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Framework for an Academic/University Library's Collection's Budget Allocation and Purchasing Model

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Abstract:

The objective of this paper is to establish a framework for budget allocation and purchasing model for the university academic libraries. The proposed framework is a modification of the earlier model introduced by Engku Abu Bakar, Rahman and Yusof (2011). The framework consists of three models. The first model, Model A, is an LP model to maximize the total budget allocated to all the academic faculties/schools in the university subject to various factors such as total faculty members, total undergraduate student population, total postgraduate student population, age of programs, number of programs, total service course slots, total distance learning students, and total non-academic staff in the faculties/schools. The second model, Model B, is also an LP model to maximize the total budget allocated to all the academic departments within a faculty/school in the university, subject to the amount allocated for the school which is obtained from the optimal result of Model C and used the same set of criteria as in Model A. The final model is Model C, which is an IP model to maximize the use of the budget allocated for each department in the respective faculty/school for the purchasing of textbooks, hardcopy journals, and electronic journals. For all the three models, the Compromised- Analytic Hierarchy Process (C-AHP) method was used to calculate the weight of the determining criteria. This new-proposed framework could ensure that university libraries have a better plan in the cost allocation and expenditure according to the needs of the libraries' stakeholders and certain conditions imposed by the university management. The three models would also help university libraries to prioritize the criteria used towards the final budget allocation decision.

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I. Introduction

Library is a place where people go to read or study and participate in the programs that the library offers. For instance, individuals seeking for a new employment could learn skills to develop resume, while students pursuing postgraduate studies can have some quiet time and fast access to materials for research. The main goal of a library is to provide resources and services from different types of media to meet the needs of library members for information, education, and personal improvement, as well as a place for leisure and recreational activities. It

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plays a significant role in the improvement and maintenance of a society. In addition, the library gives individuals access to a wide and varied collection of knowledge, ideas and opinions (Dhawan, 2008).

Early libraries were often part of religious institutions (Living in the Library World, 2008). Many private libraries and royal libraries also existed in ancient times. However, libraries are now divided into four major types as shown in Table 1 (Living in the library world, 2008).

Table 1. Types of library and the patrons served

Type of library	Patrons with service privileges
Academic	Students, faculty, non-academic and administrative staff, alumni; General public often pay for a fee for borrowing privileges.
Public	All residents of the community; Residents of other communities may have to pay a fee to borrow materials.
School	Students, teachers, administrative staff; Some schools also allow parents, students from other schools and the general public to borrow materials.
Special	Most often only employees of the company or institution; Some government libraries or libraries in social services agencies or societies lend to the general public.

In addition, there is an emerging fifth type of library, the "virtual" or "electronic library". However, this type of library is not yet "officially" included in this list of libraries (Living in the library world, 2008).

For any institution of higher learning, university and college libraries, also known as academic libraries, are the most vital source for knowledge. Faculty and students at these educational institutions may desire to conduct research along with other activities within some conceivable academic discipline. The resources of academic libraries usually reflect a huge range of interests and arrangements that directly or indirectly support these necessities. Academic libraries vary in sizes, from the modest resources found in small liberal arts colleges to the vast resources found at research universities (Issa, 2009).

However, regardless of the size, academic library management is usually focused towards the attainment of the objectives of the academic institution (Fakudze, 1996) and involves many functions and processes (Tait, Martzoukou, & Reid, 2016). The basic function of the academic library is to assist and support the study and teaching that goes on in the academic organization. In this effort the academic library basically targets to (Chowdhury, 2001):

i. captures and hold the interest of the academic community’s reading.

ii. produce intelligent users of all types of documents.

iii. cultivate in users an appreciation of libraries as academic institutions.

From another perspective, the academic library also provides essential reading materials and documents for research (Chowdhury, 2001).

The library collection must provide a wide range of materials for users of all ages, all educational levels, and all socio-economic backgrounds. In order to meet the stakeholders of the libraries demand, the library asserts the fundamentals of intellectual freedom, and purchases materials representing various sides of a subject/topic whenever possible. Even though reasonable people may disagree or object to a particular point of view it is the management team’s responsibility to represent both. Because of the great variety of resources, there is no single set of overall criteria that can be applied at all times. Some items are judged mostly in terms of artistic value or

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documentation of the times, while others are nominated to satisfy the recreational and informational needs of the library users (Krolak, 2006; Thomson, 1998).

