Journal of Engineering Technology and Applied Physics

Performance Evaluation of Subcontractors Using Weighted Sum Method Through KPI Measurement

Richard Nico Lumanauw[1], Poh Kiat Ng[2,] *, Adi Saptari[1], Isa Bin Halim[3], Mohamad Toha[1] and Yu Jin Ng[4]
[1]*Department of Industrial Engineering, President University Jababeka Education Park, Jl. Ki Hajar Dewantara, RT.2/RW.4, Mekarmukti, Cikarang Utara, Bekasi Regency, West Java 17530, Indonesia.*
[2]*Faculty of Engineering and Technology, Multimedia University, Jalan Ayer Keroh Lama, Bukit Beruang, 75450 Melaka, Malaysia.*
[3]*Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.*
[4]*Department of Social Science and Humanities, College of Energy Economics and Social Sciences, Universiti Tenaga Nasional, Putrajaya Campus, Jalan Ikram-Uniten, 43000 Kajang, Selangor, Malaysia.*
**Corresponding author: pkng@mmu.edu.my, ORCiD:* 0000-0001-7995-8251
https://doi.org/10.33093/jetap.2023.5.1.4
Manuscript Received: 2 February 2023, Accepted: 26 February 2023, Published: 15 March 2023

***Abstract* — Key Performance Indicators (KPIs) help measure objectives critical to business sustainability. This research takes place in a toy factory's injection moulding department that has yet to develop indicators for subcontractor performance. Poor subcontractor performance significantly impacts the injection moulding production. In the last three months, the delivered quantity exceeded the target by 27%, delivery time consistency is only 78%, there were 1.31% rejects, and inventory accuracy and material efficiency were 81% and 93% respectively. The objective of the study is to determine the KPI and develop an evaluation procedure for the injection moulding supplier and select the best supplier. Multi-criteria decision-making, i.e., weighted sum method, was used. Five employees were involved in determining the criteria weights. The evaluation was based on each supplier's performance. A written KPI for the company's subcontractor and performance evaluation procedures were developed. There were six subcontractors of which subcontractor H received the highest score (78.42) and subcontractor G received the lowest score (69.42). The subcontractor performance needs to be improved in the future. In the interest of the company's sustainability, it is recommended that this subcontractor performance evaluation be institutionalised to support subcontractor performance. Successful subcontractors support the business performance.**

Keywords*— *KPI, Subcontractor, Injection moulding, Multi-Criteria Decision-Making, Weighted Sum Method

I. INTRODUCTION

The toy industry makes an important contribution to the global economy. It is one of the largest manufacturing industries in the world. The main toy products manufactured in Indonesia are plastic toys, soft toys, dolls and wooden toys. The export value of children's toys was around USD 400 million in 2018 and is expected to increase further over the years. In one of the toy manufacturers in Cikarang, the factory works with some subcontractors to support the moulded parts for assembling the products.

Due to the high number of parts produced at each company's injection moulding subcontractors, competition between them has increased, raising awareness to stay active in the market and comply with all regulations. Poor control of processes/activities carried out at a subcontractor affects the operating results and process performance of the toy manufacturer, leading the company to develop a subcontractor evaluation mechanism.

Organisations have started to adopt sustainable business practices not only in their internal operations but also in their external operations/partners to achieve this goal. This is the result of the increasing global demand for industry to become more sustainable [1]. It is important to select a trustworthy, reliable and sustainable subcontractor or supplier who will make a positive contribution to the sustainability performance of a given company [2, 3]. It is not common to find a

Published by MMU PRESS. URL: https://journals.mmupress.com/index.php/jetap/index

subcontractor who shares similar goals of upholding high environmental standards [4]. Assessing and selecting the most effective suppliers who meet their sustainability requirements is a major difficulty for purchasing managers [5].

Subcontractors perform their work based on their plans and sometimes do not adhere to the company's requirements. The company has requirements and policies for all subcontractors and currently does not have performance measurement for its subcontractors. The subcontractors only carry out production activities without referring to the fulfilment of specific targets. Introducing performance measurement for subcontractors, on the other hand, is very important as it affects the company's overall delivery accuracy [6]. Another benefit of performance measurement is that it can help the company's production run smoothly and reduce problems in the process. In addition, the company can identify which subcontractors are performing both well and poorly so that the company can make a performance measurement assessment and improve their performance to better meet the company's requirements.

Measuring the performance of the company's subcontractors is important for all companies and organisations because the result has a direct impact on how processes are carried out and how the people involved in them behave so that they can assess the company's objectives. Measuring subcontractor performance is crucial as it directly impacts the quality of the final product or service delivered by the company and helps identify areas of improvement to take corrective action [7]. Measuring subcontractor performance also helps companies mitigate the risks associated with performance issues or failures that could impact their reputation, financial stability, and legal liability [8]. Identifying areas of improvement in subcontractor performance helps companies avoid cost overruns caused by delays, rework, and poor performance, ultimately leading to cost savings [9]. Defining key performance indicators (KPIs) is essential to achieve adequate performance of these types of systems.

KPIs are undoubtedly the most important measurement and control tools for the activities of any organisation. These indicators can be used to determine whether tasks are being carried out efficiently and help maximise the resources used. KPIs must reflect the organisation's business strategy and competitive variables, as well as its approach to achieving its goals. KPIs must also be relevant, coherent and goal-oriented and serve as a basis for objective comparison of different companies.

This investigation is important because the subcontractors' performance results matter to the company in order to improve the individual subcontractors' work processes and increase the company's production output [6]. If every supplier has a high delivery capability, problems in the injection moulding area are reduced and a better production process is automatically created for the company.

Currently, the company has not developed KPIs for the company's injection moulding subcontractors. There are inconsistent measurements and results in the subcontractors' operations, which has a significant impact on the Company's production process, especially in the area of injection moulding. In the last three months, the delivery volume was 27% above target, the consistency of delivery times was only 78%, there were 1.31% rejected parts from the production line with 11 average part numbers, as well as 81% inventory accuracy and 93% material efficiency. Because of this significant role in evaluating subcontractor performance, the company needs to develop a performance evaluation model.

The objectives of this research are: to determine the (KPI) of the company's injection moulding subcontractor; to develop an evaluation process for the (KPI) of the company's injection moulding subcontractor; and to select the best performing subcontractor as a benchmark or reference for other subcontractors.

II. LITERATURE REVIEW

A. Performance Management

According to Mahsun [10], the degree of success in implementing an activity/programme/policy in achieving the goals, objectives, purposes and vision set out in an organisation's strategic planning is called performance. Measuring organisational performance is critical for management to analyse the performance of the organisation and determine future goals. Various information is collected to monitor and demonstrate the work done. This is done to improve the efficiency and effectiveness of all business operations within the organisation. There are three types of performance measurement, the first is Key Results Indicators (KRI) which explains the success of the business in perspective. The next is Performance Indicator, which explains what things the company should be doing. And the last is Key Performance Indicator (KPI), which explains what needs to be done to significantly improve performance.

