Mathematical Model for Budget Planning and Execution

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***Abstract*—Many past studies have addressed budgeting which deals with yearly budget allocation planning while studies on the quarterly budget allocation and execution planning are still lacking. Our study concerns with the development of mathematical models for the faculty's budget planning and execution that aims at optimizing the efficiency of budget utilization of faculties of a local public university. This paper illustrates the design and development of models to determine the quarterly budget proportion allocation. In this paper, we propose a conceptual framework and construct the mathematical model for the budget planning and execution. Three strategies for determining budget allocation proportion per quarter which are the horizontal line approach, staircase method and zigzag strategy are put forward. These strategies are determined based on analysis of past data and they are used to recommend certain quarterly budget allocations which have the potential of maximizing the efficiency of each faculty's allocated budget utilization.**

***Index Terms*—budget planning, quarterly allocation, mathematical programming, budget utilization, faculty**

I. Introduction

Robichek and Myers [1] define financial theory as the investigation of how best to carry out the finance function, subject to the problems posed by time and uncertainty. As financial decision makers, they aim to optimize the value of the company to their stakeholders. In an economy, it is important to allocate the resources efficiently and to ensure that individuals obtain the highest level of satisfaction possible [2]. This shows that financial decision making plays an important role in planning for an efficient funding allocation and contribute not only to the success of the company but also affect the whole economy as well. Efficient fund allocation is important since it complies with the strategic planning of the organization and also ensures that the expenditures meet the objectives using the available resources. The combination of these two facts is essential for financial control. According to Bowen's Law "universities will raise all the money they can and spend all the money they raise [3]." This means that if the decision makers used their money ineffectively they did not spend the money efficiently although they spent all the money.

Effective budget allocation is defined as the best way budget can be utilized by maximizing the usage of a limited budget. According to Huang, Teng and Lin [4], an effective budget allocation is difficult to realize because of the competing claims among the related units. It becomes more challenging when a powerful unit receives more than a compliant units. However, budget planning is invented primarily to make the most effective use of resources by allocating resources to where they are most desired. This requires a good strategic planning to ensure the budgets are optimized through proportion allocation of funds.

Non-profit organization such as universities are not always be informed of their future year's allocated funding. However, they are able to forecast the required fund based on their nature of activities and historical trends [5]. Financial management is a fundamental aspect of the university's internal management which may directly affects the survival and the development of universities [6]. Budget utilization performance for the current year has certain influence over the amount of budget which will be allocated for the coming year. The government may cut the future budget, depending on the universities' performance and efficiency in budget utilization. Budget reduction would certainly affects the operations of the university. Thus, the top management of universities must give special attention to the budget planning. This is important because the amount of budget allocated can be decreased, increased or remains the same,

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subject to the previous year's performance and meticulous budget plan being carried out. Based on the budget allocated, the management of the university has to control the execution of the budget utilization so as to achieve maximum productivity and maximum efficiency in utilizing the budget. Generating own income is one of the way to help the university to fund its operations sufficiently.

Budgeting in any institution of higher learning is an important area which requires detailed planning. It is able to indicate the activities planned by each unit and the funding needed. Besides that, budgeting can also acknowledge the management on any complex task that needs cooperation among departments [7]. As described by Maxwell, to construct an effective budgeting model, one must understand the process of institution budgeting. The budgeting model needs to be structured and aligned in accordance to the existing multiple objectives. In order to ensure optimum utilization of limited funds, university managements need to make smart decisions as to which activities are to be funded and the degree of funding.

Budget execution and control or budget management plays an important role aside from budget planning. Therefore, our study aims at optimizing the efficiency of annual budget utilization at faculties of a public institution of a higher learning in Malaysia. This will be carried out by strategizing its quarterly budget allocation and budget utilization proportions. This paper presents the models developed that aimed at maximizing budget utilization of faculties at a university. The remaining of this paper is organized into sections as follows: In section two we first discuss motivation of the study based on the literature review on resource and budget allocation of public universities (Pus) in local country. The description of the problem is presented in section three. In section four, framework for the budget planning and execution model is developed. This is followed by model parameters and decision variables and lastly, conclusion in subsequent sections.

