Drivers and Barriers for Implementing Advanced Manufacturing Technology in China's Furniture Industry: An Exploratory Study

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Abstract

Results of this exploratory study provide insights into the implementation of advanced manufacturing technology (AMT) in China's furniture industry by using a multiple-case study approach. Qualitative interviews were conducted with upper managers and specialists in production and human resource management from four Chinese furniture firms that are viewed as pioneers in implementing computer-integrated manufacturing (CIM) in China's furniture industry. The findings show that key drivers for implementing AMT in the Chinese furniture firms are problems in production process, the need to reduce dependence on employees' work skills, and difficulties in recruitment arising from increased labor costs and a shortage of skilled workers. In addition, findings of the study reveal that the barriers to AMT implementation in Chinese furniture firms are not only from the technology side but also due to nontechnological aspects. These results could help decision makers in conducting process innovation with regard to both technological and nontechnological aspects, as well as in taking their interactions into account. Moreover, our findings may also help forest products industries in other emerging countries that are moving toward introducing new working systems.

Overview of China's Furniture Industry

China's furniture industry has developed rapidly over the past three decades. In 1978, the total output value of China's furniture industry was just 1.3 billion yuan. With booming development, the output value of the entire furniture industry amounted to over 600 billion yuan in 2008 and topped 700 billion yuan with a greater than 10 percent increase in 2009 (China Industry Development Research Web [Chinaidr] 2010, China Wood Web [Chinawood] 2011). This performance is impressive, especially considering the global economic slowdown at that time (CSIL Market and Industry Research Institute 2010). The total output value of China's furniture industry was expected to reach 900 billion yuan in 2010, nearly 700 times the value in 1978 (Fig. 1). Today, China has emerged as the largest furniture producer in the world, with 60,000 firms and more than 6.5 million employees (Chinaidr 2010).

As is widely known, the booming growth of China's furniture industry can be mainly attributed to an abundant work force and low costs (Cao et al. 2004, Cao and Hansen 2006, Han et al. 2009, Han 2010). However, there are gaps in productivity at labor, management, and technical levels as compared with developed countries (Han et al. 2009). The labor productivity of the Chinese furniture industry was reported to be 35,000 yuan per worker per year in 2009, which was still lower than the average level worldwide (Chinaidr 2010). Furthermore, increased domestic and international competition in an unfavorable macro-economic environment also enhanced the need for process innovation in China's furniture industry.

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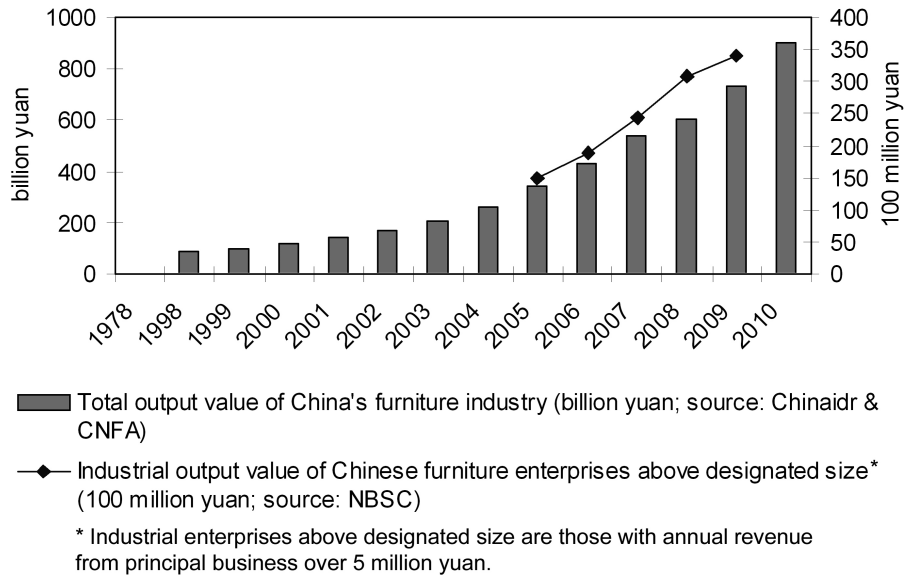

Figure 1.—Output value of China's furniture industry from 1978 to 2010 (National Bureau of Statistics of China 2006–2009, China Industry Development Research Web 2010, China National Furniture Association 2011).

