Using Sustainable Balanced Scorecard and Graph Theoretic Approach to Make Decision in Reverse Logistic

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Abstract. Rather than selects the third party reverses logistic, the aim of this study are to identify the decision should be made by the company to manage their reverse logistics activity. In this study, the company should decide whether the reverse logistic activity must be outsourced part of reverse logistics activity or all must be outsourced or nothing must be outsourced. Object of this study is PT. XYZ - a foreign-owned electronics company and there is four scenario for reverse logistic activity proposed by the company. This study uses a graph-theoretic approach as the method to consider interdependencies and maintaining the hierarchical relationship among attributes and sub-attributes which is important to determine the best scenario of reverse logistic. The attributes and sub-attributes were selected by combining four traditional balanced scorecard perspectives i.e. Stakeholder, internal business process, learning and growth, and finance with two perspectives of sustainability, i.e. environmental and social. It is known as a sustainable, balanced scorecard. To seek the response from the experts for weights of the interrelationship between attributes and sub-attributes on the selected scale, this research used primary data collected through distributing closed questionnaires to the management of the company who have expertise in reverse logistics activities. The data processing with a graph-theoretic approach generates the permanent function which is known as the outsourcing index for each scenario. The outsourcing index for first until the fourth scenario is 52.71, 70.97, 89.86, and 81.27 respectively. It seems the third scenario is the best scenario for the company to manage their reverse logistics activity.

Keywords: PT.XYZ; graph theoretic approach; reverse logistic; sustainable balanced scorecard; outsourcing index.

1 Introduction

Reverse Logistic (RL) can be defined as the set of programs aimed to transport the product in the reverse direction in the supply chain, from the customer to the producer [1] or return the product from the customer to the producer. According to reference [2], there is a challenge in the process of returning the product, which required a high speed in the stages of product collection before the product becomes obsolete due to rapid technological developments and market demand. In addition, the difference quality, and quantity of the returned product may also affect the remanufacturing stage, which this step need varies with time for each product depending on the level of product quality, quantity and return time [3]. Basically, the activity in RL can be grouped into collection, acquisition, inspection, and sorting the returning product into several categories, and, then disposing the returning product for the process of repair, remanufacture, recycle, reuse, or final disposal. In this case, the manufacturer can perform all the activities of RL inside of the company or only part of the activities of RL perform on the inside of the company and outsourcing the other part of activities through the third party or we called outsourcing [4]. Talking about outsourcing, there are some advantages and also the disadvantages of outsourcing should be considered by the company. The first advantage of outsourcing is the company have the possibility to increase their competitive position through their focus on core activities [5]. The second advantage of outsourcing is the company can make cost-saving when a certain resource, either equipment or human resources, do not require own by the company in the full time, or the company do not require to make some efforts to find the specific resources [6,7]. The third advantage of outsourcing is the possibility of the company to access a skilled personnel, who may not be available in the internal organization and the company can totally exploit the investment, innovation and specialist capabilities from the supplier [8]. The fourth advantage of outsourcing is the company can improve their performance from the economics of scale offered by the outsourcer company [9]. The fifth advantage of outsourcing is related to flexibility. In this case, the contract and also the job of Outsourcers Company depend on the changing of the business environment [10]. The disadvantages of outsourcing are related with the loss of managerial control over the outsourcers company, threat to the confidentiality and security, the problem of quality, the hidden cost and also

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the reallocation of existing team. To overcome the loss of control in the outsourcing process, it seems that management should have the power of negotiations, the skill of people and management process, and the skill for contract of management. In terms of the problem of quality in outsourcing process, the company should have the particular way to ensure that the outsourcer company does not have a bad effect to the quality of good and services produced; otherwise, the company can lose the position in the marketplace. The hidden cost can happen because not all situation can be covered by the contract; in this case, any situation that not protected by the contract will be the source for the company to pay the additional charges. Besides that, in the outsourcing decision, the company should calculate the cost for selecting the best situation, such as the cost for selecting one provider than the others and the cost for choosing the in-house sourcing over outsourcing. The outsourcing also gives some problem for the top management of the company which is related to the firing process in the minds of the employee and how to rearrange the existing employee [6, 11, 12].

Deciding what part of the activity of RL should be in-house and what part of the activity of RL should be outsourcing is one of the solutions considered by PT.XYZ to improve the performance of their RL activity since this activity faced the problem of long processing time due to limited human resources owned by the company. According to PT.XYZ's historical data, there are five groups of components of a mobile phone (chasing, battery, chipset home, chipset, and LCD) that are often returned by the consumer because the component is defective (do not comply with the specification or physical disability). The practice of RL conducted by PT. XYZ can be described as follows. After the production process of the mobile phone is completed, PT. XYZ will check the results of its production. Products that pass the inspection stage will be distributed to a number of retailers to be distributed to consumers. Consumers may return the product they have purchased and ask the warranty claim if they find a discrepancy between the performance of one or more components of the product with the written on specification list or they find some physical defects on one or more components of the product. Upon receipt from the consumer, the retail will deliver the defective product to XYZ Center which is the point of return of products owned by PT. XYZ. In this case, the main task of XYZ Center is collecting the defective products which have claimed by consumers and returning it to PT. XYZ. After PT. XYZ received the defective products from XYZ Center, PT. XYZ sorts the defective products and based on the sorting results, PT. XYZ may dispose the defective product to the department of production or to the third party for disposal. If the components of the product can still be fixed, the disposition will be directed to the department of production and the department will return the defect components to the relevant vendor for remanufacturing process. However, if the defect component cannot be fixed the dispositions will be directed to the third parties for the disposal process. From the explanation about the practice of RL conducted by PT. XYZ, it can be seen that the process of activity of RL must go through a number of stages and each stage takes time and this can make the activity of RL take a long time if everything done by the company itself. In this case, the results of the preliminary interview with one of top management of PT.XYZ indicated that, in the future, PT. XYZ plans to improve its RL practices by shortening the processing time. Related to the outsourcing process in the activity of RL, PT XYZ purpose four scenarios to shorten the processing time. The first scenario, all activity of RL are done by PT XYZ itself, from collecting, checking, sorting, shipping, remanufacturing, until recycling activities. In the second scenario, the collecting, sorting, and shipping activities are conducted by PT XYZ while remanufacturing and recycling activities are conducted by third parties (or outsourcing is only for remanufacturing and recycling). In the third scenario, collection, sorting, and recycling activities are conducted by PT.XYZ; while the shipping and remanufacturing are conducted by a third party (or outsourcing is only for shipping and remanufacturing); then, in last scenario or fourth scenario is conducted by the third party or the company outsources all the activity of RL. Only one of the four scenarios will be selected and it should be the best scenario for the company.

