High-performance work systems and open innovation: moderating role of IT capability

Jia Zheng and Hefu Liu
University of Science and Technology of China, Hefei, China, and
Jingmei Zhou
Department of Management Science and Information Systems, Huazhong University of Science and Technology, Wuhan, China

Received 10 September 2019
Revised 5 April 2020
Accepted 29 May 2020

Abstract

Purpose – This study aims to explore the impact of high-performance work systems (HPWS) on open innovation and the moderating role of information technology (IT) capability on the relationship between HPWS and open innovation.

Design/methodology/approach – This study conducted a questionnaire survey in the industrial parks of the Yangzi River Delta in China and obtained 108 useful responses.

Findings – HPWS positively impacts open innovation. IT exploration capability strengthens the relationship between HPWS and open innovation, whereas IT exploitation capability and ambidexterity do not strengthen such relationship.

Research limitations/implications – Firms should use HPWS to improve employees' motivation of external learning and searching for enhancing innovation openness. They should acknowledge the enabling role of IT exploration capability in facilitating employees' learning and searching toward open innovation and discreetly develop IT exploitation capability and ambidexterity during external knowledge searching, which may not achieve the desired facilitation purpose.

Originality/value – This study contributes to human resource management (HRM) by suggesting that a new antecedent, which is HPWS in our case, should be taken into account when considering the influence of HRM in the process of open innovation. This study has important implications for HPWS, IT capability and open innovation; open innovation can be improved by using HPWS and IT capability. This study also expands IT ambidexterity to HRM and innovation studies.

Keywords High-performance work systems, HPWS, IT capability, IT ambidexterity, Open innovation

Paper type Research paper

1. Introduction

Innovation scholars have increasingly focused on innovation that leverages the discoveries of others, which encourages firms to source knowledge for innovation across the boundaries of firms (Bogers *et al.*, 2018; Dahlander and Gann, 2010; West and Bogers, 2014). Chesbrough (2003) suggested that many innovative firms have shifted to an "open innovation" model by using various external actors and sources to help them achieve and sustain innovation. Some scholars have indicated that firms' openness to external sources of knowledge is an important driver of innovation performance (Bogers *et al.*, 2018; Laursen and Salter, 2006; West and Bogers, 2014). These studies have suggested that a large number of external sources of innovation make the firm's search strategy highly open, and this situation generates increased benefits on the firm. Open innovation is a key business imperative, and firms are motivated to explore ways to achieve innovation openness.

This work was supported by the National Key R&D Program of China (2018YFB1601401); the Fundamental Research Funds for the Central Universities, HUST: 2019WKYXQN046 and 2019kfyXJJS040.

Industrial Management & Data Systems

0263-5577
DOI 10.1108/IMDS-09-2019-0475

Open innovation has been explored from various perspectives, including knowledge management capability (Martinez-Conesa *et al.*, 2017), absorptive capability (Kim *et al.*, 2016), social capital (Laursen *et al.*, 2012; Yli-Renko *et al.*, 2001), organizational learning (OL) capability/culture (Wang *et al.*, 2017; Garriga *et al.*, 2013) and empowering leadership (Naqshbandi and Tabche, 2018). These perspectives are useful for firms to understand how to achieve open innovation; for example, firms with high learning capability can acquire and learn knowledge from other organizational members (Naqshbandi and Tabche, 2018). Among the previous perspectives, human resource management (HRM), which is a key perspective that influences the learning ability of organizational employees, has been ignored in the open innovation literature. Knowledge-related issues are closely related to HRM approaches. Searching for external knowledge is a task that relies on various organizational employees (Ardito and Petruzzelli, 2017). The openness of external search depends on how a firm sets practices to manage the searching behaviors of knowledge workers. The model of high-performance work systems (HPWS) is based on an HRM approach that elicits employees' commitment and involvement with the organizational goals to motivate them to learn considerable knowledge and achieve high work performance (Walton, 1985; Wood and Albanese, 1995). This approach has been rarely investigated in open innovation field. Our first objective is to answer the question, "how does HPWS influence a firm's open innovation?" From the OL and knowledge management perspectives, HPWS can promote and sustain organizational innovation because it manages employees' learning of knowledge (Fu *et al.*, 2015). The way in which an organization investigates and acquires information about its customers, competitors, markets, products and services can be strongly dependent on the management of employees' work performance in terms of their daily knowledge searching and absorption. HPWS supports employees to actively learn and achieve high work performance, and this situation enables employees to acquire and exchange knowledge with external sources.

Today's business firms rely heavily on information technology (IT) resources to learn the current business environments. The capability of firms to use IT plays a central role in influencing the relationship between HRM and open innovation. Our second research objective is to answer the question, "how does IT management moderate the relationship between HPWS and open innovation?" IT provides organizational members with quick and effective access to right amounts of information (Hope and Hope, 1997) and increases the ability of employees to acquire and disseminate information in a highly efficient and effective manner (Tippins and Sohi, 2003). The existence of IT facilitates the efficiency and effectiveness of employees' learning from external sources. IT ambidexterity (i.e. IT exploration and exploration) is a key IT management strategy that is necessary to survive in today's challenging environment. We explore the effects of IT ambidexterity on the relationship between HPWS and open innovation, given the rapidly changing business environments. IT ambidexterity is the ability of firms to simultaneously investigate new IT resources and practices (IT exploration) and utilize their current IT resources and practices (IT exploitation). Firms with IT capabilities can effectively allocate IT resources and applications to help employees learn from external sources.

This study aims to fill this gap in the literature by focusing on HPWS and open innovation literature to determine the impact of HPWS on open innovation. We investigate the impact of strategic management of organizational IT resources on the relationship between HPWS and open innovation. From the learning perspective, we propose that HPWS can motivate employees, especially the key knowledge workers that constitute the innovation base, to learn from external sources. IT capability plays a vital role in facilitating this process. Our study contributes to HRM by suggesting that a new antecedent should be taken into account when considering the influence of HRM on the searching for knowledge resources. Our study has significant implications for HPWS, IT capability and open innovation; open innovation can be improved by using HPWS and IT capability. We also expand IT ambidexterity to HRM and innovation studies.

