Internal Audit Resource Allocation Model Using Linear Programming

Frederick M. Baldo and Rex Aurelius C. Robielos
School of Industrial Engineering and Engineering Management
Mapua University
Intramuros, Manila, Philippines
Fbaldo824@gmail.com,racrobielos@mapua.edu.ph

Abstract

This study utilized a Linear Programming (LP) model for the assignment of internal audit staff to different audit projects with varying complexities and skill level requirements. Numerous auditor allocation studies proposed models that minimized the cost, however, since the internal audit function is not a revenue-generating function, the efficiency ratings of each audit staff were used and converted these into regrets ratings which were later on used as factors in solving this allocation problem. The Lingo 18.0 software was used to determine the proper allocation of audit staff that will maximize the audit efficiency for a mid-sized internal audit department. The results of this study were presented to the Director of the internal audit department who plans to use this model to get further insights on whether the model will be beneficial in optimizing the audit staff allocation as well as improve the overall quality and efficiency of the internal audit function as compared to the current traditional manual allocation process.

Keywords
Internal Audit, Allocation, Audit Staff, Efficiency, Quality, Linear Programming

1. Introduction

Internal auditing is an independent, objective assurance and consulting activity designed to add value to and improve an organization's operations. It helps an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control and governance processes (ISPPIA, 2017). With the recent advancement in technology, business operations have become more complex, regulations have become more rigorous and new risks have emerged. Because of these, coupled by the increasing professionalism of the internal audit profession, internal auditors are now under pressure to raise the bar of their audit quality. One of the keys to address this issue is the proper allocation of internal audit skills.

The planning stage of internal audit is quite a complex process, hence, this is often handled by the more senior members of the internal audit team. This process predetermines the what, how, where, when and by whom the audit will be carried out to achieve its goals. In other words, audit planning is an anticipatory function that will ensure timely completion of tasks, with the least audit risk, cheapest cost and maximum possible quality and efficiency (Usul & Ünal, 2009). In order to do this, internal auditors must determine the appropriate and sufficient level resources to achieve the engagement objectives based on evaluation of the nature and complexity of each assignments, time constraints and available resources. Appropriate refers to the mix of knowledge, skills, and other competencies needed to perform the assignments. Sufficient refers to the quantity of resources needed to accomplish the assignments with independence, objectivity and due professional care. Resources are deployed effectively when they are used in a way that optimizes the achievement of the approved audit plan (Uyar & Yelgen, 2015)

The allocation of internal audit resources is one of the critical parts that support the audit planning stage. Internal auditors spent a great deal of time and effort in this area. After all, improper allocation of resources, can lead to wastage of energy and manpower. If a wrong audit staff is allocated to an audit project, he/she can not only bring down the productivity but can also prolong the output time and affect the quality of the output. Therefore, it is extremely important to allocate the right audit staff to the right audit projects (Das, Verma & Gupta, 2017). Some of the criteria used to allocate internal audit staff include but not limited to the following: (i) available hours of each audit staff; (ii) estimated hours to complete each audit projects; (iii) complexity and level of risks involved in each audit area; (iv)

the staff position or skill levels required to audit a project; (v) the auditors cumulative knowledge and experience in each of the audit area; and (vi) the opportunity for personal and professional development of each audit staff.

For most internal audit organizations, the task of audit staff allocation is traditionally done using a manual process. This sounds to be fairly straight-forward to a relatively small internal audit organization, however, this has been a challenge for medium and big internal audit organizations when the number of auditors and audit projects to be completed are taken into consideration. For mid-sized internal audit organizations, on average, this task alone normally requires around two to four days to complete. However, if subsequent changes are to be made, then this could be longer. For this reason, the use of mathematical methods such as linear programming for the allocation of audit staff is proposed.

