A Conceptual Paper on Program-Budget Marginal Analysis for Optimal Performance of a University

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Abstract: Conceptual paper on program budget marginal-analysis for optimal performance of a university when making decisions with guidelines and prioritization to answer the question whether or not more needs can be included within existing resources, through the process of prioritization about cost. Appling this concept in the university system for improvement of students' performance as well is improving the university success with limited available resources. A concept through the use of Kpi for university achievement in terms of university success with budgetary allocation using integer programming to get the best ideal solution with maximum benefit and minimized cost.

Key point: PBMA, KPI, Prioritization.

Introduction

PBMA originated in the 1950s in the USA Rand Cooperation, with major application in the defense department in the 1960s. At the time, it was used as a cost-accounting tool to display overtime, deployment of resources for different military objectives, and in allocating additional missiles to destroy military targetsBrambleby, P., & Fordham, R. (2003a), For decades, Alain Einthoven, a researcher on PBMA bridged the gap between military and health care applications in the USA to maximize health gain by deploying available resources for greater benefit Brambleby, P., & Fordham, R. (2003b)Polisena, J., et.al (2013).. Nowadays, PBMA is also being applied for decision making in government funding of research, guidelines for clinicians, as well as pricing decisions by manufacturers and government Ruta, D., Mitton, C., Bate, A., & Donaldson, C. (2005). The main goal of applying PBMA is to answer the question of whether or not more needs can be included within existing resources, through the process of prioritization about cost.

Program budget is a system of budgeting which describes a program or set of activities giving details of cost of carrying out the given activities. Marginal analysis is examining an extra or additional benefit of a set of activities or program compared to an additional cost incurred by that same set of activities or program Drugs, C. A. f., & Health, T. i. (2014). Meanwhile, program-

budget marginal-analysis (PBMA) is a decision making tool for maximization of benefit and minimization of cost through resource allocation to individual program, with the aim of tracking future allocation of resources in the same organizational programs with added benefits [23]

The primary goal of a strategic plan is to identify and assess the key performance indicators (KPIs) in every particular organization. The organizational performance is measured through KPI as a critical process for current and future organizational success providing results and also process of priotization of resources towards achieving greater outcomes Vincent, D., & Nithila, T. (2010). In the context of a university, the KPIs are focused on the achievement of the university in terms of university success. The key measurement of the university achievement is based on the KPI for strategies used in its strategic planBehzadian, M., Otaghsara, S. K., Yazdani, M., & Ignatius, J. (2012). One of the aspects is the improvement of students' achievement through teaching and learningAsmar, C. (2002).

KPI priotization is done in an explicit and transparent form towards management of quality assurance and improvement, facilities and also financial planning. Some of the rating used by Universities rating system such as the QS star, THE, and STAR. QS stars is a university rating system of one to five stars depending on the performance of the university through eight criteria rating of facilities, research, teaching, employability, internationalization, online learning/culture, engagements, special center and access Weis, L. (2016), Symonds, Q. (2011). Used for evaluation of universities in a broader range about establishing thresholds rather than the performance of other universities, aimed at allowing universities to be the best, irrespective of size, with a mission for greater excellence with increase media awareness, improve institutional awareness, international recognition and also opportunity to reach out to prospective students Wan Husain, W. (2012). THE (times higher education) founded 2004 for university ranking in providing a transparent list of world's best university. The evaluation uses different criteria such as research, teaching, internationalization, employability etc. in providing vital resource for prospective students and a system trusted by government and universities. Also STARS (sustainability tracking assessment and ranking system) a frame work for universities and colleges with transparency in measurement for sustainable performance. A long term sustainability goals are encompassed for highly achieved universities as well as entry points for

recognizing institutions that are moving towards sustainability in all sectors of higher institutions through meaningful comparison among universities, creation of incentives for continuous improvement of an institution, information sharing about performance and also building a stronger and more diverse university community Fitzgerald, H. E., Bruns, K., Sonka, S. T., Furco, A., & Swanson, L. (2016).

Problem Statement and Aims of Conceptual Paper

Strategic plans used as guide and key indicator for program progress in most universities unfortunately are set up without much consideration on scares (limited) resources available. When less attention is given to the availability of resources, this may lead to mismanagement of funds. Most measures used to improve university performance has been greatly studied but little attention is given to cost of improving the performances. This conceptual paper will concentrate on management of resources through allocation and reallocation of resources to improve performance through cost effectiveness with maximized benefit.

