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The Effect of Cloud-Based Supply Chain Integration and Information Security Initiatives on Supply Chain Robustness and Performance

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Abstract

The purpose of this research is to examine the relationship among cloud-based supply chain integration, information security initiatives, supply chain robustness and supply chain performance. This research gathered from 132 respondents, professional workers of seven telecommunication service provider companies in Indonesia located in the capital city of Jakarta. The study used an online questionnaire with a Likert scale of 1-5. PLS-SEM method is used to test relationship between variables with SmartPLS software version 3.0. The results show that cloud-based supply chain integration and information security initiatives have a positive and significant effect on supply chain robustness, supply chain robustness also has a positive and significant effect on the supply chain performance. In addition, cloud-based supply chain integration and security initiatives have a positive and significant impact on supply chain performance through the mediation of supply chain robustness. This research shows that companies can take opportunities to improve supply chains through the application of cloud technology in supply system integration, but still need to improve supply information security initiative in order to create a robust supply chain against various threats, disruptions, and disasters.

Keywords

Cloud-based supply chain integration; Information security initiatives; Supply chain robustness; supply chain performance

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Introduction

In today's business environment, organization use supply chain as a competitive advantage to outperform their competitors. The existence of globalization facilities such as raw materials, manufacturing and logistics allows for an increase in quality, variety, and product innovation (Golini et al., 2017). Supply chain capabilities can be increased through supply chain integration practices. Supply chain integration is an integrated supply chain system across all supply chain elements (internal, suppliers, and customers) that supports the flow of information, materials and costs with other supply chain partners for effective decision making (Sindhuja, 2021). With the emergence of cloud computing technology in industry 4.0, it will pose challenges to implement a superior technology supply chain system based on cloud computing.

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Cloud computing is a computing system where the system is virtual with on demand computing resources, located on many site, and has high availability. Through easy access, storage, and sharing of data, cloud computing systems pose another challenge in the form of security (Sindhuja, 2021). Reseach results from the cybersecurity multinational company, Palo Alto Networks (2021) found that the supply chain is a new threat to cloud computing infrastructure. In addition, one possibility that can arise is that supply chain weaknesses will be difficult to detect. Palo Alto Networks then recommends that companies using cloud infrastructure can define their own security strategies This raises the need for effective information systems security initiatives (Steinbart et al., 2016). Information security is seen as a multidimensional aspect that includes people, processes, management, and tools (ISACA, 2012).

In addition to technology and information security, Monostori (2018) states that the supply chain has risks from demand, supply side and natural disaster risks that can disrupt the supply chain at any point. Therefore, it is important to adopt and implement a strong strategy to enable the company to manage the normal fluctuations in supply, as well as to help the company to sustain its operations in the event of disruption. The ability to withstand or manage internal and external disturbances is referred to as the robustness of the supply chain which is very important in increasing supply production (Sindhuja., 2021). From the conditions and challenges above, companies can take the opportunity to take advantage of cloud computing technology, namely in terms of real-time data utilization, data speed, efficiency in system maintenance (no physical server maintenance required), and easy scalability. It is hoped that these opportunities can improve the efficiency and effectiveness of supply chain activities. Measuring the level of efficiency and effectiveness of the activities or strategies implemented by the organization as measured by supply chain performance (Arif-Uz-Zaman and Ahsan, 2014). Through this measurement, the organization can review whether the supply chain strategy implemented is appropriate and what steps should be taken. This study aims to look at the effect of implementing cloud-based supply chain integration practices that are balanced with the application of information security initiative and their effect on the supply chain robustness and performance.

Literature Review

Supply Chain

Supply chain is a network of interconnected companies to produce goods or services and deliver them to final consumers (Fernando et al., 2018). The supply chain management process begins with producers receiving raw materials from suppliers, processing them in the manufacturing process by adding value to goods or services to become final products, distributing them by distributors to final customers. In the service industry, the supply chain produces the final product in the form of a service.

