The Moderating Role of the Lean Practices on the Relationship Between the Digital Supply Chain and Performance (A Case Study of the Indonesian Automotive Industry)

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Abstract

In this quickly evolving digital era, every industry is undergoing digital revolutions, which have an impact on business. This investigation aims to look into the effects of the digital supply chain on performance (in regards to product quality and cost reduction performance), with particular emphasis on the automobile industry in Indonesia. Additionally, the analysis investigates the moderating effect that lean practices have on the link between these factors. A total of 120 questionnaires were gathered, and analysis was performed using the PLS-SEM method. The findings indicate that the digital supply chain has a considerable impact on product quality and cost reduction performance. In addition, the results indicate that lean practices moderate the relationship between the digital supply chain and product quality performance, but not cost reduction performance. This finding contribute to the comprehension of supply chain management bridging the knowledge gap in the digital supply chain. Particular attention has been paid to the previously unstudied influence of operational performance within the framework of the automotive industry.

Keywords
Digital supply chain, lean practices, product quality performance, cost reduction performance and automotive industry

1. Introduction

Accelerated technological growth and the phenomenon of digitalization have become the standard in recent years in all industries. Every sector, including supply chain, is impacted by digital transformations (Nasiri et al., 2020). Emerging digital technologies are reshaping existing and future supply chain patterns significantly (Prakash Agrawal, 2018). A survey carried out by McKinsey and Company (2017) discovered significant variations in the degree of digitalization across industries and that businesses felt challenged by the pressures of digital technology. According to projections, a company's revenue could decrease by a third in the coming years if it does not take additional measures to counteract digital demand and rivalry from more technologically adept competitors. As digitalization and digital transformation are difficult to handle, many businesses are ignorant of how they might implement new digital technology into their business operations. Despite the tremendous opportunities afforded by digital technology, many businesses continue to underinvest in them, with the majority of their revenue still coming from traditional sources. In addition, the digital supply chain is still in its infancy, thus there is still ample room for further research (Büyükozkan and Gocer, 2018).

Today most supply chains operate according to traditional standardized processes including such plan, source, manufacture, distribute and return. Each of these components is increasingly revitalized as a result of technological advancements. Increased competition in supply chains has driven businesses to intelligently upgrade their production methods (Kamble et al., 2019). Büyüközkan and Göçer (2018) define the digital supply chain as "an intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronize interaction between organizations by making services more valuable, accessible and affordable with consistent, agile and effective outcomes".

Lean practices are commonly employed by manufacturers to obtain a competitive advantage (Garza-Reyes et al., 2012). The primary trust in lean practices is the elimination of waste through mutually beneficial partnership with suppliers (Behrouzi et al., 2011). In addition, lean approaches aim to give an enhanced customer experience and enhanced operational performance. Lean principles can be applied across the supply chain, from the time an order is placed with a supplier to the time the product is distributed and delivered to the customer (Marodin et al., 2016).

Indonesia is the world's biggest archipelago, with more than 17,000 islands, 300 languages, and more than 100 cultures. It is the fourth most populous country in the world, behind China, India, and the United States, with a population of over 270 million (BPS-Statistics, 2019). The automotive industry in Indonesia remains a promising sector that greatly contributes to the nation's economic progress. According to Minister of Sector of the Republic of Indonesia, the automobile industry in Indonesia saw an unprecedented increase of 17.82 percent in 2021. With 1.5 million direct laborers and 4.5 million indirect laborers, a total of 2.35 million vehicles can be manufactured per year (Kadinbsd, 2022). The objectives of this research are to analyze the impact of the digital supply chain on product quality and cost reduction performance, as well as the moderating effect of lean practices on the relationship between them, with a particular emphasis on the Indonesian automotive sector. Understanding these interactions is critical because it enables us to have a better understanding how the digital supply chain and lean practices impact upon product quality and cost reduction performance. This research provides insight to companies which make decisions on whether to use the digital supply chain in the long-term, particularly regarding the impact on their overall performance.

The research was organized in the following manner. Firstly, the research began with an introduction that summarizes and emphasizes the research's relevance to the digital supply chain. Secondly, there will be a review of literature research, hypothesis development and a conceptual framework of the research will be formed. Thirdly, the approach for the study will be discussed, including the stages of data collection and the variables' measures. The study will conclude with a discussion of the results and their impacts on theory and management and limitations and future recommendations for research.

