Improving Business Process by Evaluating Enterprise Sustainability Indicators using Fuzzy Rule Based Classification

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Abstract— In nowadays, business process can change rapidly. The sustainability of business process model also become consideration because of its rule in sustainability. The change of business process must rely on the evaluation based on facts. Not only use quality measurement frameworks, but also use quantity measurement frameworks. The use of event log in process mining can be as reference for evaluation of business process aligned to sustainability indicators needed. This research focuses on the classification of business processes based on sustainability indicators and business process models which have sustainability duration benchmarks. The results show that the classification of business processes based on sustainability indicators can be utilized to improve business processes.

***Keywords*— business process, sustainability indicator, classification, process mining, evaluation**

I. INTRODUCTION

Standard Operational Procedure (SOP) is fundamental for enterprises or organizations in constructing business activities. Business process is made and held correspond to SOP and selected targets.

An efficient business process makes enterprises possible to delay, change and restart the business process [6]. The change in business process itself is not necessarily possible, but there are a mechanism frameworks used to evaluate and upgrade it.

Evaluations are not only restricted on business process activity but also the concept of business process. In other word, an approach to evaluate the quality of business process is objective, quantitative and based on facts [3].

Factors contributed to produce optimal business process, directly or indirectly, can be seen from management process, operational process, and supporter of business process. Business process model can be reused as an attempt of process business management in a repository or set of business process formed [10].

The effectiveness of business process can be seen from activity relationship linkages. It is an attempt to determine the compatibility or similarity in several complex process model and to review information management flows in process model [4].

Many papers discuss the evaluation frameworks and the increasing of business process model. However, the attribution in sustainability of business process itself is slightly discussed. Mentioned by Heidari in 2014, the evaluations of business process are based on facts. The presence of log event data from business process based on true events is a reason why data from log event are used to evaluate the business process [3].

To discover the model of business process, an event log is used as starting factor of business process model analysis. Event log is a simple useful resource that helps to produce information of business process activities. [11]

Log event data in discovery will represent the business process model happened. Either the activity of the data follows SOP or not, can be seen from log event data. Log event business process model is matched to SOP business process model to know how far SOP held. Matching process is one of the techniques to identify, measure the similarity of set of business process model [2].

The similarity of business process model can be described by text, structure and behaviour similarity [10].

Some problems in measurement methods are raising when it face the worse data. Frequently, the data is not suitable with real life problems due to the human preferences so it is impossible to predict the preference in exact number. The other model such as fuzzy logic model is needed to perform such measurement because it ability to measure uncertainly such as in sustainability evaluation [12].

Business process sustainability evaluation held based on classification score of sustainability indicators. Minshu in 2014 describe how to use indicators to catch relevant aspects from business process and related phase in process management life cycle[7].

This paper will describe the way to combine the similarity evaluation of business process model results happened and the evaluation of corporation business process sustainability to do

maintenance for increasing ideal business process model correspond to addressed benchmark.

II. Previous Work

A. Similarity Graph

Research by Thada and Jaglan in 2013 shows how calculations from similarity methods from behaviour and structure[8]. This research aims to find the suitable value to collect document from website using several similarity coefficient methods such as Jaccard, Dice and Consine similarity. This research also mention that there is no best method in similarity coefficient than one methods for their research.

In other research use similarity coefficient method as use for business process method. The result is a gap of the similarity itself. There are many purpose to understand the similarity gap of business process such as Clustering, Common process finding, Scalability measurements, Flexibility measurements, Matching, Workflow finding and Fraud potential finding.

From the list above, there is no purpose that connect similarity gap to sustainability of business process model. Some questions arose for sustainability problems such as " In 5 years next, is this business process still applicable?". This question need to be answered.

B. Enterprise Sustainability

Speaking of sustainability of business process model surely rise a think of what should be done to remake or evaluate the sustainable business process model and all the thing needed to support it sustainability.

According to Doc'ecalova research in 2017 about "Evaluations of corporate sustainability indicators based on fuzzy similarity graphs", there are some indicators that can be use as references to measure sustainability [5].

In this research, 12 business processes from 12 different enterprises are compared. Each business process has a score for each subset. Then it is classified based on score resemblance of the subset. Score are differed to four levels -- very high, high, low and very low. From here, business processes that have similar sustainability indicators will be visible and classified.