This study will use the aspect in the Sustainable Balanced Scorecard (SBSC) to generate a number of attributes and sub-attributes that are important for assessing the proposed outsourcing scenario as the research conducted by Ravi et al (2005), Shaik and Kader (2012), and Tjader et al. (2014) [13-15]. SBSC is developed from Balance Scorecard (BSC). To assess the performance of the system, basically, the BSC method had considered several important aspects of the business, such as finance, business processes, operations, and quality management. However, as the RL activities are well known associated with sustainable development that has concentrations in the three bottoms three line of aspect (economic, environmental, and social aspect), therefore, some researcher add two aspects in BSC namely environmental and social aspect; so, the BSC method become a Sustainable BSC or SBSC. Not only from the SBSC method, will this study be complemented by the sub-attribute for assessing the proposed outsourcing scenario with the aspiration from the top management of PT. XYZ. Furthermore, after the attribute and sub-attributes are identified, the company can select the best-proposed scenario by using a variety of multi-criteria approach such as Graph Theoretical Approach (GTA). GTA can manage the hierarchical structure and at the same time also able to utilize interdependence between attributes that had been generated through SBCB. The final result obtained from GTA is “Outsourcing Index" as the value of a permanent function obtained for each scenario. The scenario with the greatest value of Outsourcing Index is the best outsourcing scenario.

2 Literature Review

2.1. Reverse logistics

Definition of RL can be found from several researchers. According to Rogers and Tibben-Lembke [1], RL can be defined as the process of planning, executing, and monitoring the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. According to Dowlatshahi [16], RL can be defined as the process in which a manufacturer systematically collects previously distributed products or parts from the point for consumption for probable remanufacturing, recycling, or disposal. Most recently, according to Leite [17], RL aims to plan, operate and control the return of goods after-sales and post-consumer [17]. Moreover, according to Hazen et al. [18], RL focuses on four main activities, namely reuse, product update, material recovery and waste management. The reverse logistics operations are different from the traditional logistics operations because the behavior of consumers introduces uncertainties in the quality, quantity, and timing of product returns [19]. There are five main characteristics of reverse logistics, i.e. the uncertainty of the returned time of a product, the uncertainty of quality of a returned product, the uncertainty of recovered value, the uncertainty of configurations of parts or components of returned products, the uncertainty of locations, and the uncertainty of amounts of recovered products

2.2. Sustainable Balanced Scorecard

The Balanced Scorecard (BSC) was first developed by Kaplan and Norton [20]. It's a tool used by the organization for a system performance measurement and also a tool used by the organization to explain their strategy and objectives. In this case, the BSC try to translate a mission and strategy of an organization into action. According to Kaplan and Norton's BSC (1992), there were four measurable perspectives in the BSC framework namely financial perspective, customer perspective, internal business process perspective and learning and growth perspective [20]. Since its introduction, BSC has gained a high degree of recognition and the effectiveness of the BSC is affected by the size of the company and the intensity of integrating BSC into the business process. The greater the company integrates BSC into its core business strategy, the higher the opportunities to gain benefits from the use of BSC [21]. In line with reference [21], the survey conducted by Yu, et al. [22] revealed that different organizations will use different forms of the BSC. In this case, the organization may make some variation in terms of the number of perspectives. Reference [22] also suggest that there are a number of organizations that use additional measures/perspectives such as safety, environmental, behavioral and ethical measures/targets. So, based on this condition, by adding the sustainable aspect as an additional perspective to the scorecard, the BSC evolved become Sustainable Balanced Scorecard (SBSC) as research conducted by Agrawal et al [23], Chung et al [24], and Jassem et al [25]. In this case, each researcher can use different dimension to represent the sustainable aspect. As example Agrawal et al [23] use environmental and social dimension to represent the sustainable aspect; Chung et al [24] use sustainable development dimension to represent the sustainable aspect; and, Jassem et al [25] use environmental dimension to represent the sustainable aspect. This study uses environmental and social dimension to represent the sustainable aspect as research conducted by Agrawal et al [23] since the reverse logistic concentrate on the three bottoms three line of aspect (economic, environmental, and social aspect). Moreover, referring to Agrawal et al [23], the detail attribute, sub-attribute and also operational definition of each sub-attribute can be seen in Table 1.

Basically, the SBSC offers the potential tool to create efficient and effective strategies that link the social and environmental management systems with the strategic planning and management of the company [26, 27]. Recently, the SBSC has been regarded as the important instrument for designing and achieving the ultimate goal of corporate sustainability management. SBSC can also be an appropriate framework for recording the essential information that associates with the company's sustainability performance by combining the non-financial and financial information [28]. Moreover, Epstein and Wisner [29] recognize that a well-organized SBSC can support companies in the implementation of the effective sustainability strategy. The suitability of SBSC to prepare and design a company sustainability management strategy is primarily concerned with the ability to identify the relationship between the long-term social and environmental goals and short-term corporate finance [30]. SBSC is also deliberated as an appropriate tool to disclose the company sustainability performance information [28].

