Quantitative Risk Analysis: Method And Process

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Prin articolul prezentat se demonstrează, pe baza rezultatelor obținute dintr-un studiu recent metodele utilizate şi se face analiza riscului cantitativ într-o universitate din provincia Cape de Est din Africa de Sud. S-a investigat dacă existau sau nu mari diferențe între grupe (analişti) cu privire la analiza riscului cantitativ.

ABSTRACT

Recent and past studies (King III report, 2009: 73-75; Stoney 2007; Committee of Sponsoring Organisation-COSO, 2004, Bartell, 2003; Liebenberg and Hoyt, 2003; Reason, 2000; Markowitz 1957) lament that although, the introduction of quantifying risk to enhance degree of objectivity in finance for instance was quite parallel to its development in the manufacturing industry, it is not the same in Higher Education Institution (HEI). In this regard, the objective of the paper was to demonstrate the methods and process of Quantitative Risk Analysis (QRA) through likelihood of occurrence of risk (phase I). This paper serves as first of a two-phased study, which sampled hundred (100) risk analysts in a University in the greater Eastern Cape Province of South Africa.

The analysis of likelihood of occurrence of risk by logistic regression and percentages were conducted to investigate whether there were a significant difference or not between groups (analyst) in respect of QRA.

The Hosmer and Lemeshow test was non-significant with a chi-square (X^2 =8.181; p = 0.300), which indicated that there was a good model fit, since the data did not significantly deviate from the model. The study concluded that to derive an overall likelihood rating that indicated the probability that a potential risk may be exercised within the construct of an associated threat environment, the following governing factors must be considered: (1) threat-source motivation and capability (2) nature of the vulnerability (3) existence

and effectiveness of current controls (methods and process).

Key words: Quantitative Risk Analysis, likelihood of occurrence of risk, Risk modeling, impact of occurrence of risk.

BACKGROUND OF STUDY

Recent studies (Walker, Shenkir and Barton, 2002; McNeil, Frey and Embrechts, 2005; Hedeker, 2003; Nicholas, 2004) have raised the complexity of risk modelling[1]. Firstly, the authors attributed the complexity to the type of risk modelling, thus either quantitative (mathematical/statistical models) and or qualitative (subjective/judgemental models). Secondly, there has been a long standing argument about what constitute or defines risk (Nicholas and Steyn, 2008, Standard and Poor, 2006; Reason, 2000; Power, 2004; Bedford and Cooke, 2001; Turban and Meredith, 1998). The authors view, commensurates with that of Nicholas's (2004), who cautioned what is considered as risk or risk modelling. The reason being that an appropriate modelling is considered only when there exists precise and concise definition of risk taking into account its context. Thus, the debate about a definitive constituent of risk has frequently added to the complexity of modelling risk. Suggesting that there is always difference in the specific definition of risk and thus model of risk.

Survey of literature (Committee of Sponsoring Organisations-COSO, 2004; Higher Education Quality Committee, 2004; Krishnan, 2004, Nicholas, 2004; Myers, Myers and Omer, 2003; Higher Education Funding Council for England-HEFCE, 2001) also supported varying degrees of definitive constitute of risk. While, some studies (Walker et al., 2006; McNeil et al., 2005; Nicholas, 2004; Bedford and Cooke, 2001; Turban and Meredith, 1998) argued that risk means, the uncertainty of future outcomes. Other publications (Nicholas and Steyn, 2008; Council on Higher Education -CHE, 2009**;** Turban and Meredith, 1998) noted that risk is ascribed as determination of risk consequence by quantifying risk. The risk consequence as noted by the authors defines the risk model.

For the purpose of this paper and to limit the varying definitions of risk to suit the paper, while risk means the probability (likelihood and impact) of an adverse outcome measures of risk on the other hand are generated based on observed statistical qualities of risk.

Two of the best known statistical qualities of measures of risk are variance or standard deviation. It is a statistical measure of the dispersion around an expected value (say mean) whereby a larger variance or standard deviation indicates greater dispersion Markowitz (1952, 1957) (cf. phase II). Although, there are numerous potential measures of risk for

instance in the field of financial mathematics and statistical[2] risk analysis, in HEI, it is not clear how to derive an overall likelihood rating that indicates the probability that a potential risk may be exercised within the construct of an associated threat environment. This as some authors (King III report, 2009; Stoney, 2007) requested calls for further research. However, for the purpose of the research and in subsequent discussion, the research uses a few[3], which include standard deviation, in this study potential use of skewness kurtosis as well as Bayesian Analysis would be made (cf. section 3- Results).