Past studies revealed that many mathematical models such as linear programming, integer and multiple objective linear programming and goal programming are used in audit task planning (Uyar & Yelgen, 2015). Edward L. Summer in 1972 worked on conforming with the limitations of an audit office and meeting the objectives of that office, to audit engagements by assigning the audit staff. In Summer's study, linear programming model was described for the assignment problem (Summers, 1972. In 1974 Bailey, Boe and Schnack used goal programming instead of linear programming on audit staff assignment (Bailey, Boe & Schnack, 1974). Blocher (1979) on the other hand, examined the effect of different assignment strategies on audit staff performance. The intent was to determine the relationships between assignment policy and the performance of audit seniors (Blocher, 1979). In early 1980s, Balachandran and Zoltners (1981) designed an integer programming model to assign audit staff to audit engagements in the most effective way. The objective of the study was the minimization of total costs (Balachandran and Zoltners, 1981). Also in 1982, Balachandran and Steuer published another paper about CPA firm's audit staff planning problem with multiple objectives. The results proposed recommendations about allocating the projected workload among the auditors and altering the staff levels (Balachandran and Steuer, 1982). Chan and Dodin (1986) extended the integer programming model presented by Balachandran and Zoltners (1981). Due dates, precedence constraints, penalty costs, resource levelling are added to old model (Chan & Dodin, 1986). In 1991 Chan and Dodin enhanced their study and described the methods to solve such a complex problem and applied these methods to a real-life audit schedule case (Dodin and Chan, 1991). Dodin (1999) also asserted that through efficient scheduling, audit firms can determine the load and schedule of every auditor, over time requirements, travel schedules and costs, and can respond to changes in the information set (input data) easily. Therefore, he proposed a model that used project management as assigning tool (Dodin, 1999). Chang (2002) introduced an approach in resolving audit staff scheduling for multiple and large engagements. The major advantage of the proposed method is solving staff resource allocation problems by alleviating the limitations of both linear and integer programming (Chang, 2002). Chen et. Al. (2012) investigated a model that aimed to assign auditors due to improving audit quality. They stated a genetic algorithm and optimally assigned auditors and the manager responsible for assignment (Chen, Huang & Suen, 2012). Ulyar and Yelgen (2015) developed a mathematical model assigning auditors to auditing activities through a linear programming model in a way to minimize the costs assuming that auditors with the same title have similar characteristics (Uyar and Yelgen, 2015).

Numerous auditor allocation studies proposed models that minimized the costs. However, since the internal audit function is not a revenue-generating function, the resource allocation problem for this type of organization is similar to the model made by Das et al (2017) where they converted each professors' efficiency ratings into a regret matrix and used this as a factor in the allocation (Das, Verma and Gupta, 2017). Thus, this study aims to: 1) obtain an optimal solution in allocating internal audit staff in order to maximize the audit quality of the internal audit function; and 2) improve efficiency by reducing the time spent for resource allocation by using effective mathematical methods.

2. Methodology

2.1. Data Gathering

The data for this study was collected from a mid-sized internal audit department. This internal audit department is composed of 11 internal auditors including five (5) senior auditors and six (6) junior auditors. During the period under study, the internal audit department is also expected to complete 37 audit projects based on their approved annual audit plan.

2.2. Data Analysis

2.2.1. Internal Audit Staff

As mentioned in 2.1 above, the internal audit department is composed of 11 auditors including 5 senior auditors and 6 junior auditors. Senior auditors are those which have a total of at least five (5) years of working experience and have already handled complex assignments. Junior auditors have less than five (5) years of working experience and normally handles from low to moderate risks assignments. All internal audit staff are license professionals including Certified Professional Accountants, Certified Internal Auditors, Certified Fraud Auditors, etc. Table 1 shows the details of the internal audit staff and the available number of audit hours each staff can render. Note that the differences in the available hours are due to several factors such as staff taking long vacations, maternity leave and different start dates for new staff.

Table 1: Details of the Internal Audit Staff

Audit Staff	Position	Available Hours
SA1	Senior Auditor	2,035.00
SA2	Senior Auditor	1,046.00
SA3	Senior Auditor	1,939.00
SA4	Senior Auditor	1,843.00
SA5	Senior Auditor	1,651.00
JA1	Junior Auditor	2,035.00
JA2	Junior Auditor	2,035.00
JA3	Junior Auditor	1,939.00
JA4	Junior Auditor	2,035.00
JA5	Junior Auditor	1,843.00
JA6	Junior Auditor	1,046.00
Total		19,447.00

2.2.2. Audit Projects

The internal audit department is expected to complete 37 audit projects based on the approved annual audit plan for the year. These audit projects vary in terms of complexity and level of risks involved. As such, each audit projects require a certain level of skills or experience to ensure that expected efficiency and audit quality will be achieved. Estimated hours to complete for each audit projects are also set and used as benchmarks to measure efficiency. This also ensures adequate coverage of the internal audit activity. Table 2 shows a snapshot sample of the internal audit projects. In order to have a better visual idea as to who can do what project, a mapping of the internal audit staff to individual audit projects was created. With this mapping, it will be easier to translate the constraints into mathematical equation. Refer to Table 3 for the mapping of the audit staff to individual audit projects.

