Application of Logistic Regression Model in Rasch Measurement to establish a Performance Index: A case study in Audits on Malaysian Institutions of Higher Learning

[1]RAZIMAH ABDULLAH , [2]ROSMAWATI ABD HALIM , [3]AZAMI ZAHARIM, [4]ROZEHA A RASHID AND [5]MOHD SAIDFUDIN MASODI.
[1]Chartered Accountant (Malaysia), Fellow Inst. of Taxation (Malaysia), Fellow CPA (Aust.)
Research Consultant, Research Management Centre
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, MALAYSIA
Tel/SMS: +6019 2152215 Fax: +603-4108 4292
[2] Associate Professor, Fellow ISO,
Institute of Quality and Knowledge Advancement (InQKA),
Universiti Teknologi MARA, 40800 Shah Alam, MALAYSIA
Tel/SMS: +6013 347 2988 Fax: +603-5544 2070
[3] Associate Professor, Ph.D. Faculty of Engineering,
Universiti Kebangsaan Malaysia, 43600 Bangi, MALAYSIA
Tel/SMS: +6019 286 2656 Fax: +603-8921 6681
[4] Senior Lecturer, Dept. of Telematics and Optics, Faculty of Electrical Engineering
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, MALAYSIA
Tel/SMS: +6019 720 5809 Fax: +607-5566 272
[5] Program Consultant / ISO9000 Lead Assessor, Centre of Information Technology Advancement,
Kulliyah of Information & Communication Technology,
International Islamic University Malaysia, 53100 K Lumpur, MALAYSIA.
Tel/SMS: +6012 2402821 Fax : +603-41072262

Abstract: Performance measurement has traditionally been determined using historical data to establish the 'best fit line'. Measuring performance in an appropriate way is vital to ensure valid quality information can be generated for meaningful use. A matter of prime concern in organisational excellence is internal audit, a control mechanism against systems failures. This paper promulgate the attempt of a new approach in establishing a performance measurement based on the Plan-Execute-Report-Monitor (PERM) Model, in this case the Audit Performance index; AP_i. A perception survey was conducted on auditors from selected Malaysian Institution of Higher Learning (IHL). Data obtained is used to calculate the performance indicators; D_k and index which are closely connected with various emotional, cognitive and intentional components. Instead of the common use of simple means over several ordinal variables, Rasch Measurement '*logit* unit' enable the construction of a linear scale, based on a set of survey items where the mean, $\bar{x}_i$ is the probability of a successful audit hence; the AP_i index. Using Logistic Regression Model, it was found that the probabilistic model can help establish a theoretical basis for measuring such service performance and help IHL top management in improving their judgemental decision making. Rather than deterministic linear regression, the performance index established based on probabilistic model is more appropriate since the process outcome is a dependant variable; θ which is predictable within the limit of 0.0 to 1.0. Since the index is modelled using dimensions and attributes related to the audit process, the AP_i enables a more holistic and reliable evaluation of an audit process effectiveness, A_e; hence, the level of service effectiveness rendered.

***Keywords*:** Rasch Model, performance measurement, continuous improvement, quality, engineering education.

1 Introduction

Performance measurement looks at the performance criteria, performance measures and performance standards. The performance criteria are used to evaluate performance and the values derived act as the measures. Accepted levels of performance for each criterion ultimately become the standard. Performance measurement has traditionally been determined using historical data to establish the 'best fit line'. This is reactive in nature and has limitations for repeatibilty of measurement. There is a need for a departure from the repeatibility of results when the instrument for measurement is the source of error. Measurement with the correct tool and method is of prime importance. The measure of reliability now shifts to the reproducibility of

measures rather than expressing the reproducibility of raw scores [1]. By focusing on the reproducibility of the latent trait instead of forcing the expected generation of the same raw score, the concept of reliability takes its rightful place in supporting validity rather than being in contensions. Hence; measuring performance in an appropriate way is vital to ensure valid quality information can be generated for meaningful use. This paper describes an alternative approach using bio-based Rasch Unidimensional Measurement probabilistic model as a more accurate performance measurement tool to establish a performance index.