The discussion of measures of risk is divided into likelihood of occurrence of risk (phase I) and impact of occurrence of risk (phase II). The first phase of the paper (in this case this paper) followed *likelihood of occurrence of risk.* The second phase which was the second paper would follow impact of occurrence of risk. It is important to note that these two separate papers follow Nicholas's model of risk modelling. The separate phases give equal opportunities to the fundamental dynamics of risk modeling in a University context.

Generically, Nicholas (2004:313) identified two distinct features of risk which point to the fact that risk addresses; (1) the likelihood that some problematical event would occur and (2) the impact of the event if it does occur. The risk, Nicholas (2004) claims is a joint function of the two (likelihood and impact) of risk variables representing the risk consequence. This mathematically is expressed as:

risk consequence= f(likelihood, impact)

But first, how do the above constitute risk in higher education institution (HEI)? As noted from Nicholas (2004) in previous sections, HEI can manage risk by reducing the likelihood and the consequences of harmful events happening. To manage risk, analyst considers what constitutes risk variable. The various variables (cf. results for details) under consideration as risk are (1) target of 3rd stream income (2) pass rates for all students (3) throughput targets met in the institution (4) allocation of infrastructure (5) teaching staff with masters and or doctorates qualification and (6) teaching staff involved in research. Noting that there is no any particular order in the risk elements but, literature (intranet.ufh/FinalReportForUFH_April2009.pdf; University of Fort Hare Final Strategic Risk Assessment, 2009; http://intranet.ufh/beta.php ,2009; Liebenberg and Hoyt, 2008; CHE, 2009; HEQC, 2006; Nicholas, 2004; HEFCE, 2001) both of the University under investigation and international, revealed these are the main risk elements impacting on a University. The essence of managing and quantifying risk therefore is intended to ensure that every effort is taken to protect and prevent accidents or reducing

the risk of them happening and putting in place risk management systems to control risks or manage the consequences.

In respect of risk management systems, for instance, the insurance industry uses historical information and sophisticated[4] models (Chaos theory, dynamic system theory, Monte Carlos simulation, scenario analysis, game theory, stochastic differential equations, Bayesian analysis, regression/ multivariate analysis) to work out how likely you are to be robbed or die of a heart attack. Stoney (2007) arguably asserts that HEI are not yet at this stage of sophistication. However, there are many reports and studies published that show common risks and how they are modelled particularly in the finance and manufacturing industry. This was also resonates with the objective of the study within which it intends to demonstrate how quantitative risk analysis is modelled in this study with respect to an HEI.

Motivation for Research Hypothesis and Objective

The original quantitative risk analysis was established by (Markowitz, 1952, 1957) using variance and standard deviation to define and model risk. Since, its usage over 40 years ago, it has been applied in variety of fields and has provided a basis for enhancing institutional quality. Markowitz (1957) noted that risk analysis (RA) was intended to provide for classification of institutional system goals, especially to help risk analyst, administrators, professional specialists and researchers to discuss risks monitoring and evaluation problems with greater precision. This purpose as asserted by the author is hardly ever applied in HEI. Although, in the case of HEI, there exist systems such as quality management system in South Africa, Stoney (2007) argues that this system is rather dominated by subjective models. Note that subjective models per se are not bad models, but there are geared towards judgemental analysis. To reduce the amount of subjectivity, it requires quantitative models which introduce some degree of objectivity. Additionally the essence here is to strike a balance between the two models (objective and subjective). Thus, RA could include two major categories; quantitative or qualitative risk analysis, which include the knowledge, comprehension, application, analysis, synthesis and evaluation of institutional goals. The differences though is that while the former is governed by both statistical and mathematical models to enhance degree of objectivity as reasoned above, the latter is purely subjective and most applied in social and dynamic context, due to the changing nature of such context.

A group of risk analysts (King III report, 2009; Degen, Embrechts and Lambrigger, 2007; Fan and Xiao, 2006; COSA, 2004; Hosmer and Lemeshow, 2000) revised the science of RA. Their findings suggested that RA has

to take into consideration the recent developments in risk literature. The authors suggest that there were two reasons for revising RA; (1) there is a need to refocus risk analyst attention on the value of risk management, not only as a *judgmental and historical document,* but also as one that in many respects is given by specific general models and increase objectivism using mathematical and or statistical models. (2) there is also the need to incorporate new knowledge and thought into the RA. The increases in knowledge about quality and risk processes support the need for a revision, suggesting that it should not only be judgemental. Chavez-Demoulin and Embrecht (2006) contest that RA should be a two-dimensional framework.

