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Impact of management accounting information and AMT on organizational performance

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Abstract

This study empirically examined and identified specific types of management accounting information as well as conditions of learning facilitators for effective organizational learning under high levels of advanced manufacturing technology (AMT). In this study, the interaction and communication among functions as well as job rotation and experience were considered as the facilitators of organizational learning. This research investigated the relationship between the level of AMT and the amount of management accounting information (i.e. planning and control information and nonfinancial performance information). The empirical results showed that there is a significant positive relationship between the AMT level and the amount of information produced by management accounting information systems (MAISs). Significant positive correlations among the amount of information, degree of organizational learning, and production performance were also observed. Using structural equation modeling, this study examined causal relationships among AMT level, amount of information, learning facilitators, organizational learning, and production performance. The results of the study showed that under a high level of AMT, to give rise to a high degree of learning and, consequently, an increase of performance through the provision of information, facilitators of learning must be well-coordinated (i.e. highly utilized), and MAISs must produce a large amount of management accounting information (i.e. planning and control information and nonfinancial performance information).
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Introduction

Firms must create new knowledge through organizational learning to cope with hostile and changing business environments. Without the creation of new knowledge, firms cannot adapt themselves to rapidly changing environments and will eventually perish. Nowadays, the knowledge creation capability of a firm is considered to be a critical competitive weapon (Nonaka, 1994; Nevis *et al*., 1995). Many researchers (e.g. Fiol and Lyles, 1985; Huber, 1991; Ouksel *et al*., 1997) have argued that the provision of relevant information is a prerequisite for effective organizational learning, through which new knowledge is created. However, a few studies (e.g. Vandenbosch and Higgins, 1995, 1996) empirically investigated whether the provision of information actually gives rise to organizational learning. Although a main role of information systems is to provide information to a manager for decision making and attention directing, learning and/or organizational learning effects of information have not been properly identified in prior research. Most previous studies (e.g. Alavi, 1994; Goodman and Darr, 1998; Kock and McQueen, 1998; Scott, 2000; Irani *et al*., 2001) have focused on learning support functions of information systems or information technology instead of on the learning effect of information.

It is generally assumed that under advanced manufacturing technology (AMT), some types of information

provided by management accounting information systems (MAISs) can give rise to organizational learning (Chenhall, 1997; Kloot, 1997). However, effective organizational learning is not automatically accomplished simply through the offering of information. There are structures and processes that facilitate the link of provision of information to valid organizational learning (Tyre and Hippel, 1997; Argote, 1999). According to the conditions of learning facilitators, a higher degree of organizational learning can occur. Thus, for the provision of relevant information to result in a higher degree of organizational learning, facilitators of organizational learning must be well-coordinated.

This study empirically investigated and identified both specific types of management accounting information and conditions of learning facilitators for valid organizational learning under high levels of AMT. First, relevant types of management accounting information that are required by AMT were identified. Second, with a structural equation modeling, this research analyzed the causal relationships among AMT, types of information, learning facilitators, organizational learning, and production performance. Thus, the results of this study can answer the following research questions.

(1) What types of management accounting information are demanded by AMT?
(2) Can the provision of information really lead to organizational learning?
(3) How can the organizational learning contribute to performance improvement under AMT?
(4) Is there any causal relationship between the level of AMT and conditions of learning facilitators?
(5) What are the roles of learning facilitators when types of information are provided by MAISs?

Theoretical underpinnings and hypotheses

Types of management accounting information

MAISs collect, classify, summarize, and report information to managers to assist them in their planning, control, and evaluation of production activities (Bruggeman and Slagmulder, 1995). Supporting decision making and attention directing with information is the basic purpose of MAISs. However, planning is an *ex-ante* form of control (Flamholtz and Das, 1985), since it defines the performance goals and expectations in terms of budget or forecasts. Through planning, control of production activities can proceed. Therefore, the information produced by MAISs can be classified into two types: planning and control information, and evaluation information. All kinds of planning and control information are financial information. The evaluation information of MAISs can be grouped into the financial and nonfinancial performance (evaluation) information (Abernethy and Brownell, 1997). Financial performance information represents the degree of the actual attainment of organizational financial goals, such as return on assets, return on sales, and return on investment (Miller, 1992; Chenhall and Langfield-Smith, 1998). Nonfinancial performance information refers to nonmonetary and qualitative measures, such as customer satisfaction, product quality, and cooperation (Bledsoe and Ingram, 1997; Harrison and Poole, 1997).

Information requirements of AMT

AMT relates to the physical hardware of the manufacturing process and is defined as consisting of technological advancements in automation that are able to be used in the production process (Harrison and Poole, 1997). The diversification of consumer tastes in modern society has made product life cycles shorter, which has led to firms producing multiple products with a smaller volume. AMT makes it possible for a firm to respond more quickly than ever before to changing technological and market environments by introducing more new products and offering broader product lines (Gerwin, 1993; Sanchez, 1995). AMT can facilitate the planning and execution of products in real time. Almost instantaneously, product design and manufacturing cycle can be set in motion to meet changing market needs. To fully capitalize on AMT's strengths in processing market information, engineering and production concurrently, a firm should employ a strategy of cooperation between its operations (e.g. R & D, engineering and manufacturing) on the one hand, and the external constituents relevant to product and process development (e.g. suppliers, equipment vendors, and scientific community) on the other (Parthasarthy and Sethi, 1993).