2. Literature Review

The achievement of an performance level is dependent upon the way an organization is directed and controlled, i.e., corporate governance [2]. There exist increasing calls for good governance from both the public and private sector in the wake of corporate failures as demonstrated by the collapsed of the National Safety Council of Australia in the 1980s and the Pyramid Building Society in Victoria, Australia in 1990 [3]. This was followed by the fall of HIH group with a deficiency of AUD5.3 billion in 2001. In America, Enron Corporation filed for bankruptcy in 2001 after incurring US$62 billion through manipulations of financial statements by the company executives. In 2002, American telecommunications company WorldCom collapsed with losses of about US$11 billion. More reliance on the effectiveness of an audit function and the Audit Committee becomes a significant aspect of good corporate governance. Among other controls, internal audit is employed as part of a control mechanism against systems failures within the corporate governance framework. It is a self assessment mechanism that calls for the highest order of honesty and integrity for disclosure of facts.

Tunku Abdul Aziz [4] believes that unethical public behaviour within the government administration in the long run jeopardizes the perceived integrity and economic well-being of the country. Any move for better governance goes hand in hand with fairness, accountability, transparency and responsibility of use of public funding [5]. Malaysia formulated its Vision 2020 in 1991 with the aim to be a fully developed and industrialised country by year 2020. The strategies and development programs laid out for Sixth Malaysia Plan (6MP) focused on human resource development with an allocation of RM8.5 billion for development of education and training [6]. The expenditure for education and training in 8MP stood at RM43.73 billion and escalated to RM50.6 billion in Ninth Malaysia Plan or 9MP [7]. Good governance which translates to good performance in quality education paves the way in ensuring the disclosure to the Malaysian public that the way moneys are spent is without waste and extravagance, utilised in projects efficiently and effectively.

Effective audit has been shown to aid organizational excellence. In the engineering education, audit and continued efforts by the top management of a Malaysian public IHL in taking corrective actions as part of its continuous improvement process to reduce students failure rates is highly applaud. The combined effect since 2002/03 is a significant reduction by 65.71% in year 2004/05 in institutional recurrent costs [8].

Despite it's importance; audit performance measurement has never being put in the proper perspective. Audit is central to an organisation's sustainability and it's very survival. Performance measures generally assess the efficiency and effectiveness of processes vis-à-vis an organisation strategic objectives. Measurements are made because they can indicate the degree of performance of a certain satisfactory level; measure whether the organization as a whole is functioning as intended. Psychologically, measurement acts as a motivator for the individual and the organization [9].

Wright and Mok, 2004 [1] suggested that experience is continuous but at the moment or time we notice the experience, it becomes discrete. Now it has the stochastic function of time, t_i and space; hence dimensions. There are situations where indications of more or less of a dimension can be introduced as categories within each observation. This is the assumption used of scales in Rasch Measurement Model.

3. Measurement Methodology

Following from the dimensions in an audit process, audit performance is measurable; by criterion referencing on a dichotomous scale, in terms of the extent of use of best practices by counting responses to the attributes in the respective dimensions. Reporting of audit findings and the subsequent monitoring of corrective actions by management are important as avenues for continuous improvement in organizational excellence. The sample population of this study are

the internal auditors who assess the effectiveness of an engineering teaching and learning system and the management of an institution of higher learning, who undertake the operations and disclosure of their activities to their stakeholders.

Questionnaires are constructed based on a modified dichotomous 'YES' or 'NO' model [10] and the degree of achievement [8], reflecting the relative impact of a 'YES' answer to an attribute. The rating scale for the level of agreement on the 35 items in the survey are 0 – Disagree, 1 – Agree Slightly, 2 – Agree and 3 - Agree Strongly. This ordered category is also termed as 'polytomous' [11]. Subjects are asked to rank their agreement on the items representing the audit impact.

Literature reviews revealed aplenty best audit practices using the infamous PDCA Model. This model is adapted from Shewhart's P-D-S-A Cycle which has been adopted and benefited many organisations worldwide, the performance criteria used to assess an audit effectiveness in this study is based on the same premise; their dimensions relevant to an audit process known as Plan – Execute –Report -Monitor (P-E-R-M) Model [12].