The KPI defines and measures organisational goals, which is fundamental to any running organisation and the success/sustainability of a business. KPIs are important for companies that want to implement a performance management system based on measurable aspects of organisational functions. Such systems can have many names, but the most commonly used system is called Balanced Scorecard/Implementing KPI driving force behind a social system, economies and organisations, can achieve normative effects that can change organisational behaviour and influence important decisions. To set long-term goals, rules and behaviours to achieve planned outcomes, stakeholder KPIs (such as suppliers) are integrated into performance management systems. A dynamic performance measurement system requires a multidisciplinary approach that integrates knowledge from process areas, information technologies, people and

appropriate scientific methods to ensure that KPIs meet organisational goals [11].

KPI is a quantitative index that shows the key success factors of an organisation. Therefore, the selection of KPI should be based on the context of an organisation and each KPI should be aligned and quantified with the business objectives. KPIs clarify the key responsibilities and serve as a basis for identifying the performance measurement indicators of the different departments of an organisation. Therefore, performance evaluation can be done on a quantitative basis. Setting clear and achievable KPIs is the key to effective performance management. In summary, KPIs should be established in accordance with the company's objectives. KPIs not only help to identify and analyse the performance indicators that need special attention in business operations, but also provide clues, data and real conditions for evaluation.

The use of KPIs as a control measure has become much more common due to the rapid growth and adaptation of companies to the concepts of Industry 4.0, which aim to access information through technological means, making the use of KPIs much easier. KPIs provide a set of measures that focus on the most important aspects of performance for the current and future success of the company. KPI establishes itself within the organisation and tries to get everyone to work together. According to Worldaimi [12], a good set of KPIs has a cascading effect. The development and nature of the manufacturing industry is even more evident in the pillars of the global economy riding the wave of Industry 4.0 [13]. Empirical evidence suggests that performance measurement in supplier development initiatives can promote optimism within the industry [14] and mitigate industrial risk [15].

The Key Performance Indicator explains the details to significantly improve performance. Determining the Key Performance Indicator is first about finding the 'performance indicator' that will lead an organisation to what it needs to do. The weighting of the performance indicators is done to determine the impact of each criterion on the overall performance of the company [12]. The size of the weighting indicates the extent of the impact. The greater the weighting, the more impact the criteria have on performance. The weighted assessment is based on the judgement of stakeholders or people involved in all organisational activities. logically consistent, which is a necessity. Reconciliation and validation of the numerous KPIs set by the various stakeholders in the different value chains is more important than ever [16].

B. Subcontracting in Manufacturing

In today's economic context, subcontracting is gaining significant importance, highlighting the need for better collaboration, coordination and agility between manufacturing companies to satisfy customers in terms of quantity and time. Although subcontracting has generated considerable discussion at a general level, very little has been researched and put into practise from an operational perspective. Moreover, relevant topics such as subcontracting, production and maintenance planning have been treated separately in the literature, although their interaction is obvious. The traditional approach of separating decisions from each other no longer meets the requirements of industry to ensure maximum availability of production systems, high quality standards and customer satisfaction [17].

Shimizu and Cardoso [18] define subcontracting as a legal-economic relationship between two actors in which the characteristic criteria are substitution and subordination. The substitution criterion means that the subcontractor carries out the contract with technical and financial risks instead of the principal. The subordination criterion means that the subcontractor must follow the instructions of the contractor. Subcontractors are specialists in the execution of a particular contract who supply labour in addition to materials, equipment, tools or designs. They are only responsible for the part of the work carried out and act as representatives of the contractor's production system. Nonetheless, disputes over unprofessional and unethical practices between subcontractors and the main contractor could arise, jeopardising the trust that has been built up, not to mention the substandard work being done on related projects [19].

This research is about supplier performance evaluation (SPE) in terms of KPI. Thus, there is a need to create a tailor-made assessment tool for the toy manufacturing sector, as different sectors face different challenges that may arise in the least expected circumstances. Xue, et al. [20] pointed out that a tailor-made SPE tool is required for a particular area, as some features are not suitable for that area. Although some methods work well to solve certain SPE problems, there is no single method that is suitable for all, despite the evaluation of a variety of SPE tools. Every circumstance is different, which in turn affects the decision-making process for collaboration or adoption. Even a relatively meaningful weighting of prominent factors affecting an assessment framework could be primarily subjective in nature, e.g. in the field of construction or engineering [21]. In any case, it is necessary to establish or develop a “pre-qualification criterion” when selecting subcontractors [22].

C. Multi-Criteria Decision-Making Methods

Decision making is a complicated process that organisations suffer in order to successfully achieve the desired end result. Decision making is about selecting the most appropriate action to achieve the desired goals and objectives. Since decision making is a day-to-day task, effective tools should be used to analyse all aspects of decision problems. Multi-criteria decision making (MCDM) is a well-structured and multidimensional procedure developed to address decision problems in different areas and to search for the most attractive alternative considering all relevant criteria. Thanks to its powerful tools, it analyses complex decision problems in different areas. This

method improves the quality of decision-making and makes it more rational and efficient. MCDM methods are considered the most recommended tools in addressing decision problems in different domains [23].

There are various weighting methods that have been proposed in the literature and applied to solve various MCDM problems, such as target programming, Analytic Hierarchy Process (AHP), weighted score method, VIKOR, TOPSIS, etc. These weighting methods are classified in different ways: direct criteria weighting methods (scaling, ranking weighting, point assignment methods and an indirect approach where the weight is derived from theories and mathematical models). Deciding on an appropriate weighting method is a difficult task when solving a multi-criteria decision problem. Several researchers have dismissed the difficulties in measuring criteria weights and assume that the importance of criteria weights is known to all decision makers [24]. However, the validity of the criteria weights obtained by different weighting methods should not be ignored in order to avoid misuse of MCDM models and to obtain reliable model results. MCDM methods can help improve the quality of decisions by making the decision-making process more explicit, rational and efficient.

MCDM is a decision-making technique in which there are several alternatives to choose from. In MCDM it contains elements of attributes, objectives and goals

- Attributes describe, give properties to an object. For example, height, length and so on.
- Objectives indicate the direction of improvement or preference for attributes, for example, maximising age, minimising price, and so on. The goal can also result from the attribute becoming a goal when the attribute is given a specific direction.
- Goals are set in advance. For example, if a project has the goal of maximising profit, then the project has the goal of making a profit of 10 million/month.

Criteria are standards, rules or norms that guide decision-making. Decision-making is done by selecting or formulating attributes, objectives and various goals. Then the attributes, objectives and goals are considered as criteria. The criteria are formed from basic human needs and desired values.