Definition and Benefits of Advanced Manufacturing Technology

In a broad sense, advanced manufacturing technology (AMT) refers to a variety of both hard and soft technologies developed to improve manufacturing capabilities (Chung and Swink 2009). In previous studies, AMT has been broadly and diversely categorized in several subgroups (Table 1). In general, AMT represents a wide variety of modern computer-based or numerical control-based systems devoted to improving manufacturing operations. It has been widely acknowledged that the successful implementation of AMT provides dramatic benefits to the firms adopting such technologies in terms of improving labor productivity, product quality, reliable production, production flexibility, profitability, plant performance, and meeting customer demand as well as leading to reduced manufacturing costs (Ghani and Jayabalan 2000, Efstathiades et al. 2002, Dangayach et al. 2006, Gunawardana 2006, Song et al. 2006, Chung and Swink 2009). Therefore, a study of AMT implementation is one of the key components of innovation and thereby an enhancement of industry competitiveness.

The objective of this study was to learn about recent conditions and related activities surrounding AMT implementation in China's furniture industry.

Theoretical Framework

The concept of a socio-technical system was established to stress the interrelationship between humans and machines and to foster both the technical and social conditions of work in a way that efficiency and humanity would no longer conflict with each other (Ropohl 1999). Based on the principle of a socio-technical system, the Mensch (human)–Technik (technology)–Organisation (organization) model (MTO model) by Strohm (1997) and Ulich (2005) presents the relationships and interactions of humans, organization, and technology in a sustainable working system (Fig. 2). In this study, the MTO model was used to explain the mutual relationship between technological and nontechnological factors in the process of implementing AMT.

Methodology

Based on the ''specific-general'' approach, this study used a multiple-case study method. Yin (2002) defined a case study as an empirical inquiry that investigates a contemporary phenomenon within a real-life context, especially when the boundaries between the phenomenon and context are not clearly evident. In a multiple-case study, one goal is to build a general explanation that fits each of the individual cases, even though the cases vary in their details. In addition, Yin presented the view of Herriott and Firestones (1983) that the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as more robust as compared to a single-case study.

Utilizing the principle of triangulation, data were collected by using multiple sources, including face-to-face interviews, observation, and documentation in the case-study firms. Yin (2002) argues that the use of multiple sources of evidence in case studies allows an investigator to address a broader range of historical, attitudinal, and behavioral issues. However, the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry. Thus, any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information.

Study Design

Case selection

At the beginning of the case selection process, six firms were identified as being pioneers of AMT implementation by experts in the field of Chinese furniture manufacturing. These firms were either preparing or beginning to introduce AMT within the following year. A letter of introduction, project proposal, and reference letters were sent to the top managers at the firms in April 2009. Within the next few weeks, we received positive replies from five of the six firms. Because literature and documents related to AMT implementation in the selected firms were limited, 1 to 2

Table 1.—Classifications of advanced manufacturing technology (AMT).

Resource	Classification	Description	Examples of AMT
Ghani and Jayabalan (2000), Ghani et al. (2002)	Level 1	Stand-alone machine tools or equipment that is controlled by self-contained computers	Numerically controlled machine tools and robots
	Level 2	Manufacturing cells based on a grouping of machines to perform a variety of tasks to produce a family of parts	Group technology (GT), flexible manufacturing system (FMS), and computer-aided engineering (CAE)
	Level 3	Cells are connected to form linked islands through a computerized information network	Computer-aided design/computer-aided manufacturing (CAD/CAM), automated storage and retrieval systems (AS/RS), group technology/computer-aided process planning (GT/CAPP), and manufacturing resources planning (MRP)
	Level 4	All of the manufacturing activities, including the marketing of products, are integrated through an information network	Computer-integrated manufacturing (CIM)
Dangayach et al. (2006)	Direct AMT (hardware)	Technology used on the factory floor to cut, join, reshape, transport, store, or modify materials	Computer numerical control (CNC), direct numerical control (DNC), robotics (RO), FMS, AS/RS, automated material handling systems (AMHS), automated guided vehicles (AGV), rapid prototyping (RP)
	Indirect AMT (software)	Technology used to design products and schedule production	CAD, MRP, statistical process control (SPC), bar coding (BC), material requirement planning (MRP)
	Administrative AMT (brainware)	Technology used to give administrative support to the factory and integrate its operations with the rest of the organization	Enterprise resource planning (ERP), activity-based costing (ABC), and office automation (OA)
Chung and Swink (2009), Zhou et al. (2009)	Design AMT	The focus is on product and process design	CAD and CAE
	Manufacturing AMT	Refers to computer-controlled processes in fabrication or assembly industries, automatic material handling, automatic storage, and retrieval systems	CNC, CAM, RO, real-time process control system, FMS, AMHS, environment control system (ECS), and bar coding/automatic identification (AI)
	Administrative AMT	Includes computerized shop-floor tracking systems	MRP, activity-based accounting systems, electronic mail, electronic data exchange, and OA

