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Integrated Analytical Hierarchy Process and Objective Matrix in Balanced Scorecard Dashboard Model for Performance Measurement

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Abstract

Measuring organizational performance is pivotal for a comprehensive understanding of strengths, weaknesses and to improve the quality of any organization's performance. Balanced Scorecard (BSC) is the strategic evolution tool that is widely used to measure the organizational performances, and achievements from various aspects, both financial and non-financial. In this research, BSC was not only a straight jacket concept but also a high potential tool for measuring and managing tangible and accurate data through the application of several methods. This research weighted the variables of BSC based on significance values of Analytical Hierarchy Process (AHP) and Optimization of Measurement with Objective Matrix (OMAX). Moreover, a recommendation analysis was given based on the cause and effect analysis of variables and the achievement of Key Performance Indicators (KPIs). The flow of information, data, and performance measurement processes were designed into Business Intelligence (BI) software development i.e. BI-MonevDash. The framework and software BI-MonevDash proposed can be used as a new chosen tool for measuring and monitoring organizational performance. Recommendations could facilitate the leaders in decision making to improve the organizational performance and reduce risks.

Keywords*: analytical hierarchy process, balanced scorecard, business intelligence, objective matrix, performance measurement tool*

1. Introduction

The demand for competitive advantages and business boosters forces an organization to constantly monitor, evaluate and manage strategies as an effort to improve the achievement of management performance. These management strategies are especially related to the quality of business performance measurement [1]. This measurement activity is necessary to identify the organization condition through the analysis of its operational strengths and weaknesses [2]. Root cause and effect analysis of each activity can be analyzed to minimize the risk that might occur. The fault in management decisions can also be evaluated directly as a corrective action from every operational process which takes place in the organization. Herein the role of performance measurement tools become very important in measuring impacts, influences, and triggering the organization activities periodically.

Previous researchers have studied several performance measurement tools such as Balanced Scorecard (BSC), The European Foundation for Quality Management (EFQM) Business Excellence Model, Performance Measurement Matrix, Performance Pyramid, Performance Prism, and Kanji Business Excellence Management System (KBEMS). Amongst the above methods, BSC and EFQM Business Excellence Model are the most widely used of

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performance management system. These models provide a structured approach in recognizing the possible strategy changes and threats. In addition, they are capable of translating the corporate strategy into targets which lead to a more detailed and affordable action plan [1]. However, several reviews found that BSC and Performance Pyramid are two of the best models for strategically measuring Performance Measurement Factors (PMFs). Organizations can use those models to clarify goals, set strategic goals and communicate the selected strategies. Meanwhile, the EFQM Business Excellence Model is more appropriate to use in benchmarking processes. Performance Prism and KBEMS were developed as the completion of BSC. However, various deficiencies are still found in both models, especially during the implementation of strategy measurement [1].

In the previous decade, BSC has been adopted by many forms of organization, profit or nonprofit. It showed that 44% of the organizations feel significant satisfaction in the results [2]. BSC has advantages over other models, especially when presenting the performance dimensions from a different perspective to improve the organization's business outcomes in present and future [3]. In addition, BSC has the power to outline the clarity, synergy, and consistency of vision, mission and organizational strategy from corporate to the individual level. The monitoring and evaluation process of each strategy can be controlled periodically and are flexible against any changes and improvements that occur. During the integration of the performance measurement process, the cross-platform communications are well established. This indirectly triggers the formation of knowledge creation and acquisition between level management actors. However, several weaknesses were found, particularly those related to the scorecard determination process and its analysis estimation [1]. Estimation is often generated based on managers' views as a person in charge when determining the scorecard number, thus the significance, subjectivity, and detailed analysis are bias. AHP is one of the methods that is introduced in this research to overcome the weakness of scorecard estimation in BSC.