The move from one dimension (1D) to two dimensions (2D) in the RA has led to another notable change in the structure of RA, thus, the formation of the two-dimensional taxonomy. This taxonomy is the analytical tool of the RA, which should (1) guide risk processes (risk awareness, identification, monitoring, evaluation, reporting and planning) and (2) guide objectives leading to more exact or defined risk and a stronger precision of assessment to intuitional goals. The second leg of the taxonomy could be used to: (a) analyse and reflect the objectives of a unit (b) help analyst not to confuse activities with objectives, (c) help analyst realise the relationship (correlation) between assessment and risk activities, and (d) examine the institutional alignment with its goals (Hamilton, 2003; Liebenberg and Hoyt, 2003).

Following the above move from 1D to 2D RA, most research on RA tends to favour quantitative (risk modelling) as a positive influence on achievement of institutional goals (Van Gelderen et at., 2006). Reports by Lam (2004) of 271 European companies suggested that 63% of financial companies agreed that they have clearly defined risk tolerance level. More over, the findings indicated a 79% smooth governance practices via risk analysis with a better communication response of 69%. The reports suggest that, an analyst could make changes in the statement of an objective, instructional risk element, when conducted quantitatively.

When, the African and for that matter South African literature was examined, there was a limited number of publications about RA in University context although there were several publications about the RA (king III report, 2009; HEQC, 2004; CHE, 2009). While, a few of these RA studies are research conducted by statutory bodies, most of them are about the description and discussions about the RA, creating the awareness and the need for RA.

The above review of literature suggests that although, the introduction of the quantitative risk analysis (QRA) in finance for instance was quite parallel to its development in the manufacturing industry, it is taking some time for it to be implemented in practice in a South African University (SAU). Thus,

in general, it could be concluded that, with a gap of 5 to10 years, the developments in the use of the QRA are followed quite closely in finance and related fields (King report, 2009:72-75).

In view of the deficiency regarding the usage of QRA in SAU, the purpose of this two phased study was to sample risk analyst in a South African University in the greater Eastern Cape Province and then follow up with few individuals to explore those results in depth using QRA.

Research Objective and Hypothesis

Due to the fact that the same research instrument was administered to two supposedly same risk analyst of the University, the following main objective and hypothesis have been developed.

Objective of Research

The main objective of the paper was to demonstrate the methods and process of QRA through likelihood of occurrence of risk. This served as the first part of a two phased paper. The premise underlying the entire paper was that risk is quantifiable via a mathematical relationship shown below;

Risk consequence = (likelihood of occurrence of risk **X** *impact of occurrence of risk)*

This suggests that risk is a function of two elements. This first part of the study uses this analogy to demonstrate the quantification of risk.

Research Hypothesis

Ho= There would not be significant difference between risk analyst of the University using the quantitative risk analysis.

Ha= There would be significant difference between risk analyst of the University using the quantitative risk analysis.

METHODOLOGY

The analysis of likelihood of occurrence of risk by percentages and logistic regression were done to investigate whether there is a significant difference or not between groups in respect of components in the questionnaire used. In order to examine the questionnaire of group 1 frequency and percentage were calculated. Descriptive analysis (Cohen, Cohen, West and Aiken, 2003; Hedeker, 2003; Hamilton, 2003; Tabachnick, Fidell and Osterlind, 2001; Hosmer and Lemeshow, 2000; Harrell, 2001; Hendrickx, 2000) was used for the answers to the closedended questions of the groups. A correlation coefficient based on Spearman-Brown formula was 0.91. This was done in

order to test inter-rater reliability of the scores obtained from the experts who assessed the questionnaires in groups.

Method

Sequential explanatory strategy, which is one of the mixed method strategies, was used in this study (Hamilton, 2003). Thus, the essence was to use qualitative results to assist in explaining and interpreting the findings of a primarily quantitative study.

Participants

Participants were 100 risk analyst of the University who were either managers and or directors of schools or units and were simple randomly selected. Since the participants were selected from two different campuses (termed group 1 and 2), the following comparative procedures were administered before the treatment: firstly, independent sample t-test was used among the two groups to determine if there was any statistically significant difference between the two groups in terms of responses. The distribution suggested that mean scores of group 1; (M=259.93, SD = 6.70) and that of group 2; (M= 259.77; SD = 10.55) differed. However, findings of the t-test [t (46) = 0.06, p>0.05] was not statistically significant, suggesting that group1 and 2 are similar in respect of their response scores.