Supply Chain Performance

Supply Chain Performance (SCP) is a process of measuring the level of efficiency and effectiveness of the activities or strategies implemented by the organization (Arif-Uz-Zaman & Ahsan, 2014). Shee., et al (2018) found that supply chain performance will ultimately increase the company's sustainability (firm sustainability). Therefore, SCP measurement becomes important for companies. Many studies can be found in the literature related to supply chain performance measurement. Various researchers have attempted to measure supply chain performance in unique ways and developed various performance measures. However, the Supply Chain Operation Reference (SCOR) model, developed by the Supply Chain Council, is the most commonly used tool among all existing conceptualizations and frameworks for measuring supply chain performance (Sindhuja, 2021). One view of the SCOR

model is that the supply chain should be measured in several dimensions. This study aims to look at the supply chain performance of telecommunication service provider companies. In the service supply chain, the most important assessment aspects are responsiveness, flexibility, and customer service. (Um, 2019).

Cloud Computing

Cloud Computing is a computing model, which is ubiquitous, geographically dispersed, virtualized, and has a distributed resources, which can be accessed on demand using web-based technologies (Mell & Grance, 2009). In cloud computing systems, hardware, software, and storage platforms are provided on demand and on a sharing basis. Cloud computing has high development capabilities and reliability over the internet (Talappeh & Lakzi, 2019). This technology offers organizations and users easy access to powerful computing over a network at minimal cost. In general, cloud-based services include Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Park and Ryoo, 2013). Cloud computing is the most important computing model in recent years that can reduce the cost of Capital Expenditure and also increase computing efficiency (Naseri and Navimipour, 2017). In addition, according to the same research from Naseri and Navimipour (2017) cloud services are used to reduce infrastructure costs by many organizations. The advantages of cloud technology such as flexibility, scalability and efficiency allow the creation of wider information sharing, which drives productivity and business success (Sindhuja, 2021).

Supply Chain Integration

Supply Chain Integration (SCI) consists of cooperation, interaction and collaboration across all links in the supply chain (Ellinger et al., 2016) to integrate physical, information and financial flows in the chain (Shee et al., 2018). Based on research by Jajja et al., (2018), SCI is categorized into three: (1) Internal integration (II) Customer integration (CI) and (III) Supplier integration (SI). The research of Shee et al., (2018) states that customer integration facilitates market responsiveness which is one measure of supply chain performance.

Cloud-enabled Supply Chain Integration

Sindhuja (2021) defines cloud-enabled supply chain integration (CSCI) as the practice of supply chain integration supported by cloud computing services. The SCI platform powered by cloud services enables real-time data exchange between partners in the supply chain. This is possible because the cloud operates on an internet protocol that facilitates timely communication with suppliers and customers. A seamless flow of information related to sales forecasting, production planning, order tracking, delivery status and inventory levels can occur when integration between customers, internals and suppliers is established. The study of Banchuen et al., (2017) found that the wider the supply chain integration (more involving suppliers and customers) and the deeper the integration (operations, coordination to joint collaboration) through cloud technology, the greater the perceived positive effect on supply chain performance. Apart from the advantages, the effectiveness of cloud adoption also depends on information processing and information security on internal and external information flows (Shee et al., 2018).

Information Security Initiative

In a study conducted by Safa and Von Solms (2016), information is vital for the survival of today's organizations. To have ongoing access to information-related resources, organizations need to ensure that their information is always secure. The ISO 27001:2013 standard defines information security management aspects as part of an overall management system, based on a business risk approach, to establish, implement, operate, monitor, review, maintain and improve information security. The purpose of information security is to minimize the risk of organizational loss

caused by intrusion, abuse of the system, abuse of privileges, tampering, fraud, etc. Sindhuja (2021) defines the dimensions of information security initiative (ISI) into two dimensions; internal and external dimensions. The internal dimension captures information security measures/practices that are internal to an organization. It deals with security measures that protect the company's own facilities. This includes physical security, logical security, security culture and policies adopted within the organization. The external dimension captures information security measures/practices that extend beyond the walls of the organization, including supplier, vendor, and customer. It considers physical security, logical security, security culture and policies from an interorganizational perspective

Supply Chain Robustness

Sindhuja (2021) defines supply chain robustness (SCR) as the supply chain's ability to withstand disruptions and changes and manage risks to continue normal operations, including supply chain continuity planning and supply chain disaster recovery. Wieland and Wallenburg (2012) conducted research on supply chain robustness to identify the effect of resilience and agility strategies on business performance. They found that robustness had a strong and direct positive effect on business performance, while agility had an indirect effect. Therefore, it is important to implement a robustness strategy that allows companies to manage normal, efficient supply chain fluctuations and helps companies to maintain their operations in the event of disruption (Sindhuja., 2021).