2. Theoretical background and literature review

2.1 Open innovation

Cohen and Levinthal argued that open innovation is about the ability to utilize external knowledge (Cohen and Levinthal, 1989; Laursen and Salter, 2006). We follow their opinion and focus on the openness of firms' external search strategies. Firms' external search includes scanning various sources and obtaining knowledge from these sources. Laursen and Salter (2006) provided empirical evidence that openness, which is measured as the number of external sources, positively affects a firm's financial innovation performance. They indicated that a large number of external sources make the firm's search strategy highly open. This situation is highlighted in many other open innovation literature, which underlines that innovation is frequently about leveraging the discoveries of others (Dahlander and Gann, 2010).

Previous studies have observed various antecedents of open innovation. Some researchers have stated that knowledge management capability or absorptive capability directly influences open innovation based on knowledge-based view, social exchange and contingency theories (Martinez-Conesa *et al.*, 2017; Naqshbandi and Jasimuddin, 2018). From the OL perspective, Cheng *et al.* (2019) proposed that OL capability, external collaboration and knowledge sharing are associated with the outcomes of open innovation. HRM approaches have been ignored in previous studies. Organizations cannot search for external knowledge by themselves, and this task is handled by various organizational employees (Ardito and Petruzzelli, 2017). The openness of external search may be dependent on the set specific practices of a firm to organize knowledge workers and is closely related to human resource (HR) practices. Our study aims to fill this gap by focusing on HPWS and their influence on open innovation.

2.2 HPWS

In the past three decades, many scholars have focused on HPWS – an HR system that can provide firms with competitive advantages that are difficult to imitate for outsiders (Meuer, 2017). Accordingly, we use the term HPWS to refer to a set of separate but interrelated HR practices that are designed to attract, retrain and motivate employees. On the basis of the key areas that usually form parts of HPWS, we start our research by adopting a well-established conceptualization that an HPWS involves the use of selective staffing, extensive training, internal mobility, employment security, clear job description, result-oriented appraisal and participation (Sun *et al.*, 2007). Selective staffing is the practice of firms of selecting and recruiting employees with superior skills and behavior scripts (Way, 2002). Extensive training refers to the means by which firms enhance employees' knowledge of their firm's operations, markets, customers, coworkers and products (Kim and Ployhart, 2014). Internal mobility is the practice by which firms provide employees with broad career path and promotion from within (Sun *et al.*, 2007). Result-oriented appraisal is the practice of firms to give employees appraisal on the basis of long-term and objective quantifiable results to motivate employees to work harder than before (Sun *et al.*, 2007). Clear job description is the means by which firms provide broad job descriptions and flexible job assignments to employees (Sun *et al.*, 2007). Participation is the practice of firms to encourage employees to participate in decision-making processes (Sun *et al.*, 2007). HPWS is composed of seven HRM practices and represent the complementarities within HPWS. Becker and Matthews (2008) believed that no single HRM approach is, but rather bundles of strategies may be, sufficient to promote innovation, and these bundles need to be studied empirically.

HPWS is positively associated with organizational and individual performance. Jyoti and Rani (2017) observed that HPWS positively influences knowledge management, which has a positive relationship with organizational performance. Camps and Luna-Arocas (2012) stated that HPWS brings the benefits for the firms by influencing organizational learning capability, which stimulate organizational performance. Jyoti and Dev (2016) observed that HPWS

enhances the employee's performance because of the development of learning orientation of the employees. From the knowledge management or OL perspective, some scholars have indicated that HPWS can promote and sustain organizational innovation because they manage the learning of knowledge (Fu *et al.*, 2015).

2.3 HPWS and open innovation

HPWS can improve the learning orientation of an organization, and this situation motivates employees to source knowledge externally (Adler and Kwon, 2002). Ning *et al.* (2018) found that work-unit-level learning orientation significantly impacts individual performance and positively moderates the relationship between HPWS and individual performance. Many HRM studies have stated that HRM is a fundamental tool used to lead the organization toward a culture of learning and knowledge transfer. HRM practices may have the potential to influence people's attitude toward learning (Theriou and Chatzoglou, 2008) by generating the organizational context that promotes healthy attitudes (Jaw and Liu, 2003). However, studies on the relationship between HPWS and open innovation are limited.

2.4 IT capability and ambidexterity

IT ambidexterity is the firms' ability to simultaneously pursue exploration and exploitation in their management of IT resources and practices, which can help firms perform better in responding to environmental changes (Lee *et al.*, 2015). IT exploration capability is the ability to acquire and experiment with new IT resources and practices (e.g. IT architecture, applications skills, and development methodologies) (Nambisan *et al.*, 1999), and IT exploitation capability is the ability to utilize existing IT resources and practices (Atuahene-Gima, 2005; Ravichandran *et al.*, 2005). Existing studies have provided extensive theories about the potential of firms' IT capability to promote significant innovations in business processes, products and services (Soto-Acosta *et al.*, 2018). From the OL perspective, IT capability supports the learning process through which a firm absorbs external intelligence by enhancing knowledge acquisition, assimilation and application (Cai *et al.*, 2016; Chakravarty *et al.*, 2013), which can improve firm's innovation capability. However, no research has used IT exploration and exploitation capabilities to investigate the effects of IT capability on open innovation.

3. Hypothesis development

3.1 HPWS and open innovation

From the learning perspective, HPWS can improve the searching and learning abilities of employees and thus enable them to build connections with external knowledge sources (Adler and Kwon, 2002). Extensive training can build the employees' knowledge base for learning and provide a clear understanding of organizational aims to ensure the right direction for learning processes. Selective staffing practices can help firms recruit high-quality employees with rich knowledge base or high learning orientation and capability to learn external knowledge. Selection procedures may increase the likelihood that individuals interact with each other (Jiang and Liu, 2015), which can help them share their knowledge. Participation provide employees with opportunities to share knowledge and learn new skills (Jiang *et al.*, 2012). HPWS improves employees' opportunity and motivation to learn from external sources. Result-oriented appraisal helps in directing and sustaining employees to do what can help enhance innovation performance, which motivates employees to actively seek out information externally for innovation. Employees are frequently motivated to contribute to the organization when they are given a considerable degree of job security and opportunities of internal development (Camps and Luna-Arocas, 2012), such as learning related information from external sources. Clear job descriptions are used for training, selection, career

development and pay determination, which are all designed to ensure that individuals are motivated and capable of performing jobs (Lawler, 1994). Thus, these practices may increase the interaction opportunities between employees and external sources by improving their learning motivation, and this situation increases the ties among employees and external sources. Thus, HPWS promotes the learning orientation of employees to improve openness.

Thus, we hypothesize that

H1. HPWS is positively associated with open innovation.

