Developing Key Performance Indicators for Supply Chain Resilience in Indonesian Automotive Industry

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Abstract

Since the Covid-19 pandemic entered Indonesia in April 2020, the automotive industry experienced the most significant decline compared to the other sectors. The downfall was due to weak demand for cars and motorcycles from the domestic and foreign market, leading to production cuts. This incident forced the entire automotive industry to adjust to returning to normal conditions after the disruption occurred as quickly as possible. There in need for *Key Performance Indicators* (KPI) for Supply Chain Resilience (SCR) to control and manage the company's target plans when a disruption occurs at any time. This study aims to design KPI to help firms in assessing the indicators related to disruption as long-term measures. This study utilized expert assessments, gathered from questionnaires, while quantitative data was processed using the Content Validity Index (CVI). From the literature review, 11 indicators such as security, knowledge management, visibility, risk management, collaboration, agility, flexibility, efficiency, redundancy, financial strength, market position and 46 sub-indicators of SCR were collected. Using the CVI approach for validity test results, 27 SCR sub-indicators were validated by six experts in the sector, with an average I-CVI value of 0.81.

Keywords
Supply Chain Resilience, Key Performance Indicator, Content Validity, Automotive Industry

1. Introduction
The ongoing global outbreak of COVID-19 is caused by the SARS-CoV-2 virus, first identified in December 2019 in Wuhan, China. World Health Organization declared it a global pandemic on February 11, 2020 (Lai et al. 2020). Since then, governments worldwide have been carried out various strategies and actions to fight the pandemic and recover the economic. One of the ways to prevent its spread is to restrict and completely close the border, which in the process could lead to unfavorable impacts on consumer spending, investment, and disruption to international trade and global supply chains (Belhadi et al. 2020). This situation makes all companies tightened their operations with to help their business survive.

Many problems that interfere with the company's production and distribution, such as natural disasters, political turmoil, fuel crises, disease, and terrorism, have increasingly occurred in recent years (Tukamuhabwa et al. 2015). As for now, the global pandemic gave a significant impact on every country's economy, including Indonesia. Economic conditions in a country based on a specific period can be seen from the Gross Domestic Product (GDP). Statistics Indonesia (Badan Pusat Statistik) stated that the GDP growth rate in Indonesia decreased drastically since the beginning of 2020 compared to the previous year from 4.96% to 2.97% (BPS 2020). It proves that Indonesia's economic condition has been affected and is not normal because of the pandemic.

Bappenas, the Ministry of National Development Planning Republic of Indonesia (2020) stated that from many industrial sectors in Indonesia, the automotive industry had significant negative growth of minus 30 percent due to weak demand for cars and motorcycles from the domestic and foreign market, leading to production cuts. Different sources stated that individual's purchasing power related to vehicles was disrupted because people prefer to save their money for basic needs rather than buying or replacing vehicles (Fea 2020). It indicates that this industry is vulnerable to disruption, and preventive measures are required to increase resilience in the future. One of the preventive actions is through *Key Performance Indicators* (KPI) for supply chain resilience (SCR) to control and

manage the company's target plans whenever a disruption occurs. This study aims to design KPIs to help companies assess the indicators related to disruption as long-term measures.

This study aims to construct indicators related to supply chain resilience as source for evaluating performance measurement of an automotive company. Here, the company could be aware and prepared for disturbances by using the SCR indicator. Therefore, to reduce risks, the company's supply chain must be designed to be ready, provide efficient and effective responses, and recover to its original state or even better after a disruption occurs in the process.

2. Literature Review

2.1 Supply Chain Resilience

Supply Chain Resilience (SCR) is a concept that is evolving and differs from traditional risk management (Pettit et al. 2010). By definition, SCR are supply chains designed to deal with disruptions, provide efficient and effective responses, and recover to their original state or even better after a disruptive event (Ponomarov and Holcomb 2009; Tukamuhabwa et al. 2015). SCR concept is defined as an unexpected deviation from the norm and its negative consequences, which combines the previous principles with the study of supply chain vulnerability. Mathematically, vulnerability can be measured by 'risk', a combination of the probability of an event and its potential severity (Brusset and Teller 2017; Pettit et al. 2010). Traditional risk management practices are considered incapable of handling unforeseen events. Therefore SCR complements existing risk management, helping the supply chain withstand unexpected disruptions and create a competitive advantage (Pettit et al. 2010).