Problem Formulation

The conceptual framework in this study describes the effect of supply chain integration based on cloud computing and information security initiatives related to supply chain robustness and supply chain performance. Previous research by Shee et al (2018) revealed that a well-integrated platform supported by cloud services enables real-time data transfer among partners in an extended chain. In addition, a seamless flow of information in relation to sales forecasting, production planning, order tracking and tracing, delivery status and stock levels can occur when internal, supplier and customer integration occurs using cloud-based technology. This study found a positive effect between cloud-based supply chain integration on supply chain performance which ultimately affects the company's sustainability. Another study from Erboz et al (2021) also found that industry 4.0 which includes cloud computing technology can improve supply chain performance through the parameters of resource utilization, output, and supply chain flexibility. Therefore, the authors suspect that the cloud-based supply chain integration has a positive and significant effect on the robustness of the supply chain, so the hypothesis is proposed as follows:

H_1: Cloud-based supply chain integration has positive effect on supply chain robustness.

Previous research by Sindhuja (2021) showed that information security initiatives have a positive influence on organizational SCR. Information security initiatives include effective physical security and logical access control, a good security culture climate, training and awareness, well-documented security policies and open communication channels. Another study by Sarathy (2006) provides a conceptual understanding of the importance of supply chain security and internal and external sources of risk. The research shows that the smooth functioning of the supply chain requires protection against disruptions at all levels such as facilities, information flow, transportation of goods and so on. Therefore, the following hypothesis is proposed:

H_2: Information security initiative has positive effect on supply chain robustness.

Sindhuja (2021) shows that supply chain performance is influenced by the supply chain robustness. With the supply chain disaster recovery management, routine and

audited maintenance on supply chain components, the company ensures that the supply chain can continue to run in various conditions so that supply chain performance will improve. In addition, Sarathy (2006) reveals that a secure, strong, and resilient supply chain can improve the overall SCP. Therefore, the following hypothesis is proposed:

H_3: Supply chain robustness has positive effect on supply chain performance.

A cloud-based supply chain integration allows the system to be accessed more easily and allows data to be accessed in real time that supports supply chain performance. On the other hand, the system operates virtual with high availability and has a backup system that supports the supply chain. A direct effect of CSCI on SCP has been found by Shee et al, (2021), while a direct effect of CSCI on SCR has been found by Sindhuja (2021). From this relationship, no previous research has been conducted regarding the relationship between CSCI and SCP through the SCR variable. So this research proposes the following hypothesis:

H_4: Cloud-based supply chain integration has positive effect on supply chain performance through the mediation of supply chain robustness.

Sindhuja (2021) finds that information security initiatives cannot directly affect supply chain performance. It stated that information security initiatives are only part of the solution to realize effective supply chain implementation, which is a practice that will lead to improved supply chain performance. The practice of improving supply chain performance is influenced by supply chain operational factors consisting of information integration, robustness, and supply chain decision making (Sindhuja, 2014). From these considerations, the authors suspect that information security initiatives can affect supply chain performance through mediation of supply chain robustness, so the hypothesis is proposed as follows:

H5 : Information security initiative has positive effect on supply chain performance through the mediation of supply chain robustness.

Thus, the proposed research model is shown in Figure 1

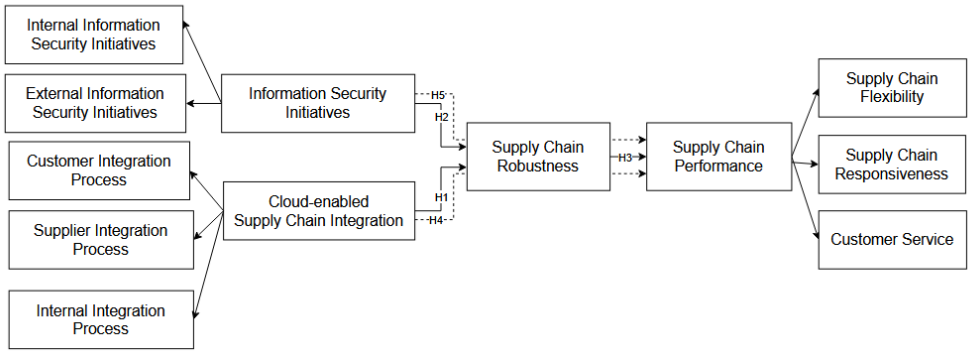

Figure 1. Reseach Framework

Research Methodology

The object of this research is the company's supply chain system of telecommunications service provider. Environment in this research is a real environment where this research takes pictures of the implementation that has been carried out in the company. The unit of analysis in this study is the individual who assessed the supply chain system in the company.