Secondly, the researcher ensured that risk management course content (RMCC) was clear to both groups, thus to determine comparable levels of understanding of risk practices of the two groups in the University. In this direction, its content (RMCC) validity was identified by experts and it was developed by considering the results of item analyses of the pilot study. The KR-20 reliability coefficient of the pretest was 0.89.

The scores that were obtained from the pretest of RMCC were examined by using independent samples t-test in order to determine if there was any statistically significant difference between the two groups. Again t-test, which was done with the means of the pretest scores [t (46) = 0.56, p>0.05] was not statistically significant. Suggesting that group 1 was not different in respect of understanding the RMCC. The next section addressed the results and discussion of studies.

RESULTS

This section addressed the percentage and logistic regression analysis of the various risk elements identified in the background of the study (cf. section1).

Analysis of likelihood of occurrence of risk

The first category of variable under investigation was shown in table 3.1, thus - what likelihood of occurrence of risk is associated with below target of 3rd stream income? Table 3.1 below represents the variables that indicate preliminary risk quantification. This was preliminary in the sense that part of the result was used in the mathematical model (cf. Bayesian analysis) that subsequently was discussed (cf phase 2). Table 3.1 shows that over two-thirds (81.2%) of respondents asserted that the likelihood of occurrence of risk associated with below target of 3rd stream income was likely not to be met, once in an academic year. This may seem plausible as compared to responses such as not meeting the target quarterly, monthly and even weekly.

Table 3.1: What likelihood of occurrence of risk is associated with below target of 3rd stream income?

	Responses	Frequency	Percent(%)
	Rare- Remote possibility (once every 3 years or more)	2	3.1
	Unlikely- Could happen but rare (typically once a year)	52	81.2
	Possible -Could happen occasionally (on average quarterly)	4	6.3
	Likely - Could happen often (on average once a month or more)	4	6.3
	Almost Certain- Could happen frequently (once a week or more)	2	3.1
	Total	64	100.0

To support the 3rd stream income, the University often depends on the fees recovered from the students. Noting from the above indexes and coupled with the interviews sessions, it was noted by Lin (a respondent) that :

...the university's recovery rate of students fees as at the academic year 2008/2009 was in the neighbourhood of 90% per academic year.

That amounted to the money (fees) recovered from students per academic year. But as an interviewee (Xolani) added;

...it takes long period to recover it (sometimes in a new academic year).

Literature (Standard and Poor, 2006; Mishra and El-Osta, 2002) advocated that in such instances, the policy of the university should be adhered to. In relation to this research, the policy of the university required that it recovers funding from students between the months of August or September,

but instead, the debt was recovered around March of each following year as aforementioned. This put the university at a risk on the cash-flow management and its capacity to operate. When the question of percentage of third stream income was raised, respondents noted that this depended on how the university defined it. This was because every university has its own definition (cf. section 1). The definition for the university as Goba, an interviewee captured was:

... money that comes to the university for which council can exercise its discretion and has control over. By that it would be the institution's interest income, the surplus generated from projects or funded projects the excess that flows, the investment in assets that come as a result of project funding.

But as the interviewees explained, the university's sources of 3rd stream income were generated from variety of sources. In the year 2008, ascertained during the interview, the university benefited either in the form of bursaries and or interest, investment in assets, acquisition of assets to the extent of about R35 million (about $5m as of June, 2009), which was about 8% to 9% of the university's income base. This to a large extent marks a good start for the university in terms of generating 3rd stream income. One respondent (Lin) commented that:

That is not too bad but in other institutions it is much higher. That is about around R30million ($4m), some of which is used to fund a project, to fund bursary students….

Lin maintained that his comment is a good indicator in terms of generating 3rd stream income, as the HEFCE (2001) noted, funders would not give you (institution) money, if they feel an institution would not mange it or would not add value to it.

The next category of variables investigated was as shown (3.2): What likelihood of occurrence of risk is associated with below target in pass rates for all students?

With regards to the likelihood of not meeting the target in pass rates for students in the institution, a similar view (70.3%), as happening once within a year was revealed. Where as the view of pass rates not being met in weekly, monthly and on average three-years as seen in table 3.2 was low, it was relatively popular (17.2%) that pass rates may not be met on average quarterly. The vast difference between codes such as pass rates not being met at least once a year and that of quarterly may be attributable to the fact that the academic year ends within one year which is a cumulative of semesters (quarters of a year).

