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Multi-Level Quadratic University Budget Allocation System under Fuzzy Environment

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***Abstract*—Budget allocation is a central problem in the university. The annual budget allocation process in the university is principally a cumbersome and complex process, often failing to achieve intended objectives to ensure a solid financial position for the university; and to maximize the university's ability to respond to favorable variances throughout the year. For that, this study concerns with optimizing the efficiency of budget allocation process for various organizational units in the university through designing a novel system based on a fuzzy multi-level quadratic optimization model. The allocation for each organizational unit has lower and upper limits. The objective function of the proposed system is to minimize the sum of the quadratic deviations of each allocation from its limits. The results are promising for helping the decision makers in the university.**

***Keywords*—Budget allocation; budget requirement; multi-level optimization; quadratic optimization.**

I. INTRODUCTION

University is non-profit business. A university has no proprietors; it is a public trust. However, both a university and a business are economic entities. So, they have to maintain financial viability to survive. This similarity is why both have budgeting. 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 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 that aid the decision makers in the university to solve such problem has become one of the most attractive interests of university strategists. [4]

The university budget allocation process is a decentralized or Multi-Level Programming (MLP) problem, 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. The MLP problem aims to find a feasible solution to a set of objectives constrained by the available resources that will also contribute maximally to the objectives developed by the upper level decision maker. Policy making in MLP systems is characterized by the following main problems: Interdependencies between the subsystems, and conflicts between the goals and priorities within each subsystem. [5, 6]

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 variables which were divided into 2 classifications: products and resources. There were 4 objectives and 30 constraints, which all were changed over into goal structures. 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 thirty six 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. The model was implemented in Microsoft Excel and optimized with its Solver optimization tool.

Abdul Aziz et al. [3] constructed a mathematical model for the budget planning 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 [4] Nasrabadi et al. provided a programming model of Performance-Based Budget in the University, using Payam Noor University of South Khorasan budget data. From one perspective, support allocation to the university depended on performance and the results of previous programs, and on the other perspective, considering the uncertainty of the upper bound; the assigned budget was enhanced through using the robust model.

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.

The remainder of this study is organized into the following sections: In Section 2 the motivation of the study based on the literature review is discussed. A short review of the proposed case study is provided in Section 3. Section 4 proposed the university budget allocation system based on the fuzzy multi-level quadratic optimization model. Experimental results are outlined in Section 5, and lastly, conclusions are represented in Section 6.

II. Motivation of the Study

University budgeting is a resource allocation problem. Decision makers in the university continually face the task of allocating resources by balancing costs, benefits and risks. Perform this task manually is more complex because many reasons: There are constraints on the available budgets in the university; Many people are usually involved, but most of them have different special agendas, which creates competition for limited resources and lead to the formation of teams secretly working on non-approved projects; Decision makers are presented with a large number of investment opportunities and they cannot know the details of each one sufficiently well to make informed decisions.

Based on the literature review on past studies pertaining to resource and budget allocation of public universities, which is shown in the previous section, we can conclude that there are no studies have developed a fuzzy multi-level quadratic based system for optimizing the efficiency of budget allocation process. This lack of research is the main motivation for us to carry out this study.

The objective of this study is to help alleviate and optimize the budget allocation problem in the university by suggesting a system based on a fuzzy multi-level quadratic optimization model. This 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.

III. A Proposed Case Study

The presented 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.

Budgeting allocated for each public Egyptian University, involving Sohag University, is determined yearly as a section in the Egyptian budget. The Egyptian budget is organized according to ten key functions. One of these functions is the education, which comprises the development, formulation, and delivery of government policies and programs at all levels of education (preschool, primary, preparatory, secondary, as well as university and higher education). Fig. 1 shows a simple pie chart, which presents an overview of the average percentage of each key function in the total Egyptian budget. [11]

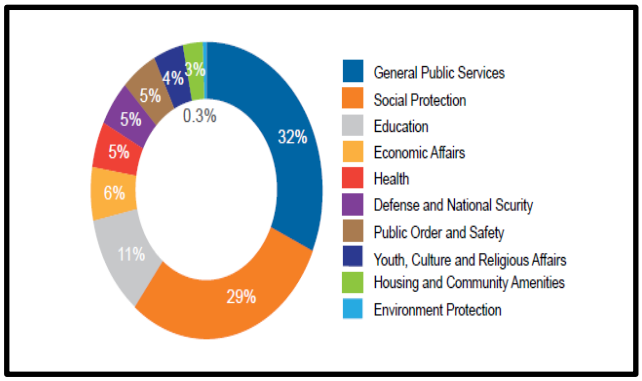

Fig. 1. *Average Percentage of Functions in the Total Budget. [11]*

The financial budget of the public Egyptian Universities, involving Sohag University, is developed based on 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 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 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. The public Egyptian Universities, involving Sohag University, care solely with uses (total expenditure) side because they are non-profit organizations that are predominantly funded by public funding sources through the government, as opposed to private universities. Table 1 shows how the economic classification for the budget would look. [11]

