Interaction Effects of Management Accounting Systems and Process Quality Management on Product Quality Performance

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Abstract

This study uses self-reported survey data from 91 U.S. manufacturing business units and examines the interaction effects of process quality management and management accounting systems on product quality performance. One measure of process quality management and three measures of management accounting systems (goals, feedback and incentives) were used. Internal quality and external quality were the two product quality performance measures. Results indicate significant positive interaction effects of process quality management and all three management accounting systems measures on internal quality management. The results also indicate that, except for incentives, external quality is a function of the interaction between quality management and management accounting systems variables. The implications, limitations, and directions for future research are also discussed.

Keywords

Process Quality Management
Goal
Feedback
Incentive
Performance

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Introduction

Prior research has viewed product quality as one of the major competitive priorities for attaining a *Sustainable Competitive Advantage (*Hill, 1994)[1], and *Process Quality Management* (hereafter PQM) as a way of achieving high *Product Quality* (Everett and Sohal, 1991; Chen and Tirupati, 1995). PQM essentially involves identifying critical components of the manufacturing processes and improving them to ensure superior product quality. (Ahire and Dreyfus, 2000). There have been already several empirical studies on the link between PQM and product quality. However, the empirical results of the effect of PQM on product quality have been inconclusive (e.g. Flynn et al., 1995; Ahire et al., 1996). Nevertheless, a lack of knowledge in this area may still be noted, especially with regard to the role of *Management Accounting Systems* (hereafter MAS) in the association between PQM and product quality.

The relevance of empirical research on how MAS may be used to support particular operational strategies and new production philosophies has been emphasised by Langfield-Smith (1997). Drake et al. (1999) state that accounting and control systems appear to offer rich ground for future study and that factors that contribute to complementary[1] management choices are not well understood.

MAS is often regarded as an important tool both for providing information for decision making and fostering certain types of behaviour in a firm (Axelsson et al., 2002). This means that MAS plays an important role when it comes to influencing the behaviour of people in the organisation as well as the behaviour of the organisation at large (e.g., Hedberg and Johnsson, 1987; Mellemvik et al., 1988). In analysing the modern manufacturing model, prior research (Alles et al., 1998; Ittner and Larcker, 1995; and Wruck and Jensen, 1994) suggest that for workers to achieve

[1] Complementarities thinking follows contingency theory in seeing performance as dependent on "fit" between key organisational variables.

product quality performance, MAS such as goals, feedback, and incentives must be used as mechanisms to motivate and influence workers' behaviour in ways that will maximise the welfare of both the organisation and the worker. That is, workers must know what they are doing (feedback for learning), and they must know what they are supposed to do (goal directing information), and they must be rewarded for their efforts (Baker, 1988). Management accounting is thus a valuable tool for decision making and controlling in general.

Clearly from both a practitioner and an academic viewpoint, research on the interactive effects of PQM and MAS on product quality is warranted. Hence, this study draws on the complementarity principle in order to provide an insight on how PQM and MAS interact to enhance product quality. The unit of focus for this paper is the strategic business unit (SBU). To the author's knowledge, this is the first study to consider the interactive effects of PQM and MAS on product quality.

Results indicate significant positive interaction effects of process quality management and all three management accounting systems measures on internal quality management. The results also indicate that (except for incentives) external quality is a function of the interaction between quality management and management accounting systems variables.

The paper is organised as follows. First, the definitions of the study variables and literature review are discussed and hypotheses are developed. This is followed by a discussion of the research methods. After the empirical results are reported, a summary and discussion are presented.

Definitions, Literature Review and Hypotheses Development

Definitions

For the purpose of this paper, three control components of MAS, i.e., quality goals, quality feedback, and quality-related incentives, are expected to create conditions that motivate workers to achieve desirable outcomes. A goal can be viewed as the objective or the performance level that an individual or organisation seeks to attain (Locke et al., 1981). Feedback is thought to fulfil several functions and usually refers to information regarding a level of performance and/or the manner and efficiency in which performance processes have been executed (Kluger and DeNisi, 1996). For example, (1) it is *directive*, by clarifying specific behaviours that should be performed; (2) it is *motivational*, as it stimulates greater effort; and (3) it is *error-correcting*, as it provides information about the extent of errors being made (Cooper et al., 1994). Incentives are defined as recognition and reward systems to acknowledge group or individual quality improvements (Spreitzer and Mishra, 1999; Ittner and Larcker, 1995).