The cost of each strategic plan, marginal cost-effectiveness for attending such strategies and also the budget allocation practice through priority setting with much emphasis on maximization of benefit and minimization of cost will proposed as the aim of these research paper. The study will focus on students' achievement about quality of education services delivery, and outcomes of students produced with cost of result achievement. Introducing PBMA procedure in an academic sector, which is widely used in the health sector. This concept will be of great importance to the university management authority on budgetary plan through cost-effectiveness of allocation and reallocation of funds with an explicit and transparent manner with maximum benefit through identification of value, comparison of strategies and hence measurements.

Literature Review

Confronted with limited resources, choices needs to be made on specific strategies to fund and not to fund about achieving the targeted KPI. Priority settings and making decisions on allocation and reallocation of limited resources must be executed with transparency and accountability. PBMA is a technique suitable for marginal analysis towards the achievement of reviewed KPI. MCDA technique can be used to decide which current strategy should be

maintained and which needs to be replaced by new strategies. Integer programming will be introduces to take care of the budgetary allocations.

Program-Budget Marginal-Analysis (PBMA)

PBMA is an economic evaluator technique for setting priorities in decision making. It is initiated with the aim of applying an economic framework to allocation and reallocation recommendations to improve benefit with minimized cost with limited available resources Karande, C., Mehta, A., & Srikant, R. (2013),Smith, N., et.al (2016).. The goal of applying PBMA is to answer the question of whether or not there is a reason to continuous the present strategy or changes has to be made about priotization with cost, techniques to priotization of strategies based on PBMA are mainly five Clark, M. D., et.al (2014), economic evaluators namely cost-effectiveness analysis CEA, CCE,CUA,CMA,CBAMitton, C., Dionne, F., & Donaldson, C. (2014).

Cost-Efficiency Analysis (CEA)

CEA is used as a method of assessing services with maximized benefit and also as priority setting in organizations aimed at benefitting public services in making decisions. The basic requirement for this economic evaluator is a fixed budget constrain, when there is a single objective for the strategic activities Kind, P., Lafata, J. E., Matuszewski, K., & Raisch, D. (2009).

Cost-Benefit Analysis CBA

CBA is regarded as the direct economic evaluation in monetary terms.Mishan, E. J. (2015). It has a single measurement for various outcomes and also allows for comparison in different multiple outcomes comprising of social and financial cost benefits. The major disadvantage with CBA is uncertainty and quantifying of alternatives in monetary value, which is the major source of in accuracy in cost-benefit analysisHall, W. (2013).

Cost-Utility Analysis CUA

CUA is most times regarded as a special case of CEA, it is used by policy makers to determine priorities. It estimates the ratio between cost and benefit of each strategy to an individual Mitton,

C., & Donaldson, C. (2001). It deals with individuals not group of individuals and gives room for comparison between strategies with complete analysis of total benefit compared to other economic evaluators. One of its greatest disadvantage is both cost and social benefit are not considered rather individual benefit Morris, S., et al (2016).

Cost-Consequences Analysis CCA

CCA is mainly used to assess the impact of strategic plans, the cost and outcomes of each strategy in disaggregated format for the purpose of showing trends, patterns and insight that cannot apply in an aggregated set of data. It actually improves the transparency of CEA, CBA, CMA, Miller, A. R. (2012), Goldstein, I., & Sapra, H. (2013). Compares interventions across different sectors and report them separately. The economic evaluation process accepts the fact that different types of benefits cannot be compared using the same unit, hence making the CCA process an important technique with multiple outcomes with different units and perspectives.

Although PBMA is mostly applied in the health sector, it can also be applied to other organizations with slight modifications to weigh alternatives and decision making based on the best alternatives.

Multi-Criteria Decision-Analysis MCDA

Deciding who gets what and who get a priority when allocating resources generally is a difficult challenge. The basic decision making cannot be applied, else uncorrected mistakes might be made with situations that are irreversible with substantial consequences Sullivan, T. (2012). In such situations decision aids are needed for decision making, especially when variety of choices are to be made. MCDA is an important branch of operational research dealing with different, difficult decision making, is a common tool used for decision making in broad fields such as medical, mathematics, psychology, economics, business etc. in making a logical, important, explicit as well as transparent decisions.