3 Research Methodology

The number of attributes and also the proposed scenario for outsourcing in RL activity will influence the method can be used for selecting the best scenario. There is some method can be used to select the best scenario in RL activity, such as TOPSIS and AHP, ANP, DEA, and GTA. Each method has any specific condition that could be not suitable to solve this problem. In this In this case, TOPSIS and AHP method is used only if the attributes are independent, and ANP method does not show the hierarchical relationship among attributes. DEA may ask for more computation and the DEA is a worse discriminator for the good and bad performer if the study large attribute [31]. Since the attribute discussed in this study are independent, large enough, and have hierarchical relationship, the TOPSIS, AHP, and ANP are not an appropriate method used in this study for selecting the best scenario.

Table 1. Attributes and sub-attributes on SBSC

Attributes/sub-attributes	Definition
Perspective of Financial (FP)	
Total Capital Input (FP1)	Investment capital needs for processes related to RL processes such as transport and infrastructure facilities including IT, inspection / remanufacturing / recycling
Logistics Cost Optimization (FP2)	Costs that involving optimization of collection, inspection and transportation
Remanufacturing/Recycling Cost (FP3)	Costs incurred relating to recycling or remanufacturing products
Recovery Value (FP4)	Values earned from products that have been returned and repaired, and need for support RL process
Perspective of Internal Business Process (IP)	
Management Quality (IP1)	Maintaining quality of every product or activity that is done
Resource Capacity (IP2)	Level of use of, transport capacity, advanced equipment, infrastructure, and network capacity
Communication Systems (IP3)	The capacity of Electronic Data Interchange and IT that support the process
Agility (IP4)	The speed of the company's response to new changes and requests
Perspective of Stakeholder (SP)	
Stakeholder Participation (SP4)	Involvement and empowerment of shareholders in the process
Customer Satisfaction (SP2)	Level of fulfillment of customer expectations in terms of quality, delivery time, service and attitude of the company
Regulatory Satisfaction (SP3)	Level of fulfillment of requirements of legislation, regulations and government rules
Investors Satisfaction (SP4)	Percentage of fulfillment of expectations from investors including environmental and financial needs
Perspective of Learning and Growth (LG)	
Employee Competency (LG1)	The level of competence of the employee of the company related to the function of RL
Management Knowhow (LG2)	Management capabilities in various areas of knowledge to assist the process of learning and innovation by the employee to achieve the effective and efficient RL systems
Process Technology and Innovation Capability (LG3)	The degree of physical automation, information and financial flow in the supply chain reverses. Use of technology to simplify the procedures and processes of RL for present and forthcoming requests
Enterprise Alliances (LG4)	Sharing risks and benefits, as well as the compatibility of corporate culture
Perspective of Environmental (EP)	
Resources Consumption (EP1)	Percentage of resource intake in terms of water, energy, and raw materials during the production process
Disposal Capability (EP2)	Ability to ensure safety and environmental protection through proper waste disposal
Environmental Management System (EP3)	The company has been certified in the field of environment such as ISO 14000, have had environmental policy, purpose that oriented to the environment, and inspection and control to achieve good environmental activity
Pollution Production Control (EP4)	The normal volume of emissions, solid waste, liquid waste, and hazardous materials produced per day during the RL process are clearly known
Perspective of Social (SO)	
Corporate Image (SO1)	Reputation and general image of the company
Geographic Location (SO2)	Good geographical location of the company to support business processes
Employment Practices (SO3)	Employee contracts, security and disciplinary practices, discrimination, equity labor sources, diversity, job opportunities, flexible working schedules, career development, and employment compensation
Health and Safety (SO4)	Rate of sickness absence, lost time injury rate, safety impacts of services and products, and, the number of incidents of non-compliance regarding health.

Different from the TOPSIS, AHP, and ANP method, the Graph Theory Approach (GTA) does not have such limitations. According to reference [23], GTA is a logical and systematic approach to make a decision making. GTA is a matrix approach which is suitable for investigating the directional graphs, specifically when numbers of nodes are large and graphs become complex to visualize. There were two basic elements in GTA, namely node and arrow or directed edges. Node (N) represents the proposed attribute which is used for assessing the best outsourcing scenario for RL activity; whereas the arrow or directed edge connecting two nodes represent their relative importance. The number of nodes (M) in the diagram same as the number of attributes proposed in this study.. Suppose there is a set of node N = {*ni*} with *i* = 1,2, 3……*M* and a set of directed edge *E* = {*aij*}, so a node *ni* and *nj* represents an *ith* and *jth* attribute for the specific outsourcing alternative with a specific value of importance *aij* digraph or matrix change, a standard form of matrix function, known as permanent function is calculated rather than the determinant of the matrix. In the case of the determinant function of a matrix, certain information could be lost because of the presence of negative signs. Therefore, this study preferred to use the permanent function of a matrix in order to deliver the whole information without any loss [31]. Shortly, referring to the number of the attribute used to select the best outsourcing scenario in RL activity, the square matrix M x M used in this study can be seen as follows.

$$A = \begin{bmatrix} - & FP & IP & SP & LG & EP & SO \\ FP & D_1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ IP & a_{21} & D_2 & a_{23} & a_{24} & a_{25} & a_{26} \\ SP & a_{31} & a_{32} & D_3 & a_{34} & a_{35} & a_{36} \\ LG & a_{41} & a_{42} & a_{43} & D_4 & a_{45} & a_{46} \\ EP & a_{51} & a_{52} & a_{53} & a_{54} & D_5 & a_{56} \\ SO & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & D_6 \end{bmatrix}$$