Its also produce the gap results of business processes that have a good score and bad score. In addition, it give a clue of the location of the weakness of business process in indicators subset group. Here, evaluations of business process be done.

Doc'ecalova research shows how to find the sustainability indicator gap only. Otherwise, each business process has a different model. It is the thing that make business process different. Indicator subset score model also can be different. According to that, this research aims to merge that 2 reason to increase the business process score itself.

III. Proposed Method

A. Sustanbility Indicators Classification

To achieve business process sustainability goals, everything related to sustainability benchmark become concern. Business process sustainability indicators by Do' cekalova are described in Table 1.

Table 1 shows that there are 4 general indicators used namely economic, environmental, social and governance indicator. Each general indicator has supported sub-indicator.

TABLE I ENTERPRISE SUSTAINABILITY

Economic Indicators
Cash Flow (eco_1)
Return on property (eco_2)
Environmental indicators
Utilization of recycled materials and raw materials (envi_1)
Fuel utilization (envi_2)
Trash production (envi_3)
Environmental charges (envi_4)
Social indicators
Salary diversification (soc_1)
Code Ethics contravention(soc_2)
Percentage of workers protected by a collective deal (soc_3)
Occupational illness (soc_4)
Percentage of products and services for which the impact on the health and safety of customers is evaluated during their life cycle (soc5)
Spending on recognize and confirm customer satisfaction (soc_6)
Corporate governance indicators
Percentage of tactics purpose accomplished (cg_1)
Percentage of women in corporate governance (cg_2)
Donation to politicians, related institutions and political parties (cg_3)
Total of denunciation received from stakeholders (cg_4)
Sum number of distrust for disobedience with laws and regulations (cg_5)

That indicators are embedded to be scored in business process that will be classified so that each business process has score per sub-indicator.

Fuzzy rule based classification is chosen for clustering business process. Fuzzy grade membership is agreed before calculations.

The aim of clustering is to divide business process to 3 sustainability categories namely short, medium and long sustainability. Then triangle shaped grade membership is applied as Figure 1.

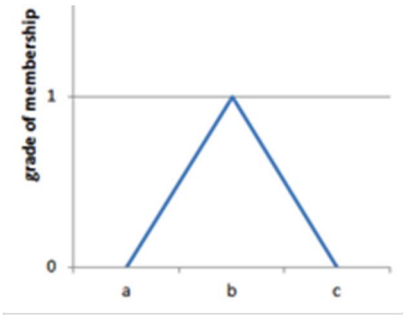

Fig. 1 Fuzzy Grade of Membership

Aligned to classification process or grouping business process for some enterprise, each business process is verbally rated (short, medium and long). Then the points of verbal score are defined to calculate fuzzy logic. Fuzzy logic dictionary is described in Table 2:

TABLE II FUZZY DICTIONARY

Verbal Score	Specification Points		
	a	b	c
Short	0	0	3
Medium	3	5	7
Long	7	8	10

Calculations of fuzzy rule based classification are performed using MATLAB 2017a.

B. *Measuring Business Process Gap using Jaccard, Dice, Consine and Wu- Palmer*

Measuring similarity gap is based on 3 approach, namely structure similarity, behaviour similarity and label text similarity. Each approach is calculated using coefficient methods which is already known such as Jaccard, Dice, Consine and [8]. Mapping of used methods for each approach is described in Table 3:

TABLE III SIMILARITY METHODS MAPPING

	Structure	Behavioral	Text
Jaccard	√	√	
Dice	√	√	
Consine	√	√	
Wu-Palmer			√

As shown in Table 3 Jaccard, Dice and Consine be used to calculate both structure similarity and behaviour similarity. According to Thada and Jaglan in 2013, there is no best calculating method of similarity coefficient so that three methods are used in this research[8].