MCDA has different methods of implementation used as criteria weight for decision making. These weight are applied directly or indirectly, the direct method is also known as the traditional method of MCDA. The indirect method is a situation of incomplete information such as DCE, AHP, TOPSIS, and PAPRICA Clark, M. D., Determann, D., Petrou, S., Moro, D., & de Bekker-Grob, E. W. (2014).

SMART and SWING

This works in two stages, firstly the criteria will be ranked according to importance, from the highest/ most important to the lowest/ less important. The weight of the alternatives reflects the range and importance of alternatives. Secondly SWING considers the level of criteria when evaluating the weight of the criteria in hypothetical alternative where all criteria are at worst level. A decision maker identifies the most Edwards, W., & Barron, F. H. (1994), Clark, M. D., et.al (2014). Important alternative to be moved from the worst to the best level, which is then allocated higher point continuously until the worst alternative with fewer points Danielson, M., Ekenberg, L., Larsson, A., & Riabacke, M. (2014).

Discrete Choice Experiment (DCE)

This method uses statistical tools to choose between two or more alternatives, estimation of the weight are done using statistical tools. Choice set depends on the total number of attributes level and experimental designs. When the number of attributes increases the number of potential profiles increases exponentially Ryan, M., et.al. (2007), Clark, M. D., et.al (2014). Most statistical designs such as factorial, probit, logit and also multinomial logit can be used to produce weights, respondent grouping terms of interaction can be included also in the statistical model through the process of taking the average weight of all responses.

Technique for Order Preference by Similarity and Ideal Solution (TOPSIS)

TOPSIS is also a classical MCDA based on the chosen alternative should be allocated the shortest distance from the positive ideal solution and on the other side the farthest distance from the negative ideal solution Chakraborty, S., & Yeh, C.-H. (2009). TOPSIS uses mathematical concept, it is easy to use, efficiency in computation and has a good ability to measure alternative performances in a mathematical form, through index by combining the closest to positive ideal solution and remoteness to the negative ideal solution, the index is therefor used to rank the competing alternative Behzadian, M., et.al (2012)Chakraborty, S., & Yeh, C.-H. (2009).

Analytic Hierarchy Process (AHP)

AHP is used for prioritizing alternatives when a multiple criteria is being considered by a decision maker. It is applied widely in variety of fields such as economics and management for

purchase and supply alternatives Jain, R., & Rao, B. (2013), Podvezko, V. (2009), in medical organization in deciding alternative treatment Hall, W. (2013), and also engineering and computer. Kumar, S. (2014), The AHP process is structured in hierarchy, the hierarchy consist of three levels known as goal, criteria and alternatives. The AHP process begins with determining the relative importance of the criteria in meeting the stated goals. The next step is measuring the extent to which the alternatives achieves each of the criteria. The last step is the results of the two analysis synthesized to compute relative importance of the alternatives towards meeting the goal.

The major disadvantage of the AHP process is rank reversal. This occurs when adding or removing an alternative. However an ideal mode AHP ranks are kept constant when an alternative is removed or added [25]. The next problem is consistency of the pairwise comparison matrices. Although revised AHP approach by Balhuwaisl can be used to solve this problems.

Balhuwaisl's Revised AHP Technique

These revised approach utilizes Saaty's likert scale of 1 to 9 and hybrid with the existing pairwise comparison. In this approach a decision maker is asked to rank the level of importance of each alternative to determine the final selection of alternatives using Saaty's procedure of nine likert scale. The next step will be the likert scale evaluations converted into Saaty's pairwise comparison tables by doing so the proposed AHP by Balhuwaisl pairwise comparison will always be consistent regardless of the number of attributes that are analyzed.

Having identified the strategies and its contribution towards achieving the KPI's, the next step will be identification of strategies to use for proper budget allocation for each strategy. The most convenient process for implementation of proper budget to alternatives is the linear programming which is suitable for problems with multiple constrains such as project selection and resource allocation problem Saaty, T. L. (2008).

Integer Programming (IP)

IP is a mathematical process applied for modelling as well as simulations to get the best possible ideal solution in planning, routing, scheduling, assessing and allocation of limited resources for maximum benefit with minimized cost. IP is used for priority setting in determining the set of

alternatives, strategies, project to be implemented based on budget allocation for maximization of benefit with minimized cost [30].

The general IP model for planning and resource allocation may appear as follows:

Decision Variables:

$$X_i = \ the\ number\ of\ times\ strategy\ i\ to\ be\ implemented$$

Where

$i = 1\ldots\ i_1, i_{1+1}\ldots i_2\ \ldots I,$

With $1\ldots\ i_1$ = strategies to achieve KPI 1, $i_{1+1}\ldots i_2$ = strategies to achieve KPI 2, and so on.

