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Impact of quality management practices on the knowledge creation process

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ABSTRACT

Contemporary quality management studies describe a range of quality improvement strategies. However, these studies do not consider the impact of quality management practices on the knowledge creation process. Based on a comprehensive literature review and a field survey, this study investigates the impact of quality management practices on the knowledge creation process. A proposed model and hypotheses are presented and tested using survey data collected from aviation firms in China. The test of the structural model supports some proposed hypotheses. We find that employee training, employee involvement, product design, benchmarking, and vision statement have significant direct impacts on the knowledge creation process. We also find that some other quality management practices, such as top management support, customer focus, supplier quality management, quality information, and recognition and rewards, do not have a direct impact on knowledge creation. Suggestions for the improvement of quality management in aviation firms in China are provided. The implications of the findings for researchers and practitioners are discussed, and further research directions are offered.

1. Introduction

Quality management (QM) is a process that has widely applied to improve competitiveness around the world (Samson & Terziovski, 1999). QM is already a mature field of study, and future research directions must be sought (Sousa & Voss, 2002). Many studies have focused on determining the relationship between QM practices and organizational performance (Gagnon & Sheu, 2003; Girard & Doumeingts, 2004; Kaynak, 2003; Kearney & Abdul-Nour, 2004; Mills & Smith, 2011). Improving organizational knowledge and knowledge management capabilities is an important means of improving organizations' performance (Molina et al., 2007).

Most quality improvement activities require the creation of new knowledge for the organization (Deming, 1994). The central role of the creation of new knowledge in quality improvement is evinced from Deming's comment that efforts and hard work that are not guided by new knowledge only continue to dig the ditch (Anderson et al., 1994). It follows from the importance of knowledge creation (KC) that a successful organization should not only manage the quality of products and practices effectively but also master and apply knowledge management (Grant, 1996; Yang et al., 2010).

However, although QM and knowledge management have recently received increasing scholarly attention, the majority of researchers treat QM and knowledge management as two entirely separate fields and independent systems of management (Flynn et al., 1994; Shan et al., 2011; Söderlund, 2010; Yang et al., 2010). In spite of the importance of knowledge management within the firm, few empirical studies examine its relationship with QM. The main studies connecting QM with organizational KC include those linking KC with idea generation from QM (McAdam, 2004), integrating the frameworks of QM practices and KC processes (Linderman et al., 2004), incorporating a KC learning model into QM (Choo et al., 2007), the total quality knowledge management system (Tsai, 2003), relating QM practices and knowledge transfer (Molina et al., 2007), examining knowledge and QM from an R&D perspective (Jayawarna & Holt, 2009), exploring the role of KC in Six Sigma project management (Anand et al., 2010), and investigating data mining and quality control (Alzghoul & Löfstrand, 2011; Ferreiro et al., 2011). Currently, research on the quantitative impact of QM practices on organizational KC process is rare.

With the growing role of information technology, organizational KC has been receiving increased interest in China. According to our survey, many firms, especially Chinese aviation firms, wish to conduct KC activities within the QM practices. However, they do not fully understand the impact of QM practices on organizational KC process. This paper addresses the research gap through

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an empirical study of aviation firms in China. Specifically, it aims to reveal the quantitative impact of QM practices on the KC process in aviation firms in China through presenting a model to demonstrate the influence of QM measures on KC.

The next section briefly reviews the literature on QM and KC and identifies the critical factors of QM. We then develop a model revealing the impact of QM practices on the organizational KC process in Section 3. The model is tested and validated in Section 4. Section 5 discusses and presents some suggestions for the improvement of QM in Chinese aviation firms. Finally, conclusions are provided in Section 6.

2. Related works

2.1. Quality management

Quality management (QM), defined as an approach to management, has of a set of mutually reinforcing principles, each of which is supported by a set of general practices and specific techniques (Dean & Bowen, 1994). QM has been shown to be particularly useful for the improvement of an organization's performance (Adam, 1994; Choi & Eboch, 1998; Hackman & Wageman, 1995; Kaynak, 2003; Mills & Smith, 2011; Samson & Terziovski, 1999).

Saraph et al., (1989) is among the first studies to examine the practices of QM. A QM instrument is used to identify eight critical factors of QM. These factors include top management support, quality reporting (which includes quality information availability and quality information usage), employee training, employee involvement, product design, supplier quality, process management, and the role of the quality department.

Since the pioneering works of Saraph et al. (1989), many studies have identified the key practices of QM and have developed measurement instruments to analyze their implementation in firms. A total of 45 different critical factors of QM have been developed by the 16 groups of researchers who conducted research in different parts of the world (Adam, 1994; Ahire et al., 1996; Anderson et al., 1994; Baidoun, 2003; Black & Porter, 1996; Choi & Eboch, 1998; Dow et al., 1999; Flynn et al., 1994; Joseph et al., 1999; Kaynak, 2003; Molina et al., 2007; Powell, 1995; Rao, Solis, & Raghunathan, 1999; Samson & Terziovski, 1999; Saraph et al., 1989; Zeitz et al., 1997), as shown in Table 1.

However, researchers in the field are unable to make a satisfactory comparison of research findings in various countries due to the disparity in the critical factors used in the research instruments. In other words, each researcher provided and discussed his or her own set of critical factors. Of the 45 different critical factors developed by the researchers, 9 were found to be the most frequently considered factors; that is, 4 or more groups of researchers developed and utilized these critical factors in their research. These 9 critical factors, ranked from the highest level to the lowest level of popularity, are as follows: (a) Top management support, (b) Customer focus, (c) Employee involvement, (d) Employee training, (e) Product design, (f) Supplier quality management, (g) Quality information availability, (h) Quality information usage, and (i) Benchmarking.

Top management acts as a driver of QM implementation, creating values, goals, and systems to satisfy customer expectations and improve an organization's performance (Ahire et al., 1996; Anderson et al., 1994). The role of top management is to formalize the organization's quality values and vision and project them in a clear, visible and consistent manner (Rao et al., 1999). Top management support not only gives high priority to quality but also provides adequate resources to the implementation of QM practices (Baidoun, 2003; Flynn et al., 1994; Joseph et al., 1999; Kaynak, 2003; Powell, 1995; Samson & Terziovski, 1999; Saraph et al., 1989; Zeitz et al., 1997).