Table 2: Details of the Internal Audit Projects

Audit Assignments	Complexity	Minimum Required Experience	Estimated No. of hours to complete
Project 1	Moderate	Senior or Junior	768
Project 2	High	Senior	864
Project 3	Low	Junior	432
Project 4	Moderate	Senior	624
Project 5	Moderate	Senior or Junior	672
Project 6	Moderate	Senior or Junior	960
Project 7	Moderate	Senior or Junior	960
Project 8	Low	Junior	480
Project 9	Low	Junior	240
Project 10	Moderate	Senior or Junior	432
Project 11	High	Senior	624
Project 12	Low	Junior	624
Project 13	High	Senior	720
Project 14	Low	Senior	864
Project 15	Low	Junior	624
Project 16	Moderate	Junior	576
Project 17	Low	Junior	384
Project 18	Moderate	Senior or Junior	558
Project 19	Low	Senior or Junior	336

Table 3. Mapping of Internal Audit Staff to Individual Projects

Audit Assignments	Internal Audit Staff										
	SA1 (X1)	SA2 (X2)	SA3 (X3)	SA4 (X4)	SA5 (X5)	JA1 (X6)	JA2 (X7)	JA3 (X8)	JA3 (X9)	JA5 (X10)	JA6 (X11)
Project 1	√	√	√	√	√	√	√	√	√	√	√
Project 2	√	√	√	√	√						
Project 3	√	√	√	√	√						
Project 4						√	√	√	√	√	√
Project 5	√	√	√	√	√	√	√	√	√	√	√
Project 6	√	√	√	√	√	√	√	√	√	√	√
Project 7	√	√	√	√	√	√	√	√	√	√	√
Project 8						√	√	√	√	√	√
Project 9						√	√	√	√	√	√
Project 10	√	√	√	√	√	√	√	√	√	√	√
Project 11	√	√	√	√	√						
Project 12						√	√	√	√	√	√
Project 13	√	√	√	√	√						
Project 14	√	√	√	√	√						
Project 15						√	√	√	√	√	√
Project 16						√	√	√	√	√	√
Project 17						√	√	√	√	√	√
Project 18	√	√	√	√	√	√	√	√	√	√	√
Project 19	√	√	√	√	√	√	√	√	√	√	√

2.2.3.Efficiency Ratings and Regrets Matrix

Since the internal audit function is not a revenue generating function, the efficiency ratings of each audit staff will be used as the factor for this allocation problem. The overall efficiency rating was derived by taking the average of each auditor's past performance evaluations for each projects handled, project knowledge and their overall performance feedback ratings (Das, Verma and Gupta, 2017). For new audit staff, the overall staff hiring assessment ratings gathered from the human resources department were used instead. Refer to Table 4 for the relative efficiency ratings of audit staff for each of the audit projects.

Table 4: Audit Staff Efficiency Rating Table

Audit Assignments	Internal Audit Staff										
	SA1 (X1)	SA2 (X2)	SA3 (X3)	SA4 (X4)	SA5 (X5)	JA1 (X6)	JA2 (X7)	JA3 (X8)	JA3 (X9)	JA5 (X10)	JA6 (X11)
Project 1	73	73	85	89	60	63	74	85	60	70	75
Project 2	96	85	73	71	67	-	-	-	-	-	-
Project 3	90	92	79	64	68	-	-	-	-	-	-
Project 4	-	-	-	-	-	82	73	94	60	78	68
Project 5	94	67	85	79	85	63	65	70	79	89	83
Project 6	97	91	65	64	60	83	65	89	60	63	68
Project 7	73	67	65	89	80	89	73	85	60	82	68
Project 8	-	-	-	-	-	89	65	90	60	77	68
Project 9	-	-	-	-	-	63	92	84	78	84	68
Project 10	88	91	65	85	60	63	85	90	60	88	84
Project 11	73	85	75	89	60	-	-	-	-	-	-
Project 12	-	-	-	-	-	63	79	93	78	84	86
Project 13	97	86	72	64	70	-	-	-	-	-	-
Project 14	90	90	65	64	60	-	-	-	-	-	-
Project 15	-	-	-	-	-	63	78	88	60	88	68
Project 16	-	-	-	-	-	70	65	93	77	63	87
Project 17	-	-	-	-	-	73	79	93	69	82	68
Project 18	95	79	84	64	60	63	84	82	60	81	92
Project 19	73	86	78	89	60	63	65	93	60	79	75