3.2 Moderating role of IT capability

IT resources and applications enable the flow of knowledge in an OL process to be supported. Thus, the development of firms' IT capability will likely enhance their employees' ability to acquire and disseminate information. Firms can experiment with promising IT applications to learn about their functionalities and select the technologies that are likely to positively impact the current and future business operations when they have high IT exploration capability (Lee *et al.*, 2015). Thus, IT exploration enables firms to quickly and economically implement advanced and new IT applications for supporting employees' learning from external sources, which can help HPWS generate considerable values on open innovation. Firms with low IT exploration capability may use outdated IT applications that cannot support the learning process of employees.

By contrast, firms with high IT exploitation capability can manage their current portfolio of IT assets, leverage and reuse them in different business activities, invest in complementary technologies to improve their effectiveness and integrate the technologies with the firm's business processes (Lee *et al.*, 2015). IT exploitation capability can enhance the efficiency of existing IT resources that are used to support the learning process and thus can help HPWS improve open innovation. Firms with low IT exploitation capability cannot effectively utilize their current IT assets to support the learning process of employees.

Thus, we hypothesize that

H2a. IT exploration capability positively moderates the influence of HPWS on open innovation.

H2b. IT exploitation capability positively moderates the influence of HPWS on open innovation.

According to ambidexterity theory, IT ambidexterity is the firms' ability to simultaneously pursue exploration and exploitation, which leads to better firms' performance than would a single emphasis on IT exploration or exploitation (Chi *et al.*, 2017). Tai *et al.* (2017) suggested that organizations should pursue IT exploitation and exploration simultaneously to improve digital innovation capability. Firms with high IT ambidexterity can explore new IT applications and utilize existing IT infrastructures to facilitate the learning process for improving open innovation.

Thus, we hypothesize that

H2c. IT ambidexterity positively moderates the influence of HPWS on open innovation.

4. Research method

4.1 Sample and data collection

We conducted a survey in the industrial parks of the Yangzi River Delta in China. We selected manufacturing industries mainly because they rely heavily on IT in the age when global manufacturing industries step into Industry 4.0 (Rüßmann *et al.*, 2015). According to Van de Vrande *et al.* (2009), the incidence and adoption of open innovation are anticipated to be

strong in the manufacturing sector. We cooperated with a government sector (the municipal commission of economy and IT) which supplied us a list of names and addresses of the firms and the names and contact information of their senior executives for conducting the survey. We requested executive managers to answer the questions of HPWS, and production and R&D managers to answer the questions of IT capability and open innovation. A two-stage questionnaire survey from 2016 to 2017 was used to collect data for verifying our hypotheses. In the first stage, we received 202 completed questionnaires, with a response rate of approximately 16.83%. In the second stage, we received 707 completed questionnaires, with a response rate of approximately 37.7%. A total of 108 useful questionnaires were obtained after matching the two-stage and completed questionnaires. Table 1 shows the demographic information of the samples.

4.2 Measures

We developed the structured questionnaire in the following stages: (1) literature review to identify previously validated measures, (2) development of a draft version, (3) review of draft by invited academics and practitioners, (4) pilot test and (5) refinements to the questionnaire. All measures were assessed using five-point Likert scales that ranged from "strongly disagree" to "strongly agree." The measurement items for each construct were presented in Table A1.

4.2.1 HPWS. We measured the second-order construct of HPWS by adapting seven first-order factors adopted from Sun *et al.* (2007). The measurement models achieved acceptable

Table 1. Sample demographic information

	N	%		*N*	%
Industry type			*Education level of production and R&D manager*		
Machinery, equipment, instruments, electronic	52	48.15%	High school and below	0	0
Petroleum, chemistry, plastics, mining, pharmaceutical	37	34.26%	Junior college	10	9.26%
Food, drink, light industry and daily use	18	16.67%	Undergraduate	88	81.48%
Other industries	1	0.93%	Master's degree or above	10	9.26%
Firm age			*Gender of production and R&D manager*		
<=5	12	11.11%	Male	100	92.59%
6–10	43	39.81%	Female	8	7.41%
11–20	46	42.59%	*Age of executive manager*		
>=21	7	6.48%	25–30	7	6.48%
Firm size			31–40	29	26.85%
<=100	32	29.63%	41–50	41	37.96%
101–200	28	25.93%	>=51	22	20.37%
201–300	32	29.63%	Missing	9	8.33%
301–400	2	1.85%	*Education level of executive manager*		
>=401	14	12.96%	High school and below	0	0
IT department size			Junior college	12	11.10%
<=10	99	91.67%	Undergraduate	83	76.85%
11–20	5	4.63%	Master's degree or above	4	3.70%
>=21	4	3.70%	Missing	9	8.33%
Age of production and R&D manager			*Gender of executive manager*		
25–30	3	2.78%	Male	78	72.22%
31–40	39	36.11%	Female	21	19.44%
41–50	50	46.30%	Missing	9	8.33%
>=51	15	13.89%	*Total*	108	
Missing	1	0.93%			

model fit (HPWS model fit χ^2/d.f. = 262.41/182 = 1.442, RMSEA = 0.064, CFI = 0.98, GFI = 0.81, SRMR = 0.061). These data were collected in the first-stage survey.

4.2.2 Open innovation. We measured open innovation by adapting a 13-item scale adopted from Laursen and Salter (2006) and Bogers *et al.* (2018). We used the method of Laursen and Salter (2006)'s study, where each source of information was given a new value of 1 when rated "relatively high" (4) or "very high" (5), and all other ratings were given a value of 0. Then, the new values were summed for each respondent. The dependent variable ranged from 0 to 13, with 0 indicating a relatively closed innovation phase and 13 suggesting a highly open innovation phase. These data were collected in the second-stage survey.

4.2.3 IT capability. We measured IT exploration capability and IT exploitation capability by adapting two three-item scales from Lee *et al.* (2015). IT ambidexterity was operationalized using item-level interaction terms of their subdimensions (Lee *et al.*, 2015). These data were collected in the first-stage survey.

4.2.4 Control variables. We also included several control variables that might affect innovation capability, namely, industry type, firm size and firm age. Dummy variables were used for industry types. Table 2 shows the specific classification of industry types. Firm size was measured by the number of full-time employees. Firm age was measured by years the company was founded. IT department size was measured by the number of full-time employees in the IT department.