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D_{ij} is the diagonal element with i=j and a_{ij} is off-diagonal element with i≠j. The diagonal element (Dij, i = j is resulted by considering all the attributes inheritance and the off-diagonal element is resulted from the assessment of the relative importance of one attribute to another. The permanent function of that matrix can be written as follows:

$$per(A) = \prod_{i=1}^{M} Di \sum_{i=1}^{M-1} \sum_{j=i+1}^{M} .... \sum_{M=t+1}^{M} (a_{ij} a_{ij}) D_k D_l D_m D_n D_o ... D_t D_m ... M \neq pus$$

$$+ \sum_{i=1}^{M-2} \sum_{j=i+1}^{M-1} \sum_{M=t+1}^{M} .... \sum_{M=t+1}^{M} (a_{ij} a_{jk} a_{ki}) D_1 D_m D_n \cdot$$

$$D_o ... D_t D_M k ... M \neq pus ..etc \qquad (1)$$

In general, the permanent of an M x M matrix, [A] with attributes a_{ij} defined by Forbert and Marx (2003) as

$$Per(A) = \sum_p \prod_{i=1}^{N} a_i, P(i) \qquad (2)$$

where, the sum is overall permutations P.

The value of the permanent function can be calculated with help Matlab Software. The value of the permanent function is known as Outsourcing Index. In detail, the steps to apply GTA can be described as follows:

Step 1: Identify the possible alternative scenario of outsourcing

Step 2: Identify the attributes and sub-attributes which important for selecting alternative scenario for RL activity This study uses the SBSC concept as a framework to select attributes and sub-attributes.

Step 3: Validate all the attributes and sub-attributes used in this study by looking at the responses from the management of management of the company. This study uses the Likert scale to validate all the attributes and sub-attributes (1= very inappropriate; 2= not appropriate; 3= hesitate; 4= appropriate; and 5= very appropriate). All the response from the management of the company is averaged using the arithmetic mean (see equation 3). Attribute or sub-attribute is considered valid when the value of arithmetic means ≥ 4. Attribute and or sub-attribute with the value of arithmetic mean <4 is not valid and will be excluded from the list.

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (3)$$

Step 4: Find the relative importance weights between valid attributes and sub-attributes by looking the responses from the management of management of the company. The scale shown in Table 2 is used to measure relative importance weights between valid attributes and sub-attributes. The value of relative importance weights between valid attributes and sub-attributes become off-diagonal elements of the matrix after all the response from the management are averaged using the geometric mean (see equation 4).

$$G = \sqrt[n]{(X_1)(X_2)(X_3)\ldots(X_n)} \qquad (4)$$

Step 5: Plot the digraph of the value of attributes and sub-attributes which results from the calculations in stage 4 and convert the graph into the matrix.

Step 6: The diagonal elements for the matrix of each alternative outsourcing scenario of RL activity may obtain as follow.

Step 6.1: Select each attribute one by one and specify the respective sub-attribute of the selected attribute. There are 6 attributes with each of the 4 sub-attributes for this research. For example, we select the sub-attribute "total capitali\ input (FP1) from attribute financial.

Step 6.2: Look for the response from management to the weights of diagonal elements of sub-attribute FPI for certain scenario (example, scenario 1) and the response from management to weight the relationships between sub-attributes. Scale in Table 2 is used to weight the relative importance of sub-attributes and the scales in Table 3 is used for giving the specific values or weigh to the diagonal elements of the sub-attributes matrix.

Step 6.3: Substitute the sub-attribute values and relations into the matrix and calculate the permanent function for the first attribute and so on using per (A) calculations. In this study, the Matlab program is used to calculate a permanent function of attributes matrix.

Step 6.4: Repeat steps 6.2 and 6.3 to calculate the permanent function for the left five attributes.

Step 7: After obtaining the value for the diagonal elements of each alternative scenario of outsourcing matrix (Dij), substitute the value on the derived matrix by using the equation per (A) or Matlab.

Step 8: Evaluate the permanent function by repeating step 5 to 7 for each alternative scenario of outsourcing. The value of this permanent function for each alternative scenario of outsourcing matrix is also called the Outsourcing Index.

Step 9: Choose the best scenario based on the highest Outsourcing Index value of all scenario of outsourcing.

Table 2. The scale used to measure the relative importance of attributes

Description	a_{ij}	$a_{ji} = 1 - a_{ij}$
Two attributes are equally important	0.5	0.5
One attribute (i) is slightly more important over the other (j)	0.6	0.4
One attribute (i) is strongly more important over the other (j)	0.7	0.3

Description	a_{ij}	$a_{ji} = 1 - a_{ij}$
One attribute (i) is very strongly important over the other (j)	0.8	0.2
One attribute is extremely important over the other	0.9	0.1
One attribute is exceptionally more important over the other	1	0

Table 3. The scale for measuring the importance of sub-attributes for each outsourcing alternative

Qualitative measure of attributes	Assigned value of Dij
Exceptionally low	0.0
Extremely low	0.1
Very low	0.2
Low	0.3
Below average	0.4
Average	0.5
Above average	0.6
High	0.7
Very high	0.8
Extremely high	0.9

4 Result of Data Processing and Discussion

This section will describe the result of validation of attribute and sub-attributes, the result of calculation the geometric mean which is depicted the relative importance of attributes and sub-attributes to the other attribute and sub-attributes, the digraph of attribute and sub-attributes, the matrix of the relationship between attributes and sub-attributes, the permanent function of the sub-attribute, and the Outsourcing Index for each alternative scenarios of outsourcing for RL activity. As we have mentioned at the beginning of this paper, there are four alternative outsourcing scenario for RL activity proposed by PT XYZ and only one scenario will be selected based on the value of outsourcing index

Scenario-1: All reverse logistics functions are performed by the company itself.

Scenario-2: Inspection and sorting, transportation and recycle are outsourced; while, collection and remanufacturing are performed by the company.

Scenario-3: Remanufacturing, recycle and transportation are outsourced; collection, inspection, and sorting are performed by the company

Scenario-4: All reverse logistics functions are outsourced to the third party.