2.2 Key Performance Indicator

The supply chain links one company to another, interconnected from upstream to downstream through different processes. In this context, one of every company's management tools is Key Performance Indicators (KPI). KPI is considered the most common and effective management tool for companies in deciding targets and being aware of the operations and processes (Anand and Grover 2015). Thus, KPIs acts as a tool for measuring process performance that develops organizational scenarios for continuous improvement (Werner et al. 2021). Chae (2009) defines KPI as a measurable metric which reflects the indicators that companies must monitor and manage to succeed. Hence, the purpose of the KPI is to describe the current condition, thereby allowing companies to observe and evaluate their operations (Karl et al. 2018).

2.3 Content Validity Index (CVI)

Of the several indicators collected based on the literature review results, it is still not certain that they are relevant in the current situation. Therefore, an indicator validation stage is needed to prove that the indicators are relevant to current conditions. Content Validity Index (CVI) will be used on the indicator validation stage. Originally, CVI was one of the most widely used techniques in nursing research (Polit and Beck 2006). However, the technique that has been developed has attracted much criticism among academics until Lynn (1986) finally calculated two types of CVI in her research. The first type of CVI involves content validity on items level (I-CVI), and the second type of CVI involves content validity on scale level (S-CVI) (Polit et al. 2007). Lynn (1986) recommended using a minimum of three experts but no more than 10. The suggested measurement scale is an ordinal scale with 4 points to avoid neutrality and ambivalent midpoints. The ordinal scale used includes: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = highly relevant.

From the literature review of the research papers, the study on the correlation between the supply chain resilience indicators and the key performance indicators is still minimal. For that reason, the author conducted research using the Content Validity Index method to validate the supply chain resilience indicators that have been collected from previous studies.

3. Methods

This study used primary data from questionnaires that six experts in the automotive field have filled out. The questionnaire results will then be processed using the Content Validity Index with the formula below with limits referring to the contents in table 1. Cause this research using six expert, so if the I-CVI value is 0.83 or higher, the SCR sub-indicator is declared valid.

$$I - CVI = \frac{Total\ expert\ agreeing}{Total\ expert} \quad (1)$$

$$S - CVI = \frac{\sum I-CVI}{Total\ item} \quad (2)$$

Table 1. Evaluation of I-CVIs with Different Numbers of Experts and Agreement

(1)	(2)	(3)[a]	(4)[b]	(5)[c]	(6)[d]
Number of Expert	Number of expert agreeing	I-CVI	P_c	K*	Evaluation
3	3	1.00	0.125	1.00	Excellent
3	2	0.67	0.375	0.47	Fair
4	4	1.00	0.063	1.00	Excellent
4	3	0.75	0.25	0.67	Good
5	5	1.00	0.041	1.00	Excellent
5	4	0.80	0.156	0.76	Excellent
6	6	1.00	0.016	1.00	Excellent
6	5	0.83	0.094	0.81	Excellent
6	4	0.67	0.234	0.57	Fair
7	7	1.00	0.008	1.00	Excellent
7	6	0.86	0.055	0.85	Excellent
7	5	0.71	0.164	0.65	Good

[a]I-CVI, item-level content validity index
[b]pc (probability of a chance occurance) was computed using the formula for a binomial random variable, with one specific outcome pc = [N! / A! (N-A)!]*.5^N where N = number of expert dan A = number of agreeing on good relevance.
[c]k *kappa designating agreement on relevance; k* = (I-CVI-pc)/(1-pc).
[d] Evaluation criteria: Fair = k 0.040 - 0.059; Good = k 0.060 - 0.74; Excellent = k >0.74
Source: Polit and Beck (2006)

4. Data Collection

SCR indicators and sub-indicators were taken from several literature related to SCR. A total of 11 indicators and 46 sub-indicators were found based on the literature review, as shown in table 2 and table 3.

