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THE SELECTION OF PRODUCTIVITY KEY PERFORMANCE INDICATORS FOR CAR MANUFACTURING COMPANIES USING INTEGRATED PERFORMANCE MEASUREMENT SYSTEM

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Abstract -- *The increase in car market 17% in 2020, and ASEAN Free Trade policy only 5% for imported products, cause tightened competition in the automotive market. Car manufacturing companies face problems in selecting their performance indicators related to competitive challenges. The purpose of this research is to develop productivity key performance indicators in car manufacturing that conform to stakeholder requirements as a strategy to win the market. The conditions are manifested in a mapping of manufacturing symbols using the Integrated Performance Measurement System (IPMS) method. That manufacturing productivity indicators will become the focus of the top management to be controlled. There are four stages to go through, starting with the identification of stakeholder requirement, which produces six criteria and 12 stakeholder requirements and mapped into 16 goals and 24 key performance indicator (KPI). The second stage is benchmarking, and preparation of KPI hierarchy and the third stage is the description of each KPI in the form of KPI specification table. The fourth stage is the weighting of the six main criteria that result in 3 priority criteria which must be reported monthly between the manufacturing division (painting), finance and administration. Those are employee safety, manufacturing process effectiveness (painting) and waste elimination activities. The priority is obtained based on questionnaires answered by ten stakeholders (experts) processed with Analytical Hierarchy Process (AHP) approach and has been tested consistency in the number 0.09. These three criteria are described in 15 KPIs: performance rate, availability rate, quality rate, trained operator ratio, training value ratio> 80, delay ratio, attendance ratio, downtime losses, setup and adjustment losses, idle time, defect losses, yield losses, manpower efficiency, environmental impact and work accident ratio.*

Keywords: *Mapping; Productivity; Indicators IPMS; AHP*

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INTRODUCTION

The car market is expected to increase by 17% by 2020 (KPMG's Competence Center Automotive, LMC Automotive). Therefore, car manufacturers in the world are competing to launch new products of excellent quality at very competitive prices. World trade also plays a role in the automotive industry competition in the form of policies that provide low tariffs on imported products increasingly open tap competition between automotive manufacturing industries (Firdaus and Umrina, 2015).

Fig. 1 describe an example of the ASEAN free trade policy for vehicles from India and Korea which are only subject to 5% import duty (previously 10% -15%) forcing domestic manufacturers to save production costs by 5-10%. Manufacturing companies seek to reduce waste, increase productivity, and maximize human and machine use optimally (Hemanand et al., 2012).

Car manufacturing companies face problems in selecting their performance indicators related to market competition challenges. At PT. X, one of the automakers, realizes that some of its department are confused that which manufacturing KPI they should reach first. In general, companies do not have systematic and planned preparation stages in making their KPIs (Parmenter, 2015). There are five main steps to develop a sustainable KPI (Kibira et al., 2017), that is to build KPI goals, identify KPIs, define KPIs, conduct KPI selection, structuring KPIs.

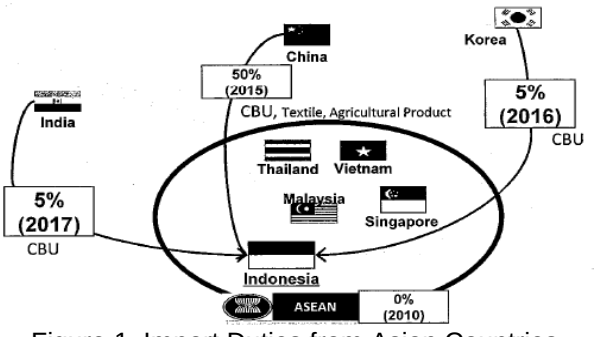

Figure 1. Import Duties from Asian Countries Destination Indonesia

In defining KPI, it is worth noting the benefits of productivity measurement for the company (Sumanth, 1998), namely:

1. Assess the efficient use of resources in producing goods and services.
2. For resource planning, both for short and long-term.
3. Can be used to reorganize the economic and non-economic goals of the company.
4. Can be used to plan the target level of productivity in the future.