The population of this study are professional workers in telecommunications service provider companies who work in Jakarta. According to Government Regulation No. 52 of 2000 concerning Implementation of Telecommunication (GR 52/2000), telecommunication service are business entities that operate fixed networks (local fixed network operation, long distance

direct dialling, international direct dialling) and mobile networks (cellular, satellite, terrestrial). There are six mobile cellular network operators and 204 fixed network operators registered with the Ministry of Communication and Information (Kemkominfo, 2022). This study selects respondents who work for seven companies that are leaders in the fixed and mobile telecommunications services sector and have implemented cloud computing in the supply chain system. Table 1 shows the list of companies where the respondent works.

Table 1. Telecommunication Service Provider

Company	Category
PT Aplikanusa Lintasarta	Fixed network
PT Telkom Indonesia Tbk	Fixed network
PT Indonesia Commnet Plus	Fixed network
PT XL Axiata Tbk	Mobile Network
PT Telekomunikasi Selular Tbk	Mobile Network
PT Smartfren Tbk	Mobile Network
PT Indosat Tbk	Mobile Network

Sampling was carried out using an online questionnaire by google form platform with a Likert scale of 1-5. This study has 26 indicators. Determination of the minimum sample size based on research by Hair et al., (2010) which can be 5 to 10 of the total indicators. So the minimum number of samples in this study is 130. PLS-SEM method is used to test relationship between variables with SmartPLS software version 3.0

Results

A total of 132 surveys were returned with detail on table 2. The largest number of respondents came from the non-structural level (Officer / Engineer, Senior Officer / Senior Engineer, Junior Officer / Junior Engineer) with presentations of 34%, 20% and 20% respectively. This shows that the respondents come from the technical level who work daily in the company's operations. Assume that respondents were able to assess the application of CSCI, ISI, SCR and SCP from the company's supply chain operational activities. In terms of years of service, the majority of respondents worked more than five years, with a percentage of 64%, this shows that respondents known very well of the company's conditions and have been able to see the difference when cloud technology has been implemented in the supply chain in recent years and conditions previously.

Descriptive statistics were used to describe the overall sample composition. Respondent completed the measures of CSCI (M=4.102, SD=0.803), ISI (M=4.316, SD=0.77), SCR (M=4.148, SD=0.784), SCP (M=4.242, SD=0.718). With a scale of 1-5, the mean value of all measurements were in the high category

Table 2. Sample Characteristic

Characteristic	Total	%
Position		
Officer / Engineer	45	34%
Senior Officer / Senior Engineer	27	20%
Junior Officer / Junior Engineer	26	20%
Junior Manager	12	9%
Expert / Advisor	9	7%
Senior Manager	8	6%
Division Head	3	2%
Director	2	2%
Total	**132**	**100%**
Year of Service		
> 5 years	85	64%
> 3 years	28	21%
> 1 year	14	11%
< 1 year	5	4%
Total	**132**	**100%**

Evaluation of Outer Model (Measurement model)

Evaluation of outer model was carried out to assess the validity and reliability of the model. The outer model with reflexive indicators were evaluated through the convergent validity and discriminant validity of the indicators and composite reliability for the indicator (Ghozali and Latan, 2015).

The convergent validity tested using outer loading and AVE as parameters, while the discriminant validity tested using cross loading parameter. The reliability of the data was tested with the cronbach alpha parameter.

Validity

Convergent validity, according to Ghozali and Latan (2015), an indicator is said to be valid if the value is greater than 0.7. Based on table 3, all indicators have outer loading > 0.7. All reflective indicators were valid to measure variable.

Another way to examine convergent validity is to compare the square of the AVE for each construct with the correlation value between the constructs in the model. The acceptable AVE value must be greater than 0.5 (Ghozali and Latan, 2015). Based on table 4 all AVE values > 0.5.

