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PRIORITY BUDGET ALLOCATION THROUGH MIXED INTEGER PROGRAMMING

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Abstract

Decision making with priority on allocation and reallocation of university funds is based on the direction of the university, this is translated in strategic planning executed with transparency and accountability. It has become very important, particularly in universities, with recent cut for allocation by the government as a result of global financial crises. This research paper proposes implementation integer programming for strategic budget planning to be applied on the university strategic plan as a part of the strategic planning process. Firstly, the marginal cost consequences was calculated considering the budget allocation from the previous year which was used for budget allocation for the current year through both existing and new introduced strategies used for improving the university rating. Secondly the budget allocation is applied to the university strategies without prioritizing the strategies, thirdly the budget allocation is applied to the university strategies without prioritizing the strategies. The outcome of this implementation using mixed integer programming model showed that the targeted achievements could be realized within the allocated budget that was provided by the university. This mixed integer programming model will be useful and suitable to be implemented by organizations that uses strategies for organizational improvement having limited budget allocation issues.

Keywords: Priority, strategies, budget allocation, mixed integer programming model.

1.0 Introduction

Decision-making is a very important aspect in most organizations are faced with the problem of decision making (Smith et al., 2016). The aim of applying mixed integer programming is to answer the question whether or not to fund a particular strategic activity within the limited availability of resources through the method of prioritization about cost. Availability of resources to fund existing strategies with adequate benefit is needed. The decision to forfeit existing strategies with high funding to new introduced strategies with lower funding and greater benefit is a great importance. PBMA was first introduced in 1950 (Brambleby & Fordham, 2003b) in the USA cooperation with much application in defense department. Then the PBMA was used as a cost accounting tool to display time, deployment of available resources for different military objectives and also in allocation of missiles for destruction of military targets. Later after a decade (Brambleby & Fordham, 2003a), a researcher on PBMA bridge the gap between the military and healthcare application of PBMA procedure. Recently PBMA is an applicable tool for decision making, guidelines for clinicians as well as decisions by manufacturers and management of organizations (Polisena, Tran, & Cimon, 2013).

Mitton, Dionne, & Donaldson (2014) outlined seven steps for PBMA:

1. Determining the goal, aim and scope of the program.
2. Identifying the available resources for funding a program, that is the program budget.
3. Conducting marginal analysis
4. Determining the decision making criteria, to maximize benefits or profits as well as minimization of cost.
5. Evaluating the potential impact of investment and disinvestment in terms of benefit and cost of the activity.
6. Validating the outcome of the model proposed.

Based on the seven steps outlined above, there is a possibility that PBMA can also be applied in

Other organizations with strategic activities using finances such as the university management to improve the university ranking with the limited available resources.

2.0 Research Problem

Strategic plan is used by different universities as a measure for rating the university. The strategic plan is used by the university as a guide and key indicator for progress in assessing the achievement of the university in line with the realities of the educational needs of this millennium (Hinton, 2012). Unfortunately most of this universities set up their strategies without due consideration on the availability of limited availability of resources, with less attention given to the cost of funding each strategy. This will sure lead to mismanagement of resources.

Recently there is a cut in allocation of budget by the government to organizations, with the university system inclusive. With this there is need to change or introduce new strategies, this will bring about three basic questions:

1. Which strategic activity need monetary allocation
2. How is the budget allocation on strategies with and without priority settings

2.1 Research Objectives

The objective of this research paper is to apply PBMA procedure with slight adjustment for budget allocation on university strategies. For illustration purposes, the scope of this research was confined to the selection and budget allocation on both existing and new introduced strategies in the university.

The selection of the activities to be funded through PBMA was executed by:

1. Identifying the strategies with monetary allocation for university strategic plan,
2. Comparing planning and budgeting of the strategies/activities in the university with and without priorities.

3.1 Methodology

Proposed Model:

To optimize the budget allocated by the management university on both existing and new strategies (i.e. assuming that the university management has already decided on the total budget amount to be allocated. The amount then will be fully-utilized to achieve the intended KPIs as much as possible)

Decision Variables:

X_i = number of times strategy i to be implemented

Where

$i = 1, 2 \ldots 10.$

Objective function:

Two objectives were considered simultaneously. The two objectives, listed according to priority are:

1. Objective 1: Minimize D
2. Objective 2: Minimize $w_i d_1 + w_2 d_2 + w_3 + w_{3new} + w_{4newT} + w_{4newI} + w_5 + w_6 + \ldots + w_{10} d_{10}$

Where D = total unused budget that is being allocated by the university management

w_i = weight of each activity $i = 1, 2, \ldots 10$

d_i = point not achieved by strategy i *(i=1, 2,3(old, new), 4(old,newT,newI), 5, …10)*

The preemptive method was used to achieve the two prioritized objectives. To achieve objective 1, the model constraints are as follows.

