Designing Performance Measurement For Supply Chain’s Actors And Regulator Using Scale Balanced Scorecard And Data Envelopment Analysis

Elisa Kusriini¹, Subagyo² and Nur Aini Masruroh³

¹Department of Industrial Engineering, Indonesia Islamic University, Jl Kaliurang Km 14,5 Yogyakarta 55584 Telp (+62) 274 898444 , Indonesia,
Mechanical and Industrial Engineering, Gadjahmada University, Jl. Grafika No. 2, Yogyakarta, 55281, Indonesia, (+62) 274 521673, Email : elisa_kusriini@yahoo.com

²Mechanical and Industrial Engineering, Gadjahmada University, Jl. Grafika No. 2, Yogyakarta, 55281, Indonesia, (+62) 274 521673, Email : subagyo@ugm.ac.id

³Mechanical and Industrial Engineering, Gadjahmada University, Jl. Grafika No. 2, Yogyakarta, 55281, Indonesia, (+62) 274 521673, Email : aini@ugm.ac.id

Abstract. 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. The combination has the disadvantage that all the performance variables have the same weight. This paper investigates whether by giving weight to performance variables will produce more sensitive performance measurement in detecting performance improvement. Therefore, this paper discusses the development of the model B-S-Rc-DEA by giving weight to its performance’variables. This model referred as Scale B-S-Rc-DEA model. To illustrate the model of development, some samples from small medium enterprises of leather craft industry supply chain in province of Yogyakarta, Indonesia are used in this research. It is found that Scale B-S-Rc-DEA model is more sensitive to detecting performance improvement than B-S-Rc-DEA model.

Keywords: Performance Measurement, Supply Chain’s Actors and Regulator, Balanced Scorecard, Data Envelopment Analysis, Scale BSC-DEA

1. Introduction

Performance measurement is defined as the process of quantifying the level of efficiency and effectiveness of an activity into a measured value [1]. Performance measurement is a process of assessing the progress of work towards the goals and objectives that have been defined previously. The measurement of supply chain performance becomes the main concern of not only the supply chain
actors but also the regulator/government. For supply chain actors, performance measurement can be used as a basis to improve its performance. For regulators, performance measurement can be used to identify the effectiveness and the impact of its program in facilitating the improvement of supply chain performance. 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 a regulator is required.

Currently, the measurement model is developed separately. 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 have been proposed and employed such as Balanced Scorecard [2,3,4,5,6,7,8,9], Supply Chain Operation Reference (SCOR) [10,11,12,13,14,15], Component of measurement, seperti quality, cost, delivery time dan sebagainya [16, 17, 18,19,20, 21], Data Envelopment Analysis (DEA) [22, 23,24,25,26]. 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. The existing models could not yet be employed for best performance management since it have not based on optimization model.

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 [27,28,29], regulator’s role in improving financial performance [30,31,32], regulator’s role in improving human resources capability [33,34], regulator’s role in improving networking and marketing [35,36]. 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.

Kusrini et al. (2014) [37], 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, B-S-Rc-DEA model has the disadvantage that all variables have the same weight. This paper investigates whether by giving weight to performance variables will produce more sensitive performance measurement in detecting performance improvement.

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

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

The following is a brief explanation of the model B-S-Rc-DEA. Development of B-S-Rc-DEA model is performed in three stages, as follows [37]:

1. Developing BSC model to obtain valid indicators
   The basic model is Balance Scorecard (BSC) model. It is selected based on its frequent use in various industries and classified as the model with the most comprehensive approach by involving all aspects in balance. Widely, it applied also to assess regulator/government’s performance. In this stage, basic model is improved, from BSC (corporate) model to BSC’s
supply chain model (BSC-SC). Later, process activity measurement that conducted based on SCOR (Plan-Source-Make-Deliver-Return) is integrated into the perspective of internal process business originated from BSC-SC. Furthermore, integration is continued by involving performance measurement on regulator contribution towards supply chain actors on each BSC-SC perspective. Then, this model is known as BSC-SCOR-Regulator Contribution integration model. Later on, it is abbreviated as B-S-Rc (Balanced Scorecard- SCOR- Regulator Contribution) as illustrated by Figure 1. The indicators in this proposed model are consisted of 31 KPIs, i.e. 19 indicators to measure performance of supply chain’s actors and 12 indicators to measure the regulator’s performance.

2. Integrating developed B-S-Rc model with Data Envelopment Analysis (DEA). This model integration is required to cover weaknesses on a model based on BSC, which are the absence of standard methodology and benchmarking facility. These could be accomplished by combining B-S-Rc model with DEA, whereas DEA is a mathematic optimization model that calculates actors’ level of efficiency and might be used for benchmarking with clear and objective methodology [38,39]. This concept integration of B-S-Rc with DEA is carried out by indentifying variables in B-S-Rc into input and output variables. Those variables will be inputted into mathematical optimization calculation of DEA. Model of B-S-Rc-DEA is illustrated by Figure 2.