5. Data analysis and results

5.1 Common method bias

Common method bias might have been solved to some extent (Podsakoff *et al.*, 2003) because our data were collected from two sources (the questions of HPWS and IT/open innovation were answered by different managers in firms). Nevertheless, we still performed statistical analyses to assess the severity of common method bias by using a correlational marker variable following Lindell and Whitney (2001). We selected a three-item scale of dysfunctional competition and used it as a method variance marker. This construct was theoretically unrelated to other scales in the study. We adjusted all correlations among measurement items by removing the CMV estimation. The results suggested that no significant change existed in the correlations. Thus, common method bias was not evident in this study.

5.2 Measurement model

We selected SPSS for the data analysis and model validation. Specifically, we tested the reliability of the measurement by using composite reliability and the value of Cronbach's alpha as suggested by Fornell and Larcker (1981). The values of the composite reliability and Cronbach's alpha presented in Table 3 were greater than 0.70. We assessed convergent validity by evaluating the loading of items and the average variance extracted (AVE). As shown in Table 4, the loadings of all items were larger than 0.70 at a significant level of 0.001. The AVE scores of every construct were higher than the recommended benchmark of 0.5 (Fornell and Larcker, 1981). The results indicated that the measurement had adequate convergent validity. The discriminant validity was evaluated by comparing the relationship between the correlations among the constructs and their square root of AVEs. As shown in Table 2, the square root of AVEs for each construct was greater than the correlations among constructs, which indicated the adequate discriminant validity of the measurement.

As shown in Table 2, the correlation among the first-order constructs of HPWS was more than 0.6. The correlations between first-order factors were statistically "caused" by a single second-order factor (Tanaka and Huba, 1984). The inter-construct correlation of IT exploration and exploitation capabilities was higher than the benchmark of 0.60. We

Table 2.
Means, standard deviation and correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. SS	0.8491																
2. ET	0.764***	0.9289															
3. IM	0.722***	0.719***	0.8724														
4. ES	0.309***	0.220*	0.351***	0.9245													
5. CJD	0.633***	0.717***	0.752***	0.365***	0.9027												
6. RA	0.638***	0.580***	0.676***	0.281**	0.688***	0.8726											
7. *p*	0.455***	0.490***	0.594***	0.417***	0.510***	0.632***	0.9683										
8. ITERC	0.324***	0.352***	0.424***	0.148	0.319***	0.287**	0.288**	0.9681									
9. ITEIC	0.286**	0.304**	0.272**	0.159	0.191*	0.215*	0.211*	0.771***	0.9646								
10. OI	0.152	0.213*	0.220*	0.088	0.127	0.201*	0.244**	0.272**	0.317***	1							
11. FA	0.014	−0.053	−0.088	−0.039	0.008	−0.033	−0.034	−0.175	−0.160	−0.384***	1						
12. FS	0.067	−0.002	0.007	0.104	0.030	0.003	0.033	0.126	0.076	0.103	0.028	1					
13. Ind 1	−0.043	−0.130	−0.089	0.012	−0.088	0.005	0.043	−0.098	−0.127	−0.152	0.031	0.010	1				
14. Ind 2	0.008	0.134	0.107	−0.001	0.011	−0.073	0.034	0.013	0.052	0.036	0.086	−0.108	−0.715***	1			
15. Ind 3	−0.019	−0.063	−0.072	−0.067	0.028	0.013	−0.150	0.090	0.085	0.069	−0.229*	0.070	−0.447***	−0.338***	1		
16. IT D size	0.092	0.059	0.049	0.050	0.077	−0.033	−0.016	0.132	0.153	0.111	0.007	0.730***	−0.016	−0.141	0.100	1	
17. Marker variable	0.207*	0.119	0.055	0.050	0.174	0.183*	0.059	0.075	0.069	0.000	−0.084	0.111	0.061	−0.212*	0.158	0.108	1
N	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108
Mean	4.4259	4.4506	4.1620	3.5556	4.3272	4.2469	3.7315	3.4969	3.5679	6.25	11.15	247.6939	0.48	0.34	0.17	4.9423	2.7438
SD	0.5198	0.5437	0.5884	0.9103	0.4929	0.5807	0.8523	0.7632	0.7309	3.6201	5.424	366.3723	0.502	0.477	0.374	10.8290	1.0388
MAX	5	5	5	5	5	5	5	5	5	13	26	3,400	1	1	1	89	5
MIN	3	3	3	1.5	3.3333	2.6667	2	2	2	0	0	35	0	0	0	0	1

Note(s): SS: Selective staffing; ET: Extensive training; IM: Internal mobility; ES: Employment security; CJD: Clear job description; RA: Results-oriented appraisal; *p*: participation; OI: Open innovation; ITERC: IT Exploration capability; ITEIC: IT Exploitation capability; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Firm age	−0.415***	−0.403***	−0.379***	−0.392***	−0.382***
Firm size	0.149	0.135	0.167	0.249	0.247
Industry 1	−1.299**	−1.171*	−1.343**	−1.399**	−1.345**
Industry 2	−1.109*	−1.004*	−1.193**	−1.249**	−1.205*
Industry 3	−0.935*	−0.825*	−0.976**	−0.993**	−0.967*
IT department size	−0.032	−0.028	−0.094	−0.161	−0.128
Marker variable	−0.004	−0.04	−0.042	−0.055	−0.067
HPWS		0.203*	0.134	0.131	0.144
IT exploration capability			0.016	0.001	0.019
IT exploitation capability			0.086*	0.246	0.277*
IT ambidexterity (IT exploration capability × IT exploitation capability)				−0.06	−0.06
HPWS × IT exploration capability				0.392*	0.379*
HPWS × IT exploitation capability				−0.349*	−0.329*
HPWS × IT ambidexterity (HPWS × IT exploration capability × IT exploitation capability)					−0.125
R^2	0.233	0.272	0.325	0.373	0.383
Adjust R^2	0.179	0.214	0.256	0.286	0.29

Note(s): *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 3. Results of regression analysis (DV: Open innovation)

	Items	Loading	Alpha	C.R.	AVE
Second-order HPWS					
Selective staffing	4	0.79–0.90	0.87	0.91	0.72
Extensive training	3	0.92–0.94	0.92	0.95	0.86
Internal mobility	4	0.85–0.89	0.90	0.93	0.76
Employment security	2	0.90–0.94	0.83	0.92	0.85
Clear job description	3	0.89–0.92	0.89	0.93	0.81
Results-oriented appraisal	3	0.81–0.91	0.84	0.91	0.76
Participation	2	0.97	0.93	0.97	0.94
IT exploration capability	3	0.96–0.98	0.97	0.98	0.94
IT exploitation capability	3	0.95–0.97	0.96	0.98	0.93

Table 4. Reliability and validity

conducted a multicollinearity test. The commonly accepted rule of thumb to judge the existence of multicollinearity is that variance inflation factors (VIFs) are greater than ten, or tolerance value is less than 0.10 (Kutner *et al.*, 2004). The results showed that the VIF of the constructs ranged from 1.351 to 4.138, which indicated that multicollinearity was not a problem in our study. In addition, the principal loadings of every construct were significantly higher than the other loadings, which again indicated that multicollinearity was not a problem in our study.