The result of validation of attribute and sub-attribute

The value of the arithmetic mean of each attribute and sub-attribute can be seen in Table 4. It can be seen that all of attribute and sub-attribute have the value of arithmetic mean ≥ 4. It means all of the attribute and sub-attribute are valid and can be used in this study for assessing the four alternative outsourcing scenario of RL activity in PT. XYZ.

Table 4. The value of arithmetic mean of each attribute and sub-attribute

Attributes	Sub Attribute	Value of Aritmathic Mean	Attribute	Sub-atrribute	Value of Aritmathic Mean	Attribute	Sub-Attribute	Value of Arithmatic Mean
FP		5	SP		5	EP		5
	FP 1	4		SP 1	4		EP 1	4
	FP 2	4		SP 2	5		EP 2	4,5
	FP 3	4,5		SP 3	4		EP 3	4
	FP 4	4		SP 4	4		EP 4	4,5
IP		5	LG		5	SO		5
	IP 1	4		LG 1	4		SO 1	5
	IP 2	5		LG 2	4		SO 2	4
	IP 3	4		LG 3	5		SO 3	5
	IP 4	4		LG 4	4		SO 4	4

The result of calculation the geometric mean of the relative importance of attributes and sub-attributes and the digraph of attribute and sub-attribute

The sample of the result of calculation the geometric mean which is depicted the relative importance of attributes and sub-attributes can be seen in the Table 5. In this case, not all of the result of calculation of the geometric mean which is depicted the relative importance of attributes and sub-attributes from all alternative outsourcing scenario shown in this paper. It can be seen in the Table 5, the weight for the relationship from attribute financial to internal business process is 0.588, so the weight for the relationship from attribute internal business process to financial is 1-0,588 or 0.412 or less than 0.588. It means the relationship between attribute financial to internal business process is stronger than the relationship from attribute internal business process to financial. Based on this condition, the arrow is directed from attribute financial to internal business perspective. This condition applies to the relationship between each attribute and sub-attribute. So, based on the value of relationship indicated in Table 5, the digraph of attribute and sub-attribute can be seen in Figure 1 and Figure 2. Next, the digraph is converted into matrix form.

Table 5. The result of calculation of the geometric mean for the scenario-1

Attribute	Value of GM	Sub-attribute of FP	Value of GM	Sub attribute of IP	Value of GM	Sub-atrribute of SP	Value of GM
FP – IP	0,588	FP 1 – FP 2	0,312	IP 1 – IP 2	0,481	SP 1 – SP 2	0,203
FP – SP	0,366	FP 1 – FP 3	0,579	IP 1 – IP 3	0,331	SP 1 – SP 3	0,522
FP – LG	0,445	FP 1 – FP 4	0,607	IP 1 – IP 4	0,252	SP 1 – SP 4	0,419
FP – EP	0,437	FP 2 – FP 3	0,597	IP 2 – IP 3	0,419	SP 2 – SP 3	0,686
FP – SO	0,632	FP 2 – FP 4	0,604	IP 2 – IP 4	0,249	SP 2 – SP 4	0,541
IP – SP	0,564	FP 3 – FP 4	0,352	IP 3 – IP 4	0,299	SP 3 – SP 4	0,341
IP – LG	0,551	Sub-attribute of LG	Value of GM	Sub attribute of EP	Value of GM	Sub-atrribute of SO	Value of GM
IP – EP	0,507						
IP – SO	0,660						
SP – LG	0,516	LG 1 – LG 2	0,448	EP 1 – EP 2	0,406	SO 1 – SO 2	0,408
SP – EP	0,486	LG 1 – LG 3	0,552	EP 1 – EP 3	0,157	SO 1 – SO 3	0,425
SP – SO	0,563	LG 1 – LG 4	0,613	EP 1 – EP 4	0,416	SO 1 – SO 4	0,263
LG – EP	0,659	LG 2 – LG 3	0,5	EP 2 – EP 3	0,135	SO 2 – SO 3	0,269
LG – SO	0,660	LG 2 – LG 4	0,395	EP 2 – EP 4	0,497	SO 2 – SO 4	0,274
EP – SO	0,670	LG 3 – LG 4	0,657	EP 3 – EP 4	0,796	SO 3 – SO 4	0,510