AHP is a method that combines the qualitative and quantitative assessment method so it can overcome the shortcoming of a single qualitative or quantitative assessment method [4]. Some previous studies applied this concept including Lee et al. in [5]. They implemented the integration of AHP fuzzy and BSC approach while evaluating the organizational performance manufacturing company in Taiwan [5]. Bhattarai in [6] studied the diffusion of AHP and BSC in Nepal [6]. Erbasi and Parlakkaya in [7] applied AHP and BSC in a Hotel Firm [7]. Finally, Feili et al. in [8] tried to integrate AHP with BSC in Information Technology industries [8]. The integration of AHP method in BSC can overcome the weakness of BSC in the subjectivity of managers or key actors assessment [5,8]. AHP through the forming pairwise comparison matrix is capable to generate the increase of redundancy and reduce some errors. This method provides the decision-making process which considers the aspects of experience, intuition, and actual data [9]. Another research from Yuhong in [10] that attempts to integrate BSC with another method, it proposed a novel balanced scorecard design based on fuzzy Analytical Network Process (ANP) for performance evaluation. The experimental result showed that the design was quite effective [10]. This becomes the main reasons to apply the AHP concept of BSC measurement in this research. However, this integration found several limitation that related to the number of comparisons and environment analysis thus restricted to AHP specifications and rules [9].

In order to complement AHP scorecard estimation, this research applied OMAX through the calculation of overall multi-factor performance index. Herein, OMAX as one of productivity measurement systems is used to monitor the company’s productivity based on the alignment of criteria to strategic objectives [11]. Therefore, each criterion can be measured by its level of effectiveness and efficiency. Matrix performance indicators are then scales and categorized into several values of groups such as very bad, poor, medium, good, and very good. This authorizes the stakeholders to track the status or performance of KPI and normalized them mathematically into a single score of performance measurement [12]. The score allows management to identify the strategy performance changes [13]. The role of OMAX is used to normalize and convert the value of BSC performance measurement into a performance index [14]. The integration of BSC and OMAX can describe the overwhelming data and provides the analysis to become more measurable, unambiguous, normal and accurate [15,12].

To automate the integration of BSC measurement, AHP weighting analysis, and the OMAX scoring processes, an application namely BI-MonevDash was then developed. BI is able to facilitate the formation of appropriate strategies as well as associate them with the

performance measurement frameworks applied; enable decision makers to take corrective actions, and adopt new management initiatives and new strategies. Integration of BI and BSC is an innovative method that can support the decision making in management level and provide an opportunity for them to act in accordance with the conditions and circumstances occurred [3]. BI is not only able to display BSC structure but also the result of analysis using graphical demonstration such as a graph, dashboard, and strategy map [3] so that the cascading of strategic objectives are clearly identified. Previous studies have proven that BI is the most successful method of presenting and following the performance measurement using BSC concept [3, 16, 17]. Herein four BSC perspectives are explained in more detail and measurable. Recommendations are given as corrective action against the performance achievements. This will aid management level in decision making, monitoring and evaluating performance periodically. To scope this research, a case study is conducted at University X based on data reported in 2015

2. Proposed Research Method

For the purpose of implementing this research, several stages were developed as depicted in Figure.1.

