Productivity Assessment Based on Different Perspectives in Industries: A Review

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Abstract—Productivity is a crucial indicator to present the performance and profit of a company. As productivity is a compulsory criterion that concerns companies, there are plenty of methods currently to calculate and measure the productivity in the industry. Multi expression of productivity causes engineers and researchers to have difficulty in selecting and applying the most appropriate mathematical model of productivity specific to the problem or condition. This paper presents a summary of the assessment and mathematical expression of productivity relating to different scopes and perspectives in the industry sector. The term productivity is presented by different mathematical expression with clear explanation relating to the current existing assessment of productivity in industries. This research paper will increase the interest of researchers to do more research on productivity based on the clear direction and concept of productivity since currently the area of productivity still lack of work and exploration from researchers.

Keywords—Productivity, Different Perspectives, Industries

I. INTRODUCTION

Productivity is the quality or state of being produced where it can be directly present the outputs and profits in industry [1]. Especially in a particular company, productivity serves as an important indicator to show its performance and profit [2]. This indicator has not only been applied in production or assembly industries but also in service industries [3,4]. Productivity has also been used to evaluate the efficiency of manufacturing system and acts as an indicator of economic development.

Since productivity plays important role in industry, forecast of productivity become common work to meet the customer demand. Forecast of productivity is usually done by applying mathematical modeling and it can be easily used to measure and analyze in term of engineering. The forecast of productivity is very important for an industry, as an accurate forecasting in productivity can help in achieving customers’ needs [2]. There are various kinds of measures of output in terms of inputs in industry thus there are many type of productivities.

Mathematical model existed in various and different models used relating to the type of field of publication. Different measures of productivity are representing the different perspectives of efficiency for machine or labor [5]. The various type of inputs including human input, material input, machinery input, technology input and time input acting as the denominator in the ratio of productivity.

The difference in types of methods used to express the term of productivity causes engineers and researchers to get confused about mathematical model selection. The different productivity term such as output rate and various type of input also confuse the researchers for further research. Based on the previous publications, mathematical model of productivity should be developed based on six ways which are...
differences of concepts, model variables, calculation order, theoretical framework, accounting technique and adjustability of the model [6]. In order to simplify the expression of productivity and solve the confusion, a clear explanation and concept has been done. The overall of production industrial productivity can be categorized into three perspectives which are economic perspective, industrial perspective and manufacturing perspective. Productivity of service industrial is not included in these three perspectives below.

II. ECONOMICAL PERSPECTIVE OF PRODUCTIVITY

In economic perspective, productivity is defined as the ratio of outputs (goods and services) divided by the inputs (resources such as labor, capital, and management) [7]. The simple definition of productivity is clearly shown in the figure below.

![Variables Relationship of Economical Perspective Productivity.](image)

From the Figure1 shows above, the mathematical model of productivity in economic perspective is defined as the ratio of output to input. It is expressed as Eq. 1 below:

\[
\text{Productivity} = \frac{\text{Output Produced}}{\text{Input Used}}
\]  

Equation 1

By referring to the principal of economic, anticipation and satisfaction of customer is the main purpose to be achieved. There are two main activities concerned in accounting the productivity which are production and consumption [8]. Consumption is focusing on the usage of manufacturing organization while production is dimension of output for every input. Productivity in economic aspect is focusing on several input variables such as cost, quality and quantity. Any of the traditional factors of production such as land, labor and capital can be used as the denominator of the ratio, though productivity calculations are actually seldom made for land or capital since their capacity is difficult to measure. Labor is in most cases where it is easily quantified as an example by counting workers engaged on a particular product. A high national productivity typically indicates efficient production of goods and services and a competitive economy, but productivity growth can occur during periods of recession and increased unemployment as businesses cut jobs and seek to become more efficient.
III. INDUSTRIAL PERSPECTIVE OF PRODUCTIVITY

