3978**	0.1224	3.2502
Q3 ← Planning	0.7556	0.1135	6.6557
Q4 ← Planning	0.7671	0.1492	5.1424
Q5 ← Planning	0.6888	0.1077	6.3964
Q6 ← Planning	**0.1868**	0.1285	1.4541
Q7 ← Planning	0.6322	0.2136	2.9600

Q8 ← Planning	0.6480	0.2162	2.9973

Fig 3. Validity of the Virtualization Technology Planning Variable Instrument (Initial Stage)

Since items Q2 and Q6 exhibited loading factors (LF) below 0.50, indicating insufficient factor loading, these items were excluded from the research model measuring the virtualization technology planning variable. Conversely, items Q3, Q4, Q5, Q7, and Q8, with loading factors exceeding 0.50, were retained in the model as they demonstrated adequate validity.

Instruments ← Variabel	Loading Factor	Standard Error	T statistic
Q9 ← Adaptation Capability	0.6745	0.1039	6.4898
Q10 ← Adaptation Capability	0.8366	0.0425	19.6964
Q11 ← Adaptation Capability	**0.4415**	0.1781	2.4790
Q12 ← Adaptation Capability	0.9117	0.0187	48.6804
Q13 ← Adaptation Capability	0.9225	0.0181	50.8553
Q14 ← Adaptation Capability	0.9289	0.0153	60.7446

Fig 4. Validity of the Virtualization Technology Adaptation Capability Variable Instrument (Initial Stage)

There is one instrument measuring the variable of virtualization technology adaptation, namely Q11, which has a Loading Factor (LF) below 0.50 (invalid) even though the resulting T-statistic (2.4790) is greater than 1.96 (significant). This instrument was still eliminated from the model. Meanwhile, the other instruments, Q9, Q10, Q12, Q13, and Q14, remained in the model measuring the variable of virtualization adaptation.

Instruments ← Variabel	Loading Factor	Standard Error	T statistic
Q15 ← Service	0.7874	0.0537	14.6595
Q16 ← Service	0.7834	0.0991	7.9049
Q17 ← Service	0.8400	0.0472	17.8029
Q18 ← Service	0.6798	0.1144	5.9420
Q19 ← Service	0.6681	0.1282	5.2113

Fig 5. Validity of the Server Consolidation Service Variable Instrument (Initial Stage)

All instruments measuring the server consolidation services variable have an LF greater than 0.50, with instrument Q17 having the highest LF (0.84). The diversity of information in the statement of Q17 (IT personnel need to undergo training before managing systems with virtualization technology) is more strongly present in the variable measuring server consolidation service.

Instruments ← Variabel	Loading Factor	Standard Error	T statistic
Q20 <- Effectiveness	0.6563	0.1926	3.4070
Q21 <- Effectiveness	0.7075	0.1922	3.6808
Q22 <- Effectiveness	0.6078	0.1691	3.5937
Q23 <- Effectiveness	0.6695	0.0961	6.9655
Q24 <- Effectiveness	0.6860	0.1275	5.3816
Q25 <- Effectiveness	0.7179	0.0518	13.8637
Q26 <- Effectiveness	0.6827	0.0692	9.8708

Fig 6. Validity of the Operational Cost-Effectiveness Variable Instrument (Initial Stage)

Seven instruments are measuring the operational cost-effectiveness variable, all of which have a Loading Factor (LF) above 0.50 and a T-statistic greater than 1.96. This indicates that all seven instruments are valid and significant in measuring the effectiveness variable. The Loading Factor values of the seven instruments are relatively homogeneous, ranging from 0.60 to 0.71.All correlation values between the virtualization technology adaptability variable (X2) and the server consolidation services variable (Y) are less than 0.80, indicating the absence of any serious correlation between the instruments.From the results of the measurement data analysis (Outer Model) and structural data analysis (Inner Model), the following final research model is obtained:

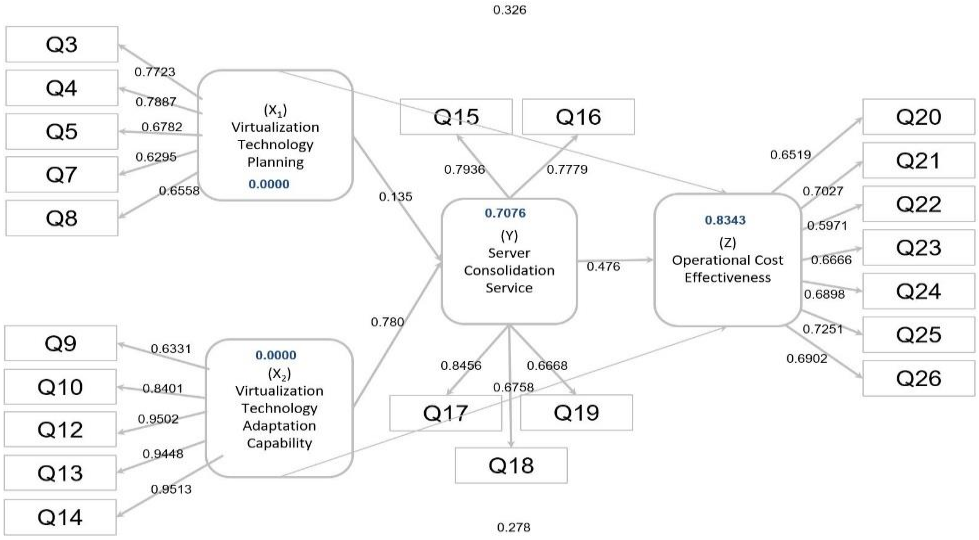

Fig 7. Summary of Loading Factor and Path Coefficient in the Second Stage

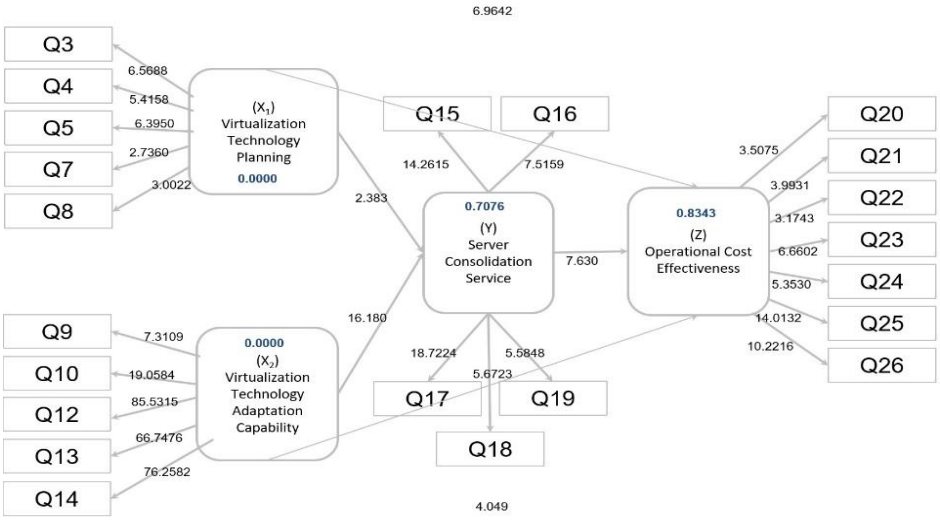

Fig 8. Summary of T-statistics in the Second Stage

IV. CONCLUSION

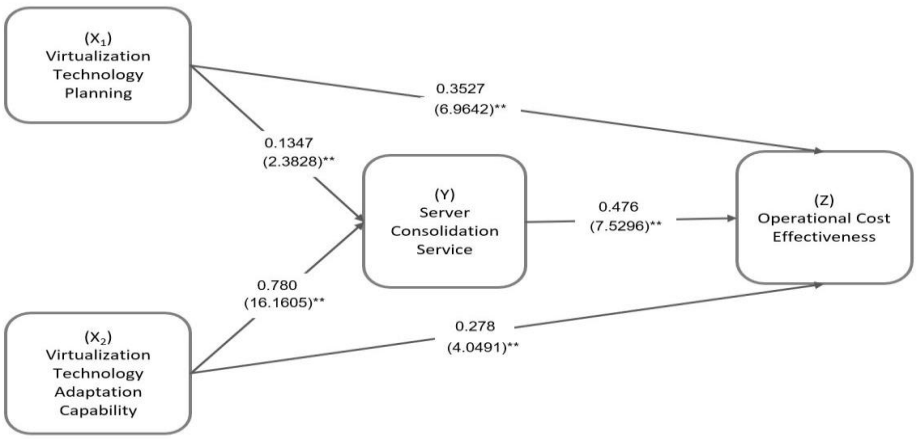

Fig 9. Path Coefficient and T-Statistic after Data Processing

Based on the results of the data analysis on the total influence, when comparing the variables of virtualization technology planning, virtualization technology adaptation ability, and server consolidation

services, it can be stated that the variable of virtualization technology adaptation ability is the most significant (64.9%) among the other two variables. This means that Indonesian SME ISPs strongly agree and understand that the effort to adapt to virtualization technology is very important to achieve the success of implementing server consolidation services to create operational cost-effectiveness. Based on this research and data collection, which is the measurement of R Square where the causal relationship between exogenous variables and endogenous variables is very significant, and the large GoF index stated, it can be interpreted that the research design proposed is in line with the conditions of Indonesian SME ISPs in using virtualization technology services through server consolidation services to reduce operational costs in data center management. Similarly, when viewed in Figure 13, in this research model design, the influence of two independent variables and one mediating variable on the dependent variable is proven to be significant (**).

SMEs with limited resources should carefully consider long-term business plans through careful planning. Regarding the implementation of virtualization technology through server consolidation services, Uddin (2012) provides a comprehensive review of the framework for a virtualization implementation. From this, it can be concluded that the ability to adapt to implementing virtualization technology must be considered early on so that it can be used as a strategy to increase operational cost-effectiveness. Compared to conventional methods, managing a data center using the implementation of virtualization technology through server consolidation services is necessary, as it has been proven to increase operational cost-effectiveness. Thus, if this can be successfully implemented, it is expected that Indonesian SME ISPs can have good governance in their data centers, be able to compete in the Cloud Computing era and be able to provide the right solutions to their customer's problems and needs.

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