Objective function:

$$Min\ f(x) = \sum_{i=1}^{I} \beta_i x_i \qquad \text{Equation 1}$$

Where f(x) = total budget needed

βi = total budget needed to implement each strategy i.

Constraints:

Constraint 1: Total points to be accumulated for each KPI

$$\sum_{i=1}^{i_1} p_1 x_i \ \geq Point_1 \qquad \text{Equation 2}$$

Where

p_1 = expected points that can be accumulated by each strategy 1 to achieve KPI 1.

$Point_1$ = total points needed for KPI 1

$$\sum_{i=i+1}^{i_2} \ p_i x_i \ \geq Point_2 \qquad \text{Equation 3}$$

And so on.

$x_i \geq 0$ and integer

Methodology

Methods for this conceptual paper, the approach sparked by slight modification of PBMA to suit the current is elaborated as follows

Step 1: identification of strategies

This involves identification of the current strategies used by the university system as the strategic plans.

Step 3: The Calculation of the Marginal Contribution of Each Strategy towards Achieving the Goal

The marginal contribution is calculated using cost-effectiveness and hence cost-consequences

$$strategy\ A = \frac{net\ cost\ of\ strategy\ \ A}{net\ profit\ \ of\ strategy\ \ A}$$ Equation 4

To perform the CCA the effectiveness of each strategy of the specific KPI will be calculated to get the maximum quality gained from each strategy among the existing KPIs with respect to the cost of the strategy and the benefit obtained.

$$Strategy\ A = \frac{net\ cost\ of\ strategy\ \ A}{net\ benefit\ \ of\ strategy\ \ A} = \frac{dollar}{quality\ \ gain}$$ Equation 5

This analysis results in periodization through allocation and reallocation of limited resources to the most effective KPI's on student achievement. New alternative plans can be compared and introduced especially when key performance indicators are involved.

Step 4: The Introduction of New Strategies

New strategies believed to improve students' achievement for the next circle of strategic plan should be introduced. The new strategies should be suggested and evaluated from management team on strategic plans believed to enhance students' achievement. Evaluation of the new strategy should be done using the revised AHP process by Balhuwaisl. Firstly the potential level

of each strategy should be rated on Saaty's nine likert scale with 11 allocated to the least effective and 9 allocated to the most effective strategy.

Table 1.2 Criteria and Rating to Use

Criteria	**Rating**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
A				*					
B					*				
C							*		
D					*				
E		*							

The new strategy should be compared with existing strategies using the same rating in the table 2 above.

Step 4.1: the ideal targeted achievement for each strategy should be set by the decision maker. When the ideal is greater than the actual achievement for a particular strategy the ideal target will be used as the bench mark value for evaluation. Else the actual achieved will be used as the bench mark value. Example the ideal targeted number of first class student is 300 and the actual achieved number is 250 students, then 300 will be used as the bench mark since it has the highest number of students.

Step 4.2: achieved result from each strategy should be converted to Saaty's nine (9) likert scale through the following formula,

$$converted\ rating = \frac{value\ \ to\ be\ converted}{benc\ h\ mark\ \ value} * 9 \qquad \text{Equation 6}$$

Applying the formula to the above example in step 4.1

$$converted\ rating = \frac{250}{300} * 9 = 7.5$$

The value should be rounded up to a whole number. For maximization problem the rating should be left "as it is" else a symmetrical value should be used for minimization problem. Once all the strategies including the new and old are given rating, the rated values are thus transferred into Saaty's AHP pairwise matrix

$C = [c_{ij}]_{n \times n}$ Where n = total number of strategies. The process will be as follows:

Suppose the rating for strategy i is r_i and the rating for strategy j is equal to r_j. Then c_{ij} will be evaluated as the value of comparison between criteria i and j as follows:

Let $b = r_i - r_j$

If

$$b > 0 \; then \; c_{ij} = b + 1 \qquad \text{Equation 7}$$

$$b = 0 \; then \; c_{ij} = 1 \qquad \text{Equation 8}$$

$$b < 0 \; then \; c_{ij} = \frac{1}{(1 - b)} \qquad \text{Equation 9}$$

When the matrix is obtained, the evaluation of each criteria can be done using the usual AHP technique. Matrix synthelization, matrix normalization and matrix consistency test are all involved.