The other variables used in this study are PQM and product quality. PQM is the tracking and improvement of manufacturing process quality (Ahire and Rana, 1995, Ahire and Dreyfus, 2000; Chen and Tirupati, 1995; Jayaram et al., 1997). Two measures of product quality are used in this study: Internal quality and external quality. Internal quality is quality of finished products assessed before shipping and associated process quality (Crosby, 1979; Reeves and Bednar, 1994; Ahire et al., 1996; Grandzol and Gershon1998; Ahire and Dreyfus, 2000). External quality is quality of finished products from customers' viewpoint upon field usage (Grandzol and Gershon, 1998; Hardie, 1998; Ahire and Dreyfus, 2000).

Literature Review and Hypotheses Development

Interaction Effect of PQM and Quality Goals on Product Quality

Goal-setting theory suggests that challenging goals lead to enhanced performance because they mobilise effort, direct attention, and encourage persistence and strategy development (Locke and Latham, 1990). According to goal-setting theory, goals are effective because they indicate the level of performance that is acceptable (Locke and Latham, 1990). Taylor (2004) remarks that a clear set of business objectives is an essential requirement in the process of aligning performance measurement with business goals. Goals serve as regulators of human action by motivating project improvement teams (Linderman et al., 2006). Since specific goals are necessary in aligning performance measures with strategy, quality-related goals set forth in the management process quality may affect product quality.

In an experimental study, Tuttle and Harrell (2001) used students in the role of workers, and showed that communicating goal priorities to workers can influence the priorities they place on accomplishing those goals. Since the new manufacturing practices rely on the workers for process improvements, their efforts may be guided by the communication of quality goals to them. Accordingly, this study argues that management of process quality would interact with quality-related goals to improve product quality. The hypothesis presented below considers this issue.

***H*$_1$**: *The interaction between process quality management and goals is positively related to: (a) internal quality*
(b) external quality

Interaction Effect of PQM and Quality Feedback on Product Quality

The extent to which employees receive and use feedback has been the subject of recent inquiry (Ren and Fedor, 2001). In terms of influencing employee behaviour, feedback derives its motivating power almost exclusively from the information provided about an employee's performance, which, in turn, enhances role clarity about a task to be performed (Kluger and DeNisi, 1996). Feedback to employees is a fundamental means for learning. This increases the workers' understanding of the process and therefore increases their ability to solve problems and maintains their motivation to make suggestions. In the long-term, this improves process capability and therefore the processes remain easily controllable. An analogous effect is obtained with the feedback from the process control operation. It has been shown that, when there is immediate feedback to the single operator (fast and short cycle feedback), better quality performance is achieved (Forza, 1995). Sarkar (1997) shows that process improvement in quality is enhanced when information sharing is encouraged in the work place. The following hypothesis is formulated further to examine the impact of the interaction between PQM and feedback on product quality performance:

***H*$_2$**: *The interaction between process quality management and feedback is positively related to: (a) internal quality*
(b) external quality

Interaction Effect of PQM and Quality Incentives on Product Quality

Chong and Eggleton (2007) suggest that a fundamental objective of an incentive-based compensation scheme is to motivate individuals to exert effort to improve performance. Sprinkle (2000) found that the reliance on an incentive-based compensation scheme improves individuals' performance by motivating them to increase both the duration and intensity of their effort. He found that incentives not only motivate individuals to work longer on a task, but also serve to enhance the quality of attention individuals devote to the task.

Reward systems tied to PQM could be used as a mechanism to motivate workers, which should lead to higher operational performance. Multiple skills and conceptual knowledge developed by the work force under flexible production are of little use unless workers are motivated to contribute mental as well as physical effort (MacDuffie, 1995). Workers will only contribute discretionary efforts to problem-solving if they believe that their individual interests are aligned with those of the company, and that the company will make a reciprocal investment in their well being. In the absence of an equitable compensation system, workers' morale may be low, and performance may be compromised.