The issues can be solved if the library can provide resources that the library user needs. A library may need many resources to continue the best service to the stakeholders. Thus, the library management should know all the information flow of the library (Nowakowska-Grunt & Grabara, 2007; Chopra & Meindl, 2007). Furthermore, and more importantly, the library should use proper mathematical/analytical information to allocate funds in the operations of the library and then apply a suitable budget allocation mathematical model to ensure the proper fund distribution to run the operations of the library (Paris, 2004; Lowry, 1992).

The purpose of this paper is therefore to propose a framework for an academic/university library's collection's budget allocation and purchasing mathematical model. To apply the mathematical model for the library's collection budgeting purpose, the following information are required:

i. Factors or criteria that will determine the allocation of budget.

ii. Techniques to be used to determine the weights for the criteria.

iii. The suitable mathematical models to be used.

II. Factors to be considered

Several factors play an important role in the acquisition of fund allocation operation for academic libraries. These factors and the researchers/practitioners adopting the factors are given in Table 2.

Table 2. The important factors of fund allocation for academic libraries

Factors	Authors
Number of faculty and rank	(Crotts, 1999), (Wise & Perushek, 1996), (Arora & Klabjan, 2002), (Kao, Chang & Lin, 2003), (Wardiah, 2005), (Engku Abu Bakar, Rahman &Yusof, 2011)
Size of students or size of student credit	(Wise & Perushek, 1996), (Crotts, 1999), (Kao, Chang & Lin, 2003), (Wardiah, 2005), (Sudarshan, 2006), (Engku Abu Bakar, Rahman, & Yusof, 2011)
Cost of library material	(Wise & Perushek, 1996), (Crotts, 1999), (Arora & Klabjan, 2002), (Kao, Chang & Lin, 2003), (Wardiah, 2005), (Engku Abu Bakar, Rahman & Yusof, 2011)
Usage of periodicals	(Arora & Klabjan, 2002) (Promis, 1996), (Kao, Chang & Lin, 2003), (Wardiah, 2005),
Number of degrees awarded	(Arora & Klabjan, 2002), (Wardiah, 2005), (Engku Abu Bakar, Rahman & Yusof, 2011)
Circulation statistics	(Crotts, 1999), (Promis, 1996), (Kao, Chang & Lin, 2003), (Wardiah, 2005), (Engku Abu
Number of staff	(Arora & Klabjan, 2002), (Wardiah, 2005), (Engku Abu Bakar, Rahman & Yusof, 2011)
Expected growth/frequency of updates	(Wise & Perushek, 1996), (Crotts, 1999), (Wardiah, 2005)
Inclusion of multimedia	(Arora & Klabjan, 2002), (Wardiah, 2005)
Subjects covered	(Goyal,1973), (Crotts, 1999), (Kao, Chang & Lin, 2003), (Wardiah, 2005), (Sudarshan, 2006)

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Determining weight for criteria or factors

There are many approaches that can be used to determine weights or preference for criteria to be embedded into any decision-making models. Some of the more notable ones are discussed here.

The first technique is the rating technique which obtains a score from a decision maker to represent the importance of each criterion. It is comparable to scales used on a Likert-scale questionnaire. Most of the time the numbers 1 to 5, 1 to 7 or 1 to 10 are used to indicate importance (Nijkamp, Rietveld & Voogd, 1990).

The second technique is the ranking method which is the simplest approach for assigning weights to criteria. Basically, the criteria are ranked in order, from most important to least important. After this is done then there are three main methods to calculate weights. They are: 1. rank sum, 2. rank reciprocal and 3. the rank exponent method (Malczewski 1999). For the rank sum, the rank position rj is weighted and then standardized by the sum of all weights. On the other hand, rank reciprocal weights are derived from the standardized reciprocals of a criterions rank. Meanwhile, the rank exponent method requires the decision maker to specify the weight of the most important criterion on a 0–1 scale. After that, the value is used in a numerical formula.

The third technique is the point allocation weighting method. In this method, the decision maker allocates numbers to label the criteria weights directly. In many cases, the analyst does not fix the total number of points to be divided but the subjects are asked to give any numbers they enjoyed to reflect the weights. The more points a criterion receives then the greater its relative importance. Although this method is easy to standardize, the weights obtained from the use of point allocation method are not very specific (Zardari et al., 2015).