Productivity can be improved through the effectiveness and efficiency of both input and output. The effectiveness value of equipment that supports productivity can be measured by OEE (Rimawan et al., 2017). OEE calculation is the multiplication of the ratio of availability, performance efficiency and rate of a quality product.

While efficiency, as part of productivity, is obtained by reducing seven types of waste (Hines and Taylor, 2000) that is too much production, defect, excess inventory, process mismatch, excessive movement, waiting, and unnecessary movement. Manufacturing efficiency performance can be achieved by increasing utilization creativity of manpower, eliminate inappropriate processing, eliminate machine breakdown time, eliminate excessive scrap, eliminate defect in a product, and eliminate excessive lead time (Susilawati et al., 2013)

This research is aimed at helping car manufacturing companies to develop productivity key performance indicators that conform with stakeholder requirements as a strategy to win the market competition, using Integrated Performance Measurement System method, focusing on KPI selection and KPI weighting done by Analytical Hierarchy Process technique. The AHP method is widely applied in the decision-making process of a complex multicriteria problem by describing the issue to a hierarchy (Santoso dan Besral, 2018; Kurniawan et al., 2017). Researchers observe and collect research data in the painting division, which is prioritized by stakeholders as a pilot.

MATERIAL AND METHODE

The design of this KPI uses the IPMS method, which is a performance measurement method created with the aim of describing an integrated, effective and efficient measurement system in the right form.

Material

The research data were obtained from questionnaires distributed to 10 stakeholders of painting division, namely:

- The president and vice president (2 persons)
- Finance director and manufacturing director (2 persons)
- Head of financial division, administration, and welding process (4 people)
- Employees, represented by union leaders (1 person)
- Customer, the head of the assembly division as a process after painting (1 person).

Questionnaires made in two types. The first is Open questionnaires, to get the requirements of stakeholders. Researchers look for common requirements stated by most stakeholders. The second is Closed-ended questionnaires in the form of a scale of interest, to get the priority of interest from every significant indicator required by stakeholders. The pairwise assessment scale is 1 to 9, with a value of 1 explaining both elements having the same effect on the goal and 9 representing the decision that an absolute element is most important than any other element. (Suryadi and Ramadhani, 1998).

Secondary data also obtained from literature study and benchmarking to PT. Y located in Thailand.

Methode

This research is done by general steps as shown in Fig. 2.

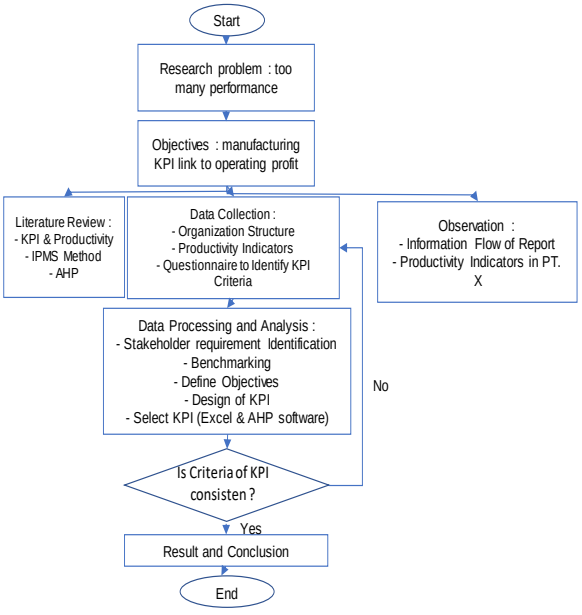

Figure 2. Research Flow Process

Determining Business Level

First of all, manufacturing organization is divided into four business level according to IPMS framework in Fig. 3 and approach criteria of PT. X's productivity system in Fig. 4.