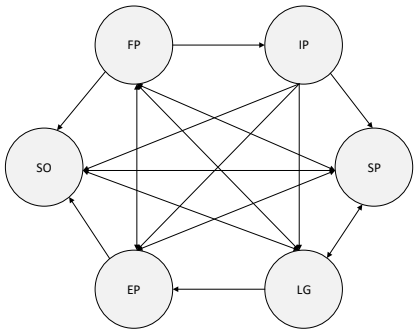

Fig 1. Digraph for the attributes

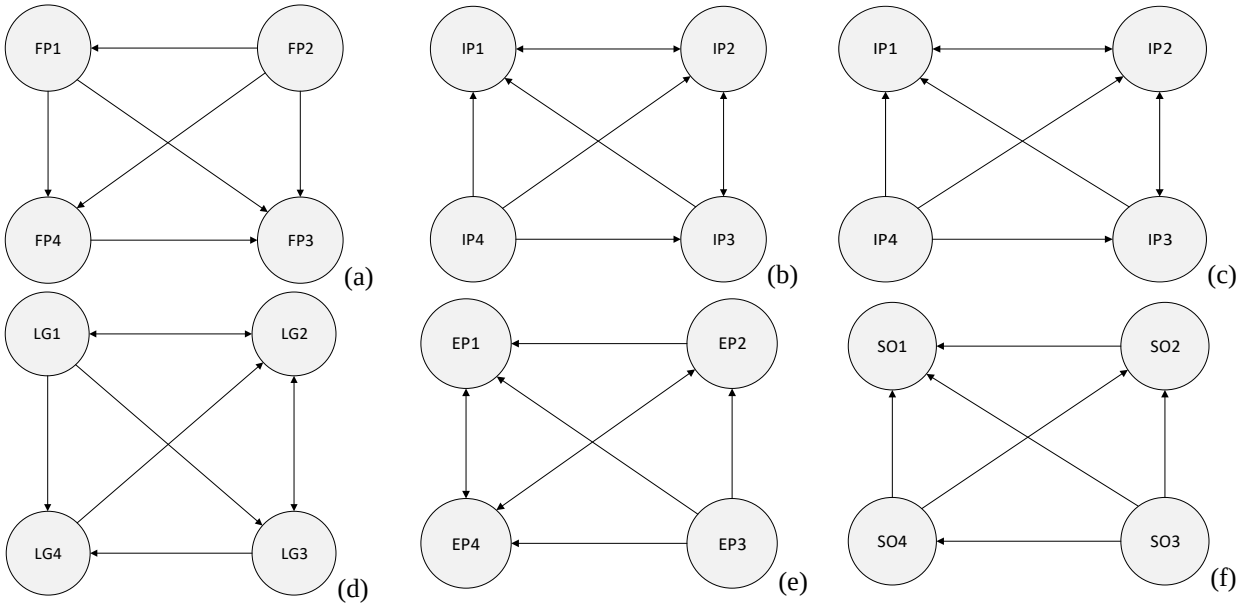

Fig 2. Digraph for the sub-attributes from all six SBSC perspectives (attributes) i.e. (a) FP, (b) IP, (c) SP, (d) LG, (e) EP, (f) SO**.**

The matrix of the relationship between attributes and sub-attributes

The geometric mean which is depicted the relative importance of attributes in Table 5 becomes the value of off-diagonal elements in the matrix. [OS1]. Similar steps were followed for developing the matrix for the rest of the three scenarios which is represented as [OS 2], [OS 3], and [OS 4]. Only the values of off-diagonal elements are written in the matrix [OS1] until [OS4], whereas, the inheritance value (the diagonal element) is not written. The value in the diagonal element be evaluated from the permanent functions of the sub-attributes matrices in the next steps.

$$OS\,1: \begin{bmatrix} \boldsymbol{D1} & 0{,}588 & 0{,}366 & 0{,}445 & 0{,}437 & 0{,}632 \\ 0{,}385 & \boldsymbol{D2} & 0{,}564 & 0{,}551 & 0{,}507 & 0{,}66 \\ 0{,}5 & 0{,}338 & \boldsymbol{D3} & 0{,}516 & 0{,}486 & 0{,}563 \\ 0{,}502 & 0{,}364 & 0{,}327 & \boldsymbol{D4} & 0{,}659 & 0{,}66 \\ 0{,}502 & 0{,}41 & 0{,}422 & 0{,}304 & \boldsymbol{D5} & 0{,}67 \\ 0{,}336 & 0{,}294 & 0{,}358 & 0{,}256 & 0{,}275 & \boldsymbol{D6} \end{bmatrix}$$

.

Table 6. Values of diagonal elements of each sub-attributes for each scenario

Attribute	Sub Attributes	Values				Attribute	Sub Attributes	Values			
		S1	S2	S3	S4			S1	S2	S3	S4
FP						LG					
	FP 1	0,6	0,7	0,6	0,7		LG 1	0,6	0,7	0,7	0,7
	FP 2	0,7	0,6	0,7	0,7		LG 2	0,6	0,7	0,7	0,7
	FP 3	0,7	0,7	0,7	0,6		LG 3	0,6	0,7	0,7	0,7
	FP 4	0,7	0,6	0,7	0,7		LG 4	0,6	0,7	0,6	0,6
IP						EP					
	IP 1	0,7	0,7	0,8	0,7		EP 1	0,6	0,7	0,7	0,7
	IP 2	0,7	0,7	0,7	0,7		EP 2	0,7	0,7	0,8	0,7
	IP 3	0,6	0,7	0,7	0,7		EP 3	0,6	0,6	0,8	0,8
	IP 4	0,6	0,7	0,8	0,7		EP 4	0,6	0,7	0,8	0,7
SP						SO					
	SP 1	0,6	0,6	0,6	0,6		SO 1	0,6	0,7	0,6	0,7
	SP 2	0,7	0,6	0,7	0,7		SO 2	0,6	0,7	0,7	0,6
	SP 3	0,7	0,6	0,7	0,7		SO 3	0,6	0,7	0,6	0,7
	SP 4	0,6	0,6	0,7	0,7		SO 4	0,6	0,7	0,7	0,7

Furthermore, to know the value of the diagonal element in matrix [OS1], [OS2], [OS3], and [OS4], the geometric mean which is depicted the relative importance of sub-attributes in Table 5 should be changed into the sub-attribute matrix. While the values of off-diagonal in the sub-attributes matrix are derived from Table 5, the diagonal value in matrix attributes is derived from the perception of management about the importance of each sub-attribute related to specific scenario based the scale shown in Table 3 (see Table 6).

So, based on the value of off-diagonal element (see Table 5) and the value of diagonal element for scenario 1 (see Table 6), the sub-attribute matrix of attribute financial [FP], sub-attribute matrix for attribute internal business process [IP], sub-attribute matrix for attribute stakeholder [SP], sub-attribute matrix for attribute learning and growth [LG], sub-attribute matrix for attribute environmental [EP], and sub-attribute matrix for attribute social [SO] for scenario 1 can be seen as follow.