One of the simplest yet powerful MCDM techniques is the weighted sum method (WSM). This method can integrate qualitative and quantitative approaches [25]. In the WSM method, researchers need to set the criteria or indicators such as KPI to score the object. Then, the score of each object is determined based on its performance on the selected criteria, which may be based on quantitative data, and translated into the score.

The final score is based on multiplying the weight of each criterion by the score of the object assessed.

III. RESEARCH METHOD

The first step of this investigation is to identify the KPI of subcontractors. For this purpose, a team of responsible employees is formed to deal with subcontractor issues and injection moulding production planning under the guidance of the researchers. Past data in the company, especially from subcontractors, was used to determine the KPI. The past performance related to the KPI performance evaluation then became the indicators. These indicators were further evaluated to identify the sub-indicators as shown in Fig. 1. The data indicators collected were:

- Delivery data consisting of delivery accuracy [6], i.e. target and actual deliveries (in quantity) of all injection moulding suppliers.
- Delivery consistency data, i.e. target and actual deliveries (time) of all injection moulding suppliers [6].
- Quality indicators consisting of rejected part indicators for each part number (in quantity) from the incoming quality control department [26].
- Supplier compliance, broken down into Blackspot, Scratch and Wrong Colour.
- Reliability indicators were assessed using material efficiency data, i.e. how many materials were sent to suppliers and how many materials were used by suppliers [27].
- Inventory data comparing subcontractors' outstanding material recorded in the company's system [28].

These KPIs became the criteria for the evaluation of each subcontractor.

In the second step, data was collected from the company's internal database, e.g., from the injection moulding area, incoming quality control and inventory control. The initial data collected was raw data from the individual areas, which was converted into a data report.

Step 3, which involves scoring, is to evaluate and compare the KPI performance of each company's injection moulding suppliers using multi-criteria decision making with the weighted sum method. The data of delivery accuracy, delivery consistency, rejects, compliance, material efficiency and inventory were used for the comparative analysis. The performance evaluation was based on the score with which both the company and the suppliers agree.

Step 4: Determine the weighting of each criterion. When all the scores of each subcontractor for each indicator were available, the researcher conducted a questionnaire for some selected employees of the company to determine the weighted score for each criterion.

Step 5: Once the weighted score is determined, the final score for each subcontractor can be calculated by multiplying the sum of all the weighted criteria by the score. The final score will indicate which

subcontractor has the highest score and which has the lowest score for KPI performance. Based on this information, the company can then make a recommendation.

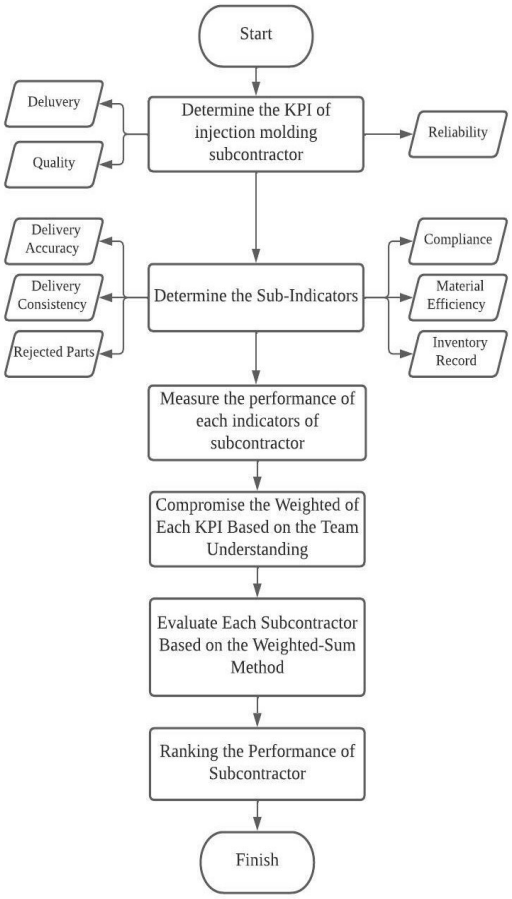

Fig. 1. Research framework for evaluating performance of the company.

IV. RESULTS AND DISCUSSION

A. Key Performance Indicator of Subcontractor

Determining the KPI as a criterion for evaluation. The company's injection moulding team prepared a written KPI for each subcontractor. It was developed based on the experience of the members of the team, which were the necessary indicators for the evaluation of the subcontractor. These were also based on the available records of the subcontractor's performance. The KPI is divided into several indicators. The Key Performance Indicator for the company's injection moulding division is shown in Fig. 2.

The company's injection moulding KPI is divided into three indicators, namely delivery, quality and reliability. Delivery consists of delivery accuracy and delivery consistency. For quality, the indicators are rejects and compliance [29]. The last indicator is reliability, which consists of inventory and material efficiency. This KPI became the criterion for the evaluation of subcon.

There were six (6) subcontractors on the list, namely subcontractors A, B, D, G, H and K. These subcontractors produced the same parts with the same specifications and all subcontractors are located in Cikarang. In this study, the company sent the raw material to its subcontractor and it is expected that the company will receive the finished parts from the subcontractor, which will then be passed on to the next subcontractor until they become finished goods.

Delivery accuracy compares the target delivery with the actual delivery. When determining the target delivery quantity or the planned delivery, it is checked whether the stock can cover the upcoming demand or not. To check the availability of the part quantity, the gap between the material requirements planning (MRP) and the stock status [30] in the warehouse and in the goods receipt area must be checked with the following formula:

$$Material\ availability = Inventory - MRP \quad (1)$$

If there is insufficient stock to meet demand, a quantity order must be created to meet the demand. If the material availability is negative, the material planner must place an order, otherwise there is no need to order. Table I shows how to determine the number of quantity orders. The total stock data shows the status of the stock in the warehouse and in the goods receipt. To determine the stock in the first week, it was calculated from the total stock minus the first week of MRP. The order quantity is calculated from the rounded-up stock of the last week. In the example for part number A, the last stock is -76,600, so the order quantity is rounded up to 77,000 units.

The ordered quantities and the required time determine the delivery target. When ordering parts, the enterprise must draw up a contract agreement for both parties (the enterprise and its subcontractor). The contract agreement between the company and its subcontractor to ensure that everything is documented and serves as proof.

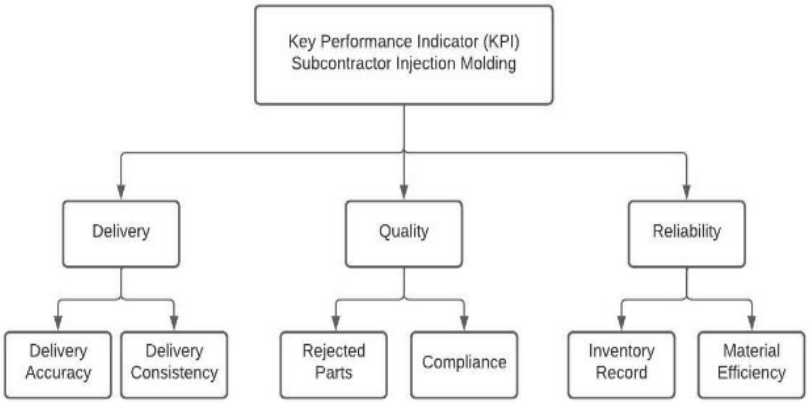

Fig. 2. Key Performance Indicator of Injection Moulding Subcontractor.