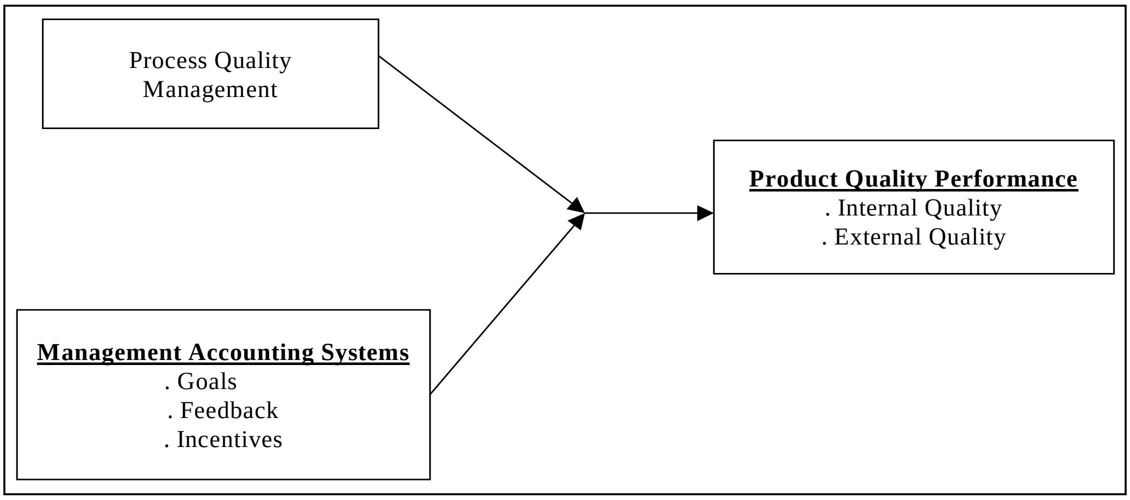
Taken together, it is expected that PQM when combined with incentives should lead to higher quality performance. To explore the interaction effect of PQM and incentives on product quality performance, the following hypothesis will be tested:

***H*$_3$**: *The interaction between process quality management and incentives is positively related to:*
(a) internal quality
(b) external quality

In summary, it is expected that product quality performance will be enhanced when there is an appropriate match between PQM and MAS. It is the synergy in the joint implementation of organisational and behavioural variables that has even greater impact on product quality performance. For example, if an organisation desires to achieve high product quality performance while pursuing PQM, then its product quality performance will be higher to the extent that PQM initiatives are used in concert with MAS. Specifically, although the use of PQM may be effective independently of MAS, the synergy between these two systems may lead to higher product quality performance.

Figure One depicts the theoretical relationships between the dependent and independent variables. In considering the "fit" of PQM and MAS, the process identified by Milgrom and Roberts (1995) was adopted. It is expected that the combination of PQM and MAS has a interaction effect on product quality performance for each hypothesis stated earlier.

Figure One: Theoretical Relationships Between Independent and Dependent Variables



Research Method

Sample and Procedure

The specific objective of this study is to investigate the interactive effects of PQM and MAS on product quality performance. To this end, a survey questionnaire was used as a cost-effective method to collect data from a cross-section of manufacturing plants. The sample selection process for this study involved searching a variety of sources to identify adopters of TQM. The primary source is the *Industry Week* series on manufacturing excellence.

Data were collected through a questionnaire instrument (see Appendix A) sent to the manager or director of each targeted SBU.[2]

[2] Before collecting the data, the researcher was aware of problems that may result from common-rater bias. Accordingly, the following recommended steps have been taken before data collection: (1) Respondents were assured of anonymity (Podsakoff et al. 2003), and (2) The question order was counterbalanced. This additional approach is known to have the effect of neutralizing some of the method biases that affect the retrieval stage by controlling the retrieval cues prompted by the question context (Podsakoff et al., 2003).

A cover letter was sent to these managers or directors asking for their participation in the study. These managers or directors were selected as they are the most appropriate personnel, since they have responsibility for the performance of their units. The survey cover-letter also promised anonymity and described the objectives of the study. As an inducement to reply, respondents were promised summarised results of the study (respondents were asked to include a business card).