In the fourth technique, the ratio method (Edwards, 1977), the decision maker is required to first rank the relevant criteria according to their importance. The least significant criterion is assigned a weight of 10 and all others are judged as multiples of 10. The resulting raw weights are then normalized to sum to one. The ratio method involves an algebraic and direct procedure.

The fifth technique is the SWING method (Edwards & Von Winterfeldt, 1986) which starts from an alternative with the worst outcome on all criteria or attributes. The decision maker is allowed to change one criterion from worst outcome to best. The decision maker is asked which ‘swing’ from the poorest to the best outcome would result in the largest, second largest, and so on, improvement. The standard with the most preferred swing is most important and given 100 points. The magnitudes of all extra swing are expressed as percentages of the biggest swing. Finally, the derived percentages are the raw weights that are standardized to yield final weights.

The sixth technique is the graphical weighting of criteria which has many variations. One tactic is to have a decision maker place a mark on a horizontal line. Criteria significance increases as the mark is placed further to the right end of the line. A quantitative weight can be calculated by determining the distance from the mark to the left extremity of the line. Scores are usually normalized to acquire an overall weights vector (Hajkowicz, McDonald, & Smith, 2000).

The seventh technique, Simple Multi-attribute Rating Technique (SMART) is originally described as the entire process of rating alternatives and weighting criteria by Edwards and Von Winterfeldt (1986). In this method decision maker is asked to rank the significance of criteria from worst levels to best levels. Then 10 points are assigned to the least important criterion and an increasing number of points are assigned to the other criteria to address their significance relative to the least significant criterion. The weights are considered by normalizing the sum of the points to one.

The eighth technique is the SIMOS weighting method where Simos (1990) proposed a technique permitting any decision maker to think about and define the way in which decision maker wishes to rank the different criteria of a family F in a given context. This process also targets to communicate to the analyst the information that are needed in order to attribute a numerical value to the weights of each criterion of F (Mousseau & Roy, 1996; Roy & Bouyssou, 1993).

The ninth technique is the pairwise comparison method. This is a very old psychometric technique that has been used by several generations of psychologists (Mardulyn & Whitfield 1999). It is a well-developed method of ordering criteria. Pairwise comparisons include the comparison of each criterion against every other criterion in pairs. One of the well-known process of the pairwise comparison method is Analytic Hierarchy

Process (AHP) which is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It is a tool for dealing with complex decision making and may assist the decision maker to set priorities and make the best decision. AHP considers a set of assessment criteria and a set of alternate options among which the best decision is to be made. AHP generates a weight for each assessment criterion according to the decision maker's pairwise comparisons of the criteria (Saaty, 1980).

Basically, to get the importance weights for all the criteria, AHP begins with the identification of all the relevant criteria to be used for the decision-making process. In the second step, a series of pairwise comparisons among the decision-making criteria to determine the importance weight of each criterion towards the final decision-making process must be performed by the decision maker(s). A questionnaire can be designed and distributed among the decision makers (can be managers, experts, or users) to collect their opinion. Each decision maker will then enter his/her desired evaluation and then these individual judgments will be converted into group judgments by taking the geometric mean (Taherdoost, 2017). The pairwise comparison scale ranges from one to nine where one implies that the two criteria are equally-important. On the other hand, scale nine implies that one criterion is extremely more important than the other one. The pairwise scale and the importance value attributed to each number are illustrated in Table 3. The completed pairwise comparison evaluations are then summarized as a pairwise comparison matrix C.

Table 3. Preference scale for AHP-pairwise comparisons (Taylor et al. 1996)

Preference Level Between Criterion i and Criterion j	Numeric Value
i is equally preferred to *j*	1
i is equally to moderately preferred than *j*	2
i is moderately preferred than *j*	3
i is moderately to strongly preferred than *j*	4
i is strongly preferred than *j*	5
i is strongly to very strongly preferred than *j*	6
i is very strongly preferred than *j*	7
i is very strongly to extremely preferred than *j*	8
i is extremely preferred than *j*	9

***Note:** If the comparison is done between j and i, the reciprocal of the numeric value above will be used.

The next step is the determination of weights for the decision criteria. This is accomplished through the vector of preference for criteria. First, the pairwise comparison matrix is normalized dividing each value in each column of the matrix by the corresponding column sum. Next, the row averages will be computed to get the normalized matrix. Finally, the preference vector is constructed.

