Designing performance measurement procedure for supply chain actors and regulator base on a modified model of Balanced Scorecard and Data Envelopment Analysis

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Abstract— *The measurement of supply chain performance becomes the main concern of not only the supply chain actors but also the regulator/government. The measurement model to evaluate the performance of supply chain actors and regulator are still very limited. This research is a sequel of the author's earlier conducted researches in the fields of designing of integrated performance measurement between supply chain's actors and regulator. In the previous paper, the design of performance measurement is done by combining Balanced Scorecard - Supply Chain Operation Reference - Regulator Contribution model and Data Envelopment Analysis. This model referred as B-S-Rc-DEA model. Thus, this research is addressed to further develop a procedure for integrated performance measurement for actors and regulator. The output of this research is a performance measurement procedure that can be used to measure and monitor the performance of actors and regulators simultaneously. This procedure has been tested and can be used to measure performance on supply chain of small medium enterprise of innovative product in Indonesia. Limitations of this study is the measurement of the performance of the supply chain actors are measured individually, so it may not be able to reach the global optimum. Further research opportunities is to measure the overall (combined supply chain actors) and formulate regulatory policies that can be applied to the entire supply chain members.*

Keywords— *Performance measurement procedure, Supply chain actors, Regulator/Government, Balance Scorecard, Data Envelopment Analysis*

I. INTRODUCTION

Performance measurement is defined as the process of quantifying the level of efficiency and effectiveness of an activity into a measured value [1]. In the modern business management, performance measurement has a wider and deeper meaning than just quantifying and calculating. From the perspective of management, performance measurement can provide feedback information that is very useful for managers in monitoring the progress of the company's performance, to increase motivation and communication and to diagnose a problem [2], [3]. Performance measurement is also used to assess the effectiveness of the strategies used in supply chain and to identify successes and opportunities in the future. Performance measurements provide a very important contribution in the process of decision making in the supply chain management (SCM), especially in the process of re-planning objectives and corporate strategy as well as on process re-engineering [4].

In the industrial environment in which the regulator's role is quite significant, the measurement of supply chain performance becomes the main concern not only by the actors but also by regulators/government. This is because the regulator/government has responsibility to formulate regulation and facilitate the economic growth of the supply chain. The regulator needs to measure key performance indicators to identify the effectiveness and the impact of the program in facilitating the supply chain actors (especially if the supply chain actor is small medium enterprise). Similarly, for supply chain actors, in order to improve their performance, they need to measure success indicator along the business chain.

Integrated supply chain performance measurement model between actors and regulators are still very limited. Reference [5] proposed a model of integrated measurement between actors and regulators by combining Balanced Scorecard - Supply

Chain Operation Reference - Regulator Contribution model and Data Envelopment Analysis. This model referred as B-S-Rc-DEA model. This B-S-Rc-DEA model has been tested in an innovative industry of leather craft in Indonesia and has managed to measure the performance of the regulator and supply chain's actor. However, the weakness of the model is not contained detailed procedures for implementation. This will complicate the supply chain actors and regulators in executing the model. Therefore, this study propose the procedure of implementation of the model B-S- Rc - DEA so that the existing model is easy to implement.

This paper is divided into 4 sections . The first part is introduction. The second part contains discussion of supply chain performance measurement and development of B-S-Rc-DEA model. The third part shows the performance measurement procedure using B-S-Rc-DEA model. The final section contains conclusions.

II. Literature Review

A. SCM Performance Measurement

Currenty, measuring the performance of the SCM aims to reduce costs, meet customer satisfaction and to increase profits [6]. Performance measurement can be used to determine in detail the process of the supply chain and how to improve it, to know the demand of SCM, to control costs and quality as well as service level [7]. Supply chain performance measurement should contain the indicators associated with aspects of the question of what should be measured and how to measure these aspects, how to use the results of these measurements to analyze, improve and control the quality of the supply chain. Performance measurement can be done either on the input, process or output in SCM [8].

The process for designing a measurement of performance as suggested by [9] includes the steps as follows: defining the corporate mission, identify goals, build understanding of each functional role in the achievement of corporate strategy, designing performance measurement, communicate strategic objectives and performance objectives at lower levels in the organization. The aim of communicating is to guarantee the consistency of the strategy among the performance criteria at each level, to ensure compliance (compatibility) performance measurement used in all functions in the company.

A process based framework is a performance measurement framework based on the activity or process that occurs in the supply chain. The step of this framework is as follows [4]: identify and connect all the processes involved both within and outside the organization, defining and limiting the core processes, determine the mission, responsibilities and functions of the core processes, identify sub processes, define the responsibilities and functions of sub processes, identify the existing activities in the sub process and connect the target from the process level to the level of activity.