Discriminant validity shows the extent to which a construct is completely different from other variables. Discriminant validity of the measurement model with reflective indicators were assessed based on the crossloading of measurements with constructs. It is expected that each measured latent variable is compared with indicators for other latent variables (Ghozali and Latan, 2015). Table 5 shows that the cross loading value of each item on its construct were greater than the loading value of the other constructs. From these results it can be concluded that there are no problems with discriminant validity.

Table 3. Outer Loading Results

Variable	Dimension	Indicator	Outer Loadings
Cloud-enabled Supply Chain Integration	Customer Integration	CIP1	0.873
		CIP2	0.847
		CIP3	0.844
	Supplier Integration	SIP1	0.947
		SIP2	0.952
	Internal Integration	IIP1	0.777
		IIP2	0.889
		IIP3	0.883
Information Security Initiative	Internal Information Security Initiatives	IISI1	0.889
		IISI2	0.927
		IISI3	0.94
	External Information Security Initiatives	EISI1	0.882
		EISI2	0.912
		EISI3	0.864
Supply Chain Robustness	Supply Chain Robustness	SCR1	0.821
		SCR2	0.821
		SCR3	0.832
		SCR4	0.799
		SCR5	0.722
Supply Chain Performance	Supply Chain Flexibility	SCF1	0.885
		SCF2	0.911
	Supply Chain Responsiveness	SCRes1	0.892
		SCRes2	0.93
		SCRes3	0.884
	Customer Service	CS1	0.914
		CS2	0.923

Table 4. AVE, Composite Reliability, Cronbach's Alpha

Variable	AVE	CR	Cronbach's α
Cloud-enabled Supply Chain Integration	**0.551**	**0.907**	**0.883**
Customer Integration Process	0.73	0.89	0.815
Supplier Integration Process	0.901	0.948	0.891
Internal Integration Process	0.724	0.887	0.807
Information Security Initiative	**0.724**	**0.94**	**0.923**
Internal Information Security Initiatives	0.844	0.942	0.907
External Information Security Initiatives	0.785	0.916	0.863
Supply Chain Robustness	**0.685**	**0.938**	**0.923**
Supply Chain Performance	**0.64**	**0.899**	**0.859**
Supply Chain Flexibility	0.807	0.893	0.762
Supply Chain Responsiveness	0.814	0.929	0.885
Customer Service	0.844	0.915	0.815

Table 5. Cross Loading Results

	CSCI	ISI	SCR	SCP
CIP1	**0.738**	0.456	0.611	0.64
CIP2	**0.702**	0.615	0.618	0.663
CIP3	**0.744**	0.406	0.696	0.708
SIP1	**0.789**	0.598	0.585	0.61
SIP2	**0.823**	0.597	0.618	0.703
IIP1	**0.716**	0.521	0.593	0.655
IIP2	**0.716**	0.462	0.421	0.577
IIP3	**0.699**	0.391	0.572	0.625
IISI1	0.596	**0.84**	0.428	0.517
IISI2	0.482	**0.858**	0.59	0.623
IISI3	0.603	**0.911**	0.55	0.631
EISI1	0.628	**0.8**	0.513	0.57
EISI2	0.645	**0.853**	0.446	0.499
EISI3	0.551	**0.839**	0.378	0.42
SCR1	0.677	0.527	**0.821**	0.643
SCR2	0.536	0.45	**0.821**	0.49
SCR3	0.655	0.557	**0.832**	0.602
SCR4	0.492	0.514	**0.799**	0.506
SCR5	0.526	0.588	**0.722**	0.485
SCF1	0.65	0.651	0.579	**0.764**
SCF2	0.677	0.594	0.57	**0.864**
SCRes1	0.654	0.581	0.557	**0.848**
SCRes2	0.613	0.657	0.553	**0.853**
SCRes3	0.661	0.668	0.583	**0.842**
CS1	0.559	0.592	0.502	**0.788**
CS2	0.702	0.635	0.643	**0.831**

Reliability

According to Ghozali and Latan (2015) composite reliability testing aims to test the reliability of the instrument in a research model. Composite reliability (CR) value > 0.7 and Cronbach's alpha > 0.7 means that the construct has good reliability. According table 4, all CR and Cronbach's alpha meet the criterion so the questionnaire used as a tool in this study was reliable or consistent.

