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Architecting Decision Support System for Allocating Budget at Egyptian Universities

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Abstract The main objective of this study is to optimize the budget allocation process for various organizational units in the university. For that, university budget allocation system based on multi-level quadratic optimization model is suggested. The objective function of the proposed system is to minimize the sum of the quadratic deviations of each allocation from its lower and upper limits. The proposed system is applied based on the budget of Sohag University as a case study. The results indicate that the proposed system can be used to support decision making for optimal financial planning.

Keywords: *budget allocation, budget requirement, multi-level optimization, quadratic optimization*

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1. Introduction

The university's budgeting is an imperative annual planning document, which reflects the available choices, priorities and strategies set forth as the aftereffect of intensive planning. The aim of the budgeting strategy is determining the optimal distribution of limited budgetary resources among competing alternative projects for enhancing the university's ability to meet changing institutional needs, prevent the extension of base operations beyond current revenue capacities, and the optimal usage of a limited budget [1,2].

University faces a difficulty to perceive the future year's allocated funding. For that, it tries to predict the required fund based on the requirements of its related organizational units. Organizational units may be faculties; central departments; or any other distinct staff or students-oriented operational activity, which has the following characteristics: Organizational permanency; Programmatic autonomy. However, it is difficult to realize effective budget allocations manually because related organizational units make competing claims for funding; also, if the resources are allocated to each unit individually, the aggregate outcome appears not to make the ideal and fair utilization of the total resource, and may resist implementation. [3]

Due to the complication of the activities and decision-making environment in the university and expanding the number of variables, activities and objectivities; university budget allocation process among conflicting plans becomes a very hard problem. As a result, designing an effective system based on mathematical models has become one of the most attractive interests of university strategists [4]. The university budget allocation process is Multi-Level Programming (MLP) problem [5,6], where each related organizational unit suggests its own budget requirements for the upcoming fiscal year. After that, these individual budget requirements are aggregated and arranged hierarchically to produce the overall university budget. These requirements are arranged based on two standards: the rate of requirements and the rate of priority level for each organizational unit.

In [7] Nopiah et al. introduced a priority based goal programming model for resource allocation in Malaysian public university, where the university's operations were modeled as those in an industry's production. The model comprised of 19 decision variables which were divided into 2 classifications: products and resources. There were 4 objectives and 30 constraints, which all were converted into goal forms, and were arranged into 3 priorities which were solved using Goal Programming algorithm. Safari et al. [8] was aimed at offering an Integer lexicographic goal programming model for university budget allocation by considering it as a manufacturing system. The coefficients and constants have all been extracted based on analyzing research and educational aspects of Shahed University. The model had 36 decision variables that were broken down into two classes of university sources and university products variables.

L. Zamfirescu and C. B. Zamfirescu [9] developed a mathematical model for the budgeting system. The model considered only the final allocation of public funds. The model had been implemented in a spreadsheet tool and built using the goal programming optimization method. The model was exemplified for a sample of budgeting from the Romanian Ministry of Health. Abdul Aziz et al. [3] constructed a mathematical model for the budget planning that aimed at optimizing the efficiency of budget

utilization of faculties of a public university in Malaysia. Three strategies were used, namely the horizontal line approach, staircase method and zigzag strategy. These strategies were determined based on analysis of past data. A linear model was used to determine the total amount of the faculty's budget that should be allocated for each quarter.

In [10] Maijama'a and Abu Bakar showed how integer programming model was used to help one of the government-funded Malaysian universities (U-XYZ's university) for allocating its budget to accomplish its research and publication agenda. Two models were developed. The first model was to determine the minimum amount of budget that should be allocated to achieve its objective for research and publication agenda. The second model was to decide the proper strategy to maximize the aggregate rating score acquired, subject to the total budget allocated.

Based on the literature review on past studies pertaining to resource and budget allocation of public universities, we can conclude that there are no studies have developed a multi-level quadratic based system for optimizing the efficiency of university budget allocation process. This lack of research is the main motivation for us to optimize the budget allocation problem in the university by suggesting university budget allocation system based on a multi-level quadratic optimization model.

This proposed system will enable decision makers in the university to: Prioritize the activities based on certain objective; Distribute the budget allocated based on certain criteria; Improve balancing between the development mission of a university and its strategic priorities; Determine the minimum amount of budget required for organizational units in the university, which encourage them to set priorities and develop new executable activities.

