

Development of Performance Indicators Relationships on Sustainable Healthcare Supply Chain Performance Measurement Using Balanced Scorecard and DEMATEL

Eko Budi Leksono^{#*}, Suparno^{*}, Iwan Vanany^{*}

[#] Department of Industrial Engineering, University of Muhammadiyah Gresik, Jl. Sumatera 101 GKB, Gresik, 61121, Indonesia
E-mail: eko_budileksono@umg.ac.id

^{*} Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo, Surabaya, 60111, Indonesia

Abstract— Sustainable healthcare supply chain performance measurement (SHSCPM) concept is still less developed. Globalization and pressure from stakeholder demand the operation of the supply chain to give attention to the environment effect, community, economic and intangibility assets. SHSCPM is feasibly developed for measuring the performance of simultaneous sustainability aspects and intangibility assets to meet customer satisfaction. This article discusses SHSCPM based on the balanced scorecard (BSC) with attention to the sustainability aspects, intangibility assets and relationships between the performance of perspectives and indicators. The perspectives and indicators of performance were identified by literature and the confirmed and validated by the survey to 7 expert respondents. We found 5 perspectives and 39 indicators from literature which were then confirmed to expert through a survey with an in-depth interview. From a survey that validated with a weighted average (WA) and level of consensus (LC), we found 31 valid indicators. Finally, 29 indicators from DEMATEL process were selected to be used on SHSCPM. The DEMATEL process found 2 indicators aren't important and influence for other, namely inventory cost and regulations and laws. Besides, the four results on this study: intangibility indicators incorporated on innovation and growth were most affect to other indicators which the intangibility indicators were related with human resource, indicators on customer perspective were most important compared to other indicators, indicators on economic aspect were most important compared indicators on environmental and social aspects, and indicators on social aspect were not affected by other indicators. After that, human resource and customer were main factors for SHSCPM. Finally, relationships between perspectives and indicators used to design of BSC strategy map.

Keywords— SHSCPM; weighted average; level of consensus; balanced scorecard; DEMATEL

I. INTRODUCTION

The service supply chain (SSC) implementation has become a trend since service sector gives a significant contribution to the *gross domestic product* (GDP) [1]–[3] and affects' global economy [4]. In 2013, services sector contribution to Indonesia GDP in 2013 was 39.87% [5]. During 2012 – 2015, the services sector contribution to *Product Domestic Regional Brute* (PDRB) of East Java Province has an average of 71.11%. The sector's contribution has increasing trends are tourism, hotel & restaurant, professional services, banking & insurance and healthcare [6]. The healthcare sector is feasible to develop in Indonesia, especially in East Java Province. Implementation of the supply chain and performance measurement can be used to develop the healthcare performance. [7]. The healthcare supply chain (HSC) implementation is part of

SSC which healthcare need an affiliation with all SC actors to meet customer satisfaction [1].

Globalization and pressure from stakeholder demand the operation of SSC to pay attention to sustainability issues, which consists of economic, social and environmental issues simultaneously [8]. The implementation of sustainable SSC can minimize the negative effect of the operation on the environment and social and maximize profit [9]. The sustainable HSC (SHSC) concept hasn't been developed so there are can be research opportunities in the future.

The concept of SHSC performance measurement (SHSCPM) has not been developed, and there are still oriented to aspects of economic and environmental (green), such as environmental SCPM [10], life cycle assessment and life cost assessment [11]. Sustainable SC performance defines as a company's capacity to reduce the use of materials, energy, or water and to find more eco-efficient solutions by improving supply chain [12]. Publications of SHSCPM concept still less and there is less of simultaneous

integration between aspects of economic, environmental and social. Furthermore, SHSCPM research is feasible to develop in Indonesia. Besides, the main characteristic of services sector are intangibility assets which related with human resources [13]–[16], so the SHSCPM implementation must attend intangibility assets on coordination process, performance measurement and customer relationship to meet the customer satisfaction.