Table 2. SCR indicators and sub-indicators

Indicators	Reference	Definition	Sub Indicators
Security	Christopher and Peck (2004), Lam and Bai (2016), Pettit et al. (2010), Chowdhury and Quaddus (2017)	Security is a key element for a supply chain to be protected from the risk of cyber or physical attack	Access restrictions, cyber-security, redundancy in IT systems
Knowledge Management	Christopher and Peck (2004), Pettit et al. (2010), Sahu et al. (2015), Fakoor et al. (2013)	Focusing on the process of recording knowledge and experiences from lessons that have been learned, so that knowledge can be well documented by the company. It aims to help managers cope with the various types of interruptions gained by experience, such as training and information sharing	Training, having multi-skilled personnel, team work, culture of caring for employees
Visibility	Soni et al. (2014), Christopher and Peck (2004), Pettit et al.	Knowledge of the status of operating assets and the environment	Information sharing, information technology, market visibility,

	(2010), Sahu et al. (2015), Singh et al. (2019)		knowledge of operating asset, demand visibility, supply chain visibility

Table 3. SCRes indicators and sub-indicators based on the literature review

Indicators	Reference	Definition	Sub Indicators
Risk Management	Soni et al. (2014), Sahu et al. (2015), Christopher and Peck (2004), Pettit et al. (2010), Rajesh (2019)	Includes factors such as identification, analysis, evaluation, control, minimization and elimination of unacceptable risks from the risk management culture	Demand forecasting, quality culture, monitoring, contingency planning
Collaboration	Tukamuhabwa et al (2015), Sahu et al (2015), Amindoust (2018), Fakoor et al (2013), Chae (2009), Johnson et al (2013)	Refers to the ability to work effectively with other entities for mutual benefit in areas such as forecasting, postponement and risk sharing. Collaboration could also involve information exchange, which can reduce uncertainty, increase transparency and facilitate the creation and sharing of knowledge, such as about supply chain risks and uncertainties.	Risk sharing, sharing resource, decision making coordination, material planning, production planning, supplier delivery efficiency
Agility	Soni et al. (2014), Sahu et al. (2015), Christopher and Peck (2004), Rajesh (2019), Werner et al. (2020), Anand and Grover (2015), Fakoor et al. (2013), Singh et al. (2019)	Capacity to respond changes quickly, which may reduce the impact of possible disruptions	Stock level, quick response, capacity utilization, order lead time, product cycle time, delivery lead time
Flexibility	Christopher and Peck (2004), Pettit et al. (2010), Rajesh (2019), Chowdhury and Quaddus (2017) , Hosseini et al. (2019), Johnson et al. (2013), Fakoor et al. (2013)	Ability of an enterprise to adapt to the changing requirements of its environment and stakeholders with minimum time and effort	On time delivery of goods, inventory management, product variation, supplier contract
Efficiency	Pettit et al. (2013), Chowdhury and Quaddus (2017), Fakoor et al. (2013)	Ability to produce output using minimum resources	Labor productivity, asset utilization, product variability reduction, preventive maintenance and repair
Redundancy	Christopher and Peck (2004), Werner et al. (2020), Pereira et al. (2014), Singh et al. (2019)	Additional capacity (production, transportation, inventory, and storage facility) that can rapidly replace losses during unexpected event	Change in production plan, recovery to shut down, peak demand, extra facilities
Financial	Christopher and Peck	Capacity to absorb fluctuations in cash	Insurance, price margin

strength	(2004), Pettit et al. (2010), Chowdhury and Quaddus (2017)	flow	
Market position	Pettit et al. (2010), Chowdhury and Quaddus (2017)	Status of a company or its products in specific market	Product differentiation, customer loyalty, customer relationship

Table 3. SCRes indicators and sub-indicators based on the literature review (continued)

After finding the indicators and sub-indicators that are relevant to Indonesia's automotive industry, the next step was to validate the indicators and sub-indicators. It was conducted by distributing questionnaires to experts in the automotive field. Six experts in the Indonesian automotive industry validated the indicator using the CVI method.