Table 3.2

What likelihood of occurrence of risk is associated with below target in pass rates for all students?		
	Frequency	Percent (%)
Rare- Remote possibility (once every 3 years or more)	1	1.6
Unlikely- Could happen but rare (typically once a year)	45	70.3
Possible -Could happen occasionally (on average quarterly)	11	17.2
Likely - Could happen often (on average once a month or more)	4	6.3
Almost Certain- Could happen frequently (once a week or more)	3	4.6
Total	64	100.0

Similarly, majority (65.6%) supported the notion that once a year there was the likelihood of not meeting percentage throughput targets (third variable). The view was also popular in terms of percentage throughput target not met quarterly (21.9%).

Regarding the trend noted above, the same could not be said about the likelihood of risk associated with not meeting the target of allocation of infrastructure in table 3.3 below. Over one-half (65.6%) were of the view that there was a likelihood of not meeting the target set forth by the institution under one academic year. In this composite percentage (65.6%), while a one- fourth (25%) of the total responses thought quarterly there was the likelihood of occurrence of risk associated with not meeting the targets set by the university, another one-fourth agreed that there was a likelihood of risk associated with not meeting the target on average once a week. Less than one-fourth (15.6%) viewed that the risk of this happening was nearly within monthly basis as seen in table 3.3.

In terms of this variable, it may appear worrying for a researcher, once the composite value less than one academic year is as huge as seen below. The reason, being notably that a business cycle of the University was normally within one academic year. Which suggest that if the risk as noted above was that high, then the likelihood of not meeting the objectives of the University within that academic year would ultimately be high. This may tie well with the previous tables where most responses attributed the likelihood of risk occurrence to this (variable) and other variables mentioned above as not being met less than one academic year.

Table 3.3

The likelihood of occurrence of risk associated with below target of allocation of infrastructure		
	Frequency	Percent (%)
Unlikely- Could happen but rare (typically once a year)	22	34.4
Possible -Could happen occasionally (on average quarterly)	16	25.0
Likely - Could happen often (on average once a month)	10	15.6
Almost Certain- Could happen frequently (once a week)	16	25.0
Total	64	100.0

Nothing from the above indexes and other technical[5] (cf. University of Fort Hare, 2009- www.ufh.ac.za) reports. Firstly, a student satisfaction index indicated that very few (40%) (departments of the university faired well in student affairs in terms of service delivery to students. In this context, respondents argued that this was because, services offered to students are not of a high standard. James (one of respondents) who is the CFO of the institution and consistently interacted with both staff and students at all levels had his frustrations about this and revealed this in disheartening way:

I think we have a serious issue at the institution concerning service culture. One has to look at the resources provided, in terms of the residential space, teacher's space, library, computers, equipment, access to laboratories etc. These are wholly inadequate for the students. So if I were a student and if you asked me to rate it from 1-10, I would give it a 2.

Lin's view was consistent with several studies (Carey and Simnett, 2006; COSO, 2004; Crouhy et al., 2006; Myers et al., 2003) who have shown that the service culture of an organisation could be the difference between success and failure in achieving its overall corporate goals and mission. Although, some aspects of an organisation's service culture are visible and tangible, such as the physical structure or overall cleanliness of the facility, other aspects are less tangible but just as apparent, like the helpfulness of the staff and the overall "attitude" of the organisation. Organisational culture is the style or personality of the organisation. Cameron and Quinn (2006) explained it as the shared assumptions, beliefs, and behavioral norms of a group. Thus these beliefs are powerful influences on the way people live and act. They drive the organisation and its actions. They guide how employees think, act, and feel. The culture defines what is "normal" and acceptable and how to sanction those who are not acting within the defined parameters. The

above concern of James together with literature (Walker et al., 2002, Myers et al., 2003; Standard and Poor, 2006, HEFCE, 2001) contest that the above view may emanate from the point that if students go to computer laboratories and have to wait for 5 minutes for a site to load up, it is not sufficient as this does not facilitate efficient usage of information. In addition to the above, James maintained that poor service culture may be a major challenge that impact on the university's sustainability. James concluded by noting that:

... the mere fact that I speak to my friend who is in matric[6] about the university, is because I am young, but when I start speaking about the real issues that is about access to the library and getting space to sit in the library, I will not pass on a very positive picture. And that does not make us an institution of first choice. That is how the public perceive it and that is how the students perceive it. We have a lot of fixing up to do and it requires substantial financial resources to do so.