Each of these four dimensions is further analysed from literature reviews to derive at relevant proxies or attributes which are vital in the implementation of an effective audit. These attributes comprised of auditing best practices and as emphasized by the Institute of Internal Auditors in its performance standards [13] and ISO Guide to Auditing [14]. Table 1 shows one of the dimensions; i.e. PLAN and it's relevant attributes under study.

Table 1. Sample of Attributes in a Dimension

	Dimension 'PLAN'
1	Audit scope
2	Evaluate policy
3	Auditors' knowledge of area audited
4	Monitoring of auditor competency
5	Frequency of audits

The conceptual framework for transforming the survey results is as follows: Suppose that for one of the dimensions, there are five attributes relating to the dimension and the survey resulted in ten responses. First, the average or mean is calculated for the responses received on an attribute. The first method of calculating the mean, $\bar{x}_i$ is simply to add the scores and divide by the number of scores added, N events; expressed as;

$$\bar{x}_i = \frac{0+1+3+2+2+2+1+0+2+1}{10}$$

$$\bar{x}_i = \frac{14}{10} = 1.4$$

This can be written as;

$$\bar{x}_i = \frac{\sum_{v=i}^{10} x_{vi}}{N} \qquad \text{Equ.(1)}$$

where, i = item in the event,
v = respondent or person, and
vi = response to item (0, 1, 2, 3)
N = total number of event

Hence; the probability of success; Pr(x=1) can be construed as the mean; $\bar{x}_i$ arising from the turn of event [11]. This fundamental is now taken to the next step. The other way is to notice that there are only 4 different values; 2 **0'**s, 3 **1'**s, 4 **2'**s and 1 **3'**s and the expression is shortened by frequency, f_{xi} instead;

$$\bar{x}_i = \frac{2(0)+3(1)+4(2)+1(3)}{10}$$

$$= \frac{0+3+8+3}{10}$$

$$= \frac{14}{10} = 1.4$$

This can be expressed in a frequency function;

$$\bar{x}_i = \frac{\sum_{x=0}^{3} x_{vi} f_{xi}}{N} \qquad \text{Equ.(2)}$$

where, x_i = possible score for item,
f_{xi} = frequency of possible score

The expression for the mean, $\bar{x}_i$ can be made as a product of a proportion. Since we know that there are 10 persons, we can divide the frequencies immediately by 10. This gives the proportion of times that a particular score appears;

$$\bar{x}_i = \frac{2}{10}(0) + \frac{3}{10}(1) + \frac{4}{10}(2) + \frac{1}{10}(3)$$

$$= (0.2)(0) + (0.3)(1) + (0.4)(2) + (0.1)(3)$$

$$= 0.0 + 0.3 + 0.8 + 0.3; \quad \bar{x}_i = 1.4$$

Thus, by dividing each frequency first by the number of cases to get the proportion of cases with

each score, and then multiplying by the score and adding, we immediately get the mean, $\bar{x}_i$. This calculation is summarised below:

$$\bar{x}_i = \sum_{x=0}^{3} p_{xi} x_i \qquad \text{Equ.(3)}$$

where p_{xi} = proportion of cases in each score
$x_i = f_{xi}$, frequency of possible score

Hence, the frequency of cases for each score is converted into a proportion. The theoretical proportion of times that each score would occur is the probability that each score would occur. The theoretical mean can be calculated by using the same equation as that of Equation (3). Thus for an estimate p_{xi} of the proportion of times each score x would appear for item i, then, it can be estimated that the average score that item would get is from using the above equation. This theoretical mean is often called the "Expected Value"; $E[X_i]$ in statistics. The theoretical Expected Value is compared with the relevant Observed Mean in tests of fit in the Rasch measurement analysis. The equation is written as:

$$E[X_i] = \bar{x}_i = \sum_{x=0}^{n} P_{xi} x_i \qquad \text{Equ.(4)}$$

This is the rational in using the mean, $\bar{x}_i$ as the audit performance index.

