A hybrid BWM-SCOR method for analysis electronic manufacturing supply chain elements that affected with COVID-19 pandemic

Patodi Parjuli Kurniawan
Graduate Student in Industrial Engineering
Faculty of Engineering
Mercubuana University
Jakarta, Indonesia
patodi_kurniawan@yahoo.co.id

Sawarni Hasibuan
Industrial Engineering Department
Faculty of Engineering
Mercubuana University
Jakarta, Indonesia
sawarni02@mercubuana.ac.id

Abstract

The current COVID-19 pandemic has had a major impact on all sectors, including the Manufacturing sector, one of which is Electronics. The decline caused by this pandemic has eroded the utilization (production capacity) of industries. In fact, it is these five industrial sub-sectors that contribute a lot to the Gross Domestic Product and generate foreign exchange from exports. The many challenges that the Electronics Manufacturing sector has to face in the Supply Chain due to the COVID-19 pandemic raises questions regarding the ability to operate manufacturing during the pandemic. Therefore, it is necessary to conduct a study to analyze what process elements in the electronics manufacturing supply chain are affected by the COVID-19 pandemic which can be used as a reference in further steps if you want to identify risks and create mitigation strategies. There are 6 dimensions identified in the SCOR, namely Plan 6 Indicators, Source 6 Indicators, Make 4 Indicators, Deliver 9 Indicators, return 9 Indicators and Enable 9 Indicators (total 43 Indicators). The indicator was screened through the Best Worth Method (BWM) by expert judgment (5 peoples) which was quite effective because it described the expert's interpretation, with the Consistency Ratio value: CR> 0.10. In total, 18 Process Elements were obtained which represent the dimensions of SCOR that were affected during the COVID-19 pandemic.

Keywords
Supply Chain Operations Reference (SCOR), Best Worth Method (BWM), COVID-19.

1. Introduction
The COVID-19 pandemic that hit the world that began on March 11, 2020 resulted in high uncertainty in industrial supply chains. This condition has damaged most of the transportation networks and distribution mechanisms between suppliers, production facilities and customers (Kumar et al. 2020).The supply chain cannot meet the shortage of raw materials, and manufacturing companies cannot increase their production capacity to meet the increasing level of demand (Deepu and Ravi 2021). This uncertain condition can also illustrate how disrupted the sustainability of industrial supply chains, especially electronics manufacturing. From the industrial sector itself, with conditions like now, where supply and demand are uncertain, so that production is disrupted and the threat of bankruptcy raises questions about the supply chain's ability to survive. As we know that the success of supply chain management in the future involves increasing transparency of raw material sources, diversifying product resources, and improving technology that is able to predict potential shortages (Okeagu et al. 2021).

The objectives of this research are to identify risks in the supply chain of the Electronics Manufacturing Industry in the operational supply chain cycle during a Pandemic.

2. Literature Review

Many research has been conducted in relation to SCRM during the COVID-19 pandemic, but in general they only discuss internal issues that have not touched the Manufacturing industry much. Such as (Ortiz-Barrios et al. 2021) which uses the AHP and TOPSIS approach, (Sajid 2021) which presents a dynamic risk assessment methodological framework for modelling biomass supply chain risks due to COVID-19, then (Deepu and Ravi 2021) which uses an integration approach between MCDM Information Systems. Other studies have even built a Business Continuity Plan Framework in order to create new ways of operating due to supply chain disruptions, organizational ability to respond to critical conditions is critical for business leaders (Margherita and Heikkilä 2021). Meanwhile (Vieweg 2021) discusses the consequences of the pandemic related to internationally distributed manufacturing.

For the Best Worth Method (BWM) approach, it is known by (Ilyas et al. 2021) to calculate the weight of the criteria and then use it to provide a structured way for companies to rank risk. So, as an update, this SCRM research focuses on the manufacturing sector, especially electronics with the SCOR model approach and uses the BWM method to identify which process elements are affected by the COVID-19 pandemic.

Risk itself from the perspective of engineering disciplines and the Australian/New Zealand Standard Risk Management (AS/NZ Standard) is defined as the possibility of an unexpected event that has a negative or positive impact for a particular purpose. This research needs to map the supply chain activities so that they are well structured, in this case based on the SCOR framework. Rosenbaum (2012) explained that the SCOR framework combines elements of business process engineering, metrics, benchmarking, leading practice, and people skills into a single framework. Under SCOR, supply chain management is defined as an integrated process of Plan, Source, Make, Deliver, and Return, and most recently an Enabler was added.