5.3 Hypothesis testing

We performed hierarchical regression analysis (Kutner *et al.*, 2004). We evaluated the five models separately using the analysis method suggested by Perrone *et al.* (2003). Table 3 presents the results of regression analysis. For the hypotheses on the effects of open innovation, we verified Hypothesis 1. The results of model two proposed that HPWS was positively related to open innovation ($\beta = 0.203$, $p < 0.05$).

In addition, the results of model five revealed that the positive moderating effect of IT exploration capability on the relationship between HPWS and open innovation was

significant ($\beta = 0.379$, $p < 0.05$), which confirmed the reliability of Hypothesis 2a. The results indicated that the negative moderating effect of IT exploitation capability on the relationship between HPWS and open innovation was significant ($\beta = -0.329$, $p < 0.05$), and thus contrary to Hypothesis 2b. The results showed that the negative moderating effect of IT ambidexterity on the relationship between HPWS and open innovation was insignificant ($\beta = -0.125$, $t = -1.21$), and thus did not support Hypothesis 2c.

We followed Aiken *et al.*'s (1991) graphical procedure to draw Figure 1 for analyzing the moderating effects. Figure 1 shows that the sloped regression line for the relationship between HPWS and open innovation was positive and significant for high IT exploration capability ($b = 0.523, p < 0.001$), whereas it was insignificant for low IT exploration capability ($b = -0.235$, $t = -1.486$). Figure 2 shows that the sloped regression line for the relationship between HPWS and open innovation was positive and significant for low IT exploitation capability ($b = 0.473, p < 0.01$), whereas it was insignificant for high IT exploitation capability ($b = -0.185$, $t = -1.068$).

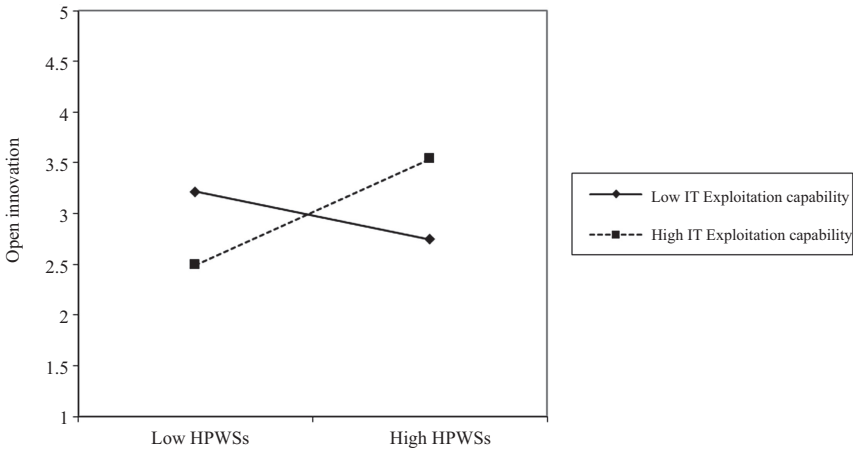

Figure 1.
Moderating effect of IT exploration capability on the relationship between HPWS and open innovation

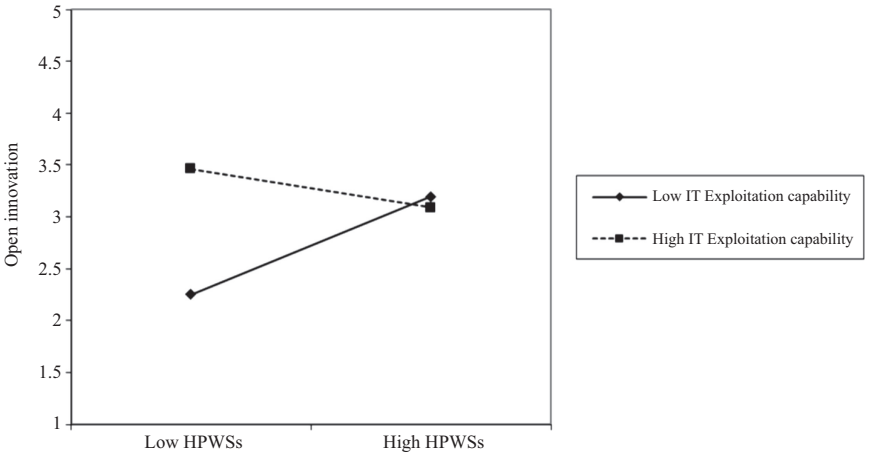

Figure 2.
Moderating effect of IT exploitation capability on the relationship between HPWS and open innovation

6. Discussion and conclusions

The results of this study suggest that HPWS significantly and positively affects open innovation. A possible explanation is that the practices in HPWS can promote employees' learning orientation, which can support and facilitate employees to learn, manage and use external knowledge. Some HR practices may increase the interaction opportunities between employees and external source by improving their motivation of external search, increasing employees' ability of learning and information searching and increasing the exchange among employees and external sources. Thus, HPWS helps employees improve their learning orientation and the openness of firms' external search.

In addition, the current research shows that IT exploration capability positively moderates the influence of HPWS on open innovation. In other words, IT exploration capability supports firms to find the newest and appropriate IT tools that can accelerate the learning process (knowledge acquisition and assimilation) and provide the necessary mechanism to store external knowledge (Trantopoulos *et al.*, 2017; Sambamurthy and Subramani, 2005; Roberts *et al.*, 2012; Von Krogh, 2012). IT exploration capability improves IT flexibility, which helps firms quickly and economically adopt IT applications for supporting the evolving knowledge sharing requirements with external sources (Cui *et al.*, 2015).

The coefficient of IT exploitation capability moderating the relationship of HPWS and open innovation is negative and significant. One possible explanation is that the returns from exploitation are short term (March, 1991). IT exploitation capability can support current learning and external knowledge searching. However, existing IT applications in a dynamic environment may become obsolete, and new IT applications that can meet the new learning requirements may be utilized.