Table I. Determining quantity order of part numbers.

Part No	Total Inventory	MRP				Inventory on Hand				Qty Order
		5-Jul	12-Jul	19-Jul	26-Jul	5-Jul	12-Jul	19-Jul	26-Jul	
A	100.000	24.800	53.200	46.000	52.600	75.200	22.000	-24.000	-76.600	77.000
B	52.640	12.000	18.000	18.000	18.000	40.640	22.640	4640	-13.360	14.000
C	2.367	4.000	6.000	6.000	6.000	-1.633	-7.633	-13633	-19.633	20.000
D	2.367	4.000	6.000	6.000	6.000	-1.633	-7.633	-13633	-19.633	20.000
E	0	0	0	3.000	5.000	0	0	-3000	-8000	8.000
F	23.200	4.000	6.000	6.000	12.000	19.200	13.200	7200	-4.800	5.000

B. Delivery Accuracy (Ratio of Target / Actual Delivery)

Table II shows a summary of the delivery accuracy in the period October 2021 to December 2021. It can be seen that subcontractor G has the highest delivery ratio (target/actual) of 168% and subcontractor K has the lowest delivery ratio of 97%. From this ratio of delivery accuracy, it can be seen that most of the subcontractors have delivered more parts than the target quantity set by the company.

Due to the over- delivery by the subcontractors, there is an undesirable accumulation of stock. If the ratio is also below 100%, the company does not want this situation either.

To determine the score for each performance, see the Appendix, Table A. Note that if the delivery performance is more than 100%, the score will decrease.

This means that the subcon has delivered more than was required. So, a penalty has to be imposed. If the company delivers more than needed, it has to provide more space and material handling.

Table II. Summary of delivery accuracy (ratio of target/actual) of subcontractors.

Subcontractor	Subcon A			Subcon B			Subcon D		
Delivery	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Target (pcs)	3337239	4110550	5480131	6429441	5554526	4620909	1344238	1228027	797845
Actual (pcs)	2707133	5185969	6105123	5844874	8942823	3721654	1734814	2144415	1531400
Performance Rate (%)	81%	126%	111%	91%	161%	81%	129%	175%	192%
Score	90	70	80	85	60	90	70	60	60
Average Score	80			78.33			63.33		
Subcontractor	Subcon G			Subcon H			Subcon K		
Delivery Accuracy	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Target (pcs)	2635135	1610070	2548560	4943822	4479835	5390239	589562	1539258	1892518

Actual (pcs)	3543448	3580217	3781746	6767662	3504465	6542975	755835	1173361	1664088
Performance Rate (%)	134%	222%	148%	137%	78%	121%	128%	76%	88%
Score	60	60	60	60	70	60	70	70	80
Average Score	60			63.33			73.33		

C. Delivery Consistency

Delivery consistency measures whether or not subcontractors deliver the target delivery according to schedule. The term consistency means comparing how often the delivery schedule in a month matches the actual on-time delivery by the subcontractors.

Sometimes subcontractors do not adhere to the daily schedule, resulting in early or late deliveries to the company. The following formula is used to measure the delivery reliability of subcontractors:

$$Delivery\ Consistency = \frac{On-time\ Delivery}{Traget\ Delivery} \quad (2)$$

Table III shows the summary of delivery consistency from October 2021 to December 2021. The average results show that Subcontractor A has the highest rate of delivery consistency at 87% and Subcontractor B has the lowest at 67%.

The researchers found that most of the subcontractors delivered less than the part quantities required by the company. This had an impact on the company's production line as the required finished parts were not enough to support the line production. See the Appendix, Table B for notes on the evaluation.

Table III. Summary of delivery consistency of subcon.

	Subcon A			Subcon B			Subcon D		
Delivery Consistency	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Target (times)	643	552	545	278	258	330	87	60	50
Early Delivery (times)	20	10	13	11	9	27	0	1	0
Late Delivery (times)	58	61	72	80	67	96	11	8	8
On-time Delivery (times)	565	481	460	187	182	207	76	51	42
Consistency	88%	87%	84%	67%	71%	63%	87%	85%	84%
Score	80	80	80	60	70	60	80	80	80
Average	80			63.33			80		
	Subcon G			Subcon H			Subcon K		
Delivery Consistency	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Target (times)	135	153	131	227	283	233	192	220	212
Early Delivery (times)	4	12	3	2	21	15	3	26	11
Late Delivery (times)	13	41	10	13	71	31	17	59	70
On-time Delivery (times)	118	100	118	212	191	187	172	135	131
Consistency	87%	65%	90%	93%	67%	80%	90%	61%	62%
Score	80	60	90	90	60	80	90	60	60
Average Score	76.7			76.7			69.9		

D. Quality Product of Subcontractor

The second indicator of the KPI is quality. Quality counts the number of rejected parts and compliance. These two sub-indicators are considered to have an impact on the quality of the finished parts from the injection moulding production in the company, which is why it is important to evaluate each indicator performance.

E. Rejected Part

Rejected goods is a condition where the part numbers received do not meet the requirements and are therefore rejected. In production, the quantity of parts ordered is kept in the warehouse/stock to support production. While production is in progress, the operator finds that the parts received have problems or, in other words, that the part numbers do not match the requirements. If there are more than 100-part numbers

with problems in an original box, the production operator informs the planner that the part numbers should be withdrawn and taken to the staging area. During this process, a reject notification document is created along with the rejected sample. The document and the rejected part sample are passed to the subcon planner, who then decides whether these part numbers need to be re-sorted or discarded. Table IV shows the summarised average acceptance rate from October 2021 to December 2021.

From the analysis, Subcontractor G has the lowest acceptance rate at 98% and Subcontractors B and H have the highest at 99.1%. This means that most subcontractors still have a large number of rejected finished parts that will be scrapped later. The rating of each subcontractor can be found in the Appendix, Table C.

Table IV. Summary of rejected part from supplier.