$$[FP] = \begin{bmatrix} 0.6 & 0{,}312 & 0{,}579 & 0{,}607 \\ 0{,}555 & 0.7 & 0{,}597 & 0{,}604 \\ 0{,}303 & 0{,}356 & 0.7 & 0{,}352 \\ 0{,}298 & 0{,}281 & 0{,}585 & 0.7 \end{bmatrix}$$

$$[IP] = \begin{bmatrix} 0.7 & 0{,}481 & 0{,}331 & 0{,}252 \\ 0{,}472 & 0.7 & 0{,}419 & 0{,}249 \\ 0{,}626 & 0{,}543 & 0.6 & 0{,}299 \\ 0{,}723 & 0{,}681 & 0{,}662 & 0.6 \end{bmatrix}$$

$$[SP] = \begin{bmatrix} 0.6 & 0{,}448 & 0{,}552 & 0{,}613 \\ 0{,}477 & 0.7 & 0{,}5 & 0{,}395 \\ 0{,}326 & 0{,}5 & 0.7 & 0{,}657 \\ 0{,}327 & 0{,}544 & 0{,}307 & 0.6 \end{bmatrix}$$

$$[LG] = \begin{bmatrix} 0.6 & 0{,}448 & 0{,}552 & 0{,}613 \\ 0{,}477 & 0.6 & 0{,}5 & 0{,}395 \\ 0{,}326 & 0{,}5 & 0.63 & 0{,}657 \\ 0{,}327 & 0{,}544 & 0{,}307 & 0.6 \end{bmatrix}$$

$$[EP] = \begin{bmatrix} 0.6 & 0{,}406 & 0{,}157 & 0{,}416 \\ 0{,}488 & 0.7 & 0{,}135 & 0{,}497 \\ 0{,}826 & 0{,}854 & 0.6 & 0{,}796 \\ 0{,}562 & 0{,}497 & 0{,}184 & 0.6 \end{bmatrix}$$

$$[SO] = \begin{bmatrix} 0.6 & 0{,}408 & 0{,}425 & 0{,}263 \\ 0{,}438 & 0.6 & 0{,}269 & 0{,}274 \\ 0{,}519 & 0{,}628 & 0.6 & 0{,}51 \\ 0{,}708 & 0{,}709 & 0{,}446 & 0.6 \end{bmatrix}$$

Evaluate the permanent function of the sub-attribute matrix

By entering the value of off-diagonal element (see Table 5) and the value of diagonal element for scenario 1 (see Table6) in matrix [FP] and subsequently calculate this matrix using Matlab Software, it gives the value of permanent function of sub-attribute matrix. This value is represented as D_{11} in matrix [OS 1]. D_{11}= 1.4929, similarly, for 2nd, 3rd and 4th scenario the values are D_{21} = 1.4124, D_{31} = 1.4929, D_{41} = 1.5008. From calculating the matrix [IP] using Matlab Software, the values obtained are D_{12} = 1.5243, D_{22} = 1.7109, D_{32} = 1.9133, D_{42} =

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1.7109 for 1st, 2nd, 3rd and 4th scenario. From calculating the matrix [SP] using Matlab Software, the values obtained are D_{13} = 1.5835, D_{23} = 1.4151, D_{33} = 1.6678, D_{43} = 1.6678 for 1st, 2nd, 3rd and 4th scenario. From calculating the matrix [LG] using Matlab Software, the values obtained are D_{14} = 1.5147, D_{24} = 1.8732, D_{34} = 1.7733, D_{44} = 1.7733 for 1st, 2nd, 3rd and 4th scenario. From calculating the matrix [EP] using Matlab Software, the values obtained are D_{15} = 1.1348, D_{25} = 1.3402, D_{35} = 1.7275, D_{45} = 1.5467 for 1st, 2nd, 3rd and 4th scenario. From calculating the matrix [SO] using Matlab Software, the values obtained are D_{16} = 1.3447, D_{26} = 1.6804, D_{36} = 1.5046, D_{46} = 1.5802 for 1st, 2nd, 3rd and 4th scenario.

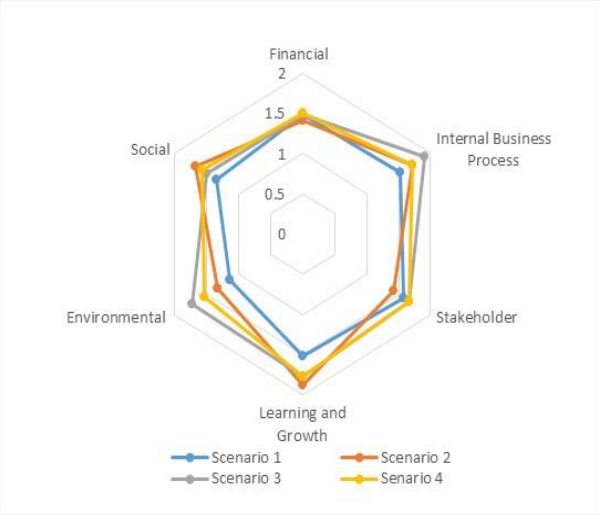

Fig 3. Radar chart of all four scenarios from all SBSC perspective (attributes)

All the values of diagonal elements or inheritance for all four scenarios have been determined above. These values are represented in the form of a radar chart as shown in Figure 3. It can be seen that scenario 1 has highest Scenario 1 has the highest score on the stakeholder perspective. Scenario 2 has the highest score in learning and growth perspective. While the third scenario is more directed at the internal business process perspective, and scenarios 4 focus on learning and growth perspective.