The remainder of this study is organized into the following sections: In Section 2 a brief description of the budget allocation process at Egyptian Universities is provided. Section 3 proposes the university budget allocation system based on the multi-level quadratic optimization model. Experimental results are outlined in Section 4, and lastly, conclusions are represented in Section 5.

2. Budget Allocation Process at Egyptian Universities

Budget decisions are expected to have clear linkages to the goals of the university's strategic plan, and provide a balance between the demands and the resources available. The budget allocation process in Egyptian Universities is accomplished in two separate stages: budget planning, and budget documentation. In the **budget planning stage**, each organizational unit in the university responsible for developing or building its own budget, which includes initial anticipated allocation amount about what is needed for the upcoming fiscal year. After that, the University Plan and Budget Committee integrate the individual budgets to produce the overall university budget and forward it to the Supreme Council of Universities for approval.

In the **budget documentation stage**, the University Plan and Budget Committee is required to document the detailed allocation of resources within their respective budget units, and load the approved university budget into the budget system for implementation, which will be distributed to the related organizational units.

The financial budget of the Egyptian Universities is developed based on specified format called the economic classification. This classification is a characterization of expenditures and resources according to the economic transactions involved or in ways that confirm the economic nature of the transactions, such as, salaries, goods and services, or transfers and interest payments. The economic classification consists of two sides: resources side, which illustrates from where the money in the budget comes; and uses side, which illustrates what will the money in the budget buy. On the resources side, the economic classification is organized into five chapters. On the uses side, the economic classification is organized into eight major chapters. Each chapter in both sides is divided into groups and each group is further disaggregated into line items [11]. Table 1 shows how the economic classification for the budget would look.

The public Egyptian Universities care solely with uses (total expenditure) side in the economic classification because they are non-profit organizations; they have no one for whom it must maximize its profits. They are predominantly funded by public funding sources through the government, as opposed to private universities. Accordingly, this study will be focused only on uses side. Some of the chapters in uses side are more important than others in budget terms of the Egyptian Universities, in that they make up larger shares of the university budget than others, such as: Wages and Compensation of Employees; Purchase of Goods and Services; Subsidies, Grants, and Social Benefits; and Other Expenditures.

Table 1. Economic classification of the budget

Uses (Total Expenditure) Side	
I.	General Expenditure
1. Wages and compensation of employees 2. Purchase of goods and services 3. Interest 4. Subsidies, grants, and social benefits 5. Other expenditures 6. Purchase of nonfinancial assets (investments)	
II.	Acquisition of Assets
7. Acquisition of domestic and foreign assets	
III.	Loan Repayment
8. Domestic and foreign loan repayment	
Resources (Total Revenue) Side	
I.	General Revenue
1. Taxes 2. Grants 3. Other (nontax) revenue	
II.	Funding resources
4. Receipts from lending and sales of financial assets 5. Borrowing and sales of securities	

3. A Proposed Multi-Level Quadratic University Budget Allocation System

3.1. A Proposed Multi-Level Quadratic Optimization Model

At first, we have to recognize the difference between two significant terms: budget requirement and budget allocation for each organizational unit in the university. Initially, budget requirement is the initial estimated expenditures required for implementing functions, projects or service plans, which are suggested from the related organizational units in the university, this requires both objective and subjective analyses of how the function employments. On the other hand, budget allocation is the actual amount of resources, to be applied towards the needs of each organizational unit in the university, taking into consideration a given allocation limits, which meets the requirements either completely or partially. Without allocation limits, expenditures can surpass revenues and result in fiscal deficit. The allocated budget is usually less than the required budget; this is because the funds given to the organizational units are usually less than what is requested.

In this study, an efficient Multi-Level quadratic optimization model is suggested to handle a given yearly university budget, after its approval by the Supreme Council of Universities, and allocate this approved university budget for each related organizational unit in the university with high performance fairly and precisely. Notable studies have been carried out in the area of the Multi-Level quadratic programming problems [12,13,14,5].

The expected allocation for each organizational unit, which will be resulted from the proposed model, has lower and upper limits. The lower limits are gotten from the budget allocations of the organizational units in the previous fiscal year, while the upper limits are gotten from the budget requirements of the organizational units for the upcoming fiscal year. The objective function of the proposed model is to minimize the sum of the quadratic deviations of each expected allocation from its lower and upper limits; the constraints are linear. The optimal solution is a compromise between the upper and lower limits of each unit.