After an appropriate evaluation of each auditor's ability to audit a certain project, an efficiency rating of 100 had been allotted. Since allocation problems usually deal with the minimization situations, the above maximization problem was reduced to a minimization problem by finding the regrets matrix, as shown in Table 5.

Table 5: Regrets Matrix

Audit Assignments	Internal Audit Staff										
	SA1 (X1)	SA2 (X2)	SA3 (X3)	SA4 (X4)	SA5 (X5)	JA1 (X6)	JA2 (X7)	JA3 (X8)	JA3 (X9)	JA5 (X10)	JA6 (X11)
Project 1	27	27	15	11	40	37	26	15	40	30	25
Project 2	4	15	27	29	33	-	-	-	-	-	-
Project 3	10	8	21	36	32	-	-	-	-	-	-
Project 4	-	-	-	-	-	18	27	6	40	22	32
Project 5	6	33	15	21	15	37	35	30	21	11	17
Project 6	3	9	35	36	40	17	35	11	40	37	32
Project 7	27	33	35	11	20	11	27	15	40	18	32
Project 8	-	-	-	-	-	11	35	10	40	23	32
Project 9	-	-	-	-	-	37	8	16	22	16	32
Project 10	12	9	35	15	40	37	15	10	40	12	16
Project 11	27	15	25	11	40	-	-	-	-	-	-
Project 12	-	-	-	-	-	37	21	7	22	16	14
Project 13	3	14	28	36	30	-	-	-	-	-	-
Project 14	10	10	35	36	40	-	-	-	-	-	-
Project 15	-	-	-	-	-	37	22	12	40	12	32
Project 16	-	-	-	-	-	30	35	7	23	37	13
Project 17	-	-	-	-	-	27	21	7	31	18	32
Project 18	5	21	16	36	40	37	16	18	40	19	8
Project 19	27	14	22	11	40	37	35	7	40	21	25

2.3. Linear Programming

As previously mentioned, the aim of the model is to allocate the internal audit staff that will maximize audit quality of the internal audit function, hence, this maximization problem was reduced to a minimization problem by finding the regrets ratings/costs for each audit staff. Based on this context, the objective function was formulated as follows:

$$Minimize\ Z = \Sigma_{i=1}^{n}\Sigma_{j=1}^{n} C_{ij}X_{ij}$$

Subject to:

$$\Sigma_{i=1}^{n}\ X_{ij}\ \leq a \quad \Big\}$$ Minimum working hour constraints for each auditors

$$\Sigma_{j=1}^{n} X_{ij}\ \geq b \quad \Big\}$$ Time constraints per audit assignments

Where:

n = total number of audit staff/ audit projects
i = audit staff
j = audit projects
a = available working hours of each audit staff
b = the expected duration of audit for each audit projects
Xij = the assignment of auditor i to audit project j
Cij = the regret cost of assigning auditor i to project j

3. Results

In this study, the LP model was solved using LINGO 18.0 software. This minimization problem consisted of 242 variables and 49 constraints. The objective function, which represents the total minimum regret that will maximize total audit efficiency, is equal to 222,478. This optimal solution was found after 69 iterations. The software was also able to compute for the optimal allocation in less than a second (10 milliseconds), a task, which is normally done in hours if not days using the traditional manual allocation. The screenshots of the results obtained and the solution for the allocation model are shown in Figure 1.