TABLE I. A STUDY ON RESOURCE AND BUDGET ALLOCATION OF LOCAL PUBLIC UNIVERSITIES

Author and year	Objectives of the Study	MP model
(A. Ahmad and Farley, 2013) [10]	▪ To explore the shift in funding reforms currently facing at Malaysian public universities (PUs) focusing on issues and challenges experienced by the focused universities in particular.	-
(A. Ahmad, Farley and Naidoo, 2012) [11]	▪ To investigate the impact of the Federal Government strategic plans and funding reforms on Malaysian Pus. ▪ To determine whether the funding reforms have appeared to be leading to the desired changes in the universities. ▪ To examine whether the universities have incorporated the reforms as intended by the government.	-
(A. R. Ahmad, Farley and Naidoo, 2012a) [12]	▪ To address the fundamental research question of whether the changes in Malaysian Federal Government funding have altered the approach in teaching and learning in Malaysian public universities.	-
(A. R. Ahmad, Farley and Naidoo, 2012b) [13]	▪ To investigate whether the funding reforms are the leading cause towards achieving the desired changes in the universities	-
(Engku Muhammad Nazri, Syariza and Norzetty, 2011) [8]	▪ To construct a MP model to determine the amount of library's budget should be allocated to each faculty and faculty's budget allocation model in terms of acquisition of books and journals.	√
(Ariffin, Mustafa, Idrus, Abdul and Ramli, 2011) [14]	▪ To present the effect of the reduction of allocation for the faculty on learning and teaching process and the results from the effect.	-
(Nopiah, Amat Kamaruddin, Ismail, Abdullah and Ahmad, 2007) [9]	▪ To present a priority based GP model for resource allocation in university management for better academic performance, where the operation of university adopted as in the production industry.	√
(Mohd Anuar, Ravindran and Syed Musa, 2007) [15]	▪ To review the theory and concepts of performance measurement and resource allocation in Malaysian PUs. ▪ To highlight the types and most common performance indicators that are practised Malaysian PUs. ▪ To determine the relationships between performance indicators and the funding mechanism or resource allocation. ▪ To show whether the use of performance measurement and practices are relevant in determining the budget or resource allocation decisions of Malaysian PUs.	-
(Tayib and Amir Hussin, 2001) [16]	▪ To identify and explain the present practice and best practices in budgeting of Malaysian Pus ▪ To provide some recommendations to the Malaysian public universities in improving their budgeting systems	-

II. MOTIVATION OF THE STUDY

Based on the literature review on past studies pertaining to resource and budget allocation of public

universities (Pus) in local country as shown in Table I, only two studies have developed mathematical programming (MP) models for budgeting. One of the studies, which was done by Engku Muhammad Nazri, Syariza and Noorezatty [8], described a mathematical model for a library's budget allocation. Another study was done by Nopiah, Amat Kamarudin, Ismail, Abdullah, and Ahmad [9] which concerned with the university resource allocations.

In the study conducted by Engku Muhammad Nazri, Syariza and Noorezatty [8], a mathematical model was constructed to determine the allocated amount of the library's budget for each faculty, where the faculty's budget allocation model is defined in terms of acquisition of books and journals. On the other hand, Nopiah, Amat Kamarudin, Ismail, Abdullah, and Ahmad [9] presented a priority based goal programming model for resource allocation in university management for better academic performance, where the university's operations were modeled as those in an industry's production. Lack of research on the development of mathematical programming models for budgeting is the main motivation for us to carry out this study. It is geared towards developing a mathematical programming model for optimizing the faculties' budget allocation and utilization in a Malaysian public university setting.