Therefore, under AMT, MAISs must produce a large amount of planning information and future-oriented trend information to cope with frequent changes in products (Nanni *et al*., 1992; Otley, 1994). Standard costing, budgeting, and long-range trend information are importantly utilized for planning under AMT. To manage the integration and collaboration within and across business functions in AMT, a large amount of control and coordination information is required. When AMT is employed, the utilization of activity-based costing (ABC) and product life-cycle cost increase to control interrelated activities (McNair, 1990; Nanni *et al*., 1992). ABC collects information on the basic activities that an organization pursues as well as the costs that they cause. This information provides a basis for understanding how changes in one area of an organization affect the activity base of others. With ABC, a firm can properly identify and control the complex inter-relationships among functions and activities. In product life-cycle costing, integrations both across business functions and across organizational boundaries are considered (Hiromoto, 1988). Life-cycle costing provides information about the inter-relationships among functions and the firm's suppliers and customers.

It has been argued that financial performance measures lack relevance to AMT in that they do not reflect, and are inconsistent with, the strategic factors of quality, flexibility, and dependability of supply, which have now become critical to achieving firm success (Bledsoe and Ingram, 1997). Under new manufacturing systems, traditional financial performance measures have many problems or shortcomings. They are usually short-term in scope and tend to foster suboptimal performance. For the advanced manufacturing environment, nonfinancial performance measurement systems are more appropriate than are financial systems (Abernethy and Lillis, 1995). AMT provides various strategic benefits such as quality improvement, economies of scope, and shortened lead and delivery times. To support and evaluate the achievement of these strategic advantages, nonfinancial performance

information is required. Under AMT, performance measurements must cross departmental lines to assist and encourage cooperation between functional departments. The performance measurement systems required for the adoption of AMT are more team or group oriented. Consequently, they are comprised mainly of nonfinancial performance information (Lessner, 1989; Otley, 1994).

Based upon the above arguments, Hypotheses 1 and 2 are proposed as follows:

Hypothesis 1: The level of AMT adoption has a positive effect on the amount of planning and control information provided by MAISs.

Hypothesis 2: The level of AMT adoption has a positive effect on the amount of nonfinancial performance information provided by MAISs.

Organizational learning effects of management accounting information

Organizational learning is the process of improving actions through better knowledge or information and understanding (Fiol and Lyles, 1985). Virany *et al.* (1992) defined organizational learning as a form of informational updating through which managers develop an understanding of relationships between organization actions and outcomes. Daft and Weick (1984) proposed three broad stages of the organizational learning process: information collection (scanning), interpretation, and learning (action taken). Huber (1991) suggested four constructs or phases that are integrally linked to organizational learning. They include information acquisition, information distribution, information interpretation, and organizational memory. Although many researchers have suggested diverse definitions of organizational learning, it is evident that information (or providing information) is a core element and prerequisite for organizational learning.

Information is a flow of messages or meanings which might add to, restructure or change knowledge (Machlup, 1983). Knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. Nonaka (1994) also differentiated information from knowledge. He asserted that information is a necessary medium or material in organizational learning for knowledge creation. Therefore, the basic step of organizational learning is to provide information. Individuals obtain and interpret information and learn by updating their mental models.

Mental models are the interpretive schemes or cognitive models of the world on which managers rely to understand various environments (Bartunek, 1984). Through interactions, individuals share information and beliefs, resulting in organizational learning, which forms the organization's shared mental models (Kim, 1993). Newly created knowledge resides in an organization's shared mental models that guide individual actions and ultimately organizational actions. An organization stores knowledge in its shared mental models, such as norms, rules, and procedures.

Accounting information is also utilized in organizational learning as the raw material of learning (Ouksel *et al.*, 1997). Accounting information plays a critical role in creating new knowledge and updating an organization's shared mental models. Kloot (1997) suggested that MAISs are closely related to the four constructs of organizational learning. Nonfinancial performance measures produced by MAISs positively affect information acquisition. Financial performance measurement and evaluation may also contribute to information acquisition and interpretation. Accounting and budgetary control reports of MAISs are likely to support information distribution as well as organizational memory. Chenhall (1997) and Sim and Killough (1998) asserted that management accounting information such as nonfinancial performance information gives rise to organizational learning in the operational and strategic control process of total quality management or a just-in-time system.

Based upon the above reasoning, it can be proposed that provision of a sufficient amount of information gives rise to organizational learning. Thus, Hypothesis 3 can be stated as follows:

Hypothesis 3: The amount of management accounting information (i.e. planning and control information as well as nonfinancial performance information) has a positive impact on the degree of organizational learning.

Organizational learning and performance

Learning consists of the development of insights on the one hand, and structural and other action outcomes on the other (Garvin, 1993). The former is a change in states of knowledge and the latter often involves a change more easily visible in terms of an organizational outcome. The ultimate result of valid organizational learning is increased or improved organizational performance (Fiol and Lyles, 1985; Kloot, 1997). The positive effects of learning on performance can be explained with a resource-based view. Resource-based theory suggests that competitive advantage of a firm is caused by the firm's unique resource (Smith *et al.*, 1996). Since knowledge is also a valuable resource of a firm, creating and sustaining a firm's competitive advantage is considerably dependent on the knowledge and knowledge creation capabilities of that firm (Little *et al.*, 2002). Therefore, effective organizational learning, by which unique knowledge is obtained, contributes to the attainment of the organization's competitive advantage and as a result, improves organizational performance.