Evaluation of Inner Models (Structural Model)

The inner model test is the development of a concept and theory-based model in order to analyze the relationship between exogenous and endogenous variables which has been described in a conceptual framework. Structural model tests were conducted to assess the coefficient of determination (R^2), predictive relevance (Q^2), and t-statistics

Rsquare (R^2)

The structural model was evaluated using R-square to assess the effect of certain independent latent variables, whether the dependent latent variable is have a substantive effect (Chin, 1998). The higher the value of R^2, the greater the ability of the independent latent variable to explain the dependent latent variable. The results of R^2 of 0.67, 0.33, and 0.19 indicate that the model is "good", "moderate", and "weak" (Chin, 1998). Based on table 6, R^2 value for CSCI is 0.581, which can be concluded that CSCI and ISI have a moderate impact on SCR. R^2 value for SCP is 0.47 which can be concluded that ISI, CSCI and SCR have a moderate impact on SCP.

Table 6. R Square Result

	R Square	R Square Adjusted
Supply Chain Robustness	0.581	0.575
Supply Chain Performance	0.475	0.471

Predictive Relevance (Q^2)

Predictive relevance (Q^2) is used to validate if the endogenous latent variable has a reflective measurement model. The results of predictive relevance (Q^2) are said to be good if the value is > 0, which indicates the exogenous latent variable is good (appropriate) as an explanatory variable capable of predicting endogenous variables and vice versa. The results of predictive relevance in this research can be seen in Table 7. The results show a predictive relevance value > 0, so the model can be said to be feasible and has a relevant predictive value.

Table 7. Predictive Relevance Results

	SSO	SSE	Q^2 (=1-SSE/SSO)
Cloud-enabled Supply Chain Integration	1,056.000	1,056.000	
Information Security Initiative	792.000	792.000	
Supply Chain Robustness	660.000	436.705	**0.338**
Supply Chain Performance	924.000	647.757	**0.299**

Hypothesis test

In PLS, each relationship is tested by using a simulation using the bootstrapping method on the sample. This test aims to minimize the problem of abnormality in research. Testing the research hypothesis using the t-statistic coefficient. Where the result / output of the bootstrapping command produces t-statistics. Indicators that have a t-statistic > 1.96 are said to be significant (Ghozali and Latan, 2015). An indicator can also be said to be influential if it has a p-value <0.05. The test results with the bootstrapping method from PLS are shown in table 7.

Table 8. Hypothesis Test

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Direct Effect					
CSCI -> SCR	0.302	0.307	0.079	3.800	0.000
ISI -> SCR	0.523	0.521	0.090	5.829	0.000
SCR -> SCP	0.689	0.694	0.050	13.792	0.000
Indirect Effect					
CSCI -> SCR -> SCP	0.208	0.213	0.056	3.702	0.000
ISI -> SCR -> SCP	0.360	0.363	0.075	4.818	0.000

Direct Effect

Based on table 7, the results of testing the direct influence hypothesis are as follows:

1) Hypothesis 1: Cloud-enabled Supply Chain Integration has positive effect on Supply Chain Robustness

CSCI has a t-statistic value of 3.800 > 1.96, p-value 0.000 <0.05 and original sample 0.302, so H1 was supported, meaning that CSCI has a positive and significant effect on SCR.

The practice of customer integration in the telecommunications service industry was in the form of a customer relationship management (CRM) system where customers are connected to the company so that the company can find out how the customer's needs and behavior, to further provide an optimal service and solution and maintain existing relationships. In a cloud-based CRM system, customers will get a login portal that can be accessed via the website / application portal from various devices through internet.

Internal integration practices in telecommunications service provider companies were included Inventory Management System (IMS), and Warehouse Management System (WMS) where both systems will be the key to managing and controlling the inventory of goods or products that will be distributed to customers. The Fault Management and Performance Management (FMPM) system was also implemented by telecommunication service companies to monitor the health of company equipment. Capacity, utility, disturbances can be fully monitored. All of these practices used cloud technology which allows the system to have high availability and minimum downtime.
With the support of cloud systems in supply chain integration, ease of access was achieved, data were visible in real-time by all company workers spread across various locations, and when a system failure occurs at a site, computing will automatically move to a computing system on other site. This created supply chain system that is reliable in the risk of natural disasters, system failures, and has the ability to continue normal operations under conditions of disruption.