B. Performance measurement model for supply chain actor and regulator

All this time, performance measurements by supply chain actors and regulator/government are conducted separately. It causes inefficiency, as well as obstructs both parties in understanding the effectiveness of each respective performance. Therefore, an efficient and effective integrated model of performance measurement by supply chain actors and regulator is required, because this far the model of performance measurement by supply chain actors and regulator is still separately developed [10].

Supply chain performance measurement takes more attention from both practitioners and academics. The performance measurement model of supply chain actors is improved by using various approaches and different focuses. Several models are proposed and employed as Extended Enterprise model (EE), Balanced Scorecard (BSC), Supply Chain Operation Reference (SCOR), Integrated Balanced Scorecard- Supply Chain Operation Reference (BSC-SCOR), Component of measurement (such as quality, cost, delivery time etc.) [10]. Until recently, there has been no agreement of researchers which model is most flattering to be used and which key indicator that important to be maintained. Recent models demonstrate its complex performance measurement due to wide range of supply chain that becomes cause of weaknesses. The complexity will put management in difficulties for selecting the most important key indicator to be maintained.

While, the models of performance measurement on regulator/government contribution towards development of supply chain actors are commonly performed but only on certain aspects, i.e. regulator's role in technology, research and development [11], [12], [13], regulator's role in improving financial performance [14], [15], [16], regulator's role in improving human resources capability [17], [18], regulator's role in improving networking and marketing [19], [20]. The measurement model for regulator/government's contribution on the whole process of chain operation still limited. Especially those which specifically effect on performance of financial, customers, internal business process and learning and growth of supply chain that have not existed yet.

Based on existing literatures and researches, model of integrated measurement between supply chain actors and regulator still limited. As mention previously, that performance measurement between actor and regulator has been proposed by [5], [10] but the model is not contained detailed procedures for implementation. This paper contain a performance measurement procedure that can be used to measure and monitor the performance of actors and regulators simultaneously.

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C. Performance Measurement For Supply Chain Actor And Regulator Using B-S-Rc-Dea Model

1. Development of BSC model

In the previous study, authors proposed a model based on Balanced Scorecard perspective, by integrating process based on SCOR (Plan,Source,Make,Deliver,Returns) into the internal business processes and incorporated the role of regulators in each perspective. This model referred as B-S-Rc model (Balanced Scorecard-SCOR-Regulator contribution) as depicted in Figure 1 [5], [10]. This research found that there were 31 valid key indicators consist of 19 indicators to measure actors' s performance and 12 indicators to measure regulator's performance.

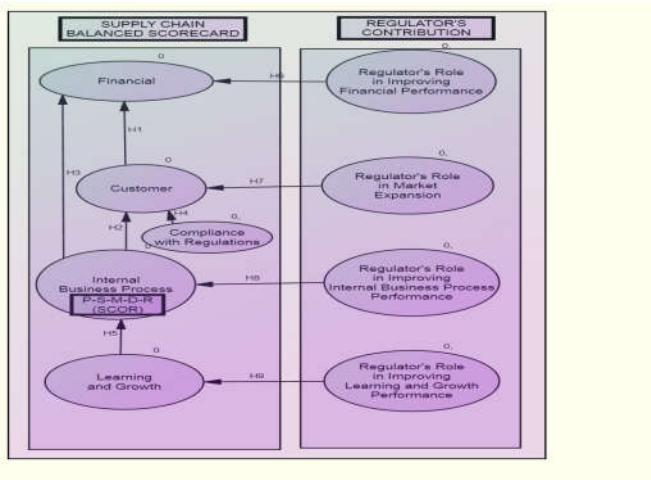

Figure 1. BSC-SCOR- Regulator Contribution Framework

2. Combining B-S-Rc model with DEA

The development of the BSC model produced a B-S-Rc model. A valid indicator to measure the performance of the SCM and the regulators is obtained in this model. Its indicators were used as input and output variable in DEA model. The combination produces a B-S-Rc-DEA model. The concept of combining B-S-Rc-DEA model is depicted in Figure 2.

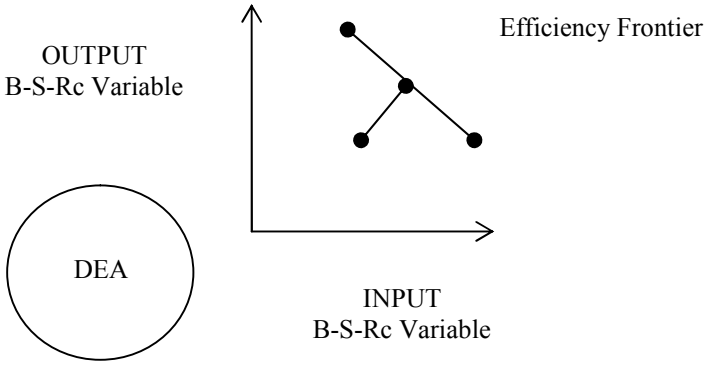

Figure 2 . Combining B-S-Rc-DEA

Input variable are divided in to seven variables: Supply chain's customer performance, Supply chain's business process performance, Supply chain's learning and growth performance, Regulator's role in improving financial performance, Regulator's role in market expansion, Regulator's role in improving Internal business process performance and Regulator's role in improving learning and growth performance. Output variable consists of one variable, known as Supply chain's financial performance.