Evaluate the outsourcing index for each alternative scenarios of outsourcing for RL activity

To calculate the outsourcing index for the scenario, first, we have to substitute the values of diagonal elements (D11 until D46) in the matrix [OS 1] until matrix [OS4]. After substitute, the matrix [OS1] until matrix [OS4] are shown below.

$$[OS\ 1]: \begin{bmatrix} \mathbf{1,4929} & 0,588 & 0,366 & 0,445 & 0,437 & 0,632 \\ 0,385 & \mathbf{1,5248} & 0,564 & 0,551 & 0,507 & 0,66 \\ 0,5 & 0,338 & \mathbf{1,5835} & 0,516 & 0,486 & 0,563 \\ 0,502 & 0,364 & 0,327 & \mathbf{1,5147} & 0,659 & 0,66 \\ 0,502 & 0,41 & 0,422 & 0,304 & \mathbf{1,1348} & 0,67 \\ 0,336 & 0,294 & 0,358 & 0,256 & 0,275 & \mathbf{1,3450} \end{bmatrix}$$

$$[OS\ 2]: \begin{bmatrix} \mathbf{1,4124} & 0,588 & 0,366 & 0,445 & 0,437 & 0,632 \\ 0,385 & \mathbf{1,7109} & 0,564 & 0,551 & 0,507 & 0,66 \\ 0,5 & 0,338 & \mathbf{1,4151} & 0,516 & 0,486 & 0,563 \\ 0,502 & 0,364 & 0,327 & \mathbf{1,8732} & 0,659 & 0,66 \\ 0,502 & 0,41 & 0,422 & 0,304 & \mathbf{1,3402} & 0,67 \\ 0,336 & 0,294 & 0,358 & 0,256 & 0,275 & \mathbf{1,6804} \end{bmatrix}$$

$$[OS\ 3]: \begin{bmatrix} \mathbf{1,4929} & 0,588 & 0,366 & 0,445 & 0,437 & 0,632 \\ 0,385 & \mathbf{1,5325} & 0,564 & 0,551 & 0,507 & 0,66 \\ 0,5 & 0,338 & \mathbf{1,6678} & 0,516 & 0,486 & 0,563 \\ 0,502 & 0,364 & 0,327 & \mathbf{1,7733} & 0,659 & 0,66 \\ 0,502 & 0,41 & 0,422 & 0,304 & \mathbf{1,7275} & 0,67 \\ 0,336 & 0,294 & 0,358 & 0,256 & 0,275 & \mathbf{1,8715} \end{bmatrix}$$

$$[OS\ 4]: \begin{bmatrix} \mathbf{1,5008} & 0,588 & 0,366 & 0,445 & 0,437 & 0,632 \\ 0,385 & \mathbf{1,7109} & 0,564 & 0,551 & 0,507 & 0,66 \\ 0,5 & 0,338 & \mathbf{1,6678} & 0,516 & 0,486 & 0,563 \\ 0,502 & 0,364 & 0,327 & \mathbf{1,7733} & 0,659 & 0,66 \\ 0,502 & 0,41 & 0,422 & 0,304 & \mathbf{1,5467} & 0,67 \\ 0,336 & 0,294 & 0,358 & 0,256 & 0,275 & \mathbf{1,5800} \end{bmatrix}$$

By entering the value of diagonal elements (D11 until D46) in matrix [OS 1] until matrix [OS4] and subsequently calculate this matrix using Matlab Software, it gives the value of the permanent function of attribute matrix for each scenario, which is known as outsourcing index. The result of the calculation shows that the outsourcing index for scenario 1 [QS1] until scenario 4 [QS4] is 52.7051, 70.9747, 89.7414, and 81.2702 respectively. It can be seen that the value of outsourcing index scenario 3> scenario 4> scenario 2> scenario 1. 2. Therefore, we can conclude that scenario 3, i.e. outsourcing only for remanufacturing process, recycle, and transportation is the best choice among the four alternative outsourcing scenario proposed by the company. Compared with the result of research conducted by Agrawal et al [23], there were differences in the best alternative of outsourcing scenario. Research conducted by Agrawal et al [23] indicated that the best alternative of outsourcing scenario is outsourced all the process in reverse logistic. It can happen because, recently, the PT. XYZ already have XYZ Center with the main task is to receipt the defective product from the customer and deliver it to PT. XYZ. In this case of implementation of scenario 3, the main task of XYZ center will change to collection, inspection, and sorting (or not only receipt and deliver the defective product); whereas remanufacturing, recycle and transportation will be done by the third party. However, both in the result of research (Agrawal et al) and this research) indicated the same condition; remanufacturing, recycle, and transportation should be done by the third party. As the object of the research by Agrawal et al [23], the PT.XYZ only has one manufacturing plant while it has distribution all over the country, which may result in higher logistics cost. Remanufacturing process and recycle are not recommended to be done by the company itself since there is uncertainty in the context of quality and also quantity. Besides that, remanufacturing may not be a good idea for the company because of lower recapturing value of the low-cost product. Moreover, the remanufacturing process, recycle, and also transportation for the activity of RL will achieve economies of scale when the volume is large. In this case, the economic will be achieved by the third party as they not only collect,

remanufacture, and recycle the defective product from PT. XYZ and also from the other company. As the third party can take advantage of the economics of scale, they can also reduce the cost of transportation, remanufacture, and recycle which is charged to the PT.XYZ. Overall, this makes the cost of reverse logistics cheaper

5 Conclusion

This study aims to identify the decision should be made by the PT.XYZ to manage their RL activity. In this study, the PT.XYZ should make a decision whether the activity in RL must be outsourced part of RL activity or all of RL activity must be outsourced or nothing must be outsourced. In order to make a good decision, PT. XYZ proposed four alternative scenarios outsourcing for RL activity and the six perspectives and their attribute in the SBSC framework will become the attribute and sub-attribute for assessing each scenario. Moreover, the best scenario of outsourcing in RL activity is selected based their value of outsourcing index which is resulted from the GTA method. Finally, the result of data processing with the GTA method indicated that the best scenario is scenario three. In this scenario, remanufacturing, recycle and transportation are outsourced; whereas, collection, inspection, and sorting are performed by the company. Since the PT.XYZ already have XYZ center, this center can be used by the company for activity collection, inspection and sorting the defective product. The result of this study cannot be generalized since the attribute, sub-attribute, and the alternative scenario of outsourcing for RL activity only based on the perception of one company. To overcome this limitation, the more case company with the different size or different industry can be included as the sample and a larger group of experts may be utilized to find more suitable attribute and sub-attribute and also to find the relative importance of each attribute and sub-attribute.

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