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**Figure 1. B-S-Rc model**

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![Efficiency Frontier Diagram](http://example.com/efficiency_frontier.png)
Figure 2. Integrated b-S-Re-DEA model

Performance measurement using B-S-Re-DEA model is initiated with identification of input and output variables from B-S-Rc model. Those variables will be inputted into mathematical optimization calculation of DEA model. DEA using primal and dual model with CRS (Constant Return to Scale) approach. Input model is consisted of 7 variables, which are regulator’s role in improving financial performance (X1), regulator’s role in market expansion (X2), regulator’s role in improving internal business process performance (X3), regulator’s role in improving learning and growth performance (X4), customer’s performance (X5), internal business process performance (X6), learning and growth performance (X7). Model output is consisted only one variable, which is financial performance (Y1) [40].

Performance measurement towards Small Medium Enterprises (SME) SC is performed on 40 innovative SME’s product of leather’s craft in Yogyakarta, Indonesia by measuring the indicators include in B-S-Re-DEA model 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. Each indicator measurement is normalized with SNORM and generates value ranged from 0-100.

B-S-Re-DEA uses linear programming model of primal and dual forms. The model solved by Linear Programming with the help of Software Win QS. Score (value) reflects the performance efficiency values are given in Table 1. Score of actors and regulators’ performance with B-S-Re-DEA model is ranged between 40.81 – 100 with average score of 60.61. Base on the measurement result using B-S-Re-DEA model, it is obtained only two SMEs that have a value of performance with 100% efficiency is Decision Making Unit (DMU/SME) 19 and 44. This shows that the two businesses can manage their input to get the optimum output [41]. The role of the regulator in these DMU is optimum with the assistance and facilitation that can be managed effectively by both DMU’s. Other DMUs can refer to both the DMU’s in managing performance.

| DMU  | A2   | A3   | A4   | A5   | A6   | A7   | A8   | A9   | A10  | A11  |
|------|------|------|------|------|------|------|------|------|------|------|
| Performance score using B-S-Re-DEA | 40.81 | 40.81 | 40.81 | 72.30 | 77.72 | 43.29 | 60.02 | 40.81 | 40.81 | 68.02 |
| DMU  | A12  | A13  | A14  | A15  | A16  | A17  | A18  | A19  | A20  | A21  |
| Performance score using B-S-Re-DEA | 40.81 | 72.79 | 72.51 | 55.18 | 64.14 | 54.05 | 48.17 | 100.00* | 80.53 | 74.15 |
| DMU  | A22  | A24  | A27  | A28  | A29  | A30  | A31  | A32  | A33  | A35  |
| Performance score using B-S-Re-DEA | 40.81 | 45.99 | 49.62 | 96.31 | 61.45 | 63.61 | 42.58 | 85.90 | 83.28 | 45.01 |
| DMU  | A36  | A37  | A38  | A40  | A41  | A42  | A43  | A44  | A45  | A46  |
| Performance score using B-S-Re-DEA | 61.50 | 50.02 | 48.91 | 40.81 | 57.38 | 60.55 | 68.70 | 100.00* | 74.15 | 60.27 |
From the above explanation, it can be concluded that the B-S-Rc-DEA model has been tested in an innovative supply chain industry and has managed to measure the performance of the regulator and supply chain’s actor. However, B-S-Rc-DEA model has the disadvantage that all variables have the same weight. The following section will discuss the development of a model B-S-Rc-DEA by giving weights to the variables. This model is called the Scale B-S-Rc-DEA.

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

Model combination of B-S-Rc-DEA excludes the consideration on indicator’s weighting. In fact, each indicator possibly provides difference contribution on performance. Hence, to acquire more sensitive result on performance improvement, then B-S-Rc-DEA will be more developed by weighting its each variable (later called as Scale B-S-Rc-DEA model). This is a model with weighting input and output variables. The concept of Scale B-S-Rc-DEA model is presented in Figure 3.

This measurement is performed by weighting the input and output variables. The performance variable weighting is carried out by conducting a survey and tested by using Analytical Hierarchy Process (AHP) technique. AHP is a tool in decision-making by many criteria. A total of 74 questionnaires distributed and filled out by the respondents with the composition of the respondents are given in Table 2. The questionnaire contains pair wise comparisons between perspective and an indicator of the scale of 1-9. Designed questionnaire was designed to determine the relative importance of each indicator and perspectives. The hierarchical structure is given in Appendix 1.