The proposed model is a decentralized or MLP problem, where each level presents the objective function of each organizational unit independently. These organizational units' levels are arranged hierarchically based on two standards: the rate of requirements and the rate of priority level (or importance) for each organizational unit. Each unit can have one of the following priority levels: Urgent priority; High priority; Normal priority; or Low priority. The priority levels are designed to characterize the impact and the urgency of the budget items for each organizational unit, based on the context of each organizational unit and the criteria that it may need to be considered for assigning the priority level. Each priority level can have one of the following criteria levels: National criteria; Local criteria; Organizational criteria; or Special criteria. Based on the above, the mathematical formulation of the proposed model can be considered as given below:

[FLDM]

$$\underset{\mathbf{x_j}}{\text{Min}}\, F_1(x)=\sum_{j=1}^{m}\frac{1}{W_{x_j}}\left(\left(x_j-U_{x_j}\right)^2+\left(x_j-L_{x_j}\right)^2\right), \quad (1.a)$$

[SLDM]

$$\underset{\mathbf{y_j}}{\text{Min}}\, F_2(y)=\sum_{j=1}^{m}\frac{1}{W_{y_j}}\left(\left(y_j-U_{y_j}\right)^2+\left(y_j-L_{y_j}\right)^2\right), \quad (1.b)$$

[n^{th} LDM]

$$\underset{\mathbf{t_j}}{\text{Min}}\, F_n(t)=\sum_{j=1}^{m}\frac{1}{W_{t_j}}\left(\left(t_j-U_{t_j}\right)^2+\left(t_j-L_{t_j}\right)^2\right), \quad (1.c)$$

Subject to:

$$\left(x_j,y_j,\ldots,t_j\right)\in G,\left(j=1,2,\ldots,m\right), \quad (1.d)$$

Where

$$G=\left\{\begin{array}{ll}\sum_{j=1}^{m}x_j+y_j+\ldots+t_j\le B, & \\ L_{x_j}\le x_j\le U_{x_j} & \left(j=1,2,\ldots,m\right),\\ L_{y_j}\le y_j\le U_{y_j} & \left(j=1,2,\ldots,m\right),\\ L_{t_j}\le t_j\le U_{t_j} & \left(j=1,2,\ldots,m\right),\\ x_j+y_j+\ldots+t_j\le B_j & \left(j=1,2,\ldots,m\right),\\ x_j,y_j,\ldots,t_j\ge 0 & \left(j=1,2,\ldots,m\right).\end{array}\right\}$$

The definition of each decision variable used in the proposed mathematical model is described in Table 2.

Table 2. The variables used in the model

The variable	Description
F_i	First level, second level and n^{th} level quadratic objective functions, respectively.
$x_j, y_j, \ldots, t_j$	The expected amounts allocated for each line item j to first, second and n^{th} organizational units respectively.
W	Non-negative weights of the line items. The weights can be equal for all the levels (W = 1)
G	Linear constraint set.
$L_{x_j}, L_{y_j}, \ldots, L_{t_j}$	Real constants indicating the lower limits allocated in the previous year for each line item j to first, second and n^{th} organizational units respectively.
$U_{x_j}, U_{y_j}, \ldots, U_{t_j}$	Real constants indicating the upper limits required in the upcoming year for each line item j to first, second and n^{th} organizational units respectively.
B	The overall amount of university budget allocated from the government.
B_j	The amount of university budget allocated for each line item j from the government.

3.2. A Proposed Algorithm for Multi-Level Quadratic University Budget Allocation System

The proposed algorithm of the university budget allocation system based on the proposed multi-level quadratic optimization model can be summarized in two phases, as follows:

Phase I: Estimate the budget requirements by the organizational units in the university: This phase is achieved by the following steps:

1. Each related organizational unit can log in to the proposed university budget allocation system for building its own budget requirements, as follows.
2. Get line_items, which represent the line items that are required from the university budget for each related organizational unit.
3. For each single_line_item in line_items
   3.1. Determine the initial amount estimated for this single_line_item to support the required resources for the organizational unit, which is called "organizational_unit_budget_requirement".
   3.2. For this single_line_item, chose the priority level's id (Urgent; denoted by A, High; denoted by B, Normal; denoted by C, Low; denoted by D) and the criteria level's id (National; denoted by R0, Local; denoted by R1, Organizational; denoted by R2, Special; denoted by R3) to arrange the line items from the most to the least important.
   3.3. Each priority level and criteria level has a specific value, which defines the rate of importance for this single_line_item, as follows:

Priority_id	Priority_level	Priority_value
A	Urgent priority	100
B	High priority	75
C	Normal priority	50
D	Low priority	25

Criteria_id	Criteria_level	Criteria_value
R0	National criteria	0
R1	Local criteria	5
R2	Organizational criteria	15
R3	Special criteria	20

   3.4. Compute total_priority = (Priority_value – Criteria_value) / 100.
   3.5. The system records this information related to this single_line_item in a database for later retrieval.
4. Next

Phase II: Allocate the approved university budget by the proposed system unit fairly: is achieved by the following steps:

1. After approving the university budget by the Supreme Council of Universities, the university receives its approved budget. Then, the line items of the approved university budget are loaded in the university budget allocation system.
2. Get related_organizational_units, which represent all related organizational units in the university that have requirements in the approved university budget.
3. Get sum_budget_requirements and sum_total_priority for all related_organizational_units.
4. For each single_organizational_unit in related_organizational_units
   4.1. Get organizational_unit_budget_requirement and organizational_unit_total_priority for this single_organizational_unit.
   4.2. Set organizational_unit_average_arrange = arrange_average_value(organizational_unit_budget_requiremet, sum_budget_requirements, organizational_unit_total_priority, sum_total_priority).
5. Next
6. Arrange the related_organizational_units according to the computed values of organizational_unit_average_arrange, which are called "arranged_related_organizational_units", and records these values in a database.
7. Get overall_approved_budget; denoted by B, which represent the total approved university budget allocated from the Supreme Council of Universities.
8. Get arranged_related_organizational_units.
9. Set i = 1, which indicating the i^{th} LDM for the arranged_related_organizational_units.
10. For each single_arranged_organizational_unit in arranged_related_organizational_units
    10.1. If overall_approved_budget > 0 then
        10.1.1. Get unit_line_items, which represent all line items that are required from the approved university budget for this single_arranged_organizational_unit.
        10.1.2. Get sum_unit_line_items_requirements and sum_unit_line_items_total_priority for all unit_line_items related to this single_arranged_organizational_unit.
        10.1.3. For each single_unit_line_item in unit_line_items
            10.1.3.1. Get unit_line_item_budget_requirement and unit_line_item_total_priority for this single_unit_line_item.
            10.1.3.2. Set unit_line_item_average_arrange = arrange_average_value (unit_line_item_budget_requirement, sum_unit_line_items_requirements, unit_line_item_total_priority, sum_unit_line_items_total_priority).
        10.1.4. Next
        10.1.5. Arrange the unit_line_items related to this single_arranged_organizational_unit according to the computed values of unit_line_item_average_arrange, which are called "arranged_unit_line_items".
        10.1.6. Get arranged_unit_line_items for this single_arranged_organizational_unit.
        10.1.7. For each single_arranged_unit_line_item in arranged_unit_line_items
            10.1.7.1. Get unit_line_item_budget_requirement (upper limit) for this single_arranged_unit_line_item.
            10.1.7.2. Get unit_line_item_previous_budget_allocation (lower limit) for this single_arranged_unit_line_item.
            10.1.7.3. If unit_line_item_previous_budget_allocation Is NULL then