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The preference vector will be meaningless if the pairwise comparisons are not being completed consistently. Hence, the last step in the AHP-process is the checking of pairwise comparison consistency, which could be done by calculating consistency ratio (CR) where:

CR = Consistency Index (CI)/ Random Index (RI) and, CI = (λmax − N)/ (N − 1).

N is the matrix size and λmax is the largest matrix eigenvalue. Meanwhile, RI can be determined using Table 4. The pairwise comparison matrix is accepted as being consistent if CR ≤ 0.10.

Table 4: Random Index (RI)

Size of matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

However, various researchers show that consistency is one of the key issues when dealing with AHP (Gastes & Gaul, 2012; Alonso & Lamata, 2006; Ishizaka & Lusti, 2004; Forman & Peniwati, 1998; Dyer, 1990; Crawford & Williams, 1985). To overcome the consistency barrier, Nazri, Balhuwaisl and Kasim, (2016) illustrated how a pre-evaluation procedure in the form of rating using a scale of 1 to 9 can be used as a guide to produce a consistent pairwise comparison matrix. Specifically, Nazri, Balhuwaisl and Kasim's procedure begins by supposing that there are N criteria to be evaluated. The evaluator then rates the level of significance of each criterion in determining the weight of that criterion to the ending goal (the decision- making process) using the scale of 1 to 9. Assuming that the evaluator rates criterion i as ri and criterion j as rj, cij which is the pairwise comparison value between criterion i and criterion j in the pairwise comparison matrix C will be determined as follows:

Let $b = r_i – r_j$

If $b > 0$ then $c_{ij}= b+1$

If $b = 0$ then $c_{ij} = 1$

If $b < 0$ then $c_{ij} = 1/(1-b)$

Once the pairwise matrix is obtained, the weight for each criterion would be calculated using the normal AHP- technique.

III. Suitable mathematical models

Goyal (1973) is arguably, the pioneer of the researchers on libraries' budget allocation model. He used a linear programming model based on non-negativity and linear objective function to find the optimum allocation of the funds to different departments for purchases of books and periodicals. Since then, modeling of budget allocation for libraries has become increasingly popular evidenced by numerous research studies such as studies by Anderson, Sweeney, and Williams (1994), Wu (2003), Kao, Chang, and Lin, (2003), Wise and Perushek (1996, 2000), Wardiah (2005), Sudarsan (2006), and Engku Abu Bakar, Rahman, and Yusof (2011), using various methods.

Anderson, Sweeney, and Williams (1994) and Wu (2003) for example, used statistics-based model methods to support the decision of the library's acquisition budget allocation operation. Statistics approaches such as forecasting, and data mining require a lot of data storing and data collection process which may not be promising by the implementers. On the other hand, Kao, Chang, and Lin (2003) introduced a model called acquisition budget allocation model via data mining (ABAMDM) that addresses the use of descriptive knowledge discovered in the historical circulation data explicitly to support allocating library acquisition budget. The primary output of the ABAMDM used to derive weights of acquisition budget allocation contains two parts. One is the descriptive knowledge via utilization concentration and the other is the suitability via utilization connection for departments concerned. Meanwhile, Wise and Perushek (1996, 2000) implemented linear goal programming for academic library goal programming-based paradigms. They applied their methodology to 90 funds representing books and periodicals in 45 subject disciplines at the University of Tennessee, Knoxville. The model's goals integrate several categories of budget constraints and user requirements. In the meantime, Wardiah (2005) proposed AHP, linear and integer programming methods to allocate the UiTM Perlis Library's budget for academic departments. The objective of this study was to minimize regrets (how many books that could not be purchased) and to minimize deviations from each department's budget allocation target. AHP was used to find the weight as a linear coefficient equation for students' population, books, journals, magazines, departments, and book selection based on faculty demand. For obtaining more accurate weights, the averages of three respondents were considered. The result provided the annual budget that should be allocated to each faculty and how many books and journals that should be bought from the recommendation.

A few years later, Engku Abu Bakar, Rahman and Yusof (2011) improved and enhanced the model by introducing three new sub-models which serve different purposes. The three sub-models are: (1) the budget allocation for faculty, (2) the budget allocation for material types such as books and journals within the faculty, and finally (3) the specific books and journals to be purchased for that faculty subject to total budget allocated. The three sub-models are described below.