The organization should look to its customers first in determining what it needs to do, such as using customer feedback in designing new products, monitoring customer satisfaction, responding to customer complaints, and evaluating success (Rao et al., 1999). The customer focus of an organization is usually assessed by the frequency and rigor of customer satisfaction surveys (Ahire et al., 1996). Customer focus is the ultimate measure of quality and the maintenance of a competitive advantage (Adam, 1994; Baidoun, 2003; Black & Porter, 1996; Dow et al., 1999; Kaynak, 2003; Molina et al., 2007; Powell, 1995; Samson & Terziovski, 1999; Zeitz et al., 1997).

Employee involvement is used to ensure employees' full participation (Ahire et al., 1996). Employee involvement has been found to positively impact employees' commitment to quality (Rao et al., 1999). Employee involvement encompasses a range of policies that permit employees to suggest improvements and give them the ability, motivation, and authority to continuously improve how the organization operates (Baidoun, 2003; Black & Porter, 1996; Dow et al., 1999; Flynn et al., 1994; Joseph et al., 1999; Kaynak, 2003; Molina et al., 2007; Saraph et al., 1989; Zeitz et al., 1997).

Training in quality-related concepts and tools is a prerequisite for the effectiveness of quality improvement activities (Rao et al., 1999). Only when employees have received formal, systematic training in quality management can they better understand quality-related issues (Ahire et al., 1996). Participation by various levels of employees in training sessions not only enhances the quality of the immediate session but, due to a breakdown of barriers between ranks, also aids subsequent employee participation (Anderson et al., 1994; Baidoun, 2003; Dow et al., 1999; Joseph et al., 1999; Kaynak, 2003; Molina et al., 2007; Powell, 1995; Saraph et al., 1989).

Product design is an important dimension of quality management (Ahire et al., 1996; Baidoun, 2003; Rao et al., 1999). Two objectives of product design are designing manufactured products and designing quality into the products (Kaynak, 2003). It is a thorough scrub-down process and involves all affected departments in design reviews. The emphasis of product design is on quality and the avoidance of frequent redesigns (Adam, 1994; Joseph et al., 1999; Molina et al., 2007; Saraph et al., 1989). Some important components of product design for quality are concurrent engineering, reliability engineering, and manufacturability (Flynn et al., 1994).

Supplier quality management is the basis for procuring quality parts and material (Ahire et al., 1996; Baidoun, 2003; Kaynak, 2003; Rao et al., 1999). It is an effective approach for an organization seeking to ensure quality at all stages of manufacturing (Black & Porter, 1996; Joseph et al., 1999; Molina et al., 2007; Saraph et al., 1989; Zeitz et al., 1997).

The maintenance and improvement of quality require a continuous flow of accurate information about processes that produce the organization's products (Rao et al., 1999). The availability of exact information on quality is a prerequisite for effective and efficient QM practices. It can be used to describe timely quality measurement and the feedback of quality data to top management and employees for quality-related problem solving (Baidoun, 2003; Black & Porter, 1996; Flynn et al., 1994; Joseph et al., 1999; Kaynak, 2003; Saraph et al., 1989).

Quality information usage is used to describe the extent to which quality information is shared and the cost of quality information for all process components and wide dissemination within the organization (Ahire et al., 1996; Baidoun, 2003; Joseph et al., 1999; Kaynak, 2003; Rao et al., 1999; Saraph et al., 1989; Zeitz et al., 1997).

Table 1
Critical factors of quality management.

No	Critical factors	Saraph et al. (1989)	Adam (1994)	Flynn et al. (1994)	Anderson et al. (1994)	Powell (1995)	Ahire et al. (1996)	Black & Porter (1996)	Zeitz et al. (1997)	Choi and Eboch (1998)	Dow et al. (1999)	Samson and Terziovski (1999)	Joseph et al. (1999)	Rao et al. (1999)	Kaynak (2003)	Baidoun (2003)	Molina et al.(2007)	Frequency
1	Top management support	•		•	•	•	•		•			•	•	•	•	•		11
2	Customer focus		•			•	•	•	•		•	•		•	•	•	•	11
3	Employee involvement	•		•			•	•	•		•		•	•	•	•	•	11
4	Employee training	•			•	•	•				•		•	•	•	•	•	10
5	Product design	•	•	•			•						•	•	•	•	•	9
6	Supplier quality management	•					•	•	•				•	•	•	•	•	9
7	Quality information availability	•		•				•					•	•	•	•		7
8	Quality information usage	•					•		•				•	•	•	•		7
9	Benchmarking					•	•				•			•		•	•	6
10	Strategic quality planning									•		•		•		•		4
11	Process management	•			•			•							•			4
12	Quality improve system			•				•	•							•		4
13	Role of the quality department	•		•									•					3
14	Employee empowerment		•			•	•											3
15	Statistics process control		•				•										•	3
16	Strategic quality management			•				•										2
17	Business quality planning							•					•					2
18	Internal cooperation				•						•							2
19	Human resource management									•		•						2
20	Procedure quality									•		•						2
21	Information and analysis									•		•						2
22	Suppliers relationships					•					•							2
23	Corporate quality culture							•								•		2

(*continued on next page*)

Table 1 (*continued*)

No	Critical factors	Saraph et al. (1989)	Adam (1994)	Flynn et al. (1994)	Anderson et al. (1994)	Powell (1995)	Ahire et al. (1996)	Black & Porter (1996)	Zeitz et al. (1997)	Choi and Eboch (1998)	Dow et al. (1999)	Samson and Terziovski (1999)	Joseph et al. (1999)	Rao et al. (1999)	Kaynak (2003)	Baidoun (2003)	Molina et al.(2007)	Frequency
24	Internal quality result													•		•		2
25	External quality result													•				1
26	Product quality						•											1
27	Supplier performance						•											1
28	Supervision								•									1
29	External interface management							•										1
30	Quality council													•				1
31	Quality policy												•					1
32	Technology use												•					1
33	Quality Method		•															1
34	Behavior activity		•															1
35	Quality measure					•												1
36	Open organization					•												1
37	Application of management					•												1
38	Flexible manufacturing					•												1
39	Zero-defect mentality					•												1
40	Employee fulfillment				•													1
41	Employee commitment										•							1
42	Advanced manufacturing systems										•							1
43	Application of real-time principle										•							1
44	Autonomy																•	1
45	Effective communication															•		1

Benchmarking can be defined as the search for and analysis of industry best practices that lead to superior performance (Rao et al., 1999). Benchmarking enables organizations to improve their internal systems by learning from external sources (Ahire et al., 1996; Baidoun, 2003; Dow et al., 1999; Molina et al., 2007; Powell, 1995).