III. Problem Description

Poor budget planning may leads to overruns or overspending, under-spending, spree spending or squander mania and excessive virements towards the end of a year. Overrun or overspending describe a high rate budget spent which is more than what available at hand. In contrast, under-spending refers to the money spent which is much less than the budget allocated, or in other words, the budget is underutilized. Due to the end-of-year appropriation, some departments or faculties may find that they still have substantial budgets unused. This may cause them to involve in spree spending or squander mania in the attempt to utilize this budget.

Virement refers to the budget transfer from one spending vote or allocation to another. This budget transfer is subjected to regulations and policies of the organization. Poor budget planning has the potential of creating an excessive number of virements which subsequently affect the effectiveness in budget utilization. Thus, budget execution and monitoring are essential. The usage of the budget in the course of the year is named budget execution while the monitoring budget during the current year and reviewed at the end of the year is called budget monitoring. Therefore, budget execution monitoring means that the budget is being monitored and reviewed based on the usage of the budget in the current year.

IV. Model Design and Development

In the development of the faculty's budget planning and execution model, we divide the work involved into two phases that are developing conceptual framework and modeling the mathematical model for the budget planning and execution.

In the first phase, we begin with constructing a framework for the budget planning and execution model, as shown in Fig. 1. In this framework, total yearly allocation for faculty i is denoted as T_i whereas the amount to be allocated for faculty i in a quarter j is referred to as A_{ij}. It is determined based on the quarterly budget proportion allocation proposed by this study.