Some researchers have empirically suggested a positive impact of organizational learning on a firm's performance. Simonin (1997) empirically demonstrated that the collaborative experience of a firm that gives rise to the development of collaborative know-how can contribute to future collaborative benefits. Kraatz (1998) empirically suggested that interorganizational networks can promote social learning and, consequently, enhance the firm's adaptation to environmental change. Barr *et al.* (1992) and Pennings *et al.* (1994) also showed positive relationships between the learning from experience or environmental change and the success and renewal of a firm.

Therefore, it is likely that the degree of organizational learning positively influences the organizational performance of a firm. Accordingly, the following Hypothesis 4 can be suggested.

Hypothesis 4: The degree of organizational learning has a positive effect on the production performance of a firm under AMT.

Facilitators of organizational learning

Organizations themselves cannot learn. Instead, organizations ultimately learn via their individual members. Thus, to only provide information is insufficient for effective organizational learning. A firm must prepare the conditions or circumstances that facilitate valid organizational learning to carry out organizational learning processes, to create new knowledge, and to update the organization's shared mental models. Facilitators of organizational learning are the structures and processes that affect how easy it is for learning to occur and the amount of effective learning that takes place (Nevis *et al*., 1995).

Organizational learning is not simply the sum of individual learning. It inherently involves group processes that begin with the sharing of information by individuals (Lee *et al*., 1992). The interaction and communication among group members, represented by the organizational practice of forming committees and working teams, are a means for organizations to pool and share the information and knowledge of their members (Nonaka, 1994). Therefore, they are important preconditions for organizational learning.

Organizational learning is also affected by the extent of diversity in the backgrounds and experience of group members (Argote, 1999). Diverse groups whose members possess different knowledge or information due to variations in their backgrounds, training or experience can support the learning process by enabling an organization to make novel associations and links. Group diversity provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known. However, the process of creating new knowledge through interaction and communication is assisted by the existence of a degree of redundant information or knowledge among members (Cohen and Levinthal, 1990; Nonaka, 1994). Redundancy in knowledge is important because it encourages frequent and effective communication.

Tyre and Hippel (1997) proposed that organizational learning occurs not simply through human interaction, but also through people interacting within one or more particular physical contexts. Since different physical settings provide different opportunities for learning, learners should shift repeatedly among several settings (e.g. lab and plant) before they can develop possible solutions for the underlying problem. Job rotation through areas such as R & D, production and marketing is another important mechanism to promote organizational learning (Cohen and Levinthal, 1990; Nonaka, 1991). Through job rotation and exchange, redundancy in knowledge is fostered and the diversity of background of members is enhanced.

Organizational learning is fostered as well by diversity in experience of a firm (Nevis *et al*., 1995). Operating in diverse circumstances increases the variety of events and ideas to which a firm is exposed. This operational variety helps a firm build a prior knowledge base and enhance future learning. There are many other factors that promote organizational learning. They include executive succession (Virany *et al*., 1992), interorganizational networks (Kraatz, 1998), and the quick and frequent reporting of information for knowledge transfer (Sim and Killough, 1998).

Based upon the above arguments, it can be suggested that under well-coordinated learning facilitators, provision of management accounting information is more likely to be linked to valid organizational learning. However, when learning facilitators are poorly prepared, provision of information may not lead to effective learning. Thus, Hypothesis 5 can be stated as follows:

Hypothesis 5: Facilitators of organizational learning have a positive impact on the degree of organizational learning.

AMT and learning facilitators

The challenge posed by a high level of AMT is primarily that caused by its higher knowledge intensity (Shani *et al*., 1992). The frequent changes of the production processes and products under AMT require, reversely, both the new level and the continuing acceleration of technological progress. The new level of technology increases the ambiguity of objectives and of paths to attaining it (Adler, 1988). To solve these obscurities, more new knowledge is continuously needed under AMT (Boynton and Victor, 1991). AMT demands a higher commitment to learning rather than routine execution to obtain the necessary advanced knowledge. Consequently, to cope with new knowledge requirements of the high level of AMT, effective organizational learning must be promoted and supported by well-coordinated learning facilitators. Therefore, it is likely that the required conditions of learning facilitators will differ according to the level of AMT. When AMT is high, well-coordinated learning facilitators may be required. However, low AMT may not demand highly coordinated facilitators. Based upon this reasoning, the following Hypothesis 6 can be suggested.

Hypothesis 6: The level of AMT adoption has a positive impact on the facilitators of organizational learning. The research model in this study, which describes the causal relationships among AMT, management accounting information, learning facilitators, organizational learning, and performance, is presented in Figure 1.

Research method

Study sample

Data for this study were drawn from a survey of the current status of MAISs used in Korean manufacturing firms. In total, 250 organizations were randomly selected from a population of about 1,000 firms that are listed on the Korean stock market. The manufacturing firms listed are medium to large in size and consequently, are likely to have more experience with MAISs and AMT applications than are smaller firms. First, the chief production managers of the selected firms were contacted to ask them for their participation in the research. At the beginning, 118 organizations responded to the request for information.

However, during the survey, 25 firms withdrew from the survey because they were unwilling to be clear about their level of AMT. As a result, 93 firms were finally included in the study.