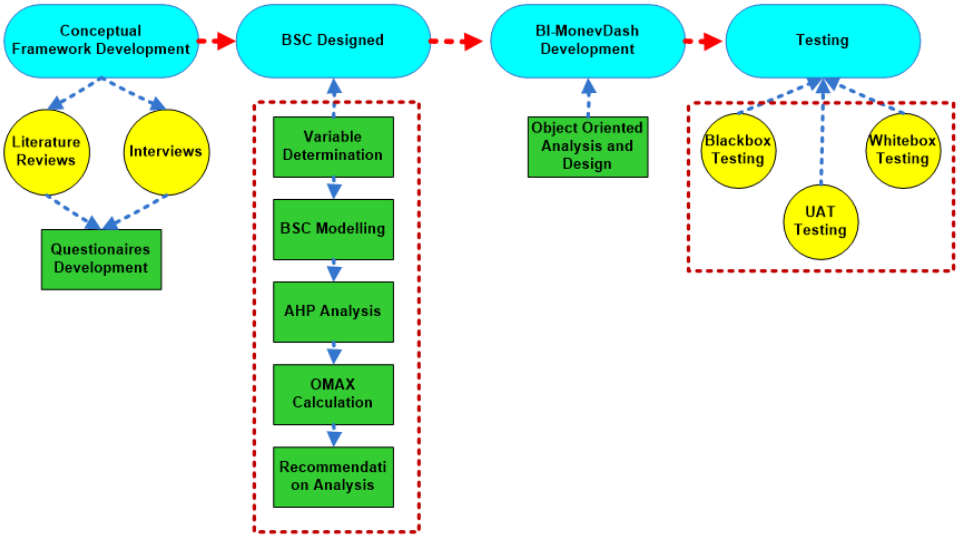

Figure 1. Proposed research methodology

Conceptual Framework was developed based on the reviewing of several literatures and conducting interviews. A case study in an X University with four persons employed as Dean and Deputy Dean was accomplished towards the development of questionnaires as instruments. Some information from the case study was obtained including organizational business process data, organizational structure, organizational strategic plan 2013-2033 and operational plan and organizational achievement 2013-2018, performance documents and portfolio. Three questionnaires were designed and distributed to the above University. The first questionnaire aimed to validate strategic target variables which were formulated based on the organization's vision and mission. Herein, a 5-scale Linkert was applied as an optional choice of respondents agreed. As the result, twenty variables were proposed in four perspective of BSC. Meanwhile, the second questionnaire was used to determine the weight or significance level of each variable through the application of AHP method. Twenty variables were tested and compared thus then ranked based on the significance level and weight. The third questionnaire was used to set the performance targets and achievements of twenty variables. These questionnaires were answered by management level from top to middle in accordance with the desired targets and consideration of previous year achievements.

Next step, BSC design was developed in several phases [2], including Collection and Documentation of Current System; Balanced Scorecard Modelling; Determining Measurement Values in AHP analysis and OMAX calculation; and Analysis Report for recommendation. Herein, manual analysis of BSC, AHP, and OMAX concepts was transformed into automated BI-Monevdash. BI-Monevdash followed Object Oriented model for Analysis and Design. UML was used as a tool in describing the interaction between objects into the development of use cases, class diagrams, and activity diagrams. This BI-Monevdash then was tested using black-box, white-box, characteristic test and User Acceptance Test (UAT).

3. Results and Analysis

3.1. Balanced Scorecard Design

As mention before, 20 variables were derived from each BSC perspective and thus acted as strategic objectives. For BSC-Financial perspective, there were five variables, namely FST-01: Increasing the amount of budget allocation, FST-02: Maximizing the realization of budget, FST-03: Increasing budget allocation for Teaching, Research and Community Services (in Indonesia Tridharma Perguruan Tinggi), FST-04: Increasing budget allocation for facilities and infrastructure, and finally FST -05: Increasing budget allocation to improve the quality of human resources and development. Detailed variables were explained in Figure 2.