This article discusses the relationship between perspectives and indicators on the SHSCPM. The balanced scorecard (BSC) performance measurement method will combine with the decision-making trial and evaluation laboratory (DEMATEL) to relationships design between perspectives and indicators of performance. Finally, combine BSC and DEMATEL were used to determine the level of importance and influence of the perspectives and indicators on SHSCPM.

II. MATERIAL AND METHOD

A. Literature Review

1) Healthcare SCPM (HSCPM) and Sustainable HSCPM (SHSCPM)

The actors on HSC are a producer, supplier (purchaser), healthcare provider and patient [17], [18]. The HSCPM concepts and performance orientation, include continuous improvement and customer satisfaction [19], information technology, demand, customer relationship, supplier relationship, capacity & resources [7], trust, knowledge exchange, IT integration between supplier and service provider [20], costs and benefit [21].

The SHSCPM concept still less and there is few of simultaneous integration between aspects of economic, environmental and social. Some concept of sustainable SSC more explores of economic and environmental aspect [22], [23], including on health care. The SHSCPM need new concept that can integrate dimensions of economic, environmental and social simultaneously

2) Balanced Scorecard (BSC) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL)

BSC is a performance measurement model that describes the relationship between perspectives and or indicators on BSC strategy map as a business strategy. The strategy map is a business strategy that is related to financial and nonfinancial execution. BSC is a dynamic and innovative performance measurement method that can be developed and collaborated with other methods [24]. Given the BSC flexibility, the SHSCPM can adopt BSC [25], [26]. Determination of performance perspectives is the starting point of BSC because the perspectives explain viewpoint of organization performance. There are five perspectives used in services sector performance: finance, customer, operation, information and innovation & growth [27].

DEMATEL is a multiple-attribute decision making (MADM) method that is used as a tool to help in decision making [28]. DEMATEL is used to analyse the component structure from decision variables. DEMATEL can be used to view the direct or indirect relationship between variable or attribute [29]. Besides, DEMATEL can describe the level of important and level of influence of an attribute or a variable

on the system, DEMATEL uses matrix system to get all causal relationships of an attribute or a variable with the others [29]. DEMATEL can integrate with BSC for build a strategy map while DEMATEL can describe the relationship between performance indicators.

3) Performance Indicator of SHSCPM

Performance indicators of SHSCPM were taken from the literature based on healthcare topics: performance measurement (PM), SSC, SSCPM and sustainable SSC.

The indicators listed in Table 1 may be used to develop SHSCPM model. Before used, the indicators must be validated by the survey to all HSC actors.

B. Method

Development of the model that was used survey with an in-depth interview. In this study, we asked one pharmaceutical industry manager, one supplier owner, two private hospital professional managers, one public hospital professional manager, and two clinical professional managers. Stages of developing the model are preliminary study, determine the relationship between perspectives and indicators, and strategy map.

1) Preliminary Study

The indicators from literature review confirmed to respondents through a survey. Survey validation use weighted average (WA) and level of consensus (LC). Steps on preliminary study [54]:

- Survey to identify important level of indicators with Likert Scale (1 = very unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = very important) .
- Validation of survey results by calculating WA and LC using the cut off : economic aspect ($WA \geq 4.2$ & $LC \geq 0.5$), environmental and social aspects ($WA \geq 4.5$ and $LC \geq 0.7$).

$$WA_n = \frac{\sum (R_i \times LS)}{\sum R} \quad (1)$$

$$LC_n = \frac{\sum (LS)}{\sum R} \quad (2)$$

Where, R_i = respondent i,

LS = Likert score with value 4 (important) and 5 (very important),

R = total of respondents

- Classifying valid indicators based on performance perspectives: financial, customer, operational, information and innovation and growth

• The Relationship between Perspectives and Indicators

This stage using DEMATEL method [29] with steps:

- Survey to identify level of influence between perspective and indicator with scale: 0 – 4 (0 = no influence, 1 = low, 2 = normal, 3 = strong, 4 = very strong).
- Building direct relation matrix (A) based on the average of influence value from a_i to a_j .