2) Hypothesis 2 Information Security Initiative has positive effect on Supply Chain Robustness
ISI has a t-statistic value of 5.829 > 1.96, p-value 0.000 <0.05 and original sample 0.523, so H2 was supported, meaning that ISI has a positive and significant effect on SCR.

Implementation of internal information security initiatives in the form of information access control to protect information assets from the use of unauthorized access, the existence of security policies and procedures that are consistently applied throughout the organization ultimately become the company's security culture. This will support the supply chain to be solid. So the company will be ready with various scenarios in case of an attack or failure on the supply chain system. Information security were not only protected from internal but also external, namely by mutual awareness between the company and suppliers of the importance of information security so that information security policies are also implemented by external parties to protect company data that is accessed by external parties. Several guidelines for information security initiatives can be used by companies, one of which is ISO 27001.

At PT Aplikanusa Lintasarta, PT Indosat Tbk, PT Telekomunikasi Indonesia Tbk, and PT Indosat Tbk access control were implemented through the Privilledged Access Management (PAM) system, this system regulated rights access, monitored the activities of users who have access, and was able to prevent users from making unauthorized changes on the system. To ensure that PAM policies are implemented throughout the company, the system was integrated with the Lightweight Directory Access Protocol (LDAP) system which is a software protocol that contains a hierarchical directory of the company's organization. With LDAP, any organizational changes will be immediately implemented in PAM, so that information security policies apply consistently throughout the organization. Password changes are also mandatory for system

users every three months to prevent leakage and misuse user account.

In the external implementation of ISI, prior to the exchange of information, partners and companies will sign an official document called a Non Disclosure Agreement (NDA). NDA is a confidentiality agreement between two parties to maintain the confidentiality of certain information and/or materials that are shared together. This agreement keeps the information exchanged from being known or shared with other parties. The NDA has legal force, and can be sued in a civil manner if there is a violation. This will ensure that all parties (companies, partners, suppliers, and customers) are aware of the importance of information security and are confident that information security will be maintained.

3) Hypothesis 3 Supply Chain Robustness on Supply Chain Performance
SCR has a t-statistic value of 13,792 > 1.96, p-value 0.000 <0.05 and original sample 0.689, so H3 was supported, meaning that SCR has a positive and significant effect on SCP. These results are consistent with previous research from Sindhuja (2021).
Companies that have implemented SCR have a disaster recovery plan system, routine maintenance schedule for production equipment, and repair scenario if there is a system failure. The company will be able to survive and be ready in various conditions that disrupt the supply chain so that in the end the supply chain performance which is judged from customer service will be better, supply chain responsiveness, and supply chain flexibility will continue to run well.

Implementation of SCR at PT Aplikanusa Lintasarta: the company has routine maintenance on all company systems, routine maintenance is proposed and informed to customers one month before implementation with documents equipped with activity objectives, implementation scenarios and rollback scenarios in case of maintenance failure were also prepared. In addition, the company has prepared a business continuity plan, which is a strategy that is prepared to deal with situations where business conditions must be able to continue after a disaster occurs, for example, how services and handling of customer disruptions can continue in the event of a disaster at the head office in Jakarta (services will be transferred to branch office in Purwakarta). In addition, the company already has a system failover schedule per year, where the system is intentionally turned off to simulate an interruption in one system to see if service to customer can move to devices in other locations

Indirect Effect
1) Hypothesis 4 Cloud-enabled Supply Chain Integration on Supply Chain Performance through mediation of Supply Chain Robustness
CSCI against SCP through SCR has a t-statistic value of 3702 > 1.96, p-value 0.000 <0.05 and original sample 0.208, so H4 was supported, meaning that CSCI has a positive and significant effect on SCP with SCR as a mediating variable.

Companies that have implemented CSCI have a communication system with customers, partners, and internally with an easily accessible system and reduced the use of physical documents, data were shared using an online platform so that service to customers were excellent. on the other hand, CSCI make it easier for companies to be able to see customer demand and be able to capture new products, new markets, and respond to changing demands. This was also supported by the SCR intermediary variable, the CSCI design will consider the company's robustness parameters, scheduled system maintenance practices, the existence of a disaster recovery plan will be used as the company's basis for making an optimal CSCI system. A solid system will keep

company employees from being busy dealing with system disturbances, but instead can focus on improvements that can improve customer service.