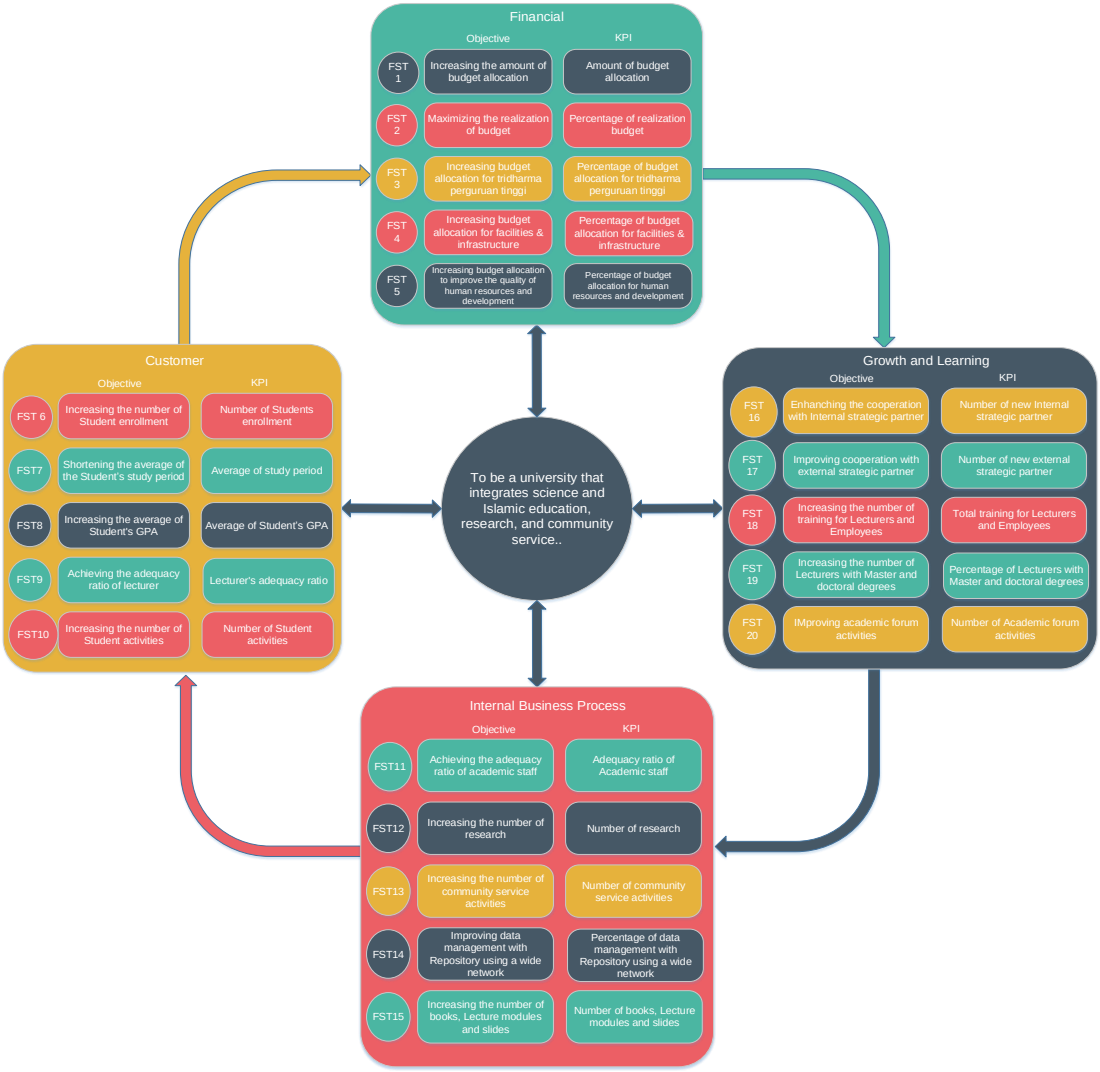

Figure 2. BSC modelling

The above variables were verified and justified through the analysis of the first questionnaire and can be accepted with an 88% agreeable percentage. Next, a cause and effect relationship between variables was mapped toward the strategic map as shown in Figure 3.