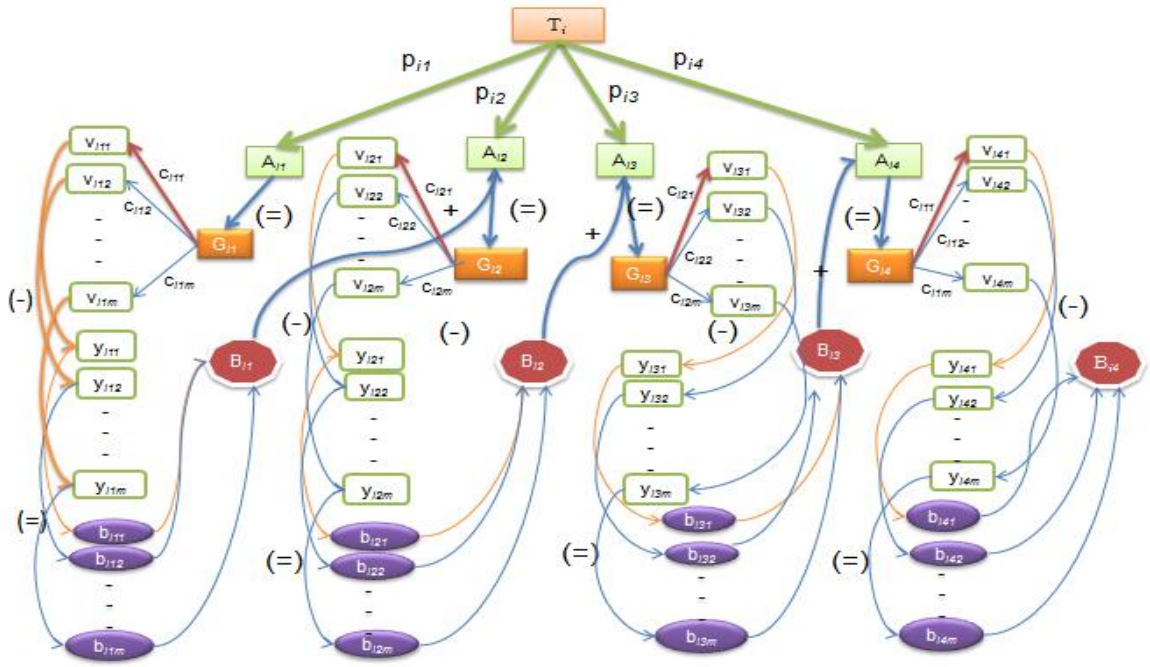

Figure 1. Budget planning and execution framewor

The quarterly allocation is then distributed for activities of the faculty i in quarter j for the project (vote) k, v_{ijk}. The variable x_{ij} represents the proportion that faculty i utilizes in the quarter j such that the total yearly utilization of faculty i is to be X_i. The balance after the utilization of faculty i in quarter j is given by B_{ij}, which is the difference between proposed quarterly allocation (A_{ij}) and quarterly utilization (x_{ij}). The actual allocation given for each quarter for faculty i in the quarter j, G_{ij}, is obtained by adding the quarterly balance from the previous quarter ($B_{i-1,j}$) and the proposed quarterly allocation (A_{ij}). In the case of the first quarter, G_{ij} is equivalent to A_{ij}. The aim of our study is to optimize the balance, B_{ij} so that the budget will be used efficiently.

In the second phase of this study, the model development steps are as follow:

Steps 1: Identification of the underlying assumptions.

Steps 2: The variables, parameters and constants of the model were identified based on data and by using statistical analysis.

Steps 3: Series of formulations are to be carried to formulate the complete model. These model's formulations will require a high analytical skill.

Steps 4: In this step, three proportions of allocation patterns are put forward. These allocation models are determined based on historical budget's utilization of the respective faculties.

Steps 5: Step involves the formulation of the objective function of the mathematical programming model. The objective function is used to find the optimum value for efficiency in the annual budget utilization.

Steps 6: Formulation of the model's constraints is performed. The constraints represent the limitations such as available budget given for each quarter, quarterly vote allocation, total budget given per year, and others.

Steps 7: The formulation of the complete mathematical programming model is done. This step includes checking that all notations and formulations are well in place. If more than one objective function is involved, further steps in prioritizing or weighting the objectives may be required.

Steps 8: The work continues with designing the solution method required for solving the model.

Steps 9: Conduct the computational experiment to perform all necessary numerical calculations.

Steps 10: The model then has to undergo the validation and verification step. If the model does not achieve the desired objective, the model must be refined, otherwise, the model is completed.

V. Model Parameters and Decision Variables

There are numerous ways to distribute allocated budget in a university system. Many past studies have addressed macro level of budgeting which deals with yearly budget allocation planning. However, the micro level budgeting that concerns with the quarterly budget allocation and execution planning is still lacking. The purpose of the quarterly budget allocation and utilization execution model proposed by this study is to assist the faculty management to distribute the allocated budget effectively. This can be done based on quarter yearly, so that the budget can be spent efficiently per quarter based upon certain specified target proportions. Quarterly proportion allocation is defined as percentage allocation of each quarter.

Two formulations for proportion allocations per quarter are involved in this study. The first formulation is to determine the proportion of available budget to be allocated by the faculty for each quarter while the second formulation is concerned with determining the proportion from the quarterly budget allocation to be allocated to each project or vote. These formulations are important features which will be incorporated in the mathematical programming model that to be developed.

Based on the faculties' historical spending data and statistical analysis, three proportion allocation models are proposed to determine the allocation proportion (in percent) for faculty i in quarter j, p_{ij}. These three models are developed since they are anticipated to give the most efficient value for quarterly budgeting which has the potential of maximizing the efficiency of budget utilization for the year. The three proportion allocation models are described below:

Proposed Model 1: The *horizontal line approach*. This model considers equally likely proportion allocations for all quarters.

Proposed Model 2: The *staircase method*. This model follows a certain decreasing pattern.

Proposed Model 3: The *zigzag strategy*. This model describes budget proportion allocations that decreases and increases according to the quarter.