Hence, for the establishment of the internal audit dimensions and indicators, Equation (2) and (4) are used to compute the attributes mean; $\overline{A}_j$ and by substitution, mathematically it can be shown as follows:

$$\overline{A}_j = \frac{\sum_{x=0}^{3} s_i o_i}{N} \qquad \text{Equ.(5)}$$

where s_i = item score (i = 0, 1, 2, 3),
o_i =frequency or number of respondents giving score i
n = total number of responses, and
j = item (1, 2,….*n*).

This yield a series of performance indicators and which is fundamentally the input to Dimension indicators of *n*-numbers; D_{kn} . Cumulatively the attribute mean, $\overline{A}_j$ is further analysed by summing it up and divided by the number of items assessed;

$$D_k = \frac{\sum_{j=1}^{n_k} A_j}{r} \qquad \text{Equ.(6)}$$

where; A_j = item indicator, from Equation (5)
n_k = total items in a dimension, and
r = total number of items assessed

As previously shown, in Rasch Measurement the mean of events, $\bar{x}_i$ is the probability of success. Hence, the internal audit performance index, AP_i , can be established by summing up all the audit dimension indicators; D_k based on the overall responses of the auditors.

$$AP_i = \frac{\sum_{j=1}^{d_k} D_k}{N} \qquad \text{Equ.(7)}$$

where D_k = Dimension indicator, from Equ. (6)
d_k = dimensions; area of study.
N = total number of dimensions (1, 2, …. d_k)

The AP_i is next converted as a proportion of the full score of 3 (the maximum item rating score, s_i in the questionaire) which serves as the measurement of the audit effectiveness. Supposed the calculated AP_i = 2.09, then, the level of Audit Effectiveness; A_e is obtained as follows:

$$A_e = \frac{2.09}{3} \times 100 = 69.55\% \qquad \text{Equ.(8)}$$

Both index and audit effectiveness, over time will then provide indications on the trend of the audit performances.

The rating is in line with the recently introduced scale by the Malaysian Government and is used in interpreting the index, A_e . The rating scale is also deemed to be the performance standard. The Auditor-General uses star ratings in evaluating the financial management skills of the ministries in Malaysia [15]. The star ratings are as follows:

4 stars -	***Excellent***	(90% - 100%)
3 stars -	***Good***	(70% - 89%)
2 stars -	***Satisfactory***	(50% - 69%)
1 stars -	***Not Satisfactory***	(49% and below)

Based on this rating scale, in this example, an audit

performance at the particular point in time when the audit function was first assessed, the audit was found to be '***satisfactory***'.

Apart from the above, as the index is computed based on the four dimensions, individual dimension's weaknesses can be assessed and evaluated further. Low ratings achieved in the attributes can be analysed by the Head of Audit Department or the Audit Committee for corrective actions to be undertaken in ensuring a better performance level in the internal audit process.

4. Findings and Discussion

A pilot study was conducted at University of Teknologi Malaysia (UTM) and subsequently followed by another surveys at three (3) IHL's. Table 2 shows the total number of responses; N=36 from UTM internal showing their level of perceptions on each attribute surveyed for the Dimension$_{\mathbf{PLAN}}$. From Equation (2), summing up the multiplication of the rating with the frequency of each score perceived;

where, $\bar{x}_i = \frac{\sum_{x=0}^{3} x_{vi} f_{xi}}{N}$;

the following raw scores and mean $\bar{x}_i$ is obtained; e.g. Attribute 1 - Audit Scope:

$$\bar{x}_i = \frac{0(0) + 4(1) + 14(2) + 18(3)}{36}$$

$$= \frac{0 + 4 + 28 + 54}{36}$$

$$\bar{x}_i = \frac{86}{36} = 2.39$$

Table 2. Responses to Attributes for Dimension PLAN

Pro-forma AUDIT PERFORMANCE SCORE ANALYSIS UTM, N=36					
Perception Rating	**0**	**1**	**2**	**3**	Raw Score
PLAN attributes					
1. Audit scope	0	4	14	18	86
2. Evaluate policy	0	2	16	18	88
3. Knowledge	0	5	18	13	80
4. Competency	0	10	19	7	71
5. Frequency	0	5	16	15	82
PLAN mean Raw Score:					**81.40**

The computation is duly completed for the rest of the other PLAN attributes; $\overline{A}_{1-5}$ and all the other dimensions respectively. This yield the 'PLAN' mean sum of raw score = 81.40 and indicator $D_{PLAN}i$= 2.26 . The process is repeated for the other dimensions and summarised in Table 3.