2. Literature Review

In the current era of global competitiveness, quality has become a crucial strategic factor in determining the longevity and effectiveness of industrial enterprises (Maani and Sluti, 1990). Neely (2007) described quality as conformance to a pre-established specification. It relates to the extent to which a product reliably follows predetermined requirements (Flynn et al., 1995). The emphasis of this study is on product quality, as this is one of the most frequently used quality metrics in previous studies and also one of the most researched characteristics of operational efficiency (Nawanir et al., 2013). Koufteros et al. (2002) state that product quality is characterized as a manufacturer's ability to deliver a product with operating characteristics that meet performance requirements. Bartezzaghi and Turco (1989) stated how critical it is to evaluate the quality of products. Fawcett et al. (2011) explored the methods through which information technology influences supply chain performance, including product quality, inventory, and supply chain cost. The study found that supply chain integration and the organizational backdrop of an information-sharing culture contribute the most to the performance of companies. Moreover, Kim and Shin (2019) discovered that blockchain technology can improve product quality and safety, inventory management and restocking, and the design of new products.

One of the factors affecting a business's success is its ability to manufacture at the lowest possible cost (Nawanir et al., 2016). According to Fisher (1997), businesses must strike a balance between overhead costs and service level efficiency in terms of lead times in order to meet customer needs. According to a thorough analysis of the literature, cost performance is often measured in relation to unit manufacturing costs (Chen and Tan, 2011). Managing the total cost of product acquisition, processing, distribution, and transportation is essential for sustaining a competitive advantage (Whicker et al., 2009). To achieve this, it is necessary to evaluate supply chain operating effectiveness from a cost standpoint (Pettersson and Segerstedt, 2013).

Manufacturing businesses have increasingly implemented lean principles in order to obtain a competitive edge over their competitors (Garza-Reyes et al., 2012). Lean practices can be adopted throughout the supply chain, with the primary objective of reducing waste through mutually beneficial collaboration with suppliers (Behrouzi et al., 2011). Additionally, lean practices are aimed at increasing consumer satisfaction, enhancing operational performance, and cost reductions at all supply chain nodes (Marodin et al., 2016).

3. Conceptual Framework and Hypothesis Development

The rationale underlying this overall framework is the need to explore the influence of the digital supply chain on operational performance, and how lean practices moderate this effect. This study focuses on three categories of variables: first, the digital supply chain as an independent variable; second, operational performance (in regards to product quality and cost reduction performance) as a dependent variable; and third, lean methods as a moderating variable. The conceptual framework for this study is depicted in Figure 1, and the ensuing section covers the formulation of hypotheses based on this conceptual framework.