10.1.7.3.1. Set unit_line_item_previous_ budget_ allocation = (50 /100) * unit_line_item_budget_ requirement.
10.1.7.4. End if
10.1.7.5. Get line_item_approved_budget; denoted by B_j, which represent the allocation form the approved university budget for this single_arranged_unit_line_item.
10.1.7.6. If unit_line_item_budget_requirement > B_j
10.1.7.6.1. Set unit_line_item_budget_gap = unit_line_item_budget_ requirement – B_j
10.1.7.6.2. Get line_items_surplus, which represent the line items that have surplus in their budget after discount the requirements from the budget of these line items.
10.1.7.6.3. For Each single_line_item_surplus in line_items_surplus
10.1.7.6.3.1. Get single_line_item_budget _surplus for this single_line_item_surplus.
10.1.7.6.3.2. Compute diff_amount = single_line_item_budget _surplus – unit_line_item_budget_ gap.
10.1.7.6.3.3. If diff_amount > = 0
10.1.7.6.3.3.1. Set $B_j = B_j$ + unit_line_item_ budget_gap.
10.1.7.6.3.3.2. Discount unit_line_item_ budget_gap from line_item_surplus_ approved_budget of this single_line_item_ surplus.
10.1.7.6.3.3.3. Set unit_line_item_ budget_gap= 0.
10.1.7.6.3.3.4. Exit For
10.1.7.6.3.4. Else
10.1.7.6.3.4.1. Set $B_j = B_j$ + single_line_item_ budget_surplus
10.1.7.6.3.4.2. Discount single_line_item_ budget_surplus from line_item_surplus_ approved_budget of this single_line_item_ surplus
10.1.7.6.3.4.3. Set unit_line_item_ budget_gap = unit_line_item_ budget_gap – single_line_item_ budget_surplus.
10.1.7.6.3.5. End If
10.1.7.6.4. Next
10.1.7.7. End If
10.1.8. Next
10.1.9. The proposed system formulates the i^{th} LDM quadratic programming problem (Problem (1.a) - (1.d)) for this single_arranged_organizational_unit.
10.1.10. The system solves the formulated i^{th} LDM quadratic problem for obtaining the compromise solution for this single_arranged_organizational_unit.
10.1.11. The system records the obtained results in a database, which represent the expected amounts from the approved university budget allocated for all unit_line_items related to this single_arranged_organizational_unit.
10.1.12. For each single_unit_line_item in unit_line_items
10.1.12.1. Discount the allocated amount for this single_unit_line_item from its line_item_approved_budget (B_j).
10.1.13. Next
10.1.14. Discount the total allocated amounts of this single_arranged_organizational_unit from the overall_approved_budget (B).
10.1.15. Set i = i+1.
10.1.16. The i^{th} LDM defines his/her problem in point of view of the $(i-1)^{th}$ LDMs (upper level decision makers) by setting the controlled variables of the $(i-1)^{th}$ LDMs to the i^{th} LDM constraints.
10.2. End If
11. Next
12. Function arrange_average_value (req_val, sum_of_req_val, priority_val, sum_of_priority_val)
12.1. If req_val > 0 then
12.1.1. Compute rate_of_requirement = (req_val / sum_of_req_val) * 100.
12.1.2. Compute rate_of_priority = (priority_val / sum_of_priority_val) * 100.
12.1.3. Compute average_arrange = (rate_of_requirement + rate_of_priority)/2.
12.2. Else
12.2.1. Set average_arrange = 0.
12.3. End If
12.4. Return average_arrange.
13. End Function
14. Stop.

3.3. A Proposed Case Study

The proposed study deals with a real-world case study of budget allocation problem in Sohag University, which is an independent regional university in Egypt. It is located in

Sohag, on the eastern bank of the Nile. It offers both undergraduate and postgraduate programs in several areas of study and it is an important cultural and educational center in Egypt.

The first higher education center in Sohag governorate was the Faculty of Education, established in 1971. In 1975, Faculties of Arts and Science were established. This center started as a branch of Assuit University in 1980 with the establishment of the Faculty of Commerce. In 1992, Faculty of Medicine was established. In 1995, Sohag Branch became a branch of South Valley University in Qena. In 1996, Faculty of Agriculture was established. In 2006, Sohag University was established to comprise all the faculties of Sohag governorate. After that, Faculties of Industrial Education and Nursing were added to the university. In 2008, Faculties of Engineering and Veterinary Medicine were set up. Finally, Faculties of Pharmacy, Law and Languages were added.

4. Experimental Results

In this section, the proposed university budget allocation system has been applied for a real-world case study of budget allocation in Sohag University. Table 3 presents a comparison between the results of the current situation (actual budget allocation provided by the decision makers in the university) and the results of the recommended situation (proposed budget allocation obtained by the system) in Sohag University. This comparison is a very useful way for shedding some light on the gap between the current situation and the targeted one, and illustrating the accuracy of the proposed system.

Table 3. Comparison of the proposed budget allocation and the actual budget allocation