The second type of productivity is industrial perspective productivity. There are requirements for more assessment in term of technology criteria when compared to economical productivity. Economic productivity is more focused on profit and cost usage only. One of the most famous methods to measure the second type of industrial productivity is Overall Equipment Effectiveness (OEE) [9]. OEE is used as a quantitative tool essential for measuring the productivity for example in automation area [10]. OEE is usually applied for measuring whole system or whole company productivity performance with three main parameters which presents in Equation 2 below:

\[
OEE = \frac{Availability \times Efficiency \times Quality}{Net \ Available \ Time \ \times \ \frac{Theoretical \ Production \ Time}{Actual \ Production \ Time} \times \frac{Accepted \ Part}{Total \ Part \ Produced}
\]

(2)

Where:
Availability = Operation Time / Net Available Time
Efficiency = Theoretical Production Time / Actual Production Time
Quality = Acceptable Parts / Total Part Produced

OEE is usually formulated as a function of a number of mutually exclusive components such as availability efficiency, performance efficiency, and quality efficiency in order to quantify various types of productivity losses, such as breakdown, setup and adjustment, idling and minor storage, reduced speed and quality defect and rework [11]. OEE is broken down into three measuring metrics of Availability, Performance, and Quality.

Availability is referring to the machine or cell that is available for production when scheduled. When a process is running, it is creating value for the end user. When a process is stopped, it's creating a cost with no associated value. The cell or machine is determined either to be producing or not producing due to the mechanical failure or operator issues. By comparing the scheduled run time with the actual run time, the availability component of OEE allows for a determination of lost production due to down time.

Performance is determined by the amount of unused waste created through running at less than optimal speed. By comparing the actual cycle times against ideal cycle times, OEE allows for a determination of amount of production waste that was lost by cycles and did not meet the ideal cycle time.

Quality focuses on identifying time that was wasted by producing defects or unused products that does not meet quality standards. By comparing the quantity of good with the reject parts, the percentage of time by producing good product is exposed.

After the various factors are taken into account, the result is expressed as a percentage. This percentage can be viewed as a snapshot of the current production efficiency for a machine, line or cell. From the equation model of OEE, it shows clearly that productivity is based on the availability that reflects the loss of operating time, performance that reflects in net operating time loss and quality which reflected in value operating time loss.

In industrial perspective of productivity, it contains of a few specific mathematical model for productivity such as maintenance productivity model. When using OEE in industry, the benefits become significant [12]:
i. Increase customer satisfaction through quality improvement
ii. Decrease costs through waste elimination
iii. Reduce inspection time for root cause analysis
iv. Directly leading production efficiencies to fiscal reporting

IV. MANUFACTURING PERSPECTIVE OF PRODUCTIVITY

In the perspective of manufacturing productivity, it is focused on the production rate of workstation or transfer line productivity in the production line. The mathematical model is focusing on the rate of production in workstation or production line where it is different categories with previous perspectives that used assessment and ratio of output to input. Mathematical models for productivity of workstation in manufacturing are important as the model is different in term of manual operated, semi-automated and fully automated and they expedite the evaluation of manufacturing system by efficiency. One general equation of fully automated workstation or lines is created and shown in Eq. 3 below [13].

\[
Q = \frac{z}{\theta} \tag{3}
\]

Where:
- \( Q \) = productivity
- \( z \) = number of parts produced
- \( \theta \) = time used of produced

This mathematical model provides the information for productivity in term of quantity and time spent. The model produced the result in unit of part/time. The observation time represented as the sum of the machine work time (\( \theta_w \)) when the machine is working and the idle time as (\( \theta_i \)) when the machine stops for repair or having failure [14]. This type of mathematical model are showing the production rate in the workstation or transfer line [15].

V. ANALYSIS OF THREE CATEGORIES OF PRODUCTIVITY MODEL

Based on the three categories of different perspective of productivity, the general assessment and criteria is about the evaluation of output of the focus area in term of input variables (such as time and cost). A combination of all the categories for the productivity model has been done and it is mainly distinguished by the perspective of study.
Referring to Figure 2 showed above, there are relationship between the different perspective of productivity and the economic perspective of productivity mathematical model is obviously conquer the larger scope compare to the another two. The economic perspective of productivity is acted as the main and wider field of consideration for productivity mathematical model where it includes all the productivity variable of industrial and manufacturing scope. Economic perspective productivity mathematical model consists of several aspect of production and consumption which cover the production productivity, profit productivity and business aspect as well.