IV. Fuzzy Multi-Level Quadratic University Budget Allocation System

In what follows, University budget allocation system is proposed in view of the fuzzy multi-level quadratic optimization model for overcoming the intricacy of allocation of funds. For this, mathematical modeling of fund allocation is optimized for formulating the quadratic objectives and the linear constraints.

A. Fuzzy Multi-Level Quadratic Optimization Model

University budget allocation is a conversion of the annual financial plan for the university into funds, with a commitment for a particular timeframe (i.e., one year for the operational budget). At first, the difference between the following two significant terms should be defined: budget requirements and budget allocations for each organizational unit in the public Egyptian university.

Budget requirement is the initial estimated expenditures required for implementing function, project or service plan, which is suggested from the organizational units of the university. On the other hand, Budget allocation is the actual amount of resources, to be applied towards the needs of each organizational unit of 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 units are usually less than what is requested.

TABLE I. 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	

In this study, an efficient fuzzy Multi-Level quadratic optimization model is suggested to allocate a given yearly budget for each organizational unit in the university with high performance fairly and precisely. Various studies have been presented in the area of the fuzzy Multi-Level quadratic programming problems [12, 13, 14, 5].

The proposed model is a fuzzy Multi-Level Programming (MLP) problem, where each level presents an objective function for each organizational unit independently. These organizational units' levels are arranged hierarchically based on three fuzzy standards: the rate of requirements, the rate of priority level, and the rate of criteria level for each organizational unit. Each unit can have one of the following priority levels: Urgent (Highest) priority; High priority; Normal priority; or Low priority. The priority is derived from the impact and the urgency, based on the context of each organizational unit and the criteria that it may need to consider for assigning the priority level. The priority can have one of the following criteria levels: National criteria; Local criteria; Organizational criteria; or Special criteria.

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 (average of the squared differences) of each allocation predicted by the model from its limits. The optimal solution is a compromise between the upper and lower limits of each unit. Based on the above, the mathematical formulation of the proposed model can be considered as given below:

[FLDM]

$$Min \quad \tilde{F}_1(x) = \sum_{j=1}^{m} \frac{1}{W_{x_j}} \left(\left(x_j - U_{x_j} \right)^2 + \left(x_j - L_{x_j} \right)^2 \right), \quad \mathbf{x_j} \qquad (1.a)$$

[SLDM]

$$\text{Min} \quad \tilde{F}_2(y) = \sum_{j=1}^{m} \frac{1}{W_{y_j}} \left(\left(y_j - U_{y_j} \right)^2 + \left(y_j - L_{y_j} \right)^2 \right), \quad \mathbf{y_j} \qquad (1.b)$$

…

[nth LDM]

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

Subject to:

$$(x_j, y_j, \dots, t_j) \in G \qquad (j = 1, 2, \dots, m), \qquad (1.d)$$

Where

$$G = \{ \quad \sum_{j=1}^{m} x_j + y_j + \cdots + t_j \le B,$$
$$L_{x_j} \le x_j \le U_{x_j} \qquad (j = 1, 2, \dots, m),$$
$$L_{y_j} \le y_j \le U_{y_j} \qquad (j = 1, 2, \dots, m),$$
$$\dots$$
$$L_{t_j} \le t_j \le U_{t_j} \qquad (j = 1, 2, \dots, m),$$
$$x_j + y_j + \cdots + t_j \le B_j \qquad (j = 1, 2, \dots, m),$$
$$x_j, y_j, \dots, t_j \ge 0 \qquad (j = 1, 2, \dots, m). \}$$

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

TABLE II. THE DECISION VARIABLES USED IN THE PROPOSED MODEL

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

B. The University Budget Allocation System's Life Cycle

The annual life cycle of the proposed system based on the fuzzy multi-level quadratic optimization model can be summarized in two phases, as follows:

Phase I: Estimate the budget requirements by the organizational units: The function of this phase is achieved by the following steps:

Step 1. Each organizational unit can log in to the proposed system for building its own budget requirements.