Contrary to our expectations, our study finds that the coefficient of IT ambidexterity moderating the relationship of HPWS and open innovation is negative and insignificant. We suggest from the results that IT exploration capability positively impacts the relationship between HPWS and open innovation, whereas IT exploitation capability negatively impacts the relationship. During external knowledge searching of employees, firms that simultaneously pursue exploration and exploitation in their management of IT resources and practices cannot support and facilitate the improvement of employees' learning orientation.

6.1 Theoretical implications

Existing studies on the relationship between HRM and innovation have evaluated the relationship of HRM practices to production innovation, technology innovation, service innovation and other classifications of innovation. Most of these studies have ignored systematic HRM. Our study has the following theoretical implications. First, the investigated open innovation is different from the innovation in previous research. The investigated open innovation focuses on improving employees' learning orientation to extend collaborative ties externally (Adler and Kwon, 2002) and then improve the openness of external sources. Specifically, our results show that HPWS, which is a set of separate but interrelated HR practices, is positively related to open innovation. Our findings contribute to HRM and indicate the importance of considering the complementarities created by bundled HR practices. Becker and Matthews (2008) indicated that bundles of strategies should be empirically investigated to promote innovation rather than a single HRM approach. Our findings suggest that a systematic view should be considered in terms of the influence of HRM on the searching of knowledge resources.

This study reveals the role of IT capability on the relationship between HPWS and open innovation. Previous studies on HRM and innovation relationships have rarely considered moderators and the role of IT. Although literature has suggested that the link between HRM practices and organizational innovation is positive (Becker and Huselid, 1998), a gap exists in understanding the influences of HRM on innovation. IT provides organizational members

with quick and effective access to the right amounts of information (Hope and Hope, 1997). Thus, they are expected to increase their ability for acquiring and disseminating information with the development of the company's IT capabilities (Tippins and Sohi, 2003). This situation can improve employees' learning orientation of the company, which positively impacts innovation. No scholar has implemented this technology, and this study has filled this gap. The findings have significant implications for HPWS, IT capability and open innovation; open innovation can be improved by using HPWS and IT capability.

Our study reveals the role of IT ambidexterity on the relationship between HPWS and open innovation. Prior studies on IT ambidexterity have not investigated its effect on the relationship. Lee *et al.* (2015) evaluated the enhancing effect of IT ambidexterity on organizational agility. Mithas and Rust (2016) assessed the influence of information IT ambidexterity on profitability and the market value of firm. Chi *et al.* (2017) investigated the influence of a contingent factor, that is, IT ambidexterity, on this value generation process. Our findings expand IT ambidexterity to innovation research. Contrary to ambidexterity perspective, our results suggest that IT ambidexterity cannot facilitate the impact of HPWS on open innovation during the external knowledge searching of employees.

6.2 Practical implications

The results show that HPWS positively impacts open innovation. Open innovation is a process in which employees acquire and exploit external knowledge. HPWS is an HRM approach that elicits employees' commitment and involvement with organizational goals to self-regulate their behavior (Walton, 1985; Wood and Albanese, 1995). Thus, HR practices should be used to improve employees' ability, motivation and opportunity of external learning for improving the openness of external sources.

Enterprises should discreetly develop IT exploitation capability and ambidexterity during external knowledge searching, which may not achieve the desired facilitation purpose. Ambidexterity theory states that IT ambidexterity may lead to improve firm's performance than a single emphasis on IT exploration or exploitation would (Chi *et al.*, 2017). However, our results show that only IT exploration capability positively impacts the relationship between HPWS and open innovation, while IT exploration capability and ambidexterity do not. Organizations should make explicit and implicit choices between the two types of IT capability because of scarce resources in the firm.

6.3 Limitations and future research directions

This study has limitations. The first limitation is that the study relies on managers' descriptions of HPWS and open innovation. The results are valuable for the company and the industry when the dependent variables of open innovation are evaluated using objective indicators. Future research can use appropriate methods to measure open innovation with objective indicators. The second limitation is that the questions related to HPWS are answered by HR managers and the innovation items are answered by production managers, which are analyzed at the enterprise level. We consider the relationship between HPWS and innovation to a multilevel analysis because they present cross-level phenomena. To date, such studies are limited. The third and last limitation is that this study acquires data only from China. Future research can collect data from other countries, such as the United States. The different preferences in selecting IT strategies under different cultural backgrounds can also be examined.

References

Adler, P.S. and Kwon, S.-W. (2002), "Social capital: prospects for a new concept", *Academy of Management Review,* Vol. 27 No. 1, pp. 17-40.

Aiken, L.S., West, S.G. and Reno, R.R. (1991), *Multiple Regression: Testing and Interpreting Interactions*, Sage, London.

Ardito, L. and Petruzzelli, A.M. (2017), "Breadth of external knowledge sourcing and product innovation: the moderating role of strategic human resource practices", *European Management Journal,* Vol. 35 No. 2, pp. 261-272.

Atuahene-Gima, K. (2005), "Resolving the capability—rigidity paradox in new product innovation", *Journal of Marketing,* Vol. 69 No. 4, pp. 61-83.

Becker, B.E. and Huselid, M.A. (1998), *Human Resources Strategies, Complementarities, and Firm Performance*, SUNY Buffalo, Unpublished manuscript.

Becker, K.L. and Matthews, J.H. (2008), *Linking HRM and Innovation: Formulating the Research Agenda*.

Bogers, M., Foss, N.J. and Lyngsie, J. (2018), "The "Human Side" of open innovation: the role of employee diversity in firm-level openness", *Research Policy*, Vol. 47 No. 1, pp. 218-231.

Cai, Z., Huang, Q., Liu, H. and Liang, L. (2016), "The moderating role of information technology capability in the relationship between supply chain collaboration and organizational responsiveness: evidence from China", *International Journal of Operations and Production Management,* Vol. 36 No. 10, pp. 1247-1271.

Camps, J. and Luna-Arocas, R. (2012), "A matter of learning: how human resources affect organizational performance", *British Journal of Management,* Vol. 23 No. 1, pp. 1-21.

Chakravarty, A., Grewal, R. and Sambamurthy, V. (2013), "Information technology competencies, organizational agility, and firm performance: enabling and facilitating roles", *Information Systems Research,* Vol. 24 No. 4, pp. 976-997.

Cheng, J.-H., Huang, J.-K., Zhao, J.-f. and Wu, P. (2019), "Open innovation: the moderating role of organizational learning capability, collaboration and knowledge sharing", *International Journal of Organizational Innovation,* Vol. 11 No. 3, pp. 260-272.