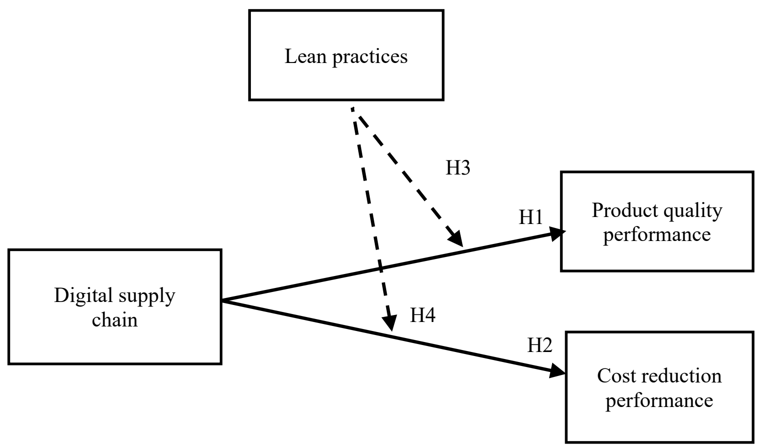

Figure 1. The conceptual model of the research

3.1 The digital supply chain and product quality performance; cost reduction performance

The introduction of technologies has increased awareness of the possibility of achieving a spectrum of organizational performance levels (Landscheidt and Kans, 2016). In addition, academic study has studied how developing technologies can augment performance enhancements in a few circumstances (Ehie and Ferreira, 2019). Marinagi et al. (2015) investigated the association between sharing of knowledge and supply chain performance. The study questioned 61 Greek industrial companies. As a result of enforcing SCM procedures that improve quality and reliability, information sharing across supply chain participants promotes a rise in total output, as indicated by the findings. In addition, Basnet et al. (2003) revealed a significant relationship between knowledge sharing with consumers and product quality via a sensitivity to client needs. Fynes et al. (2005) created a conceptual framework for supply chain linkages and quality performance based on their study. The model was validated using data from 200 vendors in the electronics industry in the Republic of Ireland. Their data strongly support their theoretical framework. In addition, they recommend that performance evaluations be based on quality and financial performance. Prior study has revealed that digital supply chain seeks to facilitate cost-cutting performance. According to Gunasekaran and Ngai (2004), integrating digital IT systems between suppliers and customers is a cost-effective option for collaborative work. In addition, Zhu and Kraemer (2002) gathered data from 260 manufacturing companies and discovered that digital information technologies are strongly and favorably associated to firm performance (cost reduction, profitability, and inventory efficiency). Based upon the literature researched, the following hypothesis is proposed:

Hypothesis 1: The digital supply chain exerts a positive effect on product quality performance

Hypothesis 2: The digital supply chain exerts a positive effect on cost reduction performance

3.2. The moderating role of lean practices

Lean techniques are renowned for boosting operational effectiveness by eliminating waste (Nawanir et al., 2016). Other study indicates that employing lean practices yields in a range of benefits, including improved quality (Fullerton and Wempe, 2009) and also cost savings (Chen and Tan, 2011; Mackelprang and Nair, 2010). Furthermore, Hajmohammad et al. (2013) developed a model illustrating the positive benefits of SCM and lean practices on operational performance when analyzing the function of lean practices in the traditional supply chain. Integrating lean thinking into SCM could pave the road for enhanced SCM performance. Cua et al. (2001) also found that lean procedures had a substantial impact on the quality, delivery, and flexibility of companies in manufacturing industries.

Zhou and Ji (2015) also noted that there is a strong association between the performance of lean practices and the adoption of digital technology solutions, and that the degree of success of lean practices in the supply chain increases as the quality of applications improves. Based upon the literature researched, the following hypothesis is proposed:

Hypothesis 3: Lean practices moderates the relationship between the digital supply chain and product quality performance

Hypothesis 4: Lean practices moderates the relationship between the digital supply chain and cost reduction performance

4. Research Methodology

4.1 Data Collection

The data were gathered by a random sampling of automotive manufacturing industries in Indonesia. E-mails containing a link to a Google form were sent to 1045 companies in Indonesia's automobile industry. From this were received 129 survey responses of which 9 were incomplete. A total of 120 available survey responses was collected, with an 11 percent response rate. Sekaran and Bougie (2016) validated this response level and indicated that the optimum response rate should be 5 to 35 percent for social-science studies.

The research framework of the current research has three latent variables (construct), which were measured using a questionnaire instrument. The scales of measurement for the survey instruments used in this study were derived from the literature (Table 1). Moreover, because this survey took place in Indonesia, the questionnaire had to be translated from English to Bahasa Indonesia. The survey was completed electronically and the responses to the survey questions were ranked and analyzed using a five-point Likert scale. The response scale ranged from 1 to 5, with strongly disagreeing (1) to strongly agreeing (5) on the digital supply chain (independent variable), lean practices (moderating variable), and product quality and cost reduction performance (dependent variable).

4.2 Measures

The research framework of the present study includes three variables that were examined utilizing a questionnaire. All questionnaire-based variables were measured with several items that have been validated and identified in a number of prior studies.