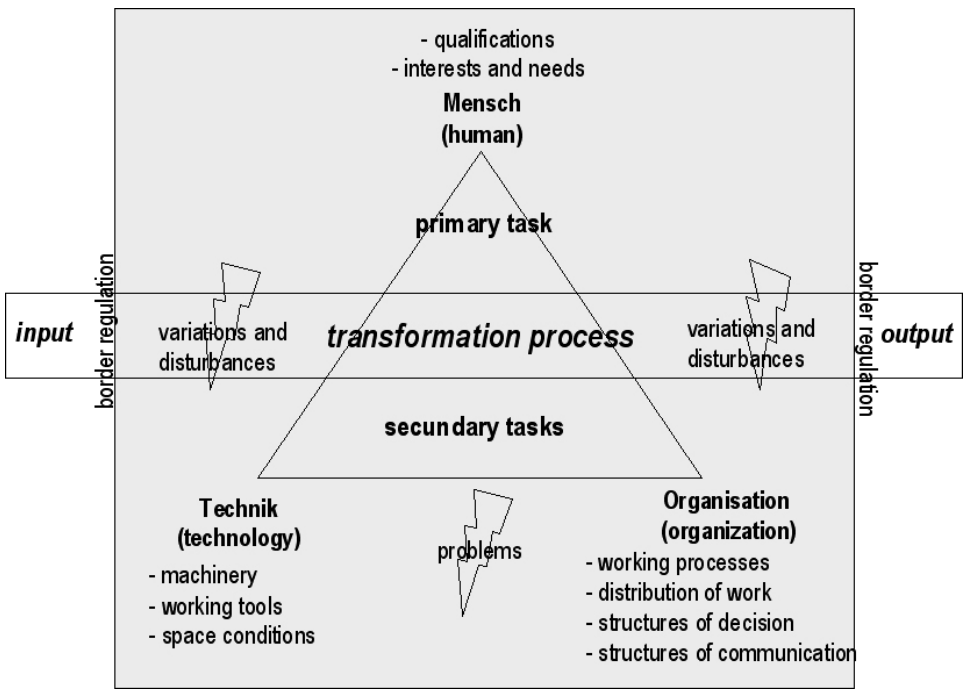

Figure 2.—Mensch-Technik-Organisation model (Strohm 1997, Ulich 2005; translated by Siegfried Lewark).

weeks of field observation in addition to a pilot study were conducted at each firm during the first visit, taking place between May and August 2009. Four firms were finally selected for the case study.

A description of the four firms is presented in Table 2. Two of the four case-study firms are located in the Yangtze River Delta region of southern China and the other two are in the Pearl River Delta region of eastern China. Both regions are ranked as the top advanced manufacturing regions with high industry gross product values and represent two of the four primary clusters of furniture manufacturing in China. Being a leader in Chinese furniture manufacturing, each of the four furniture companies has received national or local awards and been reported by Chinese media.

Sampling

Because the implementation of AMT in the case-study firms was top-down strategy, the progress in introducing AMT into the four firms was monitored by contacting the production managers within the first year after the initial visit and pilot study. Between May and August 2010, a second round of field work and interviews was conducted at the four firms.

With the aim of obtaining the views and experiences of decision makers from the process innovation, interviews were conducted mainly with upper managers and specialists in production and human resource management. The selected interviewees were required to have participated in the processes of AMT implementation in their firms within the past year.