2.2. Knowledge creation and knowledge creation process

Knowledge is defined as a justified belief that increases an entity's capacity for effective action (Nonaka, 1994; Sabherwal & Becerra-Fernandez, 2003). Knowledge may be viewed from several perspectives, such as a state of mind, an object, a process, a condition of having access to information, or a capability (Alavi & Leidner, 2001). A firm's competitive advantage is rooted in its own knowledge and the knowledge that it can obtain (Casselman & Samson, 2007). KC is an inherent trait of organizations (Sherif & Xing, 2006). Organizational KC is the capability of an organization as a whole to create new knowledge, disseminate it throughout the organization, and embody it in products, services, and systems (Nonaka & Takeuchi, 1995; Nonaka et al., 2000). Ikujiro Nonaka develops a theory of KC in which KC is claimed to take place through a continuous interaction between the epistemological and ontological dimensions of knowledge (Nonaka, 1994). The two basic types of knowledge are tacit knowledge and explicit knowledge. Tacit knowledge is difficult to transfer to another person through writing or verbalization. It often consists of habits and culture that we do not recognize by ourselves. Explicit knowledge is knowledge that has been or can be articulated, codified, and stored in certain media. It can be readily transmitted to others. The most common forms of explicit knowledge are manuals, documents, procedures, and how-to videos. New ideas are formed through interactions between explicit and tacit knowledge in individual human minds (Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995).

As defined by Ikujiro Nonaka, the KC process consists of socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). According to him, knowledge creation is a mutually reinforcing process of interactions between explicit and tacit knowledge. The interactions between explicit and tacit knowledge lead to the creation of new knowledge. The combination of the two categories makes it possible to conceptualize four conversion patterns or KC process, Socialization, Externalization, Combination, and Internalization (SECI), which are illustrated in Fig. 1 (Nonaka, 1994; Nonaka & Konno, 1998).

The socialization process focuses on linking between different types of tacit knowledge. Tacit knowledge goes beyond boundaries of the existing rules and meanings, and an organization obtains new knowledge in the process of interactions, such as observing, discussing, analyzing, spending time together, or living in the same environment. The socialization process is also known as converting new knowledge through shared experience. Organizations gain new knowledge from outside their boundaries through interactions with their customers, suppliers, and stack holders. For instance, this process occurs in traditional environments, where a son learns woodcraft techniques from his father by working with him (rather than by reading books or manuals).

	To tacit knowledge	To explicit knowledge
From tacit knowledge	Socialization	Externalization
From Explicit knowledge	Internalization	Combination

Fig. 1. Knowledge creation process model.

The externalization process focuses on linking tacit knowledge with explicit knowledge. It helps in creating new knowledge, as tacit knowledge moves past boundaries and becomes collective group knowledge. We can say that knowledge is crystallized in this process. The process of externalization is often driven by metaphor, analogy, and models. Quality circles are formed in manufacturing sectors, where workers attempt to improve or solve process-related issues.

Combination is a process, whereby knowledge is transformed from explicit knowledge to explicit knowledge. For instance, combination occurs when the finance department collects all financial reports from each department and publishes a consolidated annual financial performance report. Other examples of the combination process include making creative use of databases to sort or combine business reports.

Through the internalization process, explicit knowledge is created using tacit knowledge and is shared across the organization. When this tacit knowledge is read or practiced by individuals, it broadens the learning spiral of KC. Organizations can make innovations when new knowledge is shared in the socialization process. Organizations often provide training programs for their employees at different working stages. By reading these training manuals and documents, employees internalize tacit knowledge and try to create new knowledge following the internalization process.

3. Hypotheses

As mentioned above, we will investigate the impact of the QM practices on the KC process through a study of aviation firms in China. Next, we briefly introduce the Chinese aviation industry.

The main task of an aviation firm is to produce aeronautic products for different types of aircraft. In recent years, the aviation industry in China has entered a new era featuring technological development and diversification of market demand. Aviation firms must produce a huge variety of products in small batches, which has brought new challenges to production management. The production of aeronautic products is different from that of other industrial products in that it requires much higher reliability and maintainability. Firms must develop and manufacture products meeting the quality criteria in the shortest time and with the least capital.

Technology and management are two key elements that aviation firms must consider to improve the quality of aeronautic products. Technology determines the level of quality, and management determines the stability of quality. Along with the application of advanced manufacturing technology, human resources assume a more prominent role in product quality in many aviation firms. Through interviews conducted with the leaders of these firms, we found that these leaders almost all believe that to effectively improve product quality, organizations must implement an employee compensation system that connects quality and customer satisfaction. Therefore, we added "recognition and reward" activities to the list provided in Section 2.1 as a potential critical factor of QM practices.

Enterprises can be divided into two types on the basis of whether they have a well-accepted vision. The first type of enterprises has an explicit vision that is fully accepted by the employees. Those firms are often ranked at the top in the industry. By contrast, the second type focuses primarily on sale enhancement. These firms either do not have an explicit vision at all or a vision that is not well accepted by the employees. These companies are seldom listed at the top in their sectors. Most interviewees state that if personnel share the same vision with their company, the company has a foundation that paves the way to success. The vision is a type of expectation, forecast, or orientation on the enterprise's future development that is formed on the basis of current operation and management requirement. To implement the vision, the organization must prepare a system plan, which might be an explicit business plan, a quality guideline, a quality target, or a system quality improvement program, etc. Staff members will increase their commitment to QM if they accept all of these targets. Therefore, we hypothesize that a company's vision will significantly affect the quality of aviation products and added "vision statement" as a critical factor of QM practices.

In addition, it is found during the interviews that neither the managers nor the employees could distinguish between the availability and use of quality information. We thus combine the two critical factors as "quality information" to avoid misunderstanding.

Consequently, we obtain 10 critical factors predicted to influence the quality of aeronautic products. They are: as follows top management support, customer focus, employee involvement, employee training, product design, supplier QM, quality information, benchmarking, recognition and reward, and vision statement.