Economic Classification	Government Approved Budget	Organizational Unit	Organizational Unit's Budget Requirement	Actual Budget Allocation	% of Actual Allocation	Proposed Budget Allocation (Results)	% of Proposed Allocation	Gap between Proposed and Actual Allocation
(21000000) General Expenditures	34,472,269.77	Faculty of Science	3,781,089.98	1,503,068.48	4.360%	1,861,375.40	5.400%	358,306.92
		Faculty of Education	2,141,888.45	1,190,345.85	3.453%	1,464,074.16	4.247%	273,728.31
		Faculty of Commerce	978,274.70	669,741.91	1.943%	688,885.63	1.998%	19,143.72
		Faculty of Arts	2,713,378.85	633,549.96	1.838%	2,380,949.07	6.907%	1,747,399.11
		Faculty of Medicine	7,630,223.90	4,726,960.80	13.712%	7,040,853.06	20.425%	2,313,892.26
		Faculty of Nursing	563,118.40	389,851.20	1.131%	401,001.60	1.163%	11,150.40
		Faculty of Veterinary Medicine	989,305.85	510,405.05	1.481%	555,450.95	1.611%	45,045.90
		Faculty of Agriculture	521,957.80	321,204.80	0.932%	486,075.80	1.410%	164,871.00
		Faculty of Engineering	586,865.50	337,526.80	0.979%	337,526.80	0.979%	0.00
		Faculty of Pharmacy	295,072.70	206,550.89	0.599%	224,340.50	0.651%	17,789.61
		Faculty of Industrial Education	548,234.70	141,843.68	0.411%	317,017.21	0.920%	175,173.53
		Faculty of Law	315,376.10	166,342.55	0.483%	166,342.55	0.483%	0.00
		Faculty of Languages	846,593.15	465,718.44	1.351%	741,743.71	2.152%	276,025.27
		Central Department	17,375,075.71	12,028,898.5	34.894%	17,288,910.6	50.153%	5,260,012.08
Total percentage of utilization to the Government Approved Budget:					**67.57%**		**98.50%**	**30.93%**
(21100000) Wages and Compensation of employees	15,450,912.59	Faculty of Science	2,676,135.80	738,100.20	4.777%	756,507.40	4.896%	18,407.20
		Faculty of Education	1,993,704.70	1,087,757.10	7.040%	1,315,890.41	8.517%	228,133.31
		Faculty of Commerce	917,575.10	628,186.03	4.066%	628,186.03	4.066%	0.00
		Faculty of Arts	2,546,337.30	539,878.20	3.494%	2,213,907.52	14.329%	1,674,029.32
		Faculty of Medicine	7,408,560.90	4,590,552.80	29.711%	6,819,190.06	44.135%	2,228,637.26
		Faculty of Nursing	526,879.60	364,762.80	2.361%	364,762.80	2.361%	0.00
		Faculty of Veterinary Medicine	870,871.95	432,967.50	2.802%	437,017.05	2.828%	4,049.55
		Faculty of Agriculture	79,571.70	48,967.20	0.317%	48,967.20	0.317%	0.00
		Faculty of Engineering	517,608.00	268,269.30	1.736%	268,269.30	1.736%	0.00
		Faculty of Pharmacy	246,636.00	172,645.20	1.117%	175,903.80	1.138%	3,258.60
		Faculty of Industrial Education	471,698.50	90,034.56	0.583%	259,381.01	1.679%	169,346.45
		Faculty of Law	298,645.10	149,611.55	0.968%	149,611.55	0.968%	0.00
		Faculty of Languages	823,752.80	450,257.28	2.914%	718,903.36	4.653%	268,646.08
		Central Department	1,351,113.40	935,386.20	6.054%	1,294,415.10	8.378%	359,028.90
Total percentage of utilization to the Government Approved Budget:					**67.94%**		**100%**	**32.06%**
(21110000) Wages and Allowances (cash and in-kind)	15,450,912.59	Faculty of Science	2,676,135.80	738,100.20	4.777%	756,507.40	4.896%	18,407.20
		Faculty of Education	1,993,704.70	1,087,757.10	7.040%	1,315,890.41	8.517%	228,133.31
		Faculty of Commerce	917,575.10	628,186.03	4.066%	628,186.03	4.066%	0.00
		Faculty of Arts	2,546,337.30	539,878.20	3.494%	2,213,907.52	14.329%	1,674,029.32
		Faculty of Medicine	7,408,560.90	4,590,552.80	29.711%	6,819,190.06	44.135%	2,228,637.26
		Faculty of Nursing	526,879.60	364,762.80	2.361%	364,762.80	2.361%	0.00
		Faculty of Veterinary Medicine	870,871.95	432,967.50	2.802%	437,017.05	2.828%	4,049.55
		Faculty of Agriculture	79,571.70	48,967.20	0.317%	48,967.20	0.317%	0.00
		Faculty of Engineering	517,608.00	268,269.30	1.736%	268,269.30	1.736%	0.00
		Faculty of Pharmacy	246,636.00	172,645.20	1.117%	175,903.80	1.138%	3,258.60
		Faculty of Industrial Education	471,698.50	90,034.56	0.583%	259,381.01	1.679%	169,346.45
		Faculty of Law	298,645.10	149,611.55	0.968%	149,611.55	0.968%	0.00
		Faculty of Languages	823,752.80	450,257.28	2.914%	718,903.36	4.653%	268,646.08
		Central Department	1,351,113.40	935,386.20	6.054%	1,294,415.10	8.378%	359,028.90