Economist Intelligence Unit (2005) have demonstrated that institutions with strong positive reputations have higher market value, receive preferential treatment from the public, have more and happier customers, benefit from a more service labour force and entice the best talent. And when things do go wrong, companies with strong reputations get the benefit of the doubt. Today, as much as 75% of an institutions value is based on an intangible, hard-to-measure asset: reputation (Economist Intelligence Unit, 2005). While reputation may be the most important asset, it is also the most difficult to protect. According to a 2005 report by the Economist Intelligence Unit (2005), reputation risk is the greatest risk facing global institutions. Economist Intelligence Unit (2005) noted that of the 269 senior risk executives surveyed, 52% said that reputation risk was more significant than regulatory risk (41%) and human capital risk (41%). The above concerns raised by James including other authors (Liebenberg and Hoyt, 2008; Economist Intelligence Unit, 2005, Nicholas, 2004; Power, 2004) suggest that the first thing for the university to change is the reputation and service culture, thus getting the stakeholders (administrators and academics) to understand who their customers are. This was noted by one respondent (Lin) as:

It is the student that comes and goes through the system.

Lin argues that a lot of the staff members need training and soft skills training to change attitude and perception of customer service satisfaction. Lin captured this finally by stating that:

…an example of poor service relates to where a student requests a statement from the University and the student is asked to come back 20 days later. And it is not because they cannot do it but it is our way of exercising power.

This suggests a power struggle, inexistence and effectiveness of risk controls, as Lin concludes. Lin suggests that employees have to get through

that to make the next leap in becoming an institution of first choice.

In relation to access to information, this has been a long standing difficulty as Lin explains. Students (customers) for the first time engage with the university with an improper impression. Lin attributes this to the communication style of the university. Lin complains that there are often no clear and appropriate channels for admission processes- especially when candidate students phone in.

Literature (Liebenberg and Hoyt, 2008; Standard and Poor, 2006; Nicholas, 2004; Power, 2004) warns that the above may lead to a lost of clientele base. In some cases too, the university continues to attract student from poorer communities and under resourced schools. A large portion of the university's student population as Lin noted comes from the limited resourced schools which contribute to the risks faced. It becomes a business imperative to support those students properly. Lin contends that:

…If I come from a well resourced school and another student coming from rural area where the biggest shop was the trading store down the road, it will mean, we have two different worlds that meet here and which creates its own tensions. We need to accommodate that and bring them in the modern way of doing things.

The above as Lin maintains, is one of the risks, the university faces as historically disadvantaged institution (HDI) and it impacts on quality as well. This was because both teaching and learning facilities do not meet the demand of the both the students and staff. Lin concludes that a lot of time and space would have to be spent on upgrading their knowledge and skills so to be competitive as other candidates from other universities.

The interview revealed that the university does not attract a good proportion of best candidates. This point is consistent with the Lin's view above. He noted that the students from the under-resourced schools are put in under-resourced laboratories. This category of students are expected to pursue courses such as science and mathematics, which they end up performing poorly and or taking more than the required number of years to complete a degree. He concluded statement as:

… we [University] give them laboratories that have equipment of 1960 so it is designed for failure. I have a strong view that you take a student from a rural community and put him in a residence that is (1) not better than a shack (2) put him in a laboratory that is most probably less resourced than the one he used in high school, which was even poorer and then you award him his Bachelor of science. If this student is asked to work at Anglo American

[one of South Africa mining companies], where is most probably required to use a computer and he has never done it. You certainly expect failure in the country. So there are large imbalances and it does affect our target.

The other variable investigated was human capital. In terms of human capital, particularly academic staff qualification targets set forth by the university revealed that where as there was a low percentage (15.6%) likelihood of occurrence of risk associated with not meeting a target set forth by the university in relation to qualified staff with masters and doctoral degrees, majority responded that the likelihood of risk of not meeting the target was over two-thirds (73.4%) of the total responses.

The last variable investigated in the above sub-section under *likelihood of occurrence of risk* was the likelihood of risk associated with not meeting the target of academic staff in the university. It was revealed that a bigger percentage (67.2%) maintained that the institution was not likely to meet the target set in terms of academic staff. Although, there appears to be a low percentage rate trend in the other responses (see above tables) particularly time period of quarterly, monthly, weekly and once in three years, in this instance, there is relatively a close tie with regards to quarterly and monthly. In which case, where as 18.8% claimed the target may not be met on average quarterly, 10.9% noted that this could happened once a month or more. The above though constitute risk since there is the need to have appropriate teaching qualification for various subjects. The next sub-section investigated was impact of occurrence of risk.