5. Results and Discussion

From the 11 indicators and 46 sub-indicators submitted through a questionnaire, all indicators and 27 sub-indicators were declared valid. At least 5 of the 6 experts agreed with the proposed sub-indicators. The total value of S-CVI is 0.81, according to the minimum limit determined by Polit et al. (2006) for the universal agreement approach. It indicates that the consensus from the expert was good. The results of indicators that were declared valid are shown in table 4.

Table 4. List of valid indicators and sub indicators by expert

Indicators	Sub Indicators	Number of expert agreeing	I-CVI
Security	Cyber security	5	0.83
	Redundancy in IT system	5	0.83
Knowledge Management	Training	6	1.00
	Team work	6	1.00
Visibility	Information technology	6	1.00
	Knowledge of operating asset	5	0.83
	Supply chain visibility	6	1.00
Risk Management	Monitoring	5	0.83
	Contingency planning	6	1.00
Collaboration	Risk sharing	5	0.83
	Production planning	5	0.83
	Supplier delivery efficiency	6	1.00
Agility	Quick response	6	1.00
	Stock level	6	1.00
	Capacity utilization	6	1.00
	Order lead time	6	1.00
Flexibility	On time delivery of goods	5	0.83
	Product variation	6	1.00
	Supplier contract	6	1.00
Efficiency	Product variability reduction	5	0.83
	Preventive maintenance and repair	6	1.00
Redundancy	Change in production plan	6	1.00
	Recovery to shutdown	6	1.00
Financial strength	Insurance	5	0.83
	Price margin	6	1.00
Market position	Product differentiation	6	1.00
	Customer relationship	6	1.00

5.1 Security

Security is an essential element in the supply chain and must be designed in such a way as to continuously secure the company assets. Developing operational security means protecting companies from various types of harm related to manmade disruptions, cyber-attacks, or physical (Chowdhury and Quaddus 2017; Karl et al. 2018; Lam and Bai 2016). Cyber security is one of the examples that companies must pay attention to because it protects computers and networks from malicious cyber-attacks, prevents security breaches, and avoids unauthorized access to sensitive information. Moreover, redundancy in the IT system is vital as backup resources to support the system if there is a disturbance and ensure the company's stored data security.

5.2 Knowledge Management

Knowledge management is a way to understand the organization's environment (Karl et al. 2018). Understanding supply chain operations, needs, threats, and human resources are the first step to creating SCR indicators. Under certain conditions, resilience must be prepared in the pre-disruption phase through practices like education and training from past experiences (Christopher and Peck 2004; Pereira et al. 2014). With knowledge management, the company can focus on documenting knowledge and experiences from lessons that have been learned. It will help managers cope with the diverse types of interruptions. Training will accumulate knowledge and skills to finish each task to stay consistent or even better than the set target under any circumstances. It will form good cooperation between individuals and teams to support the company in overcoming any disruption.

5.3 Visibility

Visibility is an important indicator to achieve resilience because it can visualize the inventory situation, demand, and supply from upstream to downstream of the supply chain (Christopher and Peck 2004). It functions as a warning strategy that gives companies critical time to align their capabilities in reducing the impact of a disruption. Thus, this indicator can be achieved and improved by using KPIs to monitor organizational assets, both tangible and intangible (Karl et al. 2018). Experts consider several sub-indicators essential and relevant, including information technology, knowledge of operating assets, and supply chain visibility. Information technology can help companies track every operational activity. Of course, this can ease companies in making decisions whenever a disturbance happens. Potential disturbances can come from within or outside the company. Hence, knowledge of operating assets is vital for operators working in production as a preventive measure. It is because all assets in the company must be used in a good and right way so that the assets can last for a long time and minimize disturbances from within the company. In addition, supply chain visibility allows companies to analyze and visualize customer expectations and follow global market business developments to constantly improve over time (Sahu et al. 2017).

5.4 Risk Management

Risk management is considered part of supply chain resilience by Christopher and Peck (2004) because many risks cannot be predicted or avoided. It can help lessen vulnerabilities through forecasting, monitoring, and risk mitigation (Karl et al. 2018). Thus, with the risk management culture, the company must understand and share risks among partners. In this indicator, monitoring all the operations is considered essential and must be paid attention to together with contingency planning. It can increase preparedness and create mutual commitments between suppliers.