In order to collect data, this research both administered questionnaires and conducted interviews with the participating firms. Only chief production managers or plant managers were selected as respondents since they can well understand the utilization of management accounting information and the firm's AMT level and performance. Before mailing the questionnaire, through a first telephone interview with the respondent, the researcher of this study roughly asked him the firm's present conditions, such as level of AMT, degree of the use of management accounting information, and the benefits of his firm's AMT. The results of the first interview generally concurred with the results of questionnaire response. After a telephone interview (i.e. about 1 or 2 days later), a questionnaire with a cover letter was mailed to each respondent. A self-addressed stamped envelope was included with the questionnaire to ensure anonymous responses. After distributing the questionnaire (i.e. about one week later), through the second telephone interview, the contents of the questionnaire and the answering methods were explained. The survey was conducted during a 4-month period between January and April 2001. Finally, the results of the survey (i.e. questionnaire responses) were used in the research. Table 1 summarizes the sample characteristics according to the industrial type of the firms.

Measurements

The level of AMT adoption

Since the level of AMT is closely related to the degree of automation (Harrison and Poole, 1997), this study measured the degree of automation in the production systems to obtain the AMT measurement. Meredith and Hill (1987) suggested a four-stage model to assess the degree of automation. Based on Meredith and Hill's model, a seven-stage model was developed: partially automated stand-alone equipment, some automated stand-alone equipment, a greater number of automated stand-alone equipment, low level of integration, high level of integration, linked islands, and full integration. Since low-automated manufacturing firms in Korea are very dissimilar in the number of stand-alone equipment employed (Korea Production Committee, 1999), the first stage (i.e. the stand-alone stage) was subdivided into three stages according to the number of pieces of unitary equipment. In the second step (i.e. the cells stage), the level of integration was divided into low and high (Meredith and Hill, 1987). Hence, the second step was also subdivided into two stages in accordance with the level of integration. With the seven-stage model, respondents were asked to select the stage that best corresponds with the state of automation in their manufacturing systems.

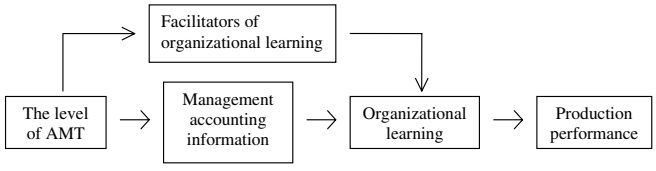

Figure 1 Research model.

Planning and control information, and nonfinancial performance information

The types of planning and control information provided by MAISs are grouped into traditional and advanced information. Traditional information is produced by traditional management accounting techniques, which comprise standard costing, budgeting, direct costing, and variable costing (Scarbrough *et al*, 1991; Chenhall and Langfield-Smith, 1998). AMT results in a larger share of product costs being fixed. As a result, cost control and analyses using direct costing or variable costing become more important in AMT because of the increased risk that attends an increased fixed cost base (Scarbrough *et al*., 1991). For planning, cost control and subsequently, production control, traditional information is provided by standard costing, budgeting, direct costing, and variable costing.

Advanced information is provided by newer techniques, which include ABC, life-cycle costing, and long-range cost trends (McNair, 1990; Chenhall and Langfield-Smith, 1998). ABC and life-cycle costing can be utilized for the control and coordination of interrelated activities. Long-range trend information is used for planning. Seven question items were used to measure planning and control information. Respondents were asked to indicate on a seven-point Likert-type scale, anchored by 'No amount of information, almost no provision' and 'Very large amount of information, very high extent of provision', the extent or the amount of information that is provided to the production department.

In all, 13 nonfinancial performance pieces of information suggested by previous research (e.g. Abernethy and Lillis, 1995; Harrison and Poole, 1997) were utilized to measure

Table 1 Sample characteristics

Type of industry	*Chemical industry*	*Machine industry*	*Auto-mobile*	*Electronic industry*	*Textile*	*Food*	*Paper & pulp*	*Nonmetal*	*Metal industry*	*Rubber & plastic*	*Total*
No. of firms	17	15	14	10	9	8	8	7	4	1	93
No. of employees	Below 300	300–500	500–1,000	1,000–5,000	5,000–	Total					
No. of firms	37	19	22	11	4	93					

nonfinancial performance information. They include: on time delivery performance records, number of customer complaints, number of product returns, incidences of product defects, customer satisfaction with the product, product quality improvement, introduction rate of new products, evaluation of the ability to vary product characteristics, length of cycle time from order to delivery, rate of material scrap loss, measurement of machine utilization and down time, evaluation of whether people in manufacturing are cooperative and responsive, and set-up and changeover times. Types of nonfinancial performance information were measured on a seven-point Likert-type scale.

The facilitators of organizational learning

The main facilitators of organizational learning are the interaction and communication among group members as well as job rotation and experience (Nonaka, 1994; Tyre and Hippel, 1997; Argote, 1999). Interaction and communication include the mode, direction, and frequency of information flows among members (Van de Ven and Ferry, 1980). Job rotation and experience imply the interchangeability and actual interchange of jobs among members. To measure interaction and communication, eight questionnaire items developed by prior research (e.g. Van de Ven and Ferry, 1980) were used. They include receiving or sending reports or memos within production and between production and other departments, discussions within production and between production and other functions, unscheduled meetings among production employees and between production and other departments, and scheduled meetings within production and between production employees and other departments' employees.

For the job rotation and experience, eight questionnaire items also developed by previous studies (e.g. Van de Ven and Ferry, 1980) were utilized. They include rotating jobs among production employees and between production and other departments, ease of job rotation within production and between production and other functions, number of production employees qualified to do other production employees' duties and other departments' jobs, and number of production employees experienced in doing other production duties and other departments' jobs. The interaction and communication as well as the job rotation and experience were measured on a seven-point Likert-type scale.