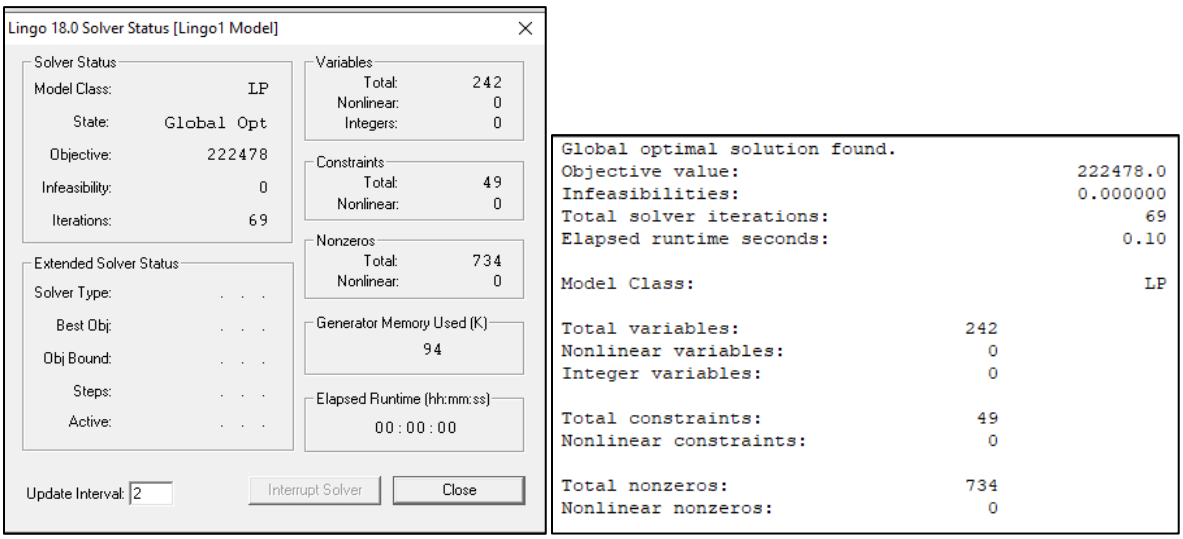

Figure 1: Results of Solver Solution

The table results at individual variables are shown in Table 6. The table consists of the Variable or the staff assignments per audit project, Value, which is the number of audit hours a staff will have to spend in auditing the projects and Reduced Cost which is the equivalent regret cost for not assigning audit staff in a particular audit project. The table can be further interpreted as follows: assign audit staff #4 (X4) to audit project #1 for a total of 768 hours, assign audit staff#2 (X2) to audit project#2 for a total of 864 hours, etc.

Table 6. Results at Individual Variables

Variable	Value	Reduced Cost
X11	0.000000	30.00000
X21	0.000000	38.00000
X31	0.000000	6.000000
X41	768.0000	0.000000
X51	0.000000	21.00000
X61	0.000000	26.00000
X71	0.000000	7.000000
X81	0.000000	10.00000
X91	0.000000	19.00000
X101	0.000000	15.00000
X111	0.000000	44.00000
X12	864.0000	0.000000
X22	0.000000	20.00000
X32	0.000000	12.00000
X42	0.000000	12.00000
X52	0.000000	8.000000
X13	410.0000	0.000000
X23	0.000000	7.000000
X33	214.0000	0.000000
X43	0.000000	13.00000
X53	0.000000	1.000000
X64	0.000000	6.000000
X74	0.000000	7.000000
X84	432.0000	0.000000
X94	0.000000	18.00000
X104	0.000000	6.000000
X114	0.000000	11.00000
X15	0.000000	12.00000
X25	0.000000	48.00000
X35	0.000000	10.00000
X45	0.000000	14.00000
X55	460.0000	0.000000
X65	0.000000	30.00000
X75	0.000000	20.00000
X85	0.000000	29.00000
X95	0.000000	4.000000
X105	212.0000	0.000000
X115	0.000000	10.00000
X16	41.00000	0.000000
X26	0.000000	14.00000
X36	0.000000	20.00000
X46	0.000000	19.00000
X56	0.000000	15.00000
X66	595.0000	0.000000
X76	0.000000	10.00000
X86	324.0000	0.000000
X96	0.000000	13.00000
X106	0.000000	16.00000
X116	0.000000	15.00000
X17	0.000000	30.00000
X27	0.000000	44.00000
X37	0.000000	26.00000
X47	0.000000	0.000000
X57	0.000000	1.000000
X67	960.0000	0.000000
X77	0.000000	8.000000
X87	0.000000	10.00000
X97	0.000000	19.00000
X107	0.000000	3.000000
X117	0.000000	21.00000
X68	480.0000	0.000000
X78	0.000000	16.00000
X88	0.000000	5.000000
X98	0.000000	19.00000
X108	0.000000	8.000000
X118	0.000000	31.00000
X69	0.000000	37.00000
X79	240.0000	0.000000
X89	0.000000	22.00000
X99	0.000000	13.00000
X109	0.000000	12.00000
X119	0.000000	62.00000
X110	0.000000	18.00000
X210	0.000000	24.00000
X310	0.000000	30.00000
X410	0.000000	8.000000
X510	0.000000	25.00000