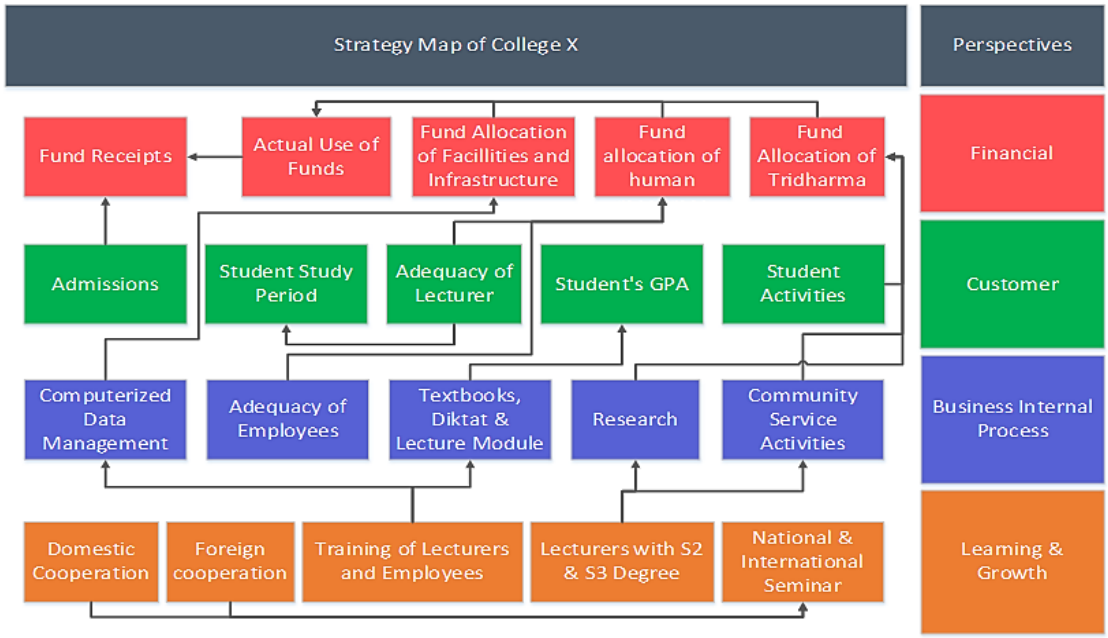

Figure 3. Strategy map of X University

The strategy map explained that in learning and growth perspectives, the increasing of variable FST-16 (Enhancing the cooperation with internal strategic partners) and FST-17 (Improving cooperation with external strategic partners) affects the increase of FST-20 (Improving academic forums activities towards national and international conferences). The effects can be shown through the involvement of sponsorship, promotion, committee, participants, and keynote speakers which are very potential for the success of academic forums. The increasing number of training for employees and lecturers (FST-18) provided the significant values on the numbers of textbooks, modules as the outcome of the knowledge development activities. Then, increasing number of lecturers with master and doctoral degrees in FST-19 will influence numbers of research in FST-12 and number of community service activities (FST-13) which also triggers the increase of students' research activities in FST-10 and budget allocation for Tridharma in FST-03. Similar explanation provided in the figure for other perspectives.

3.2. Determining the Measurement Value

Referring to the development and analysis of BSC modeling and the strategy map, it then continued by determining the measurement values using AHP calculation. As the result of the second questionnaire, the weights of each variable is measured in their significances. The result of Consistency Ratio (CR) and Consistency Index (CI) values are smaller than 0.1 which indicates that the overall perspectives and variables are accepted and consistent. The summarization of vector eigenvalue per perspectives and overall KPIs can be seen in Table 1. The significance of the BSC variables are analyzed and identified through the AHP application, creating a new contribution based on the company or organizations preferences.

Table 1 explained that from four BSC perspectives, learning and growth became the highest significance perspective with the eigenvector value in 0.425, followed by the internal business process perspective in 0.231, financial perspective in 0.195 and customer perspective in 0.149. Meanwhile, the weighting for each perspective is also defined according to local and global vector eigenvalues. Based on the local vector eigenvalues in financial perspectives,

FST-05 provided the highest significance weight (0.419) and FST-02 as the lowest one (0.118). For customer perspectives, FST-09 became the highest essential weight in 0.321 and FST-06 as the lowest one in 0.055. For the internal business process perspective, FST-12 provided the uppermost considerable weight in the 0.388 and FST-11 as the undermost one in 0.108. For growth and development perspectives, FST-19 became the uppermost significant weight in 0.311 and FST-16 as the bottommost significant weight in 0,134. Based on the global vector eigenvalues, FST-19 became the superior priority weight in 0,132 and FST-6 as the inferior one in 0.008.