Economic Classification	Government Approved Budget	Organizational Unit	Organizational Unit's Budget Requirement	Actual Budget Allocation	% of Actual Allocation	Proposed Budget Allocation (Results)	% of Proposed Allocation	Gap between Proposed and Actual Allocation
Total percentage of utilization to the Government Approved Budget:					**67.94%**		**100%**	**32.06%**
(21200000) Purchase of Goods and Services	18,837,592.39	Faculty of Science	1,099,161.38	760,957.88	4.040%	1,099,161.38	5.835%	338,203.50
		Faculty of Education	148,014.75	102,471.75	0.544%	148,014.75	0.786%	45,543.00
		Faculty of Commerce	60,699.60	41,555.88	0.221%	60,699.60	0.322%	19,143.72
		Faculty of Arts	167,041.55	93,671.76	0.497%	167,041.55	0.887%	73,369.79
		Faculty of Medicine	221,663.00	136,408.00	0.724%	221,663.00	1.177%	85,255.00
		Faculty of Nursing	36,238.80	25,088.40	0.133%	36,238.80	0.192%	11,150.40
		Faculty of Veterinary Medicine	118,433.90	77,437.55	0.411%	118,433.90	0.629%	40,996.35
		Faculty of Agriculture	425,592.70	261,903.20	1.390%	425,592.70	2.259%	163,689.50
		Faculty of Engineering	69,257.50	69,257.50	0.368%	69,257.50	0.368%	0.00
		Faculty of Pharmacy	48,436.70	33,905.69	0.180%	48,436.70	0.257%	14,531.01
		Faculty of Industrial Education	18,036.20	12,209.12	0.065%	18,036.20	0.096%	5,827.08
		Faculty of Law	16,731.00	16,731.00	0.089%	16,731.00	0.089%	0.00
		Faculty of Languages	22,840.35	15,461.16	0.082%	22,840.35	0.121%	7,379.19
		Central Department	15,871,224.01	10,987,770.4	58.329%	15,871,224.0	84.253%	4,883,453.54
Total percentage of utilization to the Government Approved Budget:					**67.08%**		**97.27%**	**30.19%**
(21210000) Goods	15,297,487.87	Faculty of Science	864,987.83	598,837.73	3.915%	864,987.83	5.654%	266,150.10
		Faculty of Education	61,116.90	42,311.70	0.277%	61,116.90	0.400%	18,805.20
		Faculty of Commerce	17,387.50	11,903.75	0.078%	17,387.50	0.114%	5,483.75
		Faculty of Arts	41,070.90	23,031.30	0.151%	41,070.90	0.268%	18,039.60
		Faculty of Medicine	112,760.70	69,391.20	0.454%	112,760.70	0.737%	43,369.50
		Faculty of Nursing	11,485.50	7,951.50	0.052%	11,485.50	0.075%	3,534.00
		Faculty of Veterinary Medicine	48,558.90	31,750.05	0.208%	48,558.90	0.317%	16,808.85
		Faculty of Agriculture	295,828.00	182,048.00	1.190%	295,828.00	1.934%	113,780.00
		Faculty of Engineering	5,200.00	5,200.00	0.034%	5,200.00	0.034%	0.00
		Faculty of Pharmacy	21,669.70	15,168.79	0.099%	21,669.70	0.142%	6,500.91
		Faculty of Languages	130.00	88.00	0.001%	130.00	0.001%	42.00
		Central Department	13,561,563.99	9,388,775.07	61.375%	13,561,563.9	88.652%	4,172,788.92
Total percentage of utilization to the Government Approved Budget:					**67.84%**		**98.32%**	**30.48%**
(21220000) Services	3,540,104.52	Faculty of Science	234,173.55	162,120.15	4.580%	234,173.55	6.615%	72,053.40
		Faculty of Education	86,897.85	60,160.05	1.699%	86,897.85	2.455%	26,737.80
		Faculty of Commerce	43,312.10	29,652.13	0.838%	43,312.10	1.223%	13,659.97
		Faculty of Arts	125,970.65	70,640.46	1.995%	125,970.65	3.558%	55,330.19
		Faculty of Medicine	108,902.30	67,016.80	1.893%	108,902.30	3.076%	41,885.50
		Faculty of Nursing	24,753.30	17,136.90	0.484%	24,753.30	0.699%	7,616.40
		Faculty of Veterinary Medicine	69,875.00	45,687.50	1.291%	69,875.00	1.974%	24,187.50
		Faculty of Agriculture	129,764.70	79,855.20	2.256%	129,764.70	3.666%	49,909.50
		Faculty of Engineering	64,057.50	64,057.50	1.809%	64,057.50	1.809%	0.00
		Faculty of Pharmacy	26,767.00	18,736.90	0.529%	26,767.00	0.756%	8,030.10
		Faculty of Industrial Education	18,036.20	12,209.12	0.345%	18,036.20	0.509%	5,827.08
		Faculty of Law	16,731.00	16,731.00	0.473%	16,731.00	0.473%	0.00