	Subcon A			Subcon B			Subcon D		
Rejected Parts	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Delivery Quantity (pcs)	2707133	5185969	6105123	5844874	8942823	3721654	1734814	2144415	1531400
Total Rejected Parts (pcs)	18700	87644	48600	58968	63042	34500	51000	28200	18550
Accepted Quantity (pcs)	2688433	5098325	6056523	5785906	8879781	3687154	1683814	2116215	1512850
Acceptance Rate	99.31%	98.31%	99.20%	99%	99.30%	99.10%	97.10%	98.70%	98.80%
Score	75	65	75	75	75	75	65	75	75
Average score		71.67			75			72	
	Subcon G			Subcon H			Subcon K		
Rejected Parts	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Delivery Quantity (pcs)	3543448	3580217	3781746	6767662	3504465	6542975	755835	1173361	1664088
Total Rejected Parts (pcs)	82071	79000	52000	40300	51000	34200	15300	11000	15400
Accepted Quantity (pcs)	3461377	3501217	3729746	6727362	3453465	6508775	740535	1162361	1648688
Acceptance Rate	97.70%	97.80%	98.60%	99.40%	98.50%	99.50%	98.00%	99.10%	99.10%
Score	65	65	75	75	75	100	65	75	75
Average score		68			83.3			72	

F. Compliance

Compliance quality measures whether or not subcontractors adhere to the specifications set by the manufacturer. If subcontractors do not adhere to the required specifications, this will affect the number of rejected parts the company receives. The indications of supplier non-compliance are black marks, scratches and wrong colours. These remarks mean that the finished parts do not conform to the specification and are later rejected.

The average cases related to compliance with the part specification. Table V shows a summary of specification compliance for each supplier. Each number represents the case of a specific part number (P/N). The data was collected from October 2021 to December 2021. Scoring refers to the Appendix, Table D.

Table V. Summary of compliance from subcontractor.

	Subcon A			Subcon B			Subcon D		
Compliance	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Black Spot (P/N)	3	7	5	4	6	5	6	4	2
Scratch (P/N)	2	4	4	5	7	4	4	2	2
Wrong Colour (P/N)	2	9	2	7	7	3	4	1	1
Total Case (P/N)	7	20	11	16	20	12	14	7	5
Score	80	60	70	60	60	70	70	80	90
Average Score		70			63.3			80	

	Subcon G			Subcon H			Subcon K		
Compliance	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Black Spot (P/N)	6	5	4	2	2	3	4	3	2
Scratch (P/N)	7	5	2	3	6	4	2	0	0
Wrong Colour (P/N)	6	5	6	5	4	0	0	0	4
Total Case (P/N)	19	15	12	10	12	7	6	3	6
Score	60	70	70	80	70	80	80	90	80
Average Score		66,7			76.7			83.3	

G. Reliability of Subcontractor

The third indicator of the KPI is reliability. Reliability represents inventory and material efficiency. These two sub-indicators are considered to influence the reliability of suppliers to the injection moulding part of the business, so it is important to evaluate the performance of each indicator.

H. Material Efficiency

Material efficiency is about how efficiently subcontractors use the raw material supplied by the company to fulfil the requested order quantity. Figure 3 shows the process flow. After the company sets the order quantity for the subcontractor, it sends the raw material to produce the desired finished parts. The subcontractor receives the raw material and manufactures it into the company's desired finished parts. The efficiency of the use of the sent material is measured by the following steps:

a) Firstly, the number of materials to be sent needs to be known

$$Material\ Sent = Quantity\ Order \times Material\ per\ piece \quad (3)$$

b) After the raw material is received by the subcontractors, they will process it into finished parts according to the Company's requirements and send it to the Company. The Company shall record the number of finished parts received and if the number of finished parts received is less than the quantity ordered, the Company shall calculate the outstanding raw material and record it in the system.

$$Expected\ OS\ Material = (Expected\ Quantity - Actual\ Quantity) \times Material\ per\ piece \quad (4)$$

c) The next activity is the verification of the subcontractor's material number by the company's auditor. The auditor records the actual outstanding material with each subcontractor. In this way, the number of materials expected and the number of materials actually used can be calculated.

$$Expected\ Material\ Used = Material\ Sent - Expected\ OS\ Material \quad (5)$$

$$Actual\ Material\ Used = Material\ Sent - Actual\ OS\ Material \quad (6)$$

d) Finally, material efficiency can be determined by this equation:

$$Material\ Efficiency = \frac{Expected\ Material\ Used}{Actual\ Material\ Used} \quad (7)$$

Table VI shows the average of the actual material efficiency from October 2021 to December 2021. The analysis shows that subcontractor B is the most efficient in using the material with an efficiency of 100%. Meanwhile, subcontractor G has the lowest accuracy with 88% efficiency. This means that the material efficiency of 5 of the 6 subcontractors is still below 100% and the material supplied by the company is not used properly. The score refers to the Appendix, Table E.

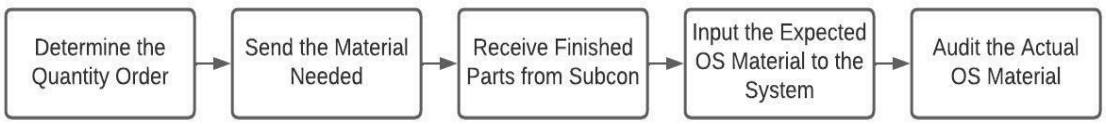

Fig. 3. Process flow of material usage.

Table VI. Summary of Average Material Efficiency (ratio of expected used/actual).

	Subcon A			Subcon B			Subcon D		
Material Efficiency	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Quantity Order (pcs)	2220400	2295938	3004374	1406451	5727951	4848148	44470	299196	410406
Material per piece (kg)	0.0025	0.0028	0.0021	0.003	0.0021	0.0024	0.024	0.0028	0.0019
Material Sent (kg)	5551	6429	6309	4219	12029	11636	1067	838	780
Actual Quantity (pcs)	1776320	1790832	2163149	1054839	4181405	3490666	31574	224397	287284
Expected Material Used (kg)	4441	5014	4543	3165	8781	8378	758	628	546
Actual Material Used (kg)	4831	5554	5229	3019	9449	8186	867	573	610
Efficiency	92%	90%	87%	105%	93%	102%	87%	110%	90%
Score	70	80	80	100	90	100	80	100	80
Average Score		76.7			96.6			86.67	
	Subcon G			Subcon H			Subcon K		
Material Efficiency	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Quantity Order (pcs)	1721781	2971237	2351351	2083275	4032111	6068022	2544756	3304099	1957200
Material per piece (kg)	0.0029	0.0027	0.0034	0.004	0.0035	0.0038	0.0031	0.0029	0.0025
Material Sent (kg)	4993	8022	7995	8333	14112	23058	7889	9582	4893
Actual Quantity (pcs)	1291336	2050153	1575405	1479125	2741836	4065575	1730434	2213746	1272180
Expected Material Used (kg)	3745	5535	5356	5917	9596	15449	5364	6420	3180
Actual Material Used (kg)	4148	6242	6325	5833	10462	16278	5969	6847	3613
Efficiency	90%	89%	85%	101%	92%	95%	90%	94%	88%
Score	70	80	70	100	80	90	80	80	70
Average Score		73.33			90			76.7	

I. Inventory Record Accuracy

Inventory compares the expected outstanding raw material recorded in the system with the actual outstanding raw material verified by the company's auditor [31]. This comparison aims to verify that the number of raw materials recorded in the system matches the outstanding raw materials at the subcontractors. The number of recorded material and the actual material at the subcontractors has already been determined in the previous section. Therefore, the following formula is used to determine the stock rate.

$$Inventory\ Record = \frac{Expected\ OS\ Material}{Actual\ OS\ Material} \quad (8)$$

Table VII shows the average of the inventory from October 2021 to December 2021. From the analysis, Subcontractor B has the most balanced material with an accuracy of 100%. Meanwhile, Subcontractor A has the lowest balance with an accuracy of only 63%. This means that the inventory records of 5 of the 6 subcontractors are still below 100% and the material comparison between the system and the actual is not balanced. The scoring refers to the Appendix, Table F.