A total of 323 manufacturing units were randomly selected and the names of managers or directors were gathered. Questionnaires were pre-coded in order to identify non-respondents. A self-addressed, postage paid envelope was attached for returning the completed questionnaire directly to the researcher. A follow-up letter and another copy of the questionnaire were sent to those who had not responded after six weeks.

Of the 323 questionnaires sent, 107 were received from first and second mailings[3]. However, 16 were excluded from the study because of incomplete responses. This resulted in 91 usable responses[4], giving a response rate of 28%.

Measures

The survey instrument used to assess respondents' perceptions of the measures used in the study is reported in Appendix A. Following the procedure used by other writers (see Sim and Killough, 1998; Ittner and Larcker, 1995; Daniel and Reitsperger, 1992; Spreitzer and Mishra, 1999; Ahire, 1997; Ahire and Dreyfus, 2000), the survey asked respondents to indicate their perceptions of both the independent and dependent variables using a seven-point Likert-scale. Measurement instrument for the variables were developed from existing studies. The study assessed the reliability and validity of the scales for each variable. Construct reliability, the extent of measurement error in a measure, was estimated using Cronbach coefficient alpha. Coefficient for the constructs was greater than .70, above the minimum acceptable level suggested by Nunnally (1978). Construct validity was supported by the fact that each question loaded on its respective construct as expected (loading greater than .60). There are six measures used in this study[5]. A mean score is used for each measure. The subsequent subsections discuss the instrument and Appendix A presents the survey questionnaire.

Management Accounting Systems

Three MAS constructs were measured with items borrowed from previous studies (e.g., Spreitzer and Mishra, 1999; Sim and Killough, 1998; and Ittner and Larcker, 1995) and modified for this study. Following Sim and Killough (1998), the first construct, goals, was measured by asking the importance of communicating specific numeric targets for product quality performance. The items were anchored on a seven-point Likert scale (1 = not important; 7 = very important). The second construct, feedback, also consisted of three items following Sim and Killough (1998) and Daniel and Reitsperger (1992). This construct was anchored on a seven-point Likert scale (1 = never; 7 = daily). The third construct, incentives, was measured following Spreitzer and Mishra (1999), and Ittner and Larcker (1995). Quality incentives was anchored on a seven-point Likert scale (1 = not important; 7 = very important). A reliability check produced a Cronbach alpha of .760 for goals, .725 for feedback, and .734 for incentives, indicating that the measures were reliable (Nunnally, 1978).

Process Quality Management

Borrowing from previous studies (e. g. see Juran, 1981; Deming, 1986; Ahire, 1997; Ahire and Dreyfus, 2000), PQM was

[3] Because of contravening company policy, some had preferred not to participate.

[4] Discriminate analysis was used to compare respondents to the first mailing, the early respondents, to those responding thereafter, the late respondents (Fowler, 1993). Results revealed that the two groups did not differ significantly in either the level of the variables or in the relationship between the variables at the .05 level. This suggests that non-response bias may not be a problem.

[5] These measures were validated in previous studies.

measured using five items. Respondents were asked to provide their agreement or disagreement using a seven-point Likert-scale (1 = strongly disagree; 7 = strongly agree).

Product Quality Performance Measures

Traditional quality measurement systems divide quality-related programs into four categories (Juran and Gyrna, 1988). These include (1) prevention programs such as equipment maintenance and design engineering to prevent production of defective products, (2) appraisal programs that include formal inspection, testing, and quality audits, which aim at maintaining quality levels, (3) internal failure such as scrap and rework which arise from internal detection of quality problems, and (4) external failure such as warranty, replacement, and customer service that arise from quality failures in the hands of the customer. This empirical test focuses on internal and external failures to measure quality performance based on Ittner et al. (2001), Dawson and Patrickson (1991); Ahire (1996) and Ahire and Dreyfus (2000). Respondents were asked to provide information on their product quality performance over a three-year time frame using a seven-point Likert-scale (1 = strongly disagree 7 = strongly agree).