TABLE I
PERFORMANCE INDICATORS FOR SHSCPM

| No | Indicators | References |
|----------------------|-------------------------------------|--|
| Economic | | |
| 1 | Patient (demand) | [1], [7], [30]–[32] |
| 2 | Human resource (HR) | [1], [21], [33] |
| 3 | Capacity & professionalism | [1], [7], [21], [30], [34]–[37] |
| 4 | Effectivity | [1], [10], [26], [30], [36], [38]–[42] |
| 5 | Inventory level | [17], [31], [32], [39], [43], [44] |
| 6 | Tariff of service | [17], [21], [34], [38], [44] |
| 7 | Quality of service | [17], [21], [30], [34], [36]–[38], [40], [43]–[46] |
| 8 | Standard of service | [21], [35], [45], [47], [48] |
| 9 | Return of Investment | [49], [50] |
| 10 | Return of Assets | [49], [50] |
| 11 | Efficiency | [21], [26], [30], [36], [42], [43] |
| 12 | Profit | [11] |
| 13 | Inventory cost | [17], [21], [48] |
| 14 | Revenue | [26], [49] |
| 15 | Innovation | [26], [30] |
| 16 | Flexibility | [36], [51] |
| 17 | Suppliers timeliness | [1], [38] |
| 18 | Commitment to supplier | [7], [10], [21], [34], [43], [47], [52], [53] |
| 19 | Integration of information system | [20], [41], [50], [52] |
| 20 | Delivery | [32], [40], [45], [47] |
| 21 | Education and training | [10], [26], [34], [35], [38] |
| 22 | Research & Development | [10] |
| Environmental | | |
| 23 | Green technology | [10], [45] |
| 24 | Green material | [10], [45] |
| 25 | Partnership with green organization | [10] |
| 26 | Waste treatment | [10], [51] |
| 27 | Environmental certifications | [10] |
| 28 | Work physic environment | [37] |
| Social | | |
| 29 | Accessibility | [37] |
| 30 | Regulations and laws | [1], [17], [26], [30], [34], [37], [38], [42], [45]–[47] |
| 31 | Customer satisfaction | [1], [7], [33], [35], [44], [47], [52] |
| 32 | Customer service | [1] |
| 33 | Medical information system | [1], [20], [45], [47], [53] |
| 34 | Patient loyalty | [1], [20], [39], [50], [52], [53] |
| 35 | Collaboration with supplier | [17], [26], [34], [42], [46] |
| 36 | Stakeholder satisfaction | [11], [21], [26], [30], [35], [36], [42], [47] |
| 37 | Health & safety | [11], [21], [26], [30], [35], [36], [42], [47] |
| 38 | Sharing of information & knowledge | [20], [44], [50], [53] |
| 39 | Organization behaviour | [34], [36], [37] |

$$A = [a_{ij}]_{n \times n} \quad (3)$$

- Building normalization matrix (X) = A x s

$$s = \min \left[\frac{1}{\max \sum_{j=1}^n a_{ij}}, \frac{1}{\max \sum_{i=1}^n a_{ij}} \right] \quad (4)$$

- Building total relationship matrix (T), with I as the identity matrix.

$$T = X (I - X)^{-1} \quad (5)$$

- Calculation of the level of importance (D + R) and influence (D – R) between perspectives and indicators.

$$\text{Element of } T = [t_{ij}]_{n \times n}, i, j = 1, 2, \dots, n \quad (6)$$

Where, i = rows, j = column.

Then, calculate D and R that represent of direct and indirect relationship from row and column [29].

$$D = \left[\sum_{j=1}^n t_{ij} \right]_{n \times 1} \quad (7)$$

$$R = \left[\sum_{i=1}^n t_{ij} \right]_{n \times 1}, (i, j = 1, 2, \dots, n) \quad (8)$$

- Building significant matrix

The significant matrix used to describe the relationship between perspectives and indicators. Steps in the significant matrix:

- Calculate the average of T :

$$\bar{X} = \frac{\sum T}{\sum ij} \quad (9)$$

Where, i = sum of row and j = sum of column

- Reduction of all T with \bar{X} or $(T - \bar{X})$, a value of significant matrix indicates the level of relationship.
- After significant matrix has made, so performance indicators can be classified based on perspectives of BSC

2) Design of BSC Strategy Map

BSC strategy maps designed based on important level, influence level, and significance matrix. The indicator with a low level of important and influence can be ignored on designing of BSC strategy map.