Table VII. Summary of inventory records accuracy (ratio of expected/actual).

	Subcon A			Subcon B			Subcon D		
Inventory Record	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Company Record (kg)	1110	1414	1767	1055	3248	3258	310	209	234
Subcon Record (kg)	720	875	1080	1200	2580	3450	200	265	170
Accuracy	65%	62%	61%	114%	79%	106%	65%	127%	73%
Score	70	70	70	100	70	100	70	100	70
Average Score		70			90			80	
	Subcon G			Subcon H			Subcon K		
Inventory Record	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21	Oct-21	Nov-21	Dec-21
Recorded Material (kg)	1248	2487	2638	2417	4516	7609	2524	3162	1713
Actual Material (kg)	845	1780	1670	2500	3650	6780	1920	2735	1280
Accuracy	68%	72%	63%	103%	81%	89%	76%	86%	75%
Score	80	90	70	100	70	90	80	90	70
Average Score		80			86.6			80	

J. Weighted Sum Scoring

In the next step, after calculating the performance score of each performance indicator or criterion, the researchers could determine the final combined score using the weighted sum method, as this is the most important part of the analysis process. The weighted scoring process begins by determining the weighted score for each indicator and then continues with the calculation between the weighted score and the performance scoring results.

K. Determining the Weighted Score

The criteria and sub-criteria were assessed by means of a questionnaire survey. A questionnaire was prepared to determine the weighting of each criterion and sub-criterion. The respondents who were asked to complete the proposed questionnaire were those who have the authority and understanding of the operations of the suppliers and have the relationships with the suppliers themselves who supply the finished parts.

The questionnaire was distributed to several staff members in production planning, engineering and quality control. Due to the limited number of staff in the organisation, the number of trusted staff who could provide meaningful information through this questionnaire was 5 respondents. The small sample size of this study was due to practical constraints, including limited resources in terms of time and access to participants, which are not uncommon in research conducted in the specialized context of toy manufacturing. Specifically, finding participants who meet the selection criteria can be challenging in this industry. This limitation is acknowledged, among others [32-34], in studies dealing with the toy industry [35, 36], which has similarly reported the use of small sample sizes due to practical limitations and challenges in participant recruitment.

The feedback from the respondents was used to determine the weighting of the criteria and sub-criteria as shown in Table VIII.

Table VIII. Respondents of the study.

No	Respondent	Position	Section	Work exp.
1	RM	Manager	Prod. Planning and Subcon Operation	11 years
2	MS	Senior Staff	Subcon Operation	24 years
3	SU	Staff	Subcon Operation	29 years
4	SP	Supervisor	Quality	4 years
5	SN	Senior Staff	Engineering	9 years

Respondents were asked to decide whether one indicator was better, the same or worse than another. The results of their responses are shown in Table IX below.

Table IX shows the results of the questionnaire in determining the weighting of the individual sub-indicators. From the average of all respondents, the weighting of delivery accuracy is 20%, followed by delivery consistency at 15%, rejected parts at 24%, compliance at 16%, material efficiency at 10% and inventory at 10%.

Table IX. Respondent's response of scoring weight.

Indicator	Sub-Indicator	RM	MS	SU	SP	SN	Average
Delivery	Del. Accuracy	25%	20%	15%	15%	25%	20%
Delivery	Del. Consistency	15%	20%	10%	15%	15%	15%
Quality	Rejected Parts	20%	20%	30%	30%	20%	24%
Quality	Compliance	20%	10%	20%	20%	10%	16%
Services	Inv. Record	10%	20%	15%	10%	20%	15%
Services	Mat. Efficiency	10%	10%	10%	10%	10%	10%

L. Weighted-Sum Scoring of All Key Performance Indicator

The results of the KPI performance assessment using the weighted sum method are shown in Table X. It shows the final scores. To obtain the final score, the weights of the criteria and the score of the criteria for each sub-area are multiplied. Then the score for each subcon is added. From the table, it can be seen that subcon H scored the highest with 78.73, followed by B with 76.46, K with 75.43, D with 75.41, A with 74.57 and G with 69.42 the lowest.

After completing the case study analysis, the researchers presented and discussed the findings with the company's team. The team gave several feedbacks after comparing the result of the method with the actual and real working of each subcontractor's performance. The analysis showed that subcontractor H has the highest score, which is acceptable according to the team. Subcontractor H is one of the best performing suppliers, serving the company well with the most accurate delivery figures, on-time delivery, lower number of rejects and good material management. This finding supports that analysing subcontractor performance can also lead to improvement opportunities for increased efficiency and cost savings for companies. By reducing rework, delays, and other performance issues, companies can streamline their operations and reduce costs, which can ultimately benefit consumers by lowering prices or improving product features [37].

Subcontractor G received the lowest score in the study, indicating poor performance and suggesting a lack of effective action steps contributing to the company's operations. The Weighted Sum Method employed in this study was straightforward, yet effective in providing an objective evaluation based on quantitative or real data. The study's results facilitated a comprehensive assessment of the company's suppliers' performance, leading to actionable insights and improved supply chain management. The results provided an opportunity for the company to identify the specific weaknesses of subcontractor G and work collaboratively with them to improve their performance. This could lead to improved product quality, faster delivery times, and more efficient supply chain operations, benefiting both the industry and consumers [38].

Based on this assessment, the company can identify the specific weaknesses of each sub-sector and ask each sub-sector to improve its performance as it affects the overall performance of the company. By identifying weaknesses in subcontractor performance, companies can work collaboratively with their suppliers to improve performance and drive better outcomes. This can lead to improved product quality, faster delivery times, and more efficient supply chain operations, which can ultimately benefit consumers [39].

Table X. Scoring results with Weighted-sum Method.