Table 1. AHP Weighted and OMAX Scoring Level Summary of Perspectives

Perspective	Priority Value (Eigen Vector)	Variable	Priority Value (Eigen Vector)-Local	Priority Value (Eigen Vector)-Global	OMAX Level	Category	Index
Financial	0,195	FST-1	0,140	0,027	8	Very good	5,176 (Average)
		FST-2	0,118	0,023	0	Review	
		FST-3	0,184	0,036	5	Average	
		FST-4	0,140	0,027	2	Bad	
Customer	0,149	FST-5	0,419	0,082	4	Average	7,873 (Good)
		FST-6	0,055	0,008	3	Bad	
		FST-7	0,274	0,041	10	Perfect	
		FST-8	0,274	0,041	3	Bad	
		FST-9	0,321	0,048	7	Good	
Internal Business Process	0,231	FST-10	0,077	0,011	10	Perfect	4,544 (Average)
		FST-11	0,108	0,025	3	Bad	
		FST-12	0,388	0,090	5	Average	
		FST-13	0,138	0,032	0	Review	
		FST-14	0,165	0,038	10	Perfect	
		FST-15	0,201	0,046	3	Bad	
Learning and Growth	0,425	FST-16	0,134	0,057	0	Review	3,22 (Bad)
		FST-17	0,154	0,065	6	Good	
		FST-18	0,187	0,079	5	Average	
		FST-19	0,311	0,132	3	Bad	
		FST-20	0,214	0,091	2	Bad	

Complementing BSC and AHP analysis, the calculation of scoring with OMAX was accordingly conducted to carry on the analysis. By applying the OMAX's leveling formula: $\Delta \boldsymbol{X_{L-H}} = \frac{\boldsymbol{Y_H - Y_L}}{\boldsymbol{X_H - X_L}}$, the interval values between high to low level ($\Delta \boldsymbol{X_{L-H}}$ **)** can be defined through the calculation of value in high level ($\boldsymbol{Y_H}$), low level ($\boldsymbol{Y_L}$), level in high ($\boldsymbol{X_H}$**)** and level in low ($\boldsymbol{X_L}$). OMAX scheme was leveled into 10 scales [18] which defined the possible factors that influencing the performance in terms of predefined KPI. The scale of achievement was in accordance with targets. Scale 0 as the lowest performance achievement; 3 shows the average achievement; and 10 as the maximum target achievement. Meanwhile, scales 1 and 2 are obtained from the calculation of interpolation values at scales 0 and 3. The result will be the values of intervals from scale 0 to 3. Scale 4-9 are obtained from the calculation of interpolation values in scale 3 and 10 and will be used as intervals values between scale 3 to 10 [19]. Finally, the index row was derived from the total calculation of performance indicator.

Recapitulation on the calculation values, scoring levels, categories, and performance index was obtained based on data reported in 2013, 2014 and 2015 which is compared to target value achievements in 2016. Table 1 found that the performance index of X Unversity in financial perspective lies in the "average" category with a weight index in 5.176. The customer perspective stands in the "good" category with weight index is 6.744. The internal business process perspective is in the "average" category with weight index in 4.544. Finally, the growth and learning perspective is in the "bad" category with weight index is 3.22. The average overall performance at X University is at a score of 5 with an "average" performance index. As of, the

level performance achievement of each variables and sub variables was then quantitatively measured in accurate numbers analysis. Herein, the OMAX fulfills the limitation of AHP and BSC for estimation analysis.

By rooting the cause and effect analysis of each KPIs and performance index achievement, the recommendations were proposed as shown in Table 2. This table explained the recommendation for performance index lies on categories in “bad” and “review”. As an example, FST-02 which category is in “review” found that the achievement of budget realization is 100%. The recommendation proposed management level to maintain this achievement. The FST-04 performance index in the “bad” category was due to the reduction of budget allocation achievement for facilities and infrastructures. The strategy changes to subsidize the budget for Tridharma. As a recommendation, the management level needs to stay focus on organizational and strategic objectives thus setting the budget allocation in alignment with it.