Converting the results in Table 6 into tabular form, we can see in Table 7 that the model was able to allocate or at least suggest the level of hours that each audit staff will need to spend for each audit projects. A detailed analysis of the allocation reveals that for at least 76% of the audit projects (28 out of 37 projects), the assigned audit staff are those with the highest efficiency ratings or lowest regret ratings/costs. Total hours for each audit projects and audit staff were also met except for audit staff#9 (X9) whose allocated hours is 44 hours less than his projected hours. This is acceptable considering that the dataset used is imbalance by the same number of hours.

Table 7: Tabular Presentation of the Linear Programming Model Results

Audit Assignments	Internal Audit Staff											Total Allocated Hours	Estimated Hours	Difference
	SA1 (X1)	SA2 (X2)	SA3 (X3)	SA4 (X4)	SA5 (X5)	JA1 (X6)	JA2 (X7)	JA3 (X8)	JA3 (X9)	JA5 (X10)	JA6 (X11)			
Project 1	-	-	-	768	-	-	-	-	-	-	-	768	768	-
Project 2	864	-	-	-	-	-	-	-	-	-	-	864	864	-
Project 3	410	-	214	-	-	-	-	-	-	-	-	624	624	-
Project 4	-	-	-	-	-	-	-	432	-	-	-	432	432	-
Project 5	-	-	-	-	460	-	-	-	-	212	-	672	672	-
Project 6	41	-	-	-	-	595	-	324	-	-	-	960	960	-
Project 7	-	-	-	-	-	960	-	-	-	-	-	960	960	-
Project 8	-	-	-	-	-	480	-	-	-	-	-	480	480	-
Project 9	-	-	-	-	-	-	240	-	-	-	-	240	240	-
Project 10	-	-	-	-	-	-	432	-	-	-	-	432	432	-
Project 11	-	-	-	624	-	-	-	-	-	-	-	624	624	-
Project 12	-	-	-	-	-	-	-	-	97	527	-	624	624	-
Project 13	720	-	-	-	-	-	-	-	-	-	-	720	720	-
Project 14	-	662	-	-	202	-	-	-	-	-	-	864	864	-
Project 15	-	-	-	-	-	-	-	-	-	624	-	624	624	-
Project 16	-	-	-	-	-	-	-	500	22	-	54	576	576	-
Project 17	-	-	-	-	-	-	229	155	-	-	-	384	384	-
Project 18	-	-	-	-	-	-	558	-	-	-	-	558	558	-
Project 19	-	-	-	336	-	-	-	-	-	-	-	336	336	-

Table 7: Tabular Presentation of the Linear Programming Model Results (continued)

