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A survey of quantitative methods in South African management

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Academics who are responsible for training South Africa's future pool of management resources need, as part of their management development programme, to emphasize the contribution of Quantitative Methods to management decision making.

To give a complete appreciation of Quantitative Methods, practice of the subject in South African management. No current research in this direction exists.

This research, undertaken through a mailed questionnaire to South African companies, aimed to establish the relative use of Quantitative techniques; their frequency of use, and their degree of success as useful information generators.

This paper summarizes the result and draws tentative conclusions about the state of art in 1982 of Quantitative Methods in South African management as a decision support tool.

S. Afr. J. Bus. Mgmt. 1983, 14: 120 – 124

Akademici wat verantwoordelik is vir die opleiding van Suid-Afrika se toekomstige bestuurshulpbronne, as deel van hulle bestuursopleidingsprogram, is genoodsaak om die bydrae van Kwantitatiewe Metodes tot Bestuursbesluitneming te aksentueer.

Om kwantitatiewe Metodes volledig na waarde te skat, is dit nodig dat voorgeskrewe materiaal aangevul moet word met kennis van die toepassing in die praktyk van Suid-Afrikaanse Bestuur. Geen huidige navorsing is beskikbaar oor hierdie aspekte nie.

Hierdie navorsing, wat gebruik maak van vraeboë wat aan talle Suid-Afrikaanse maatskappye gestuur is, het beoog om die relatiewe toepassing van kwantitatiewe tegnieke te evalueer: nie alleen die frekwensie daarvan nie, maar ook die graad van sukses as bruikbare inligtingsgenerators.

Hierdie artikel is dus 'n opsomming van die bevindinge en maak sekere gevolgtrekkings oor die status van Kwantitatiewe Metodes as besluitnemingsondersteunings-instrument in Suid-Afrika gedurende 1982.

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Introduction

Introductory and advanced courses in Quantitative Methods (Statistics and Operations Research) are offered at most institutions of higher education in South Africa. These courses are not confined only to students in the pure mathematical statistics discipline. Courses of an applied nature, aimed at creating an awareness of Quantitative Techniques, are being offered to students in Engineering, Quantity Surveying, Business Science, Accounting and even certain Social Science disciplines.

The syllabi of these courses in South Africa are strongly influenced by the contents of USA published textbooks. These texts have been validated through case studies and surveys conducted in the USA which have established the relative importance of techniques in terms of their extent of application and success in practice.

To give a complete appreciation of Quantitative Methods in decision making, the South African academic needs to complement the 'theory' from textbooks with the 'South African experience' which indicates the relative use of techniques; their frequency of usage; and their degree of success. Knowledge of the South African situation can also serve to assist academics to design courses which meet the needs of the end user community more closely.

No current studies in this direction exist at present in South Africa. The Western Cape Chapter of the Operations Research Society of South Africa, in conjunction with the Department of Business Science, University of Cape Town, therefore decided to undertake a study into the relevance of Quantitative Methods to the South African management decision making function.

Summary of literature on USA studies

A number of studies have been conducted over the past 10 years in the USA for the express purpose of determining what kinds of quantitative techniques are being used and where they are applied. Turban¹ (1972) surveyed 475 of Fortune's top 500 companies. He established that the techniques most often used are statistical analysis, simulation, and linear programming. O.R. projects last about 10 months on the average and involve about 2,5 researchers. The Gershelski study² (1970) examined the penetration of Corporate Models into US corporate planning processes. The findings indicated that 65% of the companies surveyed developed corporate-wide models, but in very little detail. Ninety five percent of the models were of a simulation type; the rest being mathematical programming or optimization models.

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Almost 90% of models were deterministic in nature, and nearly all were computerized. Cook and Russell³ (1974) surveyed 240 of the Fortune 500 companies and established that the techniques of linear programming, simulation, inventory models, and PERT/CPM are used by more than 88% of all respondents. Lesser used techniques were queueing models, dynamic programming and integer programming. Markov processes was the least used method. Kiani-Aslani⁴ (1975) conducted research into the relevance of quantitative tools of decision making for the Accounting profession. The study found that the most frequently used technique was Net Present Value concepts. In decreasing order of usage, the other techniques were ranked as follows: Forecasting Methods, Inventory Models, Simulation, Statistical Analyses, Linear Programming and Network Analysis. The study also identified reasons for the non-use of Quantitative Methods as decision aids. The primary reason cited by respondents was the lack of line management understanding of this discipline.