Table 2. Root Cause and Recommendation

No KPI	Category	Root Causes	Recommendation
FST-2	Review	Percentage of funds utilization is at 100% or maximum	Maintain the realization of the use of funds at 100% percentage.
FST-4	Bad	The percentage of allocation of funds for facilities and infrastructure was reduced to increase the percentage of fund allocation for *Tridharma* and human resources activities.	Increase fund allocation for the development of *Tridharma* and human resources activities.
FST-20	Bad	The number of national and international seminars has not increased significantly.	Increase the number of national and international seminars to develop and disseminate knowledge of the academic community of UIN Suska FST.

3.3. Analysis and BI-Monevdash Design

BI-Monevdash application is built by following the entire stages in BSC, AHP, and OMAX. Mechanism of BSC analysis and modeling which is then integrated with AHP for KPIs weighting and OMAX for performance index measurement become the main components in BI-Monevdash development. The architecture diagram informed the flow data process transaction in and out components and key actors for every level stages. Any data such a perspective analysis data, strategic target data, strategy maps, interest values data, organizational profiles, user data, weighted results data, and process, and scoring data are restored and managed in knowledge base repository in connection with the server. The server is developed by applying apache components and MySQL database. The connection to a client PC, web browser, and serial printers supported server activities. The users are involved as key actors in this application are divided into three categories, namely middle manager including the head of the administration office, head of department and secretary as a person in charge. The software administrator acts as system operator. Meanwhile, the top manager is dean and deputy dean. This application is designed to be as interactive as possible by allowing users to interact directly or indirectly in the monitoring and evaluating progress on the performance. The recommendations and corrective action was given as an evaluation, management control and to reduce the emerging risks during the strategy execution. Performance measurement, process, and result analysis are reported in forms of Gauge, Bar chart, Line chart, table, and dashboard model.

3.4. Method Testing through BI-Monevdash Application Test

White-box testing was conducted using several techniques such as a flowgraph, Cyclomatic Complexity (CC) calculation, independent path determination, and a test case. From 55 nodes, the flowgraph obtains the systematic complexity value that is running 11 test cases thus indicates that BI-Monevdash application has a complex procedure and moderate risk. This test cases value interprets that white box testing is a success. In Black-box testing, equivalence class partitioning technique was conducted thus the entire functions in the application can run as well as expected. Finally, dashboard characteristic testing was conducted to determine the feasibility and specification of the system towards dashboard characteristics. The testing was conducted by disseminating the questionnaire to several top and middle managers as respondents. The questionnaire applied scale Linkert 5. As the result, 89% of respondents

strongly agree with the suitability of BI-Monevdash system with dashboard characteristics. As well as UAT testing proposed the result that BI-Monevdash application can be well-accepted by end-users. The testing result informed that the involvement of overall stakeholders as end users from top to middle managers in determining the significances of variables in AHP analysis, through their operational data entry and perceives has proven can enrich the BSC estimation analysis as well as managers' views. Detailed information given by OMAX leveling has aided end users in identifying the performance level of each variables and sub variables. Therefore, the accurate analysis of organizational performance level was quantitatively explained.

4. Conclusion

From the series of methodologies applied in this research, it can be concluded that the BSC implementation model with integration of AHP and OMAX has been successfully in measuring the performance X university strategy. The implementation of this concept can contribute to the development of new technique for performance measurement tools and address the various weaknesses of BSC concepts in measurement. AHP Weighting provides an opportunity to prioritize KPIs variable of perspective thus the significance of the data is clearly evident within leveling and scoring of performance. The application of OMAX extends the completeness and accuracy of calculation leveling and scoring of performance measurement. The root cause analysis of this model become the bases for proposing the recommendation towards any changes and activities that occurred. Therefore, it can be used for evaluation and monitoring to control any achievements during the strategy execution. The prototype of BI-Monevdash has successfully developed an automated and computerized BSC-AHP and OMAX modeling software. The dashboard and graphical display of information and analysis come to the aid of the stakeholders involved in monitoring and evaluating the execution of their strategy. A series of software testing has been performed in ensuring the prototype of BI-Monevdash can be used properly as one of the performance measurement tools for both profit and nonprofit companies.

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