Edith Cowan University

From the SelectedWorks of Razimah Abdullah

November, 2007

Application of probabilistic model by Rasch measurement to establish a performance index: A case study in audits on Malaysian institutions of higher learning

Razimah Abdullah, Edith Cowan University
Rosmawati Abd Halim
Azami Zaharim
Rozeha A Rashid, Universiti Teknologi Malaysia
Mohd Saidfudin Masodi, International Islamic University Malaysia

Available at: https://works.bepress.com/razimah_abdullah/9/
APPLICATION OF PROBABILISTIC MODEL BY RASCH MEASUREMENT TO ESTABLISH A PERFORMANCE INDEX: A CASE STUDY IN AUDITS ON MALAYSIAN INSTITUTIONS OF HIGHER LEARNING

Razimah Abdullah1, Rosmawati Abd Halim2, Azami Zaharim3, Rozeha A Rashid4 and Mohd Saidfudin Masodi5

1Research Management Centre
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, MALAYSIA
Tel/SMS: +6019-2152215 Fax: +603-4108 4292
email: arazimah@gmail.com

2Institute of Quality and Knowledge Advancement (InQKA),
Universiti Teknologi MARA, 40800 Shah Alam, MALAYSIA

3Faculty of Engineering,
Universiti Kebangsaan Malaysia, 43600 Bangi, MALAYSIA

4Dept. of Telematics and Optics, Faculty of Electrical Engineering
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, MALAYSIA

5Centre of Information Technology Advancement,
Kulliyah of Information & Communication Technology,
International Islamic University Malaysia, 53100 K Lumpur, MALAYSIA.

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

Fakulti Kejuruteraan Elektrik, UTM (FKE) is certified to ISO9001:2000 and is subjected to audit of their engineering program effectiveness at planned intervals. A perception survey was conducted on FKE auditors and the management. Data obtained is used to calculate the indicators and indices 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 is the probability of a successful audit hence; the AP

Using probabilistic model by Rasch Measurement, it was found that the probabilistic model can help establish a theoretical basis for measuring such service performance and help top IHL management in making good judgemental decision making. Rather than deterministic, the index established is unique as it...
is probabilistic in nature. Since the index is modeled using dimensions and attributes related to the internal audit process, the \( \text{AP}_i \) enables a more holistic and reliable evaluation of a process; hence, a service effectiveness rendered.

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

**INTRODUCTION**

Performance measurement looks at the performance criteria, performance measures and performance standards (Lockamy, 1998). 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’. Measuring performance in an appropriate way is vital to ensure valid quality information can be generated for meaningful use.

**LITERATURE REVIEW**

The achievements of a certain performance level is dependent upon the way organizations are directed and controlled, i.e., corporate governance (Cadbury Report, 1992). 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 in 1990 (Somerville, 2006). 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 (Somerville, 2006). More reliance on the internal audit function and the Audit Committee becomes a significant aspect of good corporate governance. Internal audit is employed as part of a control mechanism against systems failures within the corporate governance framework.

Tunku Abdul Aziz (2004) 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 (World Bank, 2006). 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 (Mohd Kassim, 1993). 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 (Faruqi, 2006). Good governance which translate 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 internal audit has been shown to aid organizational excellence. In the engineering education, internal audit and continued efforts by management of a Malaysian public IHL in taking corrective actions as part of its continuous improvement efforts to reduce students failure rates is highly applaud. The combined effect is a significant reduction by 65.71% in year 2004/05 in institutional recurrent costs (Razimah et al., 2006).

Performance measures generally assess the efficiency and effectiveness of processes vis-à-vis their 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 (Dittenhofer, 2001).

Wright and Mok (2004) suggested that experience is continuous but at the moment; the time we notice experience, it becomes discrete. It has a function of time, \( t_i \). 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 in Rasch Measurement Model.

**MEASUREMENT METHODOLOGY**

Following from the dimensions in an internal audit process, internal 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 subjects 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 dichotomous ‘Yes’ or ‘No’ model (Chambers, 1992) and the degree of achievement (Dittenhofer, 2001), 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 is 0 – Disagree, 1 – Agree Slightly, 2 – Agree and 3 - Agree Strongly. This ordered category is also termed as ‘polychotomous’ (Andrich, 2007). Subjects are asked to rank their agreement on the items representing the internal audit best practices.

Literature reviews reveals best audit practises using the infamous PDCA Model. The performance criteria used is based on the Plan-Execute-Report-Monitor (P-E-R-M) Model to assess internal audit (Razimah et al., 2007). This model is adapted from Shewhart’s P-C-S-A Cycle which has been adopted and benefit many organisations worldwide. Table 1 shows one of the dimensions and the relevant attributes under study.
Each dimension is further analysed from literature reviews to derive at relevant sub-components or attributes which are vital in the implementation of an effective internal audit. These attributes comprise of internal auditing best practices and emphasized by the Institute of Internal Auditors in its performance standards (IIA, 2006).