		Faculty of Languages	22,710.35	15,373.16	0.434%	22,710.35	0.642%	7,337.19
		Central Department	2,309,660.02	1,598,995.40	45.168%	2,309,660.02	65.243%	710,664.62
Total percentage of utilization to the Government Approved Budget:					**63.8%**		**92.7%**	**28.9%**
(21400000) Subsidies, and Social Benefits	12,174.03	Faculty of Science	5,431.40	3,760.20	30.887%	5,431.40	44.615%	1,671.20
		Faculty of Education	169.00	117.00	0.961%	169.00	1.388%	52.00
		Faculty of Agriculture	3,071.90	1,890.40	15.528%	3,071.90	25.233%	1,181.50
Total percentage of utilization to the Government Approved Budget:					**47.38%**		**71.23%**	**23.85%**
(21430000) Social Benefits	12,174.03	Faculty of Science	5,431.40	3,760.20	30.887%	5,431.40	44.615%	1,671.20
		Faculty of Education	169.00	117.00	0.961%	169.00	1.388%	52.00
		Faculty of Agriculture	3,071.90	1,890.40	15.528%	3,071.90	25.233%	1,181.50
Total percentage of utilization to the Government Approved Budget:					**47.38%**		**71.23%**	**23.85%**
(21500000) Other Expenditures	171,590.76	Faculty of Science	361.40	250.20	0.146%	275.22	0.160%	25.02
		Faculty of Agriculture	13,721.50	8,444.00	4.921%	8,444.00	4.921%	0.00
		Faculty of Industrial Education	58,500.00	39,600.00	23.078%	39,600.00	23.078%	0.00
		Central Department	152,738.30	105,741.90	61.624%	123,271.54	71.840%	17,529.64
Total percentage of utilization to the Government Approved Budget:					**89.77%**		**100%**	**10.23%**
(21510000) Current	171,590.76	Faculty of Science	361.40	250.20	0.146%	275.22	0.160%	25.02
		Faculty of Agriculture	13,721.50	8,444.00	4.921%	8,444.00	4.921%	0.00
		Faculty of Industrial Education	58,500.00	39,600.00	23.078%	39,600.00	23.078%	0.00
		Central Department	152,738.30	105,741.90	61.624%	123,271.54	71.840%	17,529.64
Total percentage of utilization to the Government Approved Budget:					**89.77%**		**100%**	**10.23%**

As it is demonstrated in the results of the previous table, the proposed system shows an overall improved in university's budget allocation of 30.93% compared to the actual budget allocation. The results state that the proposed system gives a better allocation of university's funds than the actual budget allocation, and indicates that the proposed system is more effective to estimate future financial status of the university.

5. Conclusions

Mathematical models process data, and transform them into pertinent information. In this study, a new system based on multi-level quadratic optimization model was designed for optimizing the efficiency of budget allocation process at organizational units in the university. The allocation for each organizational unit had lower and upper limits. The objective function was to minimize the sum of the quadratic deviations of each allocation from its limits. The proposed system was implemented based on the budget of Sohag University as a case study. It was found that there exists a wide gap between the proposed allocation and the actual allocation of university's funds.

The proposed system provides compromise solutions between the lower and upper limit, which are very likely to be accepted by the various organizational units. The system was designed to empower the university to adjust its financial resources with its goal, vision and values. As a result, budgets will be better able to meet changing institutional needs and be responsive to their mission as well as new opportunities. Finally, we want to clarify that the system can be implemented in many Egyptian universities and institutions of higher education.

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