The studies referred to above briefly indicate the direction of the discipline of Quantitative Methods in the USA. A similar indication is required in South Africa. This study was conducted to this end.

Terms of reference

Broadly the objective was stated as a question; namely 'What was happening in South African companies with respect to Quantitative Methods?' The answer to this question was approached by formulating the following specific objectives:

- (a) identify the penetration level of Quantitative Methods in South African companies;
- (b) for a range of basic and more advanced methods, establish for each, their exposure; their frequency of use; and their degree of success;
- (c) identify reasons for non-usage; and finally,
- (d) identify the level of expertise in Quantitative Methods within the companies.

Methodology

The population was defined as all the companies listed on the Johannesburg Stock Exchange. This resulted in a population of 531 companies. A questionnaire was mailed to the Managing Director of each member of the population with a request to have it completed by an appropriate executive.

The data gathered was primarily qualitative in nature (nominal or ordinal). As a result, it was examined in three ways:

- (a) histograms were constructed for each question;
- (b) a cross-tabulation of the specific data with 'company size' was constructed to establish any relationship between the response and size of company; and thirdly,
- (c) the responses were cross-tabulated with 'economic sector' to examine possible links between responses and nature of business.

The analysis was performed using the UNISTAT2 and CROSTAB2 routines from the STATJOB package on the UCT UNIVAC IIIIO computer.

Companies were classified into 22 economic sectors as identified in the Johannesburg Stock Exchange handbook.

The range of techniques selected for evaluation was Linear Programming, Non-Linear Programming, Inventory Models, Queueing Models, PERT, Simulation Modelling, Net Present Value concepts, Decision Trees, Markov Pro-

cesses, Descriptive Statistics (means, dispersion, frequency graphs, crosstabulations), Inferential Statistics (sampling, confidence intervals, hypotheses testing), Forecasting Techniques (regression, correlation, time series, moving average, exponential smoothing), and Transshipment Models.

Discussion of results

A response level of 31% was achieved. It was necessary to establish the representativeness of the sample received. This was done by considering two factors. Firstly, the responses to question 1 in the questionnaire were analysed. This question was a filter question designed to identify the percentage of companies who use one or more quantitative methods in their decision support systems. The nature of the question encouraged even non users to respond. The percentage of 'users' (58%) to non users' (42%) indicates that a balanced response was received. Secondly, a sector analysis indicated that there were responses from all sectors with the exception of 'Pharmaceutical and Medicine'. The lowest response level was 11% from 'Furniture and Household Goods', while the largest response came from 'Transportation' (75%). Also more than 60% of the 22 sectors identified had responses exceeding 30%. Finally the distribution of responding companies across sectors was analysed in relation to the actual relative size of each sector. It was found that the pattern in the sample corresponded closely to the actual spread of companies across sectors.

The sample then, appears to be an unbiased representative subset of the defined population.

Who uses Quantitative Methods?

As mentioned above, almost 60% of all JSE listed companies employ some mix of quantitative methods to support their management decision making process. When company size, as measured by the staff complement, was compared to those who did or did not use any methods, it was found that larger companies (staff in excess of 2000) made more use of such techniques than smaller companies. A sector analysis shows that the Motor industry appears to be the least quantified sector. Only 14% of the responding companies use any techniques.

The Transportation, Steel, Furniture, Mining and Mining Finance sectors on the other hand appear to lean heavily on quantitative methods. All 100% of responding companies in these sector use some mix of quantitative tools.

What techniques are used, by whom, with what frequency, and with what degree of success?

