Pergamon

Accounting, Organizations and Society, Vol 19 No 4/5 pp 413–426, 1994
Elsevier Science Ltd
Printed in Great Britain
0361-3682/94 $7.00+0.00

THE EFFECTS OF MANAGEMENT ACCOUNTING SYSTEMS, PERCEIVED ENVIRONMENTAL UNCERTAINTY AND DECENTRALIZATION ON MANAGERIAL PERFORMANCE: A TEST OF THREE-WAY INTERACTION*

FERDINAND A. GUL
The Chinese University of Hong Kong

and

YEW MING CHIA
Hong Kong University of Science and Technology

Abstract

This study investigated the interaction effects of perceived environmental uncertainty (PEU), decentralization and management accounting systems (MAS) design on managerial performance. MAS design was defined in terms of perceived availability of two characteristics of information, which were scope and level of aggregation. The responses of 48 managers, drawn from a cross-section of Singapore companies, to a questionnaire survey were analysed by examining the regression equations for the three-way interaction model and the partial derivatives of the equations. The results indicated that decentralization and the availability of MAS information characteristics of broad scope and aggregation were associated with higher managerial performance under conditions of high PEU. Under conditions of low PEU, decentralization and the availability of MAS broad scope and aggregated information were associated with lower managerial performance.

A major strand of management accounting research has been the application of contingency theory to the study of management accounting systems (MAS) design and performance (Chenhall & Morris, 1986; Gul, 1991). In particular, these studies have focused on the relationship between aspects of contextual variables (e.g. perceived environmental uncertainty), MAS characteristics and performance. MAS is seen as a control subsystem within this configuration of variables that is posited to affect a firm's performance. For example, following contingency theory, a "fit" between high perceived environmental uncertainty (PEU) and broad scope MAS information is more likely to improve performance than a "misfit" such as broad scope information and low PEU (Gordon & Narayanan, 1984). This follows the reasoning of contingency theorists that the capacities for information or control systems (e.g. MAS) should meet the requirements or demands as a result of uncertainty facing the organization (Gerloff, 1985; Tushman & Nadler, 1978). By matching the capacities with the requirements, the organization can improve its performance (Nadler & Tushman, 1988; Gerloff, 1985).

To date, most of the studies relating to this area of research have adopted a bivariate interaction analysis to evaluate the joint effects of two independent variables on a dependent variable (e.g. Schoonhoven, 1981; Govindarajan, 1986; Govindarajan & Gupta, 1985; Gul, 1991). Govindarajan & Gupta (1985), for example, examined the linkages between strategy and control systems in terms of different types of incentive

* The authors wish to acknowledge the comments of Alan Dunk and the two anonymous reviewers.

bonus schemes. To evaluate these linkages several two-way interaction propositions between strategy and each of these incentive bonus schemes were set up for testing, and significant results were obtained. In a more recent study, Gul (1991) tested a two-way interaction between PEU and MAS (a control system) on managerial performance. Two drawbacks may be identified with the use of these bivariate analyses. The first is identified by Govindarajan & Fisher (1990, p. 281):

> Although bivariate analysis is an essential starting point, there is definite conceptual and practical merit in moving towards complex theories. Several variables might show significant effects in bivariate analysis, but if all these variables are simultaneously entered in a regression equation one or more may be salient as to dominate the others. Also, because "equifinality" can arise, the effects of some variables that are significant in bivariate analysis might fail to show significance in a multivariate test.

The second drawback, which is related to the first, is that those studies which considered a single control system in a two-way interaction model may not adequately capture the notion that organizations use a package of control systems to enhance performance. Otley (1980, p. 422), for example, recognized this:

> It is explicitly recognized that AIS [accounting information system] design, MIS [management information system] design, organizational design and other control arrangements of the organization .. form a package which can only be evaluated as a whole. In particular, there are extensive interdependencies between AIS design and each of the other components of the package.

Thus the control subsystem or design variable MAS could interact, not only with PEU but also another control subsystem or organizational design variable (i.e. decentralization) to affect performance. This could happen because management will use its discretion to manage the contingency in such a way that the structural arrangements (including decentralization and information systems) facilitate higher performance (Cyert & March, 1963; Thompson, 1967; Pfeffer & Salancik, 1978). While these linkages have been recognized, there has been no research that has explicitly evaluated the interdependencies and linkages between MAS and decentralization and their impact on performance (Mak, 1989).

This study therefore proposes a three-way interaction[1] model with the objective of shedding more light on the complex relationships that could exist between a contextual variable (PEU), control subsystems of MAS and decentralization and performance. This study thus extends prior research by introducing the notion that organizations have a range of control mechanisms which they could adopt and that these control mechanisms may be interdependent with each other, and PEU, which ultimately affects performance.

The second objective of this study, therefore, is to evaluate the MAS (in terms of its information characteristics), which has been identified as a control subsystem within the organization, as one of the independent variables in a three-way "fit" relationship and performance as the dependent variable. The importance of linking these three independent variables to performance was identified by Chenhall & Morris (1986, p. 31):

> Perhaps, most importantly, the effect of different types of MAS on managers' performance should be investigated. It is hoped that such approaches will enhance our abilities to understand what types of MAS are appropriate in different situations and, as a result, to improve the likelihood that MAS will help managers improve their performance and that of their organizations.

In the Chenhall & Morris (1986) study, MAS was considered in terms of perceived usefulness of the MAS information charcteristics of scope, aggregation, timeliness and integration. To link

[1] This type of analysis was identified by Drazin & Van de Ven (1985) and Gupta & Govindarajan (1989) who described it as the multivariate interaction approach where "performance is hypothesized to be a function of interaction between single (or multiple) context variables and the system of multiple design variables".

Scope :External information (e.g. economic conditions etc)

:Nonfinancial information (e.g. customer preferences etc)

:Future oriented (e.g. probabilistic)

Aggregation :Aggregated by time period (e.g. monthly etc)

:Aggregated by functional areas (e.g. marketing etc)

:Analytical or decision models (e.g. DCF etc)

Fig. 1 MAS information characteristics.

"perceived usefulness" of MAS information characteristics to performance, however, is unrealistic since it is the availability of these individual information characteristics of MAS that could have an impact on performance. Managers could perceive some characteristic of MAS to be useful but that characteristic may not be available in the MAS. Thus, the third factor that motivated this study was the need to study the relationships between PEU, decentralization and the *availability* of MAS information characteristics and the overall impact of these variables on performance. As discussed below, in this study, only the individual MAS information characteristics of scope and aggregation were considered because of their theoretical relationship to PEU and decentralization (Chenhall & Morris, 1986).

An exploration of a three-way interaction implies that the contribution of any one variable to performance is affected by the level of the other two variables. For example, the interaction effect of MAS design and decentralization on performance will not be significant at all levels of PEU. By focusing on the three independent contingency variables, it is possible to develop a more comprehensive and integrated model specifying the environmental conditions under which MAS design and decentralization will produce favourable outcomes.

THEORETICAL DEVELOPMENTS

This section discusses the relationships of the variables that are considered in the study, namely PEU, the MAS information characteristics in terms of scope and aggregation, organizational structure (discussed in terms of decentralization) and managerial performance.

Decentralization and MAS information characteristics

As pointed out earlier, both decentralization which refers to the level of autonomy delegated to the managers and MAS design constitute a significant part of the control package in an organization (Otley, 1980). More specifically, decentralization is seen as an important contingent variable in designing MAS (Watson, 1975), and it is a supportive mechanism which should be consistent with the intent of the formal structural arrangements (Chenhall & Morris, 1986).

The other control subsystem MAS is defined in terms of the availability of the information characteristics or attributes of broad scope and aggregation (Chenhall & Morris, 1986). A summary of the information characteristics of broad scope and aggregation is provided in Fig. 1. A MAS that has a higher level of each of these characteristics is considered to be more sophisticated.

It has been argued that a fit between decentralization and the MAS characteristics of broad scope and aggregation is likely to improve managerial performance (Gordon & Miller, 1976; Waterhouse & Tiessen, 1978). An appropriately structured organization will need to be complemented by appropriate information from the MAS to facilitate a higher level of managerial performance. As pointed out by Chenhall & Morris (1986) broad scope information would be needed to service the diversity of decisions faced by the decentralized manager in areas such as pricing, marketing, inventory control and labour negotiations. In a decentralized organization where different sub-unit managers have different specific needs, broad scope information will enable the managers to decide more effectively, thereby resulting in better managerial performance (Sathe & Watson, 1987, p. 72).

Similarly, it is expected that in a decentralized organization, aggregated MAS information will be associated with higher performance. This is because "decentralized managers are more likely to prefer to be evaluated on performance measures which are aggregated in ways which reflect their area of responsibility" (Chenhall & Morris, 1986, p. 21). Conventional accounting evaluation measures that do not reflect the autonomy of, and integration between, the activities of the sub-unit will result in lower morale and increased conflict (Ansari, 1979; Chenhall & Morris, 1986)

PEU, MAS and decentralization

Thus far, we have argued that a fit between decentralization and sophisticated MAS can improve performance, but this is subject to one qualification. This relates to the level of PEU. The strategy of combining decentralization with sophisticated MAS will only be more effective in terms of managerial performance when the level of PEU is high. In other words, the effects of PEU on managerial performance will be influenced by the level of MAS sophistication and the degree of decentralization. Consider first the relationship between PEU and MAS. When PEU is low, management is able to make relatively accurate predictions about the market which can be derived from some fairly common parameters in the MAS. Additionally, there are fewer classes of information that are critical and necessary for decision making. Under these conditions, interpreting the environment is relatively easy because set rules are available and traditional MAS would be adequate. However, if the MAS is highly sophisticated (in terms of broad scope and aggregation) so that reports, for example, incorporate more non-economic and non-financial information, and utilize greater application of forecasts and decision models, the managers receiving such information may suffer from an information overload,[2] and this may cause their decisions to be sub-optimal (Tushman & Nadler, 1978; Gul, 1991). Consequently, managerial performance may be adversely affected.

In contrast, when PEU is high, the organization may require additional information to cope with the complexities of the environment. More sophisticated reports from the MAS can help to reduce uncertainty and improve decision making (Amey, 1979; Chia, 1990), which in turn may improve managerial performance. Similarly, PEU may be related to organizational structure in the sense that when there is high PEU, a decentralized organizational structure is appropriate in order to respond to unexpected events and facilitate unstructured/unprogrammable decisions (Stinchcombe, 1970). Prior research suggests that the organic form of organizations (which are similar to decentralized organizations) tend to succeed in dynamic environments (e.g. Burns & Stalker, 1961; Hall, 1962; Gerloff, 1985). In an uncertain environment, the

[2] Rosen & Schneck (1969, p. 177) defined information overload as the amount of information which is greater than that which the organization or its decision-makers can adequately handle". It has been suggested that the presence of information overload on the managers is dysfunctional to organizational performance (Tushman & Nadler, 1978).

unforeseen requirements for action cannot be broken down or distributed automatically through the functional roles defined within the organization. However, through decentralization an organization is able to provide its managers with greater responsibility and control over its activities (Waterhourse & Tiessen, 1978).

Decentralization is likely to have a positive effect on organizational performance when managers perceive their environment to be uncertain, while centralized decision making is more likely to be effective when uncertainty is perceived to be low (Negandhi & Reimann, 1972). However, as pointed out earlier, we believe that decentralization complemented with broad scope and aggregated MAS information characteristics will be more effective in improving managerial performance under conditions of high PEU than decentralization or MAS information characteristics (by itself). The possibility of this complex relationship was perhaps first recognized by Gordon & Narayanan (1984) who examined the effects of PEU on MAS design and organizational structure acting singly and in combination. More recently, Chenhall & Morris (1986, p. 22) also recognized this complex relationship:

> perceived environmental uncertainty induces decentralization, and therefore the effects of the former on information characteristics may be, in part, due to the indirect path through decentralization The information characteristics which may be influenced by this indirect effect are those which are proposed to be directly related to both perceived environmental uncertainty and decentralization . these characteristics are broad scope .. and aggregation

However, a more complete formulation of this complex relationship must obviously also include performance as the end (dependent) variable. This study, therefore, examines the combined effects of PEU, decentralization and MAS on managerial performance.

THREE-WAY INTERACTION HYPOTHESES

The foregoing discussion suggests that the two control subsystems of MAS information characteristics (in terms of scope and aggregation) and decentralization will be affected by the level of PEU. In order to achieve better managerial performance there must be an appropriate "fit" between environmental certainty and the two control subsystems. In other words, managerial performance will be influenced by the interaction between the level of uncertainty in its operating environment, the degree of decentralization and the sophistication levels of the MAS information characteristics. This suggests the following hypotheses for testing:

> H1. There will be an interactive effect on managerial performance between the degree of decentralization, broad scope MAS information and the level of perceived environmental uncertainty.
>
> H2 There will be an interactive effect on managerial performance between the degree of decentralization, aggregated MAS information and the level of perceived environmental uncertainty

It has also been argued that managers faced with low PEU conditions will require less sophisticated MAS The presence of more sophisticated MAS information in terms of scope and aggregation may be dysfunctional because of information overload (Gerloff, 1985). A higher degree of decentralization may not also be appropriate as the events are fairly routine and in most cases, codified into standard operating guides or instruction manuals. This gives rise to Hypotheses 3 and 4:

> H3 A combination of a high degree of decentralization and a more sophisticated broad scope MAS information will have a negative impact on the performance of managers who have a low level of perceived environmental uncertainty.
>
> H4 A combination of a high degree of decentralization and a more sophisticated aggregated MAS information will have a negative impact on performance of managers who have a low level of perceived environmental uncertainty

Similarly, it may be argued that under high PEU conditions managers will require more sophisticated MAS information in terms of broad scope and aggregation in order to improve

their performance. A higher degree of decentralization is also in line with such an arrangement in terms of enabling the sub-unit managers to make more informed decisions. This suggests Hypotheses 5 and 6:

H5. A combination of a high degree of decentralization and a more sophisticated broad scope MAS information will have a positive impact on the performance of managers who have a high level of perceived environmental uncertainty.

H6 A combination of a high degree of decentralization and a more sophisticated aggregated MAS information will have a positive impact on the performance of managers who have a high level of perceived environmental uncertainty.

METHODS

Data sources

Sub-unit managers were approached to participate in the study as they were the most appropriate personnel with the experience, and were charged with the responsibility of the performance of their units. One-hundred questionnaires, together with a covering letter and a self-addressed prepaid envelope, were distributed to managers in companies randomly selected from the Business Listing 1990 of the Telecommunications Authority of Singapore. Recognizing the sensitive nature of some of the information requested, the covering letter provided a statement ensuring the respondents of anonymity. The covering letter also offered the respondent the choice of a summarized copy of the results. Fifty-one questionnaires were returned, of which three were not usable. Forty-eight[3] questionnaires were used in the final analysis. The average experience of the respondents in their current position was 3.5 years (range 1 year – 17 years). Of the 48 respondents, ten were from manufacturing companies and 38 from non-manufacturing companies.

Perceived environmental uncertainty

The measurement construct for PEU was adopted from the instrument developed by Duncan (1972) and Sathe (1974) and used widely (Ferris, 1977; Chenhall & Morris, 1986; Govindarajan, 1986). It is the perceptions of uncertainty, rather than the actual uncertainty that is present in the environment, that influence the decisions that managers make in response to their respective organizations' operating environments (Lawrence & Lorsch, 1967; Weick, 1969; Duncan, 1972; Downey *et al.*, 1975). Weick (1969) made the point that the environment is enacted or created by the members of the organization by a process of attention to selected stimuli. If the environment is defined as a set of stimuli, therefore, it lacks meaning or information value until perceived by the individual (Downey *et al.*, 1975). This means that the conditions of the environment facing the organization are determined perceptually. The measurement construct comprises the following items: manufacturing technology, competitors' actions, market demands, product attributes/designs, raw materials availability, raw materials prices, government regulation and labour union actions.

MAS characteristics

The instrument for measuring the availability of the MAS characteristics broad scope and aggregation was adapted from the instrument developed by Chenhall & Morris (1986). They used the instrument to measure the perceived usefulness of the MAS information

[3] In the context of the Singapore environment, the response rate was considered good in view of the "sensitive" nature of the information requested. It compared favourably to " the expected return of 25% for most postal surveys" (Seah, 1991, p 12) conducted in Singapore It was observed by Ang *et al* (1986) that the cultural orientation of companies in Singapore towards privacy does affect the response rate Chia (1992) commented that in a competitive business environment such as Singapore, there is little incentive for companies to respond to surveys that require them to indicate the details of organizational structuring and procedures which these companies have successfully employed

TABLE 1. Descriptive statistics

Variables	Mean	Standard deviation	Range	MSA values	Cronbach alpha coefficient
PEU	4 09	1.29	1.00–7 00	0 61	0.73
MAS Sophistication					
Broad scope	3.21	1.52	1.00–6 50	0 76	0 80
Aggregation	3.75	1 52	1 00–6 50	0.84	0.88
Decentralization	4 05	1.50	1.00–7 00	0.68	0.66
Managerial performance*	5 15	0 71	4 00–7.00	—	—

* No MSA and Cronbach alpha coefficient because this is a single item measure

characteristics. As pointed out earlier, the measurement of perceived usefulness, in itself, does not provide a satisfactory link between the MAS and managerial performance. In this study, the objective was to measure the extent to which the MAS provides the relevant information for enhancing managerial performance. What was perceived as useful MAS information might not be what was available MAS information to the user. Hence, the MAS instrument for this study measured the perceptions of the respondents regarding the availability of the MAS information characteristics of broad scope and aggregation.

Organizational structure — decentralization

The instrument for measuring decentralization was operationalized in terms of Burns & Stalker's (1961) classification of mechanistic–organic continuum (Gordon & Narayanan, 1984). Five questions were used to measure the degree of decentralization of decision making. The classes of decision making were the development of new products or services, the hiring and firing of managerial personnel, selection of large investments, budget allocations and pricing decisions.

Managerial performance evaluation

A subjective measure of managerial performance[4] developed by Mahoney *et al.* (1963) was adopted in this study. Respondents were asked to rate on a seven-point Likert scale (ranging from "well below average performance" to "well above average performance") their performance on eight dimensions and an overall global dimension. This measure has been used in other studies (e.g. Brownell, 1982; Brownell & Hirst, 1986; Govindarajan, 1986).

Data analysis

The results from (1) factor analysis of the data for construct validity (Kerlinger, 1964; Chenhall & Morris, 1986), (2) computation of the Cronbach alpha statistics for internal reliability of the variables, (3) descriptive statistics of the variables, and (4) tests of hypotheses for interaction effects are presented in Tables 1–3.

Table 1 reports the descriptive statistics as well as the Kaiser–Meyer–Olkin measure of sampling adequacy (MSA) (Kaiser & Rice, 1974) values for the various variables. These results provided evidence to the extent of which the items of a variable belonged together, thereby rendering the set of data appropriate for factor analysis. The MSA values provided the validity of the measurement constructs for the various variables Satisfactory internal reliability for the variables was achieved, as reflected by the Cronbach alpha statistics reported in Table 1 (Nunnally, 1978).

Managerial performance evaluation

The construct validity of the instrument for measuring personal performance evaluation was

[4] See Govindarajan (1986) for a discussion on the strengths and weaknesses of this measure He argued that, on balance, this is an acceptable way for measuring performance

TABLE 2. Intercorrelations among the dimensions of personal performance evaluation

Dimensions	1	2	3	4	5	6	7	8
1 Planning	1.00	0.53	0.13	0.33	0.49	0.41	0.37	0.26
2 Investigating		1.00	0.04	0.41	0.51	0.16	0.26	0.15
3 Coordinating			1.00	0.26	0.34	0.24	0.13	0.36
4 Evaluating				1.00	0.49	0.50	0.49	0.05
5 Supervising					1.00	0.62	0.50	0.39
6 Staffing						1.00	0.56	0.25
7. Negotiating							1.00	0.32
8 Representing								1.00

Note. r over 0.32 = significant at $p < 0.05$, r between 0.24 and 0.32 = significant at $p < 0.10$

satisfactory in view of the computed MSA value of 0.70 (Kaiser & Rice, 1974). Table 2 reports the correlations among the eight dimensions of performance. Generally, the intercorrelations were statistically significant ($p < 0.10$). The Cronbach alpha coefficient of 0.80 was satisfactory (Nunnally, 1978).

The reliability of the variable was tested by computing the correlations for each of the dimensions with the overall global rating for personal performance evaluation (Govindarajan, 1986). Each of the dimensions of performance had a positive and significant correlation ($p < 0.10$) with the overall global rating for personal performance evaluation.

A multiple regression analysis was performed by regressing the overall global rating for personal performance evaluation (dependent variable) onto the other eight dimensions of personal performance evaluation (independent variables). This was a further test of the consistency of the ratings (Govindarajan, 1986). An R^2 value of 0.68 (adjusted $R^2 = 0.61$) was obtained. This value compared favourably with the R^2 value of 0.55 in the overall global rating as suggested by Mahoney *et al.* (1963). The results of the regression model ($F = 10.31$, $p < 0.0001$) provided the verification that the overall global rating for personal performance evaluation did reflect a combined measure of all eight dimensions of personal performance. As a result, the overall global rating for personal performance evaluation was adopted as the score for the dependent variable in data analysis (Brownell & Dunk, 1991).

Multiplicative model

The multiplicative model (Althauser, 1971; Allison, 1977) was adopted for testing the interaction effects of PEU, decentralization and MAS information characteristics on managerial performance (Southwood, 1978; Schoonhoven, 1981; Govindarajan, 1986). This involved using the following multiple regression equation:

$$Y = i_1 + a_1X_1 + a_2X_2 + a_3X_3 + b_1X_1X_2 + b_2X_1X_3 + b_3X_2X_3 + c_1X_1X_2X_3, \quad (1)$$

where Y = managerial performance; i_1 = intercept, a_1, a_2, a_3, b_1, b_2, b_3, c_1 = regression coefficients; X_1, X_2, X_3 = (X_1 = PEU; X_2 = decentralization; X_3 = MAS information characteristics); and X_1X_2, X_2X_3, X_1X_3, $X_1X_2X_3$ = the interaction of X_1, X_2 and X_3. There are two important features regarding equation (1). First, since X_1, X_2 and X_3 are interval scale (but not ratio scale) the utility of equation (1) is to provide information on the interaction of X_1, X_2 and X_3 on Y not about the main effects (for further discussion of this see Southwood, 1978; Govindarajan & Gupta, 1985; Govindarajan, 1986) Second, as demonstrated by Gupta & Govindarajan (1989) and Govindarajan & Fisher (1990), the problem of multicollinearity in equation (1) is a non-issue and the focus of equation (1) should be on whether the three-way interactive results are significant.

If c_1 is significant (i.e. $c_1 \neq$), the corresponding incremental R^2 will also be statistically significant at the same probability level (Southwood, 1978). This means that the introduction of

the term $X_1X_2X_3$ in equation (1) added significantly to the variance explained. However, equation (1) provides no information on whether the posited relationship is monotonic[5] or not. This information is needed to test H3, H4, H5 and H6.

Such information can be obtained by examining the partial derivative from the larger regression equation (1) (Southwood, 1978; Schoonhoven, 1981). This would determine whether a non-monotonic or symmetrical effect was present. For example, assume that the level of PEU affects the selection of the types of control subsystems (i.e. the degree of decentralization and the level of MAS broad scope). Given this perspective, we fixed X_1 (the level of PEU) and then examined the interaction between X_3 (the degree of decentralization) and X_2 (the level of MAS broad scope or aggregation). For a fixed X_1, the interaction term, if significant, can be interpreted as changing the coefficients of X_2 or X_3. The assumptions about causality that are made determine the choice between these two variables. Mathematically, both approaches are equally valid. We chose to study the partial derivative of X_2, but the results are the same if X_3 is selected.

The partial derivative of equation (1) with respect to X_2 is shown as equation (2) below:

$$\partial Y/\partial X_2 = a_2 + b_1X_1 + b_3X_3 + c_1X_1X_3. \quad (2)$$

The partial derivative of the impact of the level of MAS sophistication in terms of scope and aggregation on managerial performance in equation (2) depends on the level of PEU and the degree of decentralization. If X_1 (PEU) is a constant, equation (2) can be rewritten as

$$\partial Y/\partial X_2 = (a_2 + b_1X_1) + (b_3 + c_1X_1)X_3. \quad (3)$$

If the value of $\partial Y/\partial X_2$ in equation (3) is always positive or always negative over the entire observable range of X_3, the relationship between Y and X_2, given a fixed value of X_1, would be regarded as monotonic; otherwise, it would be regarded as non-monotonic.

RESULTS

Tables 3(i) and 3(ii) provide the results of the multiple regression models performed to test the various hypotheses.[6] Equation A in Table 3(i) is the results of the regression done on PEU, decentralization, MAS broad scope and the interactions of PEU and decentralization, PEU and broad scope, and decentralization and broad scope. Equation B is the results for the same regression but with the inclusion of the three-way interaction term. Similarly, Table 3(ii) shows the results with aggregation as the MAS variable.

As reported in Table 3(i), the three-way interaction term (Equation B) is positive and significant ($c_1 = 0.10$, $p < 0.05$). The introduction of the interaction term results in a significant increase (at $p < 0.05$) in R^2, thus suggesting that the three-way interaction term improved the predictive ability of the model. These results provide support for the presence of a three-way interaction hypothesis between PEU, decentralization and MAS broad scope information. Similarly, the result for Equation B in Table 3(ii) shows that the three-way interaction term is positive and significant ($c_1 = 0.08$, $p < 0.09$). The introduction of the interaction term also causes a significant increase in R^2. These results provide support for Hypotheses 1 and 2.

The partial derivatives of Equation B in Tables 3(i) and 3(ii) over X_2 (scope and aggregation of MAS information, respectively) give the following results:

$$\partial Y/\partial X_2 = 1.93 - 0.53X_1 - 0.33X_3 + 0.10X_1X_3, \quad (4i)$$

[5] For a discussion on monotonic and non-monotonic effects, see Schoonhoven (1981)

[6] The statistical analyses and interpretations of the results followed the approach adopted by Govindarajan & Fisher (1990)

TABLE 3(i) Results of multiple regression analysis for managerial performance (MAS variable — broad scope)

Variables	Equation A	Equation B
PEU X_1	0.49*	2.04**
	(0.29)	(0.77)
DEC X_3	−0.19	1.45*
	(0.31)	(0.81)
SSE X_2	0.16	1.93**
	(0.29)	(0.86)
PEU × DEC	−0.02	−0.39**
	(0.06)	(0.18)
PEU × SSE	−0.11*	−0.53*
	(0.06)	(0.21)
DEC × SSE	0.09**	−0.33*
	(0.04)	(0.20)
PEU × DEC × SSE		0.10**
		(0.05)
R^2	22.16%	30.38%
F-value	1.95*	2.49*

* $p < 0.10$, ** $p < 0.05$; $N = 48$ Standard errors are in parentheses

PEU = Perceived environmental uncertainty; DEC = decentralization, SSE = sophistication of MAS information characteristic of broad scope Interactions between the variables are denoted by "×"

R^2 explained by significant three-way interaction term = 8.22%

TABLE 3 (ii). Results of multiple regression analysis for managerial performance (MAS variable — aggregation)

Variables	Equation A	Equation B
PEU	0.45	1.62**
	(0.33)	(0.76)
DEC	−0.11	1.25*
	(0.31)	(0.86)
SAE	0.02	1.30
	(0.33)	(0.82)
PEU × DEC	−0.04	−0.35*
	(0.05)	(0.19)
PEU × SAE	−0.08	−0.38*
	(0.07)	(0.19)
DEC × SAE	0.09**	−0.24
	(0.04)	(0.20)
PEU × DEC × SAE		0.08*
		(0.05)
R^2	18.79%	24.42%
F-value	1.58	1.82*

* $p < 0.10$, ** $p < 0.05$; $N = 48$ Standard errors are in parentheses

PEU = Perceived environmental uncertainty, DEC = decentralization, SAE = sophistication of MAS information characteristic of aggregation. Interactions between the variables are denoted by "×"

R^2 explained by significant three-way interaction term = 5.63%

where X_3 is MAS scope,

$$\partial Y/\partial X_2 = 1.30 - 0.38X_1 - 0.24X_3 + 0.08X_1X_3, \quad (4ii)$$

where X_3 is MAS aggregation.

Equations (4i) and (4ii) suggest that the effect of changing the degree of decentralization (X_2) on managerial performance is a function of each of the MAS characteristics (X_3) and PEU (X_1).[7] In order to analyse the relationship under low PEU, we selected the extreme value for PEU, setting it to 1.[8] Equations (4i) and (4ii) can then be expressed as follows:

$$\partial Y/\partial X_2 = 1.40 - 0.23X_3, \quad (5i)$$

where X_3 is MAS scope,

$$\partial Y/\partial X_2 = 0.92 - 0.16X_3, \quad (5ii)$$

where X_3 is MAS aggregation.

Equations (5i) and (5ii) will be zero when X_3 has a value of 6.09 and 5.75. In other words, the equations will be negative when X_3 is above 6.09 (MAS scope) or 5.75 (MAS aggregation) which are the inflection points[9] (i.e. where the change in the direction of the scope occurs) and they will be positive when X_3 is below 6.09 and 5.75, respectively. These inflection points

[7] The subsequent interpretation followed the approach adopted by Govindarajan & Fisher (1990)

[8] The extreme value of 1 (low) and 7 (high) provided the observable range for PEU, and these values were adopted to ensure the interpretability of the results for the presence of non-monotonic relationships

[9] The use of interval scale does not influence the inferential statistics yielded by the multiplicative approach (Allison, 1977; Southwood, 1978; Arnold, 1982)

are within the range of observable values for X_3 for the above equations. Therefore, for organizations operating in low PEU situations and having high degree of decentralization, a high level of broad scope and aggregated MAS information is associated with lower managerial performance. Thus, the results provide support for Hypotheses 3 and 4.

To calculate the interaction of decentralization and the level of MAS information characteristics on managerial performance for organizations operating at higher levels of PEU, equations (4i) and (4ii) were modified, inserting ⁻ as the value of X_1 (PEU). With this substitution, the equations are:

$$\partial Y/\partial X_2 = -1.^{-}78 + 0.3^{-}X_3, \quad (6i)$$

where X_3 is MAS scope,

$$\partial Y/\partial X_2 = -1.66 + 0.32X_3, \quad (6ii)$$

where X_3 is MAS aggregation.

The inflection points for equations (6i) and (6ii) were 4.81 and 5.19, which are within the observable ranges of the variable decentralization. For those organizations operating under high PEU states and having more decentralized structures, high levels of MAS scope and aggregated information are associated with superior managerial performance. These results also support Hypotheses 5 and 6.

DISCUSSION

The results suggest the presence of a contingent relationship between the degree of decentralization and managerial performance over the range of the level of MAS sophistication for organizations operating under varying PEU states. In more general terms, they provide support for the multivariate interaction conceptualization of contingency theory (Gupta & Govindarajan, 1989).

The results which supported Hypotheses 1, 2, 3, 4, 5 and 6 were consistent with the notion that decentralization promotes a high information processing capability as more managers are involved in making decisions. When PEU is also high, managers will also require more information and a MAS which provides more sophisticated information in terms of scope and aggregation will enhance the decisions of the managers, hence contributing to higher performance. This explanation is similar to that of Duncan (19⁻3), Tushman & Nadler (19⁻8) and Gerloff (1985), who suggested that organizational structure has important implications for the ability of the organization to gather and process information. A centralized organizational structure is seen as restricting the flow of information to prescribed channels. This is suitable for an organization operating in a routine environment where fixed responses and procedures are identified in advance. Thus a combination of high PEU and sophisticated MAS for a centralized structure is inappropriate and unlikely to contribute to performance.

In designing the MAS, there is a need to be conscious of two issues.

(1) The interaction effect of the state of PEU, decentralization and the level of MAS sophistication in terms of scope and aggregation on managerial performance.[10]

(2) The relationship of the degree of decentralization for organizations operating under varying PEU, on managerial performance is nonmonotonic over the range of the level of MAS sophistication in terms of scope and aggregation.

Organizational designers may benefit from being aware of the need to adopt an integrated approach towards designing the overall control systems in organizations which could be achieved by considering the interaction effects between the PEU and the control subsystems on performance. Any changes in one of the control subsystems may necessitate

[10] Based on the suggestion of a reviewer, we conducted an exploratory test for a four-way interaction, i.e. the interaction of PEU, decentralization, and say, MAS aggregation on performance will be different depending on the level of MAS scope. The test did not yield a significant result.

compensating changes in other aspects of the organizational structure and control subsystems so as to promote higher performance in the organization. Being aware of the interactive relationships between the variables enables the organizational designer to identify those feasible sets that are appropriate to meet different contingencies and also to understand the internal consistency of the control subsystems necessary to enhance performance.

In evaluating this study, several limitations should be noted. As with most empirical studies of this type, generalizing the results to other settings needs to be viewed with caution. However, this limitation is mitigated because the population consisted of organizations operating under varying PEU states and which would most likely use a range of sophisticated MAS and have varying decentralized structures. Generalizability of the results was also limited by the sample size.

The variables included in the present study represented only a small subset of the variables which might be significant to the performance of an organization and its members.

CONCLUSION

This study, using a trivariate model, examined the notion that the contextual variable (PEU) and two control subsystems (the organizational structure — decentralization, and the MAS characteristics of scope and aggregation) would interact to affect managerial performance. The results of the study provide support for all the hypotheses and suggest that any study which examines the notion that managerial performance is affected by only one control subsystem in the organization is likely to be inadequate. The main practical implication that can be drawn from the discussions of the results is that organizational designers need to consider the appropriate environment in the design and implementation of control subsystems.

BIBLIOGRAPHY

Allison, P. D., Testing for Interaction in Multiple Regression, *American Journal of Sociology* (1977) pp. 144–153.

Althauser, R. P., Multicollinearity and Non-additive Regression Models, in Blalock, H. M. (ed.), *Causal Models in the Social Sciences*, pp. 532–572 (Chicago: Aldine-Atherton, 1971).

Amey, L., *Budget Planning and Control Systems* (London: Pitman, 1979).

Ang, K. B., Choudhury, N. & Goh, C. T., Management Accounting Practices in Singapore: A Small Firms Survey, *Singapore Management Review* (January 1986) pp. 37–46.

Ansari, S. L., Towards An Open Systems Approach To Control Budgeting, *Accounting, Organizations and Society* (1979) pp. 149–162.

Arnold, H. J., Moderator Variables: A Classification of Conceptual, Analytic, and Psychometric Issues, *Organizational Behavior and Human Performance* (1982) pp. 41–59.

Briers, M. & Hirst, M., The Role of Budgetary Information in Performance Evaluation, *Accounting, Organizations and Society* (1990) pp. 373–398.

Brownell, P., A Field Study Examination of Budgetary Participation and Locus of Control, *Accounting Review* (1982) pp. 766–777.

Brownell, P. & Dunk, A. S., Task Uncertainty and Its Interaction with Budgetary Participation and Budget Emphasis: Some Methodology Issues and Empirical Investigation, *Accounting, Organizations and Society* (1991) pp. 693–703.

Brownell, P. & Hirst, M., Reliance on Accounting Information, Budgetary Participation, and Task Uncertainty: Tests of a Three-Way Interaction, *Journal of Accounting Research* (Autumn 1986) pp. 241–249.

Burns, T. & Stalker, G. M., *The Management of Innovation* (London: Tavistock, 1961).

Chenhall, R. H. & Morris, D., The Impact of Structure, Environment, and Interdependence on the Perceived Usefulness of Management Accounting Systems, *Accounting Review* (1986) pp. 16–35.

Chia, Y M., Is there a Contingency Theory of Management Accounting Systems Design, *Singapore Accountant* (May 1990) pp 11–14, 20, 31–32

Chia, Y M., The Effects of Perceived Environmental Uncertainty, Information Asymmetry and Control Subsystems on Performance A Contingency–Agency Study, Unpublished Ph.D thesis, Division of Commerce and Administration, Griffith University, Australia (1992)

Cronbach, L T., Coefficient Alpha and the Internal Structure of Tests, *Psychometrika* (September 1951) pp 297–334

Cyert, R M & March, J G., *A Behavioral Theory of the Firm* (Englewood Cliffs, NJ: Prentice-Hall, 1963)

Downey, H K., Hellriegel, D & Slocum, J. W., Jr, Environmental Uncertainty: The Construct and Its Application, *Administrative Science Quarterly* (1975) pp 613–629

Drazin, R & Van de Ven, A H., Alternative Forms of Fit in Contingency Theory, *Administrative Science Quarterly* (1985) pp 514–539.

Duncan, R B., Characteristics of Organizational Environments and Perceived Environmental Uncertainty, *Administrative Science Quarterly* (1972) pp 313–327

Duncan, R B., Multiple Decision-making Structures Adapting to Environmental Uncertainty The Impact on Organizational Effectiveness, *Human Relations* (1973) pp. 273–291

Ferris, K R., A Test of the Expectancy Theory of Motivation in an Accounting Environment, *Accounting Review* (1977) pp. 605–615

Ferris, K. R. & Haskins, M E., Perspectives on Accounting Systems and Human Behaviour, *Accounting, Auditing and Accountability* (1988) pp 3–18

Gerloff, E A., *Organizational Theory and Design — A Strategic Approach for Management* (New York: McGraw-Hill, 1985)

Gordon, L A & Miller, D., A Contingency Framework for the Design of Accounting Information Systems, *Accounting, Organizations and Society* (1976) pp 56–69

Gordon, L A & Narayanan, V. K., Management Accounting Systems, Perceived Environmental Uncertainty and Organization Structure An Empirical Investigation, *Accounting, Organizations and Society* (1984) pp 33–47

Govindarajan, V., Impact of Participation in the Budgetary Process on Management Attitudes and Performance Universalistic and Contingency Perspectives, *Decision Sciences* (1986) pp. 496–516

Govindarajan, V & Fisher, J., Strategy, Control Systems, and Resource Sharing: Effects on Business-Unit Performance, *Academy of Management Journal* (1990) pp 259–285

Govindarajan, V & Gupta, A. K., Linking Control Systems to Business Unit Strategy Impact on Performance, *Accounting, Organizations and Society* (1985) pp 51–66

Gul, F A., The Effects of Management Accounting Systems and Environmental Uncertainty on Small Business Managers' Performance, *Accounting and Business Research* (1991) pp. 57–61

Gupta, A K & Govindarajan, V., Methodological Issues in Testing Contingency Theories: An Assessment of Alternative Approaches, Paper presented at the Conference on Management and Management Science, Carnegie-Mellon University (22–24 October 1989).

Hall, R. H., Intraorganizational Structural Variations Application of the Bureaucratic Model, *Administrative Science Quarterly* (1962) pp. 295–308

Hall, R H., *Organizations. Structure and Process*, 4th Edn (Englewood Cliffs, NJ Prentice-Hall, 1987)

Kaiser, H F & Rice, J., Little Jiffy, Mark IV, *Educational and Psychological Measurement* (Spring 1974) pp 111–117

Kerlinger, F. N., *Foundations of Behavioural Research* (New York Holt, Rinehart and Winston, 1964).

Landy, F J & Farr, J L., Performance Rating, *Psychological Bulletin* (1980) pp. 72–107

Lawrence, P R & Lorsch, J W., *Organization and Environment. Managing Differentiation and Integration* (Homewood, Richard D Irwin, 1967).

Mahoney, T A., Jerdee, T H & Carroll, S J., *Development of Managerial Performance: A Research Approach* (Cincinnati, OH South-Western, 1963)

Mak, Y T., Contingency Fit, Internal Consistency and Financial Performance, *Journal of Business Finance and Accounting* (Spring 1989) pp 273–300

Merchant, K A & Simons, R., Research and Control in Complex Organizations An Overview, *Journal of Accounting Literature* (1986) pp 183–203

Nadler, D A & Tushman, M L., *Strategic Organization Design. Concepts, Tools and Processes* (U.S.A. Harper Collins, 1988)

Negandhi, A. R & Reimann, B C., A Contingency Theory of Organization Re-examined in the Context of a Developing Country, *Academy of Management Journal* (1972) pp 137–146

Nunnally, J. C., *Psychometric Theory* (New York: McGraw-Hill, 1978)

Otley, D. T., Budget Use and Managerial Performance, *Journal of Accounting Research* (Spring 1978) pp. 122–149.

Otley, D. T., The Contingency Theory of Management Accounting: Achievement and Prognosis, *Accounting, Organizations and Society* (1980) pp. 413–428

Pfeffer, J. & Salancik, G. R., *The External Control of Organizations: A Resource Dependence Perspective* (New York: Harper and Row, 1978)

Rosen, L. S. & Schneck, R. E., Some Behavioral Consequences of Accounting Measurement Systems, in Bruns, W. J. & DeCoster, D. T. (eds), *Accounting and Its Behavioral Implications*, pp. 173–180 (New York: McGraw-Hill, 1969)

Sathe, V., Structural Adaptation to Environment: Study of Insurance Company Departments and Branch Banks, Unpublished Ph.D. thesis, The Ohio State University (1974)

Sathe, V. & Watson, D., Contingency Theories of Organizational Structure, in Ferris, K. R. & Livingston, J. L. (eds), *Management Planning and Control*, pp. 59–81 (Beavercreek, OH: Century VII, 1987).

Schoonhoven, C. B., Problems with Contingency Theory: Testing Assumptions Hidden with the Language of Contingency "Theory", *Administrative Science Quarterly* (1981) pp. 349–377

Seah, V., Computer Security and Computer Abuse in Singapore, *Singapore Management Review* (January 1991) pp. 11–29

Southwood, K. E., Substantive Theory and Statistical Interaction: Five Models, *American Journal of Sociology* (1978) pp. 1154–1203.

Stinchcombe, A. L., Bureaucratic and Craft Administration of Production, in Grunsky, O. & Miller, G. A. (eds), *The Sociology of Organizations: Basic Studies*, pp. 261–271 (New York: Free Press, 1970).

Thompson, J. D., *Organizations in Action* (New York: McGraw-Hill, 1967)

Tushman, M. L. & Nadler, D. A., Information Processing as an Integrated Concept in Organization Design, *Academy of Management Review* (1978) pp. 613–624

Waterhouse, J. H. & Tiessen, P., A Contingency Framework for Management Accounting Systems Research, *Accounting, Organizations and Society* (1978) pp. 65–76.

Watson, D. J. H., Contingency Formulations of Organizational Structure: Implications for Managerial Accounting, in Livingston, J. L. (ed.), *Managerial Accounting — The Behavioral Foundations*, pp. 65–80 (Columbus, OH: Grid, 1975).

Weick, K., *The Social Psychology of Organising*, 2nd Edn (Reading, MA: Addison-Wesley, 1969).