III. RESULTS AND DISCUSSION

A. Validation and Classification of Indicators

Based on validation with WA and LC, we found eight not valid indicators. Not valid indicators indicate that indicator not important. Not valid indicators shown in Table 2.

TABLE II
INDICATOR VALIDATION

| Sustainability dimensions & performance indicators | WA | LC | Note |
|--|------|------|-----------|
| Economic aspect | | | |
| Human resource (HR) | 2.57 | 0.28 | Not Valid |
| Tariffs | 2.57 | 0.28 | Not Valid |
| Return of Investment | 2.66 | 0.28 | Not Valid |
| Return of Assets | 2.57 | 0.28 | Not Valid |
| Commitment to supplier | 2.71 | 0.28 | Not Valid |
| Environmental aspects | | | |
| Partnership with green organization | 2.71 | 0.42 | Not Valid |
| Social aspects | | | |
| Accessibility | 3.42 | 0.57 | Not Valid |
| Customer service | 3.42 | 0.47 | Not Valid |

Then, valid indicator classified based on the performance perspectives. Classification indicator to the performance perspectives was done by survey with an in-depth interview with expert respondents. Indicators classification is shown in Table 3.

TABLE III
INDICATOR CLASSIFICATION BASED ON PERSPECTIVE AND SUSTAINABILITY

| Perspective | Sustainability dimensions | | |
|-------------|--|--|---|
| | Economic | Environmental | Social |
| Financial | Patient demand (X1) Effectivity (X2) Efficiency (X3) Profit (X4) Inventory cost (X5) Revenue (X6) | | |
| Customer | Quality of service (X7) Delivery (X8) | | Customer satisfaction (X9) Patient loyalty (X10) Stakeholder satisfaction (X11) |
| Operational | Inventory level (X12) Standard of service (X13) Flexibility (X14) Suppliers timeliness (X15) | Green technology (X16) Green material (X17) Waste treatment (X18) Work physic environment (X19) | Collaboration with supplier (X20) |
| Information | Integration of inform. system (X21) | Environmental certifications (X22) | Medical inform. system (X23) Sharing inform. & knowledge (X24) |

| | | | |
|---------------------|---|--|---|
| Innovation & growth | Capacity & professionalism (X25) Innovation (X26) Education & training (X27) R & D (X28) | | Regulations & laws (X29) Health & safety (X30) Organization behaviour (X31) |
|---------------------|---|--|---|

B. Level of Importance and Influence

The DEMATEL stages were used to make relationship started from building the direct relationship matrix based on average values from respondents and finished at establishing a relationship between perspectives and indicators.

Based on direct relationship matrix, we make the total relationship matrix that indicates the level of importance and influence of perspectives and or indicators.

Table 4 show total relationship matrix of perspectives. Besides, Table 4 shows the customer perspective was most important compared to other perspectives ($D + R = 7.898$), and the innovation and growth were a most influential to other perspectives ($D - R = 1.371$). The innovation and growth related to human resource, so the existence of human resource was the most influence on SHSCPM.

TABLE IV
TOTAL RELATIONSHIP MATRIX (T) OF PERSPECTIVES

| Perspectives | D | R | D + R | D - R |
|---------------------|-------|-------|-------|--------|
| Financial | 3.27 | 3.756 | 7.026 | -0.485 |
| Customer | 3.715 | 4.183 | 7.898 | -0.468 |
| Operational | 3.518 | 3.924 | 7.442 | -0.405 |
| Information | 3.181 | 3.194 | 6.375 | -0.013 |
| Innovation & Growth | 4.421 | 3.05 | 7.471 | 1.371 |

Table 5 show total relationship matrix of indicators based on sustainability. Based on sustainability, All of the indicators have ($D + R$) positive value which indicates all indicator was important on SHSCPM. Besides, indicators incorporated on economic aspect were most important ($D + R = 5.44$) compared other indicators incorporated on the social and environmental aspects. Indicators incorporated on environmental aspects were the most influence ($D - R = 0.15$) to other indicators. Indicators incorporated on the social lowest influence to other indicators ($D - R = -0.12$).