Industrial perspective productivity mathematical model occur as the second larger scope that consider the production system variable included which are availability of time use, efficiency of work time and quality of the product. This perspective of productivity is to assess the performance and output of the whole company or whole production system. While the third category is refers to the manufacturing perspective productivity is more specific towards the production output due to finish good parts and used time in production line.

The manufacturing perspective is more focused and important for engineer to improve the productivity in terms of quality and quantity with time. Figure 2 above also presents the relationship in the aspect of variable size consideration which means the variable of manufacturing perspective productivity must also be considered in economic and industrial perspective which the variable in industrial perspective productivity must consider in economic perspective productivity.
Table 1: Comparison between different perspectives of productivity

<table>
<thead>
<tr>
<th>Type of perspective of productivity</th>
<th>Economic</th>
<th>Industrial</th>
<th>Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical Model</td>
<td>( \frac{Output}{Input} )</td>
<td>Availability x Efficiency x Quality</td>
<td>( \frac{z}{\theta} )</td>
</tr>
<tr>
<td>Unit of Model Yield</td>
<td>Depend on which output and input choose</td>
<td>In percentage or in number form</td>
<td>Parts over Time</td>
</tr>
<tr>
<td>Variable Ratio Analysis of Model</td>
<td>Any output variable to any input variable</td>
<td>Three output of variable to three input of variable.</td>
<td>A specific output variable to another one specific input variable.</td>
</tr>
<tr>
<td>Productivity role</td>
<td>Focusing on several variables like cost, quality and quantity</td>
<td>Quantitative tool to quantify various types of productivity losses, such as breakdown, setup and adjustment, idling and minor storage, reduced speed and quality defect and rework.</td>
<td>Focus on the production rate of workstation or flow line productivity.</td>
</tr>
<tr>
<td>Scope of Productivity Area</td>
<td>Large and Wide since available for any related parameter</td>
<td>Medium since focus on three parameters only.</td>
<td>Specific since focus on one output and one input only.</td>
</tr>
</tbody>
</table>

Based on the comparison in Table 1 above, this clearly analyzes and distinguishes the categories of productivity between economic, industrial, and manufacturing perspective productivity model. Regarding to the size of the scope that focus by each categories are different, so that there is analysis which narrow down of the size of the scope focus for all categories that presents in Figure 3 below.

![Funnel diagram of Three Main Productivity Model in Industries](image-url)
Based on the size of scope area of the different model of productivity, there are stated as primary productivity, secondary productivity, and tertiary productivity model which the scope of area is from larger into small or from wide to specific. The name of categorize into primary until tertiary is regarding to the size and amount of variable that consider in the different perspective of productivity. The larger size and big amount of variables is consider, the higher rank of the perspective. So that, economic perspective is primary productivity, industrial perspective is secondary productivity while tertiary productivity is manufacturing perspective since it is specific variable consider in model for production industry productivity.

VI. CONCLUSION

In conclusion, the production industries productivity can be categorized into three main perspectives which are economic perspective, industry perspective and manufacturing perspective. This review paper has been presented as the analysis of the differences of three types of mathematical model via variety of aspect. The distinguish variable has been shown and compared so that a better understanding can be achieved among the researcher and companies. A clear concept and correct application of calculation for justify the productivity with various type is very important. Hence, this research provides a systematic categorization of productivity for researcher as well as industrial engineer to enhance, analyze and improve the productivity.

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**Biography**

**Tan Chan Sin** is born in 1988’s in local of Malaysia. He is currently works as a Senior Lecturer School of Manufacturing at University Malaysia Perlis since 2015 after he graduate his Bachelor Degree of Manufacturing Engineering and PhD in Manufacturing Engineering in 2015. In the area of PhD research, he is work out in Manufacturing Engineering field which major in Industrial Productivity and Reliability Analysis. He is also interest in field of Lean Manufacturing and TQM as well. He has been published more than 10 papers in International Conference as well as ISI impact factor journals.

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