5.5 Collaboration

Supply chain collaboration refers to working effectively with other partners for mutual benefit in forecasting, postponement, and risk sharing (Pettit et al. 2013). Collaboration can also involve exchanging information, lessening uncertainty, increasing transparency, and facilitating the invention and sharing of knowledge, such as topics discussed supply chain risks and uncertainties (Christopher and Peck 2004). Risk sharing, production planning, and supplier delivery efficiency are sub-indicators of collaboration that experts consider most relevant to the current situation. Risk-sharing between supply chain partners is conducted to share risk in an unexpected disruption. As we know, many companies invest in facilities and equipment at supplier's plants, so they are prepared to share risks with both suppliers and customers. Because each partner is related, production planning is also a problem when disruption happens. It refers to estimating the required resources, such as preparing detailed plans to achieve production goals economically, efficiently, and within the scheduled timeframe (Sahu et al. 2017). Delivery of goods from suppliers is also an important thing that continues to be monitored and measured, especially during the disruption time when the rate of this indicator typically drops (Karl et al. 2018). The greater the level of supplier delivery efficiency, the more effective cooperation between suppliers and company.

5.6 Agility

In today's conditions, companies are required to be agile to survive. Christopher and Peck (2004) describe supply chain agility as a quick response to unexpected changes in demand and supply. It can be achieved by changing the company's systems and business processes (Karl et al. 2018). Several sub-indicators stated as relevant in this indicator are stock level, capacity utilization, quick response, and delivery lead time. When a disturbance suddenly occurs in one of the supplier partners, the stock in the manufacturer's warehouse may not meet production demand due to a lack of supply. Hence, monitoring stock levels from suppliers and customers is an important KPI to avoid or mitigate the bullwhip effect and help managers mitigate risk and reduce inventory costs (Karl et al. 2018). Understanding the capacity utilization every month can also improve the schedule and utilize the resources to increase the efficiency of operations. In this indicator, delivery lead time is also necessary for customer service by serving as feedback to control the day-to-day operations. Companies must swiftly and quickly respond to customers to increase their satisfaction.

5.7 Flexibility

Flexibility is an enterprise's ability to adapt to the changing requirements of its environment and stakeholders with minimum time and effort (Tukamuhabwa et al. 2015). The current pandemic pushes companies to be flexible with many changes that affect conditions within. It affects the on-time delivery of goods, product variations, and supplier contracts. On-time delivery of goods will help managers accomplish flexible operations to meet customers' needs (Karl et al. 2018). In addition, the pace in replacing or adding product variations according to customer orders will also affect the effectiveness of operations within the company. Therefore, supplier contracts need to be flexible to minimize shortages (Karl et al. 2018).

5.8 Efficiency

Efficiency is the ability to produce output with minimum resources (Pettit et al. 2010). The pandemic has pushed companies to run their operations as efficiently as possible continuously. That is why reducing product variability, preventive maintenance, and repair measures are essential to current conditions. Reduced product variability in operations can prevent the bullwhip effect. Meanwhile, preparing all preventive actions for product maintenance and repair is necessary as the company's anticipation if a disturbance happens.

5.9 Redundancy

Creating redundancy is the strategic and selective use of spare capacity and inventory that can be used to cope with disruptions (Christopher and Peck 2004). Even though redundancy can be seen as duplicating the capacity to continue operations during a disruption, it is considered flexible (Tukamuhabwa et al. 2015). Redundancy is considered to increase flexibility because it facilitates response by deploying resources and assets that can be customized (Singh et al. 2019). It helps to avoid delays in processing operations and therefore improves SCR. Change in production plan and recovery to shutdown are examples of this indicator. Production plans can change in unexpected events, so they can be moved to another facility to keep production operating. In addition, recovery to shutdown is important because the shorter the recovery period, the smaller the loss due to damage caused by the disturbance.