Knowledge management theories can enrich our understanding of QM (Choo et al., 2007). Nonaka's theory of KC in particular can shed light on QM, and various QM practices can support these knowledge conversion processes. In other words, organizations can create more knowledge by deploying QM practices that support their KC processes (McAdam, 2004). Based on the preceding analysis, we hypothesize that QM practices have positive effects on the KC process. A set of research hypotheses are developed in this study for empirical validation. Each hypothesis is to be used to measure the impact of a specific QM practice on the KC process. These hypotheses are:

H1: Top management support has a positive impact on the KC process.
H2: Employee training has a positive impact on the KC process.
H3: Customer focus has a positive impact on the KC process.
H4: Supplier QM has a positive impact on the KC process.
H5: Employee involvement has a positive impact on the KC process.
H6: Product design has a positive impact on the KC process.
H7: Benchmarking has a positive impact on the KC process.
H8: Quality information has a positive impact on the KC process.
H9: Vision statement has a positive impact on the KC process.
H10: Recognition and reward has a positive impact on the KC process.

4. Research methodology and data analyses

4.1. Research methodology

Based on the model advanced in the previous section, we designed a questionnaire and commission Aviation Industry Corporation of China (AVIC) to conduct a survey to obtain information related to QM and KC from five aviation firms located in eastern China. All of these firms have a good reputation for their QM practices and their use of more mature Information and Communication Technology (ICT). A total of 250 questionnaires were distributed, and 233 valid copies were returned. The responses received constituted a massive volume of highly dimensional data, requiring the application of advanced data analysis methods. Highly dimensional data are often transformed into lower-dimensional data via Principal Component Analysis (PCA), which enables coherent patterns to be detected more clearly. PCA is among the oldest and best-known techniques of multivariate analysis. In this study, we use SPSS 16.0 to conduct PCA and Amos 17.0 for Structural Equation Modeling.

4.2. Questionnaire development

A questionnaire was designed to measure the QM practices impacting the KC process. It was developed on the basis of a comprehensive literature review, the author's experience with quality and KC, and preliminary research. The 33 questions used for measuring the impact of QM practices on the KC process in the questionnaire are shown in Table 2. Five-point Likert scales were developed to evaluate the impact of QM practices on the KC process. Respondents were asked to indicate their degree of agreement toward each statement, from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, to 5 = strongly agree.

4.3. Characteristics of respondents

The hypotheses were examined using data collected in a survey of aviation firms in China covering three different domains, such as avionics, aviation chemicals, and aviation machinery. A total of 250 questionnaires are distributed, and 233 valid copies are returned, making the valid response rate at 93.2%. Of the respondents, 67.38% are male, and 32.62% are female. A majority of the respondents had at least a bachelor's degree (56.66%). Most respondents have worked there for over 3 years (78.54%). The respondents come from different departments, such as sales, production, design, quality and others. Table 3 lists the basic attributes of the respondents.

4.4. Skewness and kurtosis analysis

Table 4 provides descriptive statistics (by SPSS) by questionnaire items for the respondents. The results of means, median, skewness and kurtosis, as shown in the table, indicated that for the construct representing the impact of QM practices on the KC process, respondents tend to perceive very high levels of agreement on the question items with mean scores over 3.1 in a 5-range scale for all of the questions. In Table 4, the mean is closer to the median, skewness does not exceed 1.7, and kurtosis is less than 3. These data are consistent with the normal distribution.

4.5. Reliability of the scale

The reliability analysis of a measurement instrument determines its ability to yield consistent measurements. Cronbach's α is used to measure the inter-item consistency in our study. Cronbach's α ranges between 0 and l. A higher value indicates higher consistency. The results (see Table 5) show that all sub-scales have values ranging from 0.792 to 0.931, indicating that the scale is reliable.

4.6. Content validity

Content validity represents the adequacy with which a specific domain of content has been sampled, that is, whether the instrument is truly a comprehensive measure of the QM practices impacting the KC process. Strictly speaking, content validity is not a scientific measure of a survey instrument's accuracy. Nevertheless, it provides a solid foundation on which to build a methodologically rigorous assessment of a survey instrument's validity. In this research, it was argued that the 10 scales measuring the impact of QM practices on the KC process have content validity, as the development of the measurement items is primarily based on an extensive review of the literature and detailed evaluations by academicians and practitioners. To ensure the validity of the questionnaire survey, a small sample was used to test it. The references list the literature reviewed by the researchers during the period of this study.

Table 2
Questions used for measuring the impact of QM practices on KC process in our questionnaire.