Sub-model 1: Budget allocation to be distributed among faculties.

Objective function: To maximize total budget distributed to faculties =

$$\sum_{i=1}^{13} X_i [W_a \frac{S_{ui}}{S_{ut}} + W_b \frac{S_{pi}}{S_{pt}} + W_c \frac{L_i}{L_t} + W_d \frac{A_i}{A_t} + W_e \frac{P_i}{P_t} + W_f \frac{C_i}{C_t} + W_g \frac{D_i}{D_t}]$$

Subject to:

$$\sum_{i=1}^{I} X_i \leq Total\ Available\ Budget$$

$$X_i \geq 0$$

where

X_i = total budget to be allocated for faculty i,

W_a = weight factor for number of faculty members,

W_b = weight factor for undergraduate student population,

W_c = weight factor for postgraduate student population,

W_d = weight factor for age of programs in the university,

W_e = weight factor for total number of programs,

W_f = weight factor for number of service course slots,

W_g = weight factor for distance learning students,

S_{ui} = total undergraduate students in faculty i,

S_{ut} = total undergraduate students in the university,

S_{pi} = total postgraduate students in faculty i,

S_{pt} =total postgraduate students in the university,

L_i = total academic staff in faculty i,

L_t = total academic staff in the university,

A_i =average age of academic programs in faculty i,

A_t = average age of academic programs in the university,

P_i = total academic programs in faculty i,

P_t = total academic programs in the university,

C_i =total service course slots in faculty i,

C_t = total service course slots in the university,

D_i = total distance learning students in faculty i,

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D_t = total distance learning students in the university,

i = 1, 2, 3, ……., I.

Sub-model 2: The budget allocation for books, printed journals, and electronic journals within the faculty.

Once the budget that will be allocated to faculty j (X_j) is known, the amount to be distributed among books, printed journals, and electronic journals within the faculty can be decided by solving equation below.

$$\sum_{i=1}^{3} \alpha_{ij} X_{ij} = X_j, \forall_j$$

where;

α_{ij} = weight for material type i and faculty j, X_{ij} = budget allocated for material type i and faculty j, X_j = total budget allocated for faculty j.

Finally, the specific books, printed journals, and electronic journals to be purchased or subscribed can be determined by solving sub-model 3.

Sub-model 3: The determination of which books, printed journals, and electronic journals to purchase

In sub-model 3, decision variables are determined and as follows:

B_i = 1 if book i is purchased; 0 otherwise.

PJ_j = 1 if printed journal j is purchased; 0 otherwise.

EJ_k = 1 if electronic journal k is purchased; 0 otherwise

where,

B_i = book i, PJ_j = printed journal j, EJ_k = electronic journal k.

The model's objective is to maximize the purchases subjected to budget allocated for books, journals and electronic journals.

Objective Function: To maximize the total spending on books, printed journals, and electronic journals =

$$\sum_{i=1}^{I} w_i B_i + \sum_{j=1}^{J} w_j PJ_j + \sum_{k=1}^{K} w_k EJ_k$$

Subject to

$\sum_{i=1}^{I} C_i B_i \leq Total\ Budget\ Allocated\ to\ Books$
i = 1, 2, 3, …, I

$\sum_{j=1}^{J} C_j PJ_j \leq$
$Total\ Budget\ Allocated\ to\ Printed\ Journals$ j = 1, 2, 3, …, J

$\sum_{k=1}^{nK} C_k EJ_k \leq$
$Total\ Budget\ Allocated\ to\ Electronic\ Journals$
k = 1, 2, 3, …, K

Where;

w_i = weight for book i, w_j = weight for printed journal j, w_k = weight for electronic journal k, C_i = cost for book i, C_j = cost for printed journal j, C_k = cost for electronic journal k.

IV. Proposed Budget Allocation Model for Academic Library

The model that we are proposing is based on the model developed by Engku Abu Bakar, Rahman and Yusof (2011), with some modifications. It also involves three models that will be developed through three stages with one model developed in each stage.

Stage 1: Develop Model A to determine the amount/budget to be allocated to each academic school/faculty of a university.