Chesbrough, H. (2003), "The logic of open innovation: managing intellectual property", *California Management Review,* Vol. 45 No. 3, pp. 33-58.

Chi, M., Zhao, J., George, J.F., Li, Y. and Zhai, S. (2017), "The influence of inter-firm IT governance strategies on relational performance: the moderation effect of information technology ambidexterity", *International Journal of Information Management,* Vol. 37 No. 2, pp. 43-53.

Cohen, W.M. and Levinthal, D.A. (1989), "Innovation and learning: the two faces of R & D", *The Economic Journal,* Vol. 99 No. 397, pp. 569-596.

Cui, T., Ye, H.J., Teo, H.H. and Li, J. (2015), "Information technology and open innovation: a strategic alignment perspective", *Information and Management,* Vol. 52 No. 3, pp. 348-358.

Dahlander, L. and Gann, D.M. (2010), "How open is innovation?", *Research Policy,* Vol. 39 No. 6, pp. 699-709.

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research,* Vol. 18 No. 1, pp. 39-50.

Fu, N., Flood, P.C., Bosak, J., Morris, T. and O'Regan, P. (2015), "How do high performance work systems influence organizational innovation in professional service firms?", *Employee Relations,* Vol. 37 No. 2, pp. 209-231.

Garriga, H., Von Krogh, G. and Spaeth, S. (2013), "How constraints and knowledge impact open innovation", *Strategic Management Journal,* Vol. 34 No. 9, pp. 1134-1144.

Hope, J. and Hope, T. (1997), *Competing in the Third Wave: The Ten Key Management Issues of the Information Age*, Harvard Business Press, Boston, MA.

Jaw, B.S. and Liu, W. (2003), "Promoting organizational learning and self-renewal in Taiwanese companies: the role of HRM", *Human Resource Management: Published in Cooperation with the School of Business Administration, The University of Michigan and in alliance with the Society of Human Resources Management*, Vol. 42 No. 3, pp. 223-241.

Jiang, J.Y. and Liu, C.-W. (2015), "High performance work systems and organizational effectiveness: the mediating role of social capital", *Human Resource Management Review,* Vol. 25 No. 1, pp. 126-137.

Jiang, K., Lepak, D.P., Hu, J. and Baer, J.C. (2012), "How does human resource management influence organizational outcomes? A meta-analytic investigation of mediating mechanisms", *Academy of Management Journal,* Vol. 55 No. 6, pp. 1264-1294.

Jyoti, J. and Dev, M. (2016), "Perceived high-performance work system and employee performance: role of self-efficacy and learning orientation", *Metamorphosis,* Vol. 15 No. 2, pp. 115-133.

Jyoti, J. and Rani, A. (2017), "High performance work system and organisational performance: role of knowledge management", *Personnel Review,* Vol. 46 No. 8, pp. 1770-1795.

Kim, Y. and Ployhart, R.E. (2014), "The effects of staffing and training on firm productivity and profit growth before, during, and after the Great Recession", *Journal of Applied Psychology,* Vol. 99 No. 3, pp. 361-389.

Kim, B., Kim, E. and Foss, N.J. (2016), "Balancing absorptive capacity and inbound open innovation for sustained innovative performance: an attention-based view", *European Management Journal,* Vol. 34 No. 1, pp. 80-90.

Kutner, M., Neter, J., Nachtsheim, C. and Wasserman, W. (2004), *Applied Linear Statistical Model Richard D*, Irwin, Chicago IL.

Laursen, K. and Salter, A. (2006), "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing Firms", *Strategic Management Journal,* Vol. 27 No. 2, pp. 131-150.

Laursen, K., Masciarelli, F. and Prencipe, A. (2012), "Regions matter: how localized social capital affects innovation and external knowledge acquisition", *Organization Science,* Vol. 23 No. 1, pp. 177-193.

Lawler III, E.E. (1994), "From job-based to competency-based organizations", *Journal of Organizational Behavior,* Vol. 15 No. 1, pp. 3-15.

Lee, O.-K., Sambamurthy, V., Lim, K.H. and Wei, K.K. (2015), "How does IT ambidexterity impact organizational agility?", *Information Systems Research,* Vol. 26 No. 2, pp. 398-417.

Lindell, M.K. and Whitney, D.J. (2001), "Accounting for common method variance in cross-sectional research designs", *Journal of Applied Psychology,* Vol. 86 No. 1, pp. 114-121.

March, J.G. (1991), "Exploration and exploitation in organizational learning", *Organization Science,* Vol. 2 No. 1, pp. 71-87.

Martinez-Conesa, I., Soto-Acosta, P. and Carayannis, E.G. (2017), "On the path towards open innovation: assessing the role of knowledge management capability and environmental dynamism in SMEs", *Journal of Knowledge Management,* Vol. 21 No. 3, pp. 553-570.

Meuer, J. (2017), "Exploring the complementarities within high-performance work systems: a set-theoretic analysis of UK firms", *Human Resource Management,* Vol. 56 No. 4, pp. 651-672.

Mithas, S. and Rust, R.T. (2016), "How information technology strategy and investments influence firm performance: conjecture and empirical evidence1", *MIS Quarterly,* Vol. 40 No. 1, pp. 223-241.

Nambisan, S., Agarwal, R. and Tanniru, M. (1999), "Organizational mechanisms for enhancing user innovation in information technology", *MIS Quarterly*, pp. 365-395.

Naqshbandi, M.M. and Jasimuddin, S.M. (2018), "Knowledge-oriented leadership and open innovation: role of knowledge management capability in France-based multinationals", *International Business Review,* Vol. 27 No. 3, pp. 701-713.

Naqshbandi, M.M. and Tabche, I. (2018), "The interplay of leadership, absorptive capacity, and organizational learning culture in open innovation: testing a moderated mediation model", *Technological Forecasting and Social Change,* Vol. 133, pp. 156-167.

Ning, N., Wang, J., Lin, Z. and Zheng, Z. (2018), "The direct and moderating effect of learning orientation on individual performance in the banking industry in China: contextualization of

high-performance work systems", *Asia Pacific Journal of Human Resources,* Vol. 56 No. 3, pp. 360-383.