Then, total relationship matrix based on sustainability can change based on performance perspectives. Table 6 show total relationship matrix of indicators based on perspectives.

Table 6 show indicators incorporated on innovation and growth were most important ($D + R = 5.64$) and most influence to other indicators ($D - R = 0.44$). So, human resource is very important and very influential on SHSCPM.

TABLE V
TOTAL RELATIONSHIP MATRIX (T) OF INDICATOR BASED ON
SUSTAINABILITY

| Aspects | Indicators | D + R | D - R | \bar{X}_{D+R} | \bar{X}_{D-R} |
|----------------------|-----------------------------------|-------|-------|-----------------|-----------------|
| Economic | Patient (demand) | 5.94 | -0.28 | 5.44 | 0.02 |
| | Capacity & professionalism | 6.26 | 0.28 | | |
| | Effectivity | 5.6 | -0.2 | | |
| | Inventory level | 4.99 | 0.1 | | |
| | Quality of service | 6.41 | 0.1 | | |
| | Standard of service | 5.82 | 0.18 | | |
| | Efficiency | 5.1 | -0.12 | | |
| | Profit | 5.54 | -0.84 | | |
| | Inventory cost | 3.13 | -0.65 | | |
| | Revenue | 5.03 | -0.76 | | |
| | Innovation | 6.68 | 0.53 | | |
| | Flexibility | 5.86 | 0.22 | | |
| | Suppliers timeliness | 4.46 | 0.52 | | |
| | Integration of information system | 5.41 | 0.16 | | |
| | Delivery | 4.81 | -0.17 | | |
| Education & training | 5.72 | 0.77 | | | |
| R & D | 5.74 | 0.52 | | | |
| Environmental | Green technology | 5.38 | 0.51 | 4.87 | 0.15 |
| | Green materials | 4.38 | 0.2 | | |
| | Waste treatment | 5.16 | -0.07 | | |
| | Work physic environment | 4.75 | 0.22 | | |
| | Environmental certifications | 4.71 | -0.08 | | |
| Social | Regulations & laws | 4.16 | 0.01 | 5.16 | -0.12 |
| | Customer satisfaction | 5.27 | -0.87 | | |
| | Medical inform. system | 5.29 | -0.02 | | |
| | Patient loyalty | 4.62 | -0.95 | | |
| | Collaboration with supplier | 5.87 | 0.15 | | |
| | Stakeholder satisfaction | 5.57 | -0.78 | | |
| | Health & safety | 4.57 | 0.35 | | |
| | Sharing inf. & knowledge | 4.74 | 0.34 | | |
| | Organization behaviour | 6.34 | 0.65 | | |

TABLE VI
TOTAL RELATIONSHIP MATRIX OF INDICATOR BASED ON PERSPECTIVE

| Perspective | Indicators | D+R | D-R | \bar{X}_{D+R} | \bar{X}_{D-R} |
|-------------|-----------------------|------|-------|-----------------|-----------------|
| Financial | Patient (demand) | 5.94 | -0.27 | 5.06 | -0.47 |
| | Effectively | 5.6 | -0.21 | | |
| | Efficiency | 5.1 | -0.12 | | |
| | Profit | 5.54 | -0.84 | | |
| | Inventory cost | 3.13 | -0.64 | | |
| | Revenue | 5.03 | -0.76 | | |
| Customer | Quality of service | 6.41 | 0.1 | 5.33 | -0.53 |
| | Delivery | 4.8 | -0.17 | | |
| | Customer satisfaction | 5.27 | -0.87 | | |