<table>
<thead>
<tr>
<th>TABLE Sample of Attributes in a Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension ‘PLAN’</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

The conceptual framework for transforming the survey results is as follows: Suppose that for one of the dimensions, there are four items relating to the dimensions and that there are also ten responses. First, the average or mean is calculated for the responses received on an item. The first method of calculating the mean, \( \bar{x}_i \), is simply to add the scores and divide by the number of scores added, \( N \); expressed as;

\[
\bar{x}_i = \frac{0 + 1 + 3 + 2 + 2 + 2 + 1 + 0 + 2 + 1}{10} = \frac{14}{10} = 1.4
\]

This can be written as;

\[
\bar{x}_i = \frac{\sum_{v=1}^{10} x_{vi}}{N}
\]  \hspace{1cm} (3.1)

where,

- \( x_{vi} \) = item,
- \( v \) = 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 the turn of event. This fundamental is now taken to the next step. The other way is to notice that there are only 4 different values; 2 0s, 3 1s, 4 2s and 1 3 and the expression is shorten by frequency, \( f_{xi} \) instead;
This can be expressed in a frequency function;

\[ \bar{x}_i = \frac{\sum_{x=0}^3 x f_{xi}}{N} \]  

(3.2)

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;

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

\[ = \frac{0 + 3 + 8 + 3}{10} \]

\[ = \frac{14}{10} = 1.4 \]

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. This calculation is summarised below:

\[ \bar{x}_i = \sum_{x=0}^3 p_{xi}x_i \]  

(3.3)

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 (3.3). 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 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:
Application of probabilistic model by Rasch Measurement to establish a Performance Index: A case study in Audits on Malaysian Institutions of Higher Learning

\[ E[X_i] = \bar{x}_i = \sum_{x=0}^{n} P_{xi} x_i \]  

(3.4)

This is the rational in using the mean as the internal audit performance index. The computation for the mean of items is carried out separately for the internal auditors and management. For the overall perception of persons, the results from the internal auditors and the management were not averaged. Instead, the mean is computed separately to eliminate errors in computation.

For the establishment of the internal audit dimensions and indicator, equations (3.2) and (3.4) are used to compute the mean; and by substitution, is mathematically shown as follows:

\[ \bar{A}_j = \frac{\sum_{x=0}^{3} s_i o_i}{N} \]  

(3.6)

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 \( (1, 2, \ldots, n) \).

This yield a series of performance indicators and which is fundamentally the input to Dimension indicator; \( D_k \). Cumulatively the mean, \( \bar{A}_j \) is further analysed by summing it up and divided by the number of items assessed;

\[ D_k = \frac{\sum_{j=1}^{n_k} A_j}{r} \]  

(3.7)

where; \( A_j = \) item indicator, from (3.6)
\( n_k = \) total items in a dimension, and
\( r = \) total number of items assessed.

In Rasch Measurement, the mean of events 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 internal auditors and management of FKE.

\[ AP_i = \frac{\sum_{j=1}^{d_k} D_k}{N} \]  

(3.8)

where \( D_k = \) Dimension indicator, from (3.7)
\( d_k = \) dimensions; area of study.
\( N = \) total number of dimensions \( (1, 2, \ldots, d_k) \).
The AP\textsubscript{i} converted as a proportion of the full score of 3 (the maximum score in the research instrument) serves as the probability that the internal audit is effective. Suppose the calculated AP\textsubscript{i} = 2.09, then, the level of audit effectiveness; A\textsubscript{e} is obtained as follows:

\[ A_{e} = \frac{2.09}{3} \times 100 = 69.55\% \]

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

The rating recently introduced by the Malaysian Government can be used in interpreting the index. The rating scale is also seemed to be the performance standard. The Auditor-General uses star ratings in evaluating the financial management skills of the ministries in Malaysia (The Star, September 2007). The ratings are as follows:

- 4 stars - Excellent\hspace{1cm} (90\% - 100\%)
- 3 stars - Good\hspace{1cm} (70\% - 89\%)
- 2 stars - Satisfactory\hspace{1cm} (50\% - 69\%)
- 1 stars - Not Satisfactory\hspace{1cm} (49\% and below)

Based on this rating scale, the performance at the particular point in time when the internal audit function is first assessed, is 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 Internal Audit or the Audit Committee for corrective actions to be undertaken in ensuring a better performance level in the internal audit process.

**FINDINGS AND DISCUSSION**

TABLE 2 shows the format of the survey results conducted pilot study on four (4) IHL’s for the dimension ‘PLAN’ and the resultant indicator (IA\textsubscript{Pi}). The ‘PLAN’ indicator is the overall results, showing a score of 2.22 out of a total of 3. This translates to a performance rating of 73.93\%.