The result of the evaluation will be very important for priority weight for the strategies for a particular KPI. The choice for appropriate and relevant strategy to be used is regarded as an MCDA problem relating to different factors. The last step to be considered is the budgetary allocation to each strategy, which will depend on the total budget allocated to achieve expected points from each strategy and also important weight by AHP process for a proper priority allocation to the strategies.

Step 6: The Determination of Strategies and the Allocation of Budgets using 0-1 ILP

Two possible IP mathematical models, i.e. model A and model B can be developed. The model are as follow:

Model A: To decide the total budget required in order to achieve the KPI 100% (i.e. the total budget to be allocated by the university management will be decided once this model is analyzed).

DecisionVariables:

$$X_i = \textit{the number of times strategy } i \textit{ to be implemented}$$

Where

$i = 1\ldots i_1, i_{1+1}\ldots i_2 \ldots I,$

With $1\ldots i_1$ = strategies to achieve KPI 1, $i_{1+1}\ldots i_2$ = strategies to achieve KPI 2, and so on.

Objective function:

$$Min\ f(x) = \sum_{i=1}^{I} \beta_i x_i \qquad \text{Equation 10}$$

Where f(x) = total budget needed

βi = total budget needed to implement each strategy i.

Constraints:

Constraint 1: Total points to be accumulated for each KPI

$$\sum_{i=1}^{i_1} p_1 x_i \geq Point_1 \qquad \text{Equation 11}$$

Where

p_1 = expected points that can be accumulated by each strategy 1 to achieve KPI 1.

$Point_1$ = total points needed for KPI 1

$$\sum_{i=i+1}^{i_2} p_i x_i \geq Point_2 \qquad \text{Equation 12}$$

And so on.

$x_i \geq 0$ and integer

Model B: To optimize the budget allocated by the management university (i.e. 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:

$$X_i = \text{the number of times strategy } i \text{ to be implemented}$$

Where

$i = 1 \ldots i_1, i_{1+1} \ldots i_2 \ldots I,$

With $1 \ldots i_1$ = strategies to achieve KPI 1, $i_{1+1} \ldots i_2$ = strategies to achieve KPI 2, and so on.

Objective function:

$$Min\ d$$

Where d = total unused budget that is being allocated

Constraints:

Constraint 1: Total points to be accumulated for each KPI

$$\sum_{i=1}^{i_1} p_1 x_i \leq Point_1 \qquad \text{Equation 13}$$

Where

p_1 = expected points that can be accumulated by each strategy 1 to achieve KPI 1.

$Point_1$ = total points needed for KPI 1

$$\sum_{i=i+1}^{i_2} p_i x_i \geq Point_2 \qquad \text{Equation 14}$$

And so on.

Constraint 2: Total budget allocated by the management

$$\sum_{i=1}^{I} \beta_i x_i + d = TotalBudgetAllocated \qquad \text{Equation 15}$$

βi = total budget needed to implement each strategy i.

And

$x_i \geq 0$ and integer

Both models will be run with the help of QM for windows or LINGO software when the data points are more than 25 points.

Conclusion

Budgeting is an important aspect of any organization, it is essentially used to control the efficiency of operations in every management system including the university system. To achieve the objective of improving students achievement with greater benefit with minimized cost about allocation of funds to strategies. Identification of the most effective strategies to be allocated and reallocated much priority with proper monetary funding will improve students' achievement outcome significantly.

Important choices needs to be made, due to finite resources, economic evaluation helping to assist in decision making process for prioritization of strategies is based on the output from the economic evaluator conducted through the revised AHP approach. Implementing PBMA technique with MCDA will help in identification, evaluation and priotization of strategies to achieve the set goal with explicit transparent and cost-effectiveness. The PBMA is a straight forward approach for measurement and evaluation focused on result accomplishment with priotization of resources to meet the performance criteria.

The budgetary allocation on the right KPI for students' achievement should be able to answer the following questions,

I. Have the student performance improved through the strategies?
II. How effective is the cost allocation to all strategies.
III. Should more funds be allocated or reallocated to other existing or new strategies?

Lastly leadership is key, even when the perfect resources allocation is done on strategies it will fail if not managed well changes occurs when a mistake is done or when an unusual opportunity surfaces. The best time to plan on strategies is when things are going well, finally don't let the economic challenges an excuse for not acting.

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