| | | | | | |
|------------------------------|-------------------------------|-------|-------|------|------|
| | Patient loyalty | 4.62 | -0.95 | | |
| | Stakeholder satisfaction | 5.57 | -0.78 | | |
| Operational | Inventory level | 4.99 | 0.09 | 5.18 | 0.22 |
| | Standard of service | 5.82 | 0.18 | | |
| | Flexibility | 5.86 | 0.22 | | |
| | Suppliers timeliness | 4.46 | 0.52 | | |
| | Green technology | 5.38 | 0.51 | | |
| | Green material | 4.37 | 0.2 | | |
| | Waste treatment | 5.16 | -0.07 | | |
| | Work physic environment | 4.75 | 0.22 | | |
| | Collaboration with supplier | 5.87 | 0.15 | | |
| | Integration of inform. system | 4.56 | 0.34 | | |
| Environmental certifications | 5.41 | 0.16 | | | |
| Medical inform. system | 4.71 | -0.08 | | | |
| Sharing inform. & knowledge | 5.29 | -0.02 | | | |
| Innovation & Growth | Capacity & professionalism | 4.74 | 0.34 | 5.64 | 0.44 |
| | Innovation | 6.26 | 0.28 | | |
| | Education & training | 6.68 | 0.52 | | |
| | R & D | 5.72 | 0.77 | | |
| | Regulations & laws | 5.74 | 0.52 | | |
| | Health & safety | 4.16 | 0.01 | | |
| | Organization behaviour | 6.33 | 0.65 | | |

C. Relationship between Perspectives and Indicators

The relationship between perspectives and indicators can be designed based on the significant matrix. The significant matrix can be built based on total relationship matrix. Stage on build significant matrix for perspectives:

- Calculate the average of T :

$$\bar{X} = \frac{18.1}{25} = 0.724$$

- Reduction of all T with 0.724. A value of significant matrix indicates the level of relationship. A minus (-) value indicates that there is no relationship between perspectives. *Equally*, a positive (+) value indicates that a row perspective has relation with a column perspective.

Table 7 shows significance matrix of perspectives. The same stage can be used to build of the significant matrix for indicators.

TABLE VII
SIGNIFICANT MATRIX FOR PERSPECTIVES

| | F | C | O | I | IG |
|----|--------|--------|--------|--------|--------|
| F | -0.165 | 0.0157 | -0.023 | -0.174 | -0.147 |
| C | 0.108 | -0.058 | 0.056 | -0.067 | -0.088 |
| O | 0.036 | 0.105 | -0.138 | -0.138 | -0.112 |
| I | -0.071 | 0.043 | 0.0038 | -0.308 | -0.253 |
| IG | 0.226 | 0.276 | 0.2248 | 0.078 | -0.15 |

F = Financial, C = Customer, O = Operational,
I = Information, IG = Innovation and Growth

After building of the significant matrix, so BSC strategy map maybe design. From to significant matrix for indicators, the existence of inventory cost (X_5) and regulations & laws (X_{29}) are not important and do not have significant relationships with other, so inventory cost and regulations & laws can be ignored on BSC strategy map. Fig. 1 shows BSC strategy map with twenty-nine indicators on five perspectives.