QM practices	Questions		Degree of agreement
Top management support	QM11	The relative importance given by top management to quality versus cost and schedule may help us form consensus and achieve goals of KC process (Socialization or tacit to tacit process)	1 2 3 4 5
	QM12	Top management believes that QM practices affect the performance by impacting on KC process (Externalization or tacit to explicit process)	1 2 3 4 5
	QM13	Clear quality goals help us form consensus and goals of KC, or QM practices impact Socialization (tacit to tacit) process	1 2 3 4 5
	QM14	The importance of quality often mentioned by top management in management meetings encourage us to capture explicit knowledge and converting it into tacit knowledge, or QM practices impact Internalization (explicit to tacit) process	1 2 3 4 5
Employee training	QM21	More availability of resources for employee quality training gives us a better chance to reach a common understanding of the explicit knowledge, or QM practices impact Externalization(tacit to explicit) process	1 2 3 4 5
	QM22	Greater frequency of quality training enable individuals to express, summarize, understand, view explicitly the knowledge, or QM practices impact Externalization (tacit to explicit) process	1 2 3 4 5
	QM23	Quality management methods (tools) learned in the training may help employees to capturing explicit knowledge and converting it into tacit knowledge, or QM practices impact Internalization (explicit to tacit) process	1 2 3 4 5
Customer focus	QM31	Quality-related customer complaints treated with top priority and resolved enable employees to express to each other their ideas in light of their experience to correct the complaints, or QM practices impact Socialization (tacit to tacit) process	1 2 3 4 5
	QM32	Market research in order to collect suggestions and customer complaints for improving products enable individuals to express to each other their ideas in light of their experience to correct the complaints, or QM practices impact Socialization(tacit to tacit) process	1 2 3 4 5
Supplier QM	QM41	Relative emphasis placed by the organization on the quality of purchased parts versus their price enable us to take full advantage of the vendor's explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM42	Involvement of the supplier in the product development process enable us to take full advantage of the vendor's explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
Employee involvement	QM51	Extent of cross-functional teams usage enable individuals to express to each other their ideas in light of their experience, or QM practices impact Socialization(tacit to tacit) process	1 2 3 4 5
	QM52	Usage of quality circles makes us good aware of explicit relationships between QM process elements, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
Product design	QM61	New product design reviews enable us to capture and transfer of expert' tacit knowledge, or QM practices impact Externalization(tacit to explicit) process.	1 2 3 4 5
	QM62	Quality of new products emphasized in relation to cost or schedule objectives enable us to adopt and understand best practices from other fields and projects, or QM practices impact Internalization (explicit to tacit) process	1 2 3 4 5
	QM63	Productivity considered in the product design process enable us to adopt and understand best practices from other fields and projects, or QM practices impact Internalization (explicit to tacit) process	1 2 3 4 5
	QM64	Coordination among affected departments in the product development process enable individuals to express to each other their ideas in light of their experience, or QM practices impact Socialization(tacit to tacit) process	1 2 3 4 5
Benchmarking	QM71	Emphasis on benchmarking other enterprises' quality management methods enable us to take full advantage of their explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM72	Emphasis on benchmarking current competitors' product quality enable us to take full advantage of their explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM73	Emphasis on benchmarking current world leader' product quality enable us to take full advantage of their explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM74	Emphasis on benchmarking competitors' quality process enable us to take full advantage of their explicit knowledge, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
Quality information	QM81	Availability of quality data enable us focused on making sense of explicit knowledge to make it specifically useful for the quality process improvement, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM82	Timeliness ofthe quality data enable us focused on making sense of explicit knowledge to make it specifically useful for the quality process improvement, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
	QM83	Extent to which quality data are available to managers and supervisors enables us to focus on making explicit knowledge useful for quality process improvement, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5

(*continued on next page*)

Table 2 (*continued*)

QM practices		Questions	Degree of agreement
	QM84	Extent to which quality data are used to evaluate supervisor and managerial performance enables us to focus on making sense of explicit knowledge to make it specifically useful for the quality process improvement, or QM practices impact Combination(explicit to explicit) process	1 2 3 4 5
Vision statement	QM91	Clear long-term vision statement may help us form consensus and goals of KC, or QM practices impact Socialization (tacit to tacit) process.	1 2 3 4 5
	QM92	The vision statement effectively encourages employees' commitment to quality improvement, or QM practices impact Socialization (tacit to tacit) process.	1 2 3 4 5
	QM93	Effective quality improvement plan may enable us to exchange tacit knowledge by brainstorming ideas, QM practices impact Internalization (explicit to tacit) process	1 2 3 4 5
	QM94	Communication of the various quality policies and plans to the employees from different levels enables individuals to express to each other their ideas in light of their experience, or QM practices impact Socialization(tacit to tacit) process	1 2 3 4 5
Recognition and reward	QM101	Salary raises for encouraging employee participation in quality improvement enable individuals to express explicitly the knowledge they have created jointly through the exchange of tacit knowledge, QM practices impact Externalization(tacit to explicit) process	1 2 3 4 5
	QM102	Position promotions based on work quality in our company enable individuals to express explicitly the knowledge they have created jointly through the exchange of tacit knowledge, QM practices impact Externalization(tacit to explicit) process	1 2 3 4 5
	QM103	Rewarding of excellent quality suggestion senables individuals to express explicitly the knowledge they have created jointly through the exchange of tacit knowledge, QM practices impact Externalization(tacit to explicit) process	1 2 3 4 5
	QM104	Clarity of employees' rewards and penalties enables individuals to express explicitly the knowledge they have created jointly through the exchange of tacit knowledge, QM practices impact Externalization(tacit to explicit) process	1 2 3 4 5

Table 3
Characteristics of respondents ($n = 233$).

Characteristics	Frequency	Percentage (%)
Gender		
Male	157	67.38
Female	76	32.62
Age		
Less than 30	91	39.06
30–40	68	29.18
40–50	48	20.6
More than 50	26	11.16
Education		
Junior high school	8	3.43
Senior high school	36	15.45
Junior college	57	24.46
College	102	43.78
Graduate and above	30	12.88
Department		
Sale	20	8.58
Purchasing	14	6.01
Production	70	30.04
Design	59	25.32
Quality	51	21.89
Human resources	2	0.86
Finance	6	2.58
Others	11	4.72
Position		
Staff	182	78.11
Manager	48	20.6
Senior manager	3	1.29
Working time		
Less than 1 year	16	6.87
1–2 year	34	14.59
3–5 year	52	22.32
6–10 year	58	24.89
More than 10 year	73	31.33
Enterprise scale		
Large scale	51	21.89
Medium scale	99	42.49
Small scale	83	35.62
Industry		
Avionics	86	36.91
Aviation chemicals	76	32.62
Aviation machinery	71	30.47

4.7. Construct validity

Construct validity, which shows the extent to which measures of a criterion are indicative of the direction and size of that criterion, is analyzed through factor analysis. To use PCA to reduce the high dimensionality, we must apply a correlation test, as it is meaningful to conduct PCA only when the correlation test is eligible. Correlation tests included the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test. The results of the tests are shown in Table 6. The KMO Measure of Sampling Adequacy varies between 0 and 1, with values closer to 1 being better and a value of 0.5 being a suggested minimum. This value in our study is 0.958, which is greater than the suggested minimum. Bartlett's Test of Sphericity tests the null hypothesis that the correlation matrix is an identity matrix. The values in our study are eligible. Given the above results of the two tests, it is valid to proceed with a PCA.

The Communalities and Total Variance Explained are shown in Table 7 and Table 8. Communalities are the proportion of each variable's variance that can be explained by the principal components. The Initial column shows that the initial value of the communality in a PCA is 1, whereas the values in the Extraction column indicate the proportion of each variable's variance that can be explained by the principal components. Variables with high values are well represented in the common factor space,

Table 4
Descriptive statistics.