Control Variables

Size: Firm size effects are an important contingency factor that may have alternative effects. For example, smaller firms have flatter organisational structures and more informal communication channels. Thus, because smaller factories are more manageable, quality practices such as a PQM and design management maybe more effectively applied in small firms (Sonfield, 1984; Manoochehri, 1988). Research has also associated the smaller size and informal organisations with their abilities to encourage and implement innovation (Sironopolis, 1994). However, Hicks (1997) suggests that smaller companies often avoid implementing innovation because of a perceived lack of resources. Larger firms have more capital resources and professional managerial expertise (Finch, 1986).

Industry: Type of industry could have moderating effect on the model relationships. For example, adoption of implementation rigor of technological and managerial innovations has been linked to the industry structural characteristics (Porter, 1980). Industries differ in terms of types of products and production processes. For example, the chemical industry primarily uses batch and continuous manufacturing process whereas the automotive or computer industry relies heavily on modular assembly line production.

Research Model and Testing Procedures

The hypotheses above posit a two-way interaction between PQM and MAS to affect performance. To test the hypotheses, the dependent variables were regressed against the independent variables and control variables. The use of multiple regression analysis to study single or joint contributions of one or more independent variables on a dependent variable is common in contingent-type studies (e.g. Schoonhoven, 1981; Hirst, 1983; Govindarajan and Fisher, 1990; Cohen and Cohen, 1983; Cronbach, 1987). More specifically, to assess the relationship between performance and PQM/MAS interaction, a hierarchical regression analysis was used. Using this approach[6], the following regression models were employed to test the hypotheses:

$$\text{Perf}_i = \alpha_0 + \alpha_1\text{SIZE} + \alpha_2\text{IND} + \beta_1\text{Process} + \beta_2\text{Goals} + \beta_3\text{Fback} + \beta_4\text{Inc} + \varepsilon \qquad \textbf{(1)}$$

[6] Three assumptions are made when interpreting the estimation results of the models. First, it is assumed that some organisations have not chosen their process quality management and MAS optimally, so that product quality performance will vary cross-sectionally with the extent of process quality management implementation and MAS usage. Second, it is assumed that our variables have low measurement error and the functional form of the models is appropriate. Finally, it is assumed process quality management and MAS constructs are exogenous, making the coefficient estimates for our model consistent.

$$Perf_i = \alpha_0 + \alpha_1 SIZE + \alpha_2 IND + \beta_1 Process + \beta_2 Goals + \beta_3 Fback + \beta_4 Inc + \beta_5 Process \times Goals + \beta_6 Process \times Fback + \beta_7 Process \times Inc + \varepsilon \quad \textbf{(2)}$$

where:
$Perf_i$ = internal quality or external quality
SIZE = firm size as measured by the number of employees
IND = industry
Process = process quality management
Goals = goals
Fback = feedback
Inc = incentives
ε = error term.

Results

Appendix A presents the survey instrument, and Appendix B presents respondents' characteristics. Appendix C shows the descriptive statistics and also presents the bivariate correlations among the variables used in this study. The regression analyses are now presented and discussed below.

The independent variables were standardised in order to overcome multicollinearity problems due to the interaction between the variables (Cohen and Cohen, 1983). Next, a hierarchical regression model was constructed for each dependent variable. In the first step, the two control variables (size and industry), the three MAS (goals, feedback and incentives) and PQM variables were entered as a set. In the second step, the cross-products of each MAS variable and PQM (i.e., goals by PQM, feedback by PQM, and incentive by PQM) were also included in the set of independent variables[7]. Since the variance inflation factors were low (i.e. < 10), multicolinearity was not an issue after standardization (Hair et al., 1995).

Results in Table One, Equation (1) show that the main effects of size and PQM are significant (p = .044 and p = .000 respectively). However, none of the MAS variables is significantly related to internal quality. Table One, Equation (2), shows that, overall, the interaction between PQM and MAS is significantly related to internal quality (F = 12.239, p = .000, R^2-change = .109). The model explains 52.90% of the variance. The results also indicate that internal quality is a significant positive function of the interaction between goals and PQM (t = 2.668, p = .009), feedback and PQM (t = 1.995, p = .049), and incentives and PQM (t = 2.731, p = .008). Therefore, the results support H_{1a}, H_{2a}, and H_{3a}.