In total, eight interviews were conducted, including three female and five male participants. The interviewees had worked at their firms for 1 to 18 years with work experience in their current positions between 1 and 5 years. The individual characteristics of the interviewees are presented in Table 3.

Interview questions

The questions in the case-study protocol focused on answering ''what,'' ''why,'' and ''how'' linked to the implementation of AMT. Therefore, face-to-face interviews were conducted based on open-ended questions. Key questions addressed to the production managers and specialists participating in AMT implementation were as follows:

- What kind of AMT has been applied in the firm?
- What kinds of new AMT were mainly introduced in the firm during last year?
- What were key drivers of introducing the new AMT in the firm?
- Who were the decision makers and participants in the processes of AMT implementation?
- What were the main barriers in the processes of implementing AMT?

For the upper managers and specialists from the human resources department, the interviews mainly focused on human and organizational aspects linked to the implementation of AMT, such as:

- How long did it take the workers to accept the new working system?
- Were the employees willing to accept the new working system?
- How did you motivate the employees during the processes of introducing the new AMT?
- How did you select the workers and supervisors for the new working system?

Data collection and analysis

Interviews were conducted by the first author during the second round of field work, taking place in 2010. The interviews were conducted in Chinese and lasted for 1 to 2 hours each. Contents of the interviews were simultaneously recorded by a digital recorder while key notes were written by the author, with consents from the interviewees. Afterward, the recorded material from the interviews was translated by the author from Chinese into English. A bilingual person proofread and corrected the translations. The method of qualitative data analysis developed by Miles and Huberman (1994) was used to analyze the data in four steps, which included reducing the data, exploring and describing the data, deepening and explaining the data, and making sense of the data and concluding the analysis.

Moreover, with excellent support from the case-study firms, the author collected personnel data from each firm during the field work. These data included turnover rates, distribution of employees, and changes in the organizational structure during the period of implementing AMT in the firm. At the same time, additional research was conducted on the impacts of AMT implementation on the employees' working conditions, helping to provide a better understanding of the research topic. The results of this parallel study will be presented in detail elsewhere.

Results

Description of AMT implementation

In each case-study firm, AMT was implemented as a strategy of production development with the purpose of enhancing competitiveness. It was found that implementing AMT was accompanied by the introduction of new production concepts, such as mass customization (MC),

Table 2.—Description of the case-study firms.

	Firm A	Firm B	Firm C	Firm D
Products	Kitchen and home furniture	Kitchen and home furniture	Home furniture	Office furniture
Size	Medium	Medium	Large	Large
No. of employees	1,000–2000	500–1,000	>2,000	>2,000
Location	Yangtze River Delta region (eastern China)	Pearl River Delta region (southern China)	Pearl River Delta region (southern China)	Yangtze River Delta region (eastern China)
Type of company	Sino-foreign joint venture	Private	Public	Sino-foreign joint venture

Table 3.—Characteristics of interviewees in the case-study firms.

	Firm A	Firm B		Firm C		Firm D		
Code:	A-1	B-1	B-2	C-1	C-2	D-1	D-2	D-3
Position	Production manager	Production manager	Human resource manager	Production manager	Supervisor in production	Production manager	Human resource management specialist	AMT project specialist
Sex	Male	Male	Male	Male	Male	Female	Female	Female
Age (y)	30–39	30–39	30–39	30–39	30–39	30–39	25–30	25–30
Education	Master	Bachelor	Master	College	College	Secondary school	Bachelor	Secondary school
Working experience in the position (y)	4	3	1	5	2	3.5	1.5	2
Working experience in the firm (y)	11	3	1	14	—	18	1.5	—

just in time (JIT), and lean production (LP). As pioneers of AMT implementation, all four case-study firms focused on introducing computer-integrated manufacturing (CIM), starting between 2006 and 2009. However, each firm was in a different phase and at a different level of the technology adoption (Table 4).

In this study, the process of implementing AMT was divided into three phases: preparation phase, application phase, and continued improvement phase. In the preparation phase, related activities such as making a project plan, selecting the technology, and conducting the new production concept were carried out in each case-study firm under the leadership of project managers. When interviews were conducted, Firms A, C, and D were in the application phase of implementing AMT; Firm B was in the continued improvement phase.