Question no.	Mean	Median	Skewness	Kurtosis
QM11	4.08	4	−1.001	0.445
QM12	3.94	4	−0.774	0.148
QM13	4.46	5	−1.641	2.928
QM14	4.12	4	−0.881	0.203
QM21	3.62	4	−0.745	−0.076
QM22	3.65	4	−0.758	0.127
QM23	3.11	3	−0.377	−0.672
QM31	3.86	4	−0.564	−0.11
QM32	4.13	4	−0.609	−0.252
QM41	3.7	4	−0.691	0.006
QM42	3.37	3	−0.308	−0.355
QM51	3.58	4	−0.304	−0.227
QM52	3.42	4	−0.264	−0.418
QM61	4.06	4	−0.89	1.338
QM62	3.9	4	−0.77	0.613
QM63	3.87	4	−0.68	0.734
QM64	3.59	4	−0.698	0.128
QM71	3.51	4	−0.374	0.165
QM72	3.69	4	−0.468	−0.279
QM73	3.6	4	−0.528	−0.145
QM74	3.55	4	−0.407	−0.267
QM81	3.71	4	−0.377	−0.536
QM82	3.77	4	−0.508	−0.414
QM83	3.83	4	−0.435	−0.469
QM84	3.44	4	−0.467	0.021
QM91	4.14	4	−0.813	−0.19
QM92	3.81	4	−0.674	0.035
QM93	4.21	4	−1.045	1.694
QM94	3.92	4	−0.691	0.355
QM101	3.56	4	−0.719	0.096
QM102	3.47	4	−0.348	−0.572
QM103	3.65	4	−0.509	−0.163
QM104	3.74	4	−0.621	0.101

Table 5
Reliability of the scale.

Scales	Number of questions	Cronbach's α
Top management support	4	0.847
Employee training	3	0.87
Customer focus	2	0.792
Supplier QM	2	0.817
Employee involvement	2	0.818
Product design	4	0.819
Benchmarking	4	0.931
Quality information	4	0.924
Vision statement	4	0.894
Recognition and reward	4	0.904

Table 6
KMO and Bartelett's test.

Validity item	QM dimension
KMO measure of sampling	0.958
Adequacy Bartlett's test of sphericity approximately chi-square	8.361E3
df	1035
Sig.	0.000

whereas variables with low values are not well represented. In our study, we did not find any particularly low values.

The extracted principal components are shown in Table 8. There are as many components extracted during a PCA as there are variables that are input. In this study, we used 33 variables, so we have 33 components. Eigenvalues are the variances of the principal components. Because we conducted principal components analysis on the correlation matrix, the variables are standardized, indicating that each variable has a variance of 1, and the total variance is equal to the number of variables used in the analysis, i.e., 33. The first Total column contains eigenvalues, the % of Variance column contains the percent of variance accounted for by each principal component, and the Cumulative % column contains the cumulative percentage of variance accounted for by the current and all preceding principal components. The three columns of Extraction Sums of Squared Loadings exactly reproduced the values given on the same row on the left side of the table. The number of rows reproduced on the right side of the table is determined by the number of principal components whose eigenvalues are 1 or greater. We extracted 10 principal components whose eigenvalues were 1 or greater, and the cumulative percentage of variance was 73.837%, indicating that the 10 principal components could explain 73.837% of all of the variance.

The underlying dimensional structure of the QM practices impacting the KC process was assessed using a PCA with the Varimax method of orthogonal rotation. The results reveal that the construct is consistent with the target established above. The communalities of all variables are above 60%. The accumulated Variance of QM is 73.837%.

4.8. Structural model

After the specification of the validity and reliability of each criterion, we used summated scales as one of the methods for subsequent analysis. The average of the scales under each criterion was measured and used as new observed variables in a subsequent analysis. To analyze the model, Structural Equation Modeling (SEM) with Amos 17.0 was performed.

To assess the overall model fit, four absolute fit measures (χ^2/df, RMSEA, RMR, and PGFI) and two incremental fit measures (IFI and CFI) are used. The fit indices used in this study to estimate the relationship model are the ratio of χ^2 to degrees of freedom (χ^2/df), the Root Mean Square Error of Approximation (RMSEA), the Root Mean Square Residual (RMR), the Parsimony Goodness-of-Fit Index (PGFI), the Incremental Fit Index (IFI), and the Comparative Fit Index (CFI). These fit indices, with the exception of RMSEA, were chosen because of their ability to adjust for model complexity and degrees of freedom. Although RMSEA is sensitive to model complexity, it is one of the most informative criteria for absolute fit. Recommended values of these fit indices for the satisfactory fit of a model to data are presented in Table 9. All of the measures meet the recommended values. In general, the indicators conform to basic recommended values, meaning that this study possesses good model fit; i.e., our research model is the one that conforms to actual data.

To explore the findings further, we propose a detailed model as Fig. 2. The figure depicts the SEM results of the impact of QM practices on the KC process. Each path in the figure indicates the associated hypotheses as well as the estimated path coefficients ($^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$). The goodness-of-fit measures used to assess the fit of the data to the hypothesized model are presented in Table 9.

The path coefficients and their significance levels are shown in Table 10. It can be observed that employee training (0.317^{***}, *t*-value = 3.480, $P = 0.000$), employee involvement (0.357^{*}, *t*-value = 2.431, $P = 0.015$), product design (0.182^{*}, *t*-value = 2.131, $P = 0.033$), benchmarking (0.350^{***}, *t*-value = 4.091, $P = 0.000$), and vision statement (0.191^{*}, *t*-value = 2.281, $P = 0.023$) significantly influence the KC processes (the solid line in Fig. 2). However, the effects of top management support (0.097, *t*-value = 1.148, $P = 0.251$), customer focus (0.116, *t*-value = 0.294, $P = 0.769$), supplier quality management (0.067, *t*-value = 0.354, $P = 0.723$), quality information (0.084, *t*-value = 1.075, $P = 0.282$), and recognition and reward (0.012, *t*-value = 0.144, $P = 0.885$) on the KC processes are not supported (the dotted line in Fig. 2).

Table 7
Communalities.