Constraints:

Constraint 1: Total points to be accumulated for each KPI

$$P_i X_i + d_i = Point_i \qquad (3.1)$$

$$for\ each\ i = 1,2,3(old, new), 4(old, newT, newI), 5, \ldots, 10$$

Where

P_i = expected points that can be accumulated by each strategy i to achieve KPI i.

$d_i = \ point\ not\ achieved\ by\ strategy\ i$

$Point_i$ = total points needed for KPI i.

Constraint 2: Total points to be achieved by all the strategies

$$\sum_{i=1}^{I} P_i X_i \geq 80\%\ of\ SETARA\ point \tag{3.2}$$

Where $i = 1, 2, 3\ (old, new), 4(old, newT, newI), 5, 6, 7, 8, 9, 10.$

Pi = expected points that can be accumulated by each strategy i to achieve KPI i.

D = total unused budget that is being allocated

And

$X_i \geq 0$ and integer.

$d_i >= 0$ and real

$D >= 0$ and real

Here, the total expected points is by summing the points given for all the 13 strategies including the new strategies 3 to local universities, 4newT to international universities in Thailand and 4newI to international universities in Indonesia i.e 2.229 and 80% of the total point is therefore 0.8(2.229) = 1.783.

Constraint 3: Total budget allocated by the university management

$$\sum_{i=1}^{10} \beta_i X_i + D = \ Total\ budget\ allocated \tag{3.3}$$

Where $i = 1, 2, 3(old, new), 4(old, newT, newI), 5, 6, 7, 8, 9, 10.$

βi = total budget needed to implement each strategy i.

And

$X_i \geq 0$ and integer.

Therefore, the entire constraints are as given below.

Constraint set 1:

$0.004X_1 + d_1 = 0.6$

$0.00029X_2 + d_2 = 0.2625$

$0.0007X_3 + 0.0007X_{3new} + d_3 + d_{3new} = 0.3$

$0.0007X_4 + 0.0007X_{4newI} + 0.0007X_{4newT} + d_4 + d_{4newI} + d_{4newT} = 0.3$

$0.0784X_5 + d_5 = 0.250$

$0.00045X_6 + d_6 = 0.145$

$0.0003X_7 + d_7 = 0$

$0.0006X_8 + d_8 = 0.252$

$0.0032X_9 + d_9 = 0$

$0.0001X_{10} + d_{10} = 0.120$

Constraint 2:

$0.004X_1 + 0.0029X_2 + 0.0007(X_{3old} + X_{3new}) + 0.0007(X_{4old} + X_{4newI} + X_{4newT}) + 0.0784X_5 + 0.00045X_6 + 0.0003X_7 + 0.0006X_8 + 0.0032X_9 + 0.0001X_{10} \geq 1.783$

Constraint 3:

$300X_1 + 6000X_2 + 500(X_{3old} + X_{3new}) + 1000(X_{4old} + X_{4newI} + X_{4newT}) + 20000X_5 + 96000X_6 + 96000X_7 + 125000X_8 + 72000X_9 + 500X_{10} + D = \text{total budget allocated.}$

To achieve Objective 2, the same set of constraints used for Objective 1 were used, except for constraint 3. In this case, constraint 3 was replaced by constraint 3* as follows.

Constraint 3*:

$300X_1 + 6000X_2 + 500(X_{3old} + X_{3new}) + 1000(X_{4old} + X_{4newI} + X_{4newT}) + 20000X_5 + 96000X_6 + 96000X_7 + 125000X_8 + 72000X_9 + 500X_{10} + D =$ total budget given by the solution for Objective 1.

4.0 Results Interpretation for Model C Objective 1

Model C is a multi-objective mixed-IP model, involving two objective functions. The model was solved using the preemptive method. The first objective to be achieved was to optimize the total budget that is by the university management for the next round of strategic planning year for both new introduced and existing strategies. Since the budget allocated is not known, we made an assumption that RM 80,000,000 will be allocated by the university management.