Perrone, V., Zaheer, A. and McEvily, B. (2003), "Free to be trusted? Organizational constraints on trust in boundary spanners", *Organization Science,* Vol. 14 No. 4, pp. 422-439.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y. and Podsakoff, N.P. (2003), "Common method biases in behavioral research: a critical review of the literature and recommended remedies", *Journal of Applied Psychology,* Vol. 88 No. 5, pp. 879-903.

Ravichandran, T., Lertwongsatien, C. and Lertwongsatien, C. (2005), "Effect of information systems resources and capabilities on firm performance: a resource-based perspective", *Journal of Management Information Systems,* Vol. 21 No. 4, pp. 237-276.

Roberts, N., Galluch, P.S., Dinger, M. and Grover, V. (2012), "Absorptive capacity and information systems research: review, synthesis, and directions for future research", *MIS Quarterly,* Vol. 36 No. 2, pp. 625-648.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J. and Engel, P., *et al.* (2015), "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries", *Boston Consulting Group*, Vol. 9 No. 1, pp. 54-89.

Sambamurthy, V. and Subramani, M. (2005), "Special issue on information technologies and knowledge management", *MIS Quarterly*, pp. 193-195.

Soto-Acosta, P., Popa, S. and Martinez-Conesa, I. (2018), "Information technology, knowledge management and environmental dynamism as drivers of innovation ambidexterity: a study in SMEs", *Journal of Knowledge Management,* Vol. 22 No. 4, pp. 824-849.

Sun, L.-Y., Aryee, S. and Law, K.S. (2007), "High-performance human resource practices, citizenship behavior, and organizational performance: a relational perspective", *Academy of Management Journal,* Vol. 50 No. 3, pp. 558-577.

Tanaka, J.S. and Huba, G.J. (1984), "Confirmatory hierarchical factor analyses of psychological distress measures", *Journal of Personality and Social Psychology,* Vol. 46 No. 3, pp. 621-635.

Tai, J.C., Wang, E.T. and Wang, K. (2017), "Investigating the Impact of IT Ambidexterity on Digital Innovation Capability", in *Paper presented at the Pacific Asia Conference on Information Systems (PACIS 2017 Proceedings)*, Langkawi, available at: http://aisel.aisnet.org/pacis2017/67.

Theriou, G.N. and Chatzoglou, P.D. (2008), "Enhancing performance through best HRM practices, organizational learning and knowledge management: a conceptual framework", *European Business Review,* Vol. 20 No. 3, pp. 185-207.

Tippins, M.J. and Sohi, R.S. (2003), "IT competency and firm performance: is organizational learning a missing link?", *Strategic Management Journal,* Vol. 24 No. 8, pp. 745-761.

Trantopoulos, K., von Krogh, G., Wallin, M.W. and Woerter, M. (2017), "External knowledge and information technology: implications for process innovation performance", *MIS Quarterly,* Vol. 41 No. 1, pp. 287-300.

Van de Vrande, V., De Jong, J.P., Vanhaverbeke, W. and De Rochemont, M. (2009), "Open innovation in SMEs: trends, motives and management challenges", *Technovation,* Vol. 29 Nos 6-7, pp. 423-437.

Von Krogh, G. (2012), "How does social software change knowledge management? Toward a strategic research agenda", *The Journal of Strategic Information Systems,* Vol. 21 No. 2, pp. 154-164.

Walton, R.E. (1985), "From control to commitment in the workplace", *Harvard Business Review,* Vol. 63 No. 2, pp. 76-84.

Wang, Y., Guo, B. and Yin, Y. (2017), "Open innovation search in manufacturing firms: the role of organizational slack and absorptive capacity", *Journal of Knowledge Management,* Vol. 21 No. 3, pp. 656-674.

Way, S.A. (2002), "High performance work systems and intermediate indicators of firm performance within the US small business sector", *Journal of Management,* Vol. 28 No. 6, pp. 765-785.

West, J. and Bogers, M. (2014), "Leveraging external sources of innovation: a review of research on open innovation", *Journal of Product Innovation Management,* Vol. 31 No. 4, pp. 814-831.

Wood, S. and Albanese, M.T. (1995), "Can we speak of a high commitment management on the shop floor?", *Journal of Management Studies,* Vol. 32 No. 2, pp. 215-247.

Yli-Renko, H., Autio, E. and Sapienza, H.J. (2001), "Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms", *Strategic Management Journal,* Vol. 22 Nos 6-7, pp. 587-613.

Appendix

Table A1. The measurement items

1	HPWS	
	Selective staffing	1. Great effort is taken to select the right person
		2. Long-term employee potential is emphasized
		3. Considerable importance is placed on the staffing process
		4. Very extensive efforts are made in selection
	Extensive training	1. Extensive training programs are provided for individuals in customer contact or front-line jobs
		2. There are formal training programs to teach new hires the skills they need to perform their job
		3. Formal training programs are offered to employees in order to increase their promotability in this organization
	Internal mobility	1. Employees have few opportunities for upward mobility
		2. Employees do not have any future in this organization
		3. Employees have clear career paths in this organization
		4. Employees in customer contact jobs who desire promotion have more than one potential position they could be promoted to
	Employment security	1. Employees in this job can be expected to stay with this organization for as long as they wish
		2. Job security is almost guaranteed to employees in this job
	Clear job Description	1. The duties in this job are clearly defined
		2. This job has an up-to-date description
		3. The job description for a position accurately describes all of the duties performed by individual employees
	Results-oriented appraisal	1. Performance is more often measured with objective quantifiable results
		2. Performance appraisals are based on objective quantifiable results
		3. Employee appraisals emphasize long term and group-based achievement
	Participation	1. Employees in this job are often asked by their supervisor to participate in decisions
		2. Individuals in this job are allowed to make decisions
2	IT exploration capability	Relative to other firms in your industry, please indicate the ability of your IT unit(s) to
		Acquire new IT resources (e.g. new generation of IT architecture, potential IT applications, critical IT skills)
		Experiment with new IT resources
		Experiment with new IT management practices
3	IT exploitation capability	Reuse existing IT components, such as hardware and network resources
		Reuse existing IT applications and services
		Reuse existing IT skills

(*continued*)

4	Open innovation	To evaluate the extent to which the firm searched for knowledge and information from external sources (1) Supplier (2) Consumers (3) Dealers (4) Competitors (5) Consultants (6) Universities and other research institutions (7) Technology intermediary organization (8) Intellectual property organization (9) Venture capital enterprises (10) News media (11) Trade associations (12) Relevant government departments (13) Others

Table A1.

Corresponding author
Jingmei Zhou can be contacted at: zhoujingmei200888@163.com