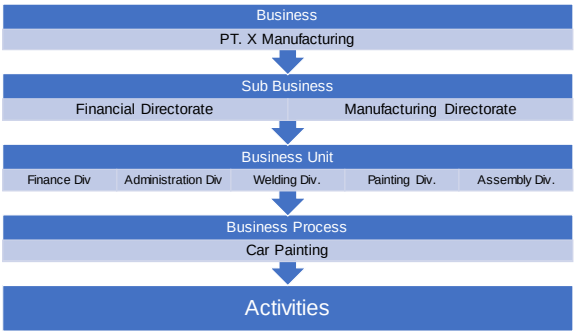

Figure 3. Division of Organization Business Unit Division Painting Division at PT. X

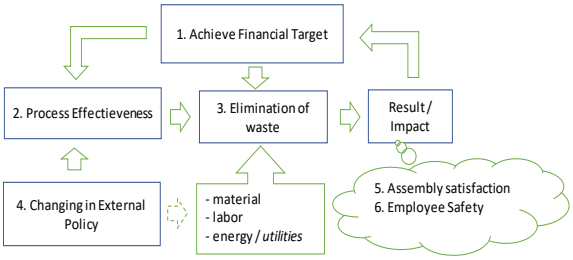

Figure 4. System Overview Organization Business Unit Division of Painting at PT. X

Identification of *Stakeholder Requirement*

Based on the results of the survey of stakeholder requirements at the end of the monthly Budget Control Meeting at PT. X, there are several similarities of answers, so researchers make the selection by writing all the answers and putting together the same answer. Table 1 shows the results of selection in the form of 12 requirements desired by stakeholders.

Benchmarking

Researchers conducted a comparative study to PT. Y which is a leading automotive manufacturing company in Thailand today, and has been declared as the company with the best management performance by the mother company. Researchers study stakeholder requirement PT. Y, and how PT. Y compile the KPI hierarchy that is used as a means of monitoring the achievement of company productivity. After comparing stakeholder requirements in both companies, there is only one difference that is for requirement number 12 related to a government facility in the form of easiness of import for export purpose.

Table 1. The result of Stakeholder Requirement Identification

Req. No	Stakeholder Requirement
1	Increased corporate profits in line with improved manufacturing processes.
2	The process runs smoothly without any interruption of the machine or equipment being damaged.
3	All resources work by established operating time standards.
4	*Zero defect, no claim from a customer.*
5	All operators master their jobs properly according to standard procedures.
6	High attendance rate.
7	Materials are used precisely and efficiently.
8	Minimize the amount of labor employed.
9	There are no workplace accidents, especially those that are fatal to employees.
10	Improving supplier capabilities that can strengthen long-term relationships with manufacturers and suppliers.
11	Building an environmentally friendly manufacturing process.
12	Use of facilities from the government to the maximum, which can support the company's business processes.

RESULT AND DISCUSSION

Setting Business Objectives and Defining KPI

The next step is to set business goals. Based on the results of internal research and benchmarking, obtained 16 business purposes as an effort to be done PT. X to meet the stakeholder requirement. The business objectives will then be mapped with key performance indicators that affect their achievement. The mapping can identify 24 KPIs shown in Table 2.

KPI Validation

All identified KPIs are arranged in the form of performance hierarchy of PT. X. The top level is Productivity Division Painting PT. X, then in the next level there are performance criteria, and at the lowest level is the KPI as in Fig. 5.

The validation process is done by way of management evaluation of Division of Painting PT. X. Based on the management decision, the compiled KPI is declared as appropriate and can be used as an indicator of productivity performance of the manufacturing division.

Table 2. Stakeholder Requirement Mapping, Business Objectives, and KPI in Painting Division PT. X