(a) The second question in the questionnaire examined the level of exposure of each of the techniques listed amongst the responding companies. The techniques enjoying the most understanding among practitioners (in descending order of exposure) are Present Value concepts (74%), Descriptive Statistics (54%), and Forecasting Methods (53%). The techniques of Simulation, Inferential Statistics, PERT, Linear Programming, and Inventory Models are understood by between 28% and 43% of the responding companies. The balance of the listed techniques, namely Non-Linear Programming, Queueing Models, Decision Trees, Markov Processes, and Transshipment Models are largely unknown to the respondents.

While not drawing any statistical conclusions because of

too few observations in each cell, a scan of the tabulated data relating companies with a working knowledge of a technique to their economic sector suggests the following trend. The techniques of Net Present Value and Descriptive Statistics are both well known in all economic sectors but one. They are followed by Inferential Statistics, Simulation, PERT, and Forecasting Methods which are known in at least 70% of the identified sectors. The spread of knowledge about Quantitative Methods is complete within the Insurance and Stores sectors. By this is meant that at least one respondent in each of these sectors has a working knowledge of all the listed techniques. The spread of knowledge is at least 85% in the sectors of Mining, Mining Finance, Banks, Industrial Holdings, Building, and Steel. On the other hand, fewer than 30% of these techniques are known to respondents in the sectors of Engineering, Other Finance, Furniture, Motor, and Printing.

In a similar manner to the sector analysis above, exposure to the listed techniques was related to company size. With the exception of the techniques of Net Present Value, Descriptive Statistics, and Queueing Models, the trend is towards the increasing awareness of Quantitative Methods as company size increases.

(b) The third question related to the frequency of usage. The results show that the three most widely known methods, namely, Net Present Value concepts (61%), Descriptive Statistics (52%), and Forecasting Methods, (53%), are also the ones that are applied most frequently in practice. Between 20% and 32% of all respondents used Linear Programming, Inventory Models, PERT, Simulation, and Inferential Statistics on a periodic to regular basis. As can be expected, the least known techniques of Non-Linear Programming, Queueing Models, Decision Trees, and Transshipment Models, are also the least used methods. Fewer than 10% of respondents used them on a regular basis. In fact, Markov Processes has rarely, if ever, been applied by any respondent.

(c) Having established usage levels, the next question sought to identify the degree of success achieved with these techniques. Since quantitative methods must be seen as information generators for decision making, it is necessary to assess the level of satisfaction derived from the application of these techniques. Good to very good results in terms of usable information for decision making was recorded by at least 80% of respondents who reported having a good working knowledge of the particular techniques. This high success rate related to the techniques of Inferential Statistics (95%), Descriptive Statistics (94%), PERT (94%), Simulation (91%), Inventory Models (89%), Linear Programming (87%), Present Value concepts (85%), and Forecasting Methods (81%). Moderate to poor success was reported with the balance of the techniques (Non-Linear Programming, Queueing Models, Decision Trees, and Transshipment Models).

Reasons for non-use

The two primary reasons cited by responding companies for reporting either no usage or very limited usage of quantitative methods in decision making are:

- (i) lack of understanding by line management; and
- (ii) inadequately trained personnel for implementation.

Other less frequently cited reasons include 'competent personnel with quantitative training are scarce'; 'the staff personnel are unable to sell these approaches and solu-

tions'; 'returns from expenditures on these techniques are inadequate'; 'data for these models are inadequate and difficult to obtain'; and finally, 'the models make too many unrealistic assumptions'.

A chi squared statistical test was conducted on the profile of reasons for non-use of all or certain techniques between 'users' and 'non-users' as identified in question (i). The test concluded that there is no statistically significant difference between 'users' and 'non-users' with respect to the primary problems faced in the implementation of quantitative methods as decision support devices. Both groups cited identical reasons in approximately the same proportion.

The reasons could broadly be grouped into 'human initiated' sources and 'model initiated' sources. An examination of these two groupings reveal that 70% of all the problems associated with the application of these techniques are attributed to the human element. Only 30% of the reasons given refer to model inadequacies.