Step 2. Get line_items that are required from the budget for each organizational unit.

Step 3. For each single_line_item in line_items

Step 3.1. Determine the amount estimated for this single_line_item to support the required resources for the unit.

Step 3.2. 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) for this single_line_item to arrange from most to least important and get an idea of where the unit wants its money to go first.

Step 3.3. Each priority level and criteria level has a specific value, which defines the importance for this single_line_item.

Step 3.4. Compute: total_priority= (Priority_value - Criteria_value) / 100.

Step 3.5. The system records this information. The organizational unit can view and modify its information.

Step 4. Next

Phase II: Allocate the budget fairly by the proposed system: The function of this phase is achieved by the following steps:

Step 1. The university receives its approved budget from the government. After that, the specific line items of this approved budget are uploaded to the system, which will be distributed to the related organizational units.

Step 2. Get the sum_budget_requirements and sum_total_priority for all related organizational units.

Step 3. For each single_organizational_unit in related_organizational_units

Step 3.1. Get unit_budget_requirement and unit_total_priority for this single_organizational_unit.

Step 3.2. Set unit_average_arrange = arrange_value (unit_budget_requirement, sum_budget_requirements, unit_total_priority, sum_total_priority).

Step 4. Next

Step 5. Arrange the related organizational units according to the computed values of unit_average_arrange and records these values, as shown in Fig. 2.

Step 6. Get overall_approved_budget (B) allocated from the government.

Step 7. Get arranged_organizational_units.

unit_id	rate_of_requirement	rate_of_priority	unit_average_arrange
205	35.74	22.6	29.17
301	6.518	27	16.759
204	12.284	19.3	15.792
209	2.497	18.9	10.6985
213	3.974	17.4	10.687
201	12.91	6.9	9.905
202	9.618	7.6	8.609
207	4.201	11.9	8.0505
212	1.441	11.9	6.6705
203	4.427	8.6	6.5135
211	2.276	6.9	4.588
210	1.19	6.9	4.045
206	2.542	3.6	3.071
208	0.384	3.6	1.992

Fig. 2. *Sample of the values of arrange for the organizational units*

Step 8. Set i=1, which indicating the i^{th} level decision maker (i^{th} LDM) for each arranged_organizational_unit.

Step 9. For each single_arranged_organizational_unit in arranged_organizational_units

Step 9.1. If overall_approved_budget > 0 then

Step 9.1.1. Get the sum_line_items_requirements and sum_line_items_total_priority for all line items related to this single_arranged_organizational_unit.

Step 9.1.2. Get line_items for this single_arranged_organizational_unit.

Step 9.1.3. For each single_line_item in line_items

Step 9.1.3.1. Get budget_requirement and total_priority for this single_line_item.

Step 9.1.3.2. Set line_item_average_arrange = arrange_value (budget_requirement, sum_line_items_requirements, total_priority, sum_line_items_total_priority).

Step 9.1.4. Next

Step 9.1.5. Arrange the line items related to this single_arranged_organizational_unit according to the computed values of line_item_average_arrange.

Step 9.1.6. Get arranged_line_items for this single_arranged_organizational_unit.

Step 9.1.7. For each single_arranged_line_item in arranged_line_items

Step 9.1.7.1. Get budget_requirement (upper limit) for this single_arranged_line_item.

Step 9.1.7.2. Get previous_budget_allocation (lower limit) for this single_arranged_line_item.

Step 9.1.7.3. If previous_budget_allocation Is NULL then

Step 9.1.7.3.1. Set previous_budget_allocation= (50 / 100) * budget_requirement.

Step 9.1.7.4. End if

Step 9.1.7.5. Get approved_budget (B_j) allocated from the government for this single_arranged_line_item.

Step 9.1.8. Next

Step 9.1.9. The system formulates fuzzy the i^{th} LDM quadratic programming problem (Problem (1.a) - (1.d)).

Step 9.1.10. The system solves the fuzzy i^{th} LDM quadratic problem for obtaining the compromise solution.

Step 9.1.11. The system records the obtained results, which represent the expected amounts allocated for all line items related to this **single_arranged_organizational_unit**.

Step 9.1.12. Discount these expected amounts of this single_arranged_organizational_unit from the overall_approved_budget (B).

Step 9.1.13. Set i=i+1.

Step 9.1.14. 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.