III. DESIGNING PERFORMANCE MEASUREMENT PROCEDURE FOR SUPPLY CHAIN ACTORS AND REGULATOR BASE ON A MODIFIED MODEL OF BALANCED SCORECARD AND DATA ENVELOPMENT ANALYSIS

Performance measurement towards Small Medium Enterprises (SME) SC using B-S-Rc-DEA model has been tested in an innovative industry of leather craft in Indonesia and has managed to measure the performance of the regulator and supply chain's actor. It is used to measure performance of 40 SME by measuring the indicators during year 2013. Regulator's measurement is held based on 'LAKIP' data (Report of Performance Accountability for Government Institution) and interview with Department of industry and trade, province of Yogyakarta, Indonesia [5]. The procedure to measure their performance base on B-S-Rc model, can be revealed in following steps:

1. Measure the performance of actors and regulator and normalized using SNORM, so a value is obtained ranging from 0 -100. There are 19 indicators to measure performance of supply chain's actors and 12 indicators to measure the regulator's performance. Then, calculate the total performance value that is obtained from the average value of the performance actors and regulators. The total value represents the performance achievement from the actor and regulator at the same time. The formula of SNORM is follow:

   Larger is better

   $$Snorm = ((Si - S\ Min)/(S\ max - S\ Min)) \times 100 \quad (1)$$

   Lower is better

   $$Snorm = ((S\ Max - Si)/(S\ Max - Smin)) \times 100 \quad (2)$$

   Si = The performance Average
   S max = The value of achieving the best performance indicators
   S min = The value of achieving the worst performance indicators

2. Classifie performance indicators into input variables and output variables.
3. Calculate the performance value using DEA model (Linier programming model using Constant Return to Scale approach) [21].
4. Calculate the performance target using input- output orientation method [22].

   a. The improvement target for input variables is calculated using the following formula;

   $$Txij = Zj * Xij - SIij \quad (3)$$

   where,
   TXij= The improvement target of input variables-i of unit j
   Zj = Efficiency value of Unit j
   Xij = Input value- i of unit j
   SIij = *Slack variable* of input i of unit j

   b. The improvement target for output variables is calculated using the following formula;

   $$TYij = Yij + SOij \quad (4)$$

   where,
   TYij = The improvement of output variable i of unit j
   Yij = Output value i of unit j
   SOij = *Slack variable* output i of unit j

   c. the increasing of efficiency is obtained by multiplying the value of dual price with a target value of improvements , as the following formula :

   $$\Delta E = (Dual\ Price - i * Improve - i) \quad (5)$$

where
ΔE = Efficiency Improvement
Improve = Initial performance value – target value

5. Calculate gap between initial and targeted indicator score of input output variables
6. Formulate the improvement to minimize the gap by decreasing the input and increasing the output.

a. Reduce the input is done by:

1). Calculate the input reduction (Δ I) that equal to Value of Initial Input multiply by percentage of input reduction, as state in the following formula:

$$\Delta I = Xij * \left(\frac{(Xij - TXij)}{Xij} * 100\%\right) \quad (6)$$

2). Calculate target input each indicator (TXijk) that equal to initial input subtract by input reduction , as stated in the following formula:

$$TXijk = Xij - \Delta I \quad (7)$$

3). Calculate riil target per indicator (TRXijk) that equal to performance target each indicator multiply by maximum value of indicator (Smax).

$$TRXijk = \left(\frac{TXijk*(Smax - Smin}{100}\right) + Smin \quad (8)$$

b. Increasing the output is done the following step:

1). Calculate the increase in output each indikator (Δ O) that equal to initial output multiply by percentage of increasing output, as expressed in the following formula ;

$$\Delta O = Yij * \left(\frac{(TYij - Yij)}{Tij} * 100\%\right) \quad (9)$$

2).Calculate the target output each indicator (TYijk) that equal to Initial output plus the increase in output, as expressed in the following formula ;

$$TYijk = Yij + \Delta O \quad (10)$$

3). Calculate the percentage of increasing output for each indicator, as follow

$$\Delta \% Oi = \left(\frac{TYijk*(Smax - Smin}{100}\right) + Smin \quad (11)$$

4). Calculate the riil target of output target per indicator by the following formula :

TRYijk = initial riil output (1+ % increasing in output)

$$TRYijk = TYijk (1 + \Delta \% Oi) \quad (12)$$

Diagrammatically, performance measurement procedure for supply chain actors and regulator is given in Figure 3. The model developed is suitable to be applied to the characteristics of the industry where the regulator's role is significant. The model is also generally accepted, either for supply chain product characterized by innovative products and functional product. Although in this study, the object of research is innovative products but the proposed framework can be used in general and only requires a slight modification if it is used for measurements on functional products.