To calculate structure and behaviour similarity, TARs (Transition Adjacency Relation set) assemblage is made from business process model compared. Tars acquired from the relation among the present activities. The relation of this pastime can also be interpreted as a sequence of execution which can occur. Within the time period referred to as the Transition adjoining members of the family [1]. In this research, existing business process model (discovery from log data) become concern. Main model (H1) will be compared to business process model that have high sustainability indicator score (H2). It can be described as:

$$H_1 = \{a_1, a_2, a_3, \dots, a_n\}$$
$$H_2 = \{b_1, b_2, b_3, \dots, b_n\}$$

Jaccard, Dice and Consine used to calculate structure and behaviour similarity are described in Table 4:

TABLE IV
SIMILARITY COEFFICIENT METHOD

Jaccard	$2\frac{X \cap Y}{X+Y}$
Dice	$\frac{X \cap Y}{X^{1/2} \times Y^{1/2}}$
Consine	$\frac{X \cap Y}{X+Y-(X \cap Y)}$

The Wu-Palmer or called WUP calculate the similarity of semantic relatedness for two word/sentences w1 and w2 in WordNet with respect to LCS (Least Common Subsummer). Similar documents in WordNet has successfully been identified by Wu-Palmer using semantic expansion. They use path length measure approach to find the similarity of two texts. [9]. The formula of WUP is :

$$Sim\ (c1, c2) = \frac{2H}{N1} + N2 + 2H$$

where :

N1 and N2 : number of is-a relation links from c1 & c2
c1 and c2 : specific common concept c
H : a number of is-a links from c to the root of the taxonomy.

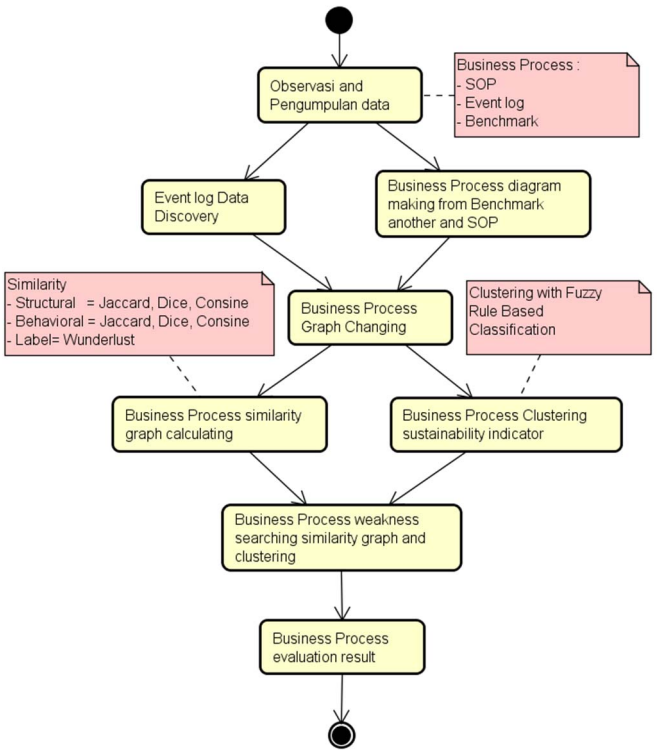

Fig. 2 Fuzzy Grade of Membership

Figure 2 explains how the flow of this research was carried out. Its need business process from event log that becomes the evaluation material, business process from another SOP and benchmark that becomes target of gap comparison. All of business process are converted to graph. After that, Its need to calculate similarity graph and clustering sustainability indicator. The results are used for evaluation and become business process improvised material.

IV. EXPERIMENT & DISCUSSION

A. *Gap of Corporate Sustainability Measurement with Fuzzy Rule Based Classification*

Research used 12 RMAs (Return Merchandise Authorization) business process of 12 enterprises. Enterprise Number 1 is a business process from event log that becomes

the evaluation material. Enterprise Number 12 is the business process from benchmark. Each business process will be rated per sub enterprise sustainability indicator. The score is given by expert judgement shown in Table 5:

TABLE V SCORE OF SUSTAINABILITY INDICATOR. ENTERPRISE NUMBER 1 CORRESPOND TO BENCHMARK AND NUMBER 12 CORRESPOND TO OBJECT OF RESEARCH