A linear model is used to determine the total amount of the faculty's budget that should be allocated for each quarter. Mathematical formulations involved are as given below:

$$T_i = \sum_{j=1}^{4} A_{ij} = \sum_{j=1}^{4} p_{ij} T_i \qquad (1)$$

$$i = 1,2,\ldots,n,\ \ j = 1,2,3,4$$

where

$$p_{ij} = \frac{A_{ij}}{T_i} \times 100\% \qquad (2)$$

$$p_{ij} \in [0,1] \text{ where, } \sum_{j=1}^{4} p_{ij} = 1$$

P_{ij} is to be determined based on the proposed models.

The budget proportion allocation (in percent) for faculty i in quarter j allocated for project (vote) k, c_{ijk} is determined as the following:

$$\sum_{k=1}^{m} v_{ijk} = G_{ij} \qquad i = 1,2,\ldots,n, \qquad (3)$$

$$j = 1,2,3,4,\ k = 1,2,\ldots,m$$

Therefore,

$$\sum_{k=1}^{m} G_{ij} c_{ijk} = \sum_{k=1}^{m} v_{ijk} = G_{ij}$$

$$i = 1,2,\ldots,n\ ,\ j = 1,2,3,4,\ k = 1,2,\ldots,m \quad (4)$$

We determine historical quarterly proportion of given vote allocation, c_{ijk} by

$$c_{ijk} = \frac{v_{ijk}}{\sum_{k=1}^{m} v_{ijk}} = \frac{v_{ijk}}{G_{ij}} \quad (5)$$

$$c_{ijk} \in [0,1] \text{ where, } \sum_{k=1}^{m} c_{ijk} = 1$$

$$i = 1,2,\ldots,n,\ j = 1,2,3,4,\ k = 1,2,\ldots,m$$

We calculate G_{ij} as below:

$$G_{ij} = \begin{cases} A_{ij} & i = 1,2,\ldots,n\ ,\ \ j = 1 \\ A_{ij} + B_{ij-1} & i = 1,2,\ldots,n\ ,\ j = 2,3,4 \end{cases} \quad (6)$$

$$\Rightarrow G_{ij} = \begin{cases} p_{ij} T_i & i = 1,2,\ldots,n\ ,\ \ j = 1 \\ p_{ij} T_i + B_{ij-1} & i = 1,2,\ldots,n\ ,\ j = 2,3,4 \end{cases}$$

where the quarterly balance of faculty i in quarter j, B_{ij} is equal to total balance after utilization of faculty i in quarter j for vote k, b_{ijk}:

$$B_{ij} = \sum_{k=1}^{m} b_{ijk}$$

$$i = 1,2,\ldots,n\ ,\ j = 1,2,3,4\ , k = 1,2,\ldots,m \quad (7)$$

Quarterly utilization is defined as a utilization of each quarter or a sum of quarterly vote utilization where

$$x_{ij} = \sum_{k=1}^{5} y_{ijk} \quad (8)$$

Thus,

$$B_{ij} = G_{ij} - x_{ij}$$

$$i = 1,2,\ldots,n\ ,\ j = 1,2,3,4 \quad (9)$$

Thus, the objective function of the mathematical programming model is to optimize the variance between allocation and utilization by minimizing the value of B_{i4}.

In the next step of our study, the model for determining the allocation proportion (in percent) for faculty i in quarter j for project (vote), k, c_{ijk}, will be developed. Upon completing all formulations concerning the quarterly budget proportion allocations, P_{ij} and c_{ijk}, the mathematical programming model development will be ensued by formulating the objective functions and constraints of the model.

VI. Conclusion

This paper proposes a quarterly budget allocation model of a public university in Malaysia. The budget planning and execution framework along with steps in the development of the mathematical programming model were presented. For faculty's budget proportion allocation per quarter, three models will be used, namely the horizontal line approach, staircase method and zigzag strategy. The general objective of these models as well as the mathematical programming based budget utilization efficiency model is to assists faculty in managing the allocated budget, where micro level budget allocation can be detailed out and budget utilization can be controlled for greater efficiency.

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