In all of the firms, top managers were the key decision makers in introducing the new working system. As project leaders, production managers participated in the AMT implementation by ensuring the progress of AMT implementation. They played a dominant role in making the project plan and implementing it based on the objectives of the production development strategy proposed by the top managers.

Firm B was the only one in which CIM software was developed and continually optimized by its internal engineers to meet the requirements of process innovation in the firm. In addition, Firm D experienced failure in introducing CIM. Meanwhile, Firm D also focused on conducting an LP project under the guidance of a consulting company in the past year.

Drivers of AMT implementation

In the study, problems in the production process were reported as one of the key drivers for implementing AMT (Table 5). In this context, bottlenecks in production were mentioned by the interviewees, referring mainly to difficulties in improving productivity and product quality under the traditional labor-intensive manufacturing system. Furthermore, the aim of reducing the human error rate by introducing the new working system was specifically reported by the interviewees from the two medium-size companies.

The production manager at Firm B reported: ''We started to think about introducing a new working system because the company was facing bankruptcy as a result of problems in production process, the increased work skills required for employees, and the need to reduce the high rate of human error in manufacturing.''

Regarding the human side of the process innovation, the interviewees mentioned two main drivers for implementing AMT in the case-study firms: the need to reduce the dependence on the employees' work skills and difficulties in recruitment. Surprisingly, it was found that China's furniture industry has recently been facing challenges from increased labor costs and a shortage of skilled workers.

The production manager at Firm C reported: ''We tried to introduce a new working system because of the increased labor costs and difficulties in recruitment, especially those caused by a shortage of skilled workers.''

The human resource manger at Firm B reported: ''A big problem for our firm is that it has been difficult to employ appropriate staff and workers, including middle and upper managers. That was not only because of a lack of staff that was compatible with organizational culture, but also because of a shortage of qualified persons. Our firm, introducing a new manufacturing system based on CIM technologies, especially requires plenty of well-educated or trained staff and workers as compared with the traditional manufacturing firms.''

In addition, the production manager at Firm A not only discussed the company's difficulties in recruitment and high pressure from the increased labor cost, but also mentioned a limitation of land resource as a high driver of implementing AMT in the firm. He reported, ''By implementing the new system, we aim to improve the output per worker and the one per unit of land.''

Table 4.—Description of advanced manufacturing technology (AMT) implementation in the case-study firms.

	Firm A	Firm B	Firm C	Firm D
New production concept	MC	MC	MC	JIT/LP
New AMT	CIM	CIM	CIM	CIM
Start to introduce the new AMT	Mar 2009	Sep 2006	Oct 2008	Jul 2008
Recent phase of implementing the new AMT	Application	Continued improvement	Application	Application

Table 5.—Key drivers and main barriers for implementing advanced manufacturing technology (AMT) in the case-study firms.

	Firm A	Firm B	Firm C	Firm D
Key drivers				
Production process	The need to improve productivity and product quality	The need to improve productivity and product quality	The need to improve productivity and product quality	The need to improve productivity and product quality
	The need to improve land productivity (referring to limited land resources)	Requirement of changes in production process to meet wide range of products		
	The need to reduce human error in production	The need to reduce human error in production		
Human side	Difficulties in recruitment caused by shortage of skilled workers	The need to reduce dependence on the work skills of employees	Difficulties in recruitment caused by shortage of skilled workers	The need to reduce dependence on the work skills of employees
	Increased labor costs		The need to reduce dependency on the work skills of employees	
			Increased labor costs	
Others	Introducing new production line	Facing bankruptcy	Requirement of changes in management	Decision of top manager were influenced by visiting a successful firm in process innovation
Main barriers				
Preparation phase	Difficulties for middle managers and supervisors in understanding the new production concept	Difficulties for middle managers and supervisors in understanding the new production concept	Difficulties for middle managers and supervisors in understanding the new production concept	Difficulties for middle managers and supervisors in understanding the new production concept
		Difficulties for first line workers in understanding the new production concept	Lack of confidence in the new working system of middle managers and supervisors	Difficulties for first line workers in understanding the new production concept
		Unwillingness to accept the new working system for skilled workers	Unwillingness to accept the new working system for skilled workers	
Application phase	Difficulties in communication between management and worker levels	Difficulties in process improvement and optimization	Shortage of qualified staff	Difficulties in communication between management and worker levels
	Shortage of qualified staff	Shortage of qualified staff	Insufficient understanding and cooperation from other departments	Insufficient understanding and cooperation from other departments
	Ill-matched organizational structure	Unsatisfied organization environment		
Continued improvement phase	—	Incomplete organizational structure	—	—
		Shortage of qualified staff		