SI	Enterprise Number											
	1	2	3	4	5	6	7	8	9	10	11	12
eco1	10	5	9	9	5	8	5	6	4	8	8	6
eco2	10	7	8	9	5	8	7	5	5	8	7	6
envi1	9	3	1	7	6	7	2	7	3	4	2	3
envi2	9	2	1	7	5	7	3	6	7	5	2	2
envi3	9	1	2	7	7	7	2	7	6	3	1	2
envi4	9	0	2	7	4	7	1	8	4	7	0	1
soc1	9	2	3	8	8	8	0	2	5	6	3	1
soc2	8	2	4	8	7	8	1	3	3	4	2	2
soc3	8	1	5	7	7	7	0	1	4	5	2	3
soc4	8	3	5	7	8	7	2	0	5	3	1	2
soc5	8	2	3	9	7	7	1	2	7	4	3	2
soc6	8	1	6	8	7	8	2	3	3	5	2	1
cg1	8	2	7	8	5	7	7	7	4	7	2	2
cg2	9	5	3	7	4	7	7	4	3	3	1	3
cg3	9	3	4	9	5	7	7	3	5	4	1	2
cg4	9	4	6	8	3	7	8	6	6	3	0	1
cg5	9	7	5	8	5	6	7	4	4	5	2	3

SI = Sustainability Indicator

The enterprises will be classified using fuzzy rule based classification. Classifications are carried out in each sub-indicator namely economic, environment, social, and corporate governance.

Table 6 show the results of fuzzy rule based classification for each sub-indicator. According to table 2, score 8.3889 is classified to Long sustainability; score 5 is classified to Medium sustainability and score 1.2412 is classified to Short sustainability. Economic, Environment, Social and Corporate Governance gap from EN 1 and 12 respectively are 3.3889; 7.1477; 3.3889 and 7.1477.

TABLE VI RESULT OF SUB INDICATOR

Enterprise Number	Economic	Environment	Social	CG
1	8.3889	8.3889	8.3889	8.3889
2	5	5	5	5
3	8.3889	1.2412	5	5
4	8.3889	8.3333	5	8.3889
5	5	5	5	5
6	8.3333	5	5	1.2412
7	5	5	1.2412	5
8	5	5	5	5
9	5	5	5	5
10	8.3333	5	5	5
11	8.3333	1.2412	5	1.2412
12	5	1.2412	5	1.2412

Data in Table 6 are recalculated to obtain gap sustainability in general. The results are shown in table 7.

TABLE VII RESULT OF INDICATOR

Enterprise Number	Score	Sustainability
1	8.344	Long
2	5	Medium
3	5	Medium
4	8.344	Long
5	5	Medium
6	5	Medium
7	5	Medium
8	5	Medium
9	5	Medium
10	5	Medium
11	5	Medium
12	1.0944	Short

Can be inferred from Table 7 business process EN 1 (research object) is classified to short sustainability, while EN 12 (reference business process with highest score) is classified to Long sustainability. Gap of enterprise sustainability for EN 1 and EN 12 value is 7.2496.

B. Gap of Similarity Measurement with Jaccard, Dice, Consine and Wu-Palmer

Gap of Similarity Measurement needed business process with graph shape. Gap similarity of EN 1 and EN 12 is calculated after gap sustainability indicator is obtained. It is use to understand how far the difference of models between two business process compared. Figure 3 is the result of event log discovery from EN 12 using Neo4j. This figure constructed by 20 nodes and 26 edges. TARs assemblage EN 12 is made from Figure 3.

The result structure assemblage is represented by H1a.

H1a = start, t1, t2, t3, t4, t5, t6, t7, t8, t9, t10, t11, t12, t13, t14, t15, t16, t17, t18, t19, t20, end, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, start-t1, t1-A, t2-B, t3-C, t4-C, t5-D, t6-E, t7-F, t8-G, t9-H, t10-I, t11-J, t12-K, t13-L, t14-M, t15-end, t16-N, t17-O, t18-P, t19-Q, A-t2, A-t4, B-t3, C-t5, D-t6, E-t7, F-t8, -, G-t9, H-t10, H-t11, H-t12, H-t16, -, J-t13, -, K-t15, K-t17, L-t14, L-t17, M-t15, N-t17, N-t18, O-t15, P-t19, Q-t17, R-t21, Q-t15

The result behavioural assemblage is represented by H1b.

H1b = AB, AC, BC, CD, DE, EF, FG, GH, HI, HJ, HK, HN, , JK, , KL, KO, LM, LO, MEnd, NO, NP, Oend, PQ, QO, REnd

The label/text assemblage is represented by H1c.

H1c = Request RMA, Check Device Status, Get Status Info, Create a service receipt, Completes RMA request form, Submit RMA request from to CSR, Device don't meet return policy criteria, Device return policy criteria, Process RMA, Issue RMA number to customer, Customer doesn't need to return device, Customer need to return device, Return Shipment, Inspects and diagnose device, Issue credit to customer.