KPI	Weight	Alternatives (Subcontractor)					
		A	B	D	G	H	K
Delivery							
Delivery Accuracy	20%	80	78.33	63.33	60	63.33	73.33
Delivery Consistency	15%	80	60.3	90	76.7	77	69.9
Quality							
Rejected Parts	24%	71.67	75	72	68	83	72
Compliance	16%	70.0	63.3	80.0	66.7	76.7	83.3
Reliability							
Material Efficiency	10%	76.7	96.6	86.7	73.3	90	76.7
Inventory Record	15%	70	90	80	80	86.6	80
FINAL SCORE		74.57	76.46	75.41	69.42	78.42	75.43

V. CONCLUSION AND IMPLICATIONS

The results of the team discussion eventually led to the definition of the KPIs: delivery, consisting of delivery accuracy and delivery consistency, quality, consisting of scrap and compliance, and finally reliability, consisting of material efficiency and inventory accuracy.

The performance evaluation was conducted using multi-criteria decision making, specifically the weighted sum method. Data collection for each indicator was conducted from October 2021 to December 2021 and then assessed based on the scoring agreement reached between the company and the subcontractors. The weighting of each criterion or indicator was developed using a questionnaire survey to determine which criterion is more important than the others.

In the final evaluation using the weighted method, Subcontractor H scored the highest with 78.42 and Subcontractor G scored the lowest with 69.42. The company team believes that this represents the daily work of the subcontractor.

The conclusion from this research is that for the sustainability of the company in the global competition in the future, it is necessary for the company to evaluate the performance of all subcontractors on a regular basis. Any instrument can be used for this performance evaluation of each subcontractor, one of the simple methods is the weighted sum method. The evaluation results can improve their performance in terms of delivery, quality and reliability, which will affect the overall productivity of the production process in the company.

A. Limitations of Study

This study has several limitations that should be considered when interpreting the findings. Firstly, the research was conducted in a single toy factory, which may limit its generalisability to other industries or settings. It is possible that different industries may have different subcontractor performance measures, which could affect the applicability of the study's results. Secondly, the study only focused on the injection moulding department and did not consider other departments that may also use subcontractors.

B. Recommendations for future research

Despite these limitations, this study provides valuable insights into the performance evaluation of subcontractors. There are several avenues for future research that could build on the findings of this study. Firstly, future research could expand the scope of the study to include multiple departments and factories within the same industry to improve generalisability. This could help to determine whether the findings of this study are applicable across different contexts. Secondly, future research could include a larger sample size of subcontractors to improve the accuracy of the evaluation and the generalisability of the findings. This would enable a more precise evaluation of the performance of the subcontractors. Thirdly, the study could be expanded to include qualitative data, such as interviews or focus groups with the subcontractors, to gain a better understanding of the factors that contribute to their performance. Fourthly, future research could explore the effectiveness of different evaluation methods for subcontractor performance, beyond the weighted sum method used in this study. Finally, future research could investigate the impact of improved subcontractor performance on business sustainability, such as customer satisfaction, increased productivity, and reduced costs. This could provide further insights into the benefits of improving subcontractor performance for businesses and their stakeholders.

APPENDIX

Scoring of Each Criterion

Table A. Delivery ratio target versus performance scoring.

Delivery Ratio	Score
< 70% or > 130%	60
71% - < 80% or 121% - < 130%	70
81% - < 90% or 111% - <120%	80
91% - < 100% or 106% - <110%	90
100% - 105%	100

Table B. Delivery consistency scoring.

Delivery Consistency	Score
< 70%	60
71% - < 80%	70
81% - < 90%	80
91% - < 100%	90
100% - 105%	100

Table C. Rejected parts scoring.

Acceptance Rate	Score
99.5% - 100%	100
99% - 99.4%	75
97% - 98.9%	65
< 97%	60

Table D. Compliance scoring.

Total Case of Rejected Part Number	Score
0	100
1-5	90
6-10	80
11-15	70
16-20	60
>21	50

Table E. Material Efficiency scoring.

Material Efficiency (Ratio Expected/Actual)	Score
< 70%	60
71% - < 80%	70
81% - < 90%	80
91% - < 100%	90
>=100%	100

Table F. Inventory record scoring.

Inventory Record (Ratio Expected/Actual)	Score
<70%	60
70% - < 80%	70
80% – <90%	80
90% - <100%	90
>=100%	100

ACKNOWLEDGEMENT

The researchers would like to thank the Department of Industrial Engineering, President University, the Faculty of Engineering and Technology, Multimedia University (MMU), the Research Management Centre of MMU, and the Technology Transfer Office of MMU for their direct and indirect support in this research. The researchers owe special thanks to Ms Chiew Fen Ng for her critical appraisal of the work. The authors declare no conflict of interest.

REFERENCES

[1] J. Sarkis, "A Boundaries and Flows Perspective of Green Supply Chain Management," *Supply Chain Management: An Int. J.,* vol. 17, no. 2, pp. 202-216, 2012.

[2] S. Luthra, K. Govindan, D. Kannan, S. K. Mangla and C. P. Garg, "An Integrated Framework for Sustainable Supplier Selection and Evaluation in Supply Chains," *J. of Cleaner Product.,* vol. 140, pp. 1686-1698, 2017.

[3] M. A. Moktadir, S. M. Ali, S. Kusi-Sarpong and M. A. A. Shaikh, "Assessing Challenges for Implementing Industry 4.0: Implications for Process Safety and Environmental Protection," *Process Safety and Environ. Protect.,* vol. 117, pp. 730-741, 2018.

[4] S. A. Khan, S. Kusi-Sarpong, F. K. Arhin and H. Kusi-Sarpong, "Supplier Sustainability Performance Evaluation and Selection: A Framework and Methodology," *J. of Cleaner Product.,* vol. 205, pp. 964-979, 2018.

[5] B. S. Silvestre, M. S. Monteiro, F. L. E. Viana and J. M. de Sousa-Filho, "Challenges for Sustainable Supply Chain Management: When Stakeholder Collaboration Becomes Conducive to Corruption," *J. of Cleaner Product.,* vol. 194, pp. 766-776, 2018.

[6] K. C. Burning. (4 October 2022). *What is a Delivery Schedule?* Available: https://www.smartcapitalmind.com/what-is-a-delivery-schedule.htm

[7] D. A. Kshaf, M. A. Mohamed and K. M. El-Dash, "The Major Problems Between Main Contractors and Subcontractors in Construction Projects in Egypt," *Ain Shams Eng. J.,* vol. 13, no. 6, pp. 101813, 2022.

[8] J. Mbachu, "Conceptual Framework for The Assessment of Subcontractors' Eligibility and Performance in the Construction Industry," *Construct. Manage. and Econ.,* vol. 26, no. 5, pp. 471-484, 2008.

[9] E. D. Debelo and Z. B. Weldegebriel, "Effect of Contractor – Subcontractor Relationship on the Performance of Construction Project: A Case Study of Dire Dawa Construction Projects," *American J. of Civil Eng.,* vol. 10, no. 2, pp. 31-42, 2022.