It is noted that the lowest Attribute score for the auditors in Dimension PLAN is Attribute 4 (*Competency*); D_{PLAN}, A_4 =1.92 while the highest score is for Attribute 2 (*Policy*); D_{PLAN}, A_2 =2.44. The analysis can delve further for each dimension; and this IS the uniqeness of Rasch Measurement; it's ability to scrutinise each moment or item individually on a unidimensional scale.

Table 3. UTM: Dimension Indicators, D_k

Attribute; A_j	**1**	**2**	**3**	**4**	**5**	D_{kn}
PLAN	2.39	2.44	2.22	*1.92*	2.28	2.26
EXECUTE	2.18	*1.98*	*1.83*	*1.76*	*1.95*	1.96
REPORT	2.31	2.41	2.17	2.36	2.31	2.32
MONITOR	2.13	2.21	2.25	2.19	2.16	2.19

Table 3 also indicate other attributes that warrants further investigation assuming the acceptable threshold value is above 2.00 (the 'Agree' level); in this case, the attributes are $D_{EXECUTE}$, $A_{2\text{-}5}$= *1.98, 1.83. 1.70* and *1.95* respectively.

The results of all these dimension indicators are summarized to form the audit performance index, AP_i, as shown in Table 4.

Table 4. UTM: Audit Performance Index; AP_i and A_e

DIMENSIONS	D_{kn}	% (Star Rating)
Plan; D_{Pi}	2.26	75.33 (**3**)
Execute; D_{Ei}	*1.96*	*65.33* (**2**)
Report; D_{Ri}	2.32	77.33 (**3**)
Monitor; D_{Mi}	2.19	73.00 (**3**)
Audit Performance Index; AP_i and A_e	2.18	72.67 (**3**)

The audit performance index for UTM based on the perceptions of auditors showed that the rating for audit carried out has a total value of AP_i =2.18 or a grading A_e =72.67%. Based on the star rating used by the Auditor-General, the audit performance is rated as '***Good'***. Note that $D_{EXECUTE}$ =1.96, or 65.33% is below the agreement level of 2.00 and star rating of 70% respectively.

This audit performance index is then compared across the other three public IHLs as shown in Table 5. This index gives an insight on the perception of the level of adequacy of each audit dimension being implemented. The overall achievement for the four IHL in this study are AP_i-

$_{IHL}$=2.09, and $A_{e\text{-IHL}}$=69.66%. Out of the four dimensions, the indicator for the 'EXECUTE' dimension shows the lowest rating of 1.99 which is below the 'Agree' or 2.00 level. The lowest audit performance index for an IHL is shown by IHL C with a rating of $AP_{i\text{-IHL C}}$=1.92, $A_{e\text{-IHL}}$=64.00% only. Note, *in italic*, IHL C has three out of four dimensions with indicators below 2.00.

Table 5. P-E-R-M Model – Public IHL's in Malaysia
Audit Performance Index; AP_i

	D_{Pi}	D_{Ei}	D_{Ri}	D_{Mi}	**AP_i**	A_e (%)
IHL A	2.27	1.96	2.32	2.19	**2.18**	72.67
IHL B	2.03	2.03	2.18	*1.99*	**2.06**	68.67
IHL C	2.00	*1.86*	*1.90*	*1.91*	***1.92***	***64.00***
IHL D	2.22	2.09	2.28	2.21	**2.20**	73.33
IHL D_k	**2.13**	***1.99***	**2.17**	**2.08**		
	OVERALL IHL-AP_i				**2.09**	**69.66**

By making A_e as the probable audit outcome; i.e. the target variable on a continuous scale range of 0.00–1.00, from Equation (3) representing the probability values or proportions of the total event, this can be construed that $\bar{x}$, in this case as the response probability to an audit; θ, the probability of a successful audit is stated as;

$$Pr(\theta=1|Audit);\ Pr(\theta_1)=1$$

whilst a failure,

$$Pr(\theta_0)=1-\theta.$$

This can be readily shown as a Logistic Regression Model where all the other probable values are along the Sigmoidal Curve [11, 16] hence; Rasch Model.