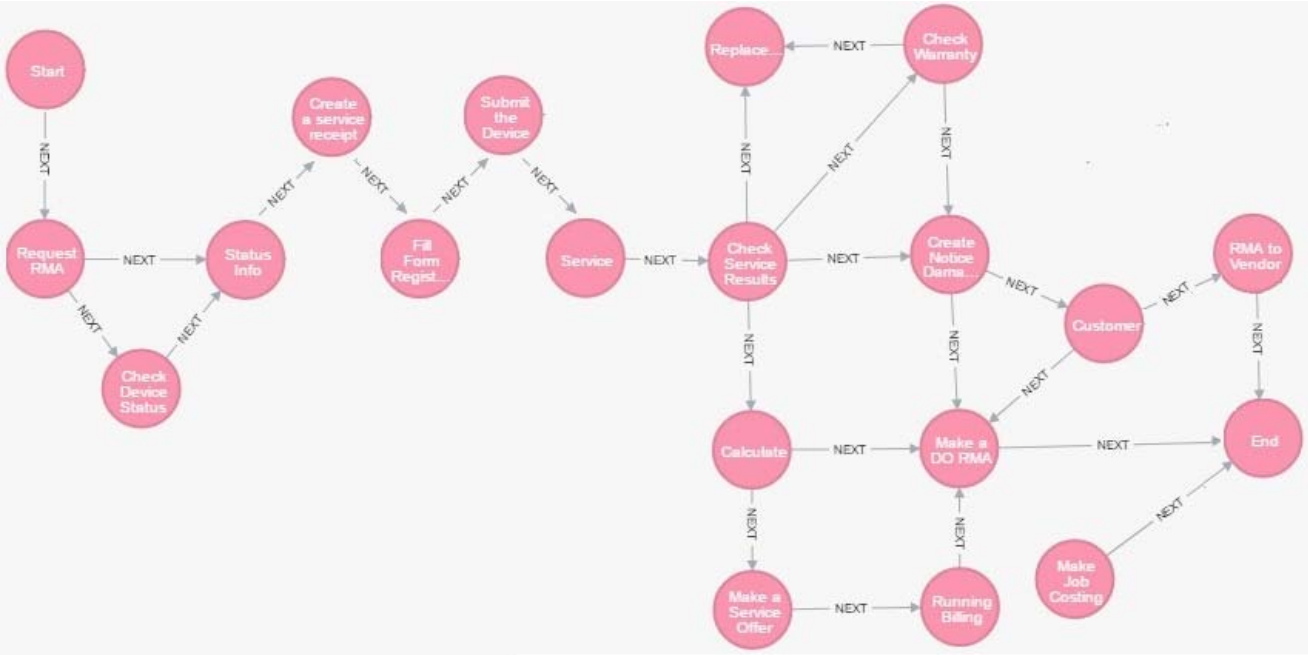

Fig. 3 Business Process of EN 12

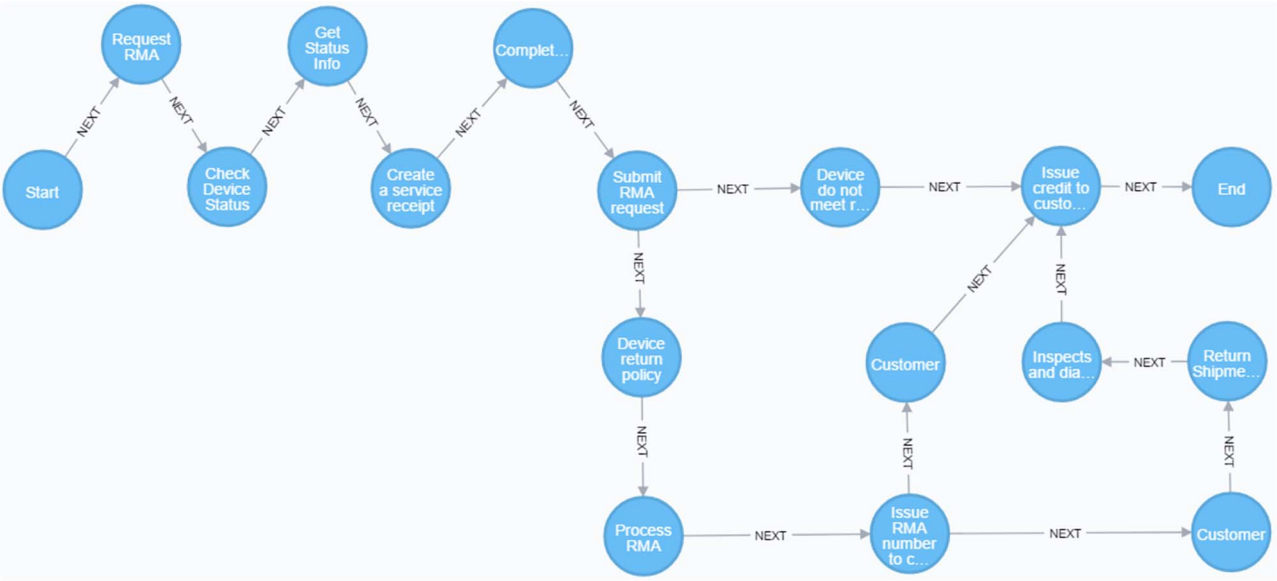

Fig. 4 Business Process of EN 1

Figure 4 is the result of modeling process business from EN 1 using Neo4j. This figure constructed by 17 nodes and 15 edges. TARs assemblage EN 1 is made from Figure 4.

The result structure assemblage is represented by H2a.

H2a = start, t1, t2, t3, t4, t5, t6, t7, t8, t9, t10, t11, t12, t13, t14, t15, end, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, start-t1, t1-A, t2-B, t3-C, t4-D, t5-E, t6-F, t7-G, t8-end, t9-H, t10-I, t11-J, t12-K, t13-O, t14-L, t15-M, t16-N, A-t2, B-t3, C-t4, D-t5, E-t6, F-t7, F-t9, G-t8, H-t10, I-t11, J-t12, J-t14, K-t13, L-t15, M-t16, N-t13, O-t8

The result behavioural assemblage is represented by H2b.

H2b = AB, BC, CD, DE, EF, FG, FH, GEnd, HI, IJ, JK, JL, KO, LM, MN, NO, OEnd

The label/text assemblage is represented by H2c.

H2c = Request RMA, Check Device Status, Status Info, Create a service receipt, Fill Form Registration RMA, Submit the Device to the technician, Service, Check Service Results via RMA Web, Calculate the cost, Make a Service Offer, Running Billing SOP, Make a DO RMA, Check Warranty, Create Notice Damaged Device Form, Customer Info, RMA to Vendor, Replacement, Check Stock RMA, Fill the Device Request Form, Make

Job Costing, Approval Replacement, Check Sale Stock, Request Stock Expenses.

H1 and H2 assemblage is used in Jaccard with equation, Dice and Consine calculation by considering union and intersect of both. For text similarity, TARs H1c and H2c assemblage is used in Wu-Palmer using ws4jdemo.appspot.com produce average score.