[10] M. Mahsun, *Pengukuran Kinerja Sektor Publik*, 1st ed. Yogyakarta: BPFE, 2006.

[11] I. Setiawan and H. H. Purba, "A Systematic Literature Review of Key Performance Indicators (KPIs) Implementation," *J. of Indust. Eng. and Manage. Res.,* vol. 1, no. 3, pp. 200-208, 2020.

[12] E. Worldaimi, "*Perancangan Key Performance Indicator sebagai Dasar Alat Pengukuran Kinerja Menggunakan Metode Performance Prism*," Master Thesis, Universitas Sebelas Maret, Indonesia, 2012.

[13] M. Zheng, Y. Li, Z. Su, Y. V. Fan, P. Jiang, P. S. Varbanov and J. J. Klemeš, "Supplier Evaluation and Management Considering Greener Production in Manufacturing Industry," *J. of Cleaner Product.,* vol. 342, pp. 130964, 2022.

[14] P. N. T. Tran, M. Gorton and F. Lemke, "Buyers' Perspectives on Improving Performance and Curtailing Supplier Opportunism in Supplier Development: A Social Exchange Theory Approach," *Indust. Market. Manage.,* vol. 106, pp. 183-196, 2022.

[15] T. G. Hawkins, M. J. Gravier and W. A. Muir, "The Role of Supplier Performance Evaluations in Mitigating Risk: Assessing Evaluation Processes and Behaviors," *Indust. Market. Manage.,* vol. 87, pp. 2-17, 2020.

[16] E. Kanellou, K. Alexakis, P. Kapsalis, P. Kokkinakos and D. Askounis, "The DigiPrime KPIs' Framework for A Circular Economy Transition in the Automotive Industry," *Procedia Manufact.,* vol. 54, pp. 302-307, 2021.

[17] H. Rivera-Gómez, A. Gharbi, J.-P. Kenné, O. Montaño-Arango and E. S. Hernández-Gress, "Subcontracting Strategies with Production and Maintenance Policies for A Manufacturing System Subject to Progressive Deterioration," *Int. J. of Product. Econ.,* vol. 200, pp. 103-118, 2018.

[18] J. Y. Shimizu and F. F. Cardoso, "Subcontracting and Cooperation Network in Building Construction: A Literature Review," in *Proceed. IGLC-10*, Brazil, 2002.

[19] P. Pishdad-Bozorgi and J. H. Yoon, "Transformational Approach to Subcontractor Selection Using Blockchain-Enabled Smart Contract As Trust-Enhancing Technology," *Automat. in Construct.,* vol. 142, pp. 104538, 2022.

[20] M. Xue, C. Fu, N. P. Feng, G. Y. Lu, W. J. Chang and S. L. Yang, "Evaluation of Supplier Performance of High-Speed Train Based on Multi-Stage Multi-Criteria Decision-Making Method," *Knowledge-Based Sys.,* vol. 162, pp. 238-251, 2018.

[21] R. Basu, V. P. S. N. Nanyam and A. Sawhney, "A Multi-Dimensional Subcontractor Evaluation Framework for Nonconventional Housing Systems," *Procedia Eng.,* vol. 196, pp. 253-261, 2017.

[22] A. Olanrewaju, M. Z. X. Bong and C. Preece, "Establishment of Pre-Qualification Criteria for The Selection of Subcontractors by The Prime Constructors for Building Projects," *J. of Building Eng.,* vol. 45, pp. 103644, 2022.

[23] J. Rahardjo, R. Yustina and R. E. Stok, "Penerapan Multi-Criteria Decision Making dalam Pengambilan Keputusan Sistem Perawatan," *Jurnal Teknik Industri,* vol. 2, no. 1, pp. 1-12, 2000.

[24] N. H. Zardari, *Weighting Methods and Their Effects on Multi-Criteria Decision Making Model Outcomes in Water Resources Management*, 1st Ed., Cham, Springer, 2014.

[25] D. Stanujkic and E. K. Zavadskas, "A Modified Weighted Sum Method Based on the Decision-maker's Preffered Level of Performance," *Studies in Inform. and Control,* vol. 24, no. 4, pp. 461-470, 2015.

[26] Siemens. (2022, 4 October 2022). *Manufacturing Quality*. Available: https://www.plm.automation.siemens.com/global/en/our-story/glossary/manufacturing-quality/38123

[27] D. C. Daniel, "Effects of Material Management on the Delivery of an Organisation," *World J. of Innov. Res.,* vol. 6, no. 1, pp. 16-22, 2019.

[28] Indian Institute of Materials Management. (4 October 2022). *Materials management - Profit Centre*. Available: http://iimm.org/materials-management-profit-center/

[29] J. Klaess. (28 October 2021). *3 Definitions of Quality in Manufacturing and Why They Matter*. Available: https://tulip.co/blog/definitions-of-quality-in-manufacturing/

[30] R. B. Ballot, *Materials Management: A Results Approach*, 2nd ed. New York: American Management Association, 2006.

[31] F. O. Florence, "Materials Management and Its Effect on the Performance of Manufacturing Sector: Evidence from Nigerian Cement Industry," *South Asian J. of Social Studies and Econ.,* vol. 1, no. 4, pp. 1-9, 2018.

[32] M. Crouch and H. McKenzie, "The Logic of Small Samples in Interview-Based Qualitative Research," *Social Sci. Inform.,* vol. 45, no. 4, pp. 483-499, 2006.

[33] D. F. Hernandez and A. Haddud, "Value Creation Via Supply Chain Risk Management in Global Fashion Organizations Outsourcing Production to China," *J. of Global Operat. and Stra. Sourc.,* vol. 11, no. 2, pp. 250-272, 2018.

[34] A. Bryman and E. Bell, *Business Research Methods*, 4th ed. New York: Oxford University Press, 2015.

[35] K. K. S. Lam, "*The Hong Kong Toy Industry – A Qualitative Study*," Doctor of Business Administration Dissertation, University of Newcastle, Australia, 2015.

[36] Z. Shen, D. Hou, P. Zhang, Y. Wang, Y. Zhang, P. Shi and D. O'Connor, "Lead-based Paint in Children's Toys Sold on China's Major Online Shopping Platforms," *Environ. Pollut.,* vol. 241, pp. 311-318, 2018.

[37] S. A. Nemati and D. Mangaladurai, "*Impact of Enterprise Resource Planning in Supply Chain Management*," Master Thesis, University College of Borås, Sweden, 2013.

[38] J. Liu and Y. Wen, "*Study of Competitiveness - A Case Study of DHL*," Master Thesis, University of Gävle, Gävle, Sweden, 2012.

[39] O. A. Akintan and R. Morledge, "Improving the Collaboration between Main Contractors and Subcontractors within Traditional Construction Procurement," *J. of Construct. Eng.,* vol. 2013, pp. 281236, 2013.