The main process of this research uses the BWM method. This method was first introduced by Rezaei (Rezaei 2015) to solve MCDM (multi-criteria decision-making) problems. Several alternatives will be evaluated with related criteria to choose the best alternative in MCDM. With the BWM method, the choice of the best criteria (highly desired, very important) and the worst choice of criteria (very little desired, very little important) is determined first by the decision maker. Then proceed with doing a pair comparison between the best criteria and the worst criteria along with other criteria. In this study, it is interpreted to be affected and unaffected. BWM Solver are distributed and filled out by experts in their fields (Expert Judgment) who have academic qualifications and policy makers and practitioners.

From several previous research, there has not been found a standard for the ideal number of expert judgments, but it can be seen from the quality of the expert from the background and experience of the expert. (Guo et al. 2020) in his research using 3 expert practitioners of the tank farm storage industry consisting of academics, technicians and managers. Then (Liu et al. 2017) using 4 experienced experts in the industry (3 people in construction and 1 risk management consultant. As for (Lo and Liou 2018) using 5 experts consisting of 3 company directors and 2 R&D Managers. there is also (Leite et al. 2021) which uses 6 people as wheelset experts. Finally (Hu et al. 2018) used 10 experts of which 6 were seismic researchers and 4 engineers.

In this research, the expert qualifications used were with a minimum education of Bachelor Degree with the following specifications: 1 Electronic Manufacturing Practitioner with Work Experience in the Electronics Manufacturing Industry ≥10 Years, 1 Manufacturing Consultant with Work Experience in the Electronics Manufacturing Industry ≥10 Years, 1 Practitioner Risk Management with Work experience as a Risk Management practitioner ≥10 Years, 1 Business Process & Systems Management Practitioner with Work Experience in Management system training ≥10 Years and 1 Certified Auditor with Experience in Audit Process and understand the business process of Electronics Manufacturing ≥10Years .Pareto diagrams are also used as a method of improving quality aspects. This method was discovered in 1906 by an Italian economist named Vilfredo Pareto. In general, the Pareto diagram uses the 80/20 principle, which means that 80% of events are caused by 20% of causes (Stojčetović et al. 2016).

3. Research methodology

This research is a mixed method research (qualitative and quantitative descriptive), with an exploratory descriptive research design using competent/expert personal judgments or perceptions in describing, explaining and interpreting a phenomenon that occurs in an object using BWM Solver. This study uses 2 sources of data, both primary and secondary. Primary data is data obtained directly from the first source, namely competent expert judgment.

Secondary data is a source of data obtained through intermediary media or indirectly. Variables are everything that is being researched. Variables can also be called research objects. While the theoretical definition of a variable according to (Sugiyono 2017) is an object under study or an attribute of a person who has "variations" between one person and another or an object with another object.Table 1 is an operational variable taken from Supply Chain Excellence A Handbook for Dramatic Improvement Using the SCOR Model (Rosenbaum 2012).

Table 1 Operational Variables

No	Item	Dimension	Data Type	Data Source
1	SCOR (The supply chain operations reference model)	Plan	Secondary	A Handbook for Dramatic Improvement Using the SCOR Model 3rd Edition, Peter Bolstorff and Robert Rosenbaum.
		Source	Secondary	
		Make	Secondary	
		Deliver	Secondary	
		Return	Secondary	
		Enabler	Secondary	
2	BWM (Jafar Rezaei ,2014)	Screening SCOR Indicator	Primer	Expert Judgement (BWM Solver)

In the BWM method used in the study, there are 2 functions, Objective Function and Constrains. Objective function is to minimize value of Consistency Ratio Ksi^L (x^L). In Best-worst multi-criteria decision-making method, in this case using Consistency ratio same with AHP, CR≥0.10 (Rezaei, 2015). It`s mean, CR≥0.10 (10%) This means that the expert answers are consistent so that the resulting solution is optimal. The constraint function will be explained in the following BWM steps, in which there are 5 BWM steps used to reduce the weight of the criteria, that is:

a. Step 1: Determine a decision criterion, in this step the decision maker (Expert) identifies n criteria (C1, C2, C3, …. C6) that used to make decisions.
b. Step 2. Determine the best (Most affected by the COVID-19 Pandemic) and worst criteria (Least affected by the COVID-19 Pandemic).
c. Step 3. Determining the preference for the best criteria for all other criteria, using a number between 1 and 9. For the preference criteria using the AHP comparison table below:

Table 2. AHP Preference

Score	Remarks
1	Equal importance
2	Somewhat between Equal and Moderate
3	Moderately more important than
4	Somewhat between Moderate and Strong
5	Strongly more important than
6	Somewhat between Strong and Very strong
7	Very strongly important than
8	Somewhat between Very strong and Absolute
9	Absolutely more important than

The table 2 above is contained in the Excel BWM Solver used to determine the score on the criteria. Modifications were made to the table without changing its essence to facilitate interpretation according to the topic such as in the table 3 below.

Table 3. Preference Modified Tables

Score	Remarks
1	both affected by the pandemic
3	Slightly more affected by the pandemic
5	obviously more affected because of the pandemic
7	very clearly more affected because of the pandemic
9	absolutely more affected because of the pandemic
2, 4, 6, 8	When in doubt between two adjacent element values

Jafar Rezaei stated that the optimal solution is the result of the following linear system (Rezaei, 2014):
$|W_B - a_{BJ} W_j| \leq x^L$, for all j
$|W_j - a_{JW} W_W| \leq x^L$, for all j
$S_j W_j = 1$
$W_j \geq 0$, for all j (2.1)

A : Preference score
J : Criteria
W_B : Weight Best
W_W : Weight worst
x :Variabel Slack

d. Step 4: Determine the preference of all the criteria over the worst criterion using a number between 1 and 9.
Objective Function: min x^L
$S_j W_j = 1$ (The sum of the value of the constraint function must be 1).
LP Model obtained is inputted into Excel BWM Solver as a data processor.

Mapping of the Process and Sub-Process of Supply Chain Activities with the SCOR perspective is done by first determining what Process Elements are involved in the dimensions Plan, Source, make, deliver, return dan enable as a dimension of the variable SCOR. In this research, the indicators (Process Elements) are taken from A Handbook for Dramatic Improvement Using the SCOR Model 3rd Edition, Peter Bolstorff and Robert Rosenbaum. a systematic improvement in supply chain performance, using a cross-industry reference called the Supply Chain Operations Reference (SCOR) model.

Table 4. SCOR Dimension Indicator

Dimension	No	Indicator
Plan	1	Assess supply resources
	2	Aggregate and prioritize demand requirements
	3	Plan inventory for distribution
	4	Plan production
	5	Material requirements
	6	Plan rough-cut capacity for all products and all channels
Source	1	Obtain
	2	Receive
	3	Inspect
	4	Hold
	5	Issue
	6	Authorize payment for raw materials and purchased finished goods

Make	1	Request and receive material
	2	Manufacture and test product
	3	Package
	4	Hold, and/or release product
Deliver	1	Execute order management processes
	2	Generate quotations
	3	Configure product
	4	Create and maintain customer database
	5	Manage accounts receivable, credits, collections, and invoicing
	6	Execute warehouse processes including pick, pack, and configure
	7	Consolidate orders
	8	Chip products
	9	Verify performance (OTD)
Return	1	Defective
	2	Excess return processing
	3	Authorization
	4	Scheduling
	5	Inspection
	6	Transfer
	7	Receiving and verifying defective products
	8	Action Plan
	9	Replacement.
Enable	1	Performance
	2	Information
	3	Policy
	4	Inventory strategy
	5	Capital assets
	6	Transportation
	7	Physical logistic network
	8	Regulatory
	9	Evidence of Priority Enable

Table 4 described that there are 6 dimensions in SCOR (Plan, Source, Make, Deliver, Return, enable) with the number: Plan 6 Indicators, Source 6 Indicators, make 4 Indicators, deliver 9 indicators, return 9 indicators and enable 9 indicators (total 43 indicators). From these indicators, it is necessary to determine which one is the most affected and not affected by the COVID-19 Pandemic conditions by using the BWM Solver which determination is made through expert judgment by 5 peoples.

4. Data and collection

The steps in calculating using BWM Solver are:

a. Determine the criteria to be measured for the BWM Plan.