The primary reason for the non-use of all or certain of the methods, namely 'lack of line management understanding' was examined in relation to company size and economic sector. The comparison with company size tends to suggest that small to medium sized companies (less than 2000 employees) are managed by executives who are less informed about quantitative methods than their counterparts in larger organizations. A sector analysis reveals that a third or more responding companies in the sectors of Printing (33%), Transportation (33%), Stores (39%), Motor (60%), Electronics (50%), Textiles (33%), and Packaging (100%) give lack of line management understanding of this discipline as the primary reason for its absence in practice.

Decision Support personnel

The level of penetration of Quantitative Methods in practice is a direct function of the size and composition of personnel charged with the responsibility to supervise their implementation. The first question in this section identified the size of such units, while the second question looked at the graduate complement within these decision support units.

In terms of size, the majority of organizations (60%) employ six or fewer persons in this specialist area. More than half of these companies (53%) have support units not exceeding three members. In fact, the most frequently occurring unit size is one person, followed by units of size four. Twelve percent of companies who use any quantitative methods do not have any formal unit performing this function. Instead, it is the responsibility of the individual executives who wish to use these approaches to undertake their implementation. When the size of the decision support unit is compared with the size of the company, the trend in the crosstabulation indicated that larger organizations tend towards no formal decision support unit. As indicated above, it is the responsibility of the individual executive. A further observation is that company size appears to have no significant influence on size of these specialist units where they do occur. At least 67% of all respondents in each company size category have decision support units consisting of six or fewer members.

An analysis of the size of the decision support units across the economic sectors indicates that four sectors, namely, Textile, Electronics, Packaging, and Steel appear to have no specific unit in this regard. Seven of the sectors have be-

tween one and three members, while eight sectors comprise between four and six members of modal size for their support unit. There are only two sectors, namely, Banking (10 to 12 modal interval), and Chemicals (7 to 9 modal interval) who have decision support units larger than six members.

An analysis of graduates employed in these units indicates that 16% of responding companies who are 'users' employ no graduates in this area. The bulk of the organizations (58%) employ between one and three graduates. The modal graduate complement was one (28% of total respondents who use quantitative methods), followed by three graduates in 23% of respondents. A crosstabulation of graduates across company size reveals that approximately one-fifth of medium to large companies employ no graduates in these units. Where graduates were employed, their numbers did not exceed three in 51% of the large companies, 56% of medium sized companies, and 70% of small companies. There is no definite trend in the data available to identify where graduates tend to be employed according to sectors. There is a fairly uniform distribution of graduates across all sectors with the exception of Steel, where none of the responding companies who have a decision support unit employ any graduates.

Conclusions

The discussion of the results obtained from the data analysis gives rise to a number of conclusions which can be drawn.

The use of Quantitative Methods in decision making in South Africa is restricted primarily to three techniques, namely, Net Present Value concepts, Descriptive Statistics, and Forecasting Methods, in that order. While other methods such as Linear Programming, Inventory Models, PERT, Simulation Modelling, Inferential Statistics, and Decision Trees are used, their penetration is not as great as the three most commonly known and used approaches. In general, there appears to be a limited awareness of and level of proficiency in Quantitative Methods amongst responding companies. There is a general lack of knowledge of a wide array of decision support tools. While accepting that not all techniques are equally applicable in all sectors and in all sized companies, there may be missed opportunities for improved information had the knowledge been available on a wider spectrum of techniques.

Where Quantitative Methods have been applied on a regular basis, the large majority of users have expressed great satisfaction with the results achieved from these Models.

While each technique has its limitations, the primary reasons for the lack of implementation of these approaches do not lie with the theoretical constructs of the Models *per se*. Instead, the causes are human initiated factors. The most important of these is the lack of line management awareness of this discipline and consequently, their ignorance of the potential benefits that can accrue from the use of the techniques. Executives in smaller organizations appear to be less informed than those in larger companies. Also, in seven out of the twenty one sectors, more than a third of the companies within each sector plead ignorant management with respect to awareness of Quantitative Methods. The second major human restraint cited is the lack of quantitative expertise within a company to implement these approaches. This is a supply problem. Lack of management awareness is a demand problem. As long as Managements do not perceive

the need for a particular quantitative approach, applications will remain dormant. Thus the penetration of Quantitative Methods into more companies in the population appears restricted by both the supply of skilled quantitative personnel to supervise their implementation, and by the demand for applications caused by a management force that is largely unaware of the existence of this discipline and the potential benefits it can offer.