Table 1. Sources of construct measurement

Constructs	Items	Sources
Digital supply chain	10	Raman et al. (2018); Schoenherr and Speier-Pero (2015)
Product quality performance	4	Maani and Sluti (1990); Safizadeh et al. (1996); Koufteros et al. (2002)
Cost reduction performance	4	Davis and Schul (1993); Maani and Sluti (1990); Koufteros et al. (2002)
Lean practices	5	Shah and Ward (2007); Bayo-Moriones et al. (2010); Panwar et al. (2018)

4.3 Analysis Technique Selection

On the gathered data, descriptive statistics and reliability analysis were performed using SPSS version 19.0 software as well as to ascertain the demographic composition of the sample and to ensure internal consistency. The research began with a rigorous assessment of Partial Least Square (PLS)-Structural Evaluation Modeling (SEM) results suggested by J. F. Hair et al. (2019). A two-step process was used to assess the measurement model and the structural model. Additionally, SmartPLS 3.3.3 software was utilized to investigate the research model. The significance of path coefficients and loadings was determined using a bootstrapping procedure (5000 resamples) (J. Hair, Joseph F et al., 2017). The data set was examined for normality since SEM requires that data do not contradict the assumption of normality. According to Hair and Joseph et al. (2017), the data was normally distributed if the kurtosis and skewness values are in the range -1 to +1. Skewness values ranged from -1.383 to -0.311 for this dataset, whereas kurtosis statistics ranged from -1.208 to 3.411. Therefore, using Hair et al. (2019) criteria, the data can be considered as violating normality. As a result, PLS-SEM is regarded a suitable analytical methodology in this investigation, when distributional concerns such as lack of normality exist. Additionally, PLS-SEM is less demanding in relation to the minimum sample size (Hair et al., 2019).

5. Results and Discussion

5.1. Assessment of Measurement Model

The purpose of assessing the measurement model is to confirm its convergent and discriminant validity. Convergent validity should be confirmed by examining the factor loadings, average variance extracted, and composite reliability. Based on Table 2, the loadings on all items were greater than the suggested amount of 0.6 (Hair et al., 2017). The composite reliability values exceeded the suggested cut-off value of 0.7, which indicates the degree to which construct indicators reflect the latent construct. The average variance extracted calculated from the data exceeded the acceptable value of 0.5, which represents the whole variance in the indicators explained by the latent construct (Hair et al., 2017).

Table 2. Construct validity and reliability

Constructs	Indicator	Loadings	AVE	CR
Digital supply chain	DSC1	0.737	0.604	0.938
	DSC2	0.888		
	DSC3	0.802		
	DSC4	0.753		
	DSC5	0.783		
	DSC6	0.763		
	DSC7	0.718		
	DSC8	0.744		
	DSC9	0.853		
	DSC10	0.713		
Product quality performance	QP1	0.763	0.657	0.884
	QP2	0.775		
	QP3	0.883		
	QP4	0.817		
Cost reduction performance	CP1	0.826	0.711	0.908
	CP2	0.856		
	CP3	0.782		
	CP4	0.905		
Lean practices	LP1	0.889	0.790	0.949
	LP2	0.895		
	LP3	0.914		
	LP4	0.836		
	LP5	0.737		

To validate discriminant validity, the Fornell and Larcker criterion (Fornell and Larcker, 1981), and the Heterotrait–Monotrait (HTMT) correlation ratio (Henseler et al., 2015) might be utilized. Table 3 demonstrates that the square root of each construct's AVE (diagonal values) is greater than its associated correlation coefficient, indicating appropriate discriminant validity. Kline (2011) states that if the HTMT value exceeds the HTMT.85 value of 0.85, then there is an issue with discriminant validity. However, all values in Table 4 were less than HTMT.85.

Table 3. Results of the Fornell–Larcker criterion

Constructs	1	2	3	4
Cost reduction performance	**0.843**			
Digital supply chain	0.454	**0.777**		
Lean practices	0.416	0.259	**0.889**	
Product quality performance	0.613	0.406	0.445	**0.811**

Table 4. Results of the HTMT

Constructs	1	2	3	4
Cost reduction performance				
Digital supply chain	0.478			
Lean practices	0.446	0.268		
Product quality performance	0.717	0.446	0.496	

5.2. Assessment of Structural Model

To assess the structural model, J. F. Hair et al. (2019) suggested looking at the coefficient of determination (R^2), the predictive relevance (Q^2) and structural model path coefficients. R^2 quantifies a latent variable's explained variance in relation to its overall variance. The greater the R^2 value, the more the independent latent variable can be used to explain the dependent latent variable. The digital supply chain explains 33.1% of variance in product quality performance ($R^2 = 0.331$) whereas the digital supply chain explains 30.4% of variance in cost reduction performance ($R^2 = 0.304$). The R^2 coefficients of 0.331 and 0.304 are more than Cohen (1988) threshold of 0.26 for a substantial model.