The degree of organizational learning

The direct results or final phase of organizational learning are changes in shared mental models or changes in the organizational paradigm (Lant and Mezias, 1992; Lee *et al*., 1992; Virany *et al*., 1992). Therefore, the degree of organizational learning can be measured by the degree of change in shared mental models. Based on the measures of Vandenbosch and Higgins (1995), five items to measure the changes in shared mental models of production employees were used. They are: production employees' understanding, or belief about, staying close to, increasing focus in, testing assumptions about and improving insights, and creativity in manufacturing systems.

The degree of organizational change caused by the changes in the organizational paradigm can be utilized as a surrogate measure for the degree of organizational learning (Fiol and Lyles, 1985; March, 1991). In this study, based on March (1991), Lant and Mezias (1992) and Virany *et al*. (1992), six questionnaire items for organizational change were developed. They include gradual or partial changes and innovative changes in production systems, gradual changes and innovative changes in product related items, and partial and innovative changes in production management related matters. Changes of mental models and organizational change were measured on a seven-point Likert-type scale.

Production performance

The strength of the manufacturing function is determined by the degree to which it meets the tasks placed on it by a firm's strategic goals or plans. The ultimate goals that can be attained through AMT are low cost, improved quality, increased flexibility and high dependability of supply (Parthasarthy and Sethi, 1992; Boyer, 1999). These four variables compose the core elements of production performance in AMT. The importance of production performance measurements is determined by the degree to which they support the attainment of strategic manufacturing goals (Youssef, 1991). Therefore, the measurements of manufacturing performance under AMT should reflect the degree of the realization of these four strategic goals.

Since a firm's performance may be positively or adversely affected by various internal and external factors aside from AMT, it is very difficult to isolate and measure the true impact of AMT on performance (Boyer, 1999). Therefore, to evaluate a firm's production performance, this study measured the degree of improvement in cost, quality, dependability and flexibility through AMT. According to the measures of Vickery *et al*. (1993) and Agarwal (1997), improvements in the four dimensions were assessed by asking respondents to indicate the extent of improvement experienced by their plants since introducing AMT.

The degrees of improvement were measured on a seven-point Likert-type scale that ranged from 'Not improved, worse' to 'Highly improved'. For cost and quality, four and six questionnaire items were utilized, respectively. To measure flexibility and dependability of supply, five and four question items were used, respectively. The 19 items were: new product, product volume, speed in new products, product changeover and R & D (five items for flexibility), lead time, delivery, production lead time and customer requirements (four items for dependability of supply), product performance, product durability, specifications, design and engineering, product features and perception of quality (six question items for quality), production cost, material cost, labor cost and overhead cost (four items for cost).

This study also collected the financial performance measures of sample firms, such as return on assets (ROA), return on sales (ROS), and ratio of cost of goods sold (RCGS), to prove the external validity of the production performance measurement. Accounting data

to compute the ROA, ROS, and RCGS were collected from the firm's balance sheets and income statements in 2001, which were provided in the Korean annual report of listed companies.

Analysis and results

Reliability and validity test

Item analyses were performed with Cronbach alpha coefficients for all multi-item scale measures. In Table 2, the results of the Cronbach alpha test are presented with all alpha coefficients above 0.8. The alpha coefficient of the job rotation and experience marginally improved after the deletion of the third item. If the alpha value is above 0.6, the reliability of the multi-item scale is satisfactory (Nunnally, 1978).

The questionnaire items measuring research variables have been used in previous empirical studies. However, the construct validities of these items are questionable. Principal component analysis with varimax rotation was used to determine if all items measuring a construct cluster together or not. That is, whether all items measuring a construct load onto a single factor or divide into multiple factors. Four separate joint factor analyses for planning and control information, nonfinancial performance information, change of shared mental models, organizational change, interaction and communication, job rotation, and experience, and production performance were performed to acquire a more stable solution by increasing the ratio of the sample size to the number of items. The results of factor analysis are presented in Table 3.

Using the 0.4 criterion for significant item loading on a factor, the results show that all items within each index except for nonfinancial performance information, job rotation and experience, and production performance are represented by a single factor. In the case of nonfinancial performance information, two factors with eigenvalues greater than 1 were extracted. However, in Factor 2, Items 6 (product quality) and 9 (length of cycle time) are confounded with the items of Factor 3. Items 6 and 9 were removed and the factor analysis for planning and control information and nonfinancial performance information was performed again. In the second factor analysis, the items of each factor did not confound with the items in the other factors. Factor 2 is comprised of on time delivery, customer complaints, product returns, product defects, and customer satisfaction. Thus, its title is quality performance information (QPI). Factor 3, which is composed of new products, product characteristics, material scrap, down time, cooperative and responsive, and set-up and change-over times, represents flexibility performance information (FPI). The alpha values for QPI and FPI were computed again and found to be 0.90 and 0.87, respectively.

In Table 3, for job rotation and experience, two factors with eigenvalues greater than 1 were obtained. In Factor 2, Item 5 (qualified to do other departments' jobs) was confounded with the item of Factor 3. After removing Item 5, second factor analysis was performed. The second factor analysis showed that no items were confounded. Factor 2 includes job rotation within production and between production and other departments as well as ease of job rotation between production and other functions. Thus, the title of Factor 2 is job rotation. Factor 3 is comprised of production employees qualified to do other production jobs and production employees experienced in doing other production works and other departments' jobs. Therefore, Factor 3 represents job experience. The alpha coefficients for job rotation and job experience were 0.83 and 0.78, respectively.