2) Hypothesis 5 Information Security Initiative on Supply Chain Performance through mediation Supply Chain Robustness

ISI on SCP through SCR has a t-statistic value of 4.818 > 1.96, p-value 0.000 <0.05 and original sample 0.360, so H5 was supported, meaning that ISI has a positive and significant effect on SCP with SCR as a mediating variable.

These results confirm the statement (Sindhuja, 2014) which states that supply chain performance improvement is influenced by supply chain operational factors consisting of information integration, robustness, and supply chain operational decision making.

Discussion

This study examines the impact of implementing cloud supply chain integration as well as the important dimensions of information security initiatives that organizations can adopt to improve supply chain robustness and performance. The implementation of cloud supply chain integration is carried out by practicing customer integration, internal integration and supplier integration with systems that use the cloud computing. Information security initiatives are carried out by the organization internally and externally, including those related to aspects of physical security, logistics, culture, policies, awareness, security personnel, and security enhancement policies. In addition, this study found that organizations need to consider security against natural disasters, or disruptions that occur in the supply chain process, because in the business world, it will be increasingly competitive, services to customers must be maintained. This research is able to develop a reliable and valid construct based on theory and use it in developing and testing cause-and-effect relationships. In this way, all the constructs developed can act as a prelude to wider future research. Cloud computing technology is currently very closely related to technology companies, by seeing the good influence other companies with other fields can start switching to cloud computing technology to improve supply chain performance but do not forget to maintain the posture of information security.

Conclusion

This study investigated the relationship between cloud-based supply chain integration, information security initiatives, supply chain robustness, and supply chain performance. All five hypotheses was supported as follows: Information Security Initiative (ISI) has a positive and significant impact on Supply Chain Robustness (SCR), Supply Chain Integration based on Cloud Computing (CSCI) has a positive and significant impact on Supply Chain Robustness (SCR), Supply Chain Robustness (SCR) has a positive and significant impact on Supply Chain Performance (SCP), Information Security Initiative (ISI) has a positive and significant impact on Supply Chain Performance (SCP) through the Supply Chain Robustness (SCR) variable, Cloud Computing-based Supply Chain Integration (CSCI) has a positive and significant impact on Supply Chain Performance (SCP) through the Supply Chain Robustness (SCR) variable.

This research shows that companies can take opportunities to improve supply chains performance through the application of cloud technology in supply chain integration, but still need to improve information security initiative in order to create a robust supply chain against various threats, disruptions, and disasters

Implication

Based on the results of this study, in order to improve supply chain performance and supply chain robustness several managerial implications can be identified. Management needs to implement information security practices to the all element in the organization. This is necessary to make the supply chain robust against information security attacks which in turn will make the supply chain performance better. It can also make it easier for companies to take adequate steps to ensure information security in a preventive rather than corrective manner. This information security practice needs to be applied to all parties, both to the company's internal parties, as well as external parties (customers, partners, suppliers) connected to the company's system. The implementation of information security initiatives in telecommunications service companies refers to the ISO 27001 International standard in implementing information security management systems. This is an indicator that the company's information security initiatives are in line with global standardized information security practices.

Management of the telecommunications service industry that has not implemented cloud-based supply chain integration can implement cloud-based supply chain integration because from this research it is proven that cloud-based supply chain integration can improve supply chain robustness, and supply chain performance through the supply chain robustness mediating variable. With cloud technology, access to the system becomes easier (accessed through the public), investment in system size will be flexible following the development of system size (on demand). Implementation is done by moving the existing system that still uses physical / conventional server technology to cloud-based technology so that availability can increase, and management does not think about the operation and maintenance of the existing physical server. CSCI practices in telecommunications companies include cloud-based CRM, IMS, WMS, FMPM systems. The entire system is an implementation of the framework issued by the TM Forum, the global industry association for service providers and suppliers in the telecommunications industry.

Limitation

This study has numbers of limitations. First, limited number of samples, future reseach mau use of a larger number of samples so that the description of the phenomenon can be more valid. Second, this study assesses conditions in the telecommunications services sector, research with a wider scope and with more diverse industries such as the automotive industry, mining, retail, health services, or financial services can be carried out in further research. Last, this research does not capture the level of investment in IT infrastructure, organizational structure, as well as cloud technology and information security used, further reseach can add characteristic of investment level parameters on IT infrastructure, organizational structure, as well as cloud technology and information security used.

Notes on Contributors

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