Along with examining the magnitude of the R^2 values as a proxy for prediction accuracy, the Stone-Q^2 Geisser's value is also evaluated (Geisser, 1974; Stone, 1974). This metric indicates the model's predictive power or predictive significance outside of the sample. Q^2 illustrates how effectively data may be empirically reconstructed using the model and PLS parameters based on the blindfolding technique. Q_2 was determined in this study utilizing cross-validated redundancy techniques. A Q^2 score greater than 0 implies that the model is significantly predictive.

A Q^2 value greater than 0 implies that the model is predictively significant, whereas a Q^2 value less than 0 implies that the model is not predictively significant (Ali et al., 2018; J. Hair, Joseph F et al., 2017). From the data showing a value at 0.199 for product quality performance and 0.202 for cost reduction performance, all of which are higher than 0.

The final step is to access the structural path coefficients, which allow each hypothesis proposed in this study to be confirmed or refuted, and have a more complete understanding of the strength of the relationship between dependent and independent variables. To determine the significance of the hypotheses, the bootstrapping approach was performed (J. F. Hair et al., 2019). To establish the statistical significance of the path coefficient and t-statistics values, a bootstrapping technique was carried out using 5000 subsamples with no sign changes, as shown in Table 5. These path coefficients show that the digital supply chain positively and statistically significant effect on product quality performance ($\beta = 0.065$; $p < 0.01$) and cost reduction performance ($\beta = 0.070$; $p < 0.01$). Thus, both H_1 and H_2 were supported. The following section discusses the path coefficients for the moderating impacts of lean practices proposed in H_3 and H_4.

Table 5. Path coefficients

Hypothesis		Beta (β)	t-Value	p-Value	Decision
H_1	Digital supply chain – Product quality performance	0.065	5.553	0.000	Supported
H_2	Digital supply chain – Cost reduction performance	0.070	5.170	0.000	Supported
H_3	Digital supply chain x Lean practices – Product quality performance	0.103	2.515	0.012	Supported
H_4	Digital supply chain x Lean practices - Cost reduction performance	0.092	0.580	0.562	Not Supported

5.3. Discussion

This study is one of the first to attempt to establish a link between the digital supply chain and operational performance with regards to product quality and cost reduction measures. Furthermore, this study has also examined how lean practices moderate the impact of the digital supply chain on product quality and cost reduction performance. Four hypotheses were examined in accordance with the study's purpose and objectives. The PLS-SEM results support two hypotheses, leading us to infer that the digital supply chain does have an effect on product quality and cost reduction performance. Additionally, the results revealed that lean practices moderate the relationship between the digital supply chain and product quality performance, but not the relationship between the digital supply chain and cost reduction performance. The findings indicate that the digital supply chain positively affects operational performance in regards to product quality as well as cost reduction performance. As organizations boost their usage of digital supply chains, their operational performance will improve dramatically, according to the conclusions of the study. Adoption of digital technology can result in substantial value addition and monetary gain for firms, and it will rapidly become the industry norm. The findings are also corroborated by prior research conducted by Haddud and Khare (2020), who emphasized the significance of businesses identifying potential improvement areas and ensuring that all potential supply chain digitization benefits are fully achieved.

Additionally, the purpose of this study was also to test the hypothesis that lean practices will function as a moderator in the interactions between the digital supply chain, product quality performance, and cost reduction performance. As W. W. Chin et al. (2003) demonstrate, by taking account for the error associated with assumed connections, PLS can provide more exact estimates of moderator effects than other methods, thus enhancing theory validation (Henseler and Fassott, 2010). To examine the moderating effect, the digital supply chain (predictor) and lean practices (moderator) are multiplied to create an interaction construct (the digital supply chain x lean practices) that may be used to predict product quality and cost reduction performance. Based on Table 5, the predicted standardized path coefficients for the moderator's effect on product quality ($ß = 0.103$; $p < 0.01$) and cost reduction performance ($ß = 0.092$; $p > 0.01$) were not statistically significant. This indicates that lean practices moderate the relationships between the digital supply chain and product quality performance. Hence, H_3 was supported. Similarly, Chen and Tan (2011) stated that regardless of the studied industry, the adoption of lean practices had a significant positive impact on company performance. In addition, Saudi et al. (2019) found that enhancing supply chain lean methods enhances the overall performance of supply chain manufacturing enterprises. However, lean practices do not moderate the relationships between the digital supply chain and cost reduction performance, and H_4 was not supported. Contrary to the findings of Wong et al. (2009), who discovered that lean solutions improved organizational efficiency by lowering costs, boosting production, and reducing inventory, this result contradicts their findings.