The above conclusion is re-enforced through the analysis conducted on the size and composition of the Decision Support Units. With almost half the responding companies having a work force in excess of 2000 persons, the most frequently occurring unit size is one to three employees. In addition, almost two-thirds of these respondents employ between one and three graduates only. (Note: Their academic specialization is not known as it was not requested in the interests of brevity.) Decision Support Units using Quantitative Methods therefore appear to be 'thin on the ground' with respect to adequately trained staff. This situation could, in part, account for the lack of awareness of a broad spectrum of techniques across the majority of respondents within the Decision Support Units themselves. It could also explain the inability of Decision Support personnel to sell these approaches and solutions to management (the end user), which in turn contributes to managements' general unfamiliarity with Quantitative Methods, their uses and limitations.

Limitations of the study

When evaluating the results of this study in terms of its objectives, the following limitations apply:

- (a) The population excluded all private and multinational companies which are not listed on the Johannesburg Stock Exchange.
- (b) Certain companies on the J.S.E. are holding companies. They may or may not perform the decision support function for their subsidiaries. This could lead to some data distortion. However, this influence was not considered to be significant, and no adjustment was made to the data.
- (c) The emphasis was placed on Operations Research type techniques. Other statistical methods such as Factor Analysis, Discriminant Analysis, MDS, Conjoint Analysis, etc., were excluded.
- (d) Certain crosstabulations could not be statistically validated due to the small cell frequencies. In these instances, relationships between the variables were subjectively postulated.

Recommendations

While giving insight into what is being used in South African management to support decision making, this study has also revealed certain obstacles inhibiting further growth of the discipline of Quantitative Methods in Management practice. The problem is essentially human orientated. It relates to the shortage of skilled quantitative personnel (the supply side), and to an uninformed end user management community (the demand side). As a result, the following recommendations are made.

On the demand side, an awareness campaign must be launched to inform the decision makers in companies of the existence of the discipline of Quantitative Methods as well as the potential benefits to their decision making function while not forgetting the limitations. Its contribution

as a Decision Support System must be the message to be communicated. The Operations Research Society of South Africa, with its pool of expertise, is in the best position to initiate such a program. The format of presentations can range from in-company seminars to industry-wide workshops. The desired objective is an informed management community who can both communicate intelligently with the specialists, as well as being able to initiate the integration of Quantitative Methods into their decision making processes. This 'lack of awareness' problem is particularly acute at present due to the majority of the current management community never being exposed to such approaches either from their past formal training or their current business practices. This problem should be alleviated to a large extent by the year 2000 when the 'old school' management will be largely replaced by the professionally qualified managers who are acquiring this basic knowledge in their formal training (such as MBA and Bachelor of Business Science degrees).

On the supply side, the throughput of skilled quantitative analysts must be accelerated to meet the demand as and when it arises. The rate at which graduates who specialize in Quantitative Methods qualify is far from adequate to meet the needs of commerce and industry even at present. The need to attract suitable candidates to the profession rests again with the Operations Research Society of South Africa. The Society must begin to actively promote this discipline at the school level. This can be achieved through brochures followed by addresses at careers sessions or to scholars in special interest groups.

Finally, what are the implications of this study on the course content of Quantitative Methods modules at academic institutions? Based on the results, it is recommended that

academics do not take the lead from the current business practices. While less emphasis in service courses should perhaps be placed on the more advanced areas such as Non-Linear Programming, Transshipment Models, and Markov Processes, the current mix of techniques taught should remain. In this manner, academics will be educating future management in not only what is currently applied, but will be paving the way for what still can be applied, given the required knowledge and understanding.

In this way, academics will be contributing to a better utilization of scarce economic resources by promoting a more thorough evaluation of alternatives based on an objective quantitative approach.

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