Assess supply resources (C1), Aggregate and prioritize demand requirements (C2), Plan inventory for distribution (C3), Plan production (C4), Material requirements (C5) and Plan rough-cut capacity for all products and all channels (C6). The criterion indicators are described in table 5.

Table 5. Criterion Indicator

No	Names of Criteria	Criterion
1	Assess supply resources	C1
2	Aggregate and prioritize demand requirements	C2
3	Plan inventory for distribution	C3
4	Plan production	C4
5	Material requirements	C5
6	Plan rough-cut capacity for all products and all channels	C6

b. Choose from the six criteria above, which criteria are most affected by the COVID-19 Pandemic. In this case Expert 1 chooses Plan rough-cut capacity for all products and all channels (C6) most affected and Aggregate and prioritize demand requirements (C2) the least affected.
c. Selecting the preference of the decision maker on " Affected criteria above all other criteria ", and preferences " all other criteria against Unaffected " by choosing a number between 1 and 9 referring to the value of the importance level of the modified AHP at Table 3.

Option Table Expert 1: Criteria Affected by Pandemic, plan rough-cut capacity for all products and all channels (C6) compared to other criteria are described in table 6 as bellow:

Table 6. Criteria Assessment "affected"

No	Item	Intensity
1	Assess supply resources (C1)	8
2	Aggregate and prioritize demand requirements (C2)	8
3	Plan inventory for distribution (C3)	5
4	Plan production (C4)	7
5	Material requirements (C5)	6
6	Plan rough-cut capacity for all products and all channels (C6)	1

From the steps above we get model Linier programming (Linear System Equations 3.1):
$W_{C6}-8W_{C1} \leq x^{L}$
$W_{C6}-8W_{C2} \leq x^{L}$
$W_{C6}-5W_{C3} \leq x^{L}$
$W_{C6}-7W_{C4} \leq x^{L}$
$W_{C6}-6W_{C5} \leq x^{L}$
$W_{C6}-1W_{C6} \leq x^{L}$

Option Table Expert 1: All other criteria against which are not affected, Aggregate and prioritize demand requirements (C2) are described in table 7 as bellows:

Table 7. Criteria Assessment "criteria preferences vs Unaffected criteria"

No	Has no effect on others	Aggregate and prioritize demand requirements (C2)
1	Assess supply resources (C1)	2
2	Aggregate and prioritize demand requirements (C2)	1
3	Plan inventory for distribution (C3)	3

4	Plan production (C4)	2
5	Material requirements (C5)	3
6	Plan rough-cut capacity for all products and all channels (C6)	9

From Step no 4 obtained model Linier programming as follows:
$W_{C1}-1W_{C2} \leq x^L$
$W_{C2}-1W_{C2} \leq x^L$
$W_{C3}-3W_{C2} \leq x^L$
$W_{C4}-5W_{C2} \leq x^L$
$W_{C5}-4W_{C2} \leq x^L$
$W_{C6}-9W_{C2} \leq x^L$
From the equation above, obtained final LP Model as follows:
Objective Functions: min x^L

Constrains:
$W_{C6}-8W_{C1} \leq x^L$
$W_{C6}-8W_{C2} \leq x^L$
$W_{C6}-5W_{C3} \leq x^L$
$W_{C6}-7W_{C4} \leq x^L$
$W_{C6}-6W_{C5} \leq x^L$
$W_{C1}-1W_{C2} \leq x^L$
$W_{C3}-3W_{C2} \leq x^L$
$W_{C4}-5W_{C2} \leq x^L$
$W_{C5}-4W_{C2} \leq x^L$
$W_{C6}-9W_{C2} \leq x^L$

For$W_{C6}-1W_{C6} \leq x^L$ dan $W_{C2}-1W_{C2} \leq x^L$ not inputted to constrains because the value is 0.
$S_jW_j=1$ (Sum of values objective function must be 1).