6. Conclusion

By providing empirical evidence, this study contributes to the body of knowledge for the critical role of the digital supply chain on product quality and cost reduction performance in the Indonesian automobile sector. While contemporary scholars have emphasized the importance of studying the digital supply chain and its effect on operational effectiveness, little research has been conducted on this subject. In summary, the findings indicate that lean practices have a stronger moderating effect on the relationship between the digital supply chain and performance at the level of quality and cost reduction. Additionally, the findings indicate that lean practices have a stronger moderating effect on the relationship between the digital supply chain and performance at the level of productivity but is weaker at the level of cost reduction. Furthermore, this study contributes to the existing body of information on this issue by examining lean practices in the Indonesian automobile industry as a stimulant that may affect product quality and cost reduction performance

References

Ahuja, I. P. S., and Khamba, J. S, An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance. International Journal of Quality and Reliability Management, 25(2), 147-172, 2008. https://doi.org/10.1108/02656710810846925.

Ali, F., Rasoolimanesh, S. M., Sarstedt, M., Ringle, C. M., and Ryu, K. , An assessment of the use of partial least squares structural equation modeling (PLS-SEM) in hospitality research. International Journal of Contemporary Hospitality Management, 30(1), 514-538, 2018. https://doi.org/10.1108/ijchm-10-2016-0568.

Bartezzaghi, E., and Turco, F, The Impact of Just-in-time on Production System Performance: An Analytical Framework. International Journal of Operations and Production Management, 9(8), 40-62, 1989. https://doi.org/10.1108/eum0000000001257.

Basnet, C., Corner, J., Wisner, J., and Tan, K. C.,Benchmarking supply chain management practice in New Zealand. Supply Chain Management: An International Journal, 8(1), 57-64, 2003. https://doi.org/10.1108/13598540310463369

Bayo-Moriones, A., Clegg, B., Bello-Pintado, A., and Merino-Díaz de Cerio, J, 5S use in manufacturing plants: contextual factors and impact on operating performance. International Journal of Quality and Reliability Management, 27(2), 217-230, 2010. https://doi.org/10.1108/02656711011014320.

Behrouzi, F., Wong, K. Y., and Behrouzi, F, A study on lean supply chain performance measures of SMEs in the automotive industry. IEEE. 2011.

Büyüközkan, G., and Göçer, F. , Digital Supply Chain: Literature review and a proposed framework for future research. Computers in Industry, 97, 157-177, 2018. https://doi.org/10.1016/j.compind.2018.02.010.

BPS-Statistics, Trends of the selected socio-economic indicators of Indonesia. Retrieved 12 February 2020 from http://www.bps.go.id/

Chen, Z. X., and Hua Tan, K., The perceived impact of JIT implementation on operations performance. Journal of Advances in Management Research, 8(2), 213-235, 2011. https://doi.org/10.1108/09727981111175957.

Cohen, J., Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc, 1988.

Cua, K. O., McKone, K. E., and Schroeder, R. G., Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. Journal of Operations Management, 19, 675-694, 2001.

Davis, P. S., and Schul, P. L., Addressing the contingent effects of business unit strategic orientation on relationships between organizational context and business unit performance. Journal of Business Research, 27(3), 183-200, 2019.

Ehie, I., and Ferreira, M. D. F., Conceptual development of supply chain digitalization framework. IF AC PapersOnLine 52(13), 2328-2342, 2019. https://doi.org/10.1016/j.ifacol.2019.11.555

Fawcett, S. E., Wallin, C., Allred, C., Fawcett, A. M., and Magnan, G. M. (2011). Information technology as an enabler of supply chain collaboration: A dynamic- capabilities perspective. Journal of Supply Chain Management, 47(1), 38-59.