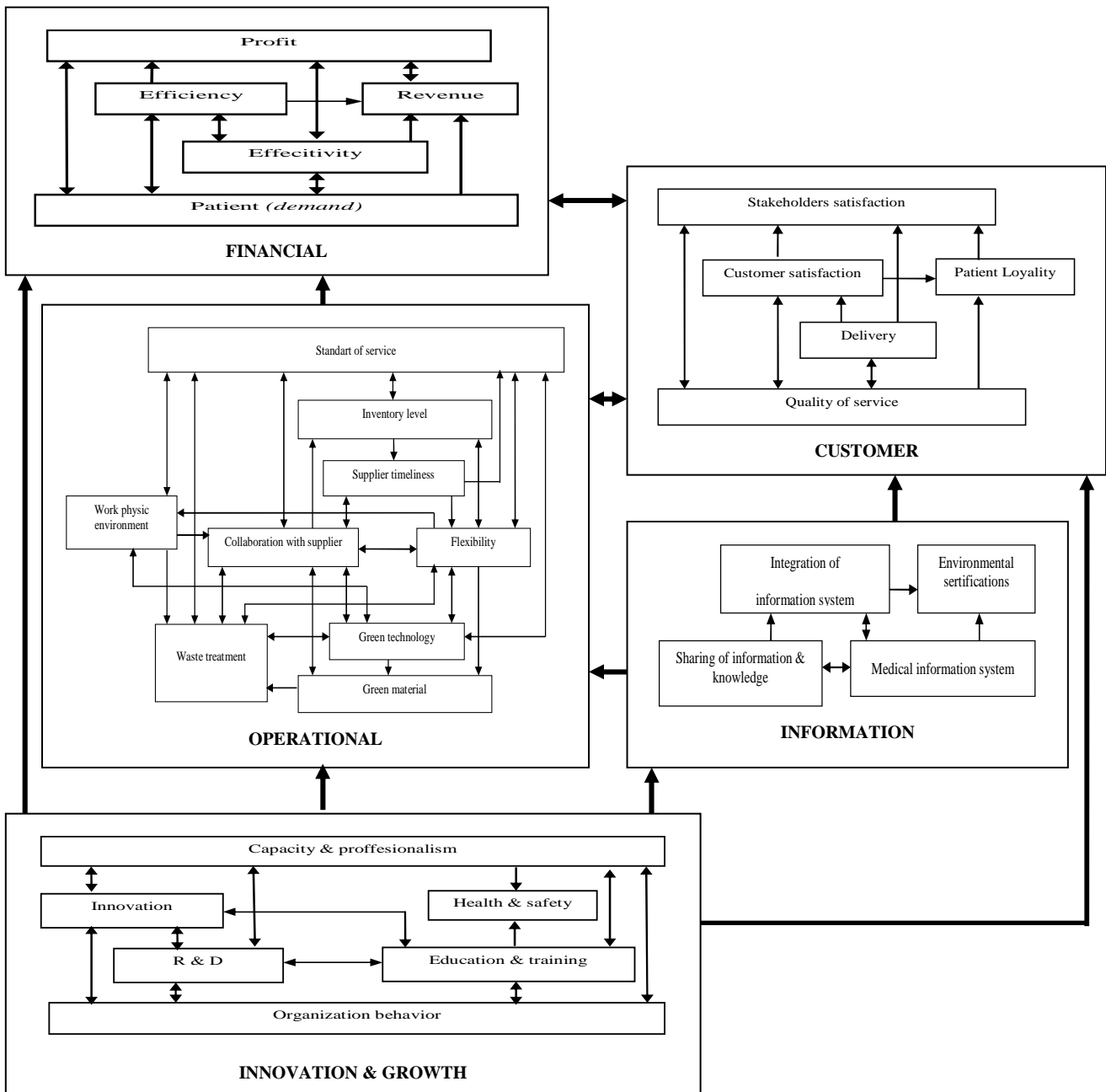


Fig. 1 BSC strategy map

IV. CONCLUSIONS

The design of SHSCPM based on BSC and DEMATEL used five performance perspectives with twenty-nine indicators. The indicators attend to sustainability aspects and intangibility assets that relate to human resource. The twenty-nine indicators are appointed from literature review, validation of survey result with WA and LC, and DEMATEL significant matrix.

From DEMATEL process, we found four results on SHSCPM: First, intangibility indicators incorporated on innovation and growth were most affect to other indicators which the intangibility indicators were related to human resource. Second, indicators on customer perspective were most important compared to other indicators, indicators incorporated on economic aspect were most important compared indicators on environmental and social aspects. Furthermore, human resource and customer were main factors for SHSCPM. Third, indicators on social aspect were not affected to other indicators. Finally, relationships between perspectives and indicators used to design of BSC strategy map. Design of SHSCPM can be ignored of indicators of inventory cost and regulations and laws because the indicators not important and do not have the effect on other indicators.

The limitation of the research, the model is a framework of the SHSCPM. There is need implementation in a healthcare service provider.

Further research needs calculate of indicators weight with attending the relationship between indicators by analytical network process (ANP). Finally, the simulation by system dynamic may be used to predict of sustainable HSC performance in the future.

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