Moreover, changes in the labor force structure in China were also considered a factor of enhancing the requirement of introducing new manufacturing systems. As the production manager at Firm C reported: ''A new generation in the workforce along with the new requirements from working conditions and individual expectations also requires changes in management and leads to the need to introduce a new working system.''

As a strategy for production development, AMT was introduced in the Chinese furniture firms with the purpose of enhancing the competitiveness. The production manager at Firm A reported: ''The objective of the company's development was to grow to be a large company by implementing the production concepts of 'mechanization,' 'automatization,' 'informatization,' and 'intelligentization.' ''

Barriers to implementing AMT

A common barrier to introducing the new working system in the preparation phase of AMT implementation was that the new production concepts were difficult for the participants to understand (Table 5). Specifically, all of the interviewed production managers in the four case-study firms felt that the difficulties in understanding the new production concept came mainly from the middle management level, including middle managers and supervisors.

The production manager at Firm A reported: ''It was a really slow process for the middle managers and supervisors to understand the concept of the new working system.''

The production manager at Firm D stated: ''There is no doubt that the middle managers and supervisors had a positive attitude towards the new working system, but it was

hard for them to completely understand it because of their low education levels.''

Furthermore, the interviewees at Firms B and D felt that the problems in understanding also extended to first line workers. In addition, the unwillingness by the skilled workers to accept the new working system in the beginning of the AMT implementation was mentioned by the interviewees at Firms B and C.

The production manager at Firm B reported: ''At the beginning, managers and workers were reluctant to accept the new system.'' He especially pointed out, ''people with more working experience and work skills found it more difficult to accept the new system, including middle managers and ordinary workers.''

The production manager at Firm C stated: ''First line workers were afraid that the implementation of AMT would lead to a salary reduction, as they acknowledged the new system may reduce the dependence on their current work skills.'' The production supervisor at Firm C reported: ''Especially for skilled woodworkers, they could not accept the new working system, and complained that it would not be helpful to improve their work skills anymore.''

Problems in communication between the management and worker levels, a shortage of knowledgeable staff, and an unsatisfying environment at the organizations were reported as the main barriers in the application phase of implementing AMT. The low education level of workers and an uncoordinated organizational structure mainly led to problems in communication. This was especially true for the middle managers and supervisors who normally started their careers as first line workers and advanced through learning by doing without receiving systematic training. They are comfortable in their old ways of working, which may cause their unwillingness to accept a new working system.

In addition, a shortage of qualified staff was mentioned as one of the main barriers to implementing AMT by the interviewees. The production manager at Firm A complained: ''Few of the current higher educated graduates would prefer to make a career in a factory.'' The production supervisor at Firm C reported that they encountered a shortage of designers and engineers during the process of implementing AMT in the firm. Facing those challenges of human resource management, the interviewees commonly recognized that completing a training system and improving employee welfare and work environment are necessary for successful AMT implementation.

Firm B is the only firm for which internal engineers developed CIM software based on the need for its process innovation. The production manager at Firm B felt that there were difficulties in improving the production process during the application phase of implementing AMT. At the time the interviews were conducted, Firm B was in the phase of continually improving its new working system. The improvement activities were mainly focused on enhancing human resource management and were carried out in order to solve the problems caused by an incomplete organizational structure and a shortage of qualified staff and workers.

The production manager at Firm B reported: ''Continued improvement should occur in several areas, but there is lack of specialists who are able to work towards that. As the fields needing to be improved range from the production process to the production site and all are closely linked to changes in personnel and organization, it is quite a slow process to make the improvements in the way we did before.''