Fisher, M. L. (1997). What is the right supply chain for your product? Harvard Business Review.

Fullerton, R. R., and Wempe, W. F., Lean manufacturing, non-financial performance measures, and financial performance. International Journal of Operations and Production Management, 29(3), 214-240, 2009. https://doi.org/10.1108/01443570910938970

Flynn, B., Sakakibara, S., and Schroeder, R., Relationship between JIT and TQM: Practices and Performance. Academy of Management Journal, 38(5), 1325-1360, 1995.

Fynes, B., Voss, C., and de Búrca, S., The impact of supply chain relationship quality on quality performance. International Journal of Production Economics, 96(3), 339-354, 2005. https://doi.org/10.1016/j.ijpe.2004.05.008

Garza-Reyes, J. A., Parkar, H. S., and Oraifige, I., An empirical-exploratory study of the status of lean manufacturing in India. International Journal Business Excellence, 5(4), 2012.

Geisser, S., A Predictive Approach to the Random Effect Model. Biometrika, 61(1), 101-107, 1974.

Gunasekaran, A., and Ngai, E. W. T., Information systems in supply chain integration and management. European Journal of Operational Research, 159(2), 269-295, 2004. https://doi.org/10.1016/j.ejor.2003.08.016

Hair, J., Joseph F, Hult, G. T. M., Ringle, C. M., and Sarstedt, M., A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). SAGE Publications, Inc., 2017.

Hair, J. F., Risher, J. J., Sarstedt, M., and Ringle, C. M., When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2-24, 2019. https://doi.org/10.1108/ebr-11-2018-0203.

Hajmohammad, S., Vachon, S., Klassen, R. D., and Gavronski, I., Lean management and supply management: Their role in green practices and performance. Journal of Cleaner Production, 39, 312-320, 2013. https://doi.org/10.1016/j.jclepro.2012.07.028

Henseler, J., and Fassott, G., Testing Moderating Effects in PLS Path Models: An Illustration of Available Procedures. In V. Esposito Vinzi, W. W. Chin, J. Henseler, and H. Wang (Eds.), Handbook of partial least Squares: Concepts, methods and applications. Heidelberg, Dordrecht, London, New York: Springer. https://doi.org/10.1007/978-3-540-32827-8, 2010.

Henseler, J., Ringle, C. M., and Sarstedt, M., A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115-135, 2015. https://doi.org/10.1007/s11747-014-0403-8.

Kamble, S., Gunasekaran, A., and Dhone, N. C., Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies. International Journal of Production Research, 58(5), 1319-1337, 2019. https://doi.org/10.1080/00207543.2019.1630772

Kadinbsd. Overview of automotive sector in Indonesia Retrieved 12 September 2022. https://bsd-kadin.id/2022/05/13/overview-of-automotive-sector-in-indonesia/

Kline, R. B., Principles and practice of structural equation modeling. New York: Guilford Press. (The Guilford Press)., 2011.

Koufteros, X. A., Vonderembse, M. A., and Doll, W. J., Examining the Competitive Capabilities of Manufacturing Firms. Structural Equation Modeling: A Multidisciplinary Journal, 9(2), 256-282, 2002. https://doi.org/10.1207/s15328007sem0902_6.

Landscheidt, S. A., and Kans, M., Automation practices in wood product industries: Lessons learned, current practices and future perspectives. In: The 7th Swedish Production Symposium SPS, 25-27 October, 2016, Lund, Sweden, 2016..

Maani, K. E., and Sluti, D. G., A Conformance — Performance Model: Linking Quality Strategies to Business Unit's Performance. In: Ettlie J.E., Burstein M.C., Fiegenbaum A. (eds) Manufacturing Strategy. Springer, Dordrecht. 1990. https://doi.org/https://doi.org/10.1007/978-94-009-2189-4_10.

Marinagi, C., Trivellas, P., and Reklitis, P., Information quality and supply chain performance: The mediating role of information sharing. Procedia - Social and Behavioral Sciences, 175, 473-479, 2015. https://doi.org/10.1016/j.sbspro.2015.01.1225

Marodin, G. A., Frank, A. G., Tortorella, G. L., and Saurin, T. A., Contextual factors and lean production implementation in the Brazilian automotive supply chain. Supply Chain Management: An International Journal, 21(4), 417-432, 2016. https://doi.org/10.1108/scm-05-2015-0170.