For production performance, four factors with eigenvalues greater than 1 were extracted. In Factor 1, Item 12 (specifications) is confounded with the item of Factor 2. Thus, Item 12 was removed. In the second factor analysis, no item was confounded. Factor 1 (product performance and durability, design and engineering, product features, and perception of quality) is quality improvement. Factor 2 (product volume, lead time, delivery, production lead time, and customer requirements) shows dependability of supply. Factor 3 (new product, speed in new products, product changeover, and R & D) represents increased flexibility. Factor 4 (production cost, material cost, labor cost, and overhead cost) is cost reduction. The alpha values for quality improvement, dependability of supply, increased flexibility, and cost reduction were 0.92, 0.87, 0.85, and 0.85, respectively.

To prove the external validity of the production performance measurement, Pearson's correlation analysis was employed. The size of the correlation is a direct indication of the degree of validity. Table 4 shows the results of correlation analyses. The correlation coefficients among quality improvement, dependability of supply, cost reduction, and objective financial measures (i.e. ROA, ROS, and RCGS) were significant and positive or negative. Thus,

Table 2 Cronbach alpha coefficients

Research variable	*Before deletion*		*After deletion*	
	No. of items	*Alpha*	*No. of items*	*Alpha*
Planning and control information	7	0.93	—	
Nonfinancial performance information	13	0.93	—	
Change of shared mental models	5	0.94	—	
Organizational change	6	0.96	—	
Interaction and communication	8	0.86	—	
Job rotation and experience	8	0.82	7	0.85
Production performance	19	0.94	—	

Table 3 Factor loadings of research variables (Varimax rotation)*

Information	*Factor*			*Learning*	*Factor*		*Facilitator*	*Factor*				*Factor*			
	1	*2*	*3*		*1*	*2*		*1*	*2*	*3*		*1*	*2*	*3*	*4*
Planning & control				Mental models			Interaction & communication				Production performance				
1	0.85			1		0.81									
2	0.83			2		0.89	1	0.66							
3	0.81			3		0.86	2	0.77			1			0.78	
4	0.74			4		0.82	3	0.77			2		0.74		
5	0.80			5		0.78	4	0.79			3			0.81	
6	0.70			Organi-			5	0.75			4			0.76	
7	0.76			zational			6	0.63			5			0.71	
Nonfinancial performance				change			7	0.63			6		0.73		
				1	0.83		8	0.67			7		0.77		
1		0.72		2	0.84		Job				8		0.57		
2		0.83		3	0.87		rotation &				9		0.53		
3		0.86		4	0.86		experience				10	0.82			
4		0.78		5	0.83		1		0.83		11	0.84			
5		0.62		6	0.83		2		0.85		12	0.58	0.57		
6		0.54	0.44				3		0.70		13	0.79			
7			0.58				4			0.86	14	0.72			
8			0.59				5		0.51	0.59	15	0.71			
9		0.58	0.52				6			0.81	16				0.71
10			0.62				7			0.65	17				0.66
11			0.58								18				0.82
12			0.76								19				0.79
13			0.83												
Eigenvalue	10	2.1	1.3		8.2	1.2		4.7	3.0	1.7		9.3	1.7	1.4	1.2
% of variance	53	11	6.7		75	11		31	20	12		49	9.0	7.7	6.6

*Factor loadings below 0.4 were not presented.

it can be concluded that the instrument for the production performance has external validity. A single scale for the research variable was created by averaging a respondent's scores over the items measuring each variable. The values of mean and standard deviation for the research variables were calculated and are summarized in Table 5.

Correlation analysis of research variables

Pearson's correlation analysis was used to assess the relationships among critical variables. Table 6 presents the correlation matrix for the research variables. There was a statistically significant positive relationship between the level of AMT and planning and control information. Significant positive correlations between AMT level and nonfinancial performance information were also found. Therefore, if the level of AMT increases, the necessary amount of management accounting information such as planning and control information and nonfinancial performance information also increases.

The correlation between AMT level and the interaction and communication was statistically significantly positive. There were significant positive correlations between the degree of organizational learning and learning facilitators. Thus, it is concluded that well-coordinated learning facilitators are positively associated with a high degree of organizational learning. The relationships among change of shared mental models, organizational change, dependability of supply, and increased flexibility were significant and positive. Therefore, when the degree of organizational learning through the provision of information is high, it is likely that production performance will also increase.

Analysis of causal relationships

This study employed a structural equation modeling technique to analyze causal relationships among research variables. AMOS 4.0 was utilized as the analytical tool for the estimation of the measurement and structural equation (theoretical) models (Arbuckle and Wothke, 1999). As theorized, distinct causal paths from AMT level, management accounting information and organizational learning predict alternative outcomes with respect to production performance. Figure 2 displays both the theoretical model structure corresponding to the hypotheses and the measurement model. Figure 2 also presents individual structural path estimates. In Figure 2, ellipse and box represent the unobserved variable (theoretical variable) and the observed variable (measurement variable), respectively.