Firm D experienced failure in its efforts to introduce CIM. The production manager at Firm D concluded the failure might be due to participants' high expectations of the success of introducing a new working system and their misunderstanding in the implementation process. The production manager reported that ''Most middle managers and supervisors had the opinion that production productivity would directly increase after applying the new working system, which was not true.'' She acknowledged that there would be a period of productivity reduction during the initial stages of implementing AMT. In the application phase of AMT implementation at Firm D, complaints and expressions of a lack of understanding also came from other departments in the firm. For instance, the production manager at Firm D felt high pressure from the marketing department because they kept asking the production department to provide the same quantity and quality of products as before, even during the initial phase of implementing AMT. She thus concluded that understanding and cooperation from related departments and choosing an appropriate time to conduct the plan were also important for successfully implementing a new working system.

Discussion

Human drivers of AMT implementation

The findings of this study show that the drivers of implementing AMT in China's furniture industry come not only from the technological side, but also from the human side. Difficulties in recruitment and the need to reduce the dependence on employees' work skills, with regard to a shortage of skilled workers and increased labor costs, are identified as the key drivers of AMT implementation from the human side.

The national wage of staff and workers in China has increased from 18,365 yuan in 2005 to 29,229 yuan in 2008, with an annual growth rate of over 10 percent (National Bureau of Statistics of China [NBSC] 2006–2009; Fig. 3). This rising wage affects the increase in Chinese furniture manufacturing costs. On the other hand, the wages of staff and workers in the Chinese wood products manufacturing sectors are generally lower than the average national level, which could perhaps lead to an increased turnover rate in China's furniture industry.

Recently, numerous innovative activities have been carried out by pioneers in the manufacturing sector in an attempt to enhance their competitiveness, particularly regarding risk factors such as a shortage of skilled workers. For instance, the manufacturing industry in the Guangdong province, a region that is home to a famous Chinese furniture manufacturing cluster, is facing the challenge presented by a shortage of skilled workers. Business for Social Responsibility (BSR; 2010) reported that ''according to the statistics published by the Guangdong Human Resource and Labor Security Administration, in 2010 there will be a 32-percent shortage of technical workers in Guangdong province, and the ratio of demand to applications of technical workers will be 54:1.'' Thus, the most forward-looking areas in the Guangdong province will likely evolve out of labor-intensive industries and strive to shift toward a more advanced industrial structure (Inagaki 2006).

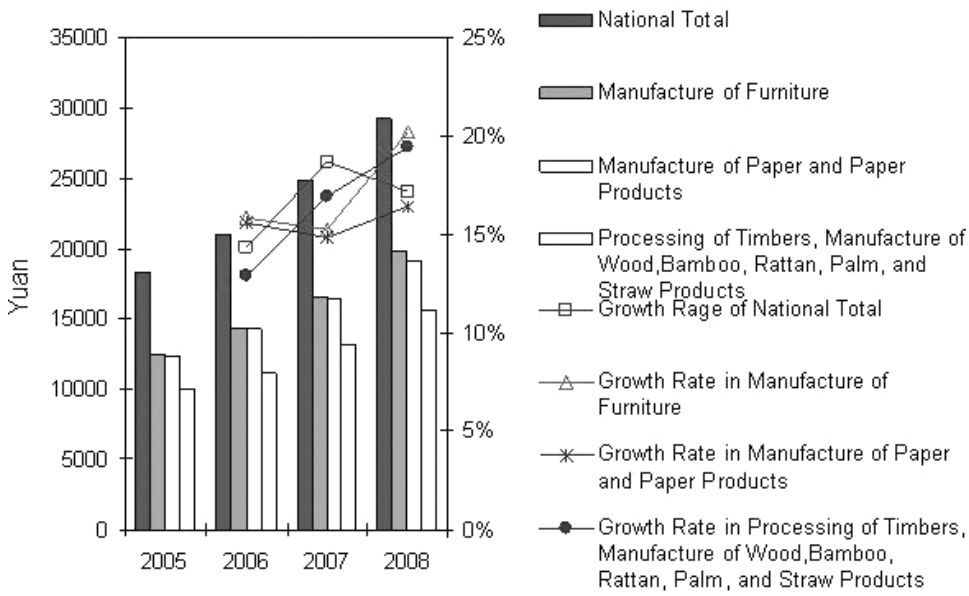

Figure 3.—Average wage of staff and workers and its annual growth rate in China between 2005 and 2008 (National Bureau of Statistics of China 2006–2009).