Project 20	-	-	-	-	768	-	-	-	-	-	-	768	768	-
Project 21	-	-	-	-	-	-	-	-	-	-	240	240	240	-
Project 22	-	-	384	-	-	-	-	-	-	-	-	384	384	-
Project 23	-	-	541	-	-	-	-	-	-	-	-	541	541	-
Project 24	-	-	-	-	-	-	-	-	288	-	-	288	288	-
Project 25	-	-	800	-	-	-	-	-	-	-	-	800	800	-
Project 26	-	-	-	-	-	-	-	-	240	-	-	240	240	-
Project 27	-	-	-	-	-	-	-	-	528	-	-	528	528	-
Project 28	-	-	-	-	-	-	-	-	-	-	752	752	752	-
Project 29	-	-	-	-	-	-	-	-	480	-	-	480	480	-
Project 30	-	-	-	-	-	-	-	-	-	240	-	240	240	-
Project 31	-	-	-	-	-	-	336	-	-	-	-	336	336	-
Project 32	-	384	-	-	-	-	-	-	-	-	-	384	384	-
Project 33	-	-	-	-	-	-	240	-	-	-	-	240	240	-
Project 34	-	-	-	-	-	-	-	-	-	240	-	240	240	-
Project 35	-	-	-	-	-	-	-	-	336	-	-	336	336	-
Project 36	-	-	-	-	-	-	-	528	-	-	-	528	528	-
Project 37	-	-	-	115	221	-	-	-	-	-	-	336	336	-
Total Allocation	2,035	1,046	1,939	1,843	1,651	2,035	2,035	1,939	1,991	1,843	1,046	19,403	19,403	-
Estimated Hours	2,035	1,046	1,939	1,843	1,651	2,035	2,035	1,939	2,035	1,843	1,046	19,447		
Difference	-	-	-	-	-	-	-	-	(44)	-	-	(44)		

The model was also able to allocate an audit project to an audit staff (1:1 basis) for 29 out of 37 (78%) audit projects. The rest of the projects (22%) were allocated to two (2) or more internal audit staff. Based on further analysis, two (2) audit projects (Project#6 and Project#16) had hours allocated to three (3) audit staff (X1, X9 and X11) with around 41, 22 and 54 hours, respectively.

The analysis of the number of audit projects allocated for each audit staff reveals that senior auditors were allocated 2-4 audit projects depending on their available time while for junior auditors, the allocated projects range from 3 to 7. For senior auditors, audit staff#X2 has the lowest number of assignments due to the fact that staff#X2 has the lowest number of available hours among all seniors. The rest of the seniors were allocated around 4 audit projects each. For junior auditors, audit staff# X6 and X11 got the lowest number of assignments at 3 projects each. However, in the case of staff#X6, further analysis shows that the lower allocation was not attributable to the low number of available staff hours but rather to the high hours required for each of the assignments allocated to staff#X6. The rest of the junior auditors were each allocated around 5 to 7 audit projects.

In terms of the allocation based on the complexity of projects, generally the allocation was balanced except for staff#X8 and X9 which were allocated with higher moderate and low projects, respectively. This could indicate a possibility of having staff workload problems. Refer to Table 9 for the details of the number of audit project allocations per audit staff as well as the allocation based on the complexity of audit projects.

Table 8. No. of Audit Assignments Based on Audit Complexity

	Audit Project Complexity			Total allocated Projects	Staff Hours Constraints
Audit Staff	**Low**	**Moderate**	**High**		
SA1 (X1)	1	1	2	4	2,035
SA2 (X2)	1	1	-	2	1,046
SA3 (X3)	1	2	1	4	1,939
SA4 (X4)	1	2	1	4	1,843
SA5 (X5)	1	2	1	4	1,651
JA1 (X6)	1	2	-	3	2,035
JA2 (X7)	3	3	-	6	2,035
JA3 (X8)	1	4	-	5	1,939
JA3 (X9)	5	2	-	7	1,991
JA5 (X10)	4	1	-	5	1,843
JA6 (X11)	-	3	-	3	1,046
Total	19	23	5	47	

4. Discussion

The findings from this study suggest that an optimal solution in allocating internal audit staff that would maximize the audit quality of the internal audit function can be obtained and that efficiency can be achieved by using mathematical methods such as LP, in the allocation of internal audit staff. The results are consistent with the approach done by Das et al (2017) where they converted each professors' efficiency ratings into a regret matrix and used this as a factor in allocating the professors to different courses with the objective of maximizing the educational quality of the department.