The lowest score for internal auditors is for item 13 with a value of 1.86 while the highest score is for items 5 with a value of 2.41. It is noted that management agree that audit has been planned effectively except for item 13 with a value of 1.80. However, the largest difference in opinion between the internal auditors and management is noted for item 17 with a gap of 0.28.
TABLE 2 IHL A: Dimension ‘PLAN’ Indicator

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>5</th>
<th>9</th>
<th>13</th>
<th>17</th>
<th>\bar{x}</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUDITORS</td>
<td>2.35</td>
<td>2.41</td>
<td>2.16</td>
<td>1.86</td>
<td>2.22</td>
<td>2.20</td>
</tr>
<tr>
<td>% score</td>
<td>73.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MGMT</td>
<td>2.60</td>
<td>2.50</td>
<td>2.00</td>
<td>1.80</td>
<td>2.50</td>
<td>2.28</td>
</tr>
<tr>
<td>% score</td>
<td>76.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERALL</td>
<td>2.40</td>
<td>2.43</td>
<td>2.13</td>
<td>1.85</td>
<td>2.28</td>
<td>2.22</td>
</tr>
<tr>
<td>% score</td>
<td>73.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2 also indicate areas or attributes that requiring further investigation based on values below 2.00 (the ‘Agree’ level). In this case, the attribute is Auditor Competency item 13 (Monitoring of auditors competency).

As mentioned earlier, the results on all dimension indicators are summarized to form the internal audit performance index, \( AP_i \), as shown in Table 3.

TABLE 3 IHL ‘A’: Internal Audit Performance Index

<table>
<thead>
<tr>
<th>DIMENSIONS</th>
<th>Auditors</th>
<th>Management</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan; ( IA_{Py} )</td>
<td>2.20</td>
<td>2.28</td>
<td>2.22</td>
</tr>
<tr>
<td>Execute; ( IA_{Ei} )</td>
<td>1.96</td>
<td>1.97</td>
<td>1.96</td>
</tr>
<tr>
<td>Report; ( IA_{Ri} )</td>
<td>2.32</td>
<td>2.39</td>
<td>2.33</td>
</tr>
<tr>
<td>Monitor; ( IA_{Mi} )</td>
<td>2.19</td>
<td>2.14</td>
<td>2.18</td>
</tr>
<tr>
<td>( AP_i = 2.17 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The internal audit performance index for the IHL based on the perceptions of both auditors and management showed that the rating for internal audit carried out has a total value of 2.17 or a grading of 72.48%. Based on the star rating used by the Auditor-General, the internal audit performance is rated as ‘Good’. However, among all the dimensions, the indicator for the ‘EXECUTE’ dimension is the lowest at a value of 1.96 and below the agreement level of 2.00.

This internal audit performance index is compared across the public IHL as shown in Table 4. 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, \( AP_e \) is 2.09, which, as a percentage of the total score of 3, equates to 69.60%. 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 internal audit performance index for a IHL is shown by IHL C with a rating of 1.92. IHL C also has three out of four dimensions (75%) with indicators below 2.00.
Management relies on internal audit 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 services of internal auditors within the corporate governance framework is important as internal 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 IHL through initiatives in the National Higher Education Action Plan 2007-2010. The Board of Directors of the public IHL will be subjected to the same principles of good governance that regulate the private sector.

In this paper, the method in computing the $AP_l$ is put forward. 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 auditor’s performance. It is an excellent tool with high potential for the public IHL top management to explore to effectively improve the quality of higher education.

### TABLE 4 P-E-R-M Model – Public IHL in Malaysia Internal Audit Performance Index

<table>
<thead>
<tr>
<th></th>
<th>$IA_{P_l}$</th>
<th>$IA_{E_l}$</th>
<th>$IA_{R_l}$</th>
<th>$IA_{M_l}$</th>
<th>$AP_l$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHL A</td>
<td>2.22</td>
<td>1.96</td>
<td>2.33</td>
<td>2.18</td>
<td>2.17</td>
</tr>
<tr>
<td>IHL B</td>
<td>2.03</td>
<td>2.03</td>
<td>2.18</td>
<td>1.99</td>
<td>2.06</td>
</tr>
<tr>
<td>IHL C</td>
<td>2.00</td>
<td>1.86</td>
<td>1.90</td>
<td>1.91</td>
<td><strong>1.92</strong></td>
</tr>
<tr>
<td>IHL D</td>
<td>2.22</td>
<td>2.09</td>
<td>2.28</td>
<td>2.21</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td><strong>2.12</strong></td>
<td><strong>1.99</strong></td>
<td><strong>2.17</strong></td>
<td><strong>2.07</strong></td>
<td></td>
</tr>
<tr>
<td>OVERALL $AP_l$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>2.09</strong></td>
</tr>
</tbody>
</table>

### CONCLUSION

Management relies on internal audit 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 services of internal auditors within the corporate governance framework is important as internal 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 IHL through initiatives in the National Higher Education Action Plan 2007-2010. The Board of Directors of the public IHL will be subjected to the same principles of good governance that regulate the private sector.

In this paper, the method in computing the $AP_l$ is put forward. 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 auditor’s performance. It is an excellent tool with high potential for the public IHL top management to explore to effectively improve the quality of higher education.
Application of probabilistic model by Rasch Measurement to establish a Performance Index: A case study in Audits on Malaysian Institutions of Higher Learning

REFERENCES