Furthermore, migrant workers are the dominant labor force in China's manufacturing industry. Therefore, changes in labor force structures have also enhanced the need to implement AMT in China's furniture industry. BSR (2010) reported that an increasing choice in destinations for migrant workers and options to work in one's home province have led to a labor shortage in eastern coastal areas, especially in the Yangtze and Pearl river deltas. In addition, the economic growth of the midwestern areas has attracted more migrant workers (BSR 2010). It was also reported that the new generation of migrant workers is different from the old ones in terms of, e.g., values, character, behavior, and work selection. The new generation of workers prefers a more clean, comfortable, and safe work environment, and cares more about personal career development and social satisfaction than ever before. Such changes may create a new challenge for China's furniture industry, especially regarding their characteristic labor-intensive manufacturing.

Effects of technological and nontechnological factors in AMT implementation

The findings of this study provide significant arguments for decision makers that technological and nontechnological factors as well as their interactions should be seriously considered during the process of introducing a new working system. For analyzing this, the MTO model is a useful approach.

The results show that nontechnological barriers to implementing AMT in Chinese furniture firms existed throughout the whole process of innovation. The requirements of nontechnological factors for the successful implementation of AMT have already been presented in numerous previous studies. In general, it could be concluded that the successful implementation of AMT requires companies to have a workforce with a higher level of skills and a flexible organizational structure; additionally, a new culture is necessary in managing, training, and planning in the manufacturing industries (Lay et al. 1999, Ghani et al. 2002, Rosnah et al. 2004, Chung and Swink 2009).

Furthermore, the introduction of a new technology is as painful for traditional management as it is for traditional employees (Ghani et al. 2002). This study shows that there was an unwillingness to accept the new AMT at the beginning of implementation by employees in China's furniture firms, including middle managers, supervisors, and skilled workers. The same phenomenon was presented by Song et al. (2006), illustrating that when a new technology is introduced, many employees do not want to give up the working style that they are accustomed to in order to adopt a new technology system. Ghani and Jayabalan (2000) recognized this as a psychological barrier for ATM implementation. They explained that employees, particularly blue collar workers, resist technological change because they fear that new technology would reduce or eliminate the need for their particular skills. New technology has the potential to isolate and remove the skills of the workers, thus diminishing their power. Technology changes faster than people's behaviors (Ghani et al. 2002). Thus, an effort should be made to minimize the negative impacts on the human side from the implementation of AMT in order to achieve a better performance. As a solution, systematic planning and preparation for implanting AMT should be conducted regarding management. Previous researchers have argued that employees should be involved from the beginning of the implementation process by being updated about the plans for new technology and the reasons why this new technology is needed (Efstathiades et al. 2000). In addition, formal training, pilot projects, and clear, long-term objectives can prepare firms for implementation and help employees gain a shared understanding of AMT, including its purpose, value, and associated challenges (Lewis and Boyer 2002).

Conclusions

The results of this study offer insights into the activities of process innovation in pioneer AMT firms in China's

furniture industry. Our findings illustrate that the implementation of CIM, accompanied by the introduction of new production concepts such as MC, JIT, and LP, was conducted as a production development strategy in the Chinese furniture firms studied. Problems in the production process are reported as one of the key drivers for implementing AMT in the firms. In addition, difficulties in recruitment and the need to reduce dependence on employees' work skills, due to a shortage of skilled workers and increased labor costs, are identified as the human drivers for AMT implementation. Moreover, difficulties in understanding the new production concept, unwillingness to accept the new working system, problems in communication for the participants, and a shortage of qualified staff were found to be main barriers to implementing AMT in the Chinese furniture firms. According to our exploration of drivers and barriers for implementing AMT in China's furniture industry, technological and nontechnological issues should both be considered in the process innovation. The mutual relationship between humans, technology, and organization, as presented in the MTO model, offers a useful theoretical support for successfully implementing AMT. We hope the findings of this exploratory study can not only be useful for decision makers in China's furniture industry, but also assist forest products industries in other emerging manufacturing countries that are moving toward introducing new working systems.

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