LP Model above is inputted into Excel BWM Solver and obtained the following values are summarized in table 8;

Table 8. Results of Excel BWM Solver

Assess supply resources	Aggregate and prioritize demand requirements	Plan inventory for distribution	Plan production	Material requirements	Plan rough-cut capacity for all products and all channels
0.077605322	0.059127864	0.124168514	0.088691796	0.10347376	0.546932742

Value of Ksi*= 0,07

As for the results of the evaluation of each expert using Tools BWM are summarized in table 9, obtained results Weight from each expert, Example from one SCOR Dimension (PLAN) :

Table 9 BWM Plan

Plan	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Assess supply resources	0,078	0,077	0,043	0,057	0,220
Aggregate and prioritize demand requirements	0,059	0,074	0,203	0,129	0,080
Plan inventory for distribution	0,124	0,193	0,093	0,100	0,060
Plan production	0,089	0,283	0,139	0,329	0,160
Material requirements	0,103	0,193	0,246	0,186	0,320
Plan rough-cut capacity for all products and all channels	0,547	0,179	0,278	0,200	0,160

Table 10. Value of Ksi* (Consistency ratio)

	Ksi*				
Variable	Expert-1	Expert-2	Expert-3	Expert-4	Expert-5
Plan	0,07	0,10	0,07	0,07	0,10
Source	0,08	0,08	0,10	0,10	0,09
Make	0,08	0,10	0,10	0,10	0,10
Deliver	0,07	0,07	0,10	0,07	0,09
Return	0,06	0,09	0,10	0,08	0,10
Enabler	0,06	0,10	0,10	0,07	0,07

On Best-worst multi-criteria decision-making method, Jafar Rezaei use Consistency ratio same with AHP (CR<0.10). Which mean CR<0.10 (10%) Expert answers are consistent so that the solution result is optimal (Table 10).

From the data obtained, due to the large number of indicator data, further screening needs to be carried out, namely by selecting through Pareto (80:20).Plan Expert 1 are described in Figure 1:

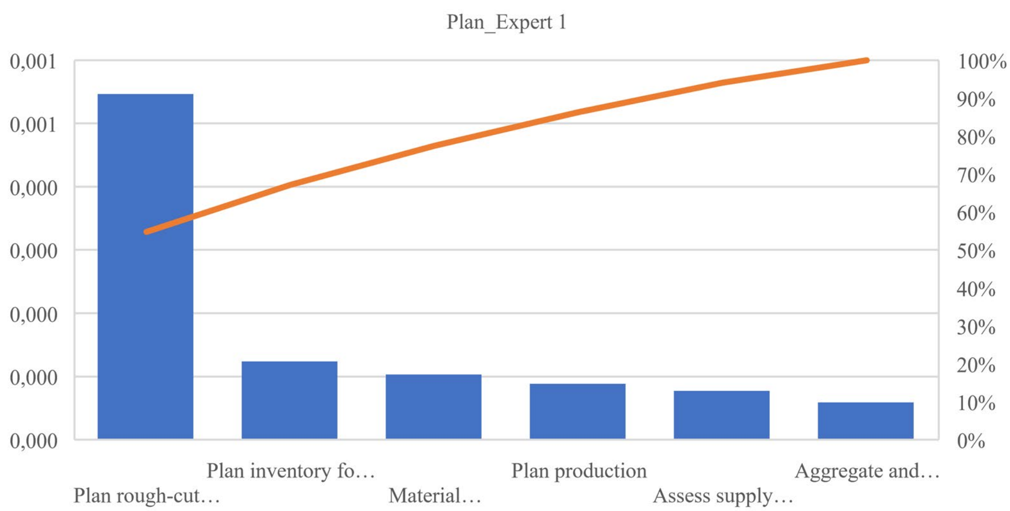

Figure 1 Plan Expert 1

From the 6 categories, those in the 80% category are: Plan rough-cut capacity for all products and all channels (C6), Plan inventory for distribution (C3), Material requirements (C5) and plan production (C4).

In total, the result is obtained as an example of one of the dimensions SCOR (PLAN) such as the following summarized in table 11:

Table 11. BWM Screening Pareto Plan

Kriteria (Plan)	Exp1	Exp2	Exp3	Exp4	Exp5	Total	%
Assess supply resources					√	1	20%
Aggregate and prioritize demand requirements			√	√		2	40%
Plan inventory for distribution	√	√				2	40%
Plan production	√	√	√	√	√	5	100%
Material requirements	√	√	√	√	√	5	100%

Plan rough-cut capacity for all products and all channels	√	√	√	√	√	5	100%

From the Pareto Screening BWM table, 3 main criteria are taken for mapping Supply Chain Activities. For the percentage of experts with a value of 60% whose criteria are 4, only 1 is taken which is an internal factor (Performance) because it's still in control. From the data obtained, maximum data (2 dominant values) are taken from each criterion based on expert calculations, the data obtained as the final supply chain mapping summarized in table 12 is as follows:

Table 12. Supply Chain Activity Mapping

Major Process	Sub Process	Kode
Plan	Plan Production	C1
	Material requirements	C2
	Plan rough-cut capacity for all products and all channels	C3
Source	Obtain	C4
	Inspect	C5
	Hold	C6
Make	Request and receive material	C7
	Manufacture and test product	C8
	Hold, and/or release product	C9
Deliver	Execute order management processes	C10
	Consolidate orders	C11
	On time delivery	C12
Return	Excess return processing	C13
	Transfer	C14
	Action Plan	C15
Enabler	Performance	C16
	Information	C17
	Evidence of Priority Enable	C18

5. Result and Discussion

The dimensions in the SCOR (Plan, Source, Make, Deliver, Return, enable) with a total of 43 indicators have been used as activities to determine risk events and by using the BWM tools it is determined which one is the most affected and not affected by the Pandemic COVID-19.

Through the results of the BWM by the appointed Expert, it can be seen that;
Plan is dominated by Plan Production, Material requirements and Plan rough-cut capacity for all products and all channels. These items result in changes to production planning, difficulties in meeting material specifications, errors in calculating material requirements and several other impacts.

For Source, was found that (material) obtain, (material) Inspection, (material) Hold has the potential for risk events that are closely related to the availability of materials, in this case the forwarder is involved.

Make it is also known that Manufacture and test product are the most affected due to the pandemic, even though there are items Request and receive material and hold and/or release product after that. However, focus on Manufacture and test product are crucial things that need attention. For Deliver, execute order management processes and Consolidate orders very impactful during the pandemic, because the suitability of conditions between the manufacturer and the customer needs to be regulated so as not to harm both parties, which later even though in the current state is not very hopeful, but Ontime delivery which is also the part affected can be maximized. For item Return was found that Action Plan it is very difficult to realize the plans made regarding the return of goods, because there is a genba process and analysis that is hindered by the conditions of government regulations, which also has an impact on Excess return processing and transfer.

Lastly, with regard to Enabler, which are activities that are often associated with supply chain management, item Evidence of Priority Enable as realization are the most affected due to the many restrictions from regulations that have arisen in connection with this pandemic, followed by Information and Performance.

6. Conclusion

By using BWM Solver, the Supply Chain Process Elements in SCOR (Plan, Source, Make, Deliver, Return, enable) are 43 Process Elements (Best Worth Method) into 18 Process Elements through Expert judgment. The selected items are the ones with the most potential to be used later as a reference in risk management.

a. Plan: Plan Production, Material requirements and Plan rough-cut capacity for all products and all channels.
b. Source: (material) obtain, (material) Inspection, (material) Hold
c. Make: Request and receive material, Manufacture and test product, Hold (and/or release product)
d. Deliver: Execute order management processes, Consolidate orders and on time delivery
e. Return: Excess return processing, Transfer and Action Plan
f. Enabler: Performance, Information and Evidence of Priority Enable

If further reviewed through the results of the BWM by the appointed Expert, it can be seen that this research is only at the stage of identifying the elements of the manufacturing supply chain process, not yet entering the strategy and implementation recommendations. It is also known that the BWM method as an initial screening of the SCOR variable is quite effective because it has described the expert interpretation, with the Consistency Ratio value: CR> 0.10. It is recommended to add to the stakeholder/Manufacturing Expert, especially Electronics if it will be continued into the risk mitigation process so that the results obtained are more comprehensive.

Refference

Deepu, T. S., and Ravi, V., Supply chain digitalization: An integrated MCDM approach for inter-organizational information systems selection in an electronic supply chain. International Journal of Information Management Data Insights, 1(2), 2021.

Guo, X., Ji, J., Khan, F., and Ding, L., Fuzzy bayesian network based on an improved similarity aggregation method for risk assessment of storage tank accident. Process Safety and Environmental Protection, 144, 242–252. 2020.