In the case of assigning two or more staff to an audit project, this is considered acceptable because in reality, bigger audit projects can have two or more audit staff. According to Ulyar and Yelgen (2015), for a small scale auditing activity, a single auditor can conduct the whole audit activity. For audit activities in medium or large-scale, a larger teamwork is necessary for an efficient audit. However, careful consideration should be made to assess whether the audit staff will be able to contribute effectively particularly if the number of hours allocated is considered very low. As a suggestion, the internal audit management can consider allocating these hours to the other internal audit staff assigned in the same project (the staff will be required to render overtime work to cover for the additional hours) or consider the possibility of reducing the estimated hours required to complete the audit project. This assessment can also provide internal audit management a better insight as to whether the internal audit organization has adequate manpower resources for it to be able to deliver the expected audit outputs.

5. Conclusion

The allocation of internal audit resources continues to be a complex and critical process in achieving audit quality and efficiency. With the recent advancement in technology, new risks started to emerge which caused more complexities in business operations and regulatory requirements. As such, internal auditors are now under pressure to raise the bar of their audit quality to cope up with the fast face of this technological revolution.

In this study, an LP model was used to obtain an optimal solution in allocating internal audit staff that would maximize the audit quality of the internal audit function. In addition, this new method significantly improved the time spent in the allocation of the internal audit resources, a process that normally takes hours if not days to complete using the traditional manual allocation process. The results of this study can be used to further assist internal audit management to assess whether the organization has sufficient manpower to deliver expected audit output, determine proper audit staff workload and the right mix of projects that would support the growth and development of each audit staff. Further, the efficiencies obtained from using this model can be used to other activities that could further add value to the company or organization as a whole.

The results of this study were presented to the Director of the internal audit department who agreed to consider the use the mathematical methods in their next audit planning activity. The model allocation results will be observed further to see whether it will help in optimizing the audit staff allocation problem as well as improve the overall quality and efficiency of the internal audit function.

References

Bailey, A. D., Boe, W. J., & Schnack, T., 1974. The audit staff assignment problem: a comment. Accounting Review

Balachandran, B.V. and Zoltners, A.A. (1981). "An Interactive Audit-Staff Scheduling Decision Support System", The Accounting Review

Balachandran, K.R. and Steuer, R.E. (1982). "An Interactive Model for the CPA Firm Audit Staff Planning Problem with Multiple Objectives", The Accounting Review

Blocher, E., 1979. Performance effects of different audit staff assignment strategies. Accounting Review

Chan, K. H., & Dodin, B., 1986. A decision support system for audit-staff scheduling with precedence constraints and due dates. Accounting Review

Chang, C. J. (2002). A decision support system for audit staff scheduling of multiple and large-scaled engagements. Review of Business Information Systems (RBIS)

Chen, R. C., Huang, C. C., & Suen, S. P. (2012). On the Optimization of Auditor Assignment. In Information and Business Intelligence. Springer Berlin Heidelberg.

Das, Verma and Gupta (2017), Human Resource Allocation Model using Linear Programming, International Journal on Emerging Technologies (Special Issue NCETST-2017) (Published by Research Trend, Website: www.researchtrend.net)

Dodin, B. and Chan, K.H. (1991). "Application of Production Scheduling Methods to External and Internal Audit Scheduling", European Journal of Operational Research

Dodin, B. (1999). Project Management in Audit Staff Scheduling. In Project Scheduling (pp. 509-527). Springer US.

International Standards for the Professional Practice of Internal Auditing (Standards) effective January 2017: Definition of Internal Auditing

Summers, E.L. (1972). "The Audit Staff Assignment Problem: A Linear Programming Analysis", The Accounting Review

Usul, H. and Ünal, F.G. (2009). "Workforce Planning in External Auditing with the Target Programming Model Approach", MÖDAV

Uyar, S. and Yelgen, Esin. "The Use of Linear Programming In Audit Task Planning". Journal of Accounting, Finance and Auditing Studies (2015)

Biographies

Rex Aurelius C. Robielos is the Dean of the School of Industrial Engineering and Engineering Management at Mapua University. Before joining Mapua, he was Section Manager of Operations Research Group, Analog Devices General Trias. He has a BS in Applied Mathematics from the University of the Philippines Los Baños, and a Diploma and MS in Industrial Engineering from the University of the Philippines Diliman. He is pursuing Ph.D in Industrial Management (candidate) at National Taiwan University of Science and Technology in Taiwan. He is the current Secretary of Human Factors and Ergonomics Society of the Philippines and Director of the Philippine Institute of Industrial Engineers and Operations Research Society of the Philippines.