5. Conclusion

Management relies on the audit function as a management tool to gauge the performance of the organization. Achieving good corporate governance is becoming the focus for both the private and public sector. A suitable method in measuring the the effectiveness of auditors, A_e within the corporate governance framework is vital as audits assure the performance level of an organization is achieved as targeted. This is relevant in the wake of the Malaysian Government calls for quality education and strengthening of the public IHLs through initiatives in the National Higher Education Action Plan 2007-2010. The Board of Directors of public IHLs will be subjected to the same principles of good governance that regulate the private sector.

In this paper, the method in computing the AP_i, is put forward based on the PERM Model. The index makes use of the mean computation applied in the Rasch Measurement Model which is found to be accurate and reliable. It gives in-depth measurement and detailed insight of the audit's performance. It is an excellent tool with high potential for the public IHL top management to explore and effectively improve the quality of higher education.

6. References

[1.] Wright, B. D. & Mok, M. M. C. (2004). An Overview of the Family of Rasch Measurement Models. *Introduction to Racsh Measurement.*

[2.] Cadbury Report (1992). Report of the Committee on the Financial Aspects of Corporate Governance.

[3.] Somerville, R. (2006). Risk assessment and management. *Keeping Good Companies. Journal of Chartered Secretaries Australia Ltd.*, 58, 6,345-347.

[4.] Tunku Abdul Aziz (2004). Good governance – a global view. *Principles and practices of good governance: the way forward for Sabah.* Sabah: Institute for Development Studies (Sabah).

[5.] World Bank, Governance, Retrieved July 3, 2006 from http://www.worldbank.org

[6.] Mohd Kassim, M. S. (1993). The relationship of Vision 2020 with the 6th MP and the 2nd OPP. *Malaysia's Vision 2020: Understanding the concept, implications & challenges.* Kuala Lumpur.

[7.] Faruqi, H. (2006). The 9th Malaysia Plan: Stepping up National Progress towards Vision 2020. *Accountants Today*, 19, 5, 12-15.

[8.] Razimah, A., Rozeha, A. R., Mazlina, E., & Saidfudin, M. S., "Value-adding through Internal Audits: A Continuous Improvement Process in Engineering Education", *Proceeding, International Conference on RF and Microwave (RFM), Putrajaya; September 12-14th, 2006.*

[9.] Dittenhofer, M. (2001). Performance auditing in governments. *Managerial Auditing Journal*, 16, 8, 438-442.

[10.] Chambers, A. (1992). *Effective Internal Audits: How to plan and implement.* London: Pitman.

[11.] Andrich, D. (2007). Background – Two approaches to measurement. *RUMM Workshop, Pacific Rim Objective Measurement Symposium, July 17 - 19th, 2007*, Taipei.

[12.] Razimah, A., Rozeha, AR., Mazlina, E. & Sadruddin, M.S. (2007). Continuous Improvement in Engineering Education through Effective Value for Money Audits. *Proceeding, 2nd International Conference on Engineering Education & Training,* April 9-11th, 2007, Kuwait.

[13.] Institute of Internal Auditors Malaysia (2006). *The Professional Practices Framework.*

[14.] ISO 19011:2002 Guidelines for QMS and/EMS Audits. International Organization for Standardization, Geneva, Switzerland.

[15.] Jobs at stake. (2007, September 15). *The Star,* N1.
[16.] Tabachnick , Barbara and Linda Fidell.1996. Using Multivariate Statistics, 3rd edition. Harper Collins.