Results in Table Two, Equation (1) show that the main effects of size and PQM are significant (p = .053 and p = .000 respectively). However, none of the MAS variables is significantly related to internal quality. Equation (2) shows that, overall, the interaction between PQM and MAS is significantly related to external quality (F = 6.638, p = .000, R^2-change = .071). The model explains 36.10% of the variance. The results also indicate that external quality is a significant positive function of the interaction between PQM and goals (t = 2.897, p = .005), PQM and feedback (t = 2.073, p = .041). However, the interaction PQM/incentives was not significant (t = .426, p = .671). Therefore, the results support H_{1b}, H_{2b}, but failed to support $H_{3b.}$

Overall, the findings provide evidence that internal quality and external quality are function of the interaction between PQM and MAS. The strength of the interaction is reflected in the difference in R^2 of models with and without interaction (Jaccard and Wan, 1996). Therefore, the results are consistent with both Milgrom and Roberts' (1990, 1995) framework and resource-based theory that claim that complementary resources may enjoy synergistic performance impact. For managers, the implication is clear: deployment of both PQM and MAS is essential for maximum performance.

[7] Allison (1977) and Southwood (1978) argued that the appropriate test of hypotheses is whether the introduction of the interaction terms adds significantly to the variance explained. If the F associated with the change in R^2 caused by the introduction of the two-way interaction terms into the regression is significant, the hypothesis is supported.

Table One: Regression Analysis for Internal Quality

	Equation (1) Standardised Beta	t	Sig.	Equation (2) Standardised Beta	t	Sig.
SIZE	0.171	2.050	0.044	0.146	1.937	0.056
INDUSTRY	–0.124	–1.131	0.176	–0.034	–0.411	0.682
Goals	0.089	0.848	0.399	0.181	1.887	0.063
Feedback	0.124	1.450	0.151	0.069	0.868	0.388
Incentives	–0.140	–1.391	0.168	–0.090	–0.971	0.334
Process	0.613	6.060	0.000	0.636	6.981	0.000
Goals × Process				0.235	2.668	0.009
Feedback × Process				0.156	1.995	0.049
Incentives × Process				0.231	2.731	0.008
Adjusted – R^2		.420			.529	
Adjusted – R^2 Change		---------			.109	
F-value		11.845			12.239	
p-value		.000			.000	

Table Two: Regression Analysis for External Quality

	Equation (1) Standardised Beta	t	Sig.	Equation (2) Standardised Beta	t	Sig.
SIZE	0.181	1.961	0.053	0.142	1.630	0.107
INDUSTRY	0.051	0.525	0.601	0.106	1.083	0.282
Goals	–0.201	–1.742	0.085	–0.135	–1.229	0.223
Feedback	–0.103	–0.100	0.920	–0.035	–0.359	0.721
Incentives	0.161	1.427	0.157	0.195	1.740	0.086
Process	0.505	4.530	0.000	0.534	5.026	0.000
Goals × Process				0.291	2.897	0.005
Feedback × Process				0.183	2.072	0.041
Incentives × Process				0.041	0.426	0.671
Adjusted – R^2		.290				.361
Adjusted – R^2 Change		-----				.071
F-value		7.125				6.638
p-value		.000				.000

Conclusions and Discussion

A goal of this research is to empirically test the interactive effects of PQM and MAS (goals, feedback and incentives) on product quality, using a hierarchical regression model. Based on survey data obtained from a sample of U.S. manufacturing units, the results of this study indicate that PQM interacts with each of the three MAS to affect internal quality. The results also indicate that, PQM interacts with MAS (with the exception of incentives) to affect external quality. The theoretical and empirical evidence indicate that, overall, the conjoint implementation of PQM and MAS has a positive significant synergistic impact on manufacturing product quality performance. In other words, this study indicates that goals, feedback and incentives must be employed in tandem with PQM to achieve desired performance effects.