The observed χ^2 for the theoretical model was 145.92 ($df = 71$; $P = 0.00$). Although the significance (P-value) of χ^2 means relatively poor fit between the model and the sample data, the goodness of fit cannot be judged by χ^2 value alone (Arbuckle and Wothke, 1999). Since the P-value of χ^2 is sensitive to sample size, the ratio of χ^2 to degrees of freedom (χ^2 value/degrees of freedom) can be employed as

Table 4 Pearson's correlation analysis ($N = 93$)

	Quality improvement	*Dependability of supply*	*Increased flexibility*	*Cost reduction*
ROA	0.22[b]	0.23[b]	−0.03	0.29[a]
ROS	0.19[c]	0.12	0.02	0.10
RCGS	−0.23[b]	−0.19[c]	−0.09	−0.20[c]

[a]$P < 0.01$, [b]$P < 0.05$, [c]$P < 0.1$. ROA, return on assets; ROS, return on sales; RCGS, ratio of cost of goods sold.

Table 5 Summary statistics of research variables

Variables	*Mean*	*Standard deviation*	*Median*	*Minimum*	*Maximum*
Level of AMT	3.3	1.7	3.0	1.0	7.0
Planning and control information	4.2	1.3	4.2	1.0	7.0
QPI	4.7	1.2	4.8	1.0	7.0
FPI	4.4	1.1	4.4	1.0	6.8
Change of shared mental models	4.0	1.4	4.0	1.0	7.0
Organizational change	3.9	1.4	4.0	1.0	7.0
Interaction and communication	4.8	1.0	5.0	2.3	6.8
Job rotation	2.7	1.2	2.3	1.0	6.0
Job experience	3.7	1.2	3.6	1.3	7.0
Increased flexibility	4.9	0.83	5.0	2.0	7.0
Dependability of supply	5.4	0.76	5.5	4.0	7.0
Quality improvement	5.3	0.87	5.2	2.4	7.0
Cost reduction	5.3	0.87	5.2	3.0	7.0

QPI, quality performance information; FPI, flexibility performance information.

Table 6 Pearson's Correlation Coefficients ($N = 93$)

Variables	*Planning & control information*	*QPI*	*FPI*	*Quality improvement*	*Dependability of supply*	*Increased flexibility*	*Cost reduction*	*Level of AMT*	*Mental models*	*Organizational change*
Level of AMT	0.41[a]	0.37[a]	0.33[a]	0.08	0.19[c]	0.10	0.21[b]	—	—	—
Mental models	0.47[a]	0.20[b]	0.32[a]	0.15	0.19[c]	0.26[b]	0.14	0.12	—	0.75[a]
Organizational change	0.54[a]	0.18[c]	0.44[a]	0.15	0.20[b]	0.21[b]	0.15	0.18[c]	—	—
Interaction & communication	0.14	0.23[b]	0.12	0.19[c]	0.29[a]	0.17[c]	0.25[b]	0.19[c]	0.19[c]	0.16
Job rotation	0.25[b]	0.18[c]	0.22[b]	0.16	0.16	0.24[b]	0.22[b]	0.05	0.48[a]	0.32[a]
Job experience	0.25[b]	0.15	0.29[a]	0.05	0.04	0.27[a]	0.17[c]	0.16	0.32[a]	0.26[b]

[a]$P \leq 0.01$, [b]$P \leq 0.05$, [c]$P \leq 0.1$. QPI; quality performance information; FPI, flexibility performance information.

fit index (Carmines and McIver, 1981). The χ^2 to degrees of freedom ratio in the range of 3:1 is indicative of an acceptable fit between the theoretical model and the sample data (Carmines and McIver, 1981).

The ratio of χ^2 to degrees of freedom (145.92/71) was 2.05. Other indices of fit for the theoretical model are GFI (goodness-of-fit index) $= 0.86$, AGFI (adjusted goodness-of-fit index) $= 0.79$ and RMR (root mean square residual) $= 0.063$. GFI and RMR reflect the relative amount of the variances and covariances jointly accounted for by the model. However, there is no basic standard with which to evaluate them because their distributions are unknown (Joreskog and Sorbom, 1981). Although GFI value above 0.9 indicates a very good fit, GFI values around 0.8 also indicate an acceptable fit (Anderson and Narus, 1990; Ping, 1993). Therefore, the theoretical model in Figure 2 is judged to provide a moderate fit for the observed covariances.

Hypotheses 1 and 2 suggested that AMT level affects amount of management accounting information directly. Consistent with this prediction, the path estimate between AMT level and management accounting information is significant and positive (0.99, $P < 0.00$). Thus, Hypotheses 1 and 2 are fully supported. Hypothesis 3 is also supported by a significant and positive relationship (0.27, $P < 0.1$) between management accounting information and organizational learning. Hypothesis 4 concerns the outcome resulting from the impact of organizational learning. Consistent with Hypothesis 4, the path predicting a relationship between learning and production performance is significant and positive (0.35, $P < 0.05$). Thus, the degree of organizational learning positively contributes to an improvement of performance. Hypotheses 5 and 6 proposed both the direct effects of learning facilitators on organizational learning and the impact of AMT level on