5.10 Financial Strength

Financial strength is the capacity to absorb fluctuations in cash flow (Christopher and Peck 2004). The overall cash flow of any business tells whether that business is generating what it needs to sustain and grow. Pettit et al. (2013) wrote that two sub-indicators included as the company's financial strength are insurance and high margin, where both are relevant to the current situation. Companies with significant insurance coverage for facilities, equipment, goods, and personnel selling their products at a relatively high margin can support this indicator.

5.11 Market Position

One indicator that is considered essential for creating SCR is market position. It is a company's status or its products in a specific market (Pettit et al. 2013). A strong market position is related to the increase in market share. It allows investment in SCR, which undoubtedly helps maintain the relationship with the customers after an unexpected disruption happens (Pereira et al. 2014). As we know, each company already has specific target markets so that each product produced can sell well in the market following customer needs. Product differentiation is required in every company because it distinct the products and makes customers more interested (Pettit et al. 2010). That is why the

Customer Relationship sub-indicator as a company's effort towards its customers should be paid attention to maintaining good relationships and retaining their customers (Chowdhury and Quadduss 2017).

6. Conclusion

Supply chain resilience is a hot topic in the research world. It attracted the attention of many individuals due to its relevance to the current pandemic conditions. Supply chain resilience itself is a concept that developed from traditional risk management. This study reveals that the Indonesian automotive industry is still vulnerable to disruption, shown by the experienced automotive industry's most significant decline compared to the other sectors during the pandemic. That is why we need indicators that are practical to develop a resilient supply chain. This research resulted in 11 indicators and 27 sub-indicators of SCR, collected from previous research and validated by automotive field experts as shown in figure 1. Therefore, this research contributes to decoding the concept of resilience into performance indicators to create a useful managerial tool for improving performance.

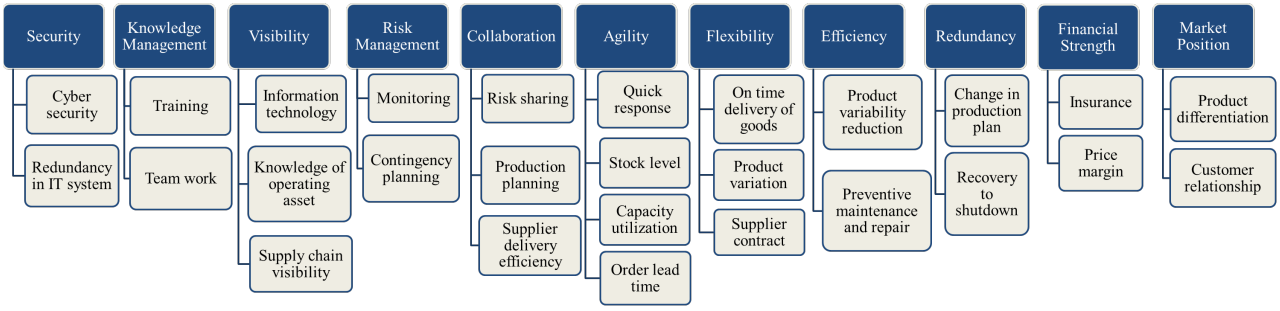

Figure 1. Indicators and sub indicators SCR in automotive industry

There are some limitations to this research. This study only discusses the SCR indicator, collected from previous research and relevant to Indonesia's automotive industry. Six experts from different automotive companies represented the validation of these indicators. There are still several indicators and sub-indicators not mentioned in this study that may be relevant in other sectors. Thus, the basis of this research cannot be generalized. Future research should be directed at indicators from other sectors that have not yet been explored and find new indicators. That way, the SCR indicator can be generalized and used in different kinds of company's sectors.

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Biography

Sela Diah Kenanga is a student of master's degree in Industrial Engineering, specializing in Production and Logistics Systems at the Universitas Indonesia. Earlier, she had completed undergraduate study majoring in Industrial Engineering at Trisakti University. She was a quality control lab assistant in the data and quality engineering domain when she was still an undergraduate. Before taking her master's degree, she worked as a quality system staff at a heavy equipment company for a year. She also had experience as an intern staff of the quality assurance department at a leather company for six months. Her research interests include quality, manufacturing, and supply chain.

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