The result of AHP analysis shows that the actors’ performance weighted as 67.3% while the regulators weighted as 32.7%. The actors’ performance that provide highest contribution is customer’s performance (27.9%), followed by, consecutively financial performance (26.8%), internal business process performance (24.3%) and learning and growth performance (21%). While, for regulator, the performance that provides highest contribution is the role in improving new market expansion (29%), followed by, consecutively, the role in improving financial performance (28.8%), the role in improving internal business process (23%) and the role in improving learning and growth (19%).

Calculation of performance using B-S-Rc-DEA model is done by first multiplying the value of each indicator with weights obtained from AHP. The performance of the weighted value is then analyzed using a mathematical model of DEA. Results of the calculation of the performance of the Scale B-S-Rcs –DEA model is given in Table 3. Score of actors and regulators’ performance with Scale B-S-Rc-DEA model is ranged between 39.69 – 100 with average score of 59.98.
To find out whether there is a significant differences in the value of the performance between B-S-Rec-DEA and Scale B-S-Rc-DEA, then the independent t test is conducted. Results of statistical test t test showed that both methods confirmed no significant difference in performance values. However, the average value (mean) of Scale B-S-Rc - DEA (59.98) is lower than B-S_Rc-DEA model (60.61). This means that Scale B-S-Rc-DEA model more sensitive in assessing the performance due to low efficiency values indicate greater gap value (towards 100 % efficiency). It will provide information about opportunities for improvement [42].

Table 2. Respondent Composition

| Number | Respondent                                                                 | Total |
|--------|-----------------------------------------------------------------------------|-------|
| 1.     | The Cooperative, Industrial and Trade service of Yogyakarta and Center for Leather, Rubber and Plastics Yogyakarta, Indonesia | 23    |
| 2.     | Leather’s craftsmen, trader and administrators of cooperative or association of leather craftsmen | 47    |
| 3.     | SCM’s Consultant                                                             | 4     |
| Total  |                                                                            | 74    |

Table 3. Performance score using Scale B-S-Rc-DEA model

| DMU   | A2   | A3   | A4   | A5   | A6   | A7   | A8   | A9   | A10  | A11  |
|-------|------|------|------|------|------|------|------|------|------|------|
|       |      |      |      |      |      |      |      |      |      |      |
| Score |      |      |      |      |      |      |      |      |      |      |
| Scale B-S-Rc - DEA | 40.01 | 39.91 | 39.89 | 73.10 | 83.44 | 42.80 | 59.68 | 39.69 | 39.69 | 67.74 |
| DMU   | A12  | A13  | A14  | A15  | A16  | A17  | A18  | A19  | A20  | A21  |
|       |      |      |      |      |      |      |      |      |      |      |
| Score |      |      |      |      |      |      |      |      |      |      |
| Scale B-S-Rc - DEA | 39.69 | 73.54 | 69.00 | 52.88 | 60.96 | 55.18 | 47.92 | 100.00 | 80.06 | 72.99 |
| DMU   | A22  | A24  | A27  | A28  | A29  | A30  | A31  | A32  | A33  | A35  |
|       |      |      |      |      |      |      |      |      |      |      |
| Score |      |      |      |      |      |      |      |      |      |      |
| Scale B-S-Rc - DEA | 39.69 | 44.67 | 51.24 | 89.74 | 61.39 | 62.47 | 43.67 | 87.87 | 83.39 | 44.12 |
| DMU   | A36  | A37  | A38  | A40  | A41  | A42  | A43  | A44  | A45  | A46  |
|       |      |      |      |      |      |      |      |      |      |      |
| Score |      |      |      |      |      |      |      |      |      |      |
| Scale B-S-Rc - DEA | 57.71 | 50.60 | 46.27 | 40.39 | 59.31 | 60.20 | 67.66 | 100.00 | 72.99 | 57.48 |

4. Conclusion
The B-S-Rc-DEA model excludes the consideration on indicator's weighting. In fact, each indicator possibly provides difference contribution on performance. Hence, B-S-Rc-DEA model is developed by weighting its input and output variable using AHP technique. This model referred as Scale B-S-Rc-DEA model. Base on case study in small medium enterprises of leather craft industry supply chain in province of Yogyakarta, Indonesia, it can be conclude there is no significant difference in performance values between B-S-Rc-DEA and scale B-S-Rc-DEA model. However Scale B-S- Rc-DEA model is more sensitive in assessing the performance than B-S-Rc-DEA model. The limitation of this study is that the sample is limited to Supply chain of innovative products, thus it is required consideration and prudent to generalize the results to apply to supply chain of functional product.
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Appendix 1. The Hierarchical Structure of Supply Chain’s Actors and Regulator’s Performance