A faculty is a division in a college or university including one subject area, or a number of correlated subject areas. In the American practice such divisions are usually referred to as schools such as "school of business", or colleges such as "college of arts

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and sciences" (Eliot, 1901). The model will be as follows:

Decision variables:

X_i = total budget to be allocated to faculty/school i,

Objective function: To maximize the total budget allocated to all the academic faculties/schools,

$$=\sum_{i=1}^{I} X_i [W_a \frac{S_{ui}}{S_{ut}} + W_b \frac{S_{pi}}{S_{pt}} + W_c \frac{L_i}{L_t} + W_d \frac{A_i}{A_t} + W_e \frac{P_i}{P_t} + W_f \frac{C_i}{C_t} + W_g \frac{D_i}{D_t} + W_h \frac{F_i}{F_t}]$$

Subject to

$$\sum_{i=1}^{n} X_i \leq Total\ Available\ Budget$$

$X_i \geq 0$, $i = 1, 2, 3, \ldots, I$

Where

W_a = weight factor for number of faculty members,

W_b = weight factor for undergraduate student population,

W_c = weight factor for postgraduate student population,

W_d = weight factor for age of programs in the university,

W_e = weight factor for total number of programs,

W_f = weight factor for number of service course slots,

W_g = weight factor for distance learning students,

W_h = weight factor for number of non-academic staff,

S_{ui} = number of undergraduate students in faculty/school i,

S_{ut} = total number of undergraduate students,

S_{pi} = number of postgraduate students in faculty/school i,

S_{pt} = total number of postgraduate students,

L_i= number of academic staff in faculty/school i,

L_t = total number of academic staff in the University,

A_i = average age of programs in faculty/school i,

A_t = average age of programs in the University,

P_i = total number of programs in faculty/school i,

P_t = total number of programs in the University,

C_i = total number of service course slots in faculty/school i,

C_t = total number of service course slots in the University,

D_i = total number of distance learning students in faculty/school i,

D_t = total number of distance learning students in the University,

F_i = number of non-academic staff in faculty/school i,

F_t = total number of non-academic staff in the University.

The model is similar to the model proposed by Engku Abu Bakar, Rahman and Yusof (2011) except that in our proposed model, we add one new factor, which is total number of non-academic staff members as proposed by Van Der Heijden et al. (2009). Although online material views are part of digital library services as described by Covi and Kling, (1997), Sloan, (1998), and Garibay, Gutiérrez and Figueroa, (2010) and the importance of books/journals borrowers was described by Sumsion, Hawkins and Morris (2002), we do not include these two factors in the model due to the difficulty in getting and managing the data. C-AHP (Engku, Balhuwaisl & Maznah, 2016) or any other

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suitable methods can be used to find the weight for the determining factors. The weights would be decided by the University top management and library management team.

Stage 2: Develop Model B to determine the amount/budget to be allocated to each academic department in school/faculty i subject to the budget allocated to school/faculty i obtained from the output of Model A.

Objective function: To maximize the allocation of budget given to school/faculty i to each academic department in the school/faculty i,

$$=\sum_{n=1}^{N} Z_n [W_a \frac{S_{un}}{S_{ut}} + W_b \frac{S_{pn}}{S_{pt}} + W_c \frac{L_n}{L_t} + W_d \frac{A_{in}}{A_t} + W_e \frac{P_n}{P_t} + W_f \frac{C_n}{C_t} + W_g \frac{D_n}{D_t} + W_h \frac{F_n}{F_t}$$

Subject to

$\sum_{n=1}^{N} Z_n \leq X_i$

$Z_n \geq 0,\ n = 1, 2, 3, \ldots, N$

Where

X_i = total budget allocated to faculty/school i obtained from the solution in Model A

Z_n = total budget to be allocated to department n of faculty/school i

W_a = weight factor for number of faculty members,

W_b= weight factor for undergraduate student population,

W_c = weight factor for postgraduate student population,

W_d = weight factor for age of programs,

W_e = weight factor for total number of programs,

W_f = weight factor for number of service course slots,

W_g = weight factor for distance learning students,

W_h = weight factor for number of non-academic staff,

s_{un} = number of undergraduate students in department n,

s_{ut} = total number of undergraduate students in faculty/school i,

s_{pn} = number of postgraduate students in the department n,

s_{pt} = total number of postgraduate students in faculty/school i,

l_n = number of academic staff in the department n,

l_t = total number of academic staff in faculty/school i,

a_n = average age of programs in the department n,

a_t = average age of programs in faculty/school i,

p_n = total number of programs in the department n,

p_t = total number of programs in faculty/school i,

c_n = total number of service course slots in the department n,

c_t = total number of service course slots in faculty/school i,

d_n = number of distance learning students in the department n,

d_t = total number of distance learning students in faculty/school i,

f_n = number of non-academic staff in the department n,

f_t = total number of non-academic staff in faculty/school i,

The same set of factors used in Model A are proposed to be used in Model B. However, the decision makers can choose whether to use the same weights for the factors as in Model A, or, obtain a new set of weights to be determined by the members of the school/faculty for Model B.