Req. No	Business Objectives	Key Performance Indicators	KPI's Formula
1	1. Setting profit indicator targets that can be understood by manufacturer and shareholder 2. Management can monitor the achievement of indicators periodically	1. Operating Profit (OP) 2. Break Event Point (BEP) 3. Percentage of On Time Report 4. Completion of Reported KPI	OP = Revenue – Cost of Goods – Selling & General Administration Expenses BEP = $\frac{Fixed\ Cost}{Revenue - Variable\ Cost}$ [On Time Report / Total Report] x 100% [numbers of actual KPI / numbers of ideal KPI] x 100%
2	3. Reduce the stop line caused by machines and equipment that are not properly maintained	5. *Machine Performance Rate* (PR) *6. Downtime Losses* (DL) *7. Setup and Adjustment Loses (SAL)*	PR= $\frac{Finished\ Good + Reject}{Std.Speed\ x\ (Load.Time - DownTime)}\ x\ 100\%$ Loading Time = total available time – planned downtime DL = $\frac{Total\ Downtime}{Loading\ Time}$ x 100% SAL = $\frac{Setup\ Time}{Loading\ Time}$ x 100%
3	4. No increase in cost due to actual production hours> standard production time	*8. Availability Rate* (AR) 9. Idle Time	AR = $\frac{Operating\ Time}{Loading\ Time}$ x 100% Idle = $\frac{non\ productive\ time}{loading\ time}$ x 100%
4	5. Ability to produce quality products 6. Satisfaction of assembly division (as a customer)	10. Quality Rate (QR) 11. Claim Rate (CR)	QR = $\frac{Total\ Produk - Defect}{Total\ Produk}$ x 100% CR = $\frac{Return\ Product\ (Reject)}{Total\ Product\ Delivered}$ x 100%
5	7. Each operator gets appropriate training	12. Trained Operator Ratio (TOR) 13. Training Score Ratio > 80	TOR = $\frac{\sum trained\ operator}{\sum\ total\ operator}$ x 100% ST = $\frac{training\ score > 80}{\sum total\ operator}$ x 100%
6	8. No jobs are delayed due to employee delays 9. No absent employee	14. Employee Late Ratio (LR) 15. Attendance Ratio	LR = $\frac{\sum employee\ late}{\sum total\ employee}$ x 100% RA = $\frac{\sum employees\ coming}{\sum total\ employee}$ x 100%
7	10. Eliminate defect due to material error 11. Eliminating waste of material	16. Defect Losses (DL) 17. Yield/Scrap Losses (YL)	DL= $\frac{Ideal\ Cycle\ Time\ x\ Total\ Reject}{Loading\ Time}$ x 100% YL = $\frac{Ideal\ Cycle\ Time\ x\ Scrap}{Loading\ Time}$ x 100%
8	12. Reduce the waste of labor	18. Man Power Efficiency (MPE)	MPE = $\frac{\sum MP\ Ideal}{\sum MP\ Actual}$ x 100% ∑MP Ideal = $\frac{\sum demand}{\sum cycle\ time}$
9	13. Maintain work safety to increase employee loyalty	19. Accident Work Ratio (IR)	IR = $\frac{\sum accident}{\sum working\ hours\ per\ year}$ x 1 million
10	14. Comparison of material price between suppliers	20. Material Purchase Price Ratio	$\frac{Current\ Price}{Alternative\ Price}$ > 1, it will be selected in the supplier changes list
11	15. Reduce energy usage	21. Environment Impact (EI)	Min EI = Electricity + Fuel + Gas + Water
12	16. The ease of import of export destinations in the form of import duty exemption of imported goods and import VAT on the import of raw materials processed/assembled / installed and the results are exported	22. Get NIPER Exemption 23. Updated NIPER Database 24. Lead Time of import raw materials and export of their products	A quota of imported raw materials = production capacity listed in Industrial Business License NIPER database = list of imported raw materials that will be processed, assembled, installed and exported products are exported Lead Time Export - Lead Time Import < 12 months

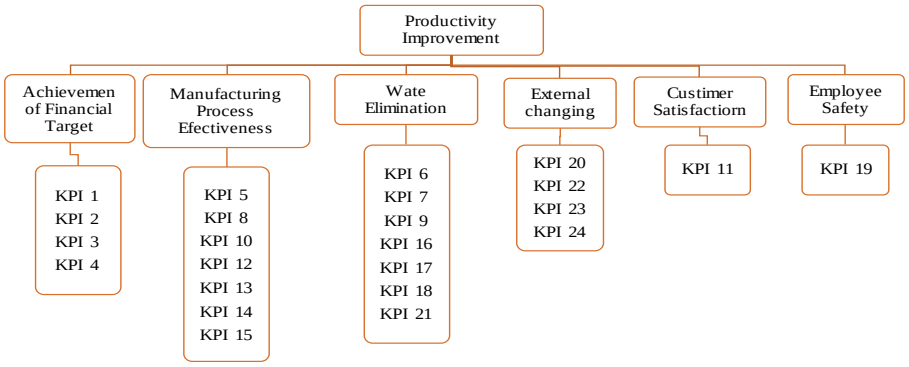

Figure 5. Hierarchy of KPI Productivity Improvement in Painting Division of PT. X

KPI Specification

This stage is necessary to enable KPI users to have a clear understanding of each KPI, including description, objectives, relevance to objectives, threshold or target interval, a method of measuring, a frequency of measurement, a frequency of review, the responsible person of measurement, data sources and KPI reporting objects. One example specification for KPI 1 (operating profit) will be shown in Table 3.