McKinseyandCompany, How digital reinventors are pulling away from the pack, 2017 https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/how-digital-reinventors-are-pulling-away-from-the-pack.

Nasiri, M., Ukko, J., Saunila, M., and Rantala, T., Managing the digital supply chain: The role of smart technologies. Technovation, 96-97, 2020. https://doi.org/10.1016/j.technovation.2020.102121.

Nawanir, G., Kong Teong, L., and Norezam Othman, S, Impact of lean practices on operations performance and business performance. Journal of Manufacturing Technology Management, 24(7), 1019-1050, 2013. https://doi.org/10.1108/jmtm-03-2012-0027.

Nawanir, G., Lim, K. T., and Othman, S. N., Lean manufacturing practices in Indonesian manufacturing firms. International Journal of Lean Six Sigma, 7(2), 149-170, 2016. https://doi.org/10.1108/ijlss-06-2014-0013.

Neely, A., Measuring performance: the operations management perspective. In A. Neely (Ed.), Business Performance Measurement: Unifying Theories and Integrating Practice (2nd ed.). Cambridge: Cambridge University Press., 64-81, 2007.

Nordin, N., Deros, B. M., and Wahab, D. A., A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry. International Journal of Innovation, Management and Technology, 1(4), 374-380, 2010.

Panwar, A., Jain, R., Rathore, A. P. S., Nepal, B., and Lyons, A. C., The impact of lean practices on operational performance – an empirical investigation of Indian process industries. Production Planning and Control, 29(2), 158-169, 2018. https://doi.org/10.1080/09537287.2017.1397788.

Pettersson, A. I., and Segerstedt, A., To Evaluate Cost Savings in a Supply Chain: Two Examples from Ericsson in the Telecom Industry. Operations and Supply Chain Management, 6(3), 94 – 102, 2013.

Prakash Agrawal, R. N., Digital supply chain management: An Overview. IOP Conf. Series: Materials Science and Engineering, 455, 2018.

Raman, S., Patwa, N., Niranjan, I., Ranjan, U., Moorthy, K., and Mehta, A., Impact of big data on supply chain

management. International Journal of Logistics Research and Applications, 21(6), 579-596, 2018. https://doi.org/10.1080/13675567.2018.1459523
Safizadeh, M. H., Ritzman, L. P., Sharma, D., and Wood, C., An Empirical Analysis of the Product-Process Matrix. Management Science, 42(11), 1576-1591, 1996. https://doi.org/10.1287/mnsc.42.11.1576
Sekaran, U., and Bougie, R., Research Methods for Business: A Skill-Building Approach John Wiley and Sons Ltd, 2016
Schoenherr, T., and Speier-Pero, C., Data science, predictive analytics, and big data in supply chain management: Current state and future potential. Journal of Business Logistics, 36(1), 120-132, 2015. https://doi.org/10.1111/jbl.12082
Shah, R., and Ward, P. T., Defining and developing measures of lean production. Journal of Operations Management, 25(4), 785-805, 2007. https://doi.org/10.1016/j.jom.2007.01.019.
Stone, M., Cross-Validatory Choice and Assessment of Statistical Predictions. Journal of the Royal Statistical Society. Series B (Methodological), 36(2), 111-147, 1974.
Whicker, L., Bernon, M., Templar, S., and Mena, C., Understanding the relationships between time and cost to improve supply chain performance. International Journal of Production Economics, 121(2), 641-650, 2009. . https://doi.org/10.1016/j.ijpe.2006.06.022.
Zhou, S. B., and Ji, F. X., Impact of lean supply chain management on operational performance. International Journal of Business Analytics, 2(3), 1-19, 2015. https://doi.org/10.4018/ijban.2015070101
Zhu, K., and Kraemer, K. L., E-commerce metrics for net-enhanced organizations: Assessing the value of e-commerce to firm performance in the manufacturing sector. Information Systems Research, 13(3), 275-295, 2002. https://doi.org/10.1287/isre.13.3.275.82

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