Stage 3: Develop Model C to determine the specific textbooks, hardcopy journals, and electronic journals to purchase for each department in school/faculty i subject to the amount/budget allocated to each department (i.e. the results obtained from Model B)

Objective function: To maximize the use of the budget allocated to purchase textbooks, hardcopy journals, and electronic journals for department, or to maximize the total collection of books, journals and electronic- journals for department *n* in school/faculty *j*,

$$= \sum_{a=1}^{A} \alpha_a T_a + \sum_{b=1}^{B} \beta_b J_b + \sum_{c=1}^{C} \gamma_c OJ_c + \sum_{d=1}^{D} £_d J_d + \sum_{e=1}^{E} €_e OJ_e$$

Subject to

1. Total amount spent on books, journals, and online journals should not exceed total budget obtained by the department.

$$\sum_{a=1}^{A} p_a T_a + \sum_{b=1}^{B} p_b J_b + \sum_{c=1}^{C} p_c OJ_c + \sum_{d=1}^{D} p_d J_d + \sum_{e=1}^{E} p_e OJ_e \leq Z_n$$

2. Total number of textbook *a* to be purchased

$T_a \leq q_a \ \forall a = 1, 2, 3, \ldots., N$

3. To purchase or not to purchase the hardcopy journal *b* if the journal does not have the electronic version.

$J_b \leq 1 \ \forall b = 1, 2, 3, \ldots., B_1$

4. To subscribe or not to subscribe the electronic version *c* if the journal does not have the hardcopy version.

$OJ_c \leq 1 \ \forall c = 1, 2, 3, \ldots, C$

5. Either to purchase the hardcopy version *d* or to subscribe to the electronic version *e* if the journal is available in both versions.

$J_d + OJ_e \leq 1 \ \forall d = 1, 2, 3, \ldots, D$ and $\forall e = 1, 2, 3, \ldots, E$ where D = E

And all decision variables ≥ 0 and integer

Where

α_a = Weight factor for textbook *a*.

β_b = Weight factor for hardcopy journal *b* that do not have an electronic version.

γ_c = Weight factor for electronic journal *c* that does not have a hardcopy version.

$£_d$ = Weight factor for hardcopy journal *d* that has an electronic version *e*.

$€_e$ = Weight factor for electronic journal *e* that has a hardcopy version *d*.

p_a = cost for textbook *a*.

p_b = cost for hardcopy journal *b*.

p_c = cost for electronic journal *c*.

p_d = cost for hardcopy journal *d*.

p_e = cost for electronic journal *e*.

The weights for each book, hardcopy journal, and electronic journal should be determined by the academic members (and perhaps the students as well) of the department.

V. CONCLUSION

This paper suggests a framework for an approach to solve the budget allocation problem for a university library's books' and journals' purchasing exercise for the library to allocate its annual budget more efficiently. The budget allocation model is suggested to distribute funds in a manner that considers a balance between resources to support undergraduate learning, postgraduate learning, subject disciplines, and research. In order to achieve the goals, the suggested approach starts with the construction of an LP-model to determine the total amount of the university' library's budget that should be allocated to each school/faculty in the university. Next, based on the budget allocated

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to each school/faculty, the approach continues with the construction of another LP-model to determine the school/faculty's budget distribution for each department in the school/faculty. Once the total budget for each department is determined, the final model, which is the IP-model to decide on which textbooks, hardcopy journals, and electronic journals that relate to the needs of the department is proposed. These three suggested budget allocation models could ensure that university libraries have a better plan in the cost allocation and expenditure according to the needs of the library's stakeholders and certain conditions imposed by the university management. The three models which were enhanced based on the previous models by Engku Abu Bakar, Rahman and Yusof (2011) would also help university libraries to prioritize the criteria used towards the final budget allocation decision.

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