Table 3. Examples of KPI Specification

KPI Numbers / Name	1. OP
Description	Operating profit
Objectives	To ensure that all manufacturing activities have an impact to the operating profit of the company
Relevance	Relevance with the main purpose
Target and Threshold	Government Target = 6% Achievement 2015 – 2017 = 5 – 7%
Calculation Formula	OP = Revenue – Cost of Goods – Selling & General Administration Expenses
Frequency of Measurement / Measured By	Once a month / Accounting Department
Frequency of Review / Reviewed By	Once a month / Finance Director
Data Source	Monthly Financial Report, sent to Mother Company
Report To	*Board of Directors*, Division Head of Manufacturing and Administration

Weighting the KPI

After the hierarchy of productivity improvement indicators for the painting division, the next step is to decide which criteria will be prioritized for monthly intensive monitoring. The method used is the AHP approach, and the tool used to calculate the weights is a questionnaire given to 10 people who are considered experts because they have become representative of stakeholders. Table 4 shows the results of pairwise comparisons of the six criteria of the painting division using criterium decision software.

Table 4. Calculation Result of Pairs Comparison

Criteria	Financial	Effectiveness of Process	Elimination of Waste	External Changing	Assembly Satisfaction	Employee Safety
Financial	1,00	1,05	1,05	1,40	1,10	0,71
Effectiveness of Process	1,58	1,00	1,10	2,00	1,00	0,53
Elimination of Waste	1,58	0,95	1,00	1,40	1,00	0,73
External Changing	0,83	0,50	0,80	1,00	1,03	0,75
Assembly Satisfaction	0,95	1,00	1,00	1,15	1,00	0,78
Employee Safety	2,20	2,00	1,60	1,50	1,50	1,00
Total	8,15	6,50	6,55	8,45	6,63	4,51

Criteria	Geometric mean	Relative Weight	λ max	CI	CR
Financial	1,03	0,157	6,54	0,11	0,09
Effectiveness of Process	1,11	0,169			
Elimination of Waste	1,08	0,164			
External Changing	0,80	0,121			
Assembly Satisfaction	0,97	0,148			
Employee Safety	1,58	0,241			
Total	6,57	1			

Weighting is done at the criterion level, while the KPI under it is a must to be a regular part overall every month if the essential criteria are selected. The weighted sequence is illustrated in Table 5. Based on the consistent calculation test (CR) it is found that the inconsistency ratio is 0.09 since the number is below 0.10, it is stated that the weighting is consistent.

Table 5. Weighting Criteria of Painting Division PT. X

Criteria	Weight Score
Achieving Financial Target	0,157
Process effectiveness	0,169
Waste elimination	0,164
External changes	0,121
Customer Satisfaction	0,148
Employee Safety	0,241
Inconsistency Ratio	0,09
Conclusion	Consistent

Analysis and Discussion

The selection of critical criteria by the requirements of the stakeholders will be monitored monthly by top management. Three main criteria with 15 KPIs will be a compass for top management to measure the extent to which the company is declared productive. These 15 KPIs can not only be implemented in painting division but also can be used by all divisions in PT. X, and even car manufacturing companies in general. Thus, the results of this study can motivate each division to benchmark against the advantages of one another, so that the overall performance of the company will increase in the long run.

CONCLUSION

From the 6 criteria desired by 10 stakeholders, 3 criteria were selected for the top positions to be monitored together every month up to the top management level, namely employee safety with a weight of 0.241, the effectiveness of the process with a weight of 0.169, and the elimination of waste with a weight of 0.164. Each criterion has a different number and type of KPI, for which the employee's safety has 1 KPI, the effectiveness of the process has 7 KPIs, and the elimination of wastage has 7 KPIs. The weighting process is stated consistently with the CR = 0.09 proof. The three criteria with 15 KPI.

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