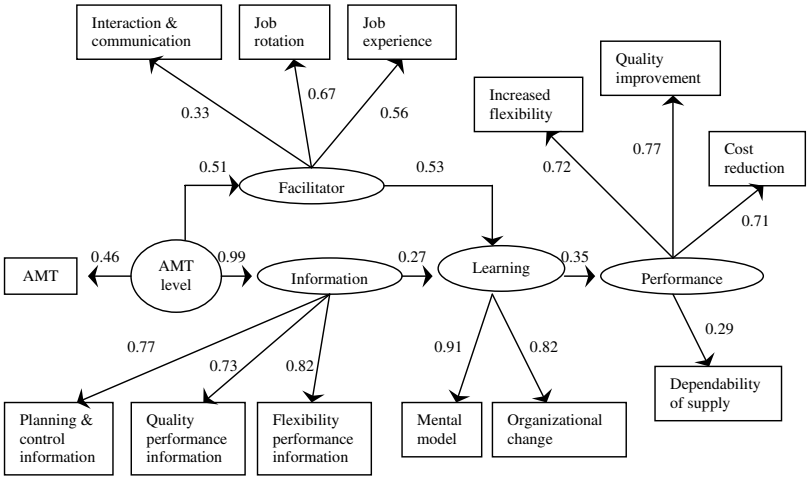

Figure 2 Structural path estimates.

Table 7 Path coefficients of the theoretical and measurement models

Model	*Path flow*	*Regression weights*			*Standardized regression weights*
		Estimate	*CR*	P-*value*	
Theoretical model	Facilitator ← AMT level	0.21	1.91	0.05	0.51
	Information ← AMT level	1.31	3.87	0.00	0.99
	Learning ← Facilitator	2.15	1.99	0.04	0.53
	Learning ← Information	0.34	1.73	0.08	0.27
	Performance ← Learning	0.15	2.54	0.01	0.35
Measurement model	AMT ← AMT level	1.0*			0.46
	Mental model ← Learning	1.0*			0.91
	Increased flexibility ← Performance	1.0*			0.72
	Quality improvement ← Performance	1.15	5.23	0.00	0.77
	Cost reduction ← Performance	1.13	5.14	0.00	0.71
	Dependability of supply ← Performance	0.63	2.27	0.02	0.29
	Job experience ← Facilitator	2.06	2.27	0.02	0.56
	Interaction & communication ← Facilitator	1.0 *			0.33
	Job rotation ← Facilitator	2.62	2.33	0.02	0.67
	Quality performance information ← Information	0.84	6.25	0.00	0.73
	Flexibility performance information ← Information	0.89	6.77	0.00	0.82
	Planning & control information ← Information	1.0*			0.77
	Organizational change ← Learning	0.91	7.02	0.00	0.82

*Regression weight was set in 1.

learning facilitators. Hypothesis 5, predicting positive impact of learning facilitators on learning, is supported by a corresponding path estimate of 0.53 ($P<0.05$). The path estimate representing Hypothesis 6 (0.51, $P<0.05$), is also consistent with prediction suggesting that as the level of AMT increases highly-coordinated learning facilitators are required. Table 7 shows these path estimates.

Discussion and conclusion

For a long time, in the design of ISs, a contingency approach has been considered to be unique and most appropriate. An organizational learning perspective has not been explicitly considered in the contingency approach of ISs design. This study adopted an organizational learning perspective to explain the positive impact of information on an organization's performance. This research strongly suggests that the organizational learning approach must be another important guideline in designing components of ISs such as information content and presentation mode. It can be suggested that ISs must be designed and built to provide information in such a way that they sustain a nice fit with contingency variables as well as support organizational learning.

Most previous studies (e.g. Alavi, 1994; Goodman and Darr, 1998; Kock and McQueen, 1998; Kwok and Khalifa, 1998; Scott, 2000) focused on the learning facilitating functions of computer-aided systems and information

technology. The learning effects of information have not been well uncovered in prior empirical research. The current study empirically examined the organizational learning effects of management accounting information. In this study, the facilitators of organizational learning (i.e. interaction and communication among functions, along with job rotation and experience) and the degree of organizational learning were considered to be the key research variables.

First, the relationships between level of AMT and amount of information provided by MAISs were investigated. The results exhibited significant positive relationships between the AMT level and amount of management accounting information: planning and control information, and non-financial performance information. Positive correlations among degree of organizational learning, production performance, and amount of information were also observed. Using a structural equation modeling, this study examined causal relationships among AMT level, amount of information, learning facilitators, degree of learning, and production performance. The results showed that a high level of AMT requires well-coordinated learning facilitators as well as a large amount of management accounting information. It was also demonstrated that both highly coordinated facilitators and sufficient amount of information give rise to valid organizational learning, and as a result, effective learning improves production performance.

Based on the results of this study, it is concluded that under high levels of AMT, in order to lead the provision of information to a high degree of learning and consequently, to an increase in performance, facilitators of organizational learning must be well-coordinated and MAISs must produce a large amount of management accounting information. The empirical results also confirmed that according to the level of AMT, both a demanded amount of information and required conditions of learning facilitators must be identified all together. From these results, it is concluded that research on learning effects of information cannot be properly conducted without consideration of learning facilitators and *vice versa*. This conclusion suggests that the prior studies on the learning support functions of computer-aided systems have been apt to omit another important research variables in their research models.

Limitations of this research and future research efforts include: This study did not include the learning support functions of computer-aided systems. There are many other mechanisms and conditions which promote effective organizational learning. In future research, various facilitators such as the learning facilitating mechanisms of computer-aided systems have to be included to find out other ways that enhance facilitating effects. The learning effects of information and the effectiveness of facilitators may be different according to the conditions of contextual variables such as task structure, environment, and organizational structure. Therefore, the organizational learning and facilitating effects must be examined under various contexts.

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