The result of calculations of Structural, Behavioural and Text similarity is represented in Table 8.

TABLE VIII RESULT OF SIMILARITY GAP

	Structure	Behavioural	Text
Jaccard	0.500	0.481481	
Dice	0.583	0.45614	
Consine	0.587	0.459619	
Wu-Palmer			0.670

Jaccard, Dice and Cosine are used to calculate structure and behavioural similarity, and Wu –Palmer to calculate text/ label similarity. The average score result of that methods is 0.557 for structural, 0.466 for behavioural, and 0.67 for text label.

V. CONCLUSION

The research has shown that sustainability business process of enterprises can be predicted using enterprise sustainability indicators. The indicator score can be compared to other business process (including benchmark, as a business process references that has long sustainability) in which sustainability gap between enterprises is obtained.

It can be inferred that about 50% business process model differ from the targeted model. The business process model must be improved. The improvements are based on sustainability indicators. In addition, object business process is classified to Short sustainability so the improvement carried out by considering all of sub sustainability indicators (economic, environment, social and corporate governance). The contribution of this study has been to confirm how to calculate gap of business process and its improvement based on sustainability indicators.

VI. FUTURE WORK

Several questions still remain to be answered. Like a verbal linkage score, such as what make business process can be classified. The further research of verbal score sustainability should be done to give a better understanding about enterprise sustainability.

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