Hu, J., Chen, J., Chen, Z., Cao, J., Wang, Q., Zhao, L., Zhang, H., Xu, B., and Chen, G., Risk assessment of seismic hazards in hydraulic fracturing areas based on fuzzy comprehensive evaluation and AHP method (FAHP): A case analysis of Shangluo area in Yibin City, Sichuan Province, China. Journal of Petroleum Science and Engineering, 170, 797–812, 2018.

Ilyas, M., Carpitella, S., & Zoubir, E., Designing supplier selection strategies under COVID-19 constraints for industrial environments. Procedia CIRP, 100, 589–594, 2021.

Kumar, A., Luthra, S., Mangla, S. K., and Kazançoğlu, Y., COVID-19 impact on sustainable production and operations management. Sustainable Operations and Computers, 1(July), 1–7, 2020.

Leite, M., Infante, V., and Andrade, A. R., Using expert judgement techniques to assess reliability for long service-life components: An application to railway wheelsets. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability, 2021.

Liu, J., Jin, F., Xie, Q., and Skitmore, M., Improving risk assessment in financial feasibility of international engineering projects: A risk driver perspective. International Journal of Project Management, 35(2), 204–211, 2017.

Lo, H. W., and Liou, J. J. H., A novel multiple-criteria decision-making-based FMEA model for risk assessment. Applied Soft Computing Journal, 73, 684–696,2018.

Margherita, A., and Heikkilä, M., Business continuity in the COVID-19 emergency: A framework of actions undertaken by world-leading companies. Business Horizons, 64(5), 683–695, 2021.

Okeagu, C. N., Reed, D. S., Sun, L., Colontonio, M. M., Rezayev, A., Ghaffar, Y. A., Kaye, R. J., Liu, H., Cornett, E. M., Fox, C. J., Urman, R. D., and Kaye, A. D., Principles of supply chain management in the time of crisis. Best Practice and Research: Clinical Anaesthesiology, 35(3), 369–376, 2021.

Ortiz-Barrios, M., Borrego-Areyanes, A. A., Gómez-Villar, I. D., De Felice, F., Petrillo, A., Gul, M., and Yucesan, M., A multiple criteria decision-making approach for increasing the preparedness level of sales departments against COVID-19 and future pandemics: A real-world case. International Journal of Disaster Risk Reduction, 62(May), 2021.

Rezaei, J., Best-worst multi-criteria decision-making method. 53, 49–57, 2014.

Rezaei, J., Best-worst multi-criteria decision-making method. Omega (United Kingdom), 53, 49–57, 2015.

Rosenbaum, P. B. and R., Supply chain excellence : a handbook for dramatic improvement using the SCOR model (Vol. 7, Issue 9), 2012.

Sajid, Z., A dynamic risk assessment model to assess the impact of the coronavirus (COVID-19) on the sustainability of the biomass supply chain: A case study of a U.S. biofuel industry. Renewable and Sustainable Energy Reviews, 151, 2021.

Stojčetović, B., Šarkoćević, Ž., Lazarević, D., and Marjanović, D., Application of the Pareto Analysis in. 9th International Quality Conference, June 2015, 655–658, 2016.

Sugiyono., Metode Penelitian Kuantitatif, Kualitatif, dan R&D. CV Alfabeta, 2017.

Thomas L Saaty, L. G. V., Decission making with the Analytic Network Process. Springer, 2006.

Vieweg, S. H., COVID-19 Effects on Distributed Manufacturing. IFAC-PapersOnLine, 54(13), 35–39, 2021.

Biographies

Patodi Parjuli Kurniawan is currently as a Graduate Student in Industrial Engineering Faculty of Engineering Mercubuana University Jakarta, Indonesia. He is Department Head of Corporate Management System at one of Electronic Manufacturing. Having job's experiences for more than 12 years in various of industries, such as Electronic Spare Parts, Automotive Filtration Company, Battery Manufacturer, Printer Manufacturer and Touch Panel Manufacturer. He also actively involves on sharing knowledge in the spare time as a Trainer and Consultant of Quality, Environmental and Safety management Systems and the core tools with supported by certified training.

Sawarni Hasibuan is an associate professor in the Industrial Engineering Department at Universitas Mercu Buana, Jakarta, Indonesia. She completed his Masters in Industrial Engineering at the Bandung Institute of Technology and obtained a Doctorate in Agro-industrial Technology, Bogor Agricultural University. She has carried out several research and publications in industrial management, green & sustainable manufacturing, supply chain management, and renewable energy.