Indicators	Initial	Extraction	Indicators	Initial	Extraction	Indicators	Initial	Extraction	Indicators	Initial	Extraction
QM11	1	0.64	QM41	1	0.746	QM72	1	0.873	QM93	1	0.684
QM12	1	0.658	QM42	1	0.718	QM73	1	0.821	QM94	1	0.692
QM13	1	0.698	QM51	1	0.75	QM74	1	0.79	QM101	1	0.779
QM14	1	0.718	QM52	1	0.784	QM81	1	0.81	QM102	1	0.732
QM21	1	0.792	QM61	1	0.673	QM82	1	0.844	QM103	1	0.72
QM22	1	0.756	QM62	1	0.633	QM83	1	0.778	QM104	1	0.726
QM23	1	0.757	QM63	1	0.76	QM84	1	0.632			
QM31	1	0.73	QM64	1	0.704	QM91	1	0.804			
QM32	1	0.706	QM71	1	0.681	QM92	1	0.777			

Table 8
Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% Of variance	Cumulative %	Total	% Of variance	Cumulative %
1	12.091	36.64	36.64	12.091	36.64	36.64
2	2.303	6.979	43.619	2.303	6.979	43.619
3	1.779	5.392	49.011	1.779	5.392	49.011
4	1.677	5.083	54.094	1.677	5.083	54.094
5	1.422	4.31	58.404	1.422	4.31	58.404
6	1.179	3.574	61.978	1.179	3.574	61.978
7	1.111	3.365	65.343	1.111	3.365	65.343
8	0.982	2.975	68.318	0.982	2.975	68.318
9	0.917	2.779	71.097	0.917	2.779	71.097
10	0.904	2.74	73.837	0.904	2.74	73.837
11	0.772	2.339	76.176			
12	0.692	2.097	78.273			
13	0.64	1.939	80.212			
14	0.608	1.841	82.053			
15	0.566	1.716	83.769			
16	0.524	1.589	85.358			
17	0.502	1.522	86.88			
18	0.459	1.392	88.272			
19	0.419	1.27	89.542			
20	0.392	1.187	90.729			
21	0.371	1.125	91.854			
22	0.342	1.037	92.891			
23	0.319	0.968	93.859			
24	0.292	0.884	94.743			
25	0.285	0.862	95.605			
26	0.262	0.793	96.398			
27	0.223	0.677	97.075			
28	0.212	0.642	97.717			
29	0.2	0.605	98.322			
30	0.177	0.537	98.859			
31	0.157	0.475	99.334			
32	0.122	0.369	99.702			
33	0.098	0.298	100			

Table 9
Fit measures result.

Goodness-of-fit measure	Value	Recommended cut-off value
χ^2/df	1.52	<5
RMSEA	0.058	⩽0.08
RMR	0.036	⩽0.08
PGFI	0.905	⩾0.90
IFI	0.952	⩾0.90
CFI	0.951	⩾0.90

5. Discussion

We hypothesize, based on a theoretical analysis of the literature, that QM practices have a significant effect on the organizational KC process (Molina et al., 2007; Nonaka, 1994; Nonaka & Konno, 1998; Saraph et al., 1989; Söderlund, 2010). We divided the general hypothesis into 10 detailed ones and then verified these hypotheses, concluding that efficient QM practices could promote the KC process in an organization, which supports the idea that QM can enhance enterprise performance. To be specific, we arrive at the following conclusions.

Employee training, employee involvement, product design, benchmarking, and vision statement can significantly impact the KC process in aviation firms in China, whereas top management support, customer focus, supplier QM, quality information, and recognition and reward have less of an effect on the KC process.

Mathews et al. (2001) consider the cornerstone of QM to be training, which determines the effect of quality measures. Aviation firms in China generally emphasize training, teaching employees new techniques and methods to enable them to gain access to more internal information, and promoting their personal knowledge and ability. Quality training gives employees more of a chance to understand explicit knowledge and helps them to capture explicit knowledge and convert it into tacit knowledge. QM practices

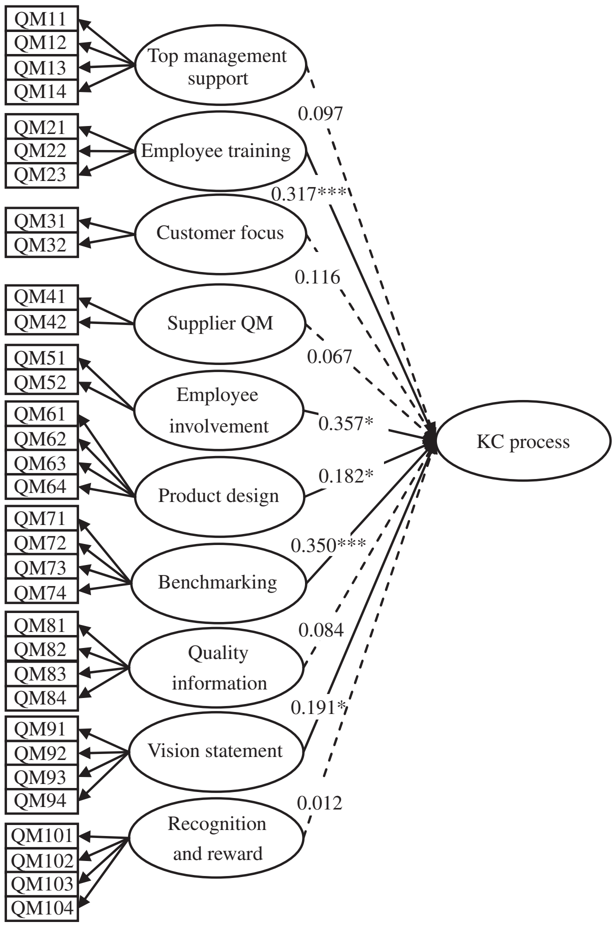

Fig. 2. Structural model of the impact of QM practices on the KC process.

Table 10
Path analysis result and hypotheses test.

Hypotheses and path	Estimate	t-Value	P	Result
H1: Top management support → KC	0.097	1.148	0.251	Unsupported
H2: Employee training → KC	0.317	3.48	0	Supported
H3: Customer focus → KC	0.116	0.294	0.769	Unsupported
H4: Supplier quality management → KC	0.067	0.354	0.723	Unsupported
H5: Employee involvement → KC	0.357	2.431	0.015	Supported
H6: Product design → KC	0.182	2.131	0.033	Supported
H7: Benchmarking → KC	0.35	4.091	0	Supported
H8: Quality information → KC	0.084	1.075	0.282	Unsupported
H9: Vision statement → KC	0.191	2.281	0.023	Supported
H10: Recognition and reward → KC	0.012	0.144	0.885	Unsupported

can significantly impact the Externalization (tacit to explicit), Socialization (tacit to tacit), and Internalization (explicit to tacit) processes. Employees are able to acquire more competence through quality training, potentially dramatically enhancing organizational KC process.