Logistic Regression Analysis

There were two logistic regression models that were used to examine and to predict the correct classification of the risk elements institutional RA. The independent variables used for these analyses were obtained from the background questionnaires of risks elements (cf. section 1) that were administered to the analyst. Note that these questionnaires were identical in the two groups. The first logistic model used variable that dealt with risk associated with below target in pass rates (RPR), while the second model looked at differences that existed in the of risk associated with below target of allocation of infrastructure (RIFR). Finally, to reduce the risk of inflating the alpha estimates, all variables that were used in the previous two models were entered into one last model. After this model was run, only the independent variable that were significant remained in the model.

3.2.1 Risk associated with below target in pass rates (RPR)

The first logistic regression that was performed included a set of 4

independent variables that examined if the two groups of risk analyst differed in risk associated with below target in pass rates (RPR). The overall chi-square test for the logistic model was significant ($X^2 = 114.00$; $p < 0.05$) which indicated that there were differences between the two groups on the two RPR. In addition, the Hosmer and Lemeshow test was non-significant with a chi-square ($X^2 = 8.181$; $p = 0.300$), which indicated that there was a good model fit since the data did not significantly deviate from the model. In terms of the variance that was explained by this set of variables, the Cox and Snell R^2 equaled 11.00%, while the Nagelkerke R^2 equaled 17.01%. Based on this model, 42.0% of the analyst was correctly classified in the group 2, while 79.9% of the analyst was correctly classified to be in group 2. So in the overall model, 79.9% of the sample was classified correctly.

In terms of the variables themselves, the ones in which there were significant differences between the groups were those of ''unlikely- could happen but rare (typically once a year)', ''possible -could happen occasionally (on average quarterly)'. When interpreting the B-values for this model, they indicate that on a scale from 1 to 5, for each unit increase in the analyst's amount of liking QRA, their probability of being in the group 1 would increase by 16.03%.

However, this variable was not statistically significant for classifying the analysts correctly in the two groups. On the same scale, for each unit increase for the variable of ''likely - could happen often (on average once a month)', Almost certain- could happen frequently (once a week)' had a 39.2% decrease in their probability of being in group 1. This indicated that the analyst in group 2 considered QRA (*likelihood of occurrence of risk*) to be more boring than the group 1. However, for each unit increase in the analyst's agreement that QRA is easy, those analyst would increase their probabilities of being in the group 1 by 30.1%. In addition, the same group 1 analyst was most likely to agree that they would like a QRA since for each unit increase of agreement that they wanted to pursue QRA, the probability of being in the group 1 would increase by 31.6%.

3.2.2 Risk associated with below target of allocation of infrastructure (RIFR)

The second logistic regression that was performed included four variables that examined the risk associated with below target of allocation of infrastructure (RIFR). Overall chi-square test for the logistic model was significant ($X_4^2 = 63.010$; $p < 0.05$). In addition, the Hosmer and Lemeshow test was non-significant with a chi-square ($X^2 = 3.900$ p-value = 0.643) which indicated that there was a good model fit since the data did not significantly

deviate from the model. From the four variables in the model, the variable of needing to 'likely - could happen often (on average once a month)' or the notes was the only significant variable. The variables of almost certain- could happen frequently (once a week), was not significant in correctly classifying the analyst into groups 1 and 2. However, based on this logistic model, 71.6% of the cases were classified correctly. More specifically, 48.3% of the group 2 was classified correctly, as well as 76.4% of the group 1. However, there was not a large proportion of the analyst's grouping variance that was explained by these variables, since the Cox and Snell R^2 equaled 4.4%, while the Nagelkerke R^2 equaled 7.3%. When interpreting the significant variable from this model, a researcher could see that for each unit increase in agreement (on a five point scale) for the variable of ''likely - could happen often (on average once a month)'', the probability of being in the group 1 decreased by 45.6%. This indicates that the group 2 tend to rely on a 'likely - could happen often (on average once a month)', in QRA. Where the average agreement for the importance of 'likely - could happen often (on average once a month)' for the group 1 was1.64, in contrast to the group 2 who had an average value of 3.02. What was also interesting was that group 1 tended to agree more strongly on the thesis that, for a good QRA, an analyst needs to understand the practices and content of risk analysis.