Incorporating theories from organisational behaviour can help inform the practical consequences of implementing operations management practices. In this setting, we find that behavioural theories interact with technical tools and method in interesting ways. That is, the use of technical tools and motivational factors must be managed jointly rather than in isolation. More broadly, quality improvement should not be understood as a purely technical problem but must be considered simultaneously with behavioural underpinnings. To this end, this study sheds light on how management can use MAS to ensure that PQM is even more effective. The use of appropriate goals, feedback and incentives should be seriously considered to ensure that PQM practices have an even greater positive effect on product quality. MAS serve as regulators of human action by motivating employees to engage in individual or group efforts to make process quality management work, that is, overall, PQM can be effective when used with MAS. Hence, this research helps illustrate that PQM is not just a technical problem but also requires behavioural consideration. Inferences from this research are that managers need to be aware of the important role PQM and MAS can play in determining performance in contemporary manufacturing environments. However, considerable work is needed to develop more complex theories arguing that, for superior performance, several implementation variables should be internally consistent with an SBU strategic context.

The results of this study should be assessed in light of the following limitations. First, the cross-sectional design of this study examined the interactive impact of PQM and MAS on product quality performance at the same point in time and does not consider the difference between short-term and long-term effects. A longitudinal research design would allow researchers to examine dynamic effects of implementing of PQM and MAS. Second, this study does not suggest that the research framework is complete as there may be other factors, both internal and external, not included in the research framework that can partially or wholly explain the results. For example, further study may incorporate the "culture of quality" that incorporates prevention, appraisal, internal and external costs. The third limitation relates to the general measure of incentives. Specific features of incentives (e.g., group vs. individual, financial vs. non financial, pay vs. promotion) could be investigated in future research.

Despite the limitations, the findings of this study have several implications for managers and researchers. The evidence suggests that the complementarity approach offers a useful way for managers to approach MAS. In particular, MAS must be incorporated into development of product quality performance and the justification of attaining higher organisational performance. The results of this study should enhance practitioners' confidence in their design of MAS and process quality efforts as enablers of performance.

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Appendix A: Survey Instrument

Part I.

Quality Goals

Importance of communicating specific numeric targets for:	1 = not important				7 = very important		
Cost of scrap	1	2	3	4	5	6	7
Rework (either in cost or units)	1	2	3	4	5	6	7
Defect (either in cost or units)	1	2	3	4	5	6	7
Quality Feedback	1 = ever				7 = daily		
We use several types of quality assessments (such as scrap, rework and defects) to measure our product quality performance.	1	2	3	4	5	6	7
The types of quality data collected (such as scrap, rework and defects) and our analyses of them are continually improving.	1	2	3	4	5	6	7
We gather quality data on scrap, rework and defects, analyse them, and disseminate them throughout our plant	1	2	3	4	5	6	7
Quality Incentives	1 = not important				7 = very important		
Rewards and recognition are given to our employees for improvement, not just for achieving a goal or target.	1	2	3	4	5	6	7
We have well-defined recognition and reward systems to acknowledge group and individual quality improvements.	1	2	3	4	5	6	7
The importance of team performance relative to individual performance in determining compensation.	1	2	3	4	5	6	7
Process Quality Management	1 = not important				7 = very important		
Process value analysis are frequently used	1	2	3	4	5	6	7
Corrective action is taken immediately when a product/process quality problem is identified	1	2	3	4	5	6	7
Key processes are systematically improved to achieve better product/process quality	1	2	3	4	5	6	7
Manufacturing facilities use statistical process control (SPC) extensively	1	2	3	4	5	6	7

Appendix A: Survey Instrument (cont.)

There is a good system of communication of product/process quality problems between management and employees.	1	2	3	4	5	6	7
Internal Quality	1 = strongly disagree				7 = strongly agree		
Our scrap rate has been reduced over the last 3 years.	1	2	3	4	5	6	7
Our rework rate has been reduced over the last 3 years.	1	2	3	4	5	6	7
Our defect rates of finished products have been reduced over the last 3 years.	1	2	3	4	5	6	7
Our manufacturing productivity has improved over the last 3 years.	1	2	3	4	5	6	7
Our internal (before shipping) product performance tests have shown improved product reliability over the last 3 years.	1	2	3	4	5	6	7
External Quality	1 = strongly disagree				7 = strongly agree		
There has been a steady decline in the number of warranty claims over the last 3 years.	1	2	3	4	5	6	7
There has been a steady decline in the number of product litigation claims over the last 3 years.	1	2	3	4	5	6	7
There has been a steady decline in the number of customer complaints over the last 3 years.	1	2	3	4	5	6	7
There has been a steady decline in the number of product recalls.	1	2	3	4	5	6	7
There has been a decline in manufacturing and process engineering expenses due to external failures.	1	2	3	4	5	6	7
There has been a decline in marketing engineering expenses incurred due to external failures.	1	2	3	4	5	6	7