Step 9.2. End If

Step 10. Next

V. EXPERIMENTAL RESULTS

In this section, the proposed system has been applied for a real-world case study of budget allocation in Sohag University. Table (3) presents a comparison between the current situation (actual budget allocation provided by the decision makers in the university) and 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 III. COMPARISON OF THE PROPOSED BUDGET ALLOCATION AND THE ACTUAL BUDGET ALLOCATION

Economic Classification	Approved University Budget	Organizational Unit	Organizational Unit's Budget Requirement	Actual Budget Allocation	Accuracy of Actual Budget Allocation	Proposed Budget Allocation (Results)	Accuracy of Proposed Budget 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	12,028,898.57	34.894%	17,288,910.6	50.153%	5,260,012.08
Overall Accuracy of Allocation According to Approved University Budget:					**67.57%**		**98.50%**	**30.93%**
Overall Accuracy of Allocation According to the Budget Requirement:					**59.29%**		**86.43%**	
(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
Accuracy of Allocation According to the Approved University 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
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		Faculty of Pharmacy	246,636.00	172,645.20	1.117%	175,903.80	1.138%	3,258.60
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Accuracy of Allocation According to the Approved University 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

Economic Classification	Approved University Budget	Organizational Unit	Organizational Unit's Budget Requirement	Actual Budget Allocation	Accuracy of Actual Budget Allocation	Proposed Budget Allocation (Results)	Accuracy of Proposed Budget Allocation	Gap between Proposed and Actual Allocation
		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	10,987,770.47	58.329%	15,871,224.0	84.253%	4,883,453.54
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University 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
Accuracy of Allocation According to the Approved University Budget:					**89.77%**		**100%**	**10.23%**

As it is demonstrated in the results of the previous table, the proposed university budget allocation system shows an overall improved in university budget allocation of 30.93% compared to the actual budget allocation provided manually by the decision makers in the public Egyptian university.

Fig. 3 and Fig. 4 show charts to compare the accuracy of budget allocation between the proposed university budget allocation system and the actual budget allocation according to two criteria: the approved university budget and the budget requirement. The overall accuracy of allocation from the approved university budget is maximized after implementing the proposed university budget allocation system. Hence it is stated that the proposed university budget allocation system gives a better allocation of university's funds than the actual budget allocation, and indicates that the proposed system is more effective and more balanced.

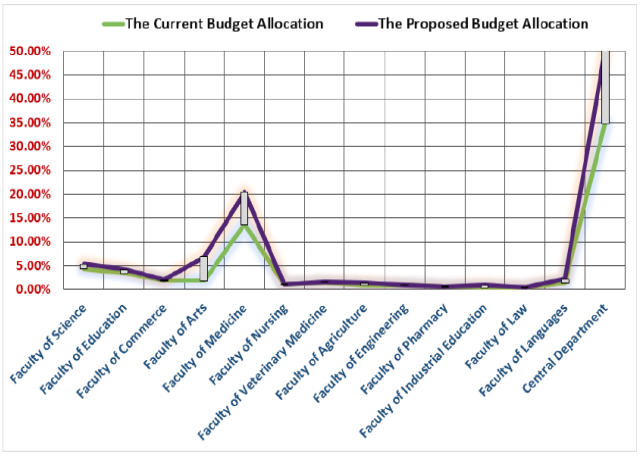

Fig. 3. *Budget Allocation Accuracy According to the University Budget*

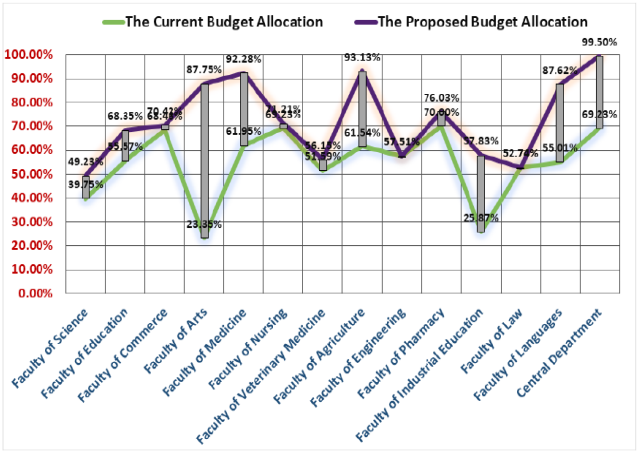

Fig. 4. *Budget Allocation Accuracy According to the Budget Requirement*

VI. CONCLUSIONS

Effective decision making is indispensable for any organization in adapting to the fast technological changes. The crucial tool in scientific decision making is the mathematical models. Mathematical models process data, and transform them into pertinent information. In this study, a new system based on fuzzy 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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