Table 4.1 Results for Model C Objective 1

Variable	**80,000,000**
X_1	150
X_2	905
X_3	428
X_{3new}	0
X_4	428
X_{4newI}	0
X_{4newT}	0
X_5	3
X_6	278
X_7	0
X_8	377
X_9	0
X_{10}	20
Optimal value (the minimum unachieved SETARA point)	0.0056

The results in Table 4.1 show than when RM80,000,000 is allocated by the university management, the entire amount will be utilized to achieve as many point as can be achieved with an optimal value 0.0056

1. 150 students development programs with an average of 30 students to be engaged in each program.
2. 905 students being offered scholarship.

3. 428 UUM students to be sent for outbound programs in local universities with credit transfer.
4. No UUM students to be sent for outbound programs in local universities with credit transfer (new introduced strategy)
5. 428 UUM students to be sent for outbound in international universities with credit transfer.
6. No UUM students to be sent for outbound in international universities with credit transfer (new introduced strategy to Indonesia)
7. No UUM students to be sent for outbound in international universities with credit transfer (new introduced strategy to Thailand)
8. Three promotional programs to selected foreign countries to increase the percentage enrollment of international students.
9. 278 staff with industrial experience to be hired.
10. No academic staff with teaching experience abroad will be needed for the next round of budget allocation. This activity has been fully achieved 100%.
11. 377 is the total number of academic staff with PhD
12. X_9 No academic staff should be employed or will be needed for the next round of budget allocation, this activity has been fully achieved.
13. Lastly, 20 staff must be sent for training.

Having achieved objective one, for objective two, is to minimize total budget allocated for the next round of strategic planning, with the allocation of weight to strategies giving priority to strategies with higher rating, the weight allocated to each strategic plan is presented in Table 3.1. Prioritization of each strategy answers the research question 4, budget allocation practices with priority settings with regards to the maximization of benefits and minimization of cost. Objective 2 is analyzed with the allocation of budget 80,000,000 less than the estimated budget as presented in model A; the results are presented in table 4.2.

Table 4.2 Agenda with Weights for Existing and New Strategies

Agenda	Points by SETARA	Weight
X_1	0.6	0.0768
X_2	0.2625	0.0336
X_3	0.6	0.0768
X_{3new}	0.6	0.0768
X_4	0.66	0.0768
X_{4newI}	0.6	0.0768
X_{4newT}	0.6	0.0768
X_5	0.25	0.0320
X_6	0.4	0.0512
X_7	0.3	0.0384
X_8	0.6	0.0768
X_9	4	0.5120
X_{10}	0.2	0.0256

Table 4.3 Results for proposed Model Objective 2

Variable	80,000,000
X_1	150
X_2	905
X_3	428
X_{3new}	0
X_4	428
X_{4newI}	0
X_{4newT}	0
X_5	3
X_6	215
X_7	0
X_8	420
X_9	0
X_{10}	1200
Optimal value (the minimum unachieved SETARA point)	0.0035

The results in Table 4.4 show than when RM80,000,000 is allocated by the university management, the minimum unachieved point (as indicated by *optimal or solution value* = 0.0037).

1. 150 students development programs with an average of 30 students to be engaged in each program.
2. 905 students being offered scholarship.
3. 428 UUM students to be sent for outbound programs in local universities with credit transfer.
4. No UUM students to be sent for outbound programs in local universities with credit transfer.
5. 428 UUM students to be sent for outbound in international universities with credit transfer.
6. No UUM students to be sent for outbound in international universities with credit transfer.
7. No UUM students to be sent for outbound in international universities with credit transfer.
8. Three promotional programs to selected foreign countries to increase the percentage enrollment of international students.
9. 215 staff with industrial experience to be hired.
10. No academic staff with teaching experience abroad will be needed for the next round of budget allocation. This activity has been fully achieved 100%.
11. *420* is the total number of academic staff with PhD
12. X_9 No academic staff should be employed or will be needed for the next round of budget allocation, this activity has been fully achieved.
13. Lastly, 1200 staff must be sent for training.

The minimized unachieved point (as indicated by *optimal or solution value* = 0.0035). The unachieved point for each strategy is less when the each strategy is prioritized.

5.0 Discussion and Conclusion

This research on adjusted PBMA is applicable to are problems with strategic activities for improvement. The Priotization of strategies which are used for ranking the quality of the university. Mixed Integer programming is used for allocation and reallocation of budget on selected activities. The result presented in this study showed for next year of budget allocation, It will be preferable and more beneficial to allocate priorities to every strategy to achieve a higher benefit with the same budget allocation. Prioritization of activities is based on MCC only, in reality, selection of determining preferences of activities by the university management to be founded should be given little consideration, hence preference factor should be included in future work.

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