Quality circles and cross-functional teams are important forms of employee involvement for Chinese aviation firms. Employees from different departments can assume responsibility for solving problems collectively, which can improve communication among employees and eliminate barriers between different functional departments. The use of cross-functional teams enables employees to share their ideas in light of their experience and promote the sharing of tacit knowledge. Quality circles make them better aware of explicit relationships between QM process elements. QM practices can significantly impact the Combination (explicit to explicit) and Socialization (tacit to tacit) process.

It is well known that aviation products are very complicated. With complicated products, faults in some development process could lead to 50% of application problems. Customer focus is one key factor in the product development process. To fully comply with customers' requirements, an increasing number of firms assemble employees from different departments, including manufacturing, marketing, purchasing, and QM, as well as various experts, to discuss details of product design and ensure product quality. The review of new product design enables employees to capture and transfer experts' tacit knowledge, adopt and understand best practices from other fields and projects, and share ideas in light of their experience. QM practices impact the Externalization (tacit to explicit), Internalization (explicit to tacit), and Socialization (tacit to tacit) processes. All of these factors may promote knowledge sharing and creation.

The key to benchmarking is to learn from the best companies in or out of one's industry. The process of benchmarking management can be divided into five procedures in Chinese aviation firms: planning, internal data collection and analysis, external data collection and analysis, implementation and adjustment, and continuous improvement. Plan establishment depends on communication and research among employees. The data collection and analysis processes include the systematization and organization of knowledge. Because implementation and improvement is a continuous process of learning and enhancement, firms can reconsider and improve their operations and set best practices after learning from advanced organizations. It can be said that QM practices may impact the Combination (explicit to explicit) process, which is shown as the knowledge imitation and creation processes.

Vision is the view shared by employees. The communication process can aid tacit knowledge sharing and promote KC among employees. Following clear statements by management, a vision can inspire morale and a spirit of utter devotion. Molina et al. (2007) deem the spirit of devotion to be the foundation of KC and to promote KC activities. It can be said that QM practices impact the Socialization (tacit to tacit) and Internalization (explicit to tacit) processes.

On the other hand, the remaining factors do not play an equally important role in promoting the KC process, which includes top management support, customer focus, suppliers QM, quality information, and recognition and reward. After interviews with top managers of these aviation firms, we find that they attach great importance to product quality because aviation products are concerned with flight safety. All of these firms have passed quality system certifications that are used to ensure product quality. The support of top management for product quality is evident in the following actions: setting explicit quality policies and goals, providing more QM training to employees, authorizing employees to participate in QM, and providing adequate resources to QM. However, these procedures do not directly affect the KC process. The impact of top management support on the KC process is reflected by the direct impact on other QM practices. For example, the practices of a vision statement and benchmarking reflect the characteristics of quality policies and goals of top management support. The training characteristic is reflected by employee training practice. The practices of employee involvement and product design reflect the other characteristics of top management support. Some employees believe that top management's support for quality is often mere empty sloganeering and propaganda. They further believe that specific QM methods and tools improve enterprise performance.

The key of customer focus is to remain in touch with customers and to obtain tacit information about customers' demand for product quality, which could be used in the product design and quality improvement process. In our survey of Chinese aviation firms, we find that the employees from the business layer do not clearly understand the key attributes affecting the use of products as well as the installing environment. This finding is primarily caused by insufficient communication with customers. In addition, some technicians and managers do not fully share their experience and knowledge, which is gained from customers. Therefore, the customer focus should be further reinforced in aviation firms in China.

Complying with the requirement of QM systems, each firm should have a list of qualified suppliers. Many aviation firms may review the supplier's quality system regularly and select the qualified partners. However, most firms would pay more attention to the delivery schedule when facing arduous orders. Meanwhile, these firms usually impose many requirements on their employees rather than have discussions with them. In such cases, the KC process cannot be effectively promoted.

By far, most quality information about aviation products is preserved and delivered in writing, which is relatively inconvenient to use and look up. This inhibits the sharing and analysis of quality information among employees. In addition, these aviation firms face a serious lack of professional employees who are proficient in the use of fundamental quantitative analysis tools. At present, quality information is not effectively used in daily production decision making processes. Quality information on the impact of the KC process is not fully reflected in the aviation industry in China.

We have also found that many firms are building their quality motivation mechanisms. Quality factor is one key part in their personnel performance evaluations. The final goal of the motivation system is to spur employees to work more proactively and participate actively in quality improvement. However, the direct impact of the quality motivation system on the KC process continues not to be reflected.

6. Conclusions

In this paper, we have studied the impact of the QM practices on the organizational KC process. Our main finding is that some QM practices directly impact the KC process and that other QM practices have a less direct impact on the KC process. The results indicate that not all QM practices have a great impact on the organizational KC process. Some studies suggest that QM practices create knowledge and that KC leads to organizational performance (Choo et al., 2007; Linderman et al., 2004). However, these studies do not distinguish using quantitative research the different roles of QM practices impacting the KC process. Our study offers new insights into the impact of the QM practices on the KC process, contributing to theoretical understanding about organizational QM practices and knowledge management behavior.

The aviation industry in China is highly representative of industrial sectors in general. From the perspective of the aviation industry, this research has great potential for practical application. Many Chinese firms conduct QM practices and KC activities and are eager to understand the interaction between QM practices and the KC process. Firms maintaining a set of QM practices supporting KC processes should be more effective in conducting these QM practices. This study indicates that some effective QM practices, such as employee training, employee involvement, product design, benchmarking, and vision statements, should be given more attention. The insights of this study provide practical guidance for practitioners of QM and employees engaging in KC activities.

Our results should be considered in light of some limitations. The sample size of 233 respondents from five aviation firms prevents us from making stronger claims about the generalizability of the results. Future studies replicating our approach but employing more participants from more firms are appropriate. This study primarily focuses on the impact of the QM practices on the organizational KC process and does not consider the impact of the KC process on QM practices. Future studies should consider the impact of an organizational KC process on QM practices.

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