In order to eliminate multicolinearity issues that might exist between all the variables that were used in the two models used in the inferential analysis, one last logistic regression was performed that originally included all of the variables used in the previous models. Once the model was run, the non-significant variables were deleted from the model, which led to the final model. This last model was significant ($X^2 = 284.301$; p=0.000), while the Hosmer and Lemeshow test was non-significant with a chi-square of 29.315 p-value > 0.05 which indicated that there was not a good model fit, since the data significantly deviate from the model. A large proportion of the variance of the dependent variable was explained by this final model, since the Cox and Snell R^2 of 29.4%, and a Nagelkerke R^2 of 31.9%. In addition, 69.4% of the cases were classified correctly with these variables. From these cases, 64.4% were in the group2, while 75.7% were in group 1. The distribution as well suggested that for each additional level of infrastructure the analyst had a 34.4% higher probability of being in the group 1. The variables that had the strongest effect based on this analysis were those of pass rate. On a five-point scale, for each additional increase in the amount of time reported that they (analyst) spent their probability of being in group 1 decreased by 49.4%. On the same scale, for each additional increase in the amount of time reported that they spent on human capital, their probability of being in group 1 decreased by 14.3%.

To sum up the findings of the *likelihood of occurrence of risk* in this section, an analyst needs to take cognisance of various model(s) that could be used in predicting the likelihood of occurrence of risk factors. As in this case, this was predominantly base on the likelihood of occurrence using percentage frequency as shown in the various indexes. Note that other model(s) other percentages may be suitable.

The findings of the likelihood of occurrence of risk in this section suggest that the University needs to take cognisance of various model(s) that can be used in predicting the likelihood of occurrence of risk factors. In this view though, the main findings of the section included: (1) once in an academic year there is the likelihood of not meeting the target of 3rd stream income (2) with regards to the likelihood of not meeting the target in pass rates for students in the institution, a similar view was revealed (3) similarly, the notion that once a year, there was the likelihood of not meeting percentage throughput targets was a matter of concern (4) poor service culture was a major challenge that impacted on the university's sustainability which impacts on its reputation (5) it was also revealed that the institution was not likely to meet the target set in terms of teaching and academic staff qualification appropriated by the institution in an academic year.

Due to the findings of the study, it was suggested that to derive an overall likelihood rating that indicates the probability that a potential risk may be exercised within the construct of an associated threat environment, the following governing factors must be considered: (1) threat-source motivation and capability (2) nature of the vulnerability (3) existence and effectiveness of current controls. Lin (respondent) summed it all by saying that "…this information can be obtained from existing organisational documentation, such as the mission impact analysis report or asset criticality assessment report".

CONCLUSIONS AND IMPLICATIONS

In summary, the findings of the *likelihood of occurrence of risk* suggest that a risk analyst needs to take cognisance of various quantitative model(s) that could be used in predicting the likelihood of occurrence of risk factors. In this regard this first of the two-phased study was predominantly base on the likelihood of occurrence using percentage frequency. In this view though, the main findings of the section included that: (1) the data (81.3%) showed that the likelihood of occurrence of risk associated with below target of 3rd stream income was likely not to be met, once in an academic year (2) with regards to the likelihood of not meeting the target in pass rates for students in the institution, a similar (70.3%) view as happening once within a year

was revealed (3) similarly, the notion that once a year there is the likelihood (65.6%) of not meeting percentage throughput targets was a matter of concern (5) poor service culture was a major challenge that impacted on the university's sustainability which impacts on its reputation (6) it was revealed that that the institution was not likely (67.2%) to meet the target set in terms of teaching and academic staff qualification appropriated by the institution. Thus, in terms of academic staff, particularly academic staff qualification targets set forth by the university, the data revealed that where as there is a low (15.6%) percentage likelihood of occurrence of risk associated with not meeting a target set forth by the university in relation to qualified staff with masters and doctoral degrees, majority (73.4%) responded that the likelihood of risk of not meeting the target was serious matter of concern.

Overall, this study has indicated that there are significant background differences between risk analysts in the University under investigation. Based on the results of this study, more than half of the variables that were used were significant in predicting the classification of the analysts, while in all two logistic regressions, more than two-thirds of the analyst was classified successfully. These results imply that these differences exist since the differences have successfully been found beyond the chance level. Using these results as well as the knowledge of how the risk analysis system works in University, one may argue that there is nothing contradictory in the QRA methods and models, why? There is candidate reason. The one which has to do with how tracking risks operates in University. As with other risk analysis processes, the University need to get into a rhythm of periodic and systematic monitoring and tracking. The University may wish to appoint a risk manager. The risk manager is responsible for staying on top of the things that could go wrong.

Due to the findings of the study, it is suggested that to derive an overall likelihood rating that indicates the probability that a potential risk may be exercised within the construct of an associated threat environment, the following governing factors must be considered by any risk analyst: (1) threat-source motivation and capability (2) nature of the vulnerability (3) existence and effectiveness of current controls.

On the other hand though, the next major step in measuring likelihood of risk is to determine the adverse impact resulting from a successful threat exercise of risks (cf. phase 2).

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