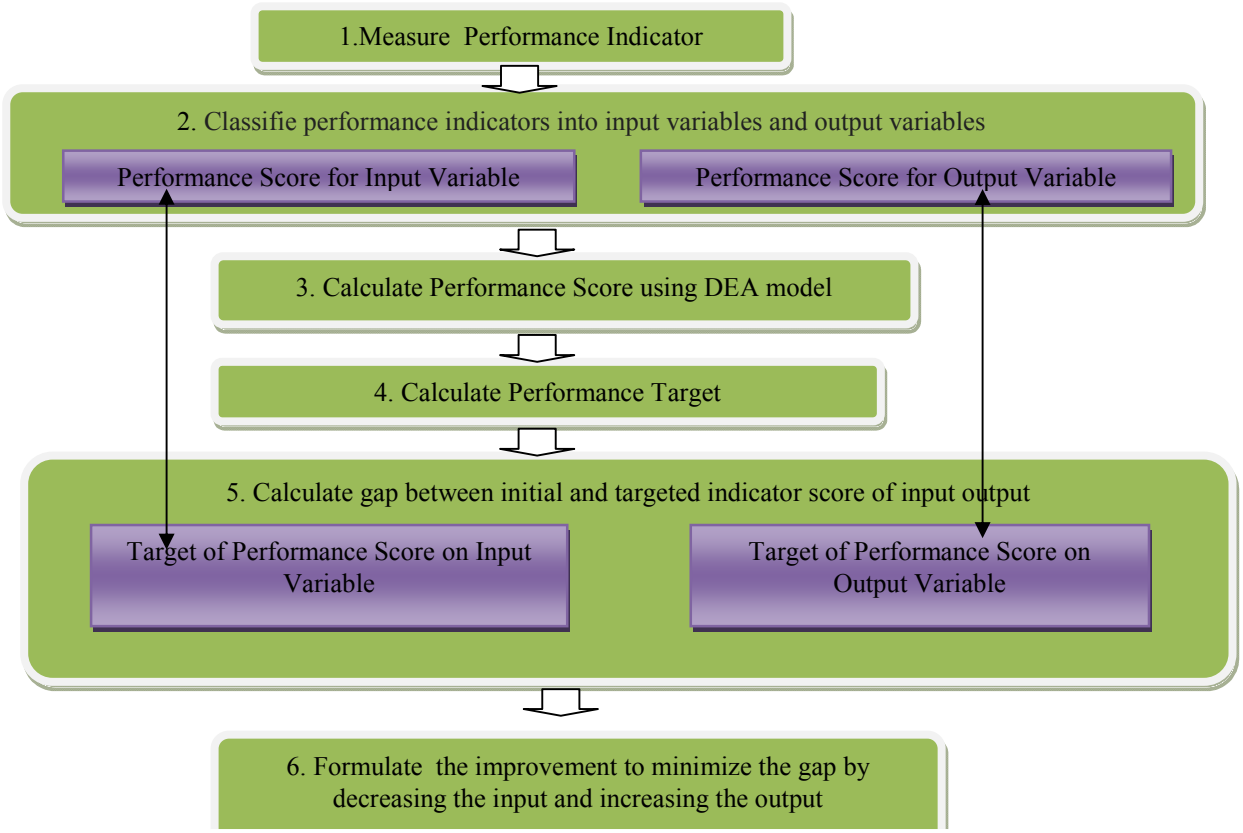

Figure 3. Performance measurement procedure

IV. CONCLUSION

Integrated performance measurement for supply chain actors and regulator can be performed using a B-S-Rc- DEA model. This B-S-Rc-DEA model has been tested in an innovative industry of leather craft in Indonesia and has managed to measure the performance of the regulator and supply chain's actor. However, the weakness of the model is not contained detailed procedures for implementation. Therefore, this study propose the procedure of implementation of B-S- Rc – DEA model, as follows: measure performance indicator, classify performance indicators into input variables and output variables, calculate performance score using DEA model, calculate performance target, calculate gap between initial and targeted indicator score of input output and formulate the improvement to minimize the gap by decreasing the input and increasing the output. The model developed is suitable to be applied to the characteristics of the industry where the regulator's role is significant. The model is also generally accepted, either for supply chain product characterized by innovative products and functional product. Limitations of this study is the measurement of the performance of the supply chain actors are measured individually, so it may not be able to reach the global optimum. Further research opportunities is to measure the overall (combined supply chain actors) and formulate regulatory policies that can be applied to the entire supply chain members.

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