Please answer the following:

1. What is your approximate dollar volume of sales (year 2000)? ________________________
2. What is the number of employees at your company? ________________________________
3. Number of years at this position? ____
4. Please provide your 2-digit SIC-code ____

Appendix B: Respondents' Characteristics

Data for the study were based on 91 manufacturing plants managers or directors' perceptions of the measures used in this study. Table A of this Appendix provides the profile of the responding companies that constitute a broad spectrum of manufacturers as defined by 2-digit SIC codes.

Table A:

Respondents' Characteristics

SIC Industry Code	Organisation Type	Number of Respondents used in the Study
20	Food and kindred products	11
23	Apparel and other fabricated textile products	9
28	Chemical and allied products	19
36	Electronic and other electric equipment	29
38	Instruments and related products	23
	Total	91

Appendix C: Descriptive Statistics

The descriptive statistics (minimum, maximum, Cronbach alphas, means and standard deviations of the variables) are presented in Table B of this Appendix. The means of the independent variables indicate that MAS and implementation of PQM rather moderate effects on performance. Table B also indicates that the reliability of the constructs, as measured by the Cronbach alpha, were acceptable.

In addition, Table B shows that survey respondents had a mean of 4.593 years in their current position with range of one to 19 years. The results also show that the average number of employees was 249. The sales amount for the 55 business units that provided sales figures ranged from $2.345 million to $8.040 billion, with a mean of $1.949 billion. The bivariate correlations among the variables used to test the hypotheses are reported in Table C of this Appendix. The correlation between industry and goal is significant, and incentives is significantly correlated with industry, and goals. PQM is also correlated with industry, goals, feedback and incentives. Internal quality is correlated with size, goals, feedback and process quality improvement, while external quality is correlated with size, industry, incentives, process quality improvement and internal quality. One interpretation of the correlation results is that there is dependence between the correlated variables, and that the adoption of PQM could be accompanied by MAS.

Table B: Descriptive Statistics

	Min	**Max**	**Mean**	**Std. Deviation**	**Cronbach Alpha**
Goals	1.000	6.000	3.894	1.341	0.760
Feedback	1.667	4.333	3.344	0.993	0.734
Incentives	1.333	5.667	3.685	1.168	0.725
Process	1.000	6.200	3.871	1.652	0.854
Size	57.000	764.000	249.077	152.152	
Industry	1.000	5.000			
Internal Quality	1.200	6.600	4.448	1.749	0.915
External Quality	1.000	5.833	4.190	1.561	0.934
Sales (in millions)	$ 2.35	$ 8,040.00	$1,949.63	2,760.37	
Number of years working at plant	1.000	19.000	4.593	3.721	

Table C: Correlations

	1	2	3	4	5	6	7	8
1. Size	1.000							
2. Industry	0.033	1.000						
	0.760							
3. Goals	0.170	0.218*	1.000					
	0.107	0.038						
4. Feedback	0.029	0.019	–0.189	1.000				
	0.786	0.860	0.072					
5. Incentives	–0.042	0.414**	0.458**	0.079	1.000			
	0.695	0.000	0.000	0.459				
6. Process	0.173	0.307**	0.439**	0.219*	0.415**	1.000		
	0.101	0.003	0.000	0.037	0.000			
7. Internal Quality	0.297*	0.032	0.267*	0.236*	0.103	0.607**	1.000	
	0.004	0.762	0.010	0.024	0.332	0.000		
8. External Quality	0.229*	0.235*	0.410	0.156	0.291*	0.526**	0.583**	